VCR REPAIRS AND ADJUSTMENTS THAT YOU CAN DO

JOHN D. LENK

Repairing and aligning VCR's isn't easy, but it is possible to do some of the work yourself if you know how! In this article we'll tell you what repairs and adjustments you can make using standard test equipment.

SO YOU WANT TO TRY SERVICING VCR'S? On the other hand, maybe you would just like to know how to make some simple adjustments to improve VCR performance or some sure-fire troubleshooting to quickly pinpoint VCR problems. Well, we'll start this article by saying there are no such tricks or simple adjustments! Servicing any VCR takes all the skill and knowledge required to service any TV set or tape recorder. More important, all VCR adjustments, particularly mechanical adjustments, are critical. An improper mechanical adjustment can not only put a VCR out of commission, but can result in permanent damage to the VCR or cassette.

Now that we have duly frightened you, let us go on to discuss what practical steps you can take in VCR servicing, without hassle, and with a minimum of danger. Before we start, however, let us set a few ground rules. First off, we will assume that you are thoroughly familiar with TV, both color and black-and-white, and with magnetic tape recorders. We also assume that you can use all forms of test equipment and tools associated with TV and tape-recorder service. If the above is not true, you probably have no business trying to service a VCR.

Now let us review how VCR's, both Beta and VHS, operate. We will not go into full circuit descriptions or mechanical details (to do so would fill a book, let alone a magazine article), but we will go through VCR functions so that you can understand the theory-of-operation sections found in VCR service literature.

The basic VCR circuit

Figure 1-a is a block diagram of a basic VCR circuit. Note that a VCR is a form of VTR, or videotape recorder. VTR's have been used in the television industry since about 1955 to record programs. Based on the same electromagnetic principles as an audio-tape recorder, a VTR has the ability to record on magnetic tape, and later play back, video signals coming from a video

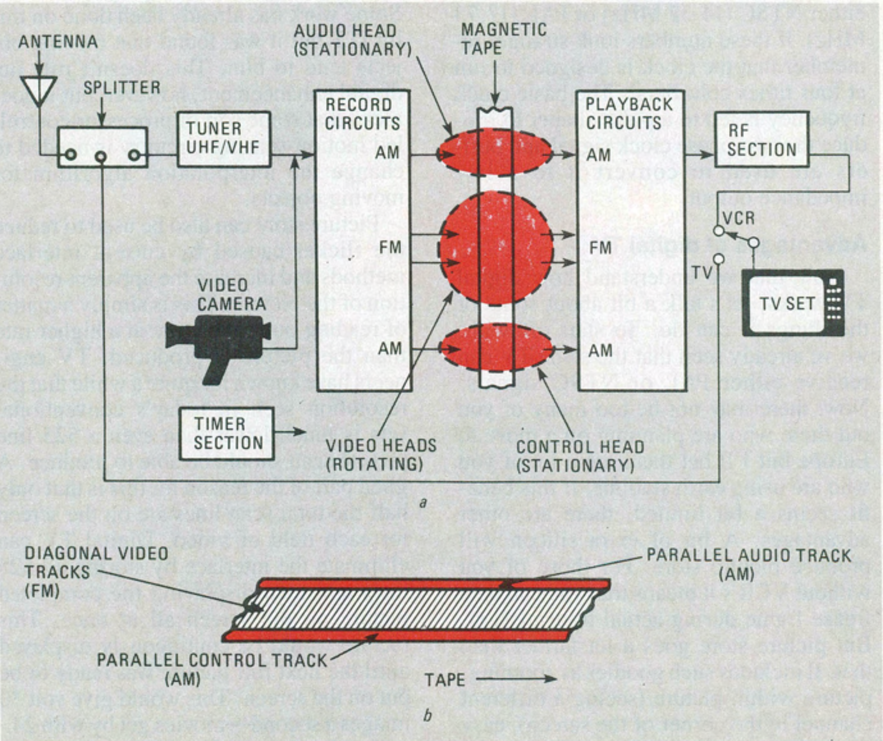
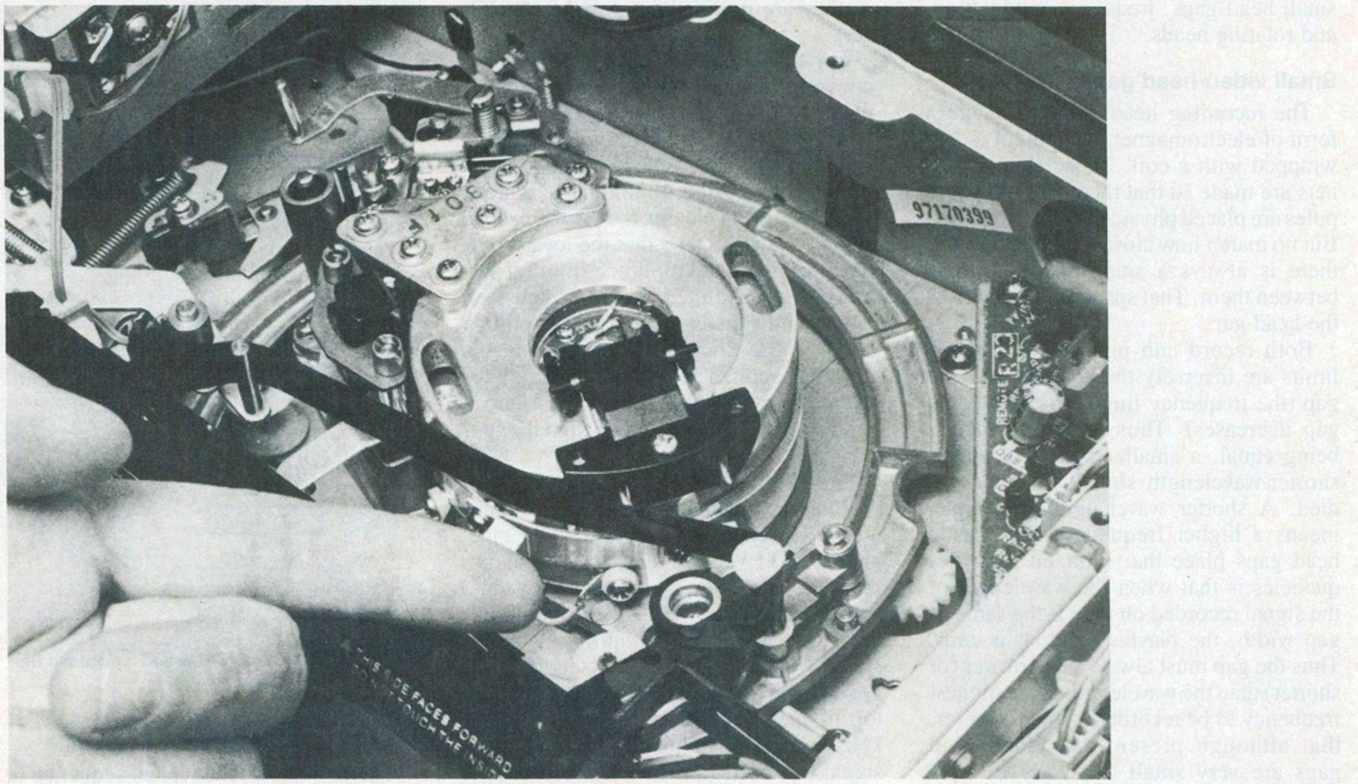


FIG. 1—SIMPLIFIED BLOCK DIAGRAM of a home VCR is shown in *a*. How that VCR records tracks on a tape is shown in *b*



camera or a TV station. That process is called video recording, and has many advantages over older TV recording processes and over motion-picture film. For example, both picture and sound can be recorded at the same time; there is no need for developing or processing the tape after recording; long-term preservation is possible; many recordings can be made using the same tape over again; continuous recording and playback are possible over relatively long periods of time, and a VTR or VCR is relatively compact and easy to use.

As shown in Fig. 1-a, a typical consumer VCR includes a tuner (VHF and UHF), an RF section, a timer section, and a mechanical section (including tape transport, stationary audio head, stationary control head, and rotating video heads). The same heads used for recording are also used for playback, and there are two rotating heads (typically) for video record/playback, whereas there is only one audio head and one control head.

The tuner section is similar to tuners found in TV sets, and functions to convert broadcast signals picked up by the antenna to frequencies and formats suitable for use by the VCR. All TV channels, 2 through 83, are covered by the tuner. Typically, tuner output to the recording circuit is 1 volt (P-P) for video, and 0 dB (0.775 volt) for audio.

The recording circuits function to convert the tuner output into electrical signals used by the heads to record the corresponding information on the magnetic tape along tracks. There are three tracks as shown Fig. 1-b (audio, video, and control or synchronization). Note that the audio and control tracks are parallel to the tape, whereas the video track is diagonal. As we will discuss later, the video track is recorded diagonally to increase tape-writing speed, and thus increase the bandwidth as is necessary to record video signals.

The playback circuits function to convert information, recorded on the tracks and picked up by the heads, into electrical signals used to modulate the RF section. In the simplest of terms, the RF section is a miniature TV broadcast station with its output on an unused TV channel (typically Channel 3 or 4, but possibly 5 or 6). The output of the RF section is applied to the TV set.

During operation, you select the channel you wish to record, using the VCR tuner controls. That need not be the channel watched on the TV set. (In fact, the TV set need not even be on while recording on the VCR.) You then turn on the timer and the program (or programs) are recorded.

When you are ready to play back the recorded program, you select the appropriate unused channel using the TV's channel-selector controls. Then you turn on the timer and play back the program using the TV set as a display device.

Many present-day VCR's also provide for recording directly from a video camera and microphone. Those are connected to the VCR's recording circuits at the same point that the tuner would be. Once the material is recorded, operation of the VCR during playback is the same, no matter what the recording source (off-air programming or video camera).

Why VCR circuits are so complex

The diagram shown in Fig. 1-a is, of course, greatly oversimplified. Although a VCR is essentially a tape recorder, there are two unique problems associated with them that are not found in audio tape recorders. Those two problems result in very complex circuits, as well as precision mechanical assemblies for both Beta and VHS VCR's.

One of the problems is the high video frequencies (4 to 5 MHz) used in TV. It is not practical to record those frequencies on tape using familiar audio-frequency techniques. The other problem is that there must be precise synchronization of video and audio during both record and playback.

Now let us see how these problems are solved in a present-day consumer VCR.

Recording the video signal

Recording the audio and control tracks is relatively simple when compared to recording the video signals. The control signals are typically 60 Hz, whereas the audio signals rarely go below about 20 Hz or above 20 kHz. The techniques used in audio-tape recorders are adequate for both of these signals. However, typical video signals can range from DC (0 Hz) up to about 4.2 MHz.

There are three methods used to increase the frequency range (or increase writing speed) that a VCR can handle—small head gaps, frequency modulation, and rotating heads.

Small video-head gaps

The recording heads in a VCR are a form of electromagnet made up of a core wrapped with a coil. Those electromagnets are made so that the north and south poles are placed physically close together. But no matter how close together they are, there is always a small space, or gap, between them. That space is referred to as the head gap.

Both record and playback frequency limits are inversely proportional to head gap (the frequency limit increases as the gap decreases). Thus, all other factors being equal, a smaller head gap means shorter-wavelength signals can be handled. A shorter wavelength, of course, means a higher frequency. The reason head gaps place that limit on high frequencies is that when the wavelength of the signal recorded on tape is the same as gap width, the playback output is zero. Thus the gap must always be narrower (or shorter) than the wavelength of the highest frequency to be recorded. Note, however, that although present-day video-head gaps are very small (typically 0.6-micrometer for Beta and 0.3-micrometer for VHS), there is an obvious physical limit on how small you can make a practical video head. Thus, other methods of increasing the frequency range must also be used.

FM recording and playback

The output voltage of any tape playback head varies in amplitude with changes in frequency; Fig. 2 shows that relationship. If only a narrow portion of the frequency range is used, as is the case with audio recording, you can ignore the amplitude variations. However, with video (where the highest frequency is about 200 times that of audio), the wide variation in amplitude produces a playback output (at the head) that is totally distorted compared to the recorded signal. An FM recording has no variation in amplitude (theoretically) and any amplitude variations that do occur in either record or playback can be virtually eliminated by limiters and amplifiers that are driven into saturation (just as they are in the audio portion of a TV set).

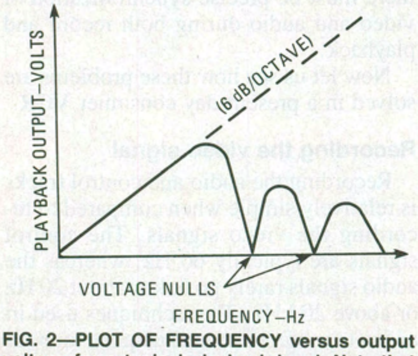


FIG. 2—PLOT OF FREQUENCY versus output voltage for a typical playback head. Note that over a wide frequency range, as is the case with a video recording, the variations in amplitude can cause unacceptable distortion.

