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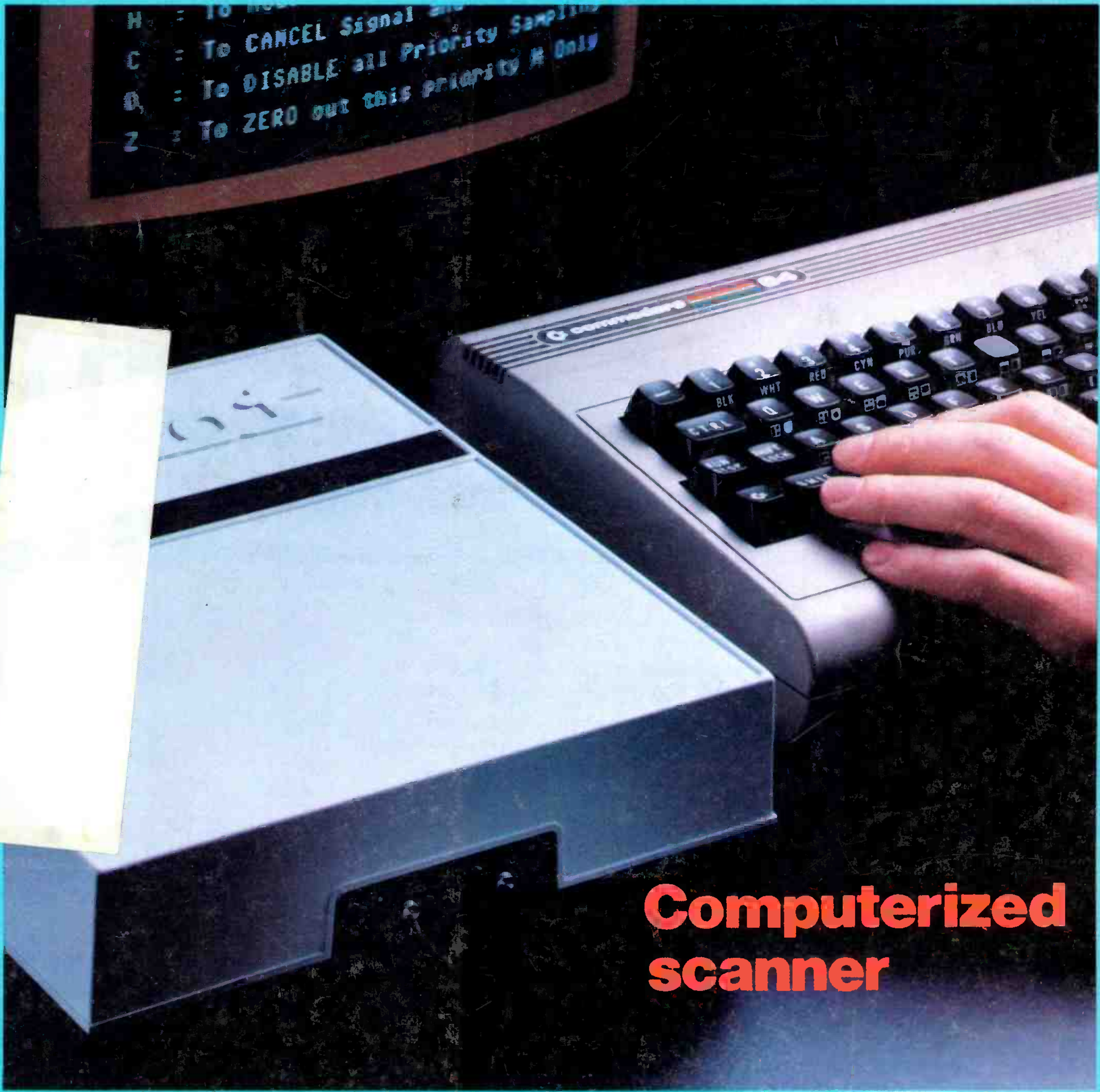

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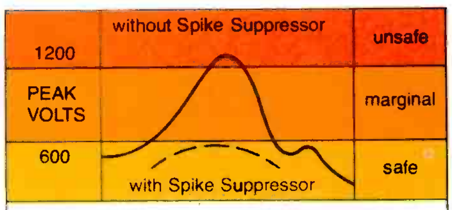

In this graph, the solid curve represents the excess voltage or "spike" imposed on an electric system and, represented by the dotted line, the protection provided household appliances as the Zenith Spike Suppressor absorbs the excess voltage and prevents it from surging thru the system.

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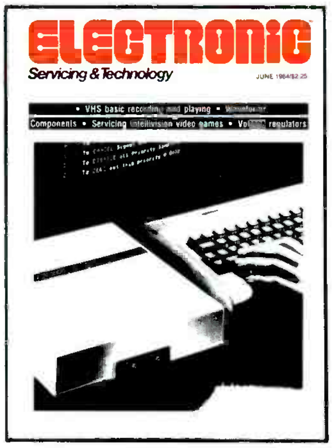
The how-to magazine of electronics...

ELECTRONIC Servicing & Technology

June 1984
Volume 4, No. 6



Computer technology has revolutionized the world of electronics. The list of products that use microprocessors to enhance their performance is long and growing. This scanner radio is an example of a product designed to be used in conjunction with a computer to increase its capacity and make it easier to use. *(Photo courtesy of Electra Company)*

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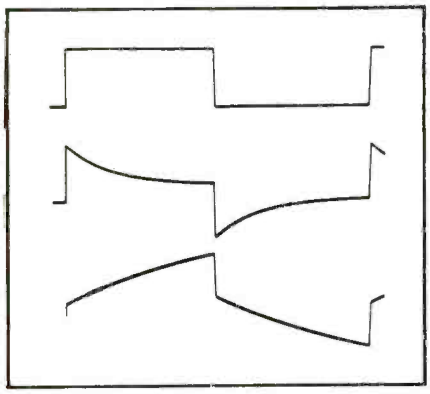

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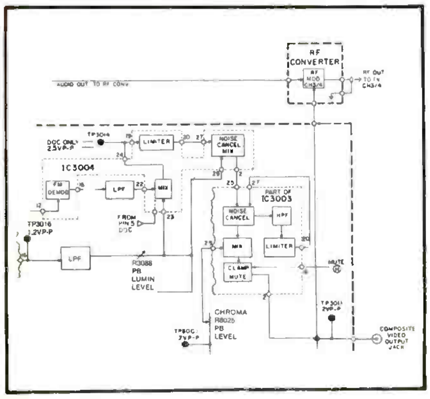

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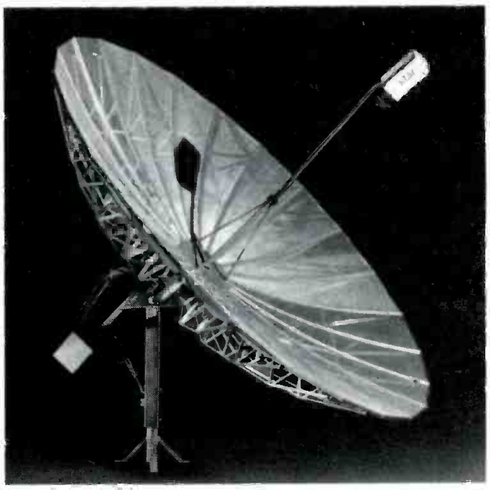
Departments



Next month...

The TVRO Dish. This article describes how a satellite TV receiving system collects the microwave signal from the satellite and feeds it to the antenna. Satellite-dish siting considerations are also discussed.

The computer in your future

"But what good is a home computer? Sure, they make great video game playing machines, but a personal computer can't do anything for me I can't do myself. I mean, I know it can balance my checkbook, but I don't need a computer for that. And as for storing recipes and stuff like that, I can buy all the 3x5 card files I'll ever need..."

That's not an actual monologue, of course, but it does sum up some of the comments I've heard about computers. And right now many of them are pretty close to the truth. Computers do cost quite a bit of money, and most of them take quite a little bit of study to learn how to operate. But I think we're on the way to a period in the not very distant future when almost every home will have a computer, maybe more than one.

Consider the automobile. When it was in its infancy, as personal computers are now, drivers frequently were heaped with abuse including "get a horse." They were considered eccentric. Cars were noisy and uncomfortable, lacking things now considered standard, like heaters and defrosters. The tires were fragile, the roads lousy, and gas stations were few and far between. Still, automobile pioneers withstood those hardships and stood with the technology as it became refined into today's age of comfortable, economical, reliable automobile transportation with a car, and sometimes two or three, in almost every garage.

In many ways the inconvenience of using a personal computer of today can be compared to the inconvenience of those cars of an earlier age. Yes, they can do a lot of routine tasks but the user has to spend a lot of time learning to use the computer.

However, personal computers are constantly becoming less expensive and more useful. You can buy integrated units with a self-contained disk drive and monitor screen and with several software programs bundled in. And even now there are many things you can do with a personal computer that you can't do otherwise. You can make your own airline reservations or do your banking. If you have money invested in stocks you can check their current value any time. And if the library's closed and your youngster has a research project due tomorrow, just dial up The Source, or Compuserve, or any of a number of other on-line data bases and see what they have on file.

You can do all these things today. Right now. Imagine what the future might bring: Betty Crocker recipes on disk, direct access to your local library's data base so you never have to go in and check out a book, local store merchandise and price information. The possibilities are almost endless.

In the automotive world solid rubber tires that jarred and jounced over the road gave way to soft-riding pneumatics. Side curtains were replaced by crank-up glass windows. Gas stations sprang up on every corner. From an expensive luxury owned only by the rich, eccentric or enthusiast, the automobile has evolved into an absolute necessity.

The evolution of the personal computer has just gotten under way. It has the potential to be every bit as dramatic as that of the automobile. Just watch.

Nils Conrad Persson

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Circle (5) on Reply Card

Technology

Computer hookup enhances operation of scanner radio

Small computers have had a more profound effect on the world than most of us realize. Besides their obvious manifestations where they have been showing up in offices and homes to store information and perform routine repetitive mathematical tasks, millions more have been imbedded in the circuitry of modern products where they perform their magic unnoticed: cars, microwave ovens, VCRs and digital audio disc players to name just a few.

In some of these applications, the computer enhances the product's value by making it easier to use, more efficient or faster. In other applications, the computer makes it possible to realize a useful, practical, marketable product that would not have been possible without the use of a microcomputer.

One recently introduced product, the Bearcat CP 2100, is a scanner radio that was designed as a peripheral for personal computers. Now available in versions compatible with the IBM PC, Atari 800, Apple II and IIe, Osborne and Commodore 64, the scanner can monitor live police and fire calls, emergency and amateur radio transmissions, Coast Guard rescues and aircraft communications.

Scanner radio information display on video screen eliminates need to handle a lot of paper.

In addition, according to the manufacturer, this is the first scanner that can display detailed information about a service being monitored. Each of its 200 channels can be programmed to display the source and location of a transmission, 10-codes, phone numbers and more. Whenever a broadcast is monitored, the information programmed into the channel will automatically appear on the screen. For scanner enthusiasts, the unit can eliminate pages of cumbersome frequency lists. In the newsroom, it can help news crews be dispatched to the scene of a story with less confusion.

Because of the computer connection, the scanner offers several other advantages. Its 200-channel capacity is three times that of the most sophisticated programmable scanners with channels grouped into banks of 20. It is also the first scanner to feature multiple priority levels. Users can select up to three different priority frequencies so most important calls will be heard first. During a priority transmission, the video monitor will flash to alert the listener.

"Search/Store/Count" lets users search frequency ranges of their choice for active channels. The scanner will automatically find all active frequencies and store them in separate memory without the need for the operator to be present. The count register shows how many transmissions were noted on each active frequency. Also, every channel includes four auxiliary settings that can be programmed to activate tape recorders, alarms and other optional equipment whenever a call is received on a programmed channel.

Other features include patented "selective scan delay," "automatic lockout," "automatic and manual search," and patented "track tuning." The scanner's frequency coverage includes 10-meter, 6-meter, 2-meter and 70-centimeter amateur, VHF low and high, VHF aircraft, UHF and UHF-"T," and military land mobile bands.

The capability of computers to store, manipulate and display information is being used in many ways to expand the capabilities of all kinds of products and processes from automobiles to zymurgy. You may try to ignore them, but they won't go away. ES&T

We advanced the technology to make the soldering simple.
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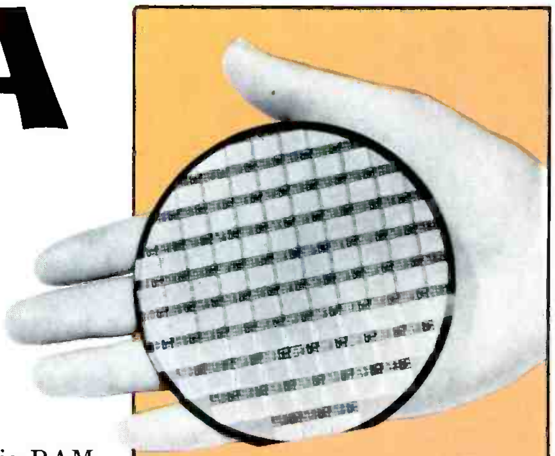
THERE'S A LIMIT!

How small can circuits get?



Channel lengths of 0.9 micron (0.000035 inch) make possible the manufacture of 256K-bit static RAM.

Someday, manufacturers will have made integrated circuits so small it will be impossible to make them any smaller. At least that sounds plausible. For the time being, however, those of us on the outside looking in can only continue to watch in fascination as manufacturers continue to push back the limits and realize ever more crowded slivers of silicon.

Researchers at Toshiba Corporation have succeeded in developing the world's first 256K-bit CMOS static random access memory (RAM)–possibly called a next generation "ULSI" (ultra large scale integration) semiconductor, to be used for various types of computers and office automation equipment as a data storage device.

Using advanced 1-micron precision lithography and other VLSI (very large scale integration) technologies, the new device integrates approximately 1.6 million elements (like transistors) on a 6.68mm by 8.86mm chip–the same level of integration as a 1-megabit dynamic RAM. Channel lengths of the transistors are 0.9 micron.

