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OCTOBER 1987/$2.25

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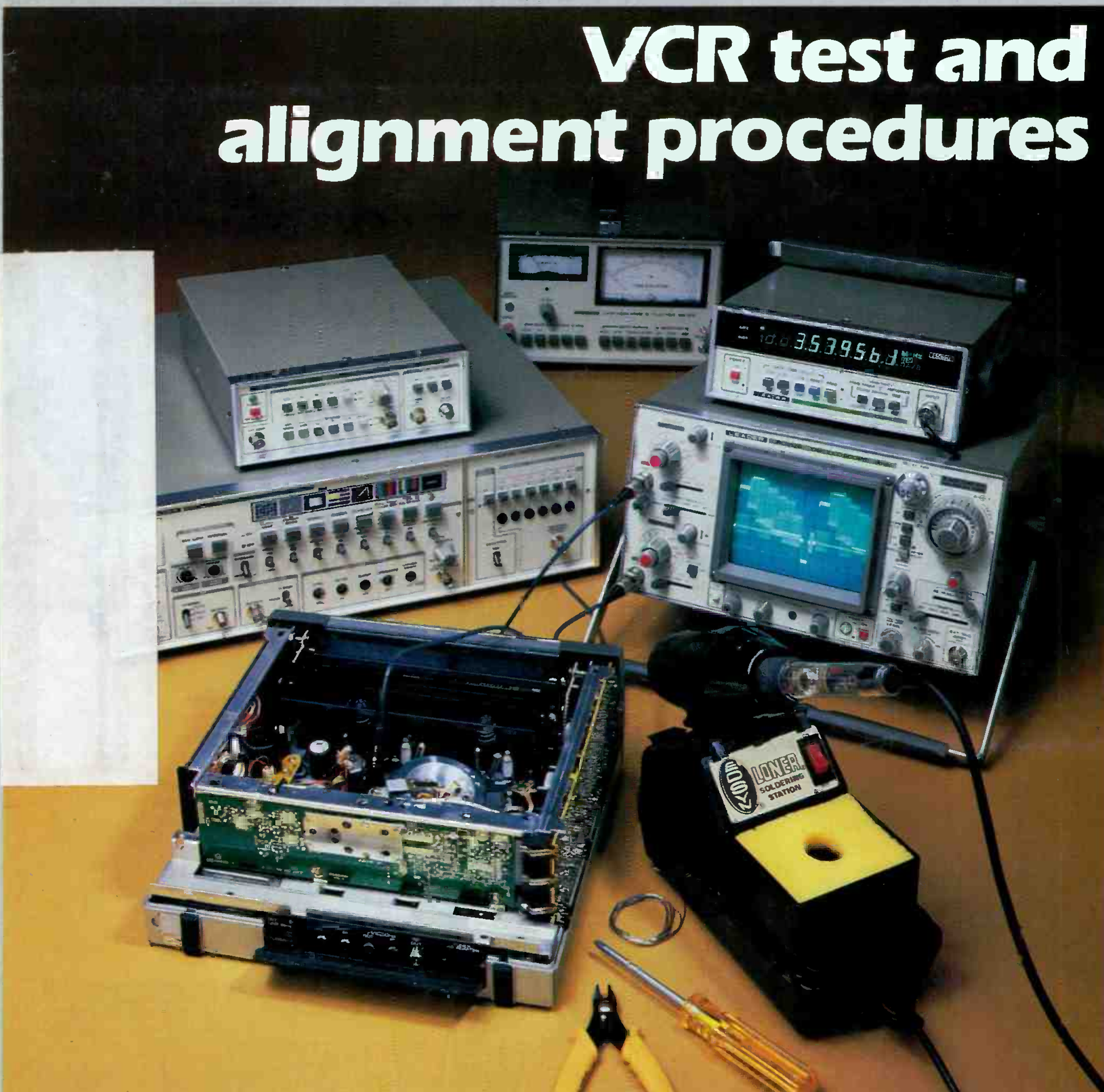
Unusual waveform/function generator circuits

VCR test and alignment procedures



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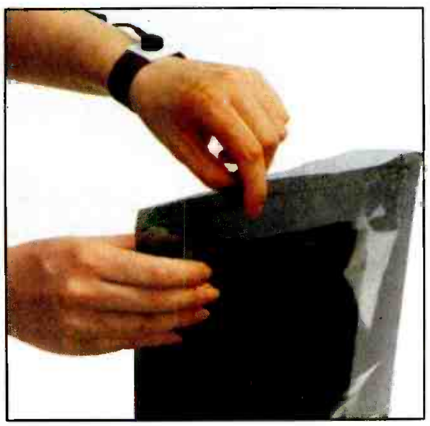
Circle (1) on Reply Card

The how-to magazine of electronics...

ELECTRONIC Servicing & Technology

Volume 7, No. 10 October 1987

page 16
A basic test-equipment setup for VCR testing and alignment can be stored on a roll-away cart for convenience. *(This photo and cover courtesy of Leader Instruments.)*



page 26
Static shielding bags and static dissipative kits can protect sensitive electronic components from ESD damage.

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*Patent issued November 8, 1983. U.S. Patent No. 4,414,260.

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Circle (4) on Reply Card

The "smart" home of the future

Wouldn't it be nice if you could dial a phone, say from where you work, from the movies or a restaurant or even from out of town, and be connected with your home. No, I don't mean *someone* at your home, I mean with a central control and sensing unit that would let you turn lights on and off, reset the temperature setting on your thermostat, turn on your VCR to record a program that you forgot you wanted to watch, check to see if you in fact left an iron turned on (and turn it off if you did), or check the outside and inside temperatures.

Sound farfetched? It does to me too, but considering the advanced state of today's electronic technology and some things that are going on in the electronics industry, it just might become possible sooner than any of us think.

The most recent issue of the EIA/CEG Newsletter features an article called "Interest grows in home automation as CEG begins to draft standard." The report is quoted here:

> There is a new American home on the horizon – one that is efficient, secure and very smart. It is the fully automated intelligent home. Although "smart" systems – automated controls for heating, air conditioning, lighting and security – have been used in office buildings for years, this technology has not been available for the family home. The EIA's Consumer Electronics Group is developing industry-wide standards that will soon make the dream of the intelligent home a reality.
>
> According to Group Vice President Thomas P. Friel: "To understand the system, one should think of a home as a network of highways. Its 'roads' are the power and telephones, infrared remotes and coaxial cables. Although all are now capable of carrying commands and information throughout the home, the roads are not yet connected. The EIA standards will join all of these into a network through which commands can be issued for various home functions."
>
> With the growing interest in the development of a standard for a remote-controlled home system, CEG envisions this system utilizing power lines, twisted wire pairs, coaxial cables and infrared wire to control audio/video, lighting, major appliances and security systems with the push of a button.

If you find it hard to imagine the idea of a home full of electrical and electronic devices that can be programmed in advance to come on and off on a set schedule, and can then be reprogrammed remotely using the buttons of a touch-tone phone, try to picture the reaction you'd get if you tried to describe a modern home to someone at the turn of the century whose home had just been wired for a few electric lights. He would no doubt find it impossible to conceive of pictures being received from a distance, even from space, or news reports received instantaneously as they happen on the other side of the globe.

And imagine if you tried to convince him that in the future he would be able to cook food in minutes without heat, or if you tried to describe what he would be able to do with the telephone and a personal computer.

This central bus proposed by the EIA Consumer Electronics Group, along with the electronics technology already in place, should serve to keep the consumer electronics revolution rolling for a long time to come. But we all know that the technology will continue to advance at a rapid pace in the meantime, making the possibilities even more incredible.

It's an exciting time to be involved with electronics and should prove to be interesting for consumers as well as rewarding for servicing professionals.

ES&T

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Test your electronics knowledge

By Sam Wilson, CET

1. The vertical antennas used with AM broadcast transmitters are
   A.) quarter-wavelength.
   B.) half-wavelength.
   C.) one-wavelength.

2. The resonant frequency of a certain series-tuned L-C circuit is adjusted by moving the turns of the coil farther apart or closer together. To lower the resonant frequency, you should move the turns
   A.) closer together.
   B.) farther apart.

3. Which of the following circuits might be found in the block marked x in Figure A?
   A.) BFO
   B.) AGC amplifier
   C.) discriminator
   D.) wideband amplifier

4. What is the highest number that can be counted with five J-K flip flops?
   A.) 32
   B.) 16
   C.) 24
   D.) 31

5. Consider the simple circuit in Figure B. With R_2 adjusted to 100Ω, the current through R_L is 0.5A. To maintain 0.5A through R_L, you would have to
   A.) increase the resistance of R_2 if the resistance of R_L decreases.
   B.) increase the resistance of R_2 if the resistance of R_L increases.

6. Each resistor in the circuit of Figure C is 10Ω. The resistance between A and B is ______.

7. What is the name of the power supply system that converts dc to ac?

8. Which of the following is true for a power supply?
   A.) A lower percent regulation is better than a higher percent regulation.
   B.) A higher percent regulation is better than a lower percent regulation.

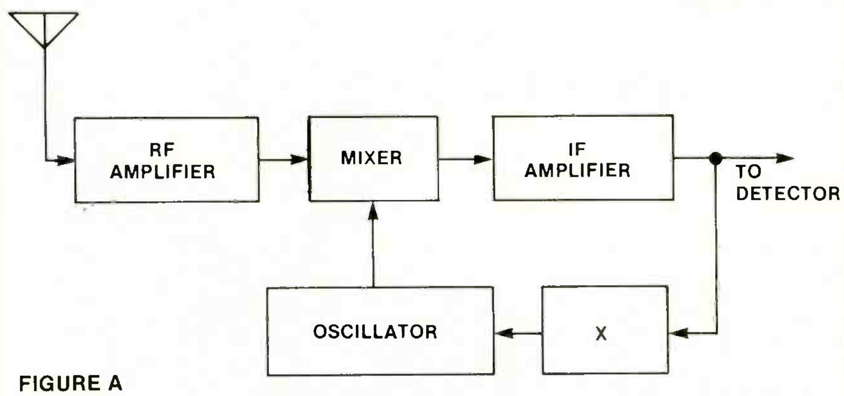

FIGURE A

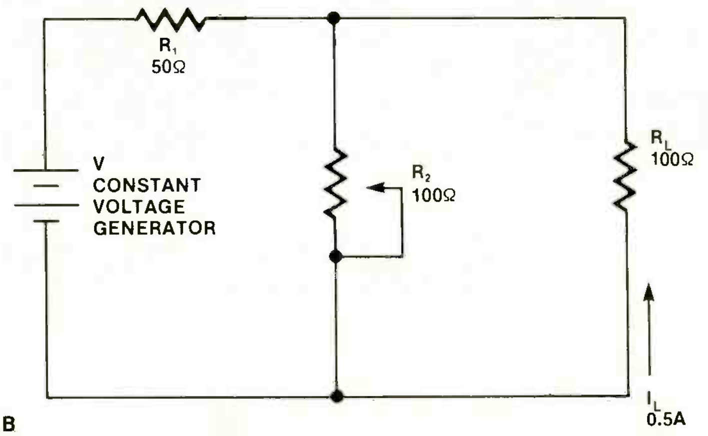

FIGURE B

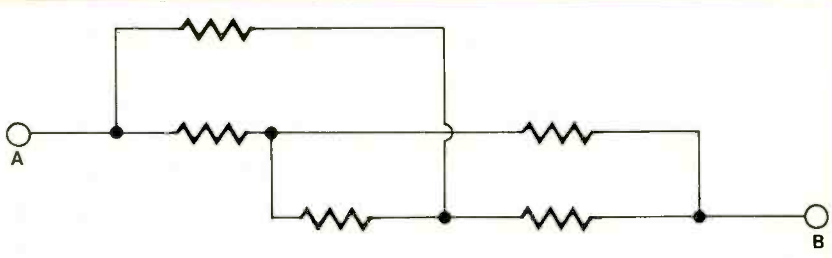

FIGURE C

9. Which of the following is true for a power supply?
   A.) It is better to have a low ripple factor.
   B.) It is better to have a high ripple factor.

10. To increase the brightness of the lamp in the circuit of Figure D, move the wiper of R
   A.) toward point A.
   B.) toward point B.

BONUS QUESTION – 10 points: Who was the first person to transmit a coded message by radio waves?
   A.) Morse
   B.) Marconi
   C.) Tesla
   D.) Edison

Answers are on page 40

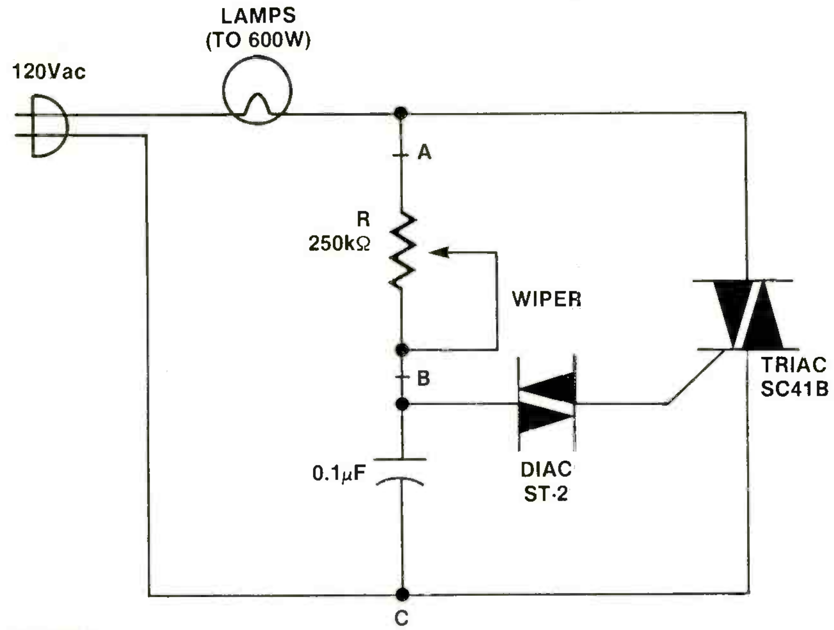

FIGURE D

News

CEG announces U.S. Skill Olympics winners

Six winners have been chosen in the Electronic Products Servicing Contest, one of 38 skill contests held during the Vocational Industrial Clubs of America (VICA) 23rd annual U.S. Skill Olympics. The contest, sponsored by the Consumer Electronics Group (CEG), tested problem-solving, soldering and desoldering skills and knowledge of safety problems.

The six winners, listed below, were awarded free subscriptions to ***ES&T*** magazine.

The six winners of the Electronic Products Servicing contest at the U.S. Skill Olympics were, left to right: postsecondary winners Mike King, 3rd place; Henrik Moller, 2nd place; and Dean Johnson, 1st place; and secondary winners Michael Belew, 1st place; William Lee, 2nd place; and Addy Little, 3rd place.

NARDA and NESDA discuss joint association

Exploratory discussions on possible future joint ventures were held August 13 by members of NARDA/NASD (the National Association of Retail Dealers of America and the National Association of Service Dealers) and NESDA/ISCET (the National Electronics Sales & Service Dealers Association and the International Society of Certified Electronics Technicians). The four members who attended the session were Dorothy Cicchetti, president of NESDA, Jim Parks, chairman of ISCET, Kent Crawford, president of NASD, and David McKalip, secretary of NARDA. The discussions may eventually lead to a consolidated international association to serve the sales and service industry.

The how-to magazine of electronics

ELECTRONIC Servicing & Technology

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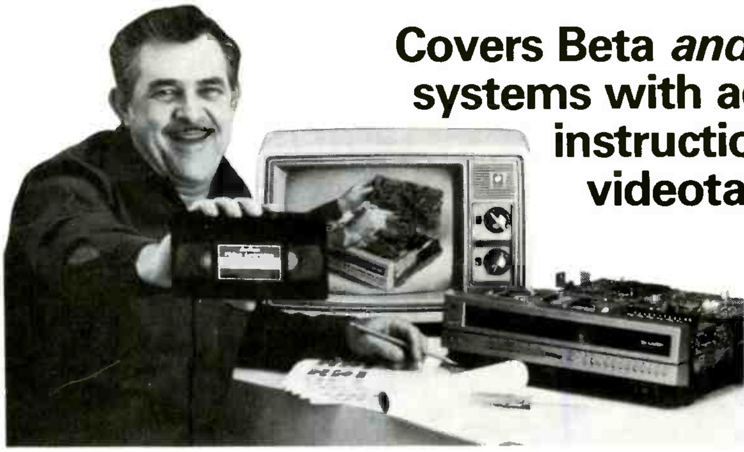

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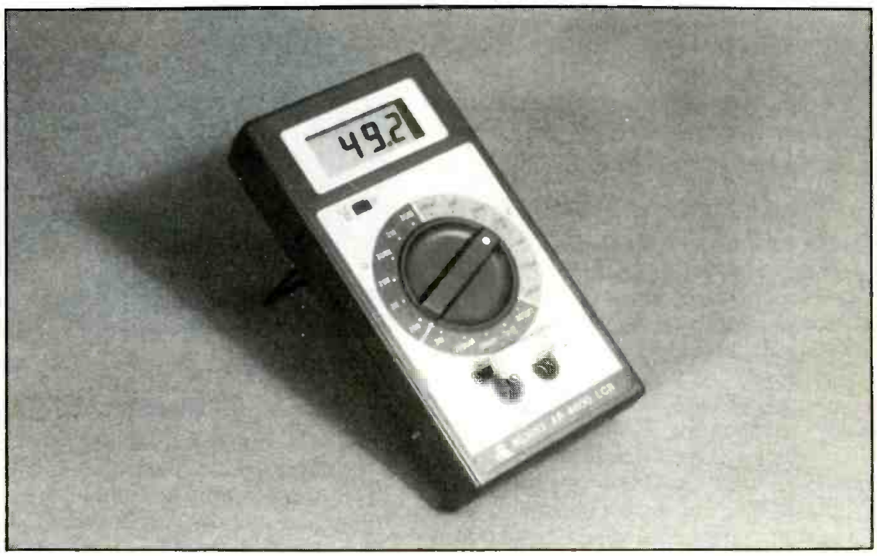
Report from the test lab

The dissipation factor... an explanation

In the last "Report from the Test Lab" (April 1987) the author evaluated the American Reliance AR-460-D LCR meter and asked the question, "What is a dissipation factor?" He pointed out that the meter being tested measures dissipation factor, but this parameter was not thoroughly discussed in the material provided with the meter.

D. Joseph Frazier, strategic marketing manager for American Reliance, provides the following explanation.



An ideal capacitor or inductor would store but not dissipate energy – energy out would be equal to energy in. However, in the real world capacitors and inductors do have losses.

The first type of loss in a capacitor is associated with the dielectric material. The dielectric losses may be represented by a *parallel model* expressed as a perfect, lossless capacitor (C_p) in parallel with a resistor (R_p) that represents the dielectric resistance. (See Figure 1.)

In this model, the dissipation factor may be expressed as:

$$D = 1 / (F \times C_p \times R_p)$$

where F represents the frequency of the applied voltage, and C_p and R_p represent the values of capacitance and resistance measured at frequency F.

The second type of loss is associated with the resistance of the conductors and plates. The resistance losses may be represented by the *series model*, which is represented as a perfect, lossless capacitor (C_s) in series with a resistor (R_s) that represents the resistance in the plates and conductors. (See Figure 2.)

In this model, the dissipation factor may be expressed as:

$$D = F \times C_s \times R_s$$

where F again represents the frequency of the applied voltage, and C_s and R_s represent the values of capacitance and resistance measured at frequency F.

Because the capacitor's dielectric material is not a perfect insulator, a current will flow between the two plates. This current is referred to as the *leakage current* and causes some of the stored energy to be lost as heat. Also, because the conductors are not perfect, they possess a certain resistance, which also causes heat (IR) losses during charge and discharge cycles. Both these losses considered together are the capacitor's *dissipation factor*.

It is important to note here that excessive leakage currents will cause errors in capacitance measurements. Therefore, it is good practice to test a capacitor for excessive leakage *before* attempting a capacitance measurement.

It may be clearly seen in the dissipation factor formula that the dissipation factor is inversely related to the leakage current.

The inductor's energy loss that we are concerned with is caused by the resistance inherent in the wire forming the inductor. This may be shown as the inductance L_s in series with the resistance R_s. (See Figure 3.)

However, the resistance of an inductor is rarely specified. Instead, a quality factor, Q, is commonly used:

$$Q = (F \times L) / R$$

where F represents the frequency of the applied voltage, L is the inductive reactance at frequency F and R is the resistance. Obviously, Q is therefore frequency dependent.

During periods of current flow, the resistance develops heat due to IR losses. This is the loss defined by the quality factor, Q.

Q is related to the dissipation factor by:

$$D = 1 / Q$$

It is easily seen, then, that the higher the Q (or lower the dissipation factor) the better an inductor's quality is.

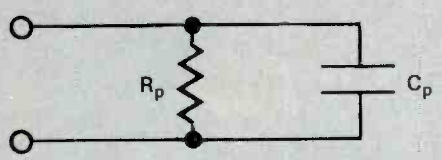


Figure 1

Figure 1. One energy loss that occurs in capacitors is associated with the dielectric material. The dielectric losses may be represented by a parallel model expressed as a perfect, lossless capacitor (C_p) in parallel with a resistor (R_p) representing the dielectric resistance. Leakage current caused by the imperfect dielectric material will cause heat loss and errors in capacitance measurements. A leakage resistance of 100MΩ or more is considered large, and 1MΩ or less will cause excessive leakage current.