For those reasons, the video signal is converted to an FM signal by an FM modulator before recording on tape in a VCR. Upon playback, the FM signals coming from the video heads go to amplifiers and limiters where the amplitude variations are removed. Typically, the playback head signal is amplified so that the lowest output is beyond the amplitude limit (at saturation) of a limiter circuit, which then reduces all signals to the same amplitude level. Those constant-amplitude signals are then applied to an FM demodulator that converts the FM signal back into a replica of the original video signal.

Rotating video heads

Rotating video heads are used to increase the relative speed between the tape and head. If you are familiar with audio tape recording, you know that a slow tape speed is sufficient for recording conversation, but music requires a faster speed (typically 19 cm-per-second) for good sound quality. If you assume that the top frequency for recording music is 20 kHz, that the top frequency limit for video signals is 4 MHz (200 times that of audio), and that a 19-cm-per-second tape speed is sufficient for good quality for audio, the required tape speed is 3800 cm-per-second ($19 \times 200 = 3800$) or 38 meters-per-second. This works out to about 2280 meters-per-minute, and would require a video cassette the size of a truck tire (or very thin tape) for only one hour of playing time!

Instead of running the tape at a high speed, the video heads are rotated to produce a high relative speed between head and tape. Figure 3 shows how the heads and tape move in relation to each other. While the video heads rotate in a horizontal plane as shown in Fig 3-a (on a drum in Beta and on a cylinder in VHS), the tape passes the heads diagonally. That is known as a helical scan system, and produces slant tracks or diagonal tracks for the video recording.

Note that the audio head and control-track head (mounted one above the other on a stack as shown in Fig. 3-b) are stationary, and are separate from the video heads, as is the erase head. That arrangement is typical for both Beta and VHS. However, because of different drum or cylinder size, the relative speed of the Beta system is typically 6.9 meters-per-second (273.2 inches-per-second), whereas the typical VHS relative speed is 5.8 meters-per-second (228 inches-per-second), even though the actual tape speed is in the range of 2 cm-per-second. Also note that the drum or cylinder (often referred to as the scanner) rotates at a speed of 1800 rpm for both Beta and VHS.

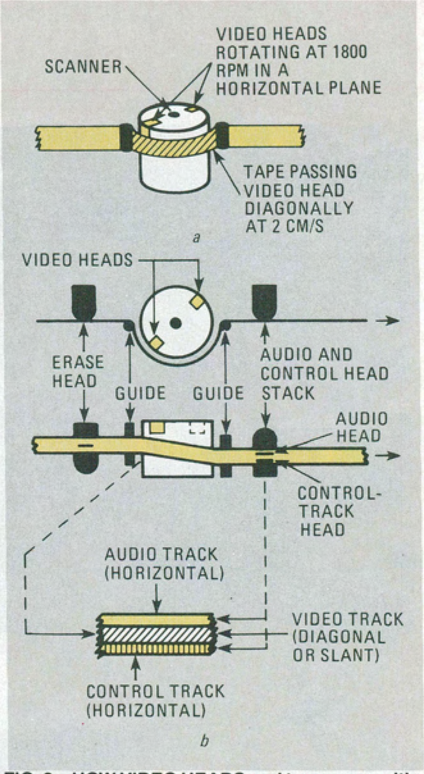


FIG. 3—HOW VIDEO HEADS and tape move with relation to each other.

Video signal recording sequence

Figure 4 shows the typical sequence in recording and playback of the luminance (black-and-white) signal on a VCR. During recording, the entire luminance signal (from sync tips to white peaks) is amplified and converted to an FM signal that varies in frequency from about 3.5 to 4.8 MHz (for Beta) or 3.4 to 4.4 MHz (for VHS). During playback, the FM signal is demodulated back to a replica of the original luminance signal. Note that this provides an FM luminance bandwidth on tape of about 1.3 MHz for Beta and 1 MHz for VHS.

TV color information is transmitted on the 3.58-MHz chrominance subcarrier. Color at any point on the TV screen depends on the instantaneous amplitude and phase of the 3.58-MHz signal. In VCR's, the 3.58-MHz subcarrier is hetrodyned or down-converted to a frequency of 688 kHz (Beta) or 629 kHz (VHS), and is then recorded directly (AM, not FM) on tape. That system is known as color-under, because the color signal frequency is always well below the luminance signal frequency.

Tracks, fields, frames

As shown in Fig. 5-a, video heads A and B are positioned 180° apart on the drum or cylinder, which rotates at 30 rps. The tape is wrapped around the drum or cylinder and passes diagonally across the surface to produce the helical scan. Since there are two heads, each head contacts the tape once each 1/60 of a second, so each head completes one rotation in 1/30 of a second, and one video track is recorded on the tape during half a rotation (1/60

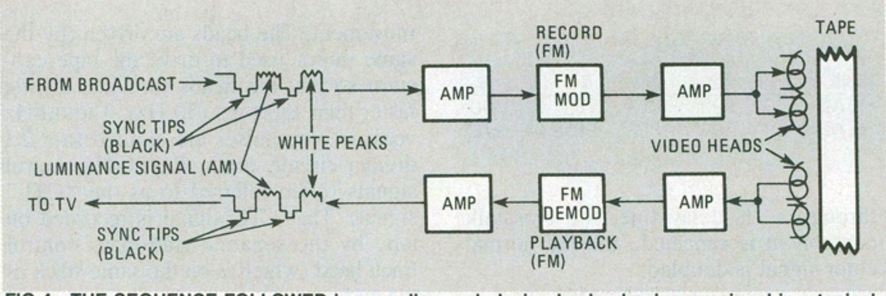


FIG 4—THE SEQUENCE FOLLOWED in recording and playing back a luminance signal in a typical VCR. Note that the same heads are used for recording and playback.

of a second).

Since the tape is moving, after the first head has completed one track the second head records another track immediately behind the first. If head A records during the first 1/60 second, head B records during the next 1/60 second. The recording continues in an A, B, A, etc. pattern as shown in Fig 5-b. During playback, the same sequence occurs—the heads trace the tracks recorded on tape and pick up the signal, producing an FM signal that corresponds to the recorded video signal.

Figure 6 shows the relationship between the video tracks and TV signals. Since there are two heads, 60 diagonal

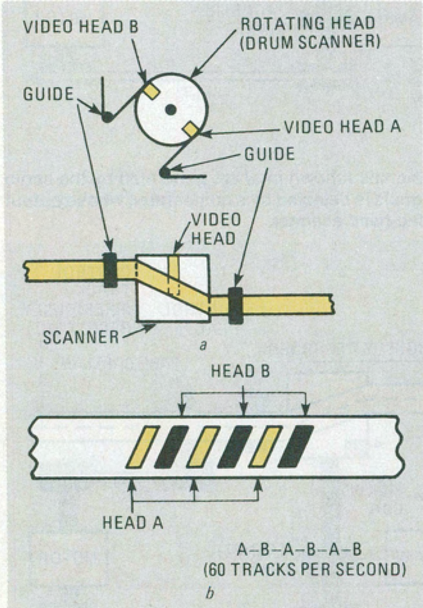


FIG. 5—THE RELATIONSHIP between the video heads and the video tracks recorded on a tape.

tracks are recorded every second as shown in Fig. 6-a. One field of the TV video signal is recorded as one track on the tape, and two fields (adjacent tracks A and B) make up one frame as shown in Fig. 6-b. In both Beta and VHS, there is some overlap between the two tracks. For example, the video signal recorded by head A (just leaving the tape) is simultaneously applied to head B (just starting its track). During playback, this overlap is eliminated by electronic switching so that the output from the two heads appears as a continuous signal.

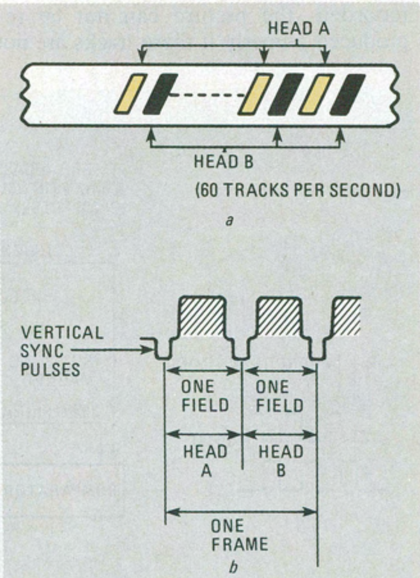


FIG. 6—HOW FIELDS, frames, and tracks are related.

Zero guard band recording

On studio-type VTR's, there is unrecorded vacant space between the video tracks. That blank area, or guard band, is necessary to eliminate crosstalk between tracks. Crosstalk occurs when the heads mistrack and play back a portion of two adjacent tracks. On consumer VCR's, there are no guard bands between the video tracks. Figure 7 shows a comparison of tapes with and without guard bands. Note that the tape without guard bands shown in Fig. 7-a (consumer VCR) contains much more information than the studio VTR tape shown in Fig. 7-b, and is often referred to as high-density recording tape. Although those high-density systems are called zero guard-band, there are guard bands that separate the audio and control tracks from the video tracks.

Without special precautions, crosstalk can occur in zero guard-band systems. In both Beta and VHS, the problem of crosstalk is eliminated by two techniques: azimuth recording and phase inversion.

Azimuth recording

If you are familiar with audio-tape recorders, you know that considerable high-frequency loss (known as azimuth loss) occurs when there is a difference in the angle of the head (in relation to the tape) between record and playback. One symp-

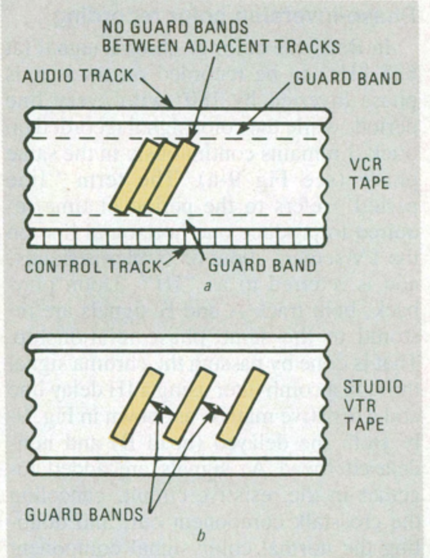


FIG. 7—THE DIFFERENCES between home VCR tape and studio VTR tape. Note that in the VCR tape there is no guard band between the tracks.

tom of an audio recorder with any misalignment (known as azimuth error) is that the recorder plays back its own recordings without high-frequency signal loss, but produces considerable loss when playing back tapes made on other machines (where the tapes are recorded with different azimuth adjustments).

In VCR's, that azimuth-loss principle is used to eliminate high-frequency luminance crosstalk. The two video heads are mounted so that one head is at a different angle from the other head, as shown in Fig. 8. In Beta, the angle for one head (arbitrarily called head A) is $+7°$ from the reference point, whereas head B has an azimuth angle of $-7°$ from the reference, producing a difference of 14° between the heads. VHS uses a $\pm$ 6° azimuth difference (resulting in a 12° difference between head A and head B). During playback, a strong signal is picked up only when head A traces track A. If head A runs over to track B, for any reason, the track B high-frequency signal is weak and does not produce interference or crosstalk.

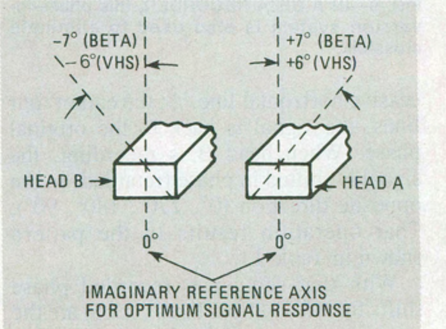


FIG. 8—TO ELIMINATE high-frequency luminance crosstalk, the heads in a VCR are mounted so that they are at opposite angles to an imaginary reference axis.

Phase-inversion color recording

In Beta, the color or chroma signal (at 688 kHz) to be recorded on track A is phase-inverted by 180° with every line period, while the color signal recorded on track B remains continuously in the same phase (see Fig 9-a). The term "line period" refers to the period of time required to produce one horizontal line on the TV screen, about 63.5 microseconds, and is referred to as "1H". Upon playback, both track A and B signals are restored to the same phase relationship. That is done by passing the chroma signal through a comb filter using a 1H delay line and a resistive matrix, as shown in Fig. 9-b. Both the delayed (head B) and non-delayed (head A) signals are added together in the resistive circuit, canceling the crosstalk component out, and doubling the normal color signal component amplitude.