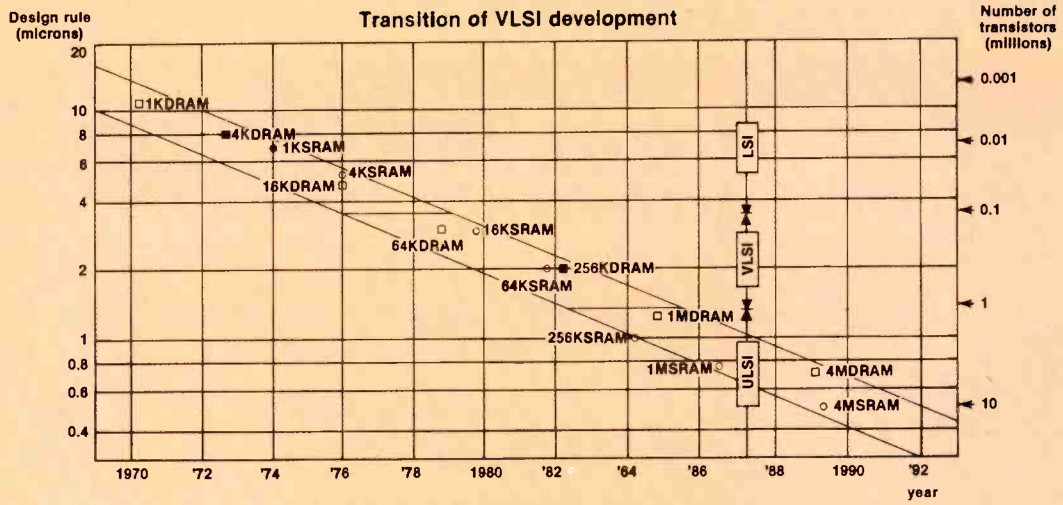
Random access memory (RAM), which is available for free writing and reading of information, is divided into two structural types: static and dynamic. A static RAM needs four to six times the number of transistors of a dynamic RAM to acquire the same memory capacity. Unlike the dynamic RAM, it does not need constant refreshing by electric pulses to keep the stored data from vanishing; therefore, it is easier to use. Static RAM also works much faster than dynamic RAM. A static RAM is often used for compact equipment with low power needs, while a dynamic RAM is used for relatively large equipment including mainframe computers where the cost of memory chips is the first priority. A 256K-bit RAM (both static and dynamic) can store a full page of a major newspaper.

Toshiba has long emphasized both dynamic and static memory LSIs and has developed a balanced operation in the LSI memory business. Samples of 256K-bit dynamic RAMs are already being shipped. The company has applied its long-standing CMOS (complementary metal oxide semiconductor) technology to static RAM, which produces chips that require much less electric power and generate less heat than standard models. Toshiba has developed a low-power consuming 64K-bit CMOS static RAM (capable of storing up to 8000 characters), which is equivalent to a 256K-bit dynamic RAM at its integration level.

The newly developed 256K-bit CMOS static RAM features access time (time needed for writing and reading information) of as fast as 46ns or billionths of a second. Power consumption has been limited to only 2mA during operation (10 to 20 times less than dynamic RAM) and 30μW during stand-by.

Because of these characteristics, it will probably be widely used as a memory in personal computers, office automation equipment, measuring instruments and medical equipment, all of which require ever-higher speed, larger memory capacity and lower power consumption.

The chip is classified as the next-generation "ultra" LSI–often called ULSI–filling the supposed qualification of more than one million integration on a chip. Generally, an LSI chip with more than 100,000 elements is called a VLSI. Both the current 256K-bit dynamic RAM and 64K-bit static RAM integrate 400,000 to 600,000 elements on a chip by precision lithography technology of two micron design standard. The 1.5μ



Static RAM featuring 256K bits may be the first of a class of memory devices called "ultra large scale integration." Projections are that by the 1990s semiconductor manufacturers will be up to tens of millions of transistors on a single chip.

level has so far been thought to be the limit of current technological development.

To develop the new ULSI chip, Toshiba employed various technologies including 1-micron precision lithography, element separation, new circuit and aluminum multi-layer wiring technology. Toshiba expects the combination of these technologies will make possible the development of 1-megabit and 4-megabit memory devices and other ULSIs in the near future. ES&T

News

Satellite service technicians honored

Mission Specialists George D. Nelson and James D. van Hoften have been honored by the International Society of Certified Electronics Technicians with the titles of Honorary Certified Electronics Technicians. They are cited for outstanding technical achievements in space during April 8-12, 1984, when the Solar Max satellite was serviced, repaired and returned to earth orbit.

The association honored the two astronauts for exemplifying the highest ideal of the electronic service industry by:

- Preparing for the maintenance of high-technology electronic equipment through study, training and retraining.
- Personal dedication to restoring faulty equipment to a standard of performance and reliability that matches or exceeds the original.
- Performing technically precise electronic service in hostile environments consisting of weightlessness, a vacuum and at orbital speeds.
- Using state-of-the-art technology testing and service equipment to perform quality service.
- Demonstrating that adequate preparation for service is essential in successful repairs.

Nelson and van Hoften used power tools designed for weightless conditions to change and repair electronic instruments. Extremely difficult and delicate work was required to repair the electronics box for the Coronagraph-Polarimeter, which was not designed to be repaired in space.

ISCET establishes program to replace FCC licensing

People who hold current and valid FCC general radiotelephone operator licenses may renew those licenses with the International Society of Certified Electronics Technicians at any time prior to their expiration. The FCC recently repealed rules that allow only licensed people to repair or install 2-way radio systems. Congress recently authorized the FCC to endorse industry certification programs for technicians as a valid substitute for the previous licensing requirements.

Individuals holding current and valid general radiotelephone operator licenses may register those licenses with ISCET for a $10 registration fee. Each registration is valid for five years. Or, they may take the Certified Electronics Technician examination with the Communications Option for a $20 fee and, if successful, receive permanent certification. The Communications Option of this exam, which has been aproved by the FCC as a replacement for the general radiotelephone operator license, includes a test of basic electronics circuitry and measurement, plus a specialized section covering 2-way transceivers, basic eommunication theory, transmitters, deviation, sensitivity, quieting and troubleshooting.

For more information on license renewal or the CET program, contact ISCET, 2708 West Berry, Fort Worth, TX 76109; 817-921-9101. ES&T

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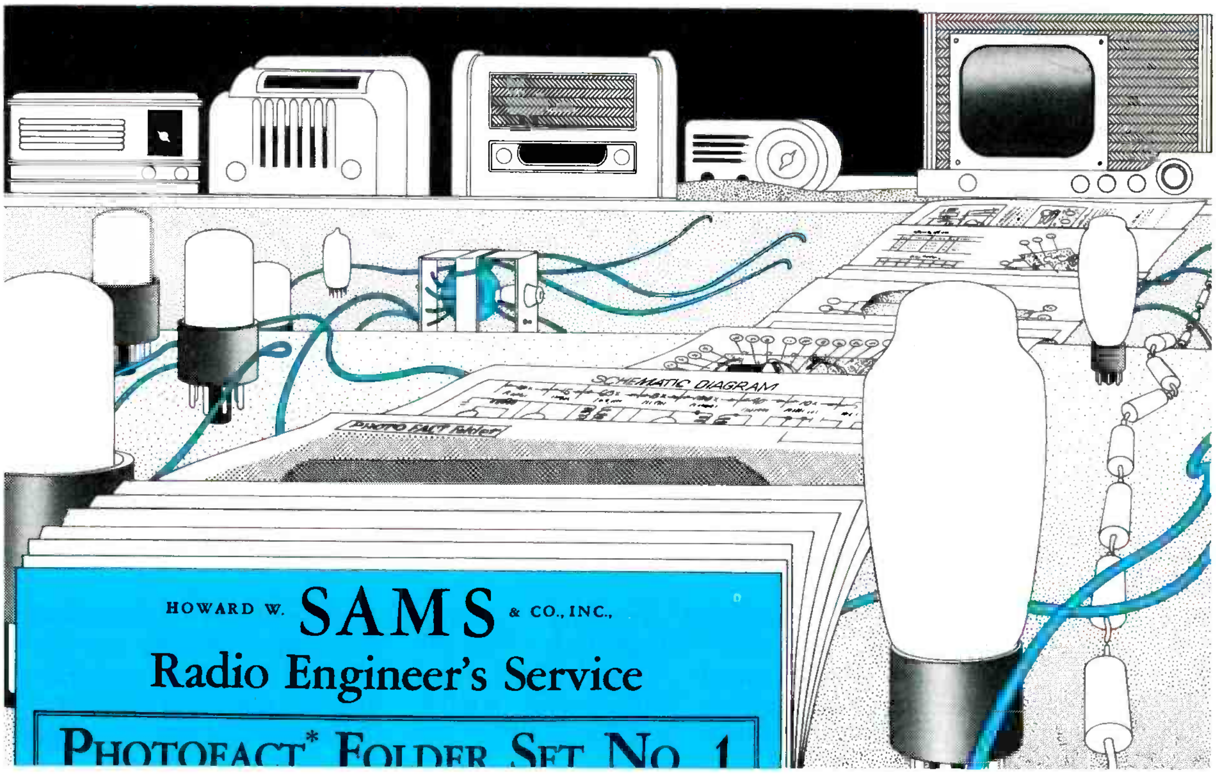

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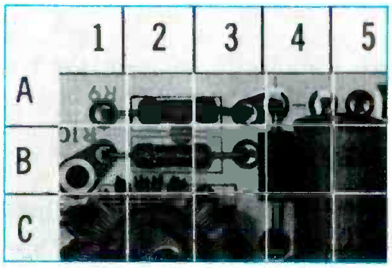

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Voltage regulators for circuit projects

How to customize the output of a 3-terminal IC voltage regulator

By Michael A. Covington

Three-terminal IC voltage regulators have practically all the virtues a circuit builder could wish for. They are inexpensive and easy to use, and they solve a whole set of thorny design problems. A 75-cent IC with three simple connections can replace what would have been a complex, difficult-to-design circuit involving large capacitors, transistors, a zener diode, and perhaps an op amp or two.

In fact, thanks to IC regulators, cheap tape recorders and desk calculators often have better power supplies than were found in even the best laboratory equipment a few years ago, and hum in audio equipment is nowadays almost nonexistent.

What they do

A 3-terminal regulator accepts a widely varying input voltage at its input pin and delivers a constant output voltage at its output pin. The third pin is connected to ground. No extra circuitry is required. For example, the popular type 7805 5V regulator accepts an input anywhere between 7V and 35V (which can be continuously varying) and delivers a rock-steady 5V of output.

IC voltage regulators are good at getting rid of residual ripple on the incoming supply line. For instance, the 7805 attenuates 120Hz ripple by about 80dB. That is, it reduces the ripple to about 1/10,000 of its original amplitude – so small that you can ignore it.

Voltage regulators also eliminate variations in output voltage caused by variations in load current. Most power supplies deliver a voltage that decreases as the load gets bigger. The decrease is due to the internal resistance of the power supply, across which there is a voltage drop proportional to the load current. The voltage regulator makes the power supply look as if its internal resistance were on the order of 0.01Ω; the voltage drop becomes negligible.

And that's not all. Voltage regulator chips include a feature – built-in current limiting – that was previously rare in power supplies of any kind. You can't damage a voltage regulator chip by connecting too heavy a load or even shorting the output. As soon as the chip begins to overheat, it shuts down, cutting off the output current. Because the current limit is set by a temperature sensor built into the chip, it doesn't matter what the ambient temperature is or whether a heat sink is present; the regulator always shuts down as soon as it goes out of its safe operating area. It can stay in shutdown mode indefinitely without damage.

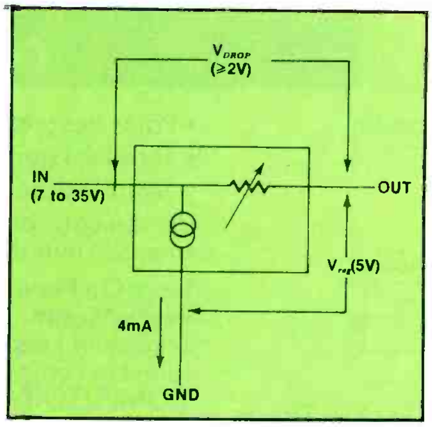


Figure 1. Equivalent circuit of type 7805 voltage regulator.

How they do it

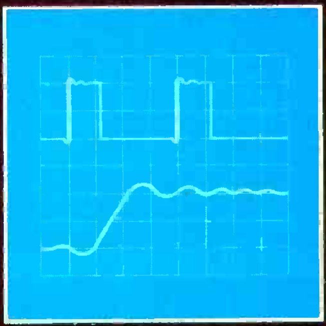
Figure 1 shows a simplified equivalent circuit of a type 7805 voltage regulator. You can think of it as a variable resistance between input and output that automatically adjusts itself to drop exactly the right amount of voltage. For instance, if you have 30V coming in and 5V going out, you need a 35V drop. The resistance needed, in turn, depends on the load current. The voltage regulator chip senses the voltage between the output and ground pins and adjusts the resistance to bring it to the correct value. The only restrictions are that the voltage drop

Type:	LM317T	LM317LZ	LM7805CT	LM78L05
Case style:	TO-220	Plastic	TO-220	Plastic
Typical wholesale price:	$1.19	$0.75	$0.79	$0.75
Regulated voltage (V_R):	1.2	1.2	5.0	5.0
Minimum V_{DROP}:	2.5	2.5	2.0	2.0
Maximum current (at $V_{DROP} = 5V$)				
without heat sink:	400mA	100mA	400mA	100mA
with heat sink:	1.5A	......	1A	......
Maximum dissipation (W)				
without heat sink:	2	0.6	2	0.5
with heat sink:	15	......	20	......
Ground pin current (mA):	0.1	0.1	5	3

Table 1. Characteristics of some popular 3-terminal regulators.