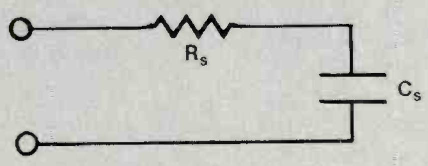


Figure 2

Figure 2. Capacitor energy loss is also caused by the capacitor's conductors and plates. These losses may be represented by a series model, with a perfect, lossless capacitor (C_s) in series with a resistor (R_s) representing this resistance.

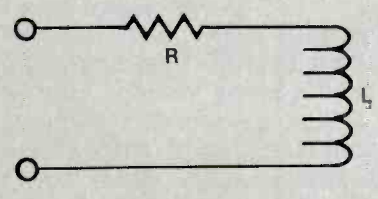
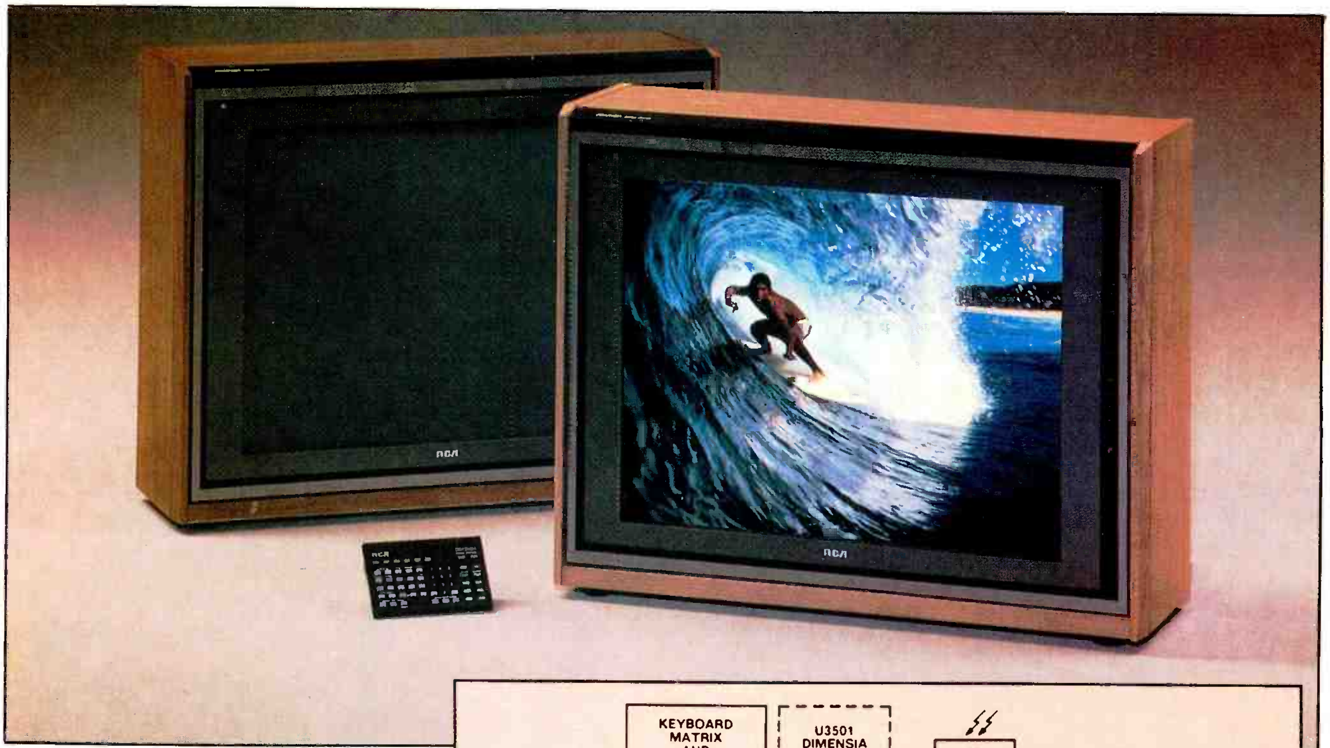


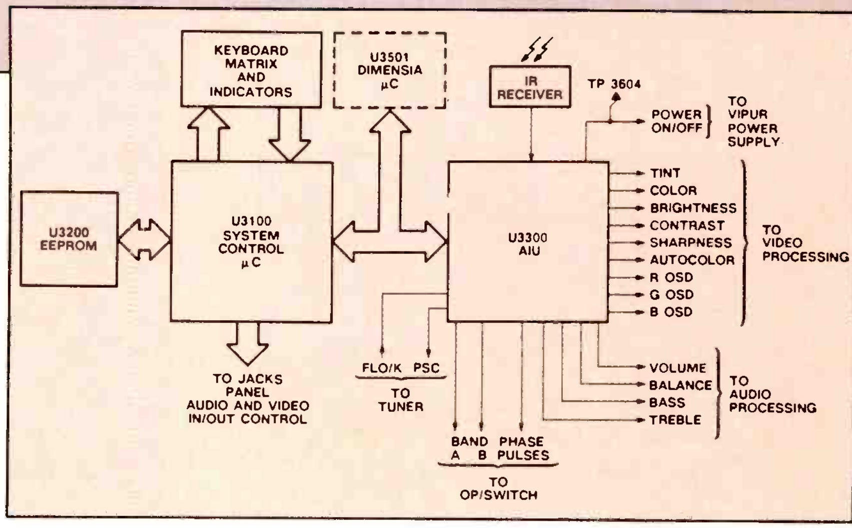
Figure 3

Figure 3. Energy loss in an inductor is primarily caused by the resistance inherent in the wire forming the inductor. This loss may be shown as the inductance L_s in series with the resistance R_s.

Technology

Total remote control





RCA has developed a new unitized chassis system that offers remote control of virtually every picture and sound adjustment, including broadcast stereo sound, alarm and sleep tuners and on-screen tuning.

The control system is a pushbutton operated, memory-equipped digital system with on-screen menus and prompts. The system controls channel and function selection and all video and audio settings, including brightness, sharpness, contrast, color, tint, volume, balance, bass and treble.

Both the tuning system control and MTS broadcast stereo circuits are an integral part of the circuit board. The tuner assembly is a single in-line package (SIP) circuit board soldered directly to the chassis circuit board.

The on-screen tuning features multicolored on-screen displays that give information about operating status and also serve as visual guides that assist in selecting and operating the receiver's functions. The tuner can receive 147 nonscrambled cable and standard broadcast channels. Some models have an electronic RF switch for choosing between two antenna inputs.

To improve serviceability, RCA kept more than 80% of the circuits identical or almost identical to those used in previous RCA unitized chassis. Of the remaining circuits that are different, most are employed in the MTS audio and the system control sections.

RCA also eliminated cabinet screws on the bottom, top and sides of the cabinet, and simplified removal of the chassis to two hold-down screws and six connectors. The bench setup for full operation with a test jig (including speakers) requires only the connection of the HV anode, kine drive, yoke and front-panel assembly. The company included extra-long cables and wires to eliminate the need for service extension cables and made the ac power cord detachable. Finally, the company included an EIA multiport connector on the back of the TV for checking composite video/audio without removing the cabinet back. ES&T

Photofact

These Photofact folders for TV receivers and other equipment have been released by Howard W. Sams & Co. since the last report in ES&T.

TELEVISION RECEIVERS:

EMERSON
MS198R, MS198RA 2525-1

GENERAL ELECTRIC
8-1445 (CH. RS-A) 2528-1

HITACHI
CT1376 2528-2

PANASONIC
CTH-2530/39/60R/69R, PC-26N60R 2523-1

PANASONIC
CTH-2053R, CTJ-2042R/53R 2527-1

PANASONIC
CTH-2600R (CH. NMX-GXLCN) 2529-1

SEARS
564.42450550/51/52 2523-2

SEARS
564.40351650/51 2525-2

SEARS
564.48101650, 564.48201650 2526-2

SYLVANIA
RAF146SL01 2526-1

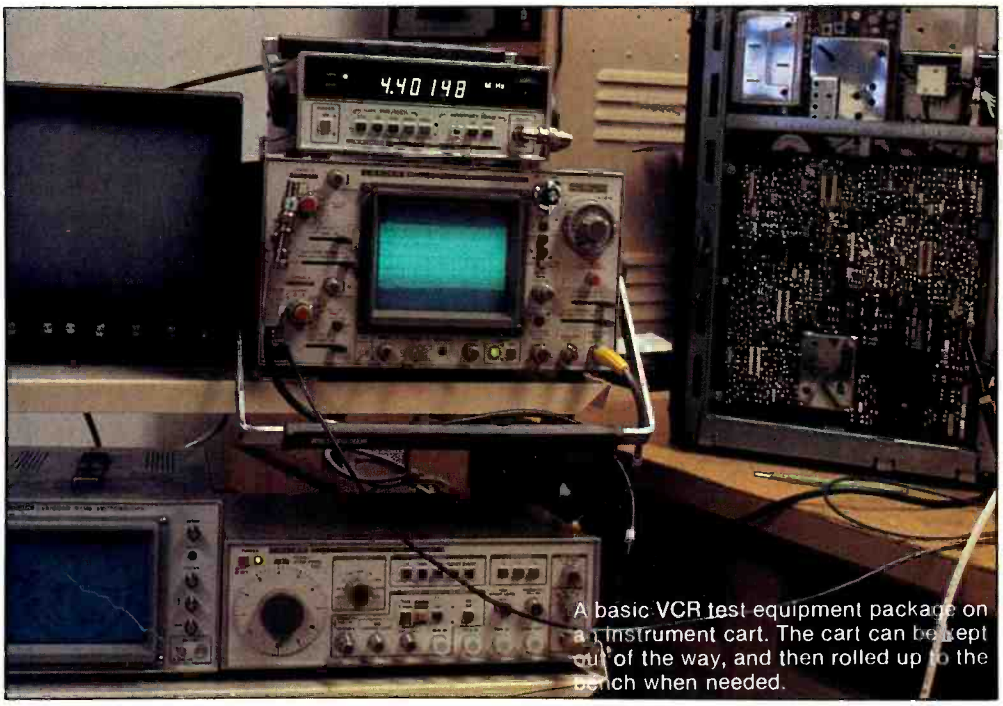
TOSHIBA
CX2676, CX2886C/96C, CZ2696 2524-2

TOSHIBA
CX2006 (CH. TAC8530) 2527-2

VIDEO CONCEPTS
AH1000 (CH. ECC-2801) 2529-2

MONITOR:

LEADING EDGE
7BM613074G 2524-1



A basic VCR test equipment package on an instrument cart. The cart can be kept out of the way, and then rolled up to the bench when needed.

Test and alignment procedures for VCRs are sometimes time consuming because you have to follow a specific procedure for each model. Just following the steps takes time, as does the search for test points, adjusting points and so on. And I guess we've all had the experience with an adjustment procedure that just doesn't work. It might have been a slip in translation or a procedure borrowed from an earlier model.

This article deals with some basic ways to do alignment checks; some are routine, others are not. The idea is to make things easier, follow procedures that will apply to all models and get maximum help from your test equipment.

Basic setup

The photograph above shows the basic VCR test equipment package on an instrument cart that can be kept out of the way and rolled up to the bench when needed. The heart of the setup is a 35MHz, dual-channel, delayed-sweep scope. The scope, a Leader LBO-324L, has recently been upgraded to 40MHz bandwidth. A frequency counter sits atop the scope and is normally connected to the CH-1 output of the scope. This permits the CH-1 amplifier in the scope to act as a counter pre-amp, and cuts down on the number of test probes in use. The system remains flexible – if you want to do a camera check, you can transfer counter input to the subcarrier output jack for the pattern generator. (See "TV Camera Test Bench – A Setup to Speed Checks and Adjustments" in the April 1986 issue of ***ES&T***.)

Just below the scope is a 10MHz function generator (Leader LFG-1310), a very versatile instrument used in one of the methods described for FM modulator deviation adjustments described later. The video monitor is a 9-inch Panasonic black and white with external sync, underscan and pulse cross. It's ideal for camera work, but useful for many VCR checks as well.

The pattern generator produces the standard NTSC color bars in the form shown in practically all VCR service manuals – split-field bars that conform to EIA standard RS-189A. This generator produces other patterns that are extremely

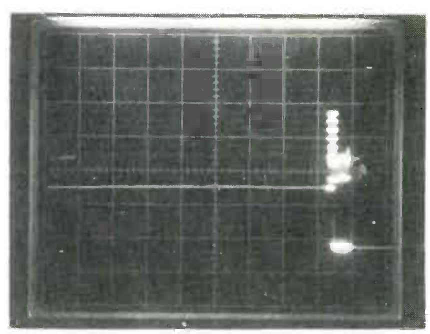


Figure 1. It's easier to check CH-1 and CH-2 if you used delayed sweep with highlighted B time base adjusted to straddle the head-switching transition.

VCR test and alignment procedures

By G. McGinty, CET

useful, such as the window pattern (used in this article to adjust luminance FM deviation), modulated staircase and a video sweep, complete with sync blanking and burst.

Video head switching

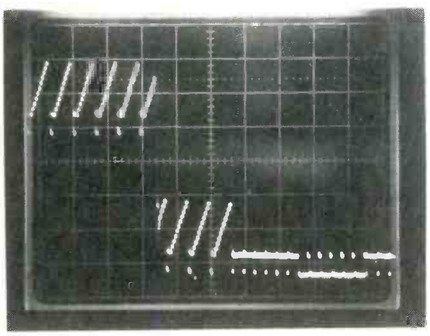
Many alignment procedures have been dropped in VCRs because of improvements in design and in component tolerances. Head-switching adjustment remains, however. The reason is that the timing of mechanical events, such as when the video heads slam into tape and when the 60Hz feedback pulse is generated, are determined by mechanical tolerances and are trimmed electronically. Head-switching should be checked every time the heads have been replaced or even if the machine has had a few years of service. To set playback head switching, you need an alignment cassette. These have been available from the VCR manufacturers, but some produced by independent manufacturers such as Astimagnetics have shown up. A dual-channel scope is also necessary. Delayed sweep is not a necessity, but it sure makes things easier.

To do the job you have to search out one internal signal – the head-switching signal, a 30Hz square wave produced on the servo-board. Sometimes it's called head switching, sometimes FF (flip flop) or something similar. This signal does a number of things, such as turning on the pre-amp for the head in contact with tape, letting system control know that the scanner is spinning, etc. It can be found on a servo board TP but also in the PB pre-amps and system control.

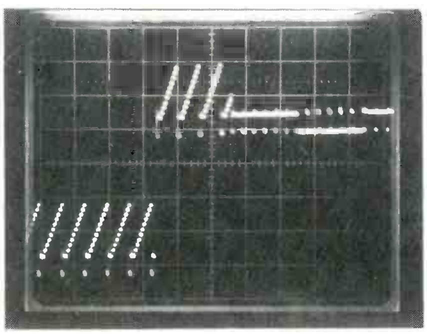
Find and monitor the head-switching square wave with a 10:1 probe on scope CH-2. And trigger from CH-2 – that's essential. You're monitoring PB video output on CH-1, so video out of the VCR is connected to the CH-1 input with a BNC tee. Terminate the tee, if this is the last stop, or route the cable to the input of the video monitor and terminate there.

Play back the section of the alignment cassette recommended for head switching (usually staircase). Check CH-2 for a stable 30Hz square wave and CH-1 for video amplitude of sufficient amplitude for observation (2cm).

I use delayed sweep because you can look at the time span ahead of the head-switching signal. To do this, highlight the A trace with A intensified by B to straddle the time zone of the next switching transition (see Figure 1). Here the scope is triggered by the positive-going edge of the switching square wave (scope slope switch set to +).



A



B

Figure 2. The head-switching signal added to PB output video makes the correct switch location easy to see.

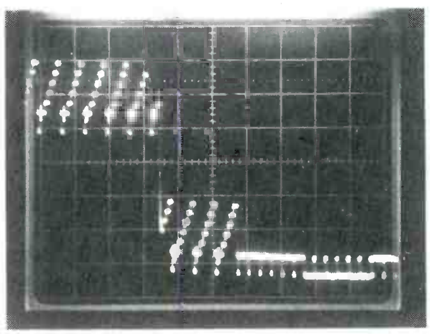


Figure 3. A head-switching adjustment made in the record mode makes the servo follow the accuracy of the alignment cassette.

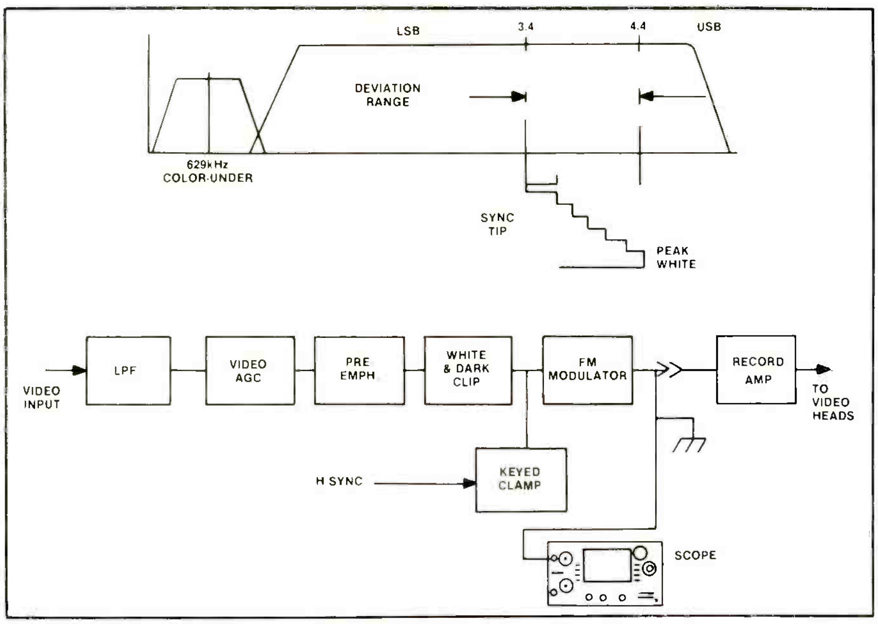


Figure 4. The basic luminance FM processing and deviation range.

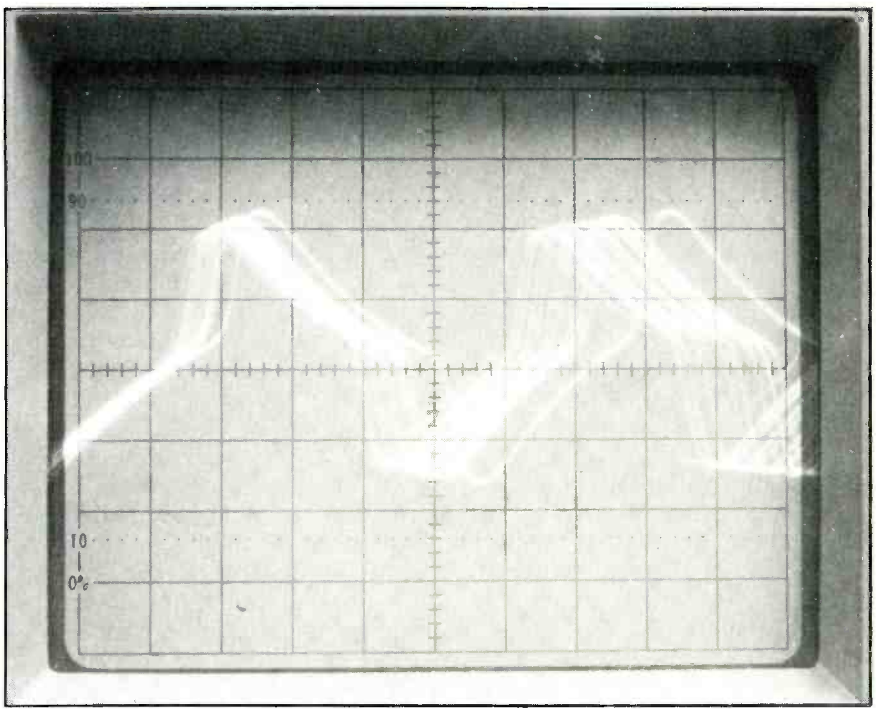


Figure 5. FM modulator output for the color-bar signal shows several discrete periods. (Waveshape is typical.)

The A time base is at 2ms/cm, and the B time base is at 0.1ms/cm, enough to see about 16 horizontal lines that straddle the switching point. The delay pot on the scope is set to make the highlighted B time base straddle the switching excursion as shown. To make the adjustment, switch the VERT MODE switch on the scope to ADD and set the H DISPLAY to show the B time base (see Figure 2A). Now you see the sum of both waves, and the negative excursion of the head-switching signal shows up as an abrupt step in the video waveform.

The VHS spec calls for the switch to occur 6.5 H lines ahead of V sync. The step makes this very easy to see. V sync is that wide, negative-going pulse with five narrow positive-going slots, the serrations. V blanking starts three lines earlier and contains six of the leading, narrow equalizing pulses.