The phase-inversion system used in VHS is entirely different from that in Beta. In VHS, the phase of the color signal being recorded on head A is advanced in phase in increments of 90° at each suc-

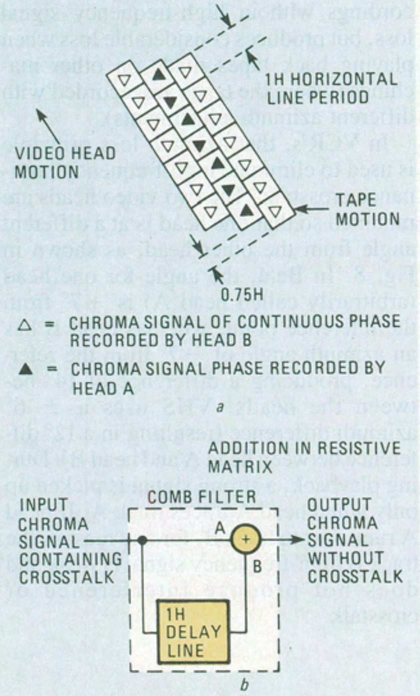


FIG. 9—IN A BETA RECORDER, this phase-inversion system is also used to eliminate crosstalk.

cessive horizontal line. At the end of four lines, the signal is back to the original phase. When head B is recording, the signal is shifted in phase (retarded) in the opposite direction (0°, 270°, 180°, 90°). That operation results in the pattern shown in Table 1.

With that sequence, recorded phase shifts for odd-number lines (1,3,5) are the same, but are opposite for even-number lines (2,4,6). Upon playback, the phase of the color signal is shifted on every other line and, when such a signal is passed

LINE	1	2	3	4	5	6
HEAD A	0°	90°	180°	270°	0°	90°
HEAD B	0°	270°	180°	90°	0°	270°

through a 1H delay line, the crosstalk component is canceled, and the normal color signal is doubled.

Synchronizing the picture

No matter how precisely the tracks are recorded, the picture can not be reproduced properly if these tracks are not

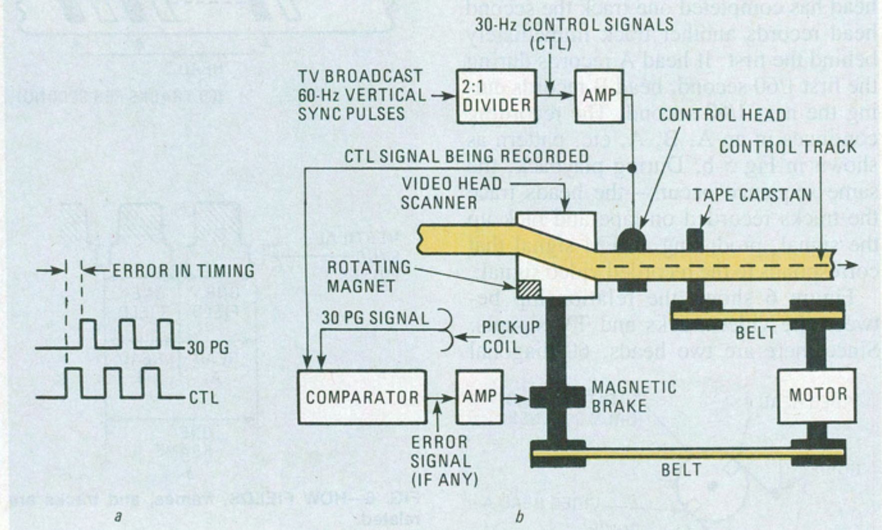


FIG. 10—DURING RECORDING, the CTL and 30 PG signals (shown in *a)* are generated by the servo system (shown in *b*. Any difference between those signals is detected by a comparator, whose output is amplified and used to control the speed of the video-head scanner.

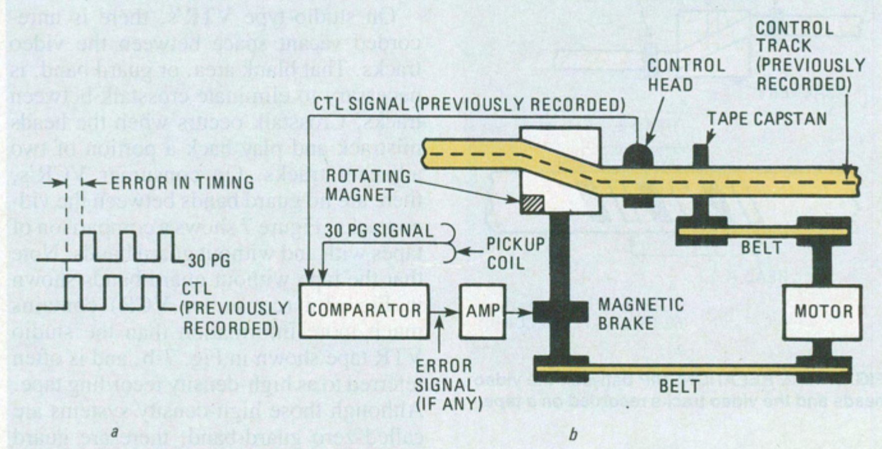


FIG. 11—THE OPERATION OF THE SERVO SYSTEM during playback is similar to that during recording. Here, however, the 30 PG signal is compared to a previously recorded CTL signal.

accurately traced by the rotating heads during playback. In addition to a high degree of mechanical precision, both Beta and VHS systems use an automatic self-governing arrangement, generally known as the servo system. Figures 10 and 11 show the operation of a typical VCR servo system during record and playback.

As shown in Fig. 10, the vertical-sync pulses of the TV broadcast are used to synchronize the rotating heads with tape movement. The heads are driven (by the same motor used to drive the tape capstan) so that the heads turn just a little faster than 1800 rps (30 Hz). The 60-Hz vertical sync pulses are applied to a 2:1 divider circuit, producing 30-Hz control signals (often referred to as the "CTL" signal). That CTL signal is recorded on tape by the separate stationary control track head (which is on the same stack as the audio head).

A pulse signal (called the "30 PG" signal) is generated by detecting the actual rotational speed of the heads. The most common way to generate the 30 PG signal is to use a stationary pickup coil and a rotating magnet. The magnet is rotated together with the heads, and produces a pulse in the pickup coil each time the magnet passes the coil. The 30 PG signal is compared with the 30-Hz CTL signal, and any difference (or error signal) is amplified. The output of the amplifier is used to control the current of a magnetic brake that controls speed of the rotating heads.

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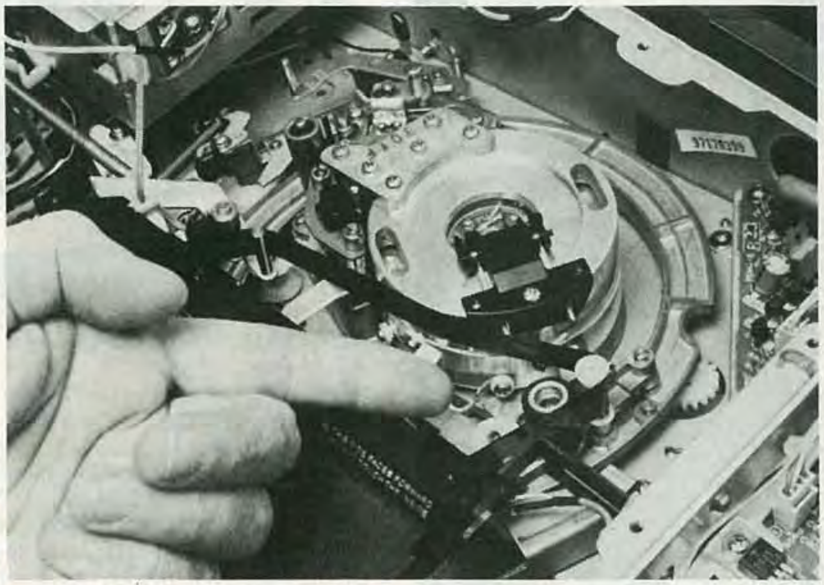
The current applied to the brake coil is increased if rotational speed exceeds 1800 rpm, and vice versa, to maintain the scanner speed at precisely 1800 rpm.

As shown in Fig. 11, the CTL control signal recorded on tape becomes the standard reference signal during playback. The CTL signal is compared with the 30 PG signal of the rotating heads, and any difference or error signal is amplified. Again, the amplifier output is used to control operation of the brake (and thus control speed of the rotating heads), so the heads trace the appropriate tracks, and playback is synchronized with record.

The system shown in Figs. 10 and 11 is a form of drum servo. There is also a capstan servo used in many VCR's. Most of the advanced servo systems used in present-day VCR's not only control speed, but also control the phase relationship between drum and capstan servos, producing even more precise synchronization.

Now that we have a basic understanding of how a VCR works, it is time to turn our attention to some more practical matters, such as the tools and procedures used in servicing those devices. We'll start by taking a look at the tools you need next time when we continue this article. **R-E**

VCR REPAIRS AND ADJUSTMENTS THAT YOU CAN DO



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Part 2 LAST MONTH, IN THE first part of this article, we skimmed through the basics of VCR's. We looked at VCR circuits and at how a video signal is recorded. Now let us drop the subject of circuits, and get on to more practical matters.

Keep in mind that about 95% of the circuits we've described are contained in a few special-purpose IC's. (That applies equally to video, audio and servo circuits.) You can not get at the detailed circuits for test or analysis. Likewise, if there is a failure of even one circuit in an IC, the entire IC must be replaced (as is the case with most TV circuits). About the only electronic components in a VCR that can be replaced on an individual basis are adjustment controls. We will talk about those components and the related adjustments later on. But before that, let us discuss the test equipment and tools you need for VCR service.

Test equipment and tools for VCR's

The test equipment used in VCR service is basically the same as that used in TV and audio service. Most service procedures are performed using meters, signal generators, color generators, oscilloscopes, frequency counters, power supplies, probes, and so on. However, there are some problems to be considered when selecting test equipment for VCR service.

The subject of tools, test jigs, and fixtures for VCR service is an entirely different matter. Generally, each VCR requires a special set of tools, available from the VCR manufacturers in the form of kits. Although there are some tools found in all kits, such as tension gauges, there are many special-purpose tools for most VCR's. Keep in mind that it is impossible to perform a full set of manufacturer-recommended test and adjustment procedures without having all of those special tools.

Let us consider the minimum requirements for test equipment and tools that you'll need to work with VCR's.

Meters

Any meter suitable for TV and audio work is probably suitable for VCR service. (However, most VCR service literature lists audio signals in terms of dB's rather than volts, so a meter with a dB scale would be useful and time-saving.)

Signal generators

As a minimum you should have a sweep/marker generator as well as an analyst and/or pattern generator for basic VCR service.

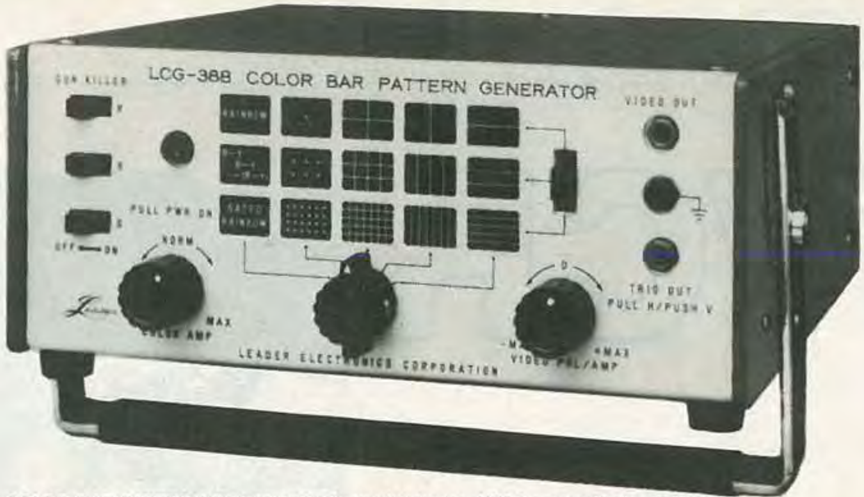
Color generators

You can perform some of the adjustments required for VCR service with a keyed rainbow generator, but you must have an NTSC color generator to perform all of the adjustments. As a minimum, the NTSC generator should produce the standard NTSC bar pattern (for display on the TV screen) and a five-step linear staircase pattern (for display on an oscilloscope being used to monitor various points in VCR circuits).

Oscilloscopes.

As in the case of meters, any oscilloscope suitable for TV and audio work will be fine for VCR service. That means a bandwidth of at least 10 MHz is best, although you probably could get by using a scope with a bandwidth of as low as 5-6 MHz.

A HANDHELD MULTIMETER like this one should be fine for VCR servicing.



A COLOR BAR PATTERN GENERATOR is useful, but an NTSC generator is preferred.

Frequency counters

If you want to go through a full set of VCR adjustments, you will need a frequency counter to check or adjust the various 3.58-MHz oscillators in the color record and playback circuits, and to measure servo-system timing. Most frequency counters have a sufficient frequency range to measure the 3.58-MHz signals; but many of the servo-system signals are in the 30-Hz range, and low-cost counters often do not go down that far, or are not that accurate. Typically, low-cost counters have an accuracy of about 100 Hz. (Accuracy is not to be confused with counter resolution, which is set by the number of digits in the readout.)