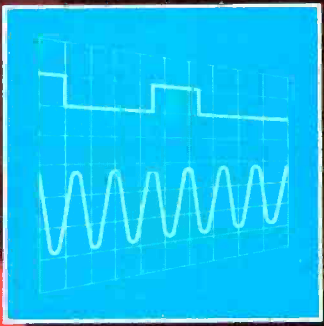
1 mV/DIV
VERTICAL
SENSIVITY

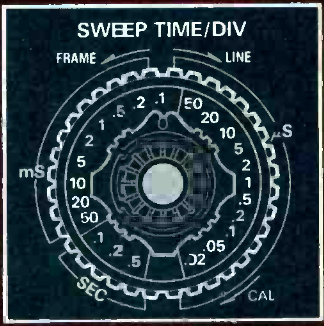
1 mV
VERTICAL
SENSITIVITY



DELAYED
SWEEP
WITH TRACE
SEPARATION

V-MODE
DISPLAYS
UNRELATED
SIGNALS





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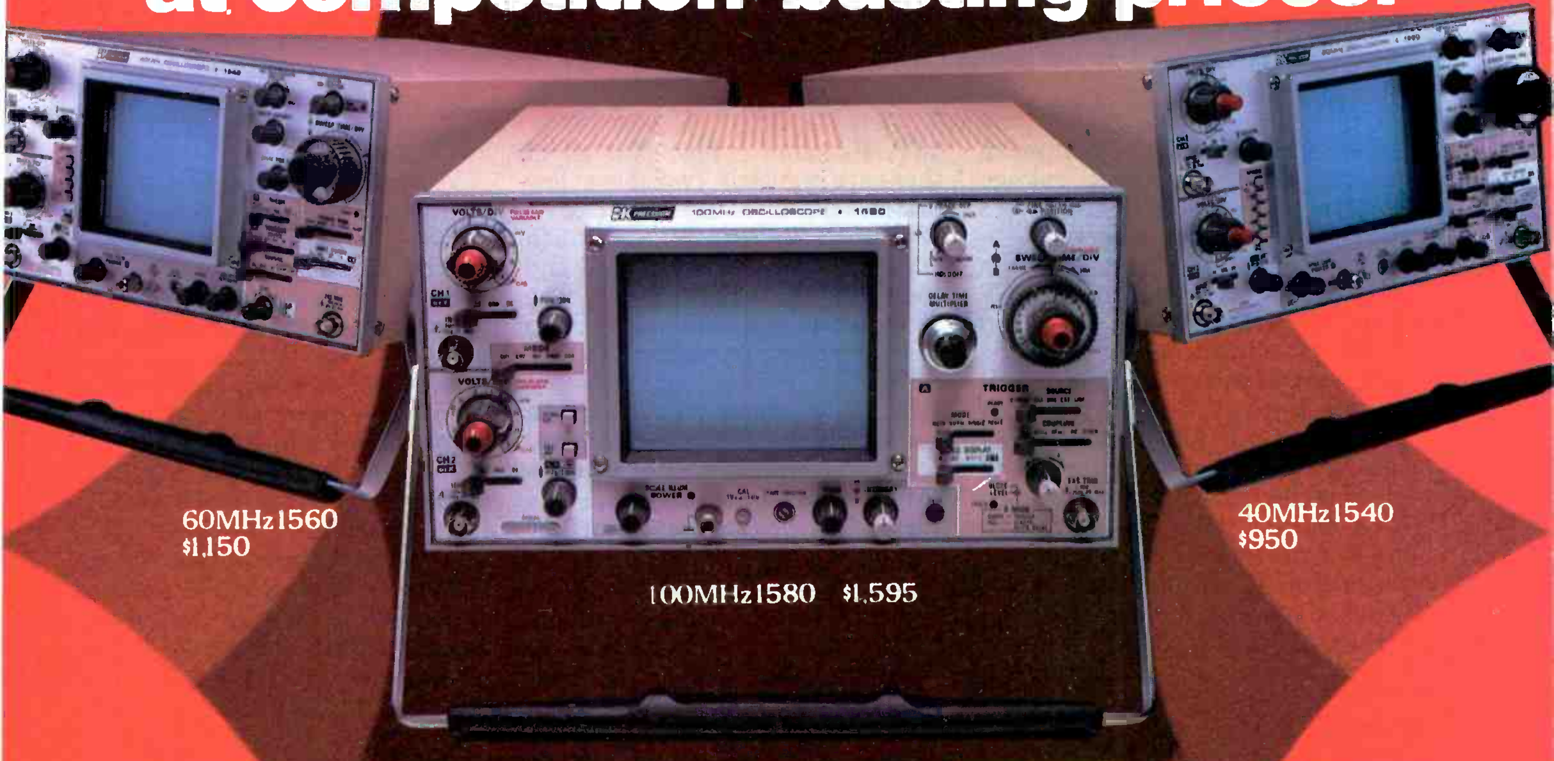

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100MHz 1580 $1,595

40MHz 1540
$950

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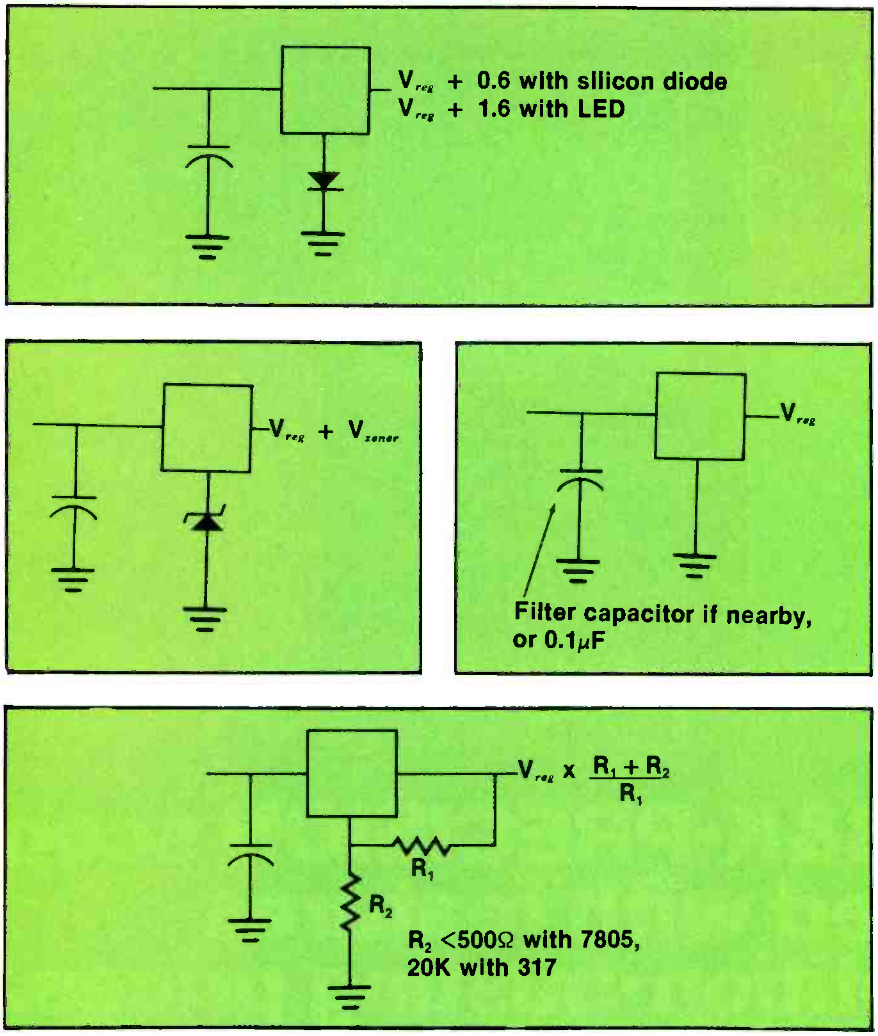


Figure 2. Circuits using 3-terminal regulator chips.

must be at least 2V, and that maximum ratings on input voltage (typically 35V), current and power dissipation must be observed.

Naturally, this voltage drop wastes power. If you have a 5V load drawing 100mA, the load itself is consuming 0.5W. However, if you power this from a 10V source through a 7805, the input current is still 100mA (plus a few mA drawn by the regulator itself), so that the total power consumed is a bit over 1W. The extra half-watt is converted to heat inside the regulator. In situations where this kind of power waste is unacceptable, a different kind of power supply known as *switching regulator* or *dc-to-dc converter* should be used. Unfortunately, switching regulators are difficult to design.

Obtaining nonstandard voltages

Three-terminal regulators are manufactured in a wide variety of voltages: 1.2, 5, 6, 8, 9, 12, 15 and 18V, to name a few. Not all of these are regularly available at low prices. Usually, the 317 (1.2V), 7805 (5V), 7812 (12V), and 7815 (15V) are easier to obtain, and cheaper, than the others. The 7805, which is used extensively in computers, is particularly abundant.

Moreover, sometimes you need a voltage that is not in the standard set, or you need to vary or trim the output voltage. In these cases a customized voltage regulator circuit is the only answer.

The key to customization is to realize that the ground pin of the regulator need not be connected to circuit ground. It can be connected to anything that is at a constant voltage above or below ground. The 7805 maintains the output pin 5V above the ground pin voltage, whatever that may be.

The simplest way to raise the ground pin above ground in a controlled way is to place a voltage drop in the path of the 3mA to 5mA current that flows out of it. This can be done with a germanium diode (0.3V), a silicon diode (0.6V), an LED (1.6V red, 2.1V green), or a zener diode (Figure 2). For example, a 7805 with a red LED in series with its ground pin gives an output of 6.6V – exactly what you need to power a 6V tape recorder or calculator from a 12V automotive supply. In fact, if the LED is a low-current type, it will even glow brightly enough to serve as a power-on indicator (no series resistor is needed).

You cannot simply place a resistor in series with the ground pin if you want good regulation, because the ground-pin current is not quite constant. But you can use a voltage divider to place the ground pin midway between the output of the regulator and true ground, as shown in the last of the four diagrams in Figure 2. The resistor from the ground pin to circuit ground should be below a limit that depends on the type of chip used (500Ω for the 7805; it could, of course, be zero). The value of the other resistor depends on the output voltage desired. The formulas are:

$$V_{out} = V_{reg} \times ((R_1 + R_2)/R_1)$$

$$R_1 = R_2/(V_{out}/V_{reg} - 1)$$

V_{out} must, of course, be greater than V_{reg}. The voltage divider does consume some current, and it reduces the quality of the regulation slightly by allowing variations in ground-pin current to affect the output.

With this in mind, compare the 7805, advertised as a fixed 5V regulator, with the 317T, billed as an adjustable voltage regulator (Table 1). The only important differences are that, for the 317, V_{reg} is lower, so that the output voltage can be as low as 1.2V, and the ground-pin current is much smaller, so that the voltage divider resistors can be larger without introducing a substantial error. Both regulators are equally "adjustable" in that they can be used in the circuits of Figure 2. Where the regulated voltage is above 5V and relatively small divider resistors are feasible, it is often cheaper to use the 7805. ES&T

Test your electronic knowledge

By Sam Wilson, CET

These questions are similar to questions used in the associate-level CET test. All questions in the actual CET test are multiple choice, and a grade of 75 percent or better is required for passing. This month's questions are about basic circuits and components. (Answers on page 59.)

1. By redrawing the circuit in Figure 1 it is easy to see that
   A. the current through R_3 equals the current through R_4.
   B. the current through R_3 is greater than the current through R_4.
   C. the current through R_3 is less than the current through R_4.
   D. there is no current through R_3.

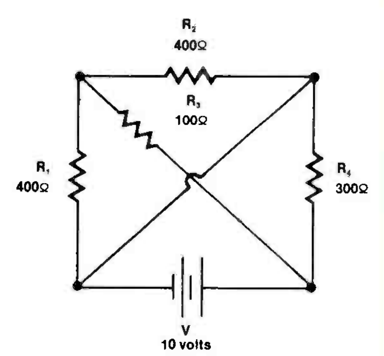


Figure 1

2. Any 2-terminal network composed of linear, bilateral circuit elements and one or more sources of dc voltage can be replaced by the circuit shown in Figure 2. This is
   A. not true.
   B. sometimes true.
   C. Norton's theorem.
   D. Thevenin's theorem.
   E. Kirchhoff's law.

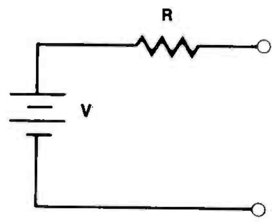


Figure 2

3. Which of the following components produces a voltage that is directly related to the strength of a magnetic field?
   A. CCD.
   B. Thyristor.
   C. Hall device.
   D. Bead ledge.

4. A relaxation oscillator
   A. has a non-sinusoidal output waveform.
   B. has a frequency that is directly related to time constant.
   C. can be synchronized.
   D. can be made with NPN or PNP transistors.
   E. All of the above.

5. Iron is attracted by a magnetic field, but some materials are repelled by a magnetic field.
   A. True.
   B. False.

6. In the circuit of Figure 3, the resistance between points A and B is
   A. 250Ω
   B. 150Ω
   C. 50Ω
   D. 37.5Ω
   E. 25Ω

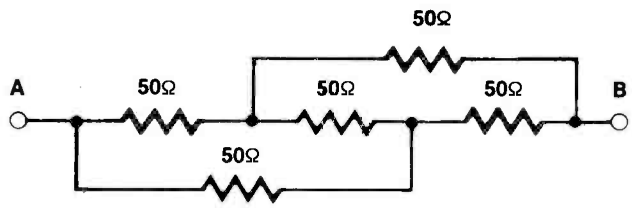


Figure 3

7. Refer to Figure 4. Which of the following statements is correct?
   A. Obviously, the circuit has no practical applications. Diodes allow current to flow in one direction, but that purpose is defeated when 2-way resistors are connected across them.
   B. There is a perfectly good reason to connect resistors across diodes as shown in Figure 4. The circuit has practical applications.

8. Which of the following statements is correct regarding a *bifilar winding?*
   A. It is used to increase the inductance of a coil.
   B. It is a non-inductive winding.

9. In Figure 5 the voltage, inductance values and switches are identical. In the circuit marked B, R = X_L. The switches in both of the circuits have been closed for a long time. Now, both switches are to be opened at exactly the same instant. Which of the following statements is correct?
   A. The induced voltage is the same in each circuit.
   B. The induced voltage is higher in circuit B.
   C. The induced voltage is lower in circuit B.

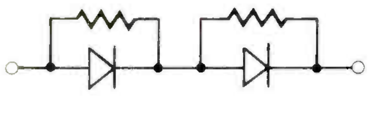


Figure 4

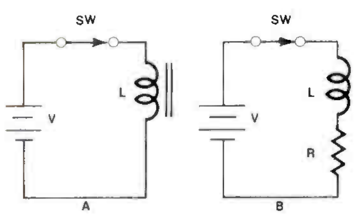
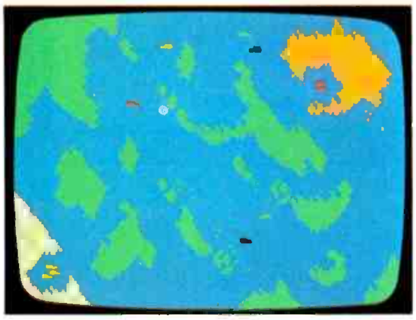


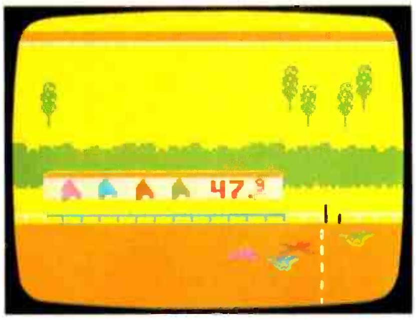
Figure 5

10. Which of the following statements is true regarding a swinging choke?
    A. Its inductance does not change if the amount of current through it changes.
    B. Its inductance *decreases* if the amount of current through it *increases*.
    C. Its inductance *increases* if the amount of current through it increases.

Servicing Intellivision video games

By Tom Strong, Director of Education,
Electronic Servicing Institute, Cleveland, OH





A video game is really nothing more or less than a single-purpose computer with limited input and output options. For that reason, fixing your video game is less involved than fixing a general-purpose small computer, but at the same time it will give you some of the skills and confidence to jump right in when you face a defective computer. And the good news is that you don't necessarily have to go out and plunk down a small fortune on specialized, sophisticated test equipment. Many problems will yield to skillful probing with two familiar pieces of test gear: a good VOM and a high-frequency oscilloscope, such as the Tektronix model 2213, 60MHz scope for measuring digital waveforms.

Figure 1 illustrates the computer operation of the Intellivision video game. Typical microcomputer stages include the microprocessor (MPU) U1, clock generator, read only memory (ROM) and random access memory (RAM) chips, TV interface chip (STIC), and U6, which is the interface between the hand controllers and the computer system.

Game objective

Two hand controllers are provided for the user's communications with the microprocessor, which in turn reacts by changing the video pattern in accordance with the user's input to the game controller and the game cartridge programming. The Intellivision circuits are processed in two ways: one computes the game action against the stored program rules of the game cartridge, and the second interprets a condensed memory area and uses this to generate the TV video display. The second processor fetches moving and background pictures from the graphic memory and presents the data as a video output. The drawing of pictures on the CRT is in accordance with the instructions of the game cartridge program. The microprocessor directs this entire system by sending timed signals to the controller interface and memory.