To the left of V blanking are three horizontal lines of active video plus that half line. That's what the adjustment is made to do. I try one of the two head-switching adjustments by trial and error to find the right one for the switch excursion I'm looking at. Remember, there are two for standard play (2-hour) and another two for extended play (6-hour). You alsc need an EP alignment cassette for the latter.

To look at the switching point for the other head, simply push the slope polarity button on the scope (see Figure 2B). Now the scope is triggering on the negative head-switching excursion and we're looking at the positive-going step. This time, adjust the remaining delay pot, again for the switching step to occur 6.5 lines ahead of V sync. The waveform looks a little different this time. Note that half line of active video before the start of V blanking. This line denotes the end of field one and the beginning of field two. (The start of field one shows a full line of video before V blanking, as shown in A of the figure.) This time, the adjustment is made for three full lines of video before that half line that occurs before blanking for a full 6.5 lines before sync. In both cases, the adjustment is very easy to see, thanks to the use of delayed sweep and the use of the ADD mode.

When you complete the PB head-switching adjustment using an alignment cassette, you have made the VCR switch video heads at precisely the right time, based on track location for the recording of V sync – a job we expect the VCR manufacturers to do correctly and under controlled lab conditions. There is more to this adjustment, however. After PB the record servo is adjusted to lay down V sync in exactly the same place, in effect imitating the alignment cassette. The adjustment is called REC PHASE or something like it, and is made in the REC mode with a work cassette. Otherwise, the setup and adjustment is exactly the same. Figure 3 shows the record-mode adjustment using the 5-step staircase produced by the pattern generator.

Luminance modulator

I recently had to replace the IC chip that processes the input luminance signal for recording purposes. I was somewhat frustrated by an alignment procedure for the FM modulator that just didn't work, so I began looking for

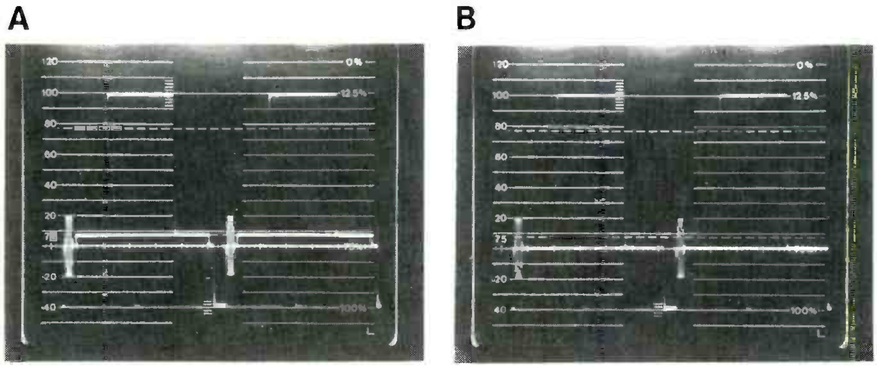


Figure 6. The window signal shown on a waveform monitor: 6A is with setup; 6B is with setup reduced to zero.

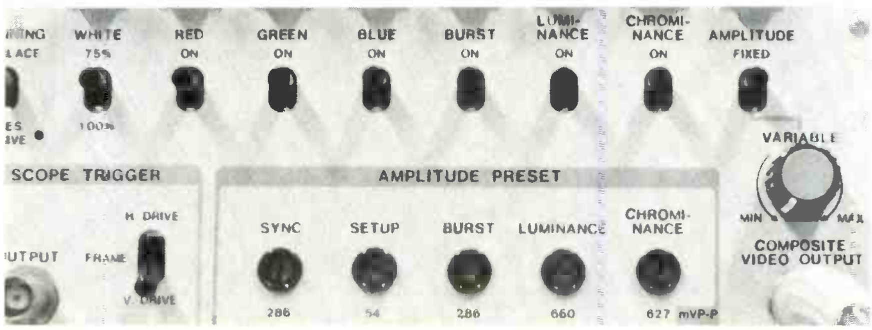


Figure 7. This generator permits front-panel adjustment of sync, setup, burst, luminance and chrominance amplitudes. Setup can be reduced to zero.

A

B

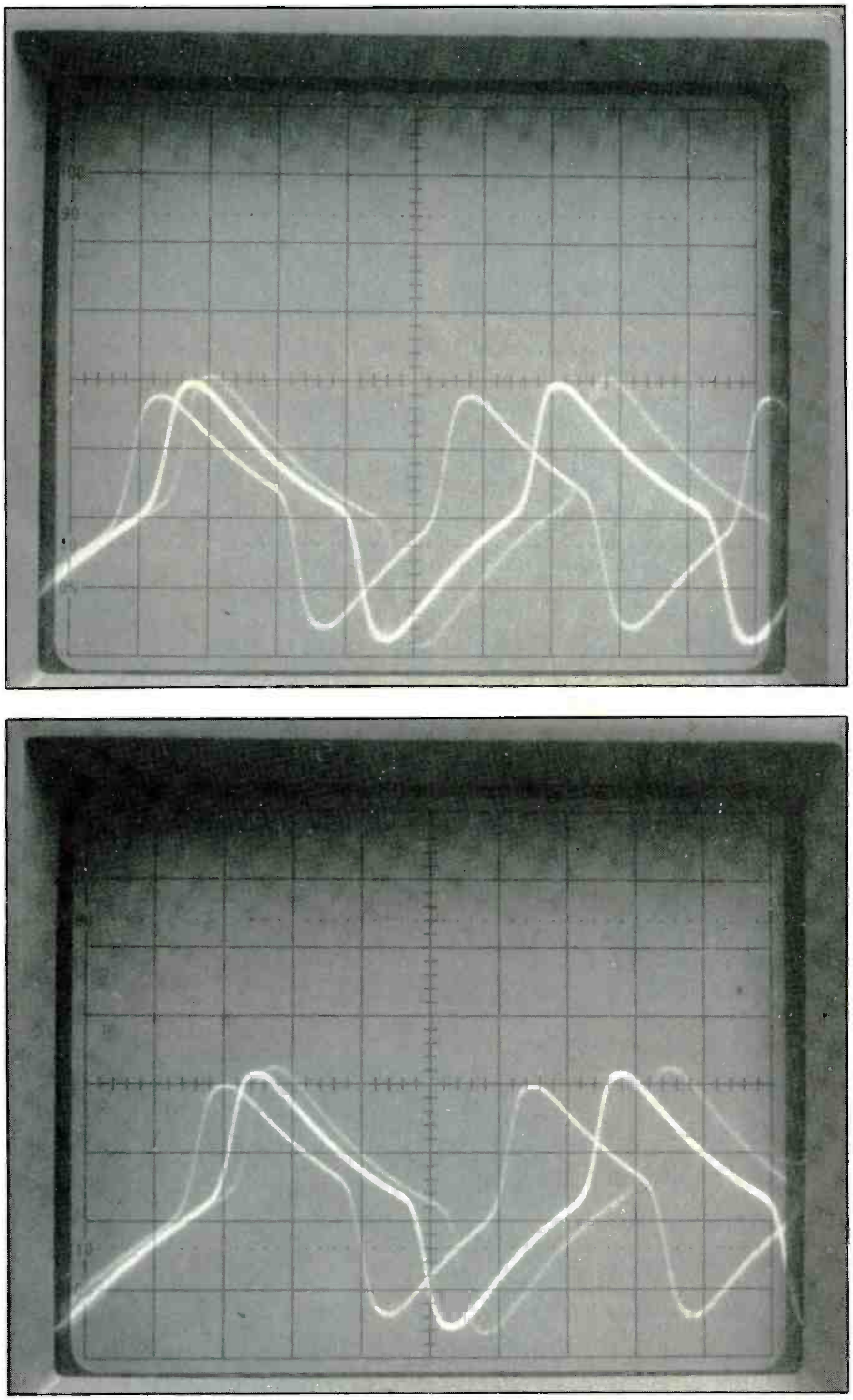


Figure 8. These three waves represent sync-tip frequency (longest period), black (brightest wave) and peak white (shortest period).

alternatives and, hopefully, universal ways of doing it. The following are two simple alternatives to the factory procedure.

Following Y-AGC and the white and black clip adjustments, the FM modulator must be set up to cover the correct deviation range for the full video excursion from sync tip to peak white. Figure 4 shows the deviation range, FM sidebands and color-under slot for the VHS system. The picture shows a drop-off in upper sidebands that really tells the story of the high frequency limits of what the playback process does. Farther into the tape, both upper and lower FM sidebands are present.

Many schemes are in use for setting the deviation range, that is, the frequencies at which the FM modulator works at the signal limits of sync tip and peak white It was easy for older VCRs that used a diode clamp circuit to clamp sync tip to an adjustable dc voltage at the input to the modulator. Just remove the signal and the modulator runs at the sync tip frequency. All you need is a frequency counter.

However, most systems now use a *keyed* clamp. In the absence of input video, the dc voltage input to the FM modulator is just about meaningless. Thus, the adjustment procedure must be done with a normal signal applied. Existing factory procedures often involve elaborate substitutions or heterodyne techniques that involve complex in-circuit connections. I looked for a scheme that requires only one observation point in the VCR, the output of the FM modulator or the input to the Y record amp.

Why not period?

This technique requires a scope with an accurate time base capable of measuring the *period* of the signal in the range of 200ns to 300ns (0.5μS/cm with a X10 magnifier yields 50ns/cm, just right). The idea is to measure the period of the FM wave out of the modulator for both sync tip and peak white video levels.

Figure 5 shows the output of the FM modulator on a typical VHS VCR when standard color bars are applied as the input signal. The scope is synced internally on the signal being observed with a 50ns/cm time base. You can see that FM is taking place because there are a number of signals with differing periods – one for each

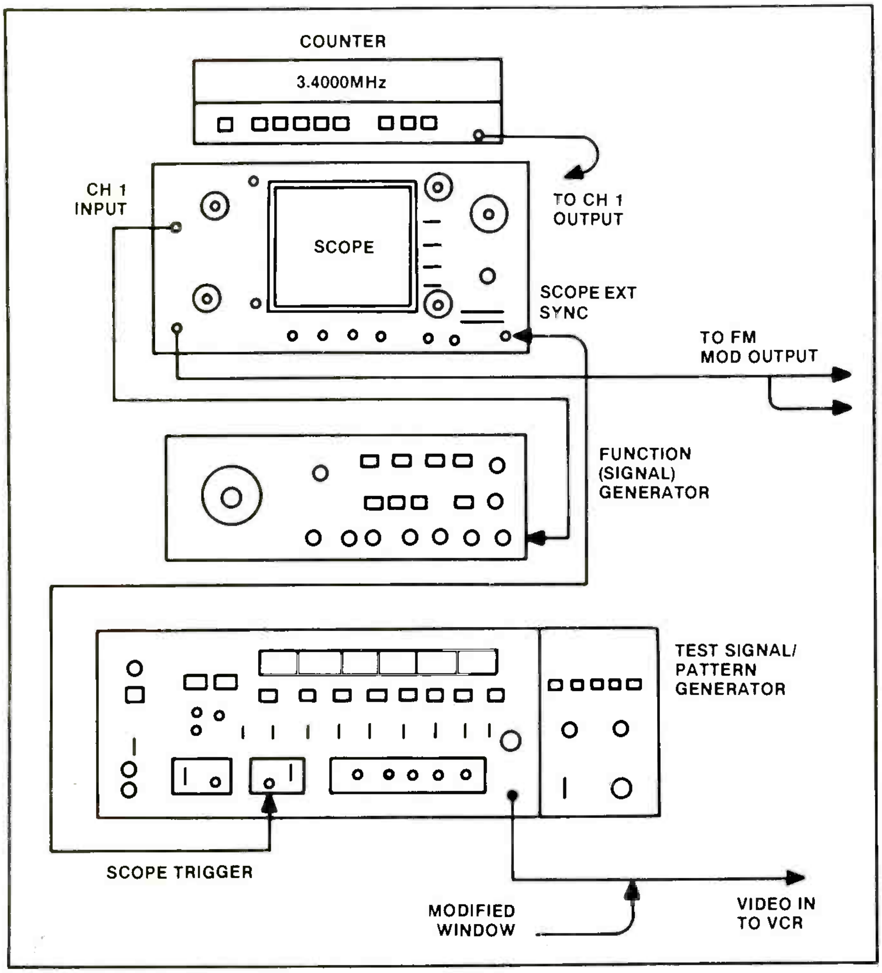


Figure 9. System hookup for the heterodyne method of deviation adjustment.

luminance step in the color-bar waveform as well as steps for blanking, setup and sync tip: too many signals of which to make sense. What's needed is the simplest signal you can devise–one that has a minimum number of levels and still represents typical video so clamp circuits and others continue to work normally.

The solution is the window signal. It normally has only four levels: peak white, sync tip, blanking and setup. The window signal is a good, simple video signal. The center half of the picture is white, the rest black, yielding a 50% average picture level. Figure 6A shows the 2H waveform for the standard window signal taken on a waveform monitor. The black level is as shown at 7.5% (7.5IRE) and peak white is at 100% (100IRE on the scale at the left). If you apply this signal to a VCR, the FM modulator operates at four discrete frequencies.

To make the situation even simpler, that 7.5% setup can be eliminated, leaving only three discrete frequencies. Figure 6B shows the window waveform with setup reduced to zero and luminance reset to bring it back to 100%. Fortunately, this generator permits these adjustments from the front panel (see Figure 7). With SETUP turned fully CCW, it goes to zero and "black" is the same as the blanking level (as it was originally intended to be).

When the modified window signal is applied, the FM modulator works at only three frequencies: sync tip, blanking and peak white, as shown in Figure 8A. The traces are not equally bright. The modulator operates at the sync tip frequency for the shortest period of time so its wave is the dimmest.

A

B

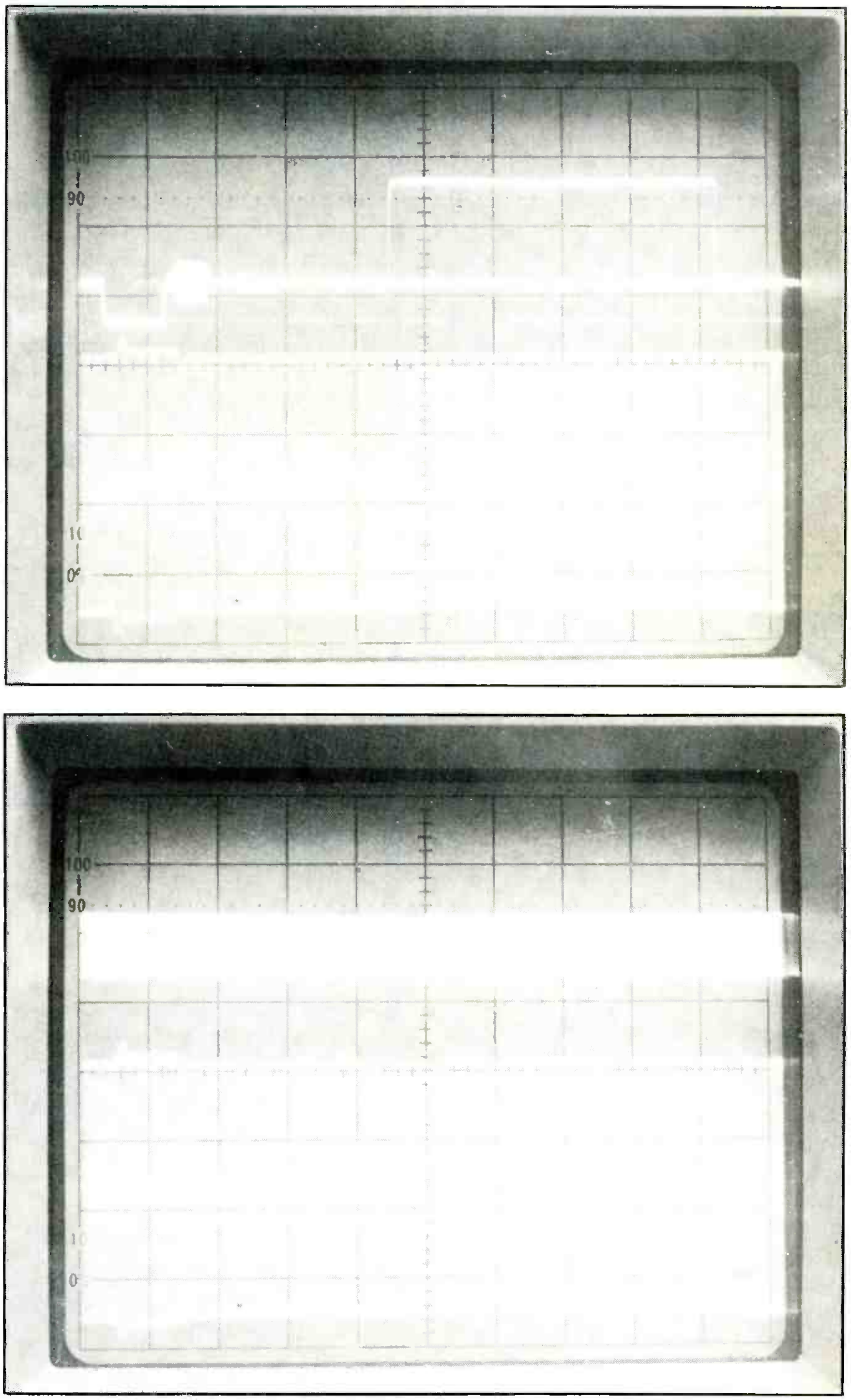


Figure 10. Heterodyne waveforms: 10A shows the window waveform, on top, and the modulator output, on bottom; 10B shows the CW signal, on top, and the modulator output, on bottom.

The modulator spends most time at black so its wave is the brightest, but we'll ignore the blanking period. We are interested in the lowest frequency (sync tip) with the longest period and in the highest frequency (peak white) with the shortest period.

Frequency vs. period

	Frequency	Period (1/f)
Sync tip	3.4MHz	294ns
Peak white	4.4MHz	227ns

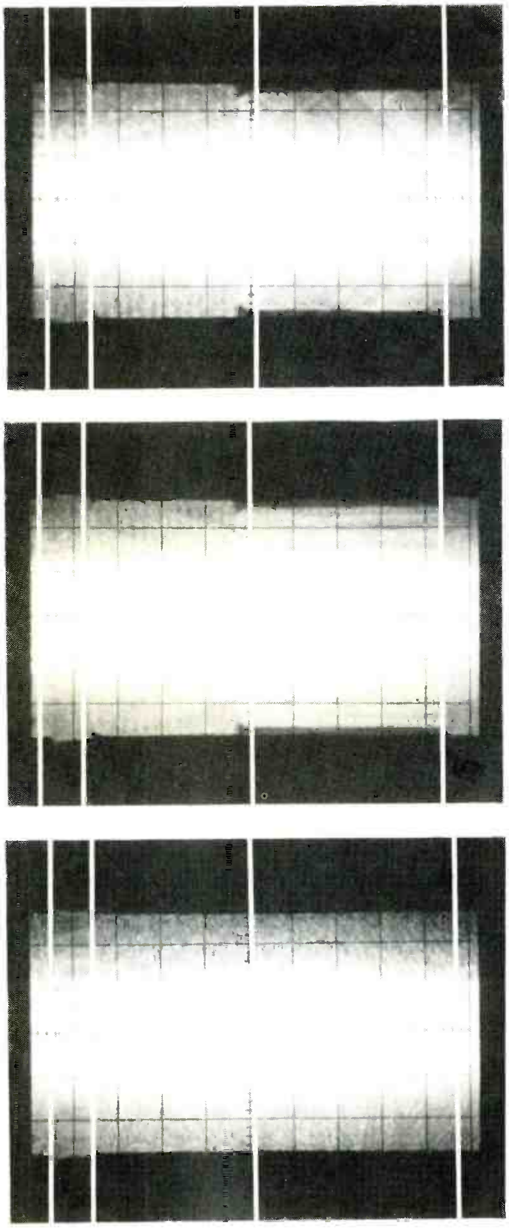
In Figure 8A, centering has been adjusted to put the longest (and dimmest) wave peak at the second graticule line from the left with the peak on the horizontal graticule line with the minor graduations. Counting to the next peak of this longest and dimmest wave, you'll see 5.8cm. This multiplied by 50ns/cm yields 290ns – close enough. If you are making adjustments at sync tip frequency, set your oscilloscope for 5.8 divisions.

Figure 8B shows scope centering reset to look at the shortest (highest frequency) wave. This time there are 4.5 divisions for 255ns, close enough to 227, which will allow adjustment of *deviation* (usually AGC gain) for a period of 4.5 divisions.

Heterodyne method

The method I prefer doesn't require the tedium of measuring period, but the indication takes some getting used to and is almost impossible to photograph. The setup is as shown in Figure 9. The scope must be triggered externally from the H DRIVE SCOPE TRIGGER signal provided by the generator, and I'll use the modified window again. The output of the VCR FM modulator is monitored on CH-2 of the scope. To start with, put generator video on CH-1. Figure 10 shows both waveforms in the ALT mode. I reset the time base (out of calibration) so one line occupies the width of the screen. Make a mental note of those parts of the display taken up for sync tip and peak white. You can also spot these on the modulator waveform, because modulator output is seldom equal at all frequencies.