One way to overcome the accuracy problem is to use the period function of the counter. (Again, many inexpensive counters do not have a period function.) When period is measured on a counter, the unknown input signal controls the counter timing gate, and the timebase frequency is counted and read out. For example, if the timebase frequency is 1 MHz, the indicated count is in microseconds (a count of 333 indicates that the gate has been held open for 333 microseconds. In effect, the timebase accuracy is divided by the time period. For 30-Hz signals, where the time period is approximately 1/30-second, an accuracy of 100 Hz is increased to 3.3 Hz (100/30). Of course, the period count must be divided into 1 to find the frequency.

No matter what frequency counter you select, check its accuracy at regular intervals. If it is not convenient to use WWV signals for such checks, a simpler method is to monitor the 3.58-MHz oscillator in a color TV receiver. That oscillator is locked in frequency to a color broadcast at a frequency of 3.579545 MHz. The TV receiver oscillator remains locked to that frequency, even though the phase and color hue may shift. Keep in mind that the TV receiver should be operating properly (with good color rendition), and that a 7-digit counter is needed to get the full frequency resolution.

Probes

Both the meters and oscilloscopes used for VCR service should have a full set of probes, including RF, demodulator, and low-capacitance probes. High-voltage probes are not usually needed for any VCR circuit.

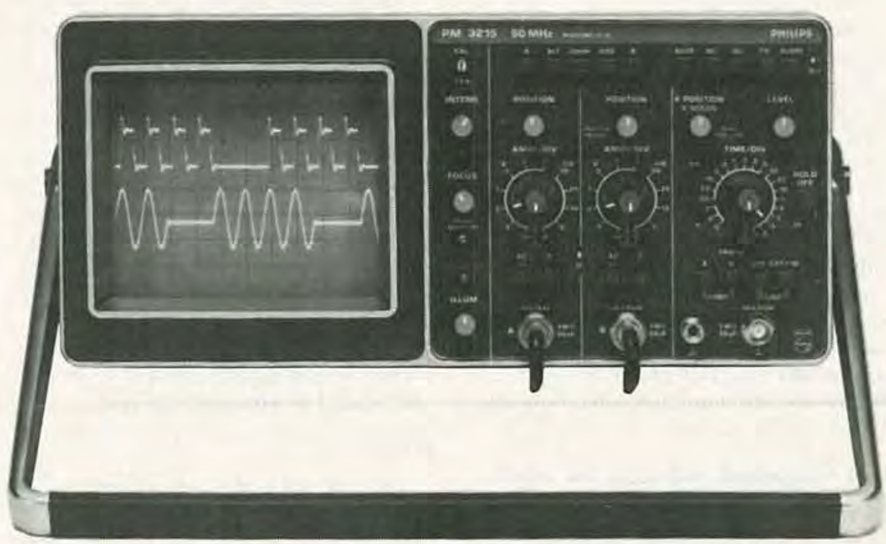
Video monitor

If you are planning to go into VCR service on a full-scale basis, you should consider a receiver/monitor such as used in studio or industrial video work. Those receiver/monitors are essentially TV receivers, but with video and audio inputs and outputs brought out to some accessible point (usually the front panel).

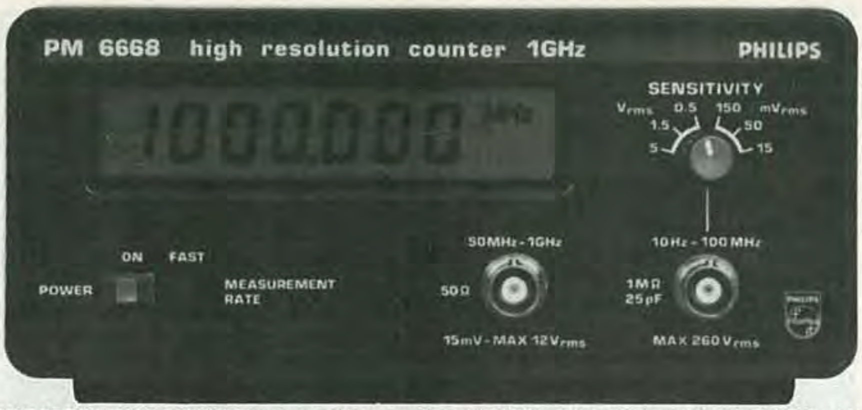
The output connections make it possible to monitor broadcast video and audio signals as they appear at the output of a TV-receiver IF section (the so-called baseband signals, in the range 0 to 4.5 MHz, at 1 volt P-P for video, and 0 dB, or 0.775 volt, for audio). Those output signals from the receiver/monitor can be injected into the VCR at some point in the signal flow after the tuner IF section.

The input connections make it possible to inject video and audio signals from the VCR (before they are applied to the RF output unit), and monitor the display. In that way, you can check the baseband output of the VCR independently from the RF unit.

If you do not want to go to the expense of a monitor, you can use a standard TV receiver to monitor the VCR. Of course, with a TV receiver the VCR video signals



THOUGH THE PHILIPS SCOPE shown here has a bandwidth of 50 MHz, you should do nicely with a scope with a 10-MHz bandwidth.



THIS FREQUENCY COUNTER measures frequencies up to 1 GHz. But more important for VCR work, it measures signals down to 10 Hz.

are used to modulate the VCR RF unit. The output of the RF unit is then fed to the receiver's antenna input. Under those conditions, it is difficult to tell if faults are present in the VCR video or in the VCR RF unit. Similarly, if you use an NTSC generator for a video source, the generator output is at an RF or IF frequency, not at the baseband video frequencies.

If you use a TV receiver as a monitor, adjust the vertical height control to underscan the picture so you can see the video switching point in relation to the start of vertical blanking.

Special tools and fixtures

VCR service literature usually describes a number of adjustment procedures in extensive detail. Those procedures are useful in that they illustrate the use of special tools and fixtures available from the manufacturer, often in kit form. There are also other tools and fixtures used by the manufacturer for both assembly and service of VCR's. Those factory tools are not available for field service (not even to factory service centers in some cases). That is the manufacturer's subtle way of telling service technicians that they should not attempt any adjustments (electrical or mechanical) not recommended in the service literature.

The author strongly recommends that you take that subtle hint! He has heard many horror stories from factory service people concerning virtually ruined VCR's brought in from the field. Most of those problems are the result of tinkering with mechanical adjustments (although there are some technicians who can destroy a VCR with a simple electrical adjustment). One effective way to avoid any chance of destroying a VCR is to use only recommended factory tools and perform only recommended adjustment procedures (i.e. when all else fails, follow instructions!).

Hand tools

Except for those cases where special tools and fixtures are required, most VCR's can be disassembled, adjusted, and reassembled with common hand tools such as wrenches and screwdrivers. Keep in mind that most VCR's are manufactured to Japanese metric standards, and your tools must match. For example, you will need metric-sized Allen wrenches and Phillips' screwdrivers with Japanese metric points. You will also need tools and applicators to apply solvents and lubricants (cleaner sticks for the video heads, etc.).

Alignment tapes

Most VCR manufacturers provide an alignment tape as part of their recommended tools. An alignment tape is housed within a standard cassette and has several very useful signals recorded at the factory using precise test equipment and signal sources. Although there is no standardization, a typical alignment tape contains audio signals (at low and high frequencies, such as 333 Hz and 7 kHz), an RF-sweep signal, a black-and-white signal or pattern, and NTSC color-bar signals. If you intend servicing one type of VCR extensively an investment in the recommended alignment tape would be well worth it.

A typical use for the audio signals recorded on the alignment tape is to check overall operation of the servo-speed and phase control systems. For example, if the frequency of an audio playback is exactly the same as recorded (or within a given tolerance), and remains so for the entire audio portion of the tape (as checked on a frequency counter), the servo control systems (both speed and phase) must be functioning normally. If there are any mechanical variations, or variations in servo control, that produce wow, flutter, jitter, and so on, the audio playback varies from the recorded frequency.

If you do not want to invest in a factory alignment-tape, or if you do not want to wear out an expensive factory tape for routine adjustments (alignment tapes do deteriorate with continued use), you can make up your own alignment tape or "work" tape using a blank cassette. The TV stations in most areas broadcast color bars before or after regular programming. (Use the VCR timer for convenience.) Those color bars can be recorded using a VCR known to be in good operating condition. Any stationary color pattern with vertical lines (such as the white color bar that extends down to the bottom of the screen) is especially useful.

Lapping cassette

A lapping cassette contains a non-magnetic tape coated with an abrasive. The idea is to load the lapping cassette and run the abrasive tape through the normal tape

A VIDEO MONITOR, such as this one from Sony, is extremely useful to have in almost any VCR-service application.

path (across the video heads, around tape guides, etc.) for a few seconds. That cleans the entire tape path (especially the video heads) quite thoroughly. However, prolonged use of a lapping tape can result in damage (especially to the video heads). Follow the manufacturer's recommendations. Never use any lapping cassette for more than a few seconds; there are other ways to clean the heads and tape path.

Installing a VCR

On the off-chance that you may not know how to install and connect a VCR, let us review some basics. Fig. 12 shows the connections for a typical VCR and applies to the great majority of VCR installations. As shown, if the antenna cable is 75-ohms, connect it directly to the VHF-IN terminal; use an F-type connector. If the cable is a 300-ohm ribbon type, connect the cable to a 300Ω-to-75Ω adapter, then connect the adapter to the VHF-IN terminal.

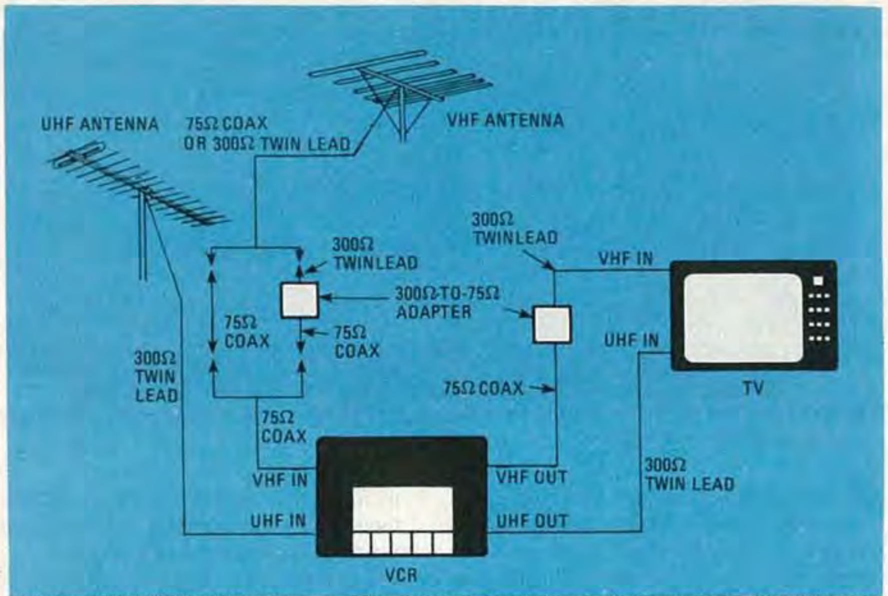


FIG. 12—FOLLOWING THIS VCR connection scheme will help insure that your video system will work properly.

Connect the VHF-OUT connector on the VCR to the VHF antenna terminal on the TV receiver with a 75-ohm coax cable. If the TV is equipped with 300-ohm antenna terminals, use an adapter. Connect the UHF-OUT terminals on the VCR to the TV's UHF-IN terminals with the 300-ohm cable.

Where a combination VHF/UHF antenna is used, separate the VHF and UHF signals using a signal separator, and connect the VHF and UHF lead-ins to VHF-IN and UHF-IN, respectively.

One note of caution: Connections between the VHF-OUT connector of a VCR and the antenna terminals of a TV should be made only as shown in Fig. 12, or as specified in the operating instructions. Failure to do so may result in operation that violates FCC regulations regarding the use and operation of RF devices. (You may broadcast TV programs to the entire neighborhood!) Never connect the output of the VCR to an antenna or make simultaneous (parallel) antenna and VCR connections at the antenna terminal of the TV!

Copying a video tape

Figure 13 shows connections for making copies of video tapes. The process is essentially the same as making a copy of an audio tape. However, keep two points in mind. First, each time a copy is made, the quality of the copy is not as good as the original. Second, you may be doing something illegal. Many of the programs broadcast by TV stations are protected by copyright, and federal law imposes strict penalties for copyright infringement. Some motion picture companies have taken the position that home recording for non-commercial purposes is an infringement of their copyrights. Until the courts have ruled on the proper interpretation of the law as applied to home video recording, a VCR used to record copyrighted material should be operated at the user's own risk.

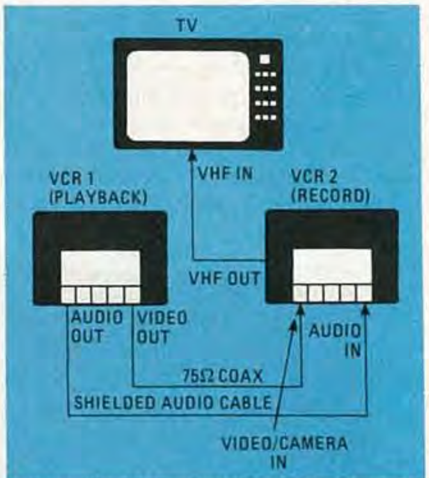


FIG. 13—BASIC SET UP for making a copy of a videotape.