Microprocessor

The microprocessor is the heart of the system. This 40-pin chip is nothing more than a device that does exactly what it's told, step by step. The instructions given to the MPU are stored in the form of binary codes in memory, which includes the game cartridge. Each instruction directs the processor to perform a single logical operation. Say you're using the Poker game cartridge and you've just won $100. The game's computer adds this amount to your previous total. As another example, if you're playing a game of Blackjack, and your card score went over 21, your hand is completed. The MPU will start performing instructions in another area of memory for the second player.

This last example is a key point: the machine has decision-making capability. Normal program execution proceeds in a single sequential fashion. The first instruction is at location 0, then 1, then 2 and so forth. In Blackjack, the MPU will allow a player to receive cards until the count exceeds 21. At this point, the processor encounters an instruction that says "Branch to location XXXX when total is more than 21." The microprocessor will obey. The first player will no longer receive any cards, and now the second player plays.

The signals in and out of an MPU can be divided into *Address*, *Data* and *Control* groups.

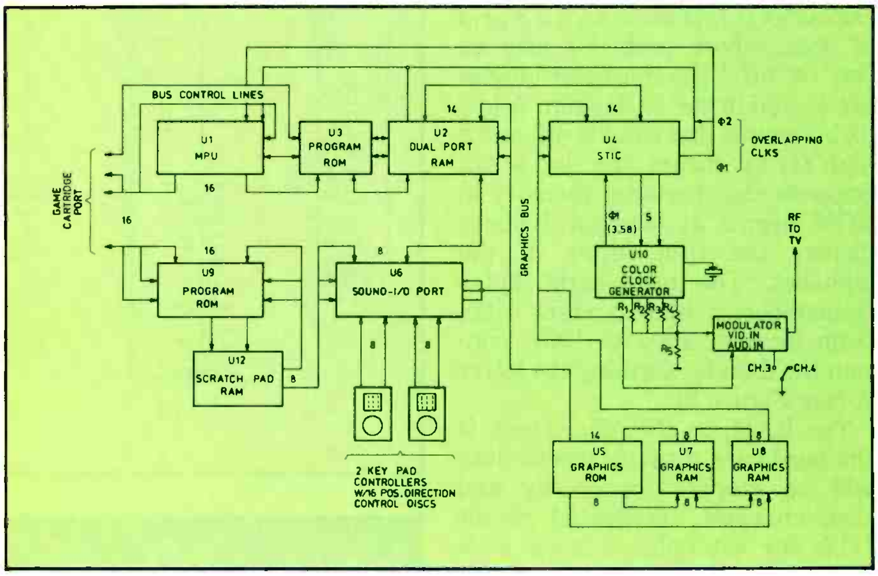


Figure 1. Block diagram shows how functional blocks that comprise the Intellivision video game are interconnected.

Memory Location	Binary Bits in ROM	Image
1000	0 0 0 1 1 0 0 0	• •
1001	0 0 1 0 0 1 0 0	• •
1002	0 1 0 0 0 0 1 0	• •
1003	0 1 1 1 1 1 1 0	• • • • •
1004	0 1 0 0 0 0 1 0	• •
1005	0 1 0 0 0 0 1 0	• •
1006	0 1 0 0 0 0 1 0	• •
1007	0 0 0 0 0 0 0 0	

Figure 2. Characters shown on the game screen are defined by digital information stored in memory. Here, eight bytes define the letter A.

- **Address**—these lines present an address in binary to access certain memory locations according to the game program.
- **Data**—after the information (data) is located in memory, it is transferred to the MPU where it is processed. The result could be the start of a new game, movement of an object on the screen or a change in the game score.

The microprocessor in the Intellivision game (CP1610) uses the same lines for both data and address. These lines are labeled D0 thru D15. The data-address lines are multiplexed or selected as needed.

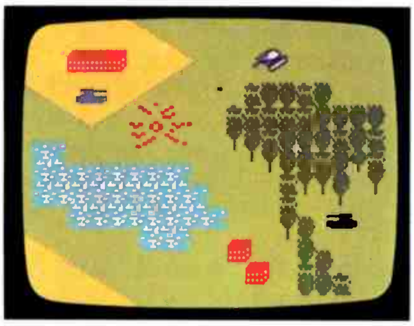
- **Control**—the control signals consist primarily of the two out-of-phase clock signals (Φ1 and Φ2), and the bus control signals BC1, BC2 and BDIR. One clock signal latches the proper address into memory and the other clock pulse retrieves the located data from memory. The clock controls the timing of all movements in orderly fashion. Each movement is timed in sequence. This prevents overlapping of signals and allocates a definite period of time to perform the required task. Without these square-wave clock signals nothing happens; the game or computer is shut down.

The bus control signals are also vital. Their signal codes select either the address or data lines to be functioning on the MPU. The bus controls designate when data is written into memory. Also, the program may introduce a special effect into the game, such as a surprise spaceship flying above. The *interrupt* in the normal program has a bus control code.

Memory chips

The memory circuits contain both ROM and RAM. A ROM memory may be considered to be like a look-up table where information is permanently recorded and may be read out. All the possible functions of the video game are contained in ROM. In a way, this may be likened to a dictionary that has the definitions of every word. The instructions in the game program select only the desired information. The complete ROM memory consists of the game cartridge and ICs U3, U9 and U5.

Servicing Intellivision video games



These *firmware* chips contain the program, game rules, special effects and graphics. For example, suppose the game cartridge program instruction calls for the video screen to display a tank. The location addressed in memory contains a series of bits that create the image of a tank when displayed on the screen. The program lists the proper addresses where this data is located. Some games include the sound of the ring of a bell. In that case, the game cartridge will contain a subroutine that reads the data from ROM to produce a bell-ringing sound.

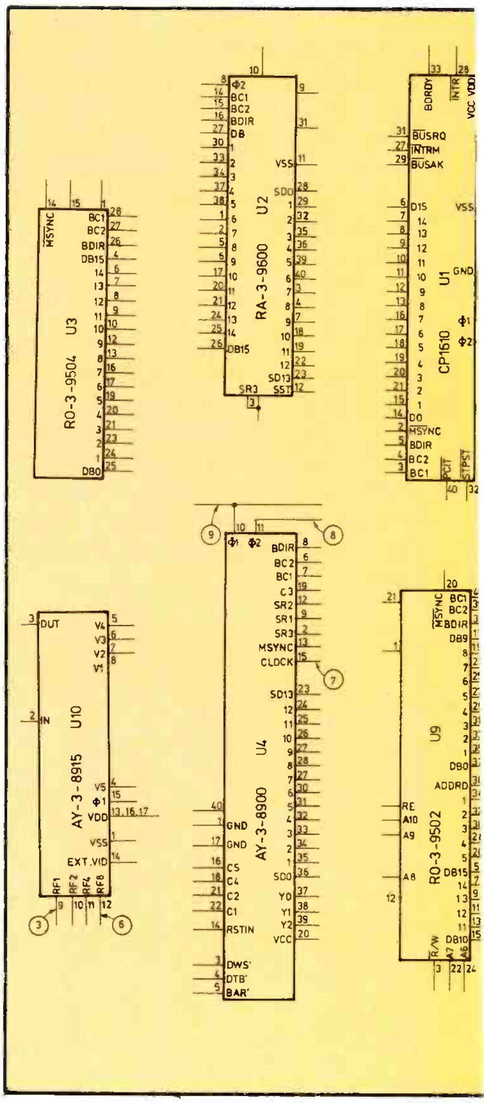
Let's take a simple example to illustrate the workings of a ROM. The program calls for the letter A to be displayed on the screen. Each character is formed in an 8 x 8 grid of dots, where each dot may be "on" or "off." The character images are stored in the ROM chip. A low (0) bit means that a dot is off, and a high (1) bit means the dot is on. Suppose the character memory in ROM begins at location 1000 to display the first letter of the alphabet. The next eight bytes (remember, a byte is eight bits), from location 1000 to 1007, contain the data for forming the letter A (see Figure 3).

The RAM, on the other hand, is the hardware memory where data will be stored temporarily and then changed. Integrated circuit U12, for example, is used as a "scratch pad" memory. One function it performs is to keep score. These functions are temporary and change as the game progresses.

Circuit operation

With power applied, U10 generates the 3.58MHz clock signal to U4, the Standard Television Interface Chip (STIC). Refer to the IC pinout diagram, Figure 3. The two overlapping clock signals are formed by the STIC to synchronize the MPU and the graphics ROM (U5) and RAM (U7 and U8). Instructions from the Program ROMs (U3 and U9) begin operating on commands from the MPU. The program ROMs provide instructions for the MPU to determine whether a game cartridge is inserted.

If a game cartridge is in place, the MPU then gathers data from



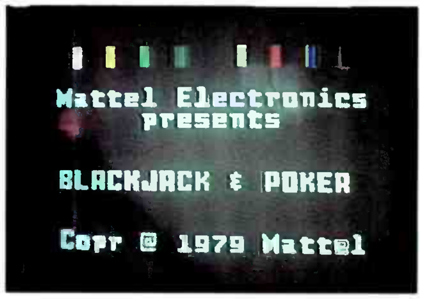


Figure 4. The title page appears on the screen when power is turned on with a game cartridge inserted.

Figure 5. Play is started by pressing any hand controller button.

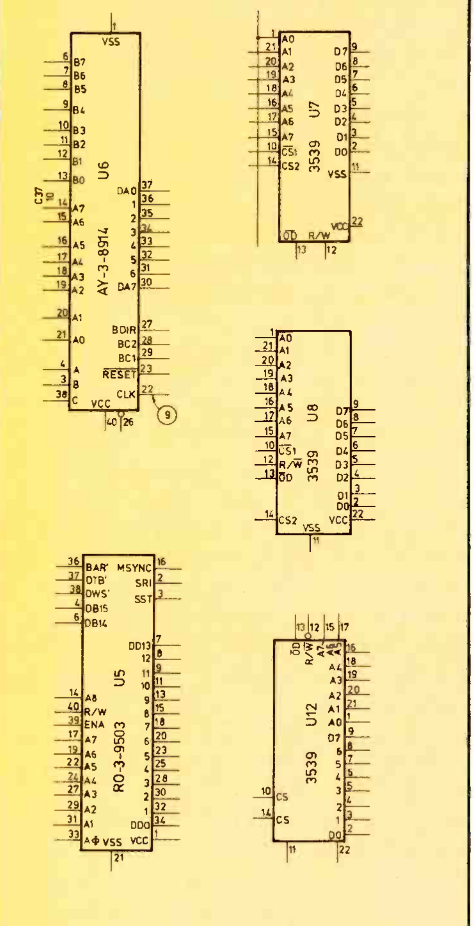


Figure 3. Pinout diagrams of some of the more important ICs in the Intellivision video game.

the cartridge ROM for U2, the dual port RAM which, in turn, passes the graphics information to the 14-bit graphics bus (SD0 thru SD13, U2). This RAM accepts data from U1 via a 16-bit bidirectional bus that is time multiplexed with address and data.

Bus Control 1 and 2 and Bus Direction (pins 14, 15 and 16) comprise the strobe signals from the MPU. The STIC decodes this graphic data and supplies video information such as sync, color burst, luminance levels and chroma to integrated circuit U10, which is a multipurpose device providing clock and color signals. The STIC may also call up a number of graphic shapes and characters from the ROM/RAM graphics. The color IC subsequently converts all coded sync and video information from digital to analog, along with the external resistor network connected to the RF modulator to form the "title page" shown in Figure 4.

The MPU then waits for signals from the two keypad controllers to start the game (Figure 5). This is accomplished by pressing any one of the keypad buttons. The hand controllers load their commands into 8-bit port registers in the sound generator and I/O chip (U6), one port for each controller. The microprocessor scans these registers for game start, speed and object direction. Sound is also generated from U6. Pins 3, 4, and 38 are tied together to provide the analog (sound) output to Q3, which amplifies the audio signal to the modulator. At the modulator, audio and video are combined on carriers for either channel 3 or 4, as selected.

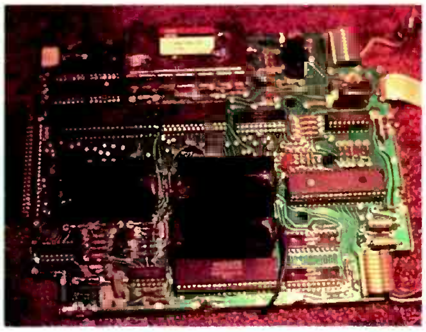


Figure 6. The ribbon connector bridges the power supply to the logic board. U1, U2, U4, and U6 are ICs that are common causes of problems. See text.

Power supply

A ribbon connector bridges the power supply to the main circuit board as shown in Figure 6. This supply provides four separate voltages that can be measured at the ribbon connector:

- 5V regulated for most of the chips
- −3V for U1 and U2
- 12V regulated for U1, the modulator and Q3
- 16V unregulated for Q1 and Q2

The 5V regulator uses a TO-220 casing IC (replacement No. 7805). Its input voltage is about 9V; the output voltage is 5V. The 12V regulator also uses a TO-220 casing IC (replacement No. 7812). Its input voltage is 16V, providing a regulated 12V output.