Next, output of the signal generator is applied to CH-1 where you can also accurately monitor frequency with the frequency counter connected to CH-1 output. Scope gains should be set for about four divisions of the FM modulator



A B C

Figure 11. Heterodyne waveforms show zero beat at peak white (11B) and sync tip (11C). If the generator is set midway between, as in 11A, you just get a jumble of signal.

signal and two divisions of the generator signal.

The VERT MODE switch on the scope is then set to ADD. This will allow you to see a zero beat between the CW signal from the generator and the output of the modulator. Figure 11A shows what it looks like when the generator is set midway between the correct sync tip and peak white frequencies—just a jumble of signal. With the generator set to 4.4MHz and deviation set correctly in the VCR, a zero beat occurs in that part of the waveform where you noted that peak white resides (refer back to Figure 10).

The zero beat appears when all the lines in the peak white zone of the waveform flatten out and become a bunch of horizontal parallel lines (see Figure 11B). This is much easier to see on the

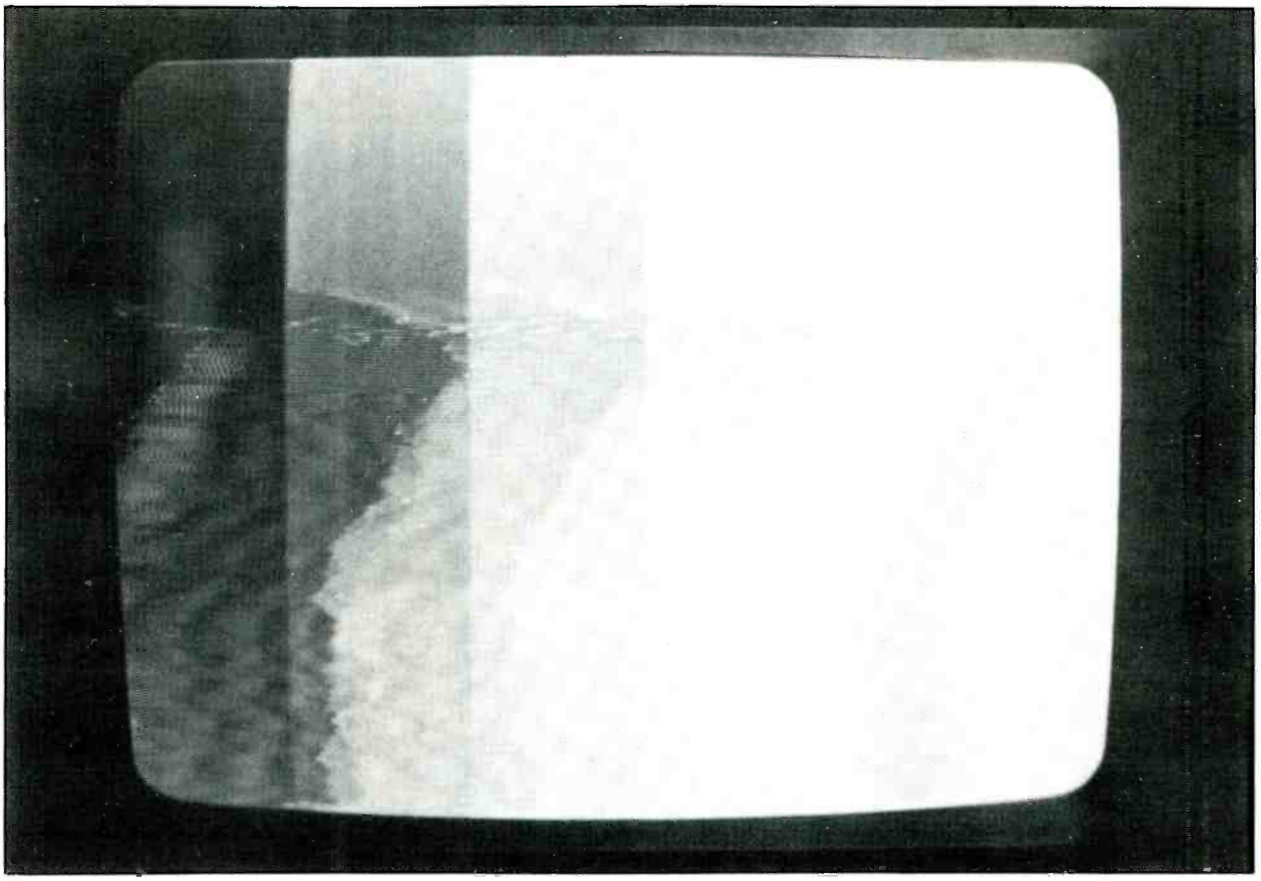


Figure 12. This symptom is caused by bad relay contacts in the relay that selects PB output from SP or EP video heads.

scope than it is to photograph because the patterns change and move due to drift, and the exposure time dictated by the camera causes the picture to blur.

Set the generator to 3.4MHz and set the sync tip adjustment for an indication of zero beat at the sync tip area (see Figure 11C). Although this method involves an indication that is somewhat difficult to recognize, it requires only one simple connection to the VCR and makes use of the accuracy of the frequency counter.

A common problem bonus

The VCR with the modulator fault had two problems. The second problem is very common and often intermittent. I had my film camera set up, so I took the picture of Figure 12. This problem has nothing to do with test equipment use, but it represents a symptom that can be recognized on sight and might save you a lot of time and trouble. The symptom looks like mistracking and is often confused with it. A beat appears in the picture.

In the standard play mode, the clue to the problem is that clear band of picture at the top. This problem is caused by bad contact on the relay in the video head circuit that selects the standard-play or extended-play heads. The relay does so by shorting out the unused heads for either mode.

However, bad contacts make the shorting action ineffective and both heads pick up signal. What you see is a beat between the signal picked up by both SP and EP heads. The EP heads are mounted to slam into tape later than the SP heads, so they don't contribute anything until the SP heads have been working for part of their swipe. Before the EP heads hit tape, the picture is clear. The EP picture has an opposite symptom; the bottom of the picture is clear. The remedy is always the same – replace the relay. This is easy on some models, a bear on others. ES&T

Literature

Video test notes

Leader Instruments is offering a series of application notes designed to augment available technical information in the application of video test equipment. The "Teleproduction Test" notes explain basic concepts and routine test procedures and offer shortcuts to complex VCR and video camera alignment procedures.

The first three issues are primers in the use of the waveform monitor. The fourth issue starts a similar series on the basic aspects of the vectorscope – what it shows and how it is used to evaluate color performance and in-phase matching of several video sources.

The fifth and sixth issues will discuss the basic operation of the vectorscope, showing how checks are made and how the vectorscope serves to bring a multicamera system into the proper phase relationship for flawless operation.

Circle (125) on Reply Card

RF design guide

Multiplex Technology is offering an illustrated, 4-page brochure for installers to use as a guide when designing RF systems. The guide offers seven steps that take the installer from setting the picture quality objective to the final system layout. A system worksheet is included for the installer to figure attenuation losses and quantities of components required.

The guide discusses when to use splitters or taps and covers system losses in various types of cable and components and at various frequencies. The guide also give three diagrammed examples of RF systems using an RF amplifier.

Circle (126) on Reply Card

Parts and tool brochure

A new line of parts, tools and service aids for audio and videotape equipment is described in an 18-page brochure now available from the distributors and special markets division of *Philips ECG*.

The fully illustrated brochure contains information on audiotape and VCR test cassettes, tape repair kits and precision adjustment tools for VHS and Beta VCRs, lubricants and cleaning materials for audio and video equipment, opto sensing devices, replacement belts and head assemblies for VCR units.

The replacement parts section lists cross-references by equipment manufacturers' model number for belt kits and video heads and includes comprehensive cross-reference charts by part numbers, for individual belts, heads and sensing devices.

Circle (127) on Reply Card

ES&T

Ruling out static

Three basic rules of static protection will protect not only static-sensitive equipment, but also your reputation

By Dixon Gleeson

This article was adapted from the article "Ruling Out Static," which was originally published in the September 1986 issue of Microservice Management magazine.

Cost of device failure in the computer industry

Point of failure detection	Economic cost	Intangible cost
Device level	Device cost, if not returned to vendor, plus test costs.	Back orders Production delays Investment in surplus inventory and storage to cover failed devices.
Board level	$15	Production slowdown Lower yields Employee frustration
System level	$150	Late shipments Disrupted production schedule
In the field	$1,500	Loss of customer goodwill Detrimental effect on market – present and future

Not too many years ago, static was simply an irritant around the house – a zap from the doorknob on a cold, dry night, a strange force field in front of the TV screen that acted like a magnet for dust and made cleaning difficult, or something that made your hair stand on end after you combed it.

Then electronics manufacturers began to realize that static electricity was more than an irritant. It was causing millions of dollars in damage to their sensitive parts. New microminiature devices were being destroyed or degraded by voltage levels of static so low that no one even noticed. Static became known as the silent killer.

Components that were catastrophically damaged would simply cease to function and were normally caught by outgoing inspection. However, the parts that were only degraded by static, the walking wounded, usually eluded detection and made it to the field. Once there, they often would operate erratically or fail prematurely.

The result was a marked increase in service problems, such as early field failures, intermittent and difficult-to-diagnose problems, more DOA (dead on arrival) boards and larger spare inventories. Service costs grew dramatically.

Many companies eventually discovered that it's a worthwhile investment for service technicians, spares storage and handling, and repair facilities to use the same static-control processes used in manufacturing.

The static control solution

If you are going to avoid electrostatic discharge damage, your organization must operate under the same three rules for static control recognized throughout the electronics industry.

• *Rule 1:* Handle static-sensitive devices only at a static-safeguarded work area.

Gleeson is market development manager of the Static Control Division of 3M, Austin, TX.

• *Rule 2:* Transport static-sensitive devices only in static-shielding packages.

• *Rule 3:* Make certain that your suppliers follow rules 1 and 2.

Inside the servicing facility

First, rule 1 involves protecting static-sensitive devices at permanently installed work stations, and requires two steps:

1. Remove static charge from conductors (including people) by grounding.

2. Neutralize static charge on nonconductors with ionized air.

The static control products commonly used to accomplish these two tasks are now widely accepted: static-dissipating table mats and floor mats, conductive wrist bands and ground cords for personnel, and ionized air blowers for controlling static on the nonconductors in the area (polystyrene coffee cups, vinyl work-order holders and cellophane cigarette wrappers). Such a system is quite effective if installed properly, audited regularly and explained accurately to the users.

Rule 2 is also fairly simple. While sensitive electronics are being handled by a properly grounded worker at a work station that is safeguarded as outlined above, they are protected from static damage. However, whenever those parts must be removed from that work station and might be handled by ungrounded personnel, they should first be put into some type of static-shielding package. A static-shielding package is defined as one that protects its contents from all three potential static problems: triboelectric charges (charges generated by friction), electrostatic discharge (current) and electrostatic fields (voltage).

Many types of packaging on the market today claim to be static-protective. However, it is important that you not confuse static-protective with static-shielding. Not all such packages protect against all three static threats. Let's take a moment to examine why this is so important.

• *Triboelectric charges.* Any time two surfaces come into contact and then separate, one surface will gain electrons and the other will give them up, so that both surfaces become charged. Such frictional charging is termed triboelectric. Because components naturally shift around inside a package during handling and transport, it is important that the material used as the inner layer of the container prevents triboelectric charging caused by this movement.

• *Electrostatic discharge.* A true static-shielding package will also prevent the penetration of a static discharge or spark. Because such a discharge is really a tiny arc of electric current from one charged object to another or to ground, it can be blocked by including an adequate dielectric or insulating layer in the protective package.

• *Electrostatic fields.* The majority of electronic devices used today are field-sensitive. That is, they operate by virtue of changes in voltage. As such, they are also sensitive to damage from electrostatic fields. Therefore, a true static-shielding package must not allow the penetration of such fields. This requires that the package include a highly conductive layer that can act as a Faraday Cage around the contents.

An important point to remember about static-protective packaging: Many bag manufacturers produce what they call a transparent antistatic bag, usually tinted pink or blue. Although such bags do have a low level of surface conductivity because of a chemical additive that draws moisture from the air to the bag's surface, they are not nearly conductive enough to offer shielding against electrostatic fields. In fact, when the air is dry and the potential for static generation is the highest, such antistatic bags are at their weakest.

To reiterate rule 2: Any time a sensitive component or assembly must be removed from a static-safeguarded work area, it should first be packaged in a static-shielding container, and should not be removed from that container by anyone who is not properly grounded or at another protected work station.

Rule 3 is easy to understand and applies equally to a manufacturing or a service situation. Make sure your suppliers of sensitive devices follow rules one and two. You should not have to inherit the liability for damaged or degraded parts from vendors.

Even though static control is important in the plant and has been shown to provide tremendous returns on the manufacturer's investment, it is more critical and cost-effective in the field.

In the field service environment

As mentioned at the beginning of this article, there are two types of damage caused by static: complete destruction and degradation. Catastrophic failures, although expensive, can be detected before the parts leave the plant. However, degraded or weakened devices can make it past quality control and usually find their way into customers' hands before they fail. Then this costly and troublesome problem falls to the technician.

Computer industry estimates indicate that correcting a static-caused defect in an individual component costs a company only the value of that part if the defect is noticed at the device level. However, if the defect is not discovered until after the device has been mounted on a PC board, that cost rises to about $15 because of quality-control time, extra handling and rework.

If the faulty part is not found until after it has become part of finished assembly, the cost is then estimated to be about $150. If it doesn't show up until the component is in the customer's hands and then results in a service call, the total cost for the company averages about $1,500. (See the table on page 26.)

Because it is estimated that about 90% of all static damage results in weakened devices and latent failures rather than immediate, catastrophic failures, it is obvious that most damaged devices will fall into this last, most expensive category.

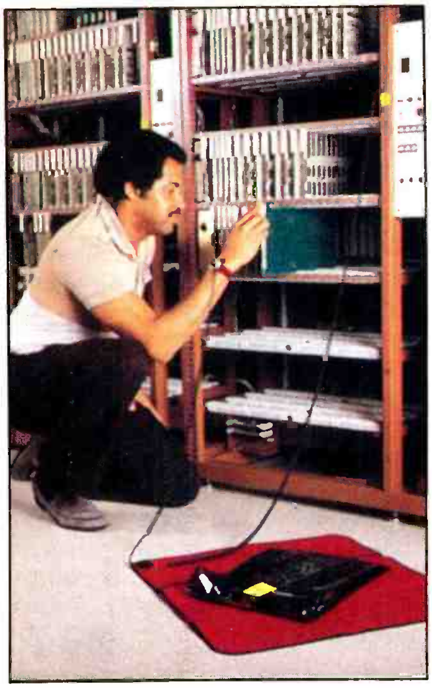
It is absolutely essential that static control be brought into the field. It really is a similar process to that described for the plant.

Rule 1: Field service technicians' work sites are never permanent, because the technicians must move about. However, it is still possible to have a properly static-safeguarded work station anywhere. Technicians should carry in their tool kit a portable, static-dissipative field service kit.

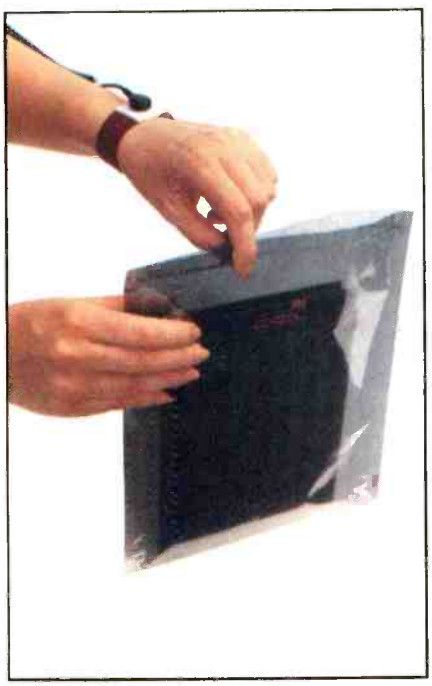
These kits consist of a lightweight, foldable mat of static-dissipating material, a wrist band for the technician to wear and grounding cords and clips to connect both components together and to ground. The foldable kit fits into a standard tool case or pouch, and should be the first item removed on a service call.

The mat is unfolded and connected to ground by the cord provided. The wrist band is slipped on and also connected to ground. The mat offers a static-free area you can lay sensitive parts on, and the wrist band and cord prevent charges from building up on the technician's body. (It should be noted here that the technician's practice of touching the equipment frame occasionally to drain static from the body is not an adequate procedure. As soon as the frame is let go, body movements are enough to build up additional new charges that can damage components.)

Aside from the portability, the only way this field work site now differs from a permanent static-safeguarded work station in a plant is that it does not include an ionized air blower to neutralize the static charge on nonconductors. Because it would be impractical to carry the type of ionizer used to-



Static-dissipative service kits provide a static-safeguarded work area for a service technician on site.



Some static-shielding bags provide total protection against static charges and also offer greater security for the contents with a new single-track closure mechanism.

day to each job site, it is doubly important for the technician to remember to keep such things as nylon windbreakers, common plastics and vinyl work-order folders from the sensitive components.

Rule 2: All sensitive spare parts being stored or handled by service technicians in the field should already have been packaged in static-shielding bags or containers. If they were properly static-protected during manufacture and have been stored in static-shielding packaging since they left assembly, then DOA rates should be minimal.

It is then the technicians' responsibility to make sure they wear a grounded wrist strap before unpacking the spare. The final important step is to repackage the faulty board in a static-shielding container so that it will suffer no additional damage during the return trip to be repaired.

Rule 3: Every service organization should insist that its suppliers adhere to rules one and two.

Static control products

Quite a few products are uniquely adapted to fulfill the static control needs of servicing technicians. Some of these are general products that also have wide application in manufacturing, but others have been developed specifically for field service.

Rule 1 products: The basic rule 1 product has already been described – the portable, static-dissipative kit, consisting of a static-free work surface, a conductive wrist band and a ground cord system to connect the components together to ground.

Rule 2 products: The most common static-shielding container, even in field service, is the transparent static-shielding bag. (This transparency is, of course, an important feature for field service, because it allows a technician to verify the contents of the package without opening it up and exposing them to static.)

A typical static-protected work station includes mats, wrist straps and an ionized air blower.

However, packaging has actually gotten quite a bit more sophisticated in the past few years.

- The standard static-shielding bag has been modified to include a layer of cushioning antistatic bubblepack, thus affording the contents physical protection as well as static protection.
- A recloseable feature is also now available to keep the bags more securely closed and to keep the components cleaner.
- A static-shielding bubblepack material has been introduced that can be used to wrap oddly shaped components. It also offers both physical and static protection.

Although static control can save time and money, it can also save something even more important – a reputation as a quality service organization. ES&T

Books

Understanding Electricity and Electronics Principles; Understanding Electricity and Electronics Circuits; revised by David L. Heiserman; Howard W. Sams & Company, 256 pages and 328 pages respectively, $14.95 each.

These two books cover some basic areas of electronics principles and circuits. "Understanding Electricity and Electronics Principles" discusses basic principles, using ample illustrations and highlighting important concepts. Summaries and self-quizzes help the reader see what he's learned. "Understanding Electricity and Electronics Circuits" covers the building blocks for all electronic equipment, from basic electrical principles to the control of electricity by using transformers. Principles and applications are presented at an easy-to-learn pace.

Published by Howard W. Sams, 4300 W. 62nd St., Indianapolis, IN 46268; 317-298-5400.

ABCs of Electronics, 4th Edition; by Farl Jacob Waters; Howard W. Sams & Company, 200 pages, $12.95.

This completely revised tutorial on the fundamentals of electronics includes a new chapter on computer basics. The book provides a quick introduction to such electronics concepts as atoms, electrons and magnetic forces, along with basic electronic components and their applications. Other topics covered include impedance, electron tubes, solid-state physics, transistors, integrated and digital circuits, basic amplifier circuits, operational amplifiers and radio frequency production.

Published by Howard W. Sams, 4300 W. 62nd St., Indianapolis, IN 46268; 317-298-5400.

Encapsulation of Electronic Devices and Components (Electrical Engineering and Electronics Series, Volume 36), by Edward R. Salmon; Marcel Dekker, 240 pages, $59.75 (U.S. and Canada), $71.50 (all other countries) hardbound.

Before encapsulating an electronic device or component, two important decisions must be made: which material and which method to use. The solid advice of a materials chemist, someone who can clarify the trade-offs in any encapsulation choice, is needed at this point. Anyone responsible for selecting the material and means to protect any electronic device will find that this book progresses logically through the various classes of materials, providing descriptions, advantages and limitations, application methods for each material, and lists of names and addresses of suppliers. To avoid communication problems, basic definitions, terms and symbols, and guidelines used throughout the industry are included.

Published by Marcel Dekker, Inc., 270 Madison Ave., New York, NMY 10016; 212-696-9000.