Connecting a VCR to a CATV system

It is recommended that you consult with the cable TV company before installing any VCR. Always follow their recommendations for installation. Also, before operating the VCR with any cable TV system, set the RF-modulator channel selector on the VCR to channel 3 or 4, whichever is not active in the area. If both channels are in use, check which gives better results.

Fig. 14 shows the most often recommended configuration for connecting a VCR to a CATV system. With the set up shown in that figure, it is possible to record programs from all CATV channels, as well as VHF channels 2 through 13. Set the TV channel selector to that of the VCR RF unit channel selector. Set the VCR channel selector to receive the output channel of the converter. Set the VCR program select switch to the VCR position. With that connection, the channel to be viewed or to be recorded is selected on the converter.

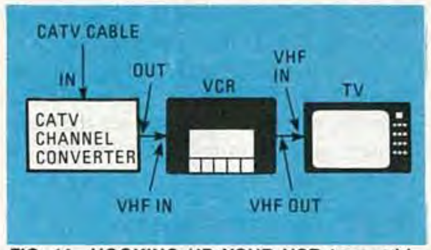


FIG. 14—HOOKING UP YOUR VCR to a cable system.

Figure 15 shows another possible configuration for connecting a VCR to CATV. With that set up it is possible to view one program from the converter, while recording another program on VHF channels 2 through 13. Set the TV channel selector to the output channel of the converter and set the VCR program select switch to the TV position. For playback of the program recorded on the VCR, set the channel selector on the converter to that of the VCR RF-modulator channel selector. When the CATV channel converter is not needed, connect the CATV input to the VCR, then connect the VCR and TV receiver in the normal manner.

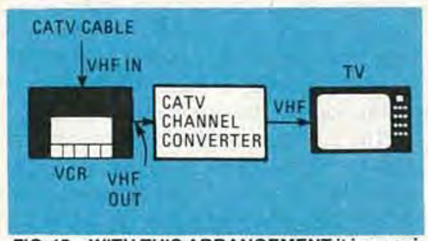
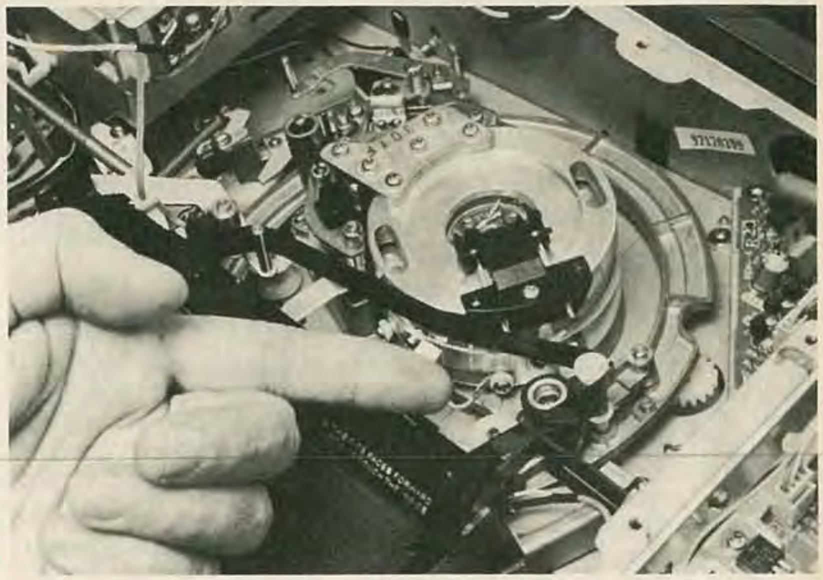


FIG. 15—WITH THIS ARRANGEMENT it is possible to record a cable channel while viewing a VHF channel.

When we continue, we'll look at some troubleshooting procedures for VCR servicing. **R-E**

VCR REPAIRS AND ADJUSTMENTS THAT YOU CAN DO



JOHN D. LENK

Repairing and aligning VCR's isn't easy, but it is possible to do some of the work yourself if you know how! In this article we'll tell you what repairs and adjustments you can make using standard test equipment.

Part 3 IN THIS MONTH'S ARTICLE we'll be looking at some VCR symptoms, and their likely causes. We'll also look at the steps that should be followed to be sure that your VCR is properly aligned.

Precautions when installing a VCR

In addition to all precautions described in the service or operating literature for the VCR, keep the following points in mind. Avoid placing the VCR in areas of high temperature or high humidity. Exposure to those environmental factors can harm the VCR and (especially) the cassette tape. The rear of the VCR should be at least 4 inches from the wall to maintain adequate heat dissipation. Make certain that the TV fine-tuning has been properly adjusted for either channel 3 or 4. The VCR output is displayed on the selected channel, but since that channel is not ordinarily used the fine tuning may not be precisely adjusted. Play back a tape that you know to be good, and adjust the TV fine tuning to get the best picture. Also make sure that the VCR fine tuning is properly adjusted.

If you have the job of demonstrating use of the VCR to someone, go over the operating instructions of the instruction manual in boring detail. Although operation of a VCR is simple to those familiar with electronic equipment, it may not be so to the general public, especially since a VCR has many more capabilities, and controls, than a TV. As a minimum, describe how to do the following: watch the TV, record a TV program, record one program on the VCR while watching another on the TV set, use the automatic recording timer to record while away from home, play back a recorded tape. If you can not do any of those yourself, do not attempt to service that VCR until you have studied the instructions, please!

One point often confused by those familiar with Beta or VHS, but not both, is in loading and unloading the cassette. With Beta, when the cassette compartment lid is closed, the tape is automatically loaded. For VHS, tape loading occurs after the lid is closed and the PLAY button is pressed.

To remove a Beta cassette, make sure that the power is turned on, and that the VCR is in the STOP mode. Press EJECT, remove the cassette, and close the lid. When a Beta compartment lid is raised by pressing the EJECT button, the tape is automatically unloaded, and the cassette supply and take-up reels disengage from the tape drive motors. (On some Beta VCR's, the EJECT button cannot be pressed except in the STOP mode. In other Beta VCR's, the EJECT button can be pressed, but does not actuate the circuit unless the VCR is in STOP.)

For VHS, when the STOP button is pressed, the tape is unloaded. The cassette can then be removed by pressing the EJECT button to release the cassette holder.

Checkout procedures for a VCR

Before we get into the detailed service notes where we discuss specific problems related to the major functional sections of a VCR, let us go over some simple, obvious steps to be performed before you start any service (and long before you tear into the VCR).

If the video playback or the TV picture is bad, set the program select switch to TV and check picture quality for each TV channel (using the TV channel selector). If the picture quality is still bad, check for defective antenna connections (or a faulty TV). Also check the TV fine tuning.

If the TV picture is good when the program select switch is set to TV, but the video playback is not good, set the program select switch to VCR, turn the TV to the inactive channel (3 or 4), and check reception on each channel by changing the setting on the VCR channel selector. If picture quality is bad, or there is no picture on all channels, it is possible that the TV fine tuning is not properly adjusted. If the problem appears only on certain channels, the VCR fine tuning is suspect (as is the VCR tuner).

If picture quality is good when viewing a TV broadcast through the VCR, try recording and playing back the program.

If noise is apparent (resulting in poor picture quality on playback but not when viewing through the VCR) it is possible that the video heads are dirty (head gaps are slightly clogged). If there is sound but no picture, the video head gaps may be badly clogged. If the playback picture is unstable with a new TV set (never previously used with the VCR), it is possible that the TV's AFC circuits are not compatible with the VCR. (We'll discuss that problem latter on.) If there is color beat (rainbow-like stripes on the screen) the problem may be interference rather than a failure in the VCR or TV.

Let's now go over specific symptoms and possible causes for some basic VCR troubles.

Record button cannot be pressed

Check that there is a cassette installed and that the safety tab has not been removed from the cassette. If necessary, cover the safety tab hole with tape. (The safety tab engages a plunger rod or switch when the cassette is inserted and the lid closed.) In most Beta systems, the RECORD button cannot be pressed unless the rod is pushed down by the tape. In VHS, the tab prevents a switch from closing. Closing the switch disables the record operation. If you want to keep a recorded program from being accidentally erased, you break off the tab so that the plunger is not pushed down, for Beta, or the switch can close, for VHS, and the record function is disabled. If you want to record on a cassette with the tab removed, cover the tab hole with vinyl tape.

No E-E picture.

If there is no E-E picture, check that the VCR program select switch is in the correct position. Also check the fine tuning on the TV. (The term E-E, or *E*lectric-to-*E*lectric, can be explained as follows. When the VCR is in the record mode, the record output circuit is also connected to the playback input circuit so that the video signal to be recorded can be monitored on the TV. Since the magnetic components (head, tape, etc.) have nothing to do with that signal, and the signal is passed directly from one electrical circuit to another, the function is called the E-E mode. When the heads and tape are involved in the normal record/playback cycle, the term V-V, or *V*ideo-to-*V*ideo is sometimes used.)

No color, or very poor color

If there is no color on playback, check the fine tuning on the TV. If the VCR fine tuning is misadjusted during record, color may appear while recording, but may not appear during playback. Always check the fine tuning of both the VCR and TV as a first step when there are color problems.

Playback picture is unstable

If you have periodic problems of picture instability, check the following: Has the VCR been operated in an area having a different AC line frequency? While recording, it is possible that a fringe-area signal was weak (intermittently) so that the video sync signal was not properly recorded? During recording, could there have been some interference or large fluctuations in the power supply voltage? Could the cassette tape be defective. Could the tracking control be improperly adjusted.

Both Beta and VHS machines have some form of tracking control that adjusts for minor variations between tapes recorded on one machine and played back on another machine. If the physical distance between the control head and video heads is different for the two machines, the playback signals are not synchronized, even though the servo is locked to the CTL signal. That condition can be corrected by physically moving the control/audio head stack in relation to the scanner. (That is one of the recommended service adjustment procedures for some VCR's.) But it is more practical to use the front panel tracking control, which shifts the relationship of CTL signal to the video tracks electrically.

Snow or noise during playback only

Check the tracking control!

Sound but no picture

Check for very dirty video heads. The same holds true for excessive black-and-white snow.

Tape stops during rewind

If the VCR has a memory counter, is the counter switch on? If the memory switch is on, the tape stops automatically at 999 during rewind (on most VCR's).

Rewind and fast-forward problems

If the rewind and fast-forward buttons can not be locked or operated, check to see if the cassette tape is at either end of its travel If the tape is at the beginning, rewind does not function. Fast forward does not function if the tape is at the end.

Cassette will not eject

Is the power on?

Feedback when using a microphone

Keep the microphone away from the TV. Turn down the TV volume.

Tape-speed-related problems

Those include such things as a noise band in the playback picture and picture instability with too high or too low pitched sound.

In some VCR's, the tape is automatically locked to the correct speed by the servo. However, many VCR's also require some manual switching. For example, certain Beta VCR's have a front-panel switch to select between Beta II and Beta III, as well as a rear panel switch for Beta I.

Some VCR service suggestions

The following points summarize some practical suggestions for servicing any VCR.

Initial setup

When a VCR is first connected to a TV, it is likely that the unused channel (3 or 4) of the TV is not properly fine tuned. When fine tuning the TV, operate the VCR in the playback mode using a known good cassette, preferably with a color program. If you try to fine tune the TV in the record or E-E mode, both the VCR and TV tuners are connected in the circuit, and the picture is affected by either or both tuners. With playback, the picture depends only on the TV tuner. Once the normally unused channel of the TV is fine tuned for best picture, the VCR tuner can be fine tuned as necessary.

Replacing a tuner

In many VCR's, the entire tuner is replaced as a unit in the event of failure, although some manufacturers supply replacement parts for their tuners, and include adjustment procedures for the tuner in the service literature. As a point of reference, a typical VCR tuner (including the IF) produces 1 volt P-P of video into a 75-ohm load. Typically, the audio output from the tuner is in the −10- to −20-dB range.

Replacing an RF modulator

In most VCR's, the RF modulator must be replaced as a package in the event of failure. No adjustments or parts replacement are possible. If you have proper audio and video inputs (and power) to the modulator, but there is no output (or low output), the modulator is most likely defective. As a point of reference, a typical RF modulator produces 1000 microvolts into a 75-ohm load (or 2000 microvolts into a 300-ohm load) on the selected channel.

Black-and-white picture circuits

Although the black-and-white (or luminance) circuits of any VCR are very complex, they are not the major cause of trouble. Mechanical problems are on top of the list, closely followed by servo and system control troubles. Also, although many circuits are involved, all of the circuits are found in three or four IC's. If all else fails, you can replace the few IC's, one at a time, until the problem is solved. (If only mechanical problems were that simple!)