IC VOLTAGE CHART

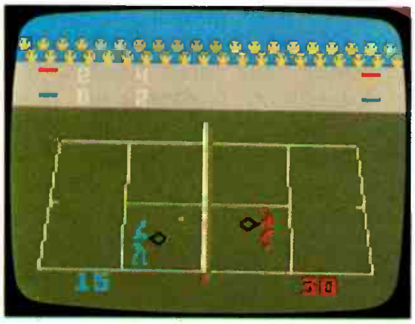
Pin	U1	U2	U3	U4	U5	U6	U7	U8	U9	U10	U11	U12	U13	U14	U15	U16	U17
1	4.6	1.5	5	0	5	0	0	0	5	0	2.4	1.3	3.7	5	5	5	.9
2	5.2	1.9	0	1.4	5.3	0	1	1	4.4	••	5.6	1.7	0	0	0	1	0
3	1	.8	0	.2	4.3	.7	1.3	1.3	4.5	••	2.4	2	4.8	2.9	2.9	3.2	.9
4	.9	.9	.6	2.5	0	.7	1.3	1.3	.1	1.3	5.6	2.2	3.2	5	5	.2	.9
5	.9	1.1	0	1.3	0	0	1.3	1.3	.6	2.4	1.4	1.7	0	0	0	4.2	.17
6	.6	1.8	1.9	.8	0	4.7	1	1	3.3	1.7	.2	1.7	.17	1.9	2.9	5	.9
7	1.9	1.9	1.8	.9	.6	4.7	.9	.9	1.9	1.2	0	1.9	0	0	0	0	0
8	1.8	5.6	1.9	.9	.6	4.7	1	1	3.2	2.4	.2	1.5	1	2.9	2.9	4.8	1
9	1.9	5	1.1	5.3	1.7	4.7	.8	.8	1.8	.7	1.1	1.9	1.9	0	0	.9	1
10	1.1	11	.6	2.4	.1	4.7	3.3	3.3	3.3	.2	.2	.2	.2	5	5	.9	.17
11	.6	3	0	2.4	1.9	4.7	0	0	1.9	.5	1.2	0	5	3	3	3.7	4.4
12	1.8	4.3	1.8	4.8	.4	4.7	4.4	4.4	1.2	1	.2	4.2	.2	0	0	.4	.5
13	1.1	1.4	1.1	5.2	1.9	4.7	4.4	4.4	1.1	5	1.9	4.2	0	5	5	.1	5
14	1.7	1	5.2	5.4	.4	4.7	.4	.4	0	0	5	.2	4.8	5	5	5	5
15	2	.9	0	2.1	.9	4.7	.5	.5	.6	2.1		1.2					
16	1.9	.9	1.9	2.4	5.2	4.7	.7	.7	1.7	5		1.9					
17	1.5	.6	1.5	0	.5	4.7	.5	.5	1.8	5		1.4					
18	1.9	1.9	0	1.7	.8	4.7	.5	.5	1.2	0		1.1					
19	1.7	1.7	1.9	1.3	.5	4.7	1.2	1.2	1.1			1.2					
20	1.7	1.1	1.7	5.5	1	4.7	1.6	1.6	5.2			1.7					
21	2.2	1.9	1.7	1.2	0	4.7	1.7	1.7	0			2.3					
22	1.1	.6	0	2.4	.7	2.4	5	5	1.2			5					
23	2.1	.8	2.2	.6	.9	5.2			1.9								
24	.7	1.8	2	.6	.5	.1			1.4								
25	1.2	1.9	1.7	1.7	1	4.7			1.5								
26	0	.6	.9	1.9	0	3.7			1.9								
27	5.3	1.7	.8	1.9	1.2	.9			1.9								
28	4.7	1.8	.9	.9	1.3	.8			1.1								
29	4.3	2.4		.8	1.6	.9			1.7								
30	0	2		1	1.3	1.9			1.2								
31	4.8	0		.9	1.7	1.5			1.7								
32	5	2.3		1	1.3	1.9			1.7								
33	5	2.2		1.3	0	1.7			2.2								
34	5	1.7		5	1	1.7			2.3								
35	3	1.3		2.4	0	2.2			2								
36	12	1		1.8	1.3	2			1.3								
37	5.6	1.7		1	2.5	1.7			1.7								
38	5.6	1.9		1.3	.2	.7			.9								
39	0	.9		1.3	3.3	0			.8								
40	4.7	1		3	4.4	5			.9								

Figure 7. IC voltage chart. Readings are with reference to ground measured with a DVM.

Troubleshooting

When the game console is turned on with a game cartridge inserted, the title page of the game appears on the TV screen. To start the game, press any button on either hand controller. This will cause the game program to be switched on from the title page. As mentioned in the circuit description, IC U6 serves as the interface between the hand controllers and the MPU. Pins 6 thru 21 on U6 are

Servicing Intellivision video games



connected to the two hand controllers. Notice on the IC voltage chart in Figure 7 that these 16 pins read HIGH (4.7V). When one of the pins is brought low (0V) by pressing any button, the game is enabled.

The most common difficulty in the Intellivision game is the inability to switch from the title page to the game program. If any of pins 6 through 21 read low when the unit is turned on, the title page cannot be switched to the game program. This could be caused by either a shorted hand controller or defective U6. A less likely cause would be any one of capacitors C34 to C39 shorted to ground.

The two hand controllers can cause problems because of continuous hard use. On each hand controller (Figure 8), there are 17 buttons (switches) located on a plastic matrix. When defective, this switch assembly can be replaced as a single unit. Bad connections and broken wires are other problems associated with the controllers. A check of continuity of the wires can locate this defect.

It is possible that some buttons on the controller may function and others may not. Figure 9 shows what hand controller buttons are connected to U6 and the individual IC pins. Pins 6 thru 21 are normally high; the chart shows which pin goes low corresponding to the controller buttons when pressed.

Another common problem is a blank white screen (no video and no snow). This is the most difficult symptom to diagnose because almost any of the unit chips can cause a blank screen. (The exception is U6 – experience has shown when this chip is defective only the title page will appear.)

Troubleshooting steps

These steps assume that power supply voltages are normal.

- Check both clock pulses at MPU (U1) on pins 37 and 38. They should read 13V peak to peak. If readings are normal, this clears U4 and U10 because U10 (color IC) generates the master clock pulse, and U4 (STIC) forms the two out-of-phase clock pulses. *Notice:* The two clock pulse outputs of U4 (pins 10 and 11) are 5V, and at the MPU they read 13V. Buffer IC U11's open collector design develops this larger voltage going to the microprocessor. Also, if the clock signals and DC voltages are normal at the MPU, the probability is that U1 is OK.
- Check pin 2 at the MPU (M sync). It should read 5Vdc, and when RESET is pressed a momentary low should be recorded. The reset switch when activated sets the program counter to a known location in ROM, which causes the title page to appear.
- Check the 16 data lines and bus control lines (pins 3, 4, 5) at the MPU for waveforms on the 5V range of the scope. It is impossible with an oscilloscope to ascertain if the shapes of the data and bus control signals are correct. The waveforms will look strange. Fortunately, you're only concerned that there are signals present at these pins. If so, you can then feel confident the system is working at these stages. If the signals are missing, a shorted chip directly connected to these lines is loading down the MPU. Suspect U2 (RAM), U12 (RAM), U3 (ROM), or U9 (ROM). Remove one chip at a time and recheck if the data and bus control signals appear at the MPU.
- If the data and bus control lines are normal at the MPU, trace the BC1, BC2, and BDIR signals to U16 (nand gate), U13 (nor gate) and U17 (exclusive or gate). These bus control signals continue to the game cartridge socket on pins 32, 34 and 36. Here they are distributed to U3 and U9 (program

Figure 8. The hand controller is the player's input device to the game.

ROMs), U4 (STIC), U6 (controller – sound chip).

Figures freeze or wrong sequence of events

In some cases, while playing the game the figures on the screen won't move, or there is an improper sequence of events, or the letters and images on the screen are inaccurate. These symptoms all point to a "senile" memory. Try replacing U2, the dual port RAM.

Snow on screen

This symptom suggests little or no modulated video signal is being received at the TV's antenna input. This series of troubleshooting steps should isolate the problem:

- Substitute another antenna game switch
- Substitute antenna coax cable
- Check if modulator output jack is loose
- Check game's channel selector switch.

No audio

- Measure the voltages on Q3, the audio amplifier
- If there is no sound when a hand controller button is depressed and a waveform is scoped at the audio input to the modulator, this suggests the modulator is defective.

Controller A, right (Referring to UG pinout diagram)

A0, Pin 21 correspond to buttons	1,2,3
A1, Pin 20 correspond to buttons	4,5,6
A2, Pin 19 correspond to buttons	7,8,9
A3, Pin 18 correspond to buttons	clear, 0, enter
A4, Pin 17 correspond to buttons	disk
A5, Pin 16 correspond to buttons	3,6,9, enter, left side top and bottom, right side top
A6, Pin 15 correspond to buttons	2,5,8,0, left side bottom, right side bottom
A7, Pin 14 correspond to buttons	1,4,7, clear, left side top, right side top and bottom

(On the circuit board, controller A socket is located in front of two chips.)

Controller B, left

B0, Pin 13 correspond to buttons	1,2,3
B1, Pin 12 correspond to buttons	4,5,6
B2, Pin 11 correspond to buttons	7,8,9
B3, Pin 10 correspond to buttons	clear, 0, enter
B4, Pin 9 correspond to buttons	disk
B5, Pin 8 correspond to buttons	3,6,9, enter, left side top and bottom, right side top
B6, Pin 7 correspond to buttons	2,5,8,0, left side bottom, right side bottom
B7, Pin 6 correspond to buttons	1,4,7, clear, left side top, right side top and bottom

(On the circuit board, controller B socket is located next to the power supply **ribbon connector).**

Figure 9. Hand controllers are connected to U6 (Sound-I/O Port) as shown by this chart.

Circuit layout

Address, data and bus control signals are present on all chips when the game cartridge is inserted. *Without the game cartridge,* the data and address signals are not present at any of the video and graphic chips (STIC, U4; graphics ROM 9503, U5; the two graphics RAM chips 3939, U7, U8; and output pins of the system RAM 9600, U2). Also, without the game cartridge the bus control signals do not go any further than the output of U17 (exclusive or gate). Therefore, U6, U4, U9, and U3 will not receive the bus control signals without the game cartridge inserted.

In summary, without the game cartridge, only the chips whose lines are directly coupled to the MPU will receive signals. The game socket (J1) has 44 pins. Only the odd-numbered pins are accessible from the top of the circuit board with the scope (pins 1, 3, 5 etc. to 43). Q1 and Q2 along with zener diodes CR2 and CR5 regulate the B+ for pins 37 and 38 (clock inputs) at the MPU.

Comments

Probably, the most frequent part replacement you will make is the matrix plastic switch assembly inside the hand controller. One known video game parts distributor that sells them is:

Best Electronics
4440 E. Sheena
Phoenix, AZ 85302

There are four ICs that have a history of failure (Figure 6). They include in order of likely failure: U2 – dual port RAM, U6 – Sound-I/O, U4 – STIC and U1 – the microprocessor. These 40-pin chips are manufactured by the same company:

General Instrument
600 West John St.
Hicksville, NY 11802

ES&T

What do you know about components?

There's more to those circuit elements than meets the eye

By Sam Wilson, CET

> This is the first in a series of articles on components and their uses in fundamental circuits. If you would like to have any particular components discussed, write to Sam Wilson in care of Electronic Servicing & Technology, P.O. Box 12901, Overland Park, KS 66212. He will do his best to make this series a response to your requests.

The most common resistor in electronic circuits is the *carbon composition* type. It has looked about the same, and has been used for the same applications for many years.

There has been a slight change in the appearance of the color code. A fifth band now gives reliability information.

I'm told they are no longer making carbon resistors with a 20 percent tolerance. A few years ago, I tried to order five thousand 20 percent 10K resistors and I was told there was no such thing. The cheapest I could get were 10 percent tolerance.

There is no mystery about why carbon composition resistors are most popular. They are the cheapest production type you can buy. Also, they come in a wide range of values (1Ω to more than 20MΩ). They can be bought in tolerances of ±3 percent, ±5 percent, and ±10 percent.

The disadvantages of these resistors are high noise and high temperature coefficient. Both factors become *very* important when the resistor temperature gets above 60° Celsius.

If you're looking for a high resistance value in a small package, you will probably choose a *carbon film* type. They can be bought in values up to 100MΩ, and down to 10Ω. You can get them with a closer tolerance – in fact, down to ½ percent, but you pay more for that.

Compared to carbon composition resistors, the carbon film type generates less noise. That could be an important thing to remember if you need to replace one – especially in an RF or IF amplifier circuit. Carbon film resistors have a negative temperature coefficient. That could also be an important factor when a replacement is necessary. Reversing the temperature coefficient could produce an undesired effect in an oscillator circuit, or for the emitter temperature compensating resistor of a bipolar transistor.

If you want low noise and a low temperature coefficient, and cost is not a factor, you might choose a *metal film* resistor. They come in lower resistance values from 0.1Ω to more than 1MΩ. *Never* replace a metal film resistor with a cheaper carbon type. Metal film resistors can be purchased in 1/10 to 1W sizes.

Wirewound resistors come in power ratings as low as ¼W, and as high as 200W. If you need a non-inductive type, use one with a bifilar winding. Wirewound resistors are best known for producing less noise than carbon composition types. Also, they can be purchased with a very close resistance tolerance.

As a general rule, you can replace a less expensive resistor with a more expensive type. You should *not* go the other way.

Uses of resistors

Resistors are generally used for

- limiting current
- producing a voltage drop
- generating heat

Don't write and explain that they are also used as coil forms in peaking coil construction. Also, you needn't write and explain that they are good noise generators. When I give the three general uses of resistors I am not referring to those specialized applications.

Sometimes, we are misled about the uses of resistors when they are given names such as

- surge limiters
- parasitic suppressors
- swamping resistors
- bleeders
- pullup or pulldown resistors

I am *not* arguing against the use of these terms. My point is that all of these applications fall into one or another of the three basic uses. By looking at it in that way it will be easier to analyze circuits that you are seeing for the first time.

Resistor noise

As a general rule, you can assume that any resistance in a circuit is a noise maker. Sometimes this noise is hard to measure, and it may even be hard to detect, but it is always there.

Suppose you have a communications receiver that receives local stations with acceptable performance. You decide to add an external antenna. Do you realize that the antenna resistance will add noise to the total receiver system?

That is hard to understand because the increased signal strength improves the signal-to-noise ratio. However, that does not mean the noise has decreased. It just means that the signal *and* noise have increased, but the signal increased more than the noise. The point of this is, when you are considering the effect of resistance in a circuit, there are places you have to look besides the resistors.

Surge limiting resistors

In the half-wave rectifier of Figure 1, the electrolytic capacitors will charge in a few cycles after the switch is closed. The charging current can reach values of 20A to 100A in circuits that do not have a surge-limiting resistor. The short-term current can easily destroy the diode.

The real purpose of R_s is to limit the charging current. The high voltage drop across R_s during charge reduces the actual voltage across the capacitor. Because it is charging to a lower voltage, the capacitor current is reduced.

The value of R_s is usually below 100Ω. It may serve as a fuse for the supply, so you should never install a replacement that has a higher power rating.

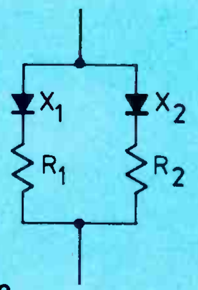


Figure 2

Startup resistors

When diodes are connected in parallel, as shown in Figure 2, it is necessary to use series resistors. Diodes are not perfectly matched, so it can be assumed that one has a lower forward voltage drop. As an example, suppose X_1 has a forward drop of 0.6 volts and X_2 has a forward drop of 0.7 volts. If the resistors are not present, X_1 will start to conduct first. Because the drop across X_1 is less than the forward voltage needed to start X_2, it follows that X_1 will hog all of the circuit current. It will burn out because the reason for putting diodes in parallel is that a single diode cannot handle the current.

With the resistors in place, the drop across the parallel circuit will always be high enough to start both diodes. Starting resistors must also be used for parallel-connected tubes and transistors. Their purpose, as in Figure 2, is to introduce a voltage drop.

In the circuit of Figure 2, the resistors may also serve as fuses. If one diode opens, all of the current will flow in the other one. If the power rating of the resistor is low enough, it will burn out and protect the more expensive diode. To be on the safe side, never replace the resistor with one having a higher power rating.

Equalizing resistors

Diodes are connected in series to increase the peak inverse voltage rating of the circuit rectifiers. As shown in Figure 3, equalizing resistors may be connected in parallel with the diodes. They are necessary because the reverse resistances of the diodes are not matched. If X_1 has twice the reverse resistance of X_2, then it will have twice the reverse voltage across it. By connecting high-resistance resistors, such as R_1 and R_2, across the series combination, the reverse voltages across the diodes are made more nearly equal.

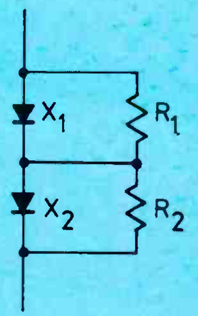


Figure 3

Swamping resistors

A high Q is a detriment to the broad tuning that is often needed in certain industrial and consumer circuits. A swamping resistor is connected across the tuned circuit to broaden its response. Figure 4 shows an example of this connection.