ANSWERS to the QUIZ

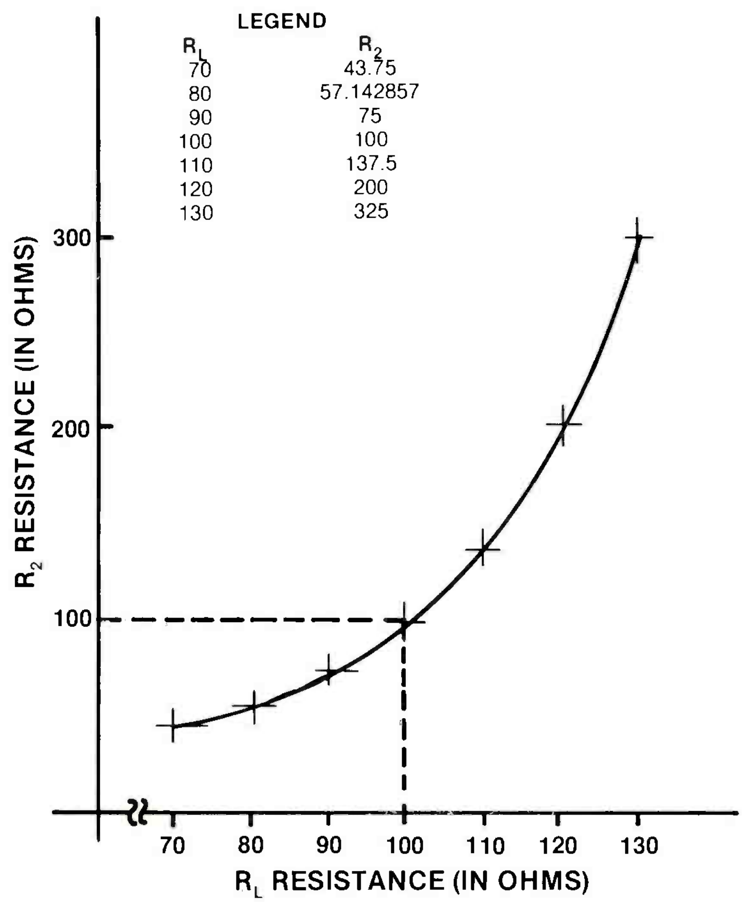


Figure E

1. A.) They are Marconi quarter-wave antennas.
2. A.) Moving the turns closer together increases the inductance. The equation for resonant frequency is

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Making L larger lowers the value of f.
3. C.) A discriminator is used to sense any shift in the carrier frequency. In the I-F stage of an AM receiver, the carrier is usually at 455kHz. It is assumed that a shift in the carrier frequency must be due to a drift in the oscillator frequency.
4. D.) Five flip flops can make 32 counts. Zero is one of the counts, so the highest number counted is 31.
5. B.) If R_L increases, the resistance of the parallel branch also increases. Because the voltage is constant, the corresponding increase in circuit resistance causes a decrease in circuit current and a corresponding decrease in the current through R_L. To get the current through R_L back up to 0.5A, you have to increase the resistance of R_2 more than R_L increased. That raises the resistance of the parallel branch so that the voltage across that branch is sufficient to get 0.5A through R_L. The graph in Figure E shows values of R_2 for corresponding values of R_L. It is based upon the equation

$$R_2 = \frac{25R_L}{75 - 0.5R_L}$$

which, in turn, assumes that V, R_1 and I_L are constant.
6. 10Ω. The circuit in Figure C is another example of a balanced Wheatstone bridge. (You'll have to redraw the circuit to see that.) No current flows through the center leg, so it can be removed. That leaves the circuit shown in Figure

F and a resistance of 10Ω.

7. Inverter. Do not confuse this power supply circuit with a converter, a circuit that converts one value of dc to a higher value of dc.

8. A.) The equation for percent regulation is:

$$\% \text{ regulation} = \left(\frac{\text{no load V} - \text{full load V}}{\text{full load V}}\right) 100$$

In a perfect (ideal) supply the no load and full load voltages would be equal, and there would be zero percent regulation.

9. A.) Ripple factor $= \sqrt{\frac{I_{rms}}{I_{dc}} - 1}$

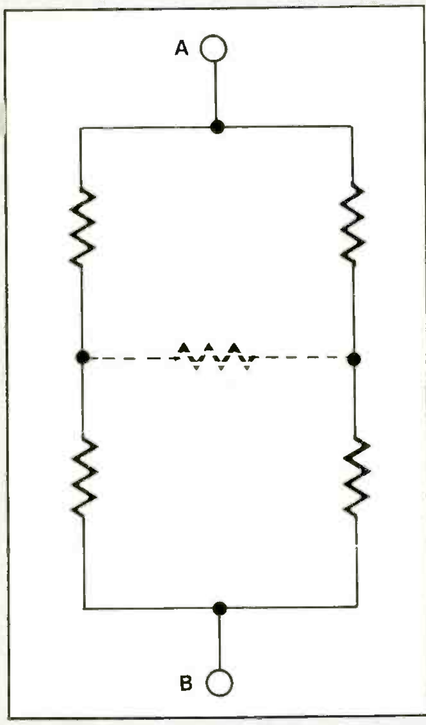
where I_{rms} is the effective voltage of the output voltage and I_{dc} is the average value of the output voltage. For a perfect power supply, where $I_{rms} = I_{dc}$, the ripple factor is zero.

10. A.) With the wiper of the variable resistor at A, there is no phase difference between the voltage across the triac and the input gate voltage. The triac will start conducting at the start of each half cycle, and the brightness of the lamp will be maximum.

ANSWER TO BONUS QUESTION:

D.) Thomas Edison was really the first. I know this will be hard to take if you are a Tesla fan, but it's true!

ES&T



Measuring tape tension and torque in VCRs

By Wayne Graham

VCRs are complex devices from an electronics standpoint, but they also contain complex mechanical systems for driving the tape. It is these mechanical systems that cause the majority of VCR failures. Proper diagnosis of problems with VCR mechanical components such as clutches, brakes, belts, pinch rollers, solenoids and motors requires a good comprehension of the terms *torque* and *tension*. Many service technicians treat these terms almost equally, but in fact they are quite different, although they are related.

Tension

Tension is simply the pull force exerted and is expressed in units of grams, ounces, pounds or, for the really scientific, newtons. The few purists and Ph.D.s among us are concerned with the terms grams of force vs. grams of mass, or pounds of force vs. pounds of mass. Suffice it to say that here on earth, the rest of us can merely use the terms grams or ounces and we'll all know what we mean. (The purists will be the ones talking about newtons.) Useful conversion factors are:

28.35 grams = 1 ounce
16 ounces = 1 pound
453 grams = 1 pound
1,000 grams = 1 kilogram

and to allow us to communicate with the purists:

102 grams = 1 newton

It is easy to simulate tension – just hang a weight on a string or piece of magnetic tape and the value of the weight equals the amount of tension in the string or tape. (See Figure 1.)

Graham is general manager of Tentel, Campbell, CA.

Torque

Torque is a little more complex than tension. Torque is a rotational force; it is the result of a force (tension) acting at a point some distance from a center of rotation. (See Figure 2.) Torque is therefore a computed value.

Torque is equal to the tension multiplied by the perpendicular distance between the axis of rotation and the applied force (for tape transports this is equal to the radius of the tape pack):

torque = tension x radius

Torque is a function of both the force applied and the distance to this force, so the units of torque are:

g-cm (gram-centimeters),
in-oz (inch-ounces), and
ft-lb (foot-pounds).

Other convenient conversion factors are:

72g-cm = 1in-oz,
192in-oz = 1ft-lb,
1152g-cm = 1in-lb.

Relating this to a VCR, the torque (in gram-centimeters) exerted by a reel is equal to the tape tension (in grams) multiplied by the radius of the tape reel (in centimeters). Remember that the radius equals the diameter divided by two.

Torque = tension x radius
Radius = diameter ÷ 2
2.54cm = 1in

Measuring tension and torque

Let's compare some of the common methods used for measuring torques and tensions in VCRs:

1. The hope-and-pray method
2. The tension cassette
2. The spring (fish) scale
4. The Tentelometer tension gauge
5. The dial-torque gauge

1.) The *hope-and-pray* method is by far the easiest but the least effective. Spray some oil or clean with a Q-tip and hope and pray it keeps working – no tools or gauges required. This method is not recommended for building a large base of satisfied customers.

2.) *Tension cassettes* look like actual tape cassettes but have a meter built in. They are available from a number of VCR manufacturers. Although they are configured like a standard cassette, they are not interchangeable from one brand of VCR to another. Because they work by measuring the torque (tension times radius) exerted by the holdback reel inside the cassette, as the tape guidance system between the cassette and video head changes, different torques are required for providing the proper tape tension going into the scanning video heads.

Keep in mind that consistency in tape tension going into the video heads is required between VCRs to maintain interchangeability from one machine to another. Care must also be taken to keep tension cassettes properly calibrated, because a faulty tension cassette would cause VCRs with proper tension to be "corrected" to a faulty tension.

Because service technicians are usually working on malfunctioning machines, chances are good that the tape inside a tension cassette will become damaged and will require replacement. After tape replacement, it is recommended that the readings be checked against another new tension cassette to make certain that the rebuilt gauge is reading correctly. This procedure would automatically double your tension cassette investment, and tension cassettes are not available for all brands and models of VCRs.

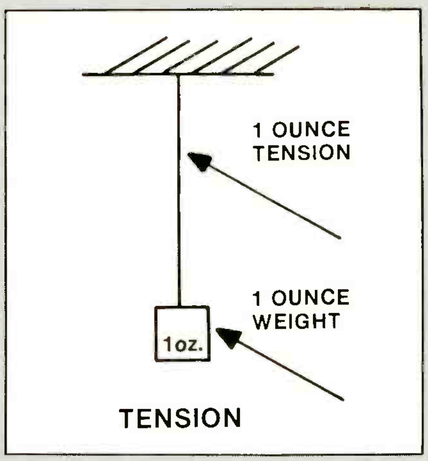


Figure 1. Tension is just the pull force exerted and can be simulated by hanging a weight from a piece of string. The tension is the same value as the weight.

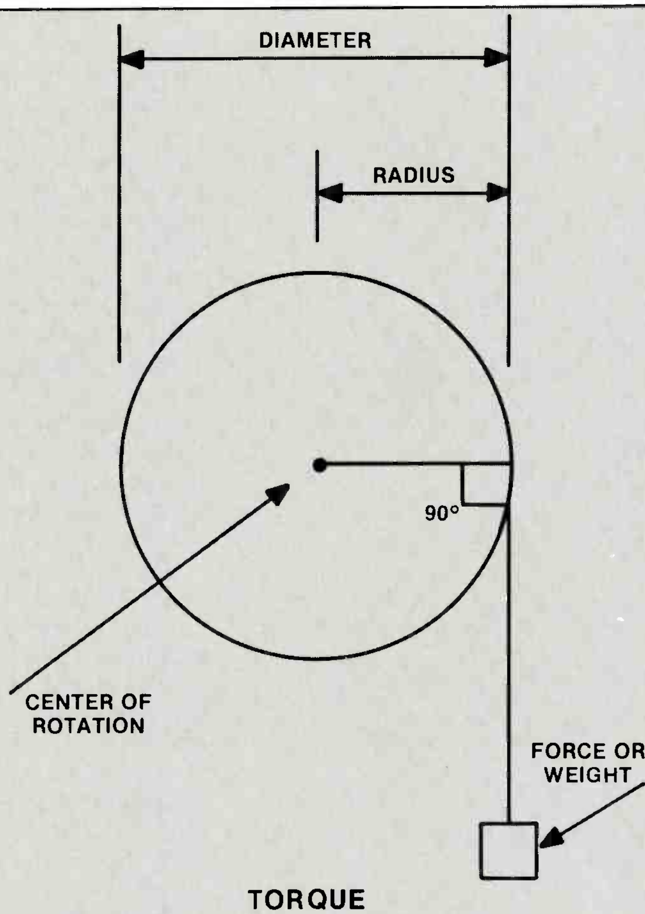


Figure 2. Torque is a rotational force, the result of a force acting at a point some distance from the center of rotation. The value of the torque is the tension multiplied by the radius.

3.) *Spring scales,* sometimes called *fish scales* because they are similar to the scales used to weigh fish, can be used to pull on tape. For measuring supply holdback tension, a reel (obtained by taking apart a cassette) is placed onto the supply spindle, the tape is threaded out into the machine, simulating the tape path during PLAY, and the back tension is determined by measuring the tension exerted on the tape by the holdback torque of the supply reel.

It is usually necessary to remove at least one side of the VCR to gain access to the tape so that you can connect the spring scale to the tape's end. The tape and spring scale must be pulled smoothly and at the approximate tape speed that the tape would encounter during normal play. The various sensors on the machine would have to be "fooled" to allow the VCR to go into the play mode or into other modes where torques or tensions need to be measured.

4.) The *Tentelometer* tape tension gauge consists of three tiny probes that protrude from one side of a small case. The case contains a meter scale and pointer that provides readings in grams and ounces of tension. The gauge provides a method of measuring the supply holdback tension by sliding the probes of the gauge over the tape while the VCR is moving the tape. VCRs can move tape smoothly and at the correct speed quite easily, so these variables are removed from the measurement.

Calibration can easily be checked in the field, allowing service technicians to be confident of their readings. Because the tension measurement is made out in the tape path next to the inlet idler (on a VHS), the correct specification is the same on all VHS recorders. Measuring a specification of $\pm 30g$ (25g to 35g) will assure proper back tension for skewing interchange.

The device can also be used for checking the functioning of the holdback tension servo. By comparing the holdback tension on a full supply reel to that of a nearly empty reel, the device tells you that the servo requires adjustment if the readings change by more than five grams. The Tentelometer is referenced in many of the factory service manuals, including Panasonic, GE, Gold Star and Hitachi, but will work on any brand of VCR.

5.) The *dial torque gauge* is an excellent, fast method of determining the torques (usually in gram-centimeters) exerted by both the supply spindle and the take-up spindle during the various modes of the VCR. These desired torques are specified in both the clockwise and counter-clockwise direction for fast-forward, rewind and stop modes.

Torques are also associated with take-up during play as well as between modes such as "play to stop" and "stop to play." In all, there are approximately eleven torques that could contribute to tape damage or an inoperable VCR and should be checked with a dial torque gauge. Dial torque gauges are available from the individual VCR manufacturers and from independent suppliers. All units measure directly in gram-centimeters.

No matter how you do it, there are mechanical measurements that should be made when servicing a VCR. Problems with supply back-tension can cause tape damage or hooking (flagging) tape-interchange problems. Problems with fast forward or rewind can cause slow FF or REW times, tape cinching (tight pack), edge damage and subsequent tape destruction. Problems with various take-up torques can cause tape destruction because the tape is not drawn back into the cassette and is crinkled in the cassette door when the tape is ejected.

With the proliferation of low cost VCRs, it is imperative that the service technician choose a fast, reliable, repeatable, field verifiable method of performing the various mechanical tests. To do otherwise is to invite problems and complaints.

Unusual waveform/ function generator circuits

By Joseph J. Carr, MSEE, CET

Many different types of electronic equipment use internal circuits that generate waveforms. Most readers are familiar with ordinary sine wave and square wave generator circuits, so in this article we are going to deal with sine/cosine generators, sawtooth generators and pulse generators. Because these circuits are based on an electronic circuit called an integrator, let's look first at the elementary Miller integrator circuit.

Integrators

Integration is a mathematical process used frequently in electronic instrumentation circuits. Although the details of integration are from calculus and are thus beyond the scope of this article, you need to know a few details about integration on at least a descriptive level. Figure 1 demonstrates some of these principles. Keep in mind one fact: The *integral* of a curve (the result of integration) is the area under the curve.

Consider Figure 1A. In this case, a dc voltage is turned on at time T_1 and turned off at time T_2. Between T_1 and T_2 the voltage remains constant at V_1. The mathematical "curve" represented by voltage V is simple because $V = V_1$ at all times. The integral of this curve is the area under the curve, which for this simple case is merely the product of the base and height of the rectangle: $V_1 \times (T_2 - T_1)$. If the signal of Figure 1A is applied to an integrator, the output of the integrator will initially be zero and will rise at a constant rate from T_1 until T_2, reaching a value dependent upon the values of V_1 and $(T_2 - T_1)$.

Figure 1B shows a practical example from medical electronics.

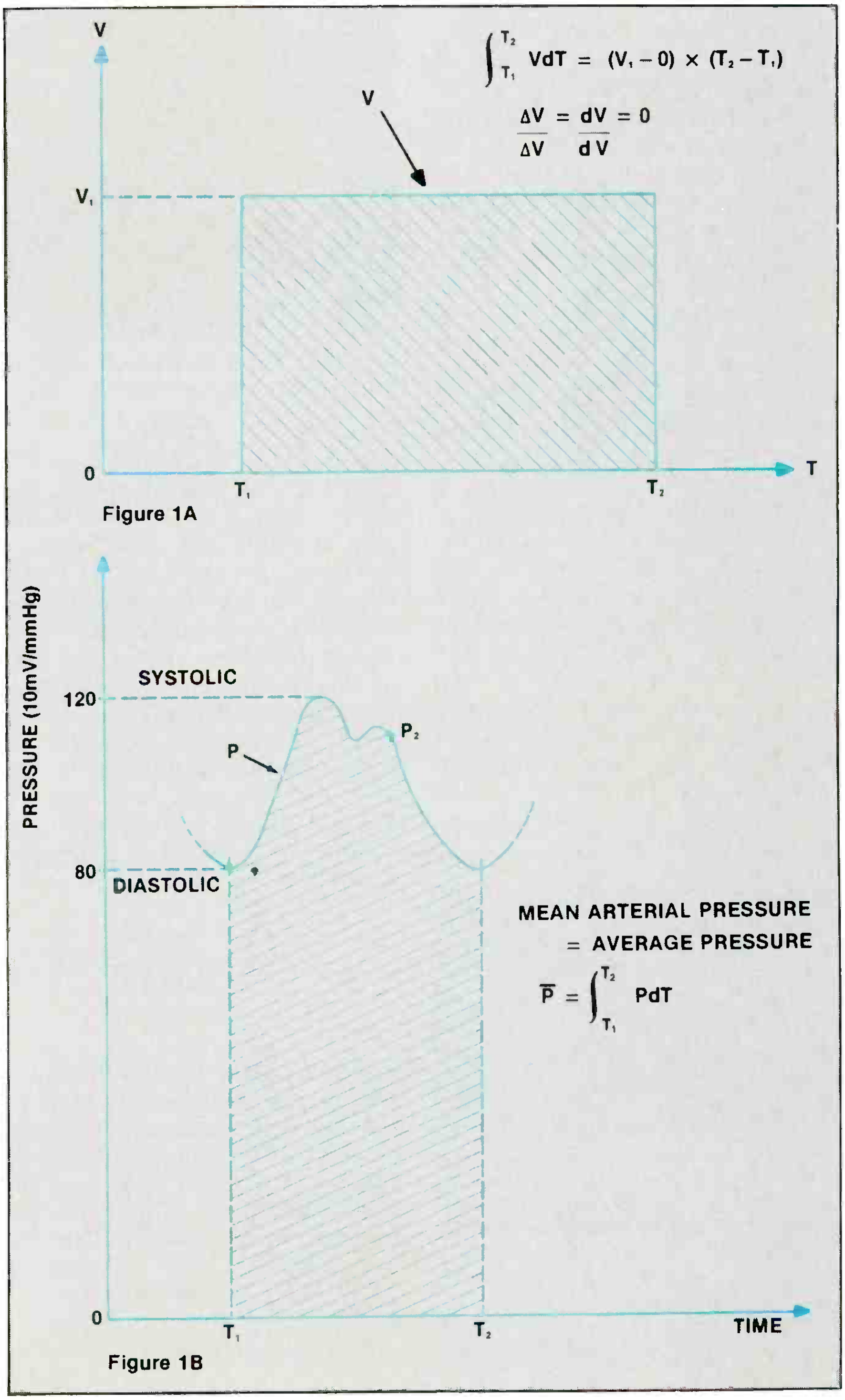


Figure 1. The integral of a curve that's described by a mathematical formula is equal to (for the simple curve in 1A) the product of its base times the height. A practical use of integration is in medical electronics. Figure 1B shows how mean arterial pressure is calculated by integrating instantaneous arterial pressure over one cardiac cycle.

Arterial blood pressure monitors represent blood pressure with a voltage. In modern devices, the voltage analog of pressure is usually 10 millivolts per millimeter of mercury (10mV/mmHg) of pressure. Thus, for the case shown, a systolic pressure of 120mmHg is represented by 1,200mV, while the 80mmHg diastolic pressure is represented by 800mV.

Doctors, especially in intensive care units, sometimes want the mean arterial pressure (MAP). The MAP is the time average of the blood pressure waveform (P) over one cardiac cycle (that is, between two beats of the heart, as represented by points T_1 and T_2). If we apply the pressure voltage waveform to an integrator, the output of the integrator will be the MAP.

The simplest form of integrator is the resistor capacitor (RC) network shown in Figure 2. In this circuit, the output voltage changes as the charge caused by I_1 accumulates in the capacitor. The rate of increase in V_0 is dependent on the input voltage and the values of R and C. If you recognize the circuit as a low-pass filter (LPF), or as a part of a vertical integrator from TV sets, you are correct. The integrator also functions as an LPF with a roll-off of −6dB/octave above the −3dB knee frequency (1/6.28 RC).

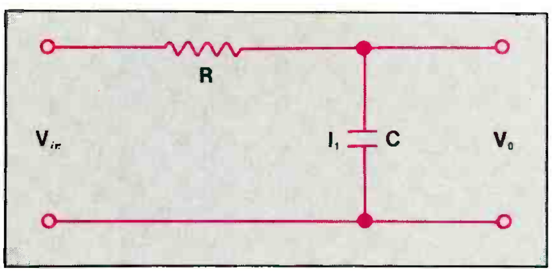


Figure 2. A simple form of integrator is the RC circuit, where the charge on the capacitor is proportional to the total amount of current that has flowed in the circuit.