The first step in servicing luminance circuits is to play back a known good tape, or an alignment tape. That will pinpoint the problem to playback or record circuits, or both. Then run through the electrical adjustments that apply to luminance, or picture, using the manufacturer's procedures.

If playback from a known good tape has poor resolution (picture lacks sharpness) look for an improperly adjusted noise canceler circuit, and for bad response in the video-head preamps. When making the manufacturer's adjustments, study the stairstep or color-bar signals for any transients at the leading edges of the white bars.

If the playback has excessive snow, try adjusting the tracking control, since mistracking can cause snow. Then try cleaning the video heads before making any extensive adjustments. (Cleaning the video heads clears up about 50% of all noise or snow problems.) If neither of those do the trick, then try electrical and mechanical adjustments. Make mechanical adjustments only as a last resort (even though snow and mistracking can be caused by mechanical problems).

If playback of a known good tape produces smudges on the leading edge of the white parts of a test pattern (from an alignment tape) or a picture, the problem is usually in the preamps, or in adjustments that match the heads to the preamps. The head/preamp combination is not reproducing the high end (5 MHz) of the video signals. The adjustment procedures usually show the head/preamp response characteristics.

If you see a herringbone (beat) pattern in the playback of a known good tape, look for carrier leak. There is probably some unbalance condition in the FM demodulators or limiters, allowing the original carrier to pass through the demodulation process. If very excessive carrier passes through the demodulator, you may get a negative picture. Recheck all carrier lead adjustments.

Most adjustment procedures include a check of the video output level (typically 1 volt P-P). If the VCR produces the correct output level when playing back an alignment tape, but not from a tape recorded on the VCR, you probably have a problem in the record circuits. The record current may be low (one symptom of low record current is snow), or the white-clip adjustment may be off. Look for details of those two adjustments in the manufacturer's literature.

Servicing color circuits

As in the case of black-and-white, the color (or chroma) circuits of a VCR are very complex, but not necessarily difficult to service (nor do they fail as frequently as the mechanical section). Again, the first step in color-circuit service is to play back an alignment tape, followed by a check of all adjustments pertaining to color. As in the black-and-white circuits, when performing adjustments, you are tracing the signal through the color circuits. (At least that is the case in most well-written VCR service literature.)

There are two main points to remember in regard to VCR color circuits. First, most color circuits are contained within IC's, possibly the same IC's as the black-and-white circuits. Also, both circuits are interrelated. If you find correct inputs and power to an IC, but an absent or abnormal output, you must replace the IC. A possible exception in the color circuits are the various filters and traps located outside the IC.

Second, in most VCR's, the reference signal input to the color converters comes from the same source for both playback and record (from crystal-controlled oscillators). If you get good color on playback, but not on record, the problem is definitely in the record circuits. However, if you get no color on playback of a known good tape, the problem can be in the color playback circuits or in the common reference signal. A good place to start color circuit signal tracing is to check any common source reference signals. Then check the AFC signals. If any of those signals are missing (or abnormal), the color will be absent or abnormal.

The following describes a few VCR color circuit failure symptoms, together with some possible causes.

If you get a "barber pole" effect, indicating a loss of color lock, the AFC circuits are probably at fault. Check that the AFC circuit is receiving the horizontal-sync pulses, and that the AFC voltage-controlled oscillator (VCO) is nearly on-frequency, even without the correction circuit. (Most electrical adjustments include such a procedure.)

If the hue control of the TV must be reset when playing back a tape that has just been recorded, check the color subcarrier frequency using a frequency counter.

If you get bands of color several lines wide on saturated colors (such as alternate blue and magenta bands on the magenta bar of a color-bar signal), check the automatic phase-control circuits, as well as the 3.58-MHz oscillator frequency.

If you get the herringbone (beat) pattern during a color playback, try turning the color control of the TV down to produce a black-and-white picture. If the herringbone is removed on black and white, but reappears when the color control is turned back up, look for leakage in both the color and luminance circuits.

If you get flickering of the color during playback, look for failure of the automatic color-control system. It is also possible that one video head is bad (or that the preamps are not balanced), but such conditions show up as a problem in black-and-white operation.

If you have what appears to be very severe color flicker on a Beta VCR, you may be losing color on every other field. That can occur if the phase of signal is not shifted 180° at the horizontal-sync rate when one head is making its pass. The opposite head works normally, making the picture appear at a 30-Hz rate.

If you lose color after a noticeable dropout, look for problems in the dropout-compensation circuit. Most VCR's have some form of dropout compensation circuit to sense any dropout of recorded signal. Those circuits compensate for dropout by using the preceding horizontal line signal. It is possible that the phase reversal circuits have locked up on the wrong mode after a dropout. In that case, the color signals have the wrong phase relation from line to line, and the comb filter is canceling all color signals.

It's usually easy to spot total failures in the servo system. If a servo motor fails to operate, check that the power is applied to the motor at the appropriate time. If power is there, but the motor does not operate, the motor is at fault (burned out, open windings, etc.). If the power is absent, trace the power-supply line back to its source. See if the system control circuits (usually a microprocessor) are delivering the necessary control signals.

The problem is not so easy to locate when the servo fails to lock on either (or both) record and playback. If the control signal is not recorded (or is improperly recorded) on the control track during record, the servo cannot lock properly during playback. So your first step is to see if the servo can play back a properly recorded tape.

There are usually some obvious symptoms when the servo is not locking properly. Often there is a horizontal band of noise that moves vertically through the picture if the servo is out of sync during playback. The picture may appear normal at times, possibly leading you to think that it is an intermittent condition. With a true out-of-sync condition, the noise band appears regularly (even though moving) and may cover the entire screen at times.

The symptoms for failure of the servo to lock during record are about the same as during playback, with one major difference. During record, the head-switching point (the point where head A is switched off and head B switched on, usually appearing as a break in the horizontal noise band) appears to move vertically through the picture in a random fashion.

Another way to check if the servo is locking on either record or playback involves looking at some point in the rotating scanner or video-head assembly under fluorescent light. When the servo is locked, the fluorescent light produces a blurred pattern on the scanner that appears almost stationary. When the servo is not locked, the pattern appears to spin. Try observing the scanner of a known-good VCR under fluorescent light. Stop and start the VCR in the record mode. Note that the blurred pattern spins when the scanner first starts, but settles down to almost stationary when the servo locks.

Once you have studied the symptoms and checked the servo playback with a known good tape, you can use the results to localize the trouble in the servo. For example, if the servo remains locked during playback of a good tape, you can assume that the circuits between the control head and servo motors are good.

Keep in mind that servo troubles may be either mechanical or electrical, and may be the result of either improper adjustment or component failure (or both). As a general guideline, if you suspect a servo problem, start by making the electrical adjustments that apply to the servo. That may cure the servo problem. If not, you will at least see if all of the servo-control signals are available. A block diagram of a servo-control system is shown in Fig. 16. That diagram shows where in the servo system the control signals are found. If one or more of the signals are missing or abnormal, you have a good starting point for servo troubleshooting.

If the VCR has rubber belts to drive servo motors, the belts may stretch (or be otherwise damaged) and cause servo problems. If you have replacement belts available, compare the used VCR belts for size. Hold a new and used belt on your finger under no strain. If the used belt is larger, or does not conform to the new belt, install the new belt and recheck the servo for proper locking.

Keep in mind that the servo adjustments may be so far from normal that the servo simply cannot lock up. The only sure way to check that is to run through the servo adjustments.

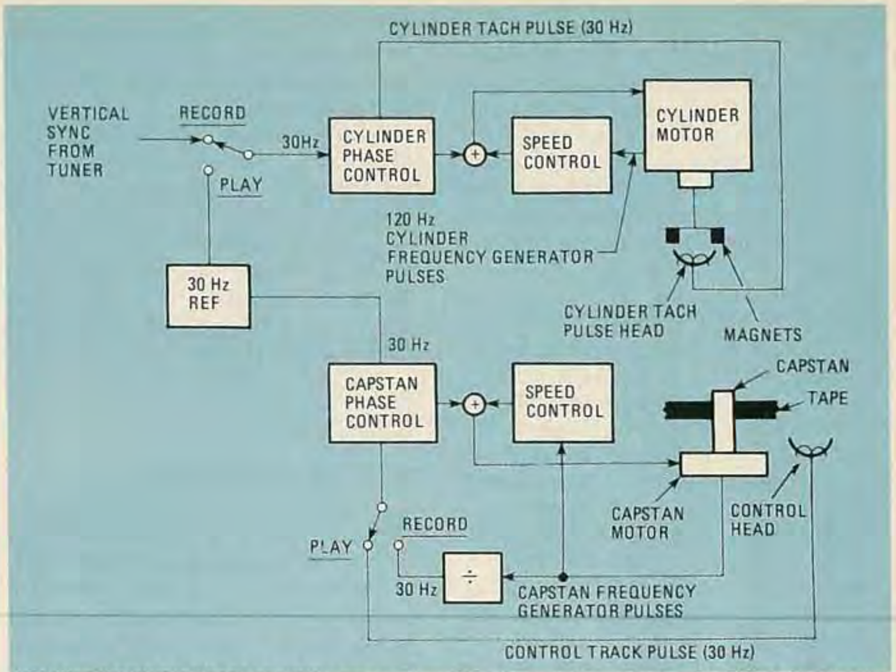


FIG. 16—BLOCK DIAGRAM of a VHS servo system. This diagram shows the location of all of the typical servo control signals.

Interchange operation

When a VCR plays back its own recordings with good quality, but the playback of tapes recorded on other machines is poor, the VCR is said to have *interchange* problems. Such problems are almost always located in the mechanical section of the VCR (usually in the tape path) and are often the result of improper adjustment. The simplest way to make interchange adjustments is to monitor the RF output from the video heads during playback and adjust elements of the tape path to produce a maximum, uniform RF output from a factory alignment-tape. Generally, the output is measured at a point after head switching so that both heads are monitored. But always follow the manufacturer's alignment procedures.

Wow and flutter

As is the case with audio recorders, wow and flutter are almost always present in all VCR's. To find out how much wow and flutter are present, use the low-frequency tone recorded on the alignment tape and a frequency counter connected to the audio line at some convenient point. Typically, the low-frequency tone is on the order of 333 Hz, and an acceptable tolerance is $\pm 0.03\%$. You will probably use the period mode of the frequency counter to make that measurement. You can also use the special wow-and-flutter test equipment found in audio and hi-fi shops, but it is not really necessary. Any wow and flutter that does not show up when using the alignment tape and frequency counter is most probably not objectionable. The cause of wow and flutter can be either electrical or mechanical in origin.

Servicing systems-control circuits

Each VCR has its own system-control functions, and you must learn those functions to properly service any VCR. However, all system-control circuits have elements in common. In most VCR's, microprocessors accept logic-level control-signals from the VCR operating controls, and from various tape sensors. In turn, the microprocessor sends control signals to the various circuits, as well as drive signals to solenoids and motors. We will concentrate on the stop control-functions here, since those stop (or failure) functions are most likely to confuse those not familiar with VCR's.

Figure 17 shows the basic circuits of a VHS-system stop control. The VCR is stopped when the STOP button is pressed, when the tape runs to either end (forward and reverse), or when there is mechanical trouble.

Both ends of a VHS tape are transparent. The tape passes between an end-sensor lamp and two end-sensor phototransistors. When the tape reaches either end (supply or take-up), the light passes through the transparent portion of the tape onto one of the phototransistors. When either phototransistor receives light, it applies a signal to the IC, which stops and unloads the VCR. The VCR also stops should the end-sensor lamp fail. Without that feature, the tape could break at either end. If the lamp burns out, the cathode voltage of the Zener diode increases, and the increase is applied to

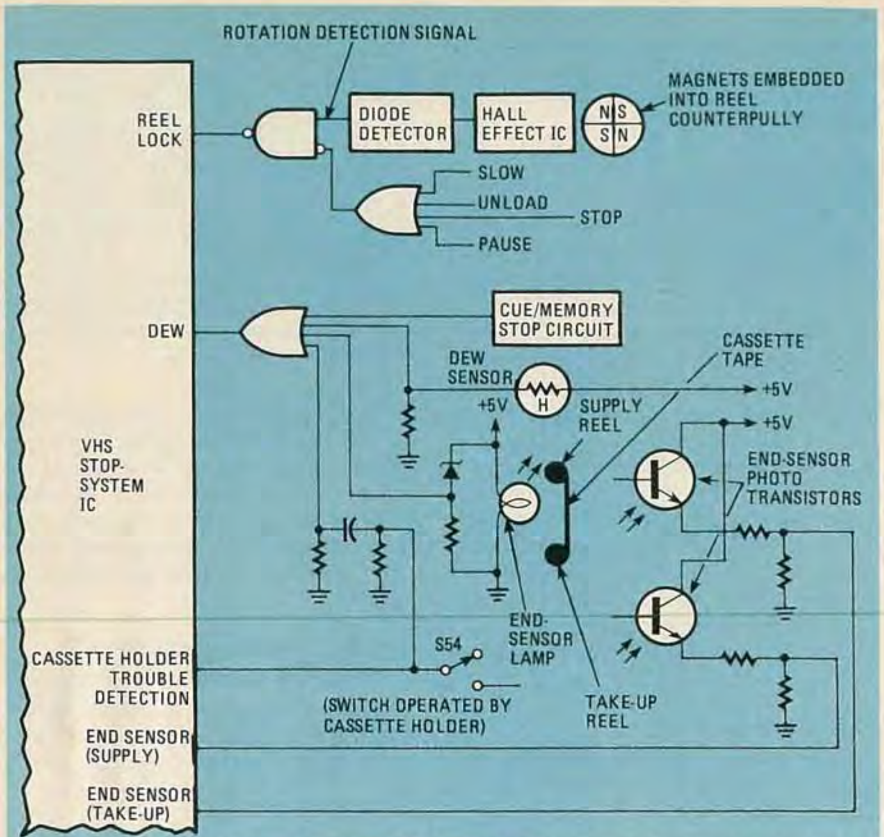


FIG. 17—THE STOP SYSTEM used in a typical VHS recorder. Its functions include sensing end-of-tape and excess humidity conditions.

the stop-system IC through the OR gate. The end-of-tape condition can be simulated by exposing the phototransistors to light; that should result in an immediate stop and unload. The end-of-tape function can be disabled (for service) by covering the phototransistor with opaque tape or a cap. Do not remove the light source for the end-of-tape sensor on a VHS machine! That is sensed as a lamp-failure condition by most VHS units.