Remember this important relationship: The *lower* the value of resistance, the *more broadly* the circuit tunes. Think of it this way: If the resistance is so low it is a short circuit, then the circuit will have the frequency response of a straight piece of wire.

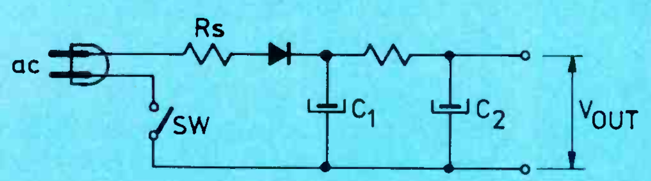


Figure 1

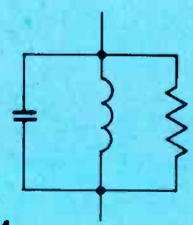


Figure 4

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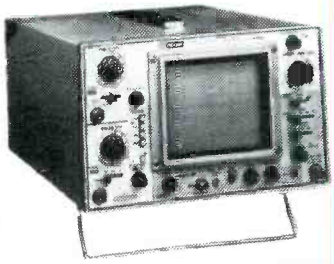

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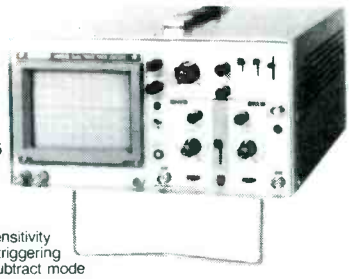

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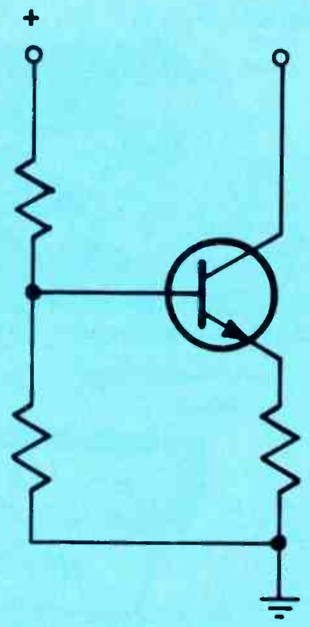


Figure 5

Pullup resistors

The transistor circuit of Figure 5 has an open collector. Many integrated circuit devices are made this way. You cannot make the transistor operate unless you connect a resistor between the collector and positive supply terminal. That resistor serves two purposes. It acts as a collector load resistor, and it produces a positive voltage to the collector for transistor operation. In some literature it is called a *pullup resistor*. Its true purpose is to provide a voltage drop.

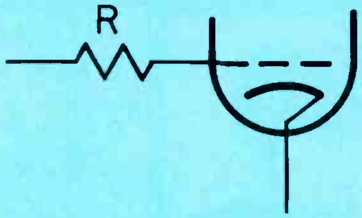


Figure 6

Parasitic suppressors

This resistor has been replaced in modern circuits by a ferrite bead, but there are still many of them around. The one shown in Figure 6 is connected to the grid of a vacuum tube. The distributed capacity and self-inductance of a tube (or transistor, or FET) circuit can produce feedback paths that turn the amplifier into an oscillator. The parasitic suppressor greatly reduced the likelihood of such oscillations.

Current sensors

To make it possible to display current on an oscilloscope, a small resistor is connected in series with the current. The purpose of the resistor is to introduce a voltage drop. If a 1Ω resistor is used, the current is numerically equal to the voltage drop. The current can be measured with the same technique used for voltage measurement. Current sense resistors are also used in regulated power supplies. The sense resistor is in series with the supply load. It converts the current to a voltage used for regulation.

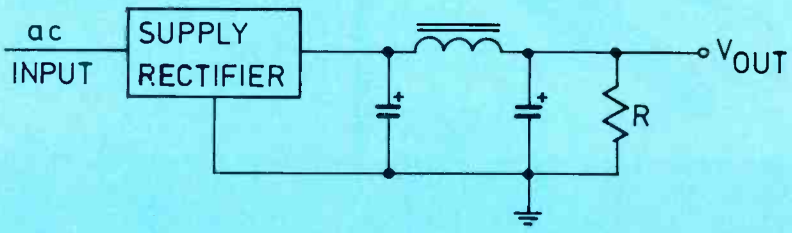


Figure 7

Bleeder resistors

The purpose of the resistor in Figure 7 is often stated to be "to discharge the capacitors." The resistor is said to bleed off the capacitor charge. There is another important function that is not always mentioned. This resistor is in parallel with the load resistance of the supply. If it is designed so that no less than 10 percent of the load current flows through it, the bleeder will improve the regulation of the supply. (The *regulation* of a supply is a measure of how well it maintains its output voltage when the load current is changed.)

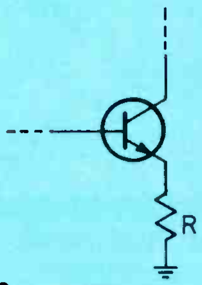


Figure 8

Temperature stabilizing resistors

If you define bipolar transistor bias as the forward base current required to get the transistor into operation, then R of Figure 8 is definitely *not* a bias resistor. As a matter of fact, the resistor has the opposite effect of providing bias.

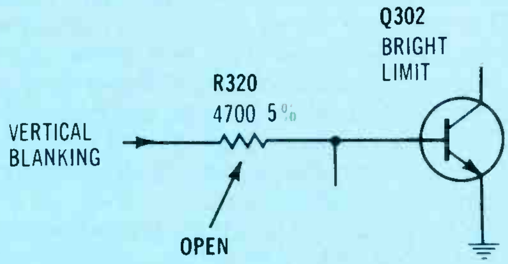
Actually, the resistor stabilizes the transistor amplifier against changes in temperature. An increase in temperature causes the transistor to conduct harder and increases the forward bias. The increase is current causes a greater drop across R and reduces the forward bias. Without R, a thermal runaway could occur. That is an unchecked increase in forward bias that accompanies an increase in transistor temperature.

There is another purpose for the resistor: It provides degenerative current feedback, reducing the gain of the amplifier, but broadening its frequency response. This assumes the resistor is not bypassed with a capacitor. ES&T

Symcure

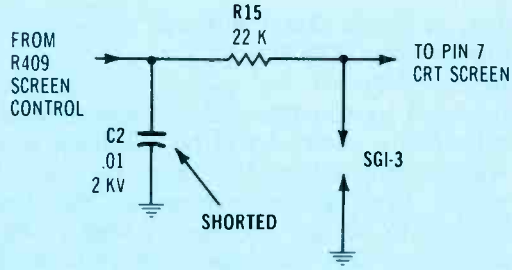
Symptoms and cures compiled from field reports of recurring troubles

Chassis – RCA CTC60 1
PHOTOFACT – 1330-2



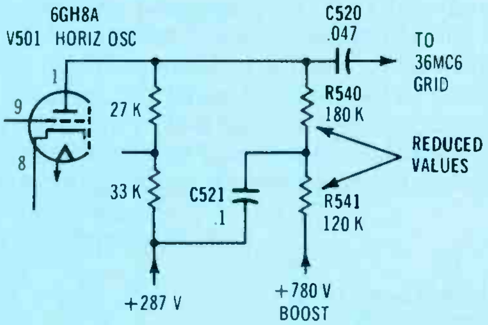
Symptom – Height changes with brightness or contrast
Cure – Check resistor R320, and replace it if open.

Chassis – RCA CTC101C 2
PHOTOFACT – 1945-2



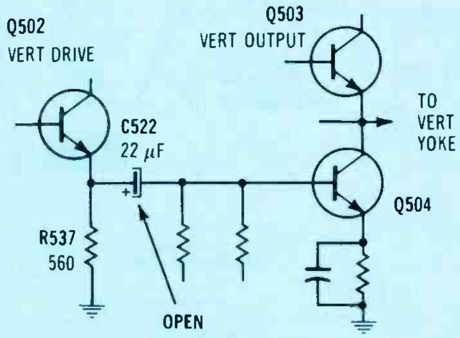
Symptom – No brightness, but HV is normal
Cure – Check C2 on PW5000 board, and replace it if shorted.

Chassis – RCA CTC53 3
PHOTOFACT-1452-3



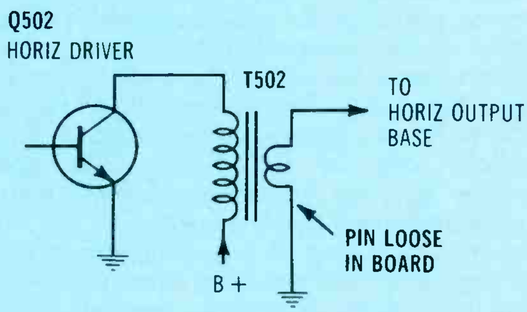
Symptom – Parasitic oscillation (Christmas tree) when changing channels
Cure – Check plate resistors R540 and R541, and replace them if out of tolerance.

Chassis – Sony 63A 4
PHOTOFACT – 1503-1



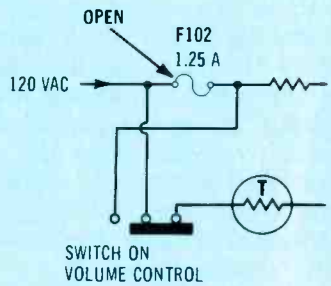
Symptom – Insufficient height
Cure – Check C522, and replace it if partially or completely open.

Chassis – Quasar TS958 5
PHOTOFACT – 1648-2



Symptom – Intermittent shut-down
Cure – Visually examine all T502 pins, and resolder any bad joints.

Chassis – RCA CTC62 6
PHOTOFACT – 1345-2

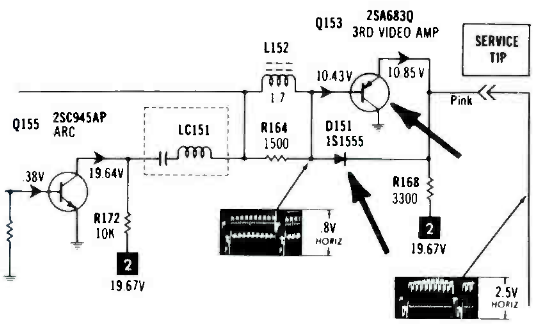


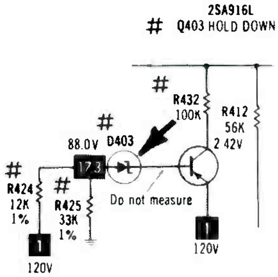
Symptom – Picture lights up slowly
Cure – Check fuse F102, and replace it if open.

Troubleshooting Tips

No raster, or blank raster without picture
Sears model 564.42220702
(Photofact 1763-2)

When turned on, sometimes the screen showed no light, but when a raster could be obtained, it was blank without any video. I decided to check the blank raster first. After turning on the power several times to obtain a raster, I tested the dc voltages at the picture-tube base (grid, cathodes and screen) and found they were about normal. Dc voltages at bases of the R/G/B output transistors also were in tolerance. Evidently, the video signal was lost in some video stage.





Moving back to the third video-amplifier transistor, I measured the dc voltages of Q153 and found a problem. Both the base and emitter measured +10.9V. Therefore, Q153 had zero forward bias and could not amplify the video signal. There was a possibility that the transistor was shorted, so the Q153 base lead and the anode lead of diode D151 were disconnected from each other and the circuit. The B/E junction of Q153 checked normal, but diode D151 had almost a dead short. Installation of a new diode (and restoration of other disconnected leads) brought back the missing video.

Unfortunately, the receiver continued to produce a raster about one time in every three attempts. Then I noticed that the rustling sound of high voltage was heard each time, whether or not the picture came on. But failure to produce a raster was accompanied by zero high voltage. This strongly indicated start-up closely followed by shut-down, and shifted my attention to the shut-down circuit. Base of Q403, the hold-down transistor, was marked "Do not measure" on the schematic. I could see no source of voltage high enough to harm my meter; nor could I see any way that connecting a meter there could harm the circuit. So I touched a meter probe to the Q403 base. *Instantly, the receiver shut down.* I concluded that this must be a very sensitive circuit if a 20MΩ meter load would trigger it. I disconnected 1% resistors R424 and R425 and tested them, but they were well within tolerance. Zener diodes have given trouble before many times, so I replaced zener D403 (although it tested perfect) and (*surprise*) the raster and high voltage started dependably each time power was switched on.

While trying all the functions and adjustments, I noticed the tint, color and volume controls were erratic when rotated. I removed the tuner assembly and cleaned and lubricated them. After the tuner assembly was reinstalled, the controls operated dependably, but the electronic tuner was on channel 11. Touching other channel buttons switched to those channels, but as soon as my finger was removed from the button, the tuner jumped back to channel 11. I wondered if static electricity had zapped the channel-memory IC, and I replaced it without obtaining any improvement. Then I remembered that the lubricant I used on the controls would detune a tuner oscillator if it reached certain tuner capacitors. Perhaps some spray had overshot the controls. I gave the memory circuit board a thorough cleaning, and all operations finally were normal. This proved I should always be alert for technician carelessness, including my own.

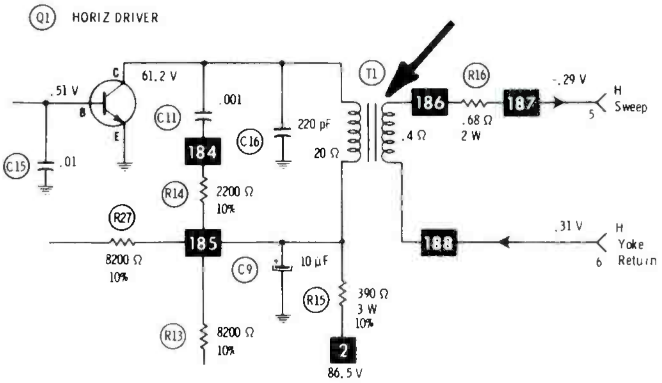
Roger Redden, CET
Beaver, West Virginia

Audio without raster
Magnavox T991
(Photofact 1684-1)

When tested on the bench, this receiver had sound but no picture or raster. Usually, a loss of high voltage is the cause. That was true here, but none of the usual measurements identified the problem's origin.

T201 flyback, D100 tripler and C220 (the 4-lead *safety* capacitor, which has had a high failure rate) all checked good. Scoping the horizontal oscillator showed it was operating, so the start-up circuit was operating properly. But measurements of dc-supply voltages on the voltage-regulator board pointed to problems there. Voltage of the +151V source was normal, but at the +24V source, I found only about +12V. Of course, I immediately thought a defect in the 24V regulator had reduced the voltage. However, Q10, Q9, Z2 diode and other regulator components were in good shape.

This was confusing. A regulator circuit with all good components should not produce a half-voltage output. Analysis by scope waveforms appeared to be the next logical step. Because +259V and +24V sources are produced by rectification of flyback horizontal pulses, I scoped the D10 and D11 anodes, finding the expected pulses, but the amplitudes were lower than normal and distorted. The next step was to scope the Q103 horizontal-output stage. The Q103 base waveform was about half the proper amplitude with serious distortion. At first, I thought the lower drive was due to the reduced +24V supply, but the second thought canceled that, for only the oscillator is powered from +24V.