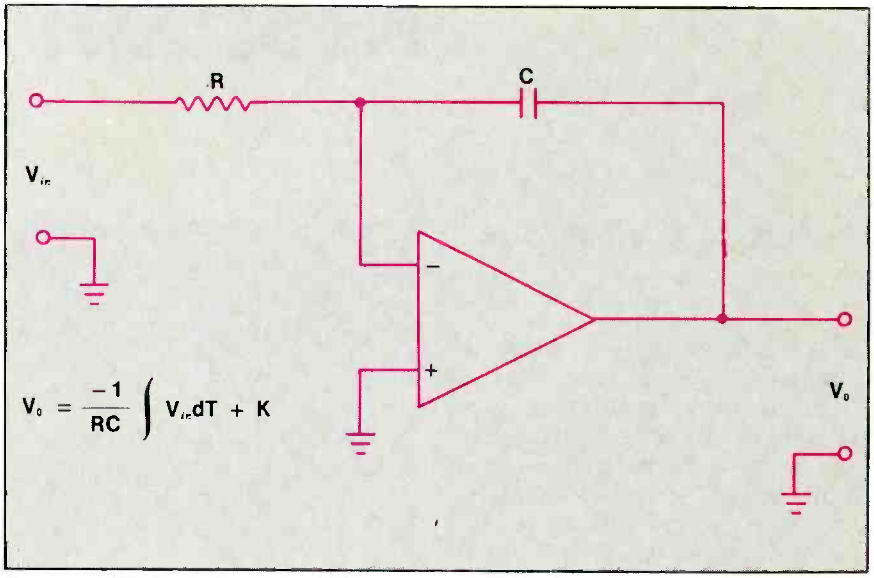


Figure 3. A Miller integrator is basically an op-amp inverting follower with the feedback resistor (R_2) replaced with a capacitor.

The electronic *Miller integrator* circuit is shown in Figure 3. The active element is an operational amplifier that has a capacitor in the feedback network. This circuit basically is the inverting follower with the feedback resistor (R_2) replaced by a capacitor. The gain of this circuit is −1/RC. Keep in mind that with small values of R and C, this gain can be extremely high, resulting in problems for the designer. Consider an example: What is the gain of an inverting integrator in which R = 10kΩ, and C = 100pF?

$$\text{Gain} = -1/RC$$
$$= -1/(10{,}000\Omega \times [100\times10^{-12}F])$$
$$= -1/0.000001$$
$$= -1{,}000{,}000$$

With a gain of 1,000,000, we find that a small error or dc offset at the input will result in a very large error at the output. For example, suppose we have a 1Vp-p sine wave that has a 10mV dc offset (not very much). This dc offset will be integrated with a gain of 1,000,000 so the 10mV becomes

$$10mV \times 1{,}000{,}000 = 10{,}000V.$$

Of course, the output of the op-amp is limited to about 10V or 12V, so the output will saturate quickly. The normal offset of a 741 will saturate the output of such an integrator so fast you'll think it's shorted. In general, the rule of thumb is to make the time-constant of the RC network long (about 5×) relative to the period of the input signal.

Figure 4 shows some common electronic signals at the input and output of an electronic integrator. In each case, the upper trace is the input and the lower trace is the output. For the case of the sine wave shown in Figure 4A, the output is phase-shifted 90° to become a cosine wave. Thus, the output is in quadrature with respect to the input signal.

The integrator action on square waves is shown in Figure 4B. Because the amplitude of a square wave is constant, the integrator output will rise at a constant rate until the square wave drops low again. At that time, the slope of the output waveform changes and starts decreasing. Thus, the integrator makes a triangle waveform out of a square wave. Incidentally, this technique is used by function generators to form triangle waveforms.

A practical integrator

Almost all textbooks on linear integrated circuits or operational amplifiers, including mine, show the circuit of Figure 3. However,

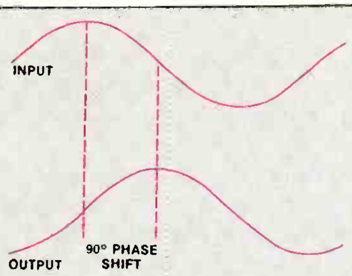


Figure 4A

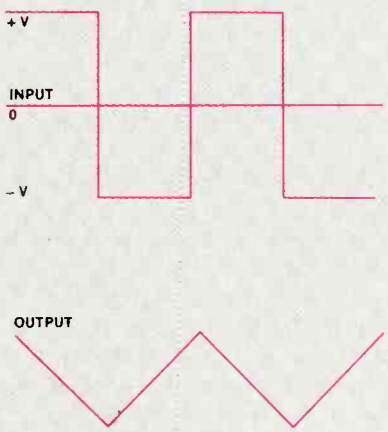


Figure 4B

Figure 4. The effect of an integrator is the same regardless of the input waveform: The output waveform is proportional to the area under the curve of the input waveform. The apparent effect, however, will differ greatly with different waveforms. In Figure 4A, a sinusoidal waveform will be phase shifted by 90°, while in Figure 4B, a square wave will be turned into a triangular waveform.

with real operational amplifiers it doesn't work. Unfortunately, some articles and books don't tell you what the problem is or how to deal with it.

The principal problem in practical integrators is that the dc offset voltage normally present at the output of real operational amplifers will charge capacitor C_1, and thereby soon saturate the op-amp. The output voltage will start rising immediately after turn-on, and soon it will be off the scale. If you have a signal applied to V_{in}, the output will show that signal with a constantly increasing dc offset potential.

One tactic used to cancel the effects of offset is to use an opera-

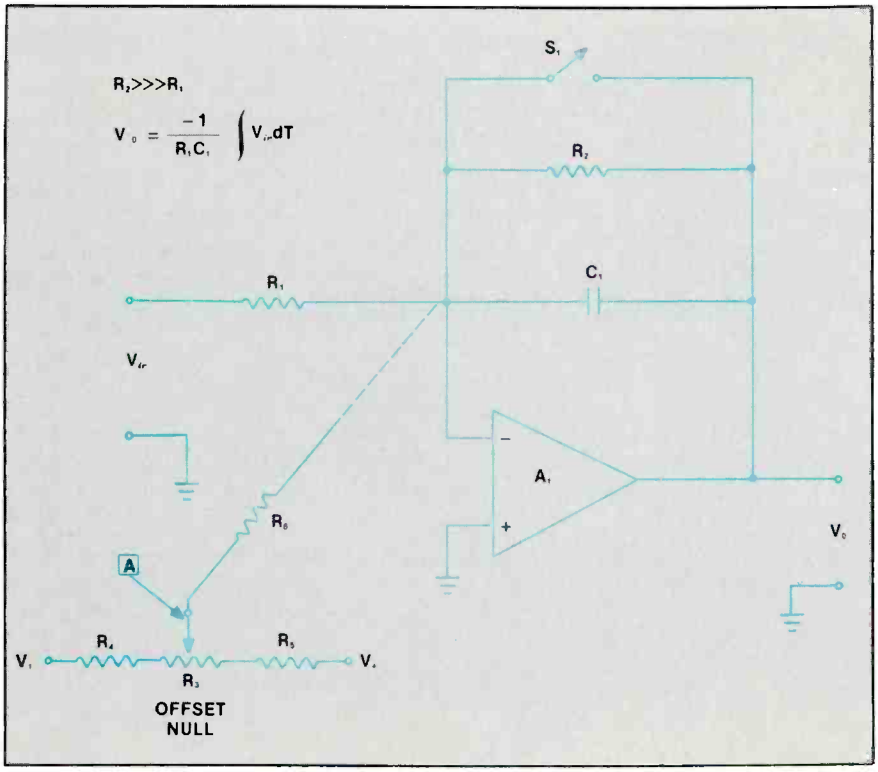


Figure 5. This drawing shows two ways to construct a practical Miller integrator. One is to connect a resistor across the integrator capacitor in order to keep the dc from building up. (R_2 must be much larger than R_1.) Or, as shown by the arrow marked A and described in the text, you can use an offset null potentiometer.

tional amplifier that has a very low offset potential and no input bias current (or very little). For low-cost applications, the CA-3140 BiMOS op-amp (which uses MOSFET input transistors) is a good selection (see Figure 5). Devices of the 741 family, however, are practically useless for integrator service.

Another tactic is to connect a resistor across the integrator capacitor to keep the dc from building up. This tactic is especially useful for integrators that see periodic input signals. The rule of thumb is to make the shunt resistor (R_2) much larger than R_1. In the test case, I used a 470kΩ input resistor and an 18MΩ shunt resistor, which worked quite nicely.

Finally, you may also have to use an offset null potentiometer in some circuits. In my test case, with 400Hz sine, square and triangle wave input signals, the potentiometer was not needed. Other cases, however, may require a counter offset provided by R_3. Although the values of the resistors in this network are dependent upon the application, most of the time a 5kΩ value for R_3 and 10kΩ and 27kΩ values for R_4 and R_5 will suffice. Make R_6 equal to R_1 for starters—it can be increased or decreased as needed after the circuit is tested.

To adjust the potentiometer, short the input of the integrator (making V_{in} = 0). Adjust R_3 for a

$R_3 >> R_2$

$R_1 = R_4$

$$T = \frac{2V_zR_3C_1}{V-}$$

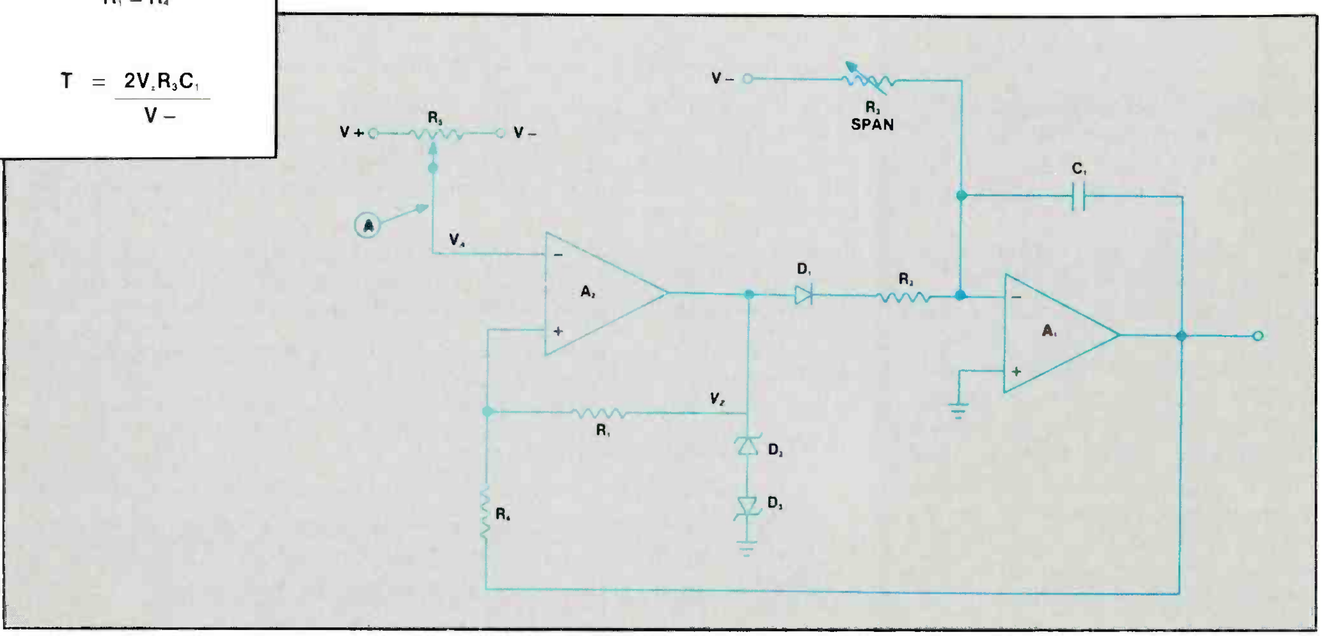


Figure 6. This circuit will produce the classic sawtooth waveform.

potential of 0V at point A. Momentarily close S_1 to force the output voltage to zero. If the output voltage rises to either positive or negative values after S_1 is opened, adjust R_3 to cause the rate of increase to slow down to zero. Again close S_1 and see if the output voltage changes. Repeat the procedure until the output voltage remains at zero following every closing of S_1.

In normal operation, switch S_1 is used to reset the integrator after it performs an operation. It is used in some instruments where a value is calculated, but it only occasionally is needed in cases where an integrator sees a periodic signal with no dc offset component.

A sawtooth generator circuit

Figure 6 was derived from a circuit given in a classic op-amp book. The ramp generator circuit is the integrator formed with A_1, C_1 and R_3 (being driven by V-). The output voltage ramps up until it reaches the threshold of comparator A_2. That comparator uses positive feedback and a reference voltage V_{ref} provided by a potentiometer. The trip threshold is $V_{ref} + V_1$ (which is set to 0.7V greater than the zener voltage of D_1/D_2, assuming that these diodes are identical).

When the output voltage hits the threshold voltage, the comparator output snaps positive and forward biases diode D_3. If resistor R_2 is much less than R_3, then C_1 will discharge very rapidly, resulting in the classical sawtooth waveshape. The reset time, T_2, will be much shorter than the period, T_1, if R_2 is much less than R_3.

Another means of generating a sawtooth waveform is to use a special function generator chip, such as the Exar XR-2206, which is available from Jim-Pak and others. Although in another circuit the XR-2206 will generate sine, square wave and triangle waveforms, in the circuit of Figure 7A the chip generates a sawtooth and a short duty-factor pulse.

The frequency of this sawtooth generator circuit is set by resistors R_1 and R_2, plus capacitor C_2:

Figure 7A

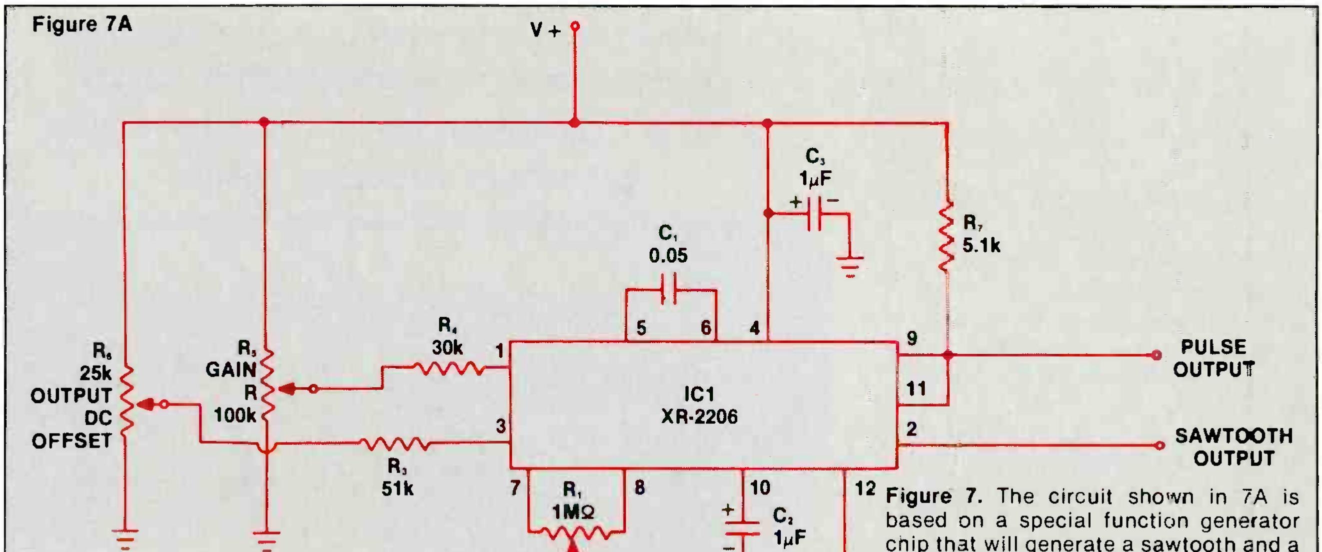
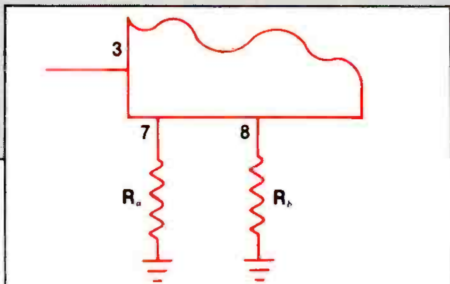


Figure 7. The circuit shown in 7A is based on a special function generator chip that will generate a sawtooth and a short duty-cycle pulse. The waveforms it produces are shown in Figure 7B.



$$F = \frac{2}{C_1}\left[\frac{1}{R_a + R_b}\right]$$

$$DF = \frac{R_a}{R_a + R_b}$$

NOTE: THE VOLTAGE DIVIDER ABOVE MAY BE REDRAWN LIKE THIS IN ORDER TO MAKE CALCULATIONS OF F AND DF

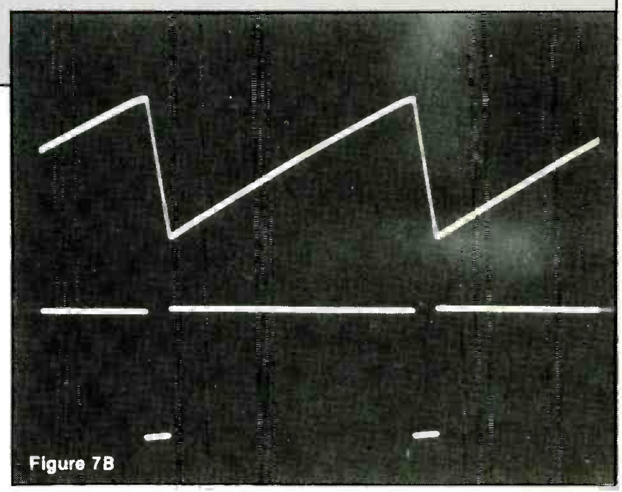


Figure 7B

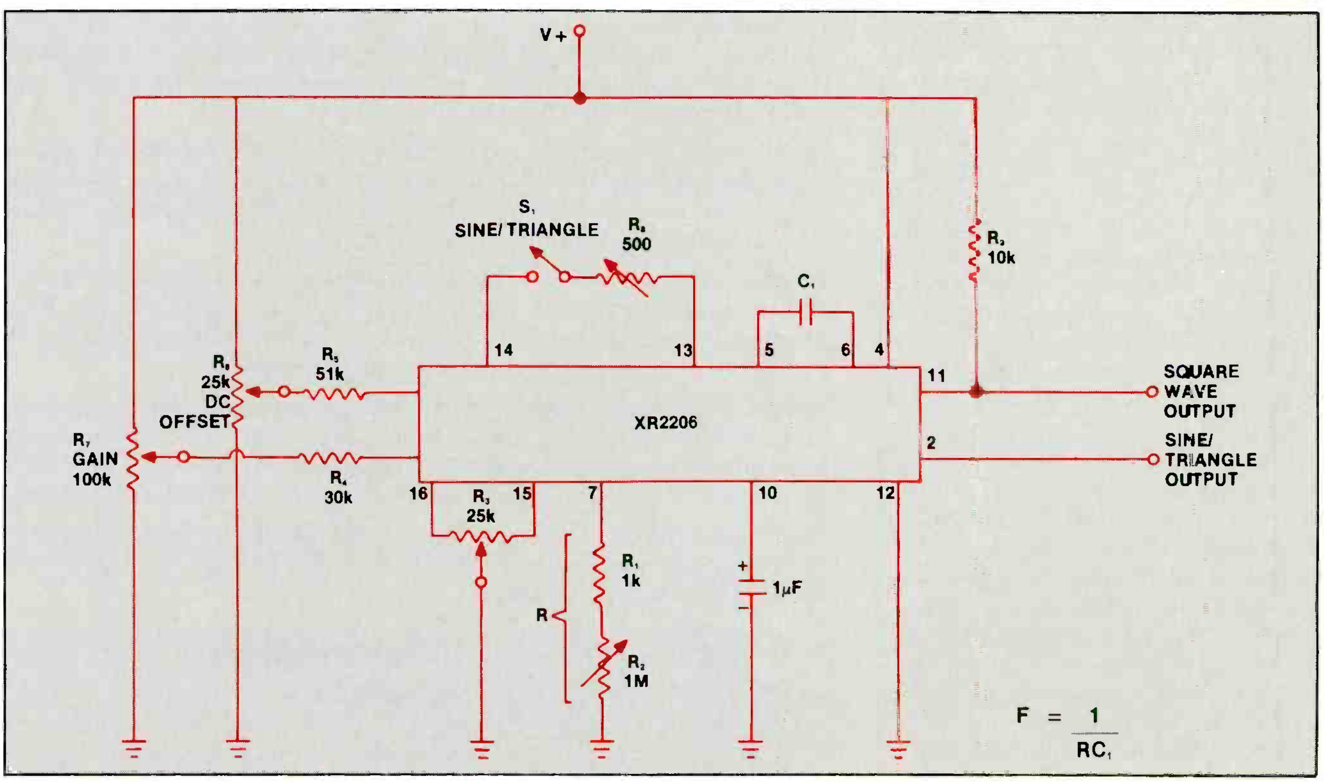


Figure 8. The same special function generator chip connected here will produce a square wave and a sine/triangle output.

$$F = \frac{2}{C_1} \times \frac{1}{(R_1 + R_2)}$$

Where F is in hertz, C_1 is in farads, R_1 and R_2 are in ohms.