When changes of temperature and humidity cause condensation of dew on the surface of the video scanner, that is detected by the dew sensor; and the stop mode is produced to prevent damage to the tape and mechanism. In Fig. 17, the dew-sensor output is applied to the IC through the OR gate. When relative humidity is less than about 80%, the resistance of the dew sensor is about 100 megohms. When humidity increases above about 80% the resistance drops to about 3 megohms, and the voltage at the junction of the sensor and the resistor increases. That increase is applied to the IC through the OR gate, and stops the VCR.

The reel-lock circuit detects when the reel motor has stopped rotating, except when the tape should not be running at the normal speed (unloading, loading, pause, step slow, etc.). The NAND-gate output is high when the reel disk is rotating, or when operating mode signals are applied to the OR gate. When reel rotation stops, the NAND-gate output goes low, and the IC causes the VCR to unload and stop. That can be prevented by applying an override signal to the OR gate. The rotation-detection signal is developed by diode detectors, a Hall-effect element, and magnets (usually embedded into the reel counterpully). When the reel is rotating, the magnetic field also rotates, and causes the Hall element to produce a current. That current is rectified and doubled by the detector to become the rotation-detection signal. If rotation stops, the alternating current stops, as does the detection signal, and the IC removes power to the tape-drive motor, preventing damage to the tape. The detector can be checked by holding the take-up reel. That causes the take-up clutch to slip (to prevent damage) but the detector senses that the reel is not turning, and produces an automatic stop.

The cassette-holder trouble-detection circuit detects if the cassette holder is in the eject condition (by sensing a switch that is operated by the holder). If the eject button has been pushed, the VCR is placed in the stop mode by the switch. To disable the cassette-holder-trouble function (that is often necessary to do during service), locate the mechanism that actuates the switch and hold the mechanism in place with cellophane tape. In many cases, it is possible to operate the VCR through all its modes without a cassette installed if the switch can be actuated manually. Always check that all automatic-stop functions work, and that all by-passes and simulations (covers on lamps, tape on switches, etc.) are removed after service!

Beta VCR's have similar stop functions (in the event of trouble) but the circuits are different. The two major differences are in the end-of-tape and reel sensors. Both ends of Beta tape are covered with foil. When the foil at the start of the tape approaches a forward sensor coil (the coil of an oscillator), the Q of the sensor coil decreases, as does the oscillator output (indicating that the tape is at the start position). The rewind sensor operates the same way, except that the rewind-circuit oscillator-signal output drops when the foil at the end of the tape passes the oscillator coil (placing the VCR in the stop mode, and indicating that the tape must be rewound). For Beta, the end-of-tape foil can be simulated by placing a piece of foil near the coil of either sensor.

The reel-sensor circuit of a Beta VCR usually consists of a phototransistor and an LED, arranged around the base of a take-up reel as shown in Fig. 18. The phototransistor receives light from the LED; the light passes through the slots at the bottom rim of the take-up reel base while the reel is in motion. When the take-up reel stops rotating, the light is blocked off from the phototransistor. When that happens, the sensor circuit produces a signal that places the VCR in its automatic-stop mode to prevent the damage to the tape.

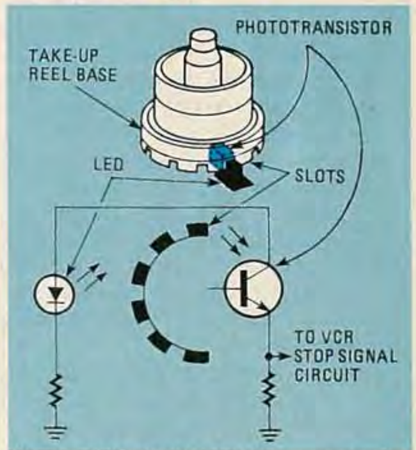


FIG. 18—THIS REEL-MOTION sensor circuit is used in Beta VCR's.

Most VCR's have some form of tape-slack sensor. Slack tape can cause damage (as can condensation, belt rupture, a sudden stop of the reel motor, etc.). Tape-slack sensors can be checked by visual inspection and by pressing on the switch with your fingers to simulate slack tape. If the tape-slack sensors include a micro-switch (as is the case with most Beta VCR's), the sensor circuit can be disabled by forcing something like a match against the sensor to keep the switch from triggering. (That is useful if you want to run the VCR without a tape.)

Video-camera sync

If you have trouble using a video camera (perhaps one not designed for the VCR, possibly an inexpensive surveillance camera) you may have an interlace problem. Most cameras designed for use with VCR's—even those from different manufacturers—are compatible with any VCR. That's because such cameras have a 2:1 interlace. Some inexpensive cameras have a random-interlace, where the horizontal and vertical sync are not locked together. The playback of a recording made with a random interlace camera usually has a strong beat pattern (herringbone effect). One way to confirm a random-interlace condition is to watch the playback while observing the last horizontal line above the vertical-blanking bar. Operate the TV's vertical-hold control as necessary to roll the picture so that the blanking bar is visible. If the end of the last horizontal line is stationary, the camera has a 2:1 interlace and should be compatible. If the end of the last horizontal line is moving on a camera playback, the camera is not providing the necessary sync and probably has random interlace.

TV AFC compatibility

If the AFC circuits of a TV are not compatible with a VCR, skewing may result. In most VCR literature, the term "skew" or "skewing" is used to indicate that the upper part of the reproduced picture is being bent or distorted by incorrect back-tension on the tape (caused by improper mechanical adjustment). However, you can get that same effect if the TV's AFC circuits can not follow the VCR playback output. That condition is very rare in newer TV sets (designed for VCR's and videodiscs), and appears only in about 1% of older TV sets (and almost never when the TV and VCR are made by the same manufacturer). So do not go into the TV's AFC unless you are absolutely certain that there is a problem. First try the VCR with a different TV, then try the TV with a different VCR.

Once you are convinced that there is a compatibility problem, the easiest cure is to reduce the time constant of the integrating circuit of the TV's AFC (see Fig. 19); that's done by changing the circuit values.

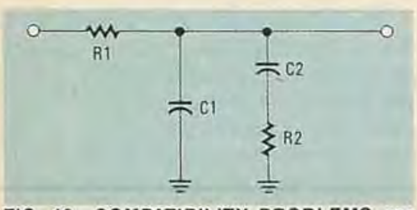


FIG. 19—COMPATIBILITY PROBLEMS can sometimes be solved by making changes in the TV AFC's integrating circuit.

To reduce the time constant, reduce the values of either or both capacitors C1 and C2, reduce the value of R1, or increase the value of R2. It is generally not necessary to change all four values. Be sure to check the stability of the TV's horizontal sync after changing any of the values in the AFC circuit.

Maintenance

We'll end this article by describing some typical maintenance procedures for VCR's. Keep in mind that those procedures do not necessarily apply to your specific VCR. When servicing VCR's, *be sure that you follow the manufacturer's instructions exactly*. Also, the procedures here are only the highlights, and only cover those areas common to most VCR's. All VCR's have many special-purpose adjustments that apply to their particular circuits. However, by studying the examples here, you should be able to relate the procedures to a similar set of adjustment points on any VCR, and to identify typical signals found in most VCR's (even though the signals may appear at different points in your particular unit).

Cleaning and lubrication

Table 1 shows the recommended maintenance intervals for most VCR's. However, never lubricate or clean any part not recommended by the manufacturer. Most VCR's use sealed bearings that do not require lubrication. A drop or two of oil in the wrong places can cause damage!

TABLE 1—SUGGESTED MAINTENANCE

Component	Operation
Video Heads	Clean every 500 hours
Audio/Control Heads	Clean every 500 hours
Pinch Head	Clean every 500 hours
Erase Head	Clean every 500 hours
Supply Head	Clean and lubricate every 2000 hours
Take-up Reel	Clean and lubricate every 2000 hours
Fast-Forward Roller	Clean and lubricate every 1000 hours
Clutch Pully	Lubricate at 2000 hours, then every 1000 hours
Rewind Idler	Lubricate at 1000 hours, then clean and lubricate every 1000 hours
Capstan Assembly	Clean every 1000 hours
Loading Gear	Clean and lubricate every 1000 hours

Clean off any excess, or spilled, oil. In the absence of a specific recommendation, use a light machine oil, such as sewing-machine oil. Although there are spray cans of head cleaner, most manufacturers recommend alcohol and cleaning sticks or wands for all cleaning. Methyl alcohol does the best cleaning job but can be a health hazard. Isotropyl alcohol is usually satisfactory for most cleaning.

Video-head cleaning

Turn the power switch off, and pull out the power cord. Rotate the video-head disk by hand to a position convenient for cleaning the video heads, as shown in Fig. 20. Moisten a cleaner stick with alcohol, lightly press the buckskin portion of the stick against the head drum, and move the head disk by turning the motor back and forth. Clean both heads (on opposite sides of the drum) following the same procedure. **CAUTION:** Do *not* move the cleaner stick vertically while in contact with the heads. Always clean the heads in the same direction as the tape path. Cleaning across the tape path can damage the heads.

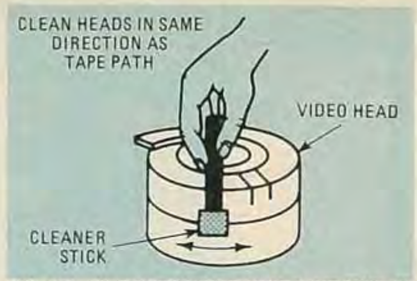


FIG. 20—CLEANING THE VIDEO HEADS. Be sure to always clean in the same direction as the tape path.

Audio/control and erase-head

Moisten the cleaner stick with alcohol, press the stick against each head surface, and clean the heads by moving the stick horizontally, as shown in Fig. 21.

Tape-path cleaning

Figure 22 shows the tape path for a typical Beta VCR. Clean the drum surface and each tape-guide surface with a soft cloth moistened with alcohol. When cleaning the drum surface, be careful not to touch the video heads with the cleaning cloth. Rotate the video-head disk by hand

FIG. 21—WHEN CLEANING the audio/control and erase heads, move the cleaning stick horizontally as shown.