Q1 horizontal-driver waveforms were scoped. Base waveform and collector waveform were almost normal. However, the T1 driver secondary waveform was weak and distorted. At this point, I changed to my DMM and measured the T1 resistances. The secondary resistance was about right, but the primary measured about 8Ω rather than the specified 20Ω. Replacement of T1 horizontal-driver transformer brought back the picture, gave correct waveforms at Q103 base and anodes of D10 and D11, produced average high voltage, and the 24V source measured +24V.

B.H. Mineer
South Portsmouth, KY

Erratic loss of sound and picture
General Electric 10JA
(Photofact 1339-3)

An IF or tuner problem was thought to cause the total loss of video and audio signals that occurred intermittently but very frequently. However, an exchange of the tuner did not solve the problem. Next, I cleared the IFs of suspicion by injecting a modulated IF signal at the IF input plug. The pattern stayed steadily on the screen.

A similar receiver (but with a different problem) was in the shop at the same time, so I removed IC101 from the other chassis and installed the IC in this chassis, as a test. The intermittent loss of signal continued unchanged, so the ICs were returned.

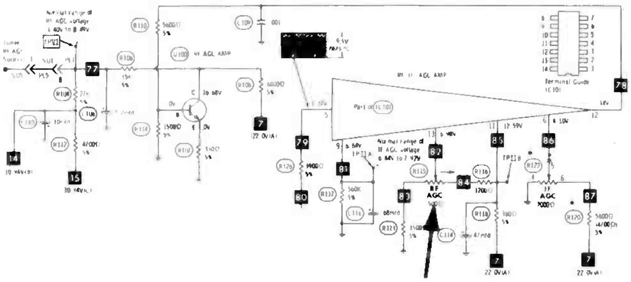
Several times when the IF signal was missing, I noticed that the RF AGC voltage would drop to near zero and then become negative when the signal disappeared. I concentrated on the AGC circuit, measuring many resistor values, substituting several electrolytic capacitors, and testing Q100 (the RF-AGC-amplifier transistor) out-of-circuit. Heating and cooling were applied alternately several times. Unfortunately, none of these tests pinpointed the defect or stopped the intermittent symptom.

Substitution of several AGC voltages was attempted next. An external voltage of about +5V was connected to testpoint VI (junction of C106 and R106), and the picture was steady for the first time during the tests. Measurements of the −10.94V and

+22V supplies showed the negative voltage was within tolerance, but the +22V supply was about +19V. However, this +19V reading did not change when the picture disappeared or when the AGC clamping provided steady operation. Therefore, the low supply voltage apparently was not a factor in the erratic picture.

Because bad solder joints are always a possibility, I checked and resoldered several joints, but with no improvement. I adjusted the R115 RF-AGC control (while the receiver was working normally) and found the rotation provided normal results (from almost overload at one end to picture snow at the other). R115, therefore, was dismissed as a possible cause.

I measured all dc voltages at the IC101 pins when the receiver was operating and when it had no picture. These readings showed significant changes only at pins 12 and 13. The pin-12 voltage *should* change when the signal strength varies. But, pin 13 should have little or no voltage variation from signal-strength changes. This condition demanded an investigation.



Voltage changes at pin 13 can occur from excessive IC101 current, erratic resistance in any of four resistors (R113, R115, R116 and R118) or leakage in C114. Potentiometer controls become intermittent more often than do fixed resistors. So, although R115 AGC control had been tested partially before, I removed R115 and measured the resistances between the three pins while the control was rotated. Occasionally, the resistance between the center lug and the other two would open. *R115 was intermittent.* Replacement of R115 and adjustment for minimum snow (on medium-strength station signals) eliminated all intermittent sound and video symptoms.

Michael B. Danish
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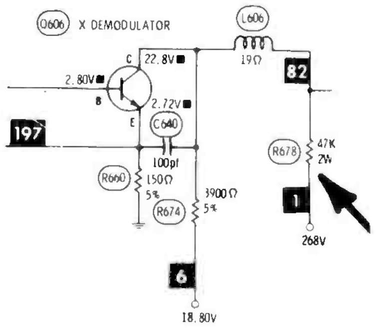
Poor height and linearity
Sylvania D16-2
(Photofact 1325-2)

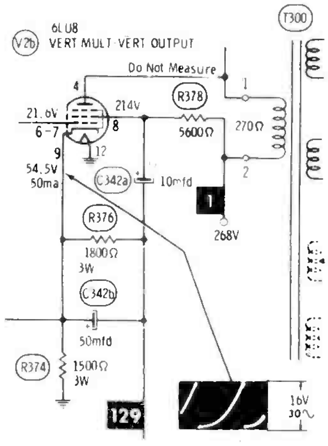
Replacement of the 6LU8 vertical-oscillator/vertical-output tube in the D16 old model Sylvania color receiver and adjustment of the height and linearity controls failed to provide normal height, linearity and vertical locking.

Dc-voltage measurements at the 6LU8 socket did not uncover anything important. The pin-8 screen voltage was slightly higher than the nominal value shown on the schematic. Other voltages were within tolerance. Resistor R376 (2.2KΩ in some and 1800Ω in other production runs), resistor R378 (5600Ω) and R374 (1500Ω) all tested normal.

The next suspect of the vertical-output stage was 2-section electrolytic C342 that bypasses both the screen grid and the cathode to the convergence circuit. Replacement of C342 and adjustments of height and linearity restored normal height, linearity and locking.

Incidentally, when troubleshooting Sylvania D14, D15 and D16 series receivers, carefully test R678 (and also R682, its counterpart in the Z demodulator) for a suspected reduction of its 47K





resistance. These demodulator resistors bring part of the +268V supply to the demodulator collectors, which also are supplied by resistors connected to the +18.8V supply. Therefore, a low resistance of R678 or R682 raises the +18.8V supply, causing the failure of several transistors, usually Q906 (X demodulator), Q608 (Z demodulator) and burst-amplifier Q616. Therefore, R678 and R682 should be checked *each time* one of these chassis is serviced. Replace any resistors that are out of tolerance.

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VHS basic recording and playing

By Steve Bowden

Extensive signal-processing functions, including separation of luminance and chrominance signals, are required for recording video signals. Equally complicated but different processing is necessary during playback.

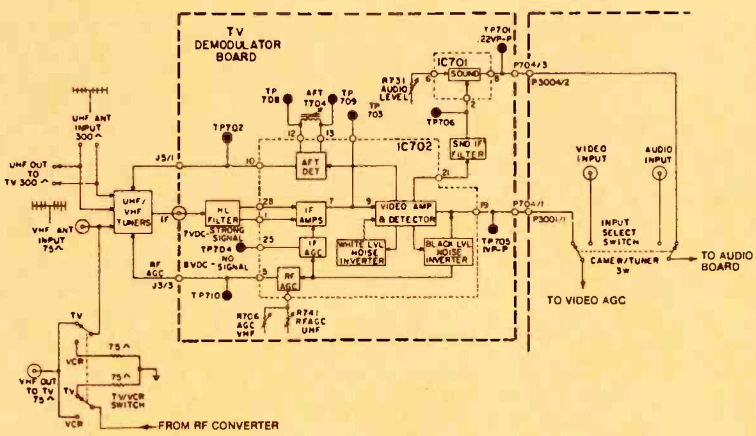
Although the details described here apply only to VHS videocassette machines, some broad general principles also apply to Beta machines.

Circuit operations will be described stage by stage by reference to block diagrams, beginning with the input signals.

Input signals

A VHS machine can record videocassettes with video and audio from external sources (such as a video/audio camera or another videocassette machine) or with signals from the internal UHF/VHF TV tuners.

The UHF and VHF antennas connect to the VCR tuner, then the UHF-antenna cable loops back to the TV receiver UHF terminals, while the VHF-antenna cable is routed through the TV/VCR switch to the VHF terminals of the receiver (Figure 1). Therefore, the receiver either has a signal from one of these antennas (that allows it to function as a conventional receiver), or it has a video/audio-modulated RF signal from the VCR so the receiver functions as a monitor for picture and sound.



VCR INPUTS

Figure 1

Video and audio from internal circuits

The two tuners and the TV-demodulator circuit board inside the VCR have identical functions to those of the front end of a conventional TV receiver (Figure 1). Output of the tuner is an IF signal that is tuned and amplified on the TV demodulator board. A video detector retrieves the composite video signal, which is then amplified. Sound circuitry extracts the audio signal from the sound-IF signal. Auxiliary circuits include AFT and AGC.

Composite video and audio signals are sent from the demodulator board to the video-input and audio-input jacks on the servo board. These jacks are special RCA types that automatically disconnect the internal video or sound signal from a jack when an external video or audio signal is plugged into it. Thus, automatic switching between two sets of input signals is accomplished without the use of an additional switch.

Audio recording

During recording and electronics-to-electronics (E-E) operation (such as stop, fast-forward and rewind), the incoming audio signal is coupled through Q410 to the tone amplifier inside IC401 (Figure 2).

Output of the tone amplifier is applied to the output amplifier and then to the recording amplifier. The sound-muting circuits connect into the audio at this point. However, the sound muting is defeated during recording and E-E modes by a low from Q411 that keeps the mute switch Q412 open; thus audio passes through.

Boosting of high frequencies in the audio is necessary at LP and SLP recording speeds (because of the slower tape-to-audio-head speeds). This is done by the LP-emphasis and SLP-emphasis circuits in the recording amplifier. Amplified audio from the recording-amplifier output is applied to the audio head, along with the proper amplitude of 67kHz bias signal obtained from the bias oscillator. The bias reduces distortion. Audio automatic-gain-control circuits maintain a relatively constant audio signal amplitude.

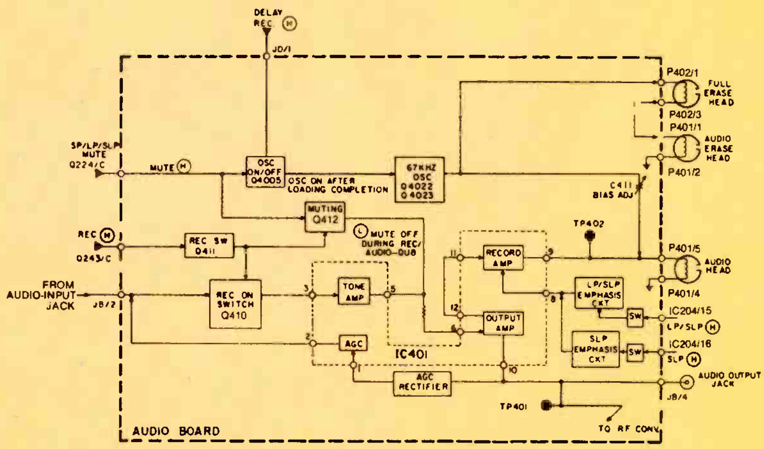
Also, a stronger signal from the bias oscillator drives the full-width erase head and the audio erase head. Of course, the bias oscillator is active only during recording, and then only after the tape is completely loaded. When the load-completion input goes high, +12V is supplied to the bias oscillator and the video-head recording amplifiers to start the recording.

From the line-output amplifier (IC401 pin 10), the audio signal is sent to the audio-output jack (for use with another VCR) and to the RF converter that supplies E-E audio through the monitor receiver during recording.

Video recording

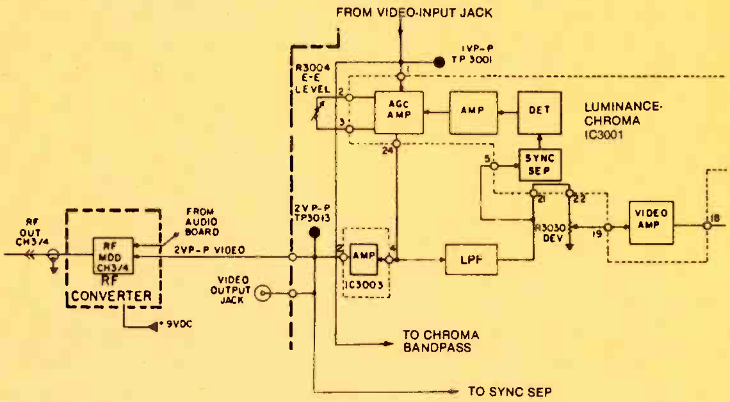
The composite-video signal at TP3001 and the video-input jack (either from the demodulator or an external source) passes through a 3.58MHz bandpass amplifier (Figure 3) that removes the video and retains the chroma that is further processed and down-converted before it and the luminance are used to drive the video heads, as explained later.

Also, the same composite-video signal at TP3001 (Figure 3) is connected to the AGC-amplifier input. Output of the AGC amplifier (IC3001 pin 24) feeds another amplifier (inside IC3003) whose output supplies video to the RF modulator. Also, the AGC-ampli-



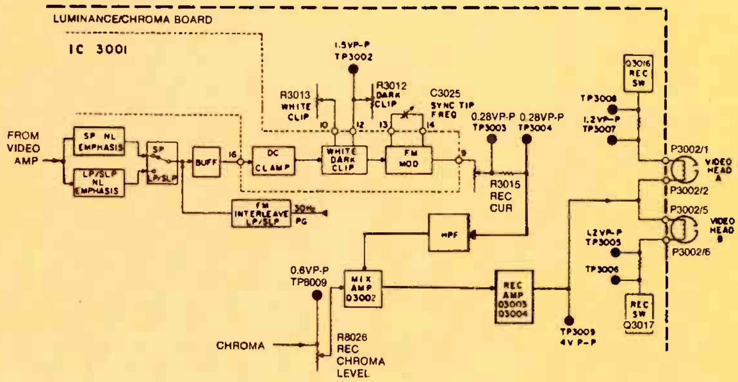
AUDIO RECORDING

Figure 2



VIDEO AGC DURING RECORDING

Figure 3



VIDEO RECORDING

Figure 4

fier output goes through a lowpass filter that removes the chroma signal before the remaining luminance signal is sent to the video amplifier. This luminance also activates a sync separator. The sync-separator output signal is rectified and amplified to produce a gain-controlling dc voltage for the AGC amplifier. After proper adjustment of R3004 (E-E level control), the video signal at IC3001 pin 24 has a constant 1VPP output, which is suitable for good recording.

E-E level control R3004 determines the video level for E-E viewing during recording (as the name implies). But it does more. R3004 has the same function as the AGC control in a color receiver; its adjustment varies the video amplitude at IC3001 pin 24. *Warning:* If R3004 is misadjusted, all other recording adjustments and levels will be incorrect as well. R3004 must be adjusted correctly before other adjustments are made.

Amplitude of the luminance (composite video after the chroma is removed by filtering) is adjusted by deviation control R3030. Therefore, the R3030 control setting determines how far the FM carrier swings. For compatibility, all VHS machines should have the same FM-carrier deviation.

Video from the deviation control is amplified and sent to the LP and SLP non-linear emphasis circuits (Figure 4), which boost the amplitudes of the low-level high frequencies. This signal is routed through electronic switching to the dc clamp, white and dark clipping, and FM-modulator circuits. The dc clamp holds the blanking pedestal to the desired dc level for correct operation of the FM modulator, while the clippers remove excessive amplitude excursions beyond the black and white portions of the video signal.