The duty factor (DF) is found from:

$$DF = \frac{R_1}{(R_1 + R_2)}$$

Jim-Pak makes a circuit-board "function generator" kit for less than $20. The kit creates the sine wave, square wave and triangle wave signals. It can be easily modified for sawtooth applications. The sawtooth and pulse output waveforms of Figure 7A are shown in Figure 7B.

The same Exar XR2206 device can also be used for generating sine wave and square wave signals. Figure 8 is the circuit for this application. Switch S_1 determines whether the signal at Pin 2 is a sine wave or triangle waveform. This circuit is similar, but not identical, to the function generator circuit. The operating frequency is:

$$F = 1/R\,C_1$$

Where:

F is in hertz

R is in ohms, and is the sum of $R_1 + R_2$

C is in farads

The amplitude and dc offset of the output waveform is adjusted using trimmer potentiometers R_6 and R_7.

Waveform generators are the building blocks of complex electronic equipment such as televisions, personal computers and oscilloscopes. If a technician wants to understand these devices well enough to service them effectively, he must understand these signal forming circuits. ES&T

What do you know about electronics?

A new zener diode

By Sam Wilson, CET

In a previous article I discussed the strange behavior of a transistor that amplified when its emitter and collector were interchanged in an amplifier circuit. Since that article was written, I've learned that many types of bipolar transistors behave that way.

Transistors may be fabricated with the emitter-base-collector (EBC) leads arranged in that order. However, the ECB configuration is also used. It wouldn't be hard to make a wrong turn and get one reversed in a circuit. The point is that the transistor would work, but the gain would be greatly reduced. That would give the false indication that there is something else wrong in the circuit.

What I want to discuss now is the strange behavior of light-emitting diodes. They produce a zener diode characteristic on a curve tracer. At the present time I have a young man trying to design a regulated power supply using this reverse-current characteristic. If he comes up with a useful design, I'll put it in a future article.

Let me explain – before I get a boxcar full of letters – that I know the readers of this magazine are too highly organized to get a transistor or LED in the circuit backwards. But I also know of places that start students into the field by having them replace defective components. Students are often well organized too, but they lack experience.

Build your dimmer

The light dimmer (Figure D) in this month's "Test Your Elec-

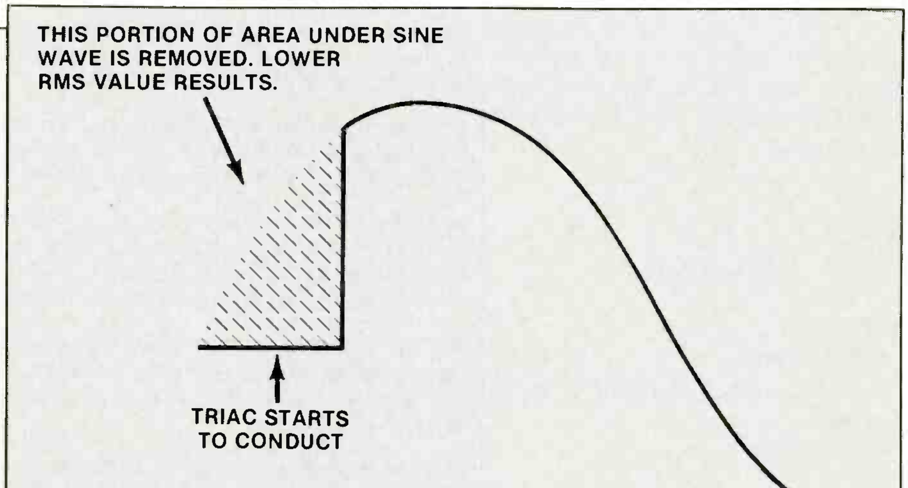


FIGURE 1

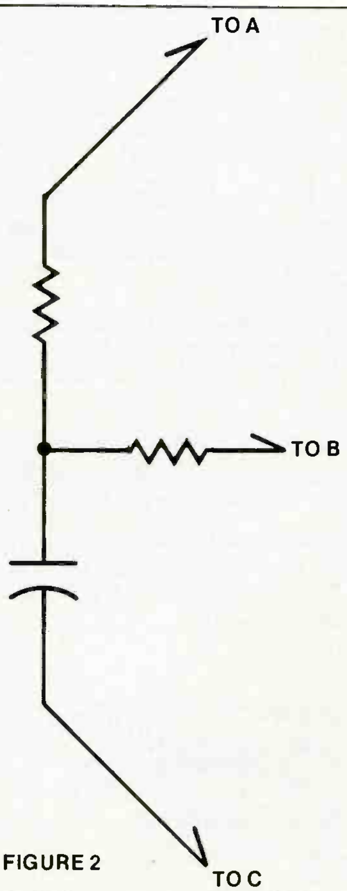


FIGURE 2

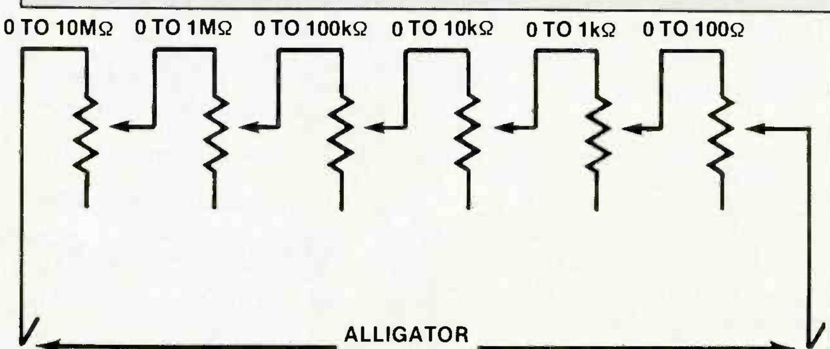


FIGURE 3

tronics Knowledge" quiz really works with the values shown. However, the range of control is limited.

The R-C circuit produces a lagging phase shift at point B. The greater the phase shift, the greater the delay in turning on the lamp for each half cycle.

A typical lamp current is shown in Figure 1. The greater the delay – and shaded area – the lower the rms value. If you decide to build one to cut glare, add the circuit shown in Figure 2. It will increase the range of brightness.

The circuit was given in an applications manual that was distributed by General Electric many years ago. It still works very well. It is *not* for motors or any other inductive load. Also, it will *not* work with fluorescent lights.

Another type of decade

In the next few issues I'm going to include some basic test equipment that you can make. You can't buy these. I don't think manufacturers could make and distribute them at a reasonable price.

Decade boxes are useful for temporarily substituting resistor and capacitor values into circuits. Another type of resistor substitution box is shown in Figure 3. Use variable resistors that are linear and have a relatively high power rating.

I didn't go to the trouble of trying to mark resistance values on the unit. I set the desired resistance with an ohmmeter.

Six color code brands

Without looking at Table 1, what is the value of a resistor that has the following six bands of color (in the order given):

brown-red-brown-black-brown-red

From Table 1, note that the *fifth* band tells the tolerance (1% in the example) and the *sixth* band tells the temperature coefficient (TC).

Don't get fooled by this resistor color code. The answer is:

121Ω, ±1%, ±50ppm/°C

The designation ppm/°C means parts per million per degree Celsius. For the example, a change of 1°C would result in a resistance change of 50 parts for every million parts of resistance.

The standard values for 1% and 2% resistances are given in Table 2. Note that they are given to three places and a multiplier. The 5% and 10% resistances are given to two places and a multiplier. The resistor given in the example is a standard value.

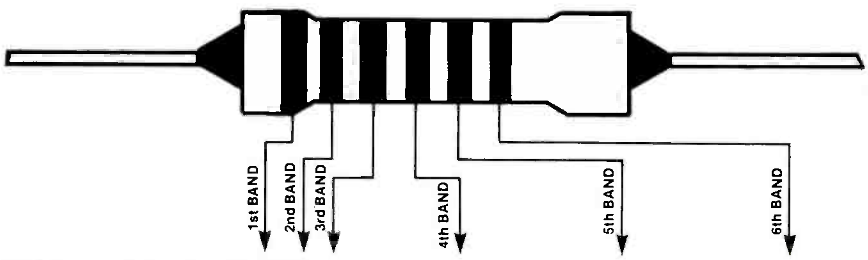
When to multiply, when to divide

Over the years of working with technicians and students, there is one complaint that I've heard more than any other: "I'm not good at mathematics." (There are two variations: "I never was good at mathematics," and "I'll never be good at mathematics."

I'm convinced that there is no such thing as a special *talent* for

Continued on page 57

Table 1.
Resistor color codes



Color	1st, 2nd, 3rd significant figure	Multiplier	Tolerance	TC
Black	0	1		
Brown	1	10	±1%	
Red	2	10^2	±2%	±50ppm/°C
Orange	3	10^3		
Yellow	4	10^4		±25ppm/°C
Green	5	10^5	±0.5%	
Blue	6	10^6		
Violet	7	10^7		
Grey	8	10^8		
White	9	10^9		
Silver		10^{-1}		
Gold		10^{-2}	±5%	

Table 2.
Standard values for 1% and 2% resistors

±2%	±1%	±2%	±1%	±2%	±1%	±2%	±1%	±5%
1.00	1.00	1.78	1.78	3.16	3.16	5.62	5.62	1.0
	1.02		1.82		3.24		5.76	1.1
1.05	1.05	1.87	1.87	3.32	3.32	5.96	5.90	1.2
	1.07		1.91		3.40		6.04	1.3
1.10	1.10	1.96	1.96	3.48	3.48	6.19	6.19	1.5
	1.13		2.00		3.57		6.34	1.6
1.15	1.15	2.05	2.05	3.65	3.65	6.49	6.49	1.8
	1.18		2.10		3.74		6.65	2.0
1.21	1.21	2.15	2.15	3.83	3.83	6.81	6.81	2.2
	1.24		2.21		3.92		6.98	2.4
1.27	1.27	2.26	2.26	4.02	4.02	7.15	7.15	2.7
	1.30		2.32		4.12		7.32	3.0
1.33	1.33	1.33	2.37	2.37	4.22	7.50	7.50	3.3
	1.37		2.43		4.32		7.68	3.6
1.40	1.40	2.49	2.49	4.42	4.42	7.87	7.87	3.9
	1.43		2.55		4.53		8.06	4.3
1.47	1.47	2.61	2.61	4.64	4.64	8.25	8.25	4.7
	1.50		2.67		4.75		8.45	5.1
1.54	1.54	2.74	2.74	4.87	4.87	8.66	8.66	5.6
	1.58		2.80		4.99		8.87	6.2
1.62	1.62	2.87	2.87	5.11	5.11	9.09	9.09	6.8
	1.65		2.94		5.23		9.31	7.5
1.69	1.69	3.01	3.01	5.36	5.36	9.53	9.53	8.2
	1.74		3.00		5.49		9.76	9.1

Continued from page 54
math. That myth is the basis for such statements as "You really have to be born with the gift of math." Actually, people with that so-called gift were given a positive attitude when they were young and were taught the simple rules necessary for working problems.

If you got off to a wrong start, and you're not yet 100 years old, you can still acquire a math skill. First, you get a positive attitude by saying to yourself – ten times – "If Sam Wilson can do it, anyone in the world can do it." Then you set out to learn the 30 or 40 basic laws and a few good tricks of the trade. The example I'm giving here is how to know if you multiply or divide to get an answer.

Problem: How many nanoamperes (nA) are there in 270 microamperes (270μA)?

Solution: Table 3 shows some basic relationships between units. Remember that you can multiply anything by the number 1 without changing its value.

Table 3.
Relationships between units

1 unit	=	1,000 milliunits
1 milliunit	=	1,000 microunits
1 microunit	=	1,000 nanounits
1 nanounit	=	1,000 picounits

From this table you pick what you want and what you got. Then, you make one or more fractions that are equal to 1. Make the fractions in such a way that the units you *have* will cancel and the units you *want* don't cancel. Remember, if two things are equal, dividing one by the other always gives a value of one, and you can multiply by one without changing the value of a number.

In the sample problem we *want* nanounits and we *have* microunits. So, make a fraction:

$$\frac{1{,}000 \text{ nanounits}}{1 \text{ microunit}} = 1$$

$$270\mu A \times \frac{1{,}000nA}{1\mu A} = 270{,}000nA$$

Note that the microunits cancel and all you have left is nanounits. In some problems you may have to make two or more fractions. Keep going until you have cancelled out all of the undesired units.

Problem: Convert 660 picoamperes (660pA) to microamperes (μA).

Solution:

$$660pA \times \frac{1nA}{1{,}000pA} \times \frac{1\mu A}{1{,}000nA}$$

$$= 660 \times \frac{1}{1{,}000} \times \frac{1}{1{,}000}\mu A$$

$$= 0.000660\mu A$$

To get the answer, divide by 1,000, then divide by 1,000 again. There are 0.000660μA in 660pA.

As with anything else that is new, this procedure seems clumsy at first. However, once you use it a few times you get to believe in it because it eliminates the possibility of mistakes. Here are some additional examples.

Problem: There are 2.54cm in an inch. How many inches are there in 153cm?

Solution:

$$153\text{cm} \times \frac{1\ \text{inch}}{2.54\text{cm}} = 60.2^{+}\ \text{inches}$$

Problem: How many inches are there in a meter? (Note: 1 meter = 1,000cm)

Solution: You are looking for *inches per meter*. The word *per* always means to divide.

$$\frac{\text{inches}}{\text{meter}} \times \frac{1\text{m}}{2.54\text{cm}} \times \frac{100\text{cm}}{1\text{m}}$$

$$= 39.37\ \frac{\text{inches}}{\text{meter}}$$

The fall of E

When you first learned Ohm's law, it may have been in the form I = E/R. The letter I means the intensity of current and E stands for electromotive force (emf).

When students progress from Ohm's law to more advanced work, they get into trouble if they cancel units as shown in the previous section. It would seem that when you get done cancelling units, you should end up with force to represent voltage.

The trouble is that voltage is a unit of *work* – not force. In science the word *work* is simply translated as force times distance. The voltage of a battery, for example, is the amount of work required to move a unit negative charge (one coulomb) from its positive terminal to its negative terminal.

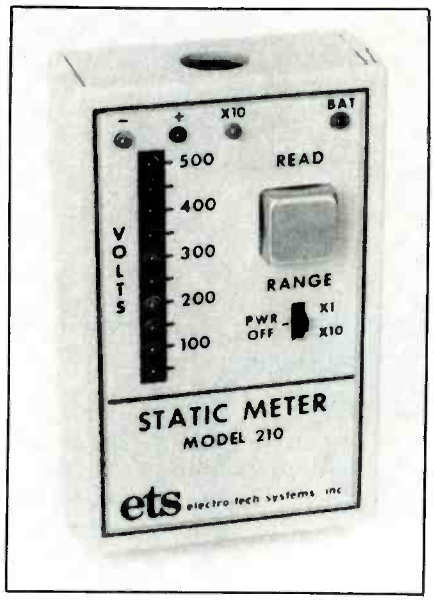
If you've been reading your technical materials and looking into company catalogs, you must have noticed that E is now very rarely used to represent voltage. The reason, of course, is that you shouldn't use the term electromotive *force* to represent a unit of *work*. Besides, the units won't cancel when you are doing advanced math problems.

Products

Anti-static cleaner

The Zero-Charge anti-static cleaner from *Tech Spray* is a topically applied solution that cleans work areas, mats and computer workstations while also controlling static. The cleaner is non-toxic, non-staining, non-flammable and chloride-free. It can be applied by spraying or wiping to control static charge generation on fabrics, acrylics, laminates and other surfaces.

Circle (75) on Reply Card



Electrostatic instrumentation

The model 210 electrostatic field meter from *Electro-Tech Systems* uses an array of 12 solid-state light-emitting diodes to detect and indicate the magnitude and polarity of electrostatic fields. Four different colors indicate the relative levels and polarity of the detected field. It has two user-selectable ranges that set measurements sensitivity at ±500V or ±5000V full scale. Its circuits provide for automatic overscale and low-battery indication.

Circle (76) on Reply Card

Digital power and VSWR meter

The *Coline TPI* meter displays true rms power and VSWR on a 0.5-inch digital readout. Frequency coverage is continuous from dc to 1,500MHz without the need for plug-in elements. The meter measures power to 100W CW or 200W with 50% duty cycle. Resolution is 100mW. VSWR differences of 0.1 are detected and displayed over a range of 1:00-99:1. The meter operates up to a year on an internal 9V battery.

Circle (77) on Reply Card

Copper desoldering braid

A line of flux-impregnated copper braid, available in four sizes, is available from *M.M. Newman Corporation*. Kwik-Wik is a pure copper braid that is flux-impregnated to absorb solder by capillary action when touched by a hot soldering iron tip. The braid comes packaged on spools in 5-foot lengths in four sizes: thin (0.03-inch), small (0.06-inch), medium (0.08-inch) and wide (0.01-inch).

Circle (78) on Reply Card

Test and measurement lab test

Rapid Systems has introduced the R200 series personal computer-based instrumentation lab courses. The course allows immediate hands-on application of the 500-page course text, which accompanies a variety of hardware packages priced from $999 to $2,995. The courses teach the skills needed to operate PC-based instruments and covers the theory necessary for understanding the acquisition and use of digitized data. Course topics include: elements of computer systems, assembly and high-level programming languages, data acquisition, instrument tools, instruments, data links and buses, operating systems, applications and experiments. Hardware includes an oscilloscope, a spectrum analyzer and a data-acquisition peripheral.

Circle (79) on Reply Card

Probe assemblies

Hirschmann has introduced Kleps probe assemblies with standard 250mm (10-inch) plug-in leads. These assemblies will allow the user to attach to any 25^2 or round posts. Other connections or lead lengths can be ordered.

Circle (80) on Reply Card

Soldering iron control unit

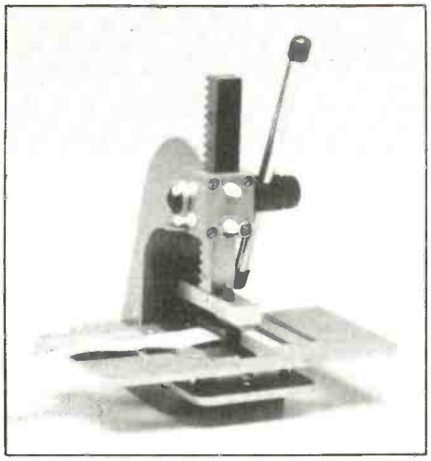
The model S-4 control unit from *Sibex* is designed to convert any soldering iron into an adjustable-temperature soldering station. The unit works with any 110Vac-powered iron up to 100W in size. Solid-state circuitry produces a spike-free, adjustable dc voltage and minimizes the possibility of damaging critical components.

Circle (81) on Reply Card

Printer cleaner

3M has added two new filters to the service vacuum cleaner. The unit's high-capacity filtration system now has three filters for a variety of specialized applications. In addition to the toner/dirt filter, the unit now has a fine-particle filter for cleaning laser printers that use toners in the 0.3 to 0.5 micron range, plus a dust/dirt filter for general cleaning that traps dust and larger particles.

Circle (82) on Reply Card



IDC manual press

The *PanaVise* IDC bench assembly press is capable of low-volume mass termination of various IDC connectors on flat (ribbon) cable. The ¼-ton manual press has cartridge-style interchangeable base plates (no tools required) and accommodates a broad range of IDCs, including female socket transition connectors, card edge connectors, standard DIP plugs and D-subs. An interchangeable base plate terminates up to 64-pin IDCs.

Circle (83) on Reply Card

Degreaser

Lectra-Clean cleaner and degreaser from *CRC Chemicals* removes grease, oil, wax, dirt, moisture and other foreign substances that can cause leakage, excessive resistance and hazardous operation of electrical equipment. The degreaser is non-flammable, nonconducting, does not stain and is non-corrosive to metals.

Circle (84) on Reply Card

Modem/ac line protector

The P208 modem/ac line protector from *MCG Electronics* protects both ac power lines and modem I/O ports from transients caused by lightning, disk drives and switching surges. The unit is a solid-state, plug-in protector that offers 1ns response time and has heavy-duty protection components for use in industrial applications. It plugs into a local 120Vac, 15A outlet.

Continued on page 61

Read-only memories

This installment of Computer Corner begins a 4-part series on non-volatile memories. Part 2 will cover programmable ROMs, Part 3 will cover erasable ROMs, and Part 4 will discuss accessing the different types of read-only memory.

Most technicians are already familiar with read/write memories (RAM), and will recall that those Random Access Memories are volatile – the data and/or programs they store are lost as soon as power is turned off.

For applications where the program will be reused over and over and should be available at all times, you need a non-volatile memory. Non-volatile semiconductor memories range from the ordinary read-only memory (ROM) that, once manufactured, cannot be reprogrammed, to read mostly memories (RMM) that can be erased and reprogrammed thousands of times.