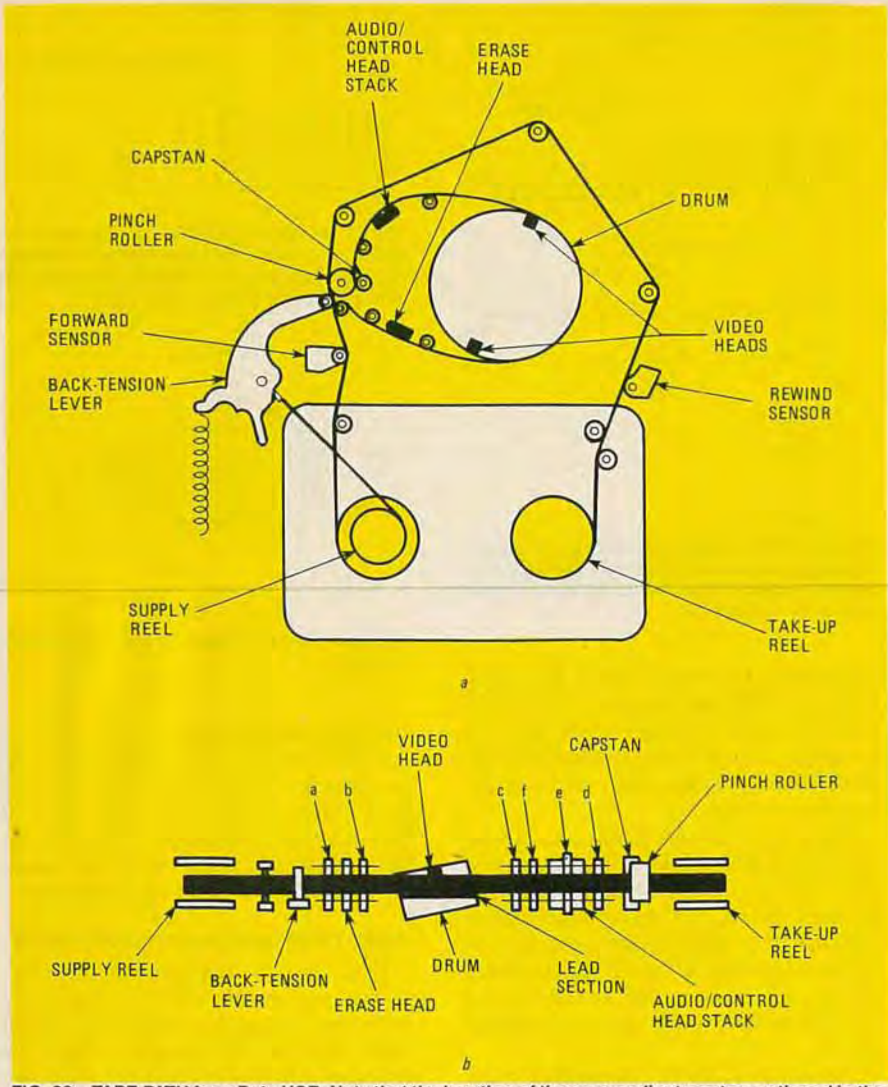


FIG. 22—TAPE PATH for a Beta VCR. Note that the location of the screw adjustments mentioned in the text are shown in *b*.

to move the head away from the spot to be cleaned.

Tape-path adjustments

The tape path for most VCR's is critical to proper operation. For that reason, the position and height of the tape guides and heads are precisely adjusted at the factory. Since those components greatly affect normal tape running, never touch the them unless necessary. First check operation of the VCR using an alignment tape and a known good monitor or TV. If the playback is good, quit while you are ahead. If you have playback problems, then (and only then) make the following adjustments (which are typical for VCR's with a tape path similar to that shown in Fig. 22).

1. Connect a good monitor or TV to the VCR, and an oscilloscope to a test point that monitors the video-color signal output of the playback amplifier circuits.

2. Play back an alignment tape (video portion) and observe the waveform (envelope) on the scope. Figures 23 and 24 show some typical envelopes.

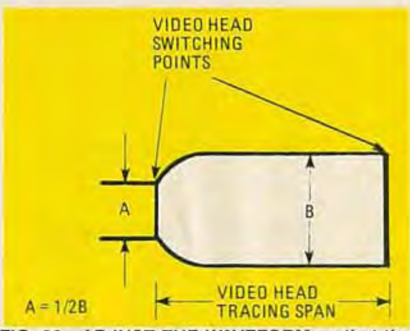


FIG. 23—ADJUST THE WAVEFORM so that the amplitude at A is equal to one half that at B. Note that only one period of the waveform is shown here for simplicity.

3. Adjust the VCR tracking control for the maximum waveform amplitude on the scope.

4. Observe the running state of the tape around the back-tension lever (Fig. 22). If you see any slack at the top or bottom edges, slightly bend the back-tension lever (with the appropriate tool) to eliminate the slack.

5. Adjust screw B (see Fig. 22-b) so that the top edge of the tape does not hit against the guide at the side below the screw.

6. Observe the waveform on the oscilloscope, and adjust screws A and B so that the amplitude at A is equal to one-half of the amplitude at B, as shown in Fig. 23. Note that A is measured at the video-head-switching point, and B is measured at 40% of the video-head-tracing span. Check that slack does not develop along screw A, screw B, or the lead section during those or any other adjustments.

7. Adjust screw C so that the tape top edge does not hit against the guide below. Then adjust screw C and D to make the waveform amplitude at C equal to one-half that at B, as shown in Fig. 24. While doing that adjustment, check that the tape-bottom edge is steadily in contact with the flange shoulder below screw D. Also, use an inspection mirror to check for slack along screws C, D and the lead section. The type of mirror used by dentists is very handy for checking tape slack at inaccessible points. The proper adjustment of screw C will give you the optimum waveform as described with no slack.

8. Ideally, the center portion of the video-head waveform should be flat after all the adjustments are complete. For acceptable performance, the minimum amplitude should be no less than 60% of the maximum amplitude at the center portion of the waveform.

9. Switch the scope from the video-head test point to the audio-output test point.

10. Play back the alignment tape (audio portion) and monitor the audio-signal output waveform. Adjust screw E for maximum amplitude.

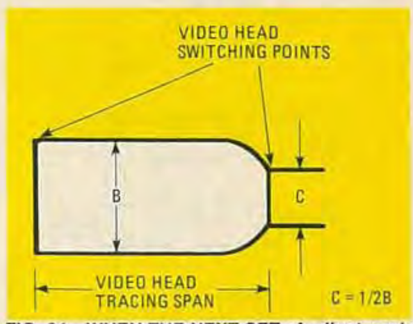


FIG. 24—WHEN THE NEXT SET of adjustments is completed, the amplitude at C should be one half that at B.

11. Switch the scope back to the video-head test point. Set the tracking control at the center position (at the click stop).

12. Adjust screw F for maximum video-signal amplitude.

13. Turn the tracking control to the right and left, and make sure that the waveform changes symmetrically.

14. Check operation of the VCR by recording and playing back a program. If the playback is good, you have made all of the adjustments correctly. Either that or you have fantastic luck!

Video-head-switching adjustments

Most VCR's have some form of video-head-switching adjustments. Before we get into some typical adjustments, let us consider how the switching circuits operate. The playback signals from the video heads are amplified and mixed to produce a continuous noise-free signal as shown in Fig. 25. Note that the overlap of the signals from channel 1 (head A) and channel 2 (head B) at the heads is eliminated by pulses that switch the channel 1 and 2 outputs so that channel 1 is off at the instant channel 2 is on (and vice versa). The switching pulses are called by various names (RF switching pulses, drum FF pulses, etc.) and originate in the servo system.

The video-head-switching adjustments for Beta and VHS are essentially the same, but with minor variations. In both cases you connect a scope to the video output of the VCR, and trigger the scope with pulses from the servo. Then you insert an alignment tape, and play back a color-bar signal. For VHS, the display is something like that shown in Fig. 26 on both channels, except that the switching pulse is inverted on one channel. (Generally, it is necessary to set the scope's trigger slope to " + " for one channel, and to " – " for the other channel.) With VHS, you set the switching adjustment so that head switching occurs 6.5 horizontal lines (6.5 H) before the start of the vertical sync pulse, as shown in Fig. 26. (If you don't know the difference between the vertical-sync pulse and the equalizing pulses of a TV signal, please stay away from my VCR!) Because it is difficult to measure 6.5 H, you may want to measure for about 220 microseconds between the start of the scope triggering and the equalizing pulses instead.

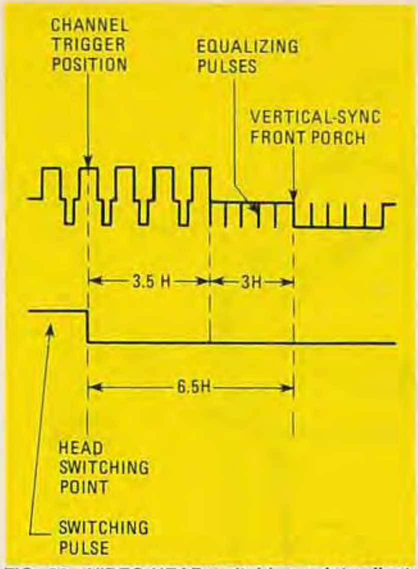


FIG. 26—VIDEO-HEAD-switching-point adjustments are made while observing the video output of a recorder. The output waveform shown here is for a VHS VCR.

Most Beta service literature recommends that the switching pulse occurs so that there is a 7-H (± 0.5 H) difference between the edge of the switching pulse and the front edge of the vertical-sync signal, as shown in Fig. 27. Often, there are two adjustments (one for trailing and one for leading edge of the switching pulse).

No matter what is recommended by the VCR service literature, keep the following in mind when you make the head-switching adjustments: If head switching occurs too soon, a narrow band of noise may appear at the bottom of the picture on the TV being used to monitor the VCR. If the head-switching pulse is late, noise can be introduced during vertical sync, possibly resulting in vertical-sync problems.

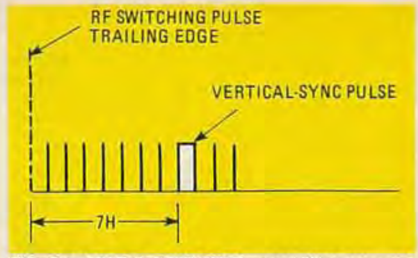


FIG. 27—FOR A BETA VCR, most literature recommends a 7 horizontal-line difference between the trailing edge of the switching pulse and the front edge of the vertical-sync pulse.

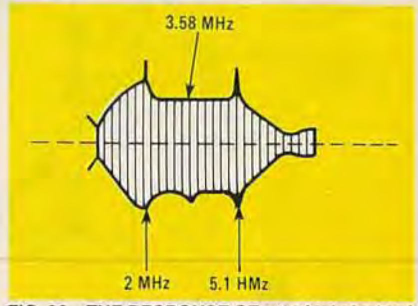


FIG. 28—THE RESPONSE OF a typical playback preamp.

Video-head resonance adjustments

Since the playback signal from the video heads is on the order of a few millivolts, their output is amplified by one or more preamps. The preamp circuits are provided with controls that make it possible to adjust video-head resonance and Q to produce an overall flat response (or some particular response). Figure 28 shows the response of a typical preamp. It was obtained by playing back the RF-sweep portion of an alignment tape. Typically, you set the adjustments so that the response is flat between about 2 and 5 MHz, and so that the signal levels on channels 1 and 2 (heads A and B) are equal. In some VCR's, you need to set the controls to get a peak response at one frequency.

Other adjustments

Although we have been through the major adjustments found on all VCR's, you will find many more adjustments in VCR literature. We will not cover those since they are unique to each model of VCR, or are similar to adjustments in other equipment. For example, all VCR's have power-supply adjustments where you set the various outputs to given voltage levels, and all VCR's have tuner/IF adjustments that are usually quite similar to those of a TV set. Both Beta and VHF

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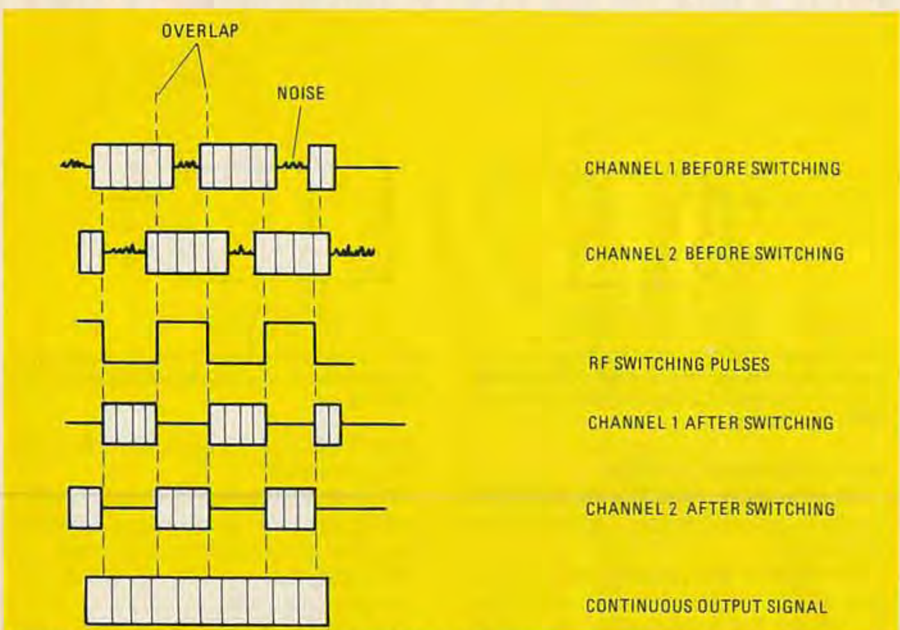

FIG. 25—THE SWITCHING PROCESS shown here produces a continuous output signal from the two video heads.

VCR REPAIRS

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units have servo, video, audio, and system-control adjustments that must be performed according to the manufacturer's recommendations. However, keep the following points in mind no matter what the literature says:

If you get good performance on record and playback, leave the VCR alone!

If you make the adjustments for the three basic functions described here (tape path, switching, and head resonance/Q) with an alignment tape (using the video, audio, and RF-sweep portions of the tape), and get good performance after adjustment, all of the other adjustments are probably OK, and need not be made.

If you cannot get good response by adjusting the three basic functions, you have other problems (possibly terrible problems), and you must consult the manufacturer's literature. **R-E**