Non-volatile memories can be classified into several different categories, depending on their semiconductor technology, internal structure, programming and erasing method, and electrical characteristics.

Read-only memory

The ordinary read-only memory consists of an IC that is mask-programmed at the factory during the manufacturing process. ROM chips feature either MOSFETs or BJTs. The ROM's storage locations (addresses) are written into – programmed – by the manufacturer according to the customer's specifications. In other words, the designer of the computer or microprocessor-based equipment that will use the ROM tells the IC manufacturer what data and/or programs are to be stored in the memory chip.

A suitable mask (photographic template of the integrated circuit) is then made, and the chip is programmed during the last phase of fabrication. ROMs are generally used in large production runs because the IC manufacturer charges thousands of dollars for the initial mask.

Once manufactured, read-only memories cannot have their contents changed – new information cannot be written into them. Therefore, they are used for long-term storage of information that is not intended to change during the operation of a system. For example, ROMs can permanently store the data, monitor program and subroutines that make up the operating system of a computer, as well as the language interpreter (such as BASIC) that translates computer language instructions into binary code that the computer can understand. This built-in program storage makes it possible to use some computers, such as the Commodore 64, immediately after they're turned on, compared to the majority of computers whose operating system and language interpreter must first be loaded from disk before they can be used.

Note – Programs stored in ROM are referred to as *firmware* because they are not subject to change; programs stored in RAM are called *software* because they can easily be altered. *ROM packs* (program cartridges) used to run video games on a home computer are another good example of firmware; the cartridges simply contain a ROM IC mounted on a small printed circuit board.

ROM applications

ROMs are used to store tables of data that do not change, such as logarithmic and trigonometric "look-up" tables that contain values of logs, sines, cosines and more in calculators. They are also used to store code conversion tables (for example, binary to BCD conversion), and can be used as *character generators* for video display on CRT screens; in this application, the ROM stores the binary codes that represent the dot patterns for each alphanumeric or graphic character.

In summary, a ROM is a memory that cannot be written into but can be read from as often as desired. Next month we'll cover PROMs – user-programmable ROMs.

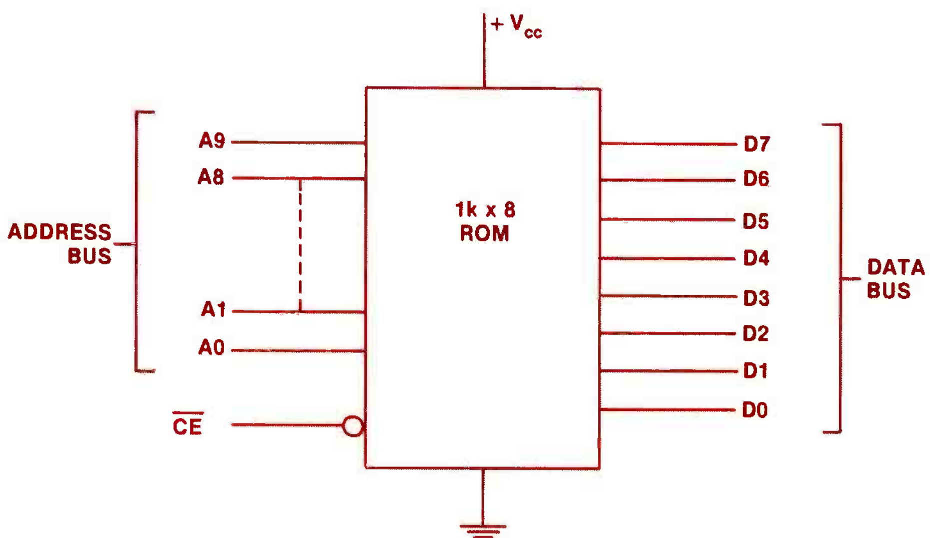


Figure 1. An ordinary ROM can be read from but cannot be written to. A 1k x 8 ROM can store 1024 data words because of its 10 address lines (A9 through A0). The data words are eight bits wide because the IC has eight data pins (D7 through D0).

Continued from page 59

Clamp voltage is 200V peak initial, 300J minimum, ±200V peak.

Circle (85) on Reply Card

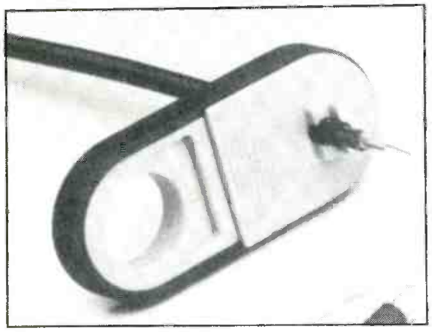
Digital Probes

Two logic probes (20MHz and 50MHz) and a pulser probe are now being marketed by *Mercer Electronics,* division of *Simpson Electric Company.*

Models 9604 (20MHz) and 9605 (50MHz) logic probes have a slim, compact design that makes them easy to use in densely populated PC boards. Levels and pulses can be viewed from two front-mounted LEDs and stored as desired. Two additional LEDs in the base of the unit display any improper connection or over-voltage applications.

The Pulser model 9606 is multifunctional. In the pulse mode, it can inject 50μs pulses into a logic circuit without isolating ICs. It has a sync input permitting use of an external synchronizing signal.

Circle (86) on Reply Card



Coax wire stripper

Paladin Corporation's Toggle coaxial wire stripper uses a *toggling* blade system to strip braid and dielectric off coax cable in any number of strip configurations for any type of coax connectors. Toggle is available in sizes suited for cables from RG58 up to RG8/11. Custom sizes can be accommodated upon request.

Circle (87) on Reply Card

PC monitor tester

The MONTEST-D4 PC monitor tester from *Network Technologies* tests monochrome, CGA, EGA and high-resolution monitors. The device can be used to align, converge and color balance. It is battery powered for portable operation, and generates four patterns – color bars, cross hatch, full raster and windows. It also controls colors, intensity and reverse video.

Circle (88) on Reply Card

Static-dissipative grounding kit

The static dissipative grounding kit from *Contact East* reduces sparking and shorting damages. The resistance to ground is greater than $10^6\Omega$ and less than $10^9\Omega$. It is designed to remove static charges from the service engineer and to provide a static-free surface during field repair of PC boards. The kit includes a 24"x24" static-dissipative work mat with two pockets; one medium and one large wrist band; and a ground-cord assembly, model 3051. It folds to an 8"x12" unit.

Circle (89) on Reply Card

ES&T

The VCR mechanical-state switch

In a modern VCR, a lot goes on mechanically that you might not ordinarily think about. Let's contrast the mechanics of a VHS VCR with an audio cassette deck. In an audio cassette deck, you insert the tape (there might be a loading motor in one of the modern audio cassette decks), close the door, press the PLAY button and it goes. The pressure pad on the tape cassette provides the proper pressure to hold the tape against the stationary play head as the tape is drawn across the head by the capstan. The take-up motor turns the take-up reel to wind the tape.

In a videocassette recorder, a lot more happens, and it all has to be in precise synchronization. Take a front-loading VHS VCR, for example the GE 1VCR4012. Within the loading mechanism there are three switches: an UP switch, a DOWN switch and an IN switch. Table 1 shows the possible combinations of open and closed positions of these switches and the action that takes place as a result of each combination.

Table 1.
Switch positions

	Cassette unloaded	Loading/ unloading	Cassette loaded
IN Switch	open	closed	open
UP Switch	closed	open	open
DOWN Switch	open	open	closed

When a cassette is inserted into the VCR, it physically causes the UP switch to open. Further insertion closes the IN switch. This combination of switch conditions is sensed by the system-control microprocessor, which in turn puts out a signal that turns on the cassette loading-motor drive system so that the motor runs in the loading direction. After the cassette is loaded, the DOWN switch closes. Again, this signal is sensed by the microprocessor, which in turn puts out a signal that turns the motor off.

One of the important features of a VCR is the mechanical-state switch. This switch serves as the interface between the mechanical and the electrical portions of the VCR. The switch monitors the position of the tape transport system and sends it to the system-control microprocessors. When an operation mode is selected, the system-control stages (microprocessors) tell the loading motor to turn in either the load or the unload direction.

Movement of the loading motor governs the operational timing of all mechanical modes. In other words, the action of the loading motor through belts, pulleys, gears and rods changes the mechanical configuration of the tape transport mechanism. The mechanical-state switch is also linked to the loading motor so that it moves as the loading motor moves. Therefore, as the loading motor drives the tape transport mechanism into the mechanical configuration, the mechanical-state switch monitors those configurations as they occur.

There are two types of mechanical-state switches you may find in a VCR: a slide type of switch and a rotary type. The particular type of tape transport mechanism determines which type of state switch is used. A 5-position, slide-type switch is shown in Figure 1, while an 8-position, rotary mechanical-state switch is shown in Figure 2. Even though they are physically different, both switches perform the same function in a similar manner.

A simplified schematic of the slide type of mechanical-state switch and its connections to the system control stages is shown in Figure 2. The five contacts of the switch are converted to three data lines by a diode matrix before being sent to the system-control stages.

The switch is shown in the STOP position. Should the PLAY key be pressed at this time, the loading motor will

	POSITION (3)	POSITION (2)	POSITION (1)
PLAY(P)	L	H	L
PAUSE(P)	L	H	H
REV(P)	H	L	L
STOP(P)	H	L	H
FF/REW(P)	H	H	L

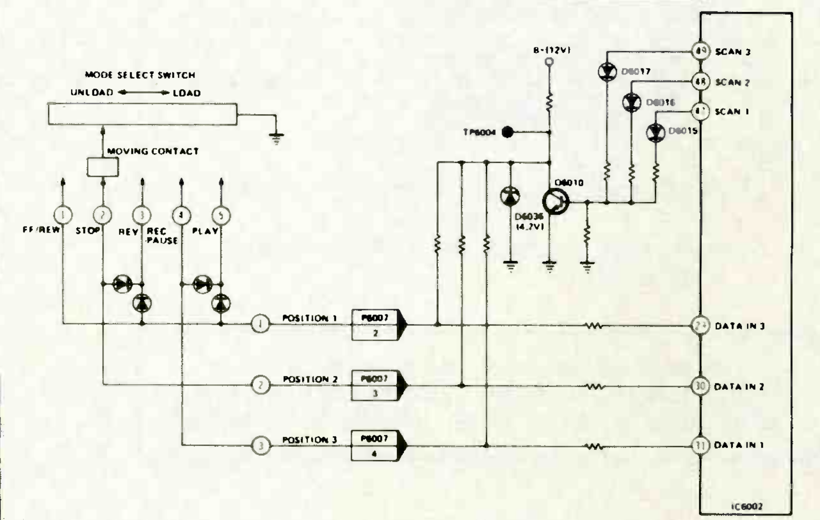


Figure 1. Information from this 5-position, slide-type switch is converted to three data lines by a diode matrix before being sent to the system-control stages.

begin to move in the load direction. Between position 2 and position 3, the loading posts will move, loading the tape. At the same time, as the contact inside the mechanical-state switch reaches position 3, the loading posts are caught by the V stoppers and the posts can move no further because of the construction of the cam gear.

Loading-motor movement continues, however, and during the period that the mechanical-state switch advances through positions 4 and 5, the pressure roller, tension post and other parts of the mechanism are moved to suitable positions for the playback operation. When position 5 is reached by the mechanical-state switch, the data (L,H,L) sent to the microprocessor (IC 6002) causes the loading motor to stop.

The rotary mechanical-state switch is an 8-position device. The intelligence from this switch is also delivered to the system-control microprocessor by three data lines.

As we said at the outset, there's a lot going on in a VCR mechanically. An understanding of the role of the mechanical-state switch will help you understand how the VCR operates and what is supposed to be going on at any time. This will help you diagnose and correct problems when the unit malfunctions.

ES&T

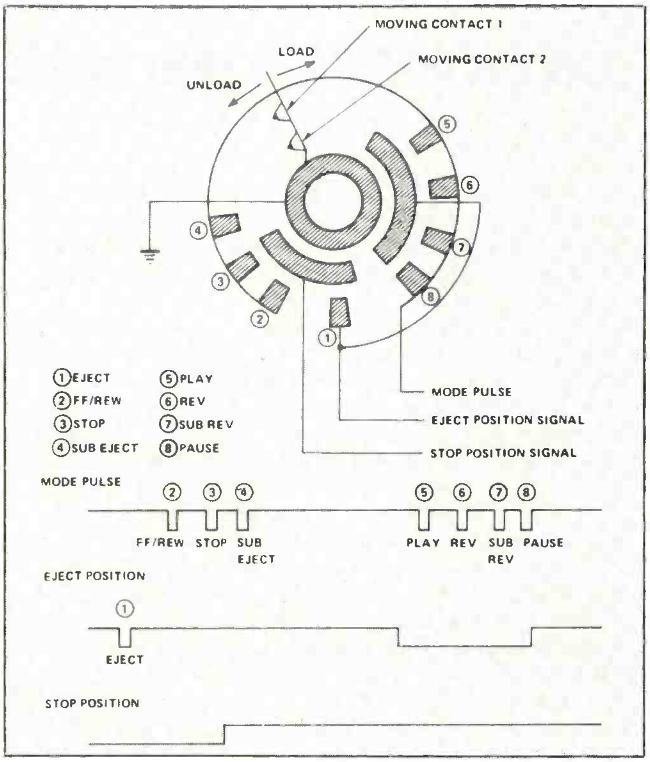


Figure 2. This rotary-type switch has eight positions.

By Kirk Vistain

Component interactions

Ever since video and audio tied the knot, the number of components and interconnections in the typical "home entertainment system" (remember when it used to be called just a stereo or TV?) has multiplied. As in any family, there are occasional spats.

As video and audio have become more complicated, people find it hard to keep up, and many a service call can result. Knowing the fundamentals might reduce the number of these nuisance problems. Not only that, but much trouble these days is *synergistic* in nature, meaning it only occurs when the entire system is hooked up.

Component placement

Let's start with the most egregious example of erroneous placement, the glass-doored stereo rack. This was surely developed by a marketing type turned interior decorator. It looks nice, keeps dust off the units, but shortens their lives. Then you can buy new ones.

The key drawback is heat build-up. The inside of a typical rack can easily run 20° or 30° above ambient after an hour or two of operation. The resultant thermal cycling is a common cause of component failure, particularly in the output section.

Even though the manufacturer usually makes a perfunctory attempt to ventilate through cutouts in the back, the only thing that will even come close to working is a fan, which I haven't seen in anything except professional 19-inch rack cabinets. Leaving the front door open would help, but most people don't. The natural tendency is to keep a door closed. Otherwise, why have a door at all?

What's a user to do? First of all, put the amplifier at the top of the stack. It generates the most heat. Granted, there will still be a phono above it, but this is the best we can do and still keep it convenient. Second, leave the door open when the system is powered up. Unless it's structurally necessary, leave the back off the rack. This improves airflow and accessibility.

Acoustic feedback

I've lost count of how many times a customer has called me up to complain that his phono sounds distorted whenever he turns it up loud. But of course, his friend, who has exactly the same stereo system, has no such problem. After some interrogation, we usually find that the phonograph is sitting on top of one of his speakers.

The name of the phenomenon is *acoustic feedback.* The musical material being played causes the speaker cabinet to vibrate, which in turn makes the tone-arm rattle, which becomes part of the music signal going back to the amp. Here we have both necessities for an oscillator: positive feedback and lots of gain. Setting the volume high enough creates a positive feedback loop, causing distortion, howling, and perhaps a blown speaker driver or amp.

Keep the turntable well away from the speakers, preferably on a wall-mounted shelf, which makes it less susceptible to vibration. Even small amounts of acoustic feedback, perhaps too weak to result in oscillation, can muddy the bass.

Impurity on TV

Ever know someone who's just had his TV repaired and finds a misplaced blob of color on the screen? He brings it back. You degauss it. It looks A-OK on the bench.

Two hours later the blob has returned. After some questioning, you discover that he has a pair of 18-inch Altec Lansings right next to the set. Of course, he won't believe you when you tell him to put some space between the speakers and the TV. After all, the other TVs in his house have built-in speakers, and they don't have a problem!

This is where patience comes in handy. The speakers built into most TVs are puny, low-fi devices, with magnets that would be shamed by those little daisies people use to hold notes to the refrigerator. The few sets that do have good speakers usually also have magnetic shielding. High-fidelity systems don't.

Micropollution

Thanks to microprocessors, most home entertainment equipment doubles as a small RF noise generator. To prove it, use a portable AM radio to "sniff" around a VCR or late model hi-fi receiver. You'll probably get an earful of noise across most of the band. This radio garbage can cause some strange interactions. When you detect unusual interference in a home entertainment system, try changing the relative positions of various pieces of equipment.

One egregious example of poor positioning is setting a VCR on top of a TV, just above the flyback. Maybe 15.734kHz isn't really RF, but large doses of it do some strange things to the CMOS microprocessors in the typical VCR. Clocks keep bad time, function buttons work erratically. Sometimes even the video output is polluted.

Snakes out back

The spaghetti behind most audio/video systems makes the snake house at the Brookfield Zoo look underpopulated. Shields notwithstanding, every inch of that stuff is radiating a magnetic field. The best we can do is try to position cables so their interactions will be as benign as possible. Two electromagnetic characteristics work in our favor. First, cables that cross each other at right angles interact little. Second, magnetic flux falls off as the square of distance, which means that doubling the space between cables quarters the interaction.

Avoid long, parallel runs of cable, and don't mix low- and high-amplitude signal carriers in the same bundle. A good example of the worst possible setup is a parallel run of phono cable and ac power cord. Second worst would be to run the phono and speaker cables together. Not only do the signal amplitudes differ greatly, but a potential feedback path is established whenever input and output cables run together.

Remember that cables fail more often than the equipment they connect, and always suspect them first if you have an intermittent signal problem. Also, a few years of experience have taught me that if there's a dead channel and a Y connector in the same system, the Y connector is usually the culprit. I don't know why.

Any of you with good component-interaction stories ought to send them to me, care of ***ES&T***. The best ones will make it into the column, and you'll have the satisfaction of seeing your name in print and helping your fellow technicians at the same time.

Readers' Exchange

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Service manual or wiring diagram for Lafayette transistor stereo amplifier, LA-125T. *E. Cardona, Cardona Radio Music Shop, Apeninos 633, Puerto Nuevo, Puerto Rico, 00920.*

SMK11 3½-inch B&W televisions, model TPS 5050, made for or by Symphonic Electronic Corporation of Lowell, MA. Need not be in working condition but must be complete. Also need the power supply or adaptor, AC30 (in Sams 1060-3). State price. *Cleo Zarella, 937 Center St., Brockton, MA 02402.*

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Schematic/service manual or operator's manuals: Cimron (Lear-Siegler) DMM, model 7630; Orion VTVM, model V-100M; Redeo frequency counter, model RFC-250; Dumont scope, type 301-A; Radio Specialty FM deviation meter, type 1163-60-3. Will buy original, pay for copies or copy and return. *Donald H. Nash, 1444 Palaski St., Port Charlotte, FL 33952; 813-629-3934.*

I have a 1967 Lafayette model LR1000T stereo receiver with a faulty 6-position selector. Lafayette has gone out of business. Does anyone have information on Lafayette or the selector? *Wayne Holmqwit. 42 Woodway Drive. Shrewsbury. MA 01545.*

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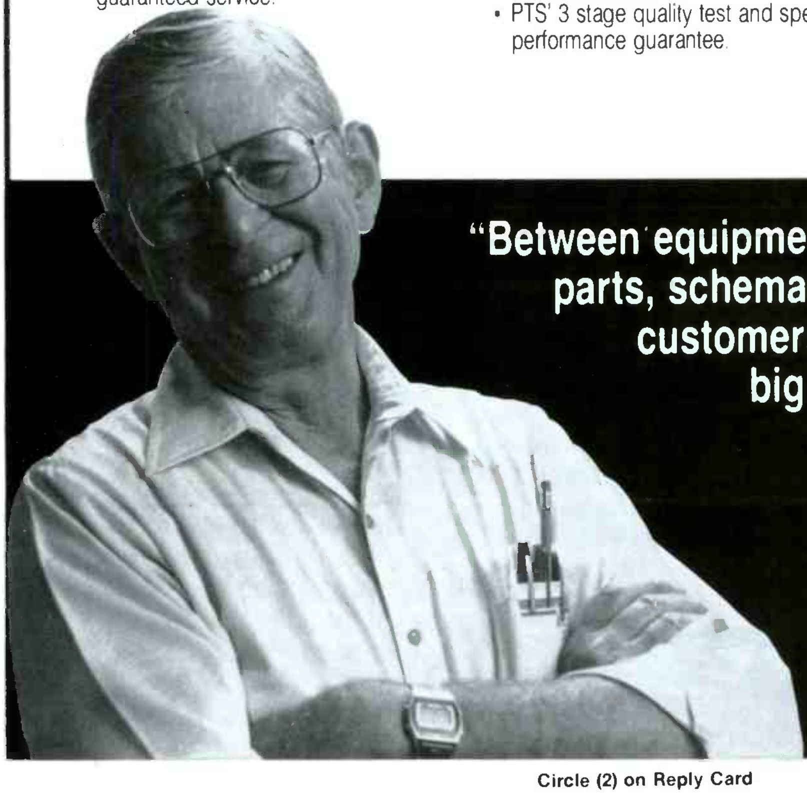

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