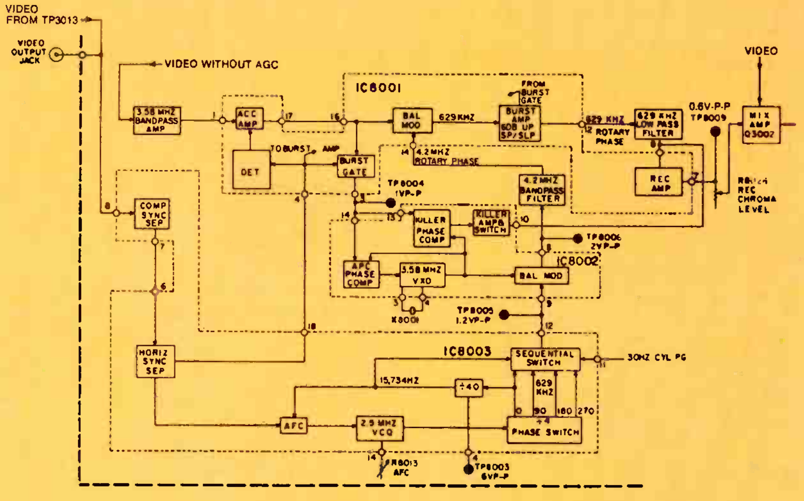
The FM interleave section of LP/SLP Modes (connected at the output of the electronic switch and a buffer amplifier in Figure 4) applies a 30Hz square wave to the FM modulator's input. The waveform offsets the FM carrier by 7867Hz (half the color horizontal frequency), which produces visual (on screen of the monitor) cancellation during playback of beat frequencies that have been created by incomplete track erasure in overlapped areas and by overlapping of track with LP/SLP recordings.

Luminance recording current is measured between TP3003 and TP3004, and it is adjusted by control R3015. When the FM-modulator carrier swings between 3.4MHz and 4.4MHz, sidebands are produced that beat with the lower-frequency chroma signal if they are not removed. The sidebands are removed by a highpass filter located between TP3004 and the mixer transistor.

Luminance from the highpass filter and chroma from R8026 (the chroma recording level adjustment) control are inputs for the Q3002 mixer amplifier. Q3002 output drives Q3003 and Q3304 recording-amplifier transistors, and they in turn drive the two video heads.

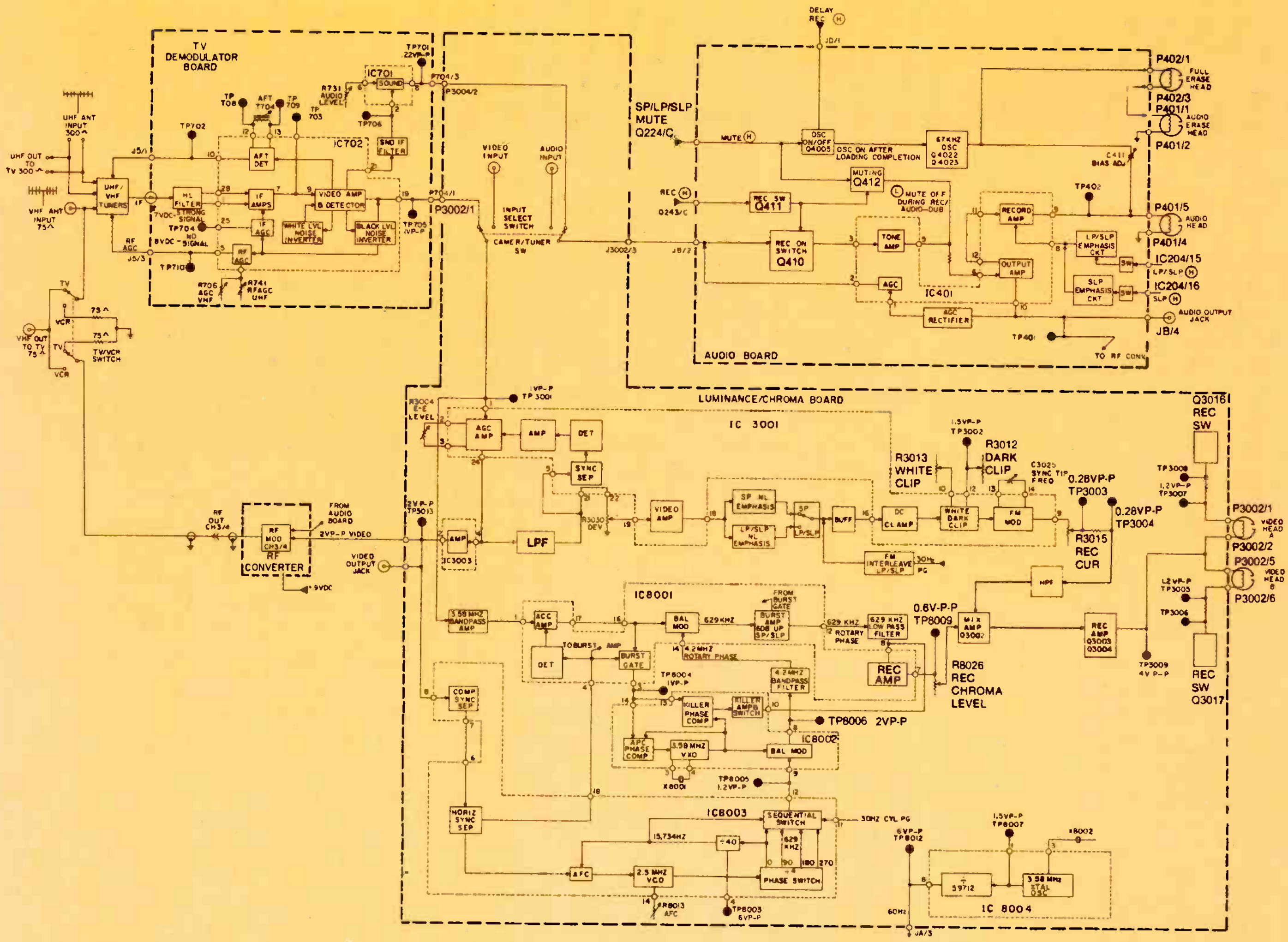
Chroma recording

Composite video from TP3001 (without AGC) is passed through a 3.58MHz bandpass amplifier that removes the luminance signal, leaving the chroma, which is applied to the ACC amplifier (IC8001 pin 1 in Figure 5). Burst is separated by the burst gate, and its amplitude is detected by the burst detector. The resulting 3.58MHz chroma signal at pin 17 of IC8001 is applied to the balanced modulator along with a 4.2MHz rotary-phase signal. From the balanced modulator comes the difference frequency of 629kHz, which is applied to the burst amplifier. Incidentally, in SP and SLP modes, the burst amp produces 6dB higher burst-amplitude output, which gives better stability in the playback chroma operation. The 629kHz chroma signal passes



VIDEO-RECORDING PROCESSING

Figure 5



VHS RECORDING

Figure 6

through a 629kHz bandpass filter to the recording amplifier. Output of the recording amplifier at IC8002 pin 7 (also TP8026) is amplitude-adjusted by control R8026 and is applied to mixer amplifier Q3002, along with the processed luminance signal. The luminance and down-converted chroma is sent on to the video recording heads.

When the video signal is monochrome, the killer amplifier is switched on to kill the color-signal circuits, preventing colored snow. A change to color pictures causes the burst gate to emit a burst signal that turns off the killer switch, allowing the chroma signal to be added to the luminance signal and color to be seen in the picture.

Composite video from TP3013 is brought to the input of another sync separator (this one in IC8003). Composite sync from this sync separator is processed to remove the horizontal-sync pulses that appear at TP8001 and are applied to the AFC circuit where they are compared to a horizontal-rate ramp, and the dc voltage output is used to control the exact frequency of the 2.5MHz voltage-controlled oscillator (VCO), while R8013 sets the VCO's nominal frequency.

Output of the 2.5MHz VCO is divided by the divide-by-four phase switch (Figure 5), so the result is a 629kHz rotary-phase signal, with the direction of rotation reversed every alternate field by the 30Hz PG pulse signal. Four outputs of 629kHz are present, each 90 degrees different in phase from the others. The signal applied to the balanced modulator is switched at a horizontal rate from one 629kHz output to the next. Also, a 3.58MHz unmodulated carrier from the 3.58MHz crystal-controlled oscillator is applied to the balanced modulator. Therefore, the balanced-modulator output is a 4.2MHz CW signal (TP8006), but the phase is shifted 90 degrees during each horizontal line. This 4.2MHz rotating-phase signal passes through a 4.2MHz bandpass filter and is applied to the second balanced modulator. Because the other balanced modulator input signal is 3.58MHz chroma, the modulator output is a 629kHz chroma signal with a rotating phase. It passes through a 629kHz lowpass filter, a recording amplifier, R8026 chroma recording-level adjustment control and finally reaches mixing transistor Q3002 where it joins the luminance signal. Both signals are processed further before they drive the two rotating video-recording heads, as described before.

Also, one of the 629kHz outputs from the divide-by-four phase switch is divided by 40 to produce the 15,734Hz reference signal for the 2.5MHz VCO's AFC circuit.

Figure 6 is the complete block diagram of a VHS VCR during recording. Previous smaller schematics were taken from this one so it will be easier for you to visualize how the various circuits are interconnected.

Audio playback

During playback, the audio head picks up the previously recorded audio signal on the tape. Then the signal is amplified and equalized before its amplitude is adjusted by

R414 (playback-level) control and amplified by the tone amplifier and the output amplifier before it reaches the audio-output jack and the audio-input terminal of the RF modulator (Figure 7). During speed changes and the pause mode, a muting signal from the system control is sent to eliminate the output-amplifier's input signal. (A high from the system control mutes the audio channel.) Different equalization and de-emphasis characteristics are provided by signals from IC204, as needed for the LP and SLP speeds.

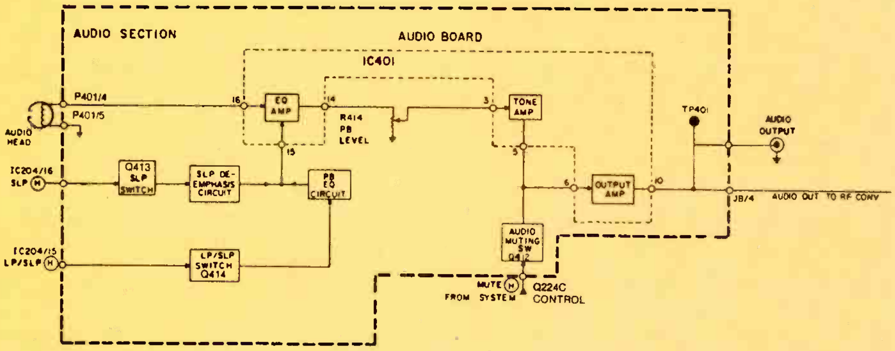
Notice that the tone amplifier and the output amplifier have gain and are operational during recording and playing modes.

Video/luminance playback

Video heads A and B (Figure 8) sequentially scan their appointed diagonal tracks across the tape, supplying signals to head amplifier A and head amplifier B, located in the luminance section of IC3002. These head-signal amplifiers are switched on alternately so only one has conduction and gain at a time. This minimizes the pickup of noise and other unwanted signals by the head that is not in contact with the tape. The 30Hz PG signal (which switches the head amplifiers on and off) is applied to IC3002 pin 12 and also to the FM-interleave circuit, which adds an inverted 30Hz signal to the playback signal at R3088 during LP and SLP modes.

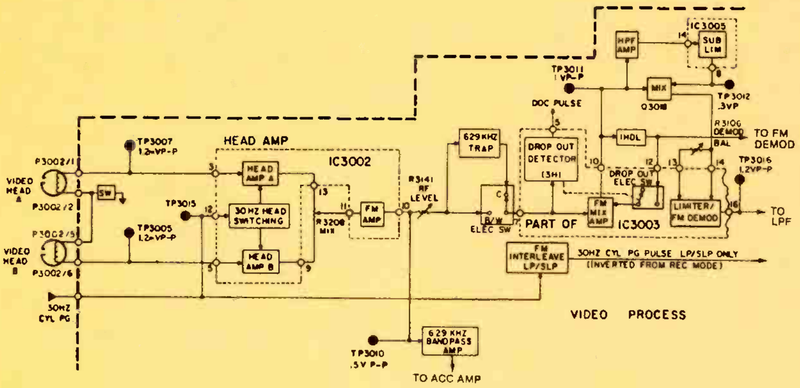
The A and B head signals are balanced for equal amplitude by mixer control R3208. Specifically, TP3010 is monitored by a scope while the R3208 mixer control is adjusted for identical head-signal amplitudes of about 0.5VPP during playback of a normally recorded tape.

At IC3002 pin 10, the amplified and mixed signal from the video heads is made up of an FM carrier that will be processed and demodulated to produce the playback luminance signal and a 629kHz chroma signal that will be processed and up-converted to provide a conventional 3.58MHz chroma signal. Finally, these two signals will be combined to form NTSC composite color video that exits at the video-output jack or it modulates the RF modulator, and the modulator output signal is sent to the receiver that is used as a monitor.



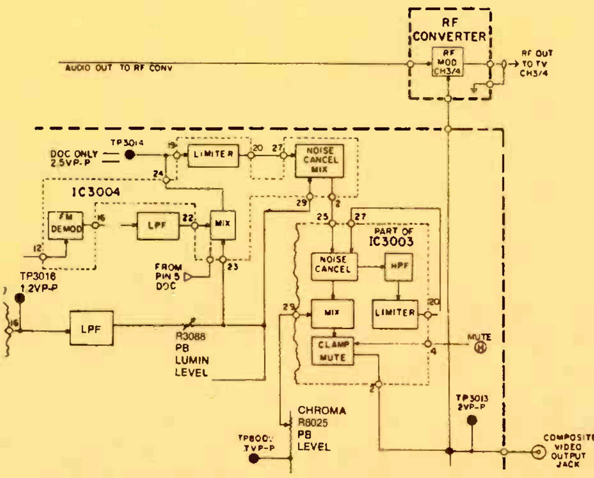
AUDIO PLAYBACK

Figure 7



VHS HEAD AMPS AND DOC

Figure 8



VHS VIDEO DEMOD

Figure 9

This brief description alerts you to the purposes of circuit actions described next.

From IC3002 pin 10 (TP3010), the RF FM and AM signals pass through R3141 on their way to the FM-mixer amplifier and the drop-out detector. However, a 629kHz trap is switched into the path when the program is in color, or it is shorted if the program is in black-and-white (monochrome). The trap is necessary to remove the AM color signal from the FM luminance signal. When the program is monochrome, the trap is not needed, and its removal broadens the bandwidth, giving a sharper monochrome picture.

All VCRs have some form of drop-out compensation. A drop-out is a momentary loss of the RF playback signal, and it might be caused by dirt on the head or tape, a rough tape surface that causes a short loss of tape/head contact, or missing oxide on the tape's surface. These uncompensated drop-outs produce white or black streaks in the monitor's picture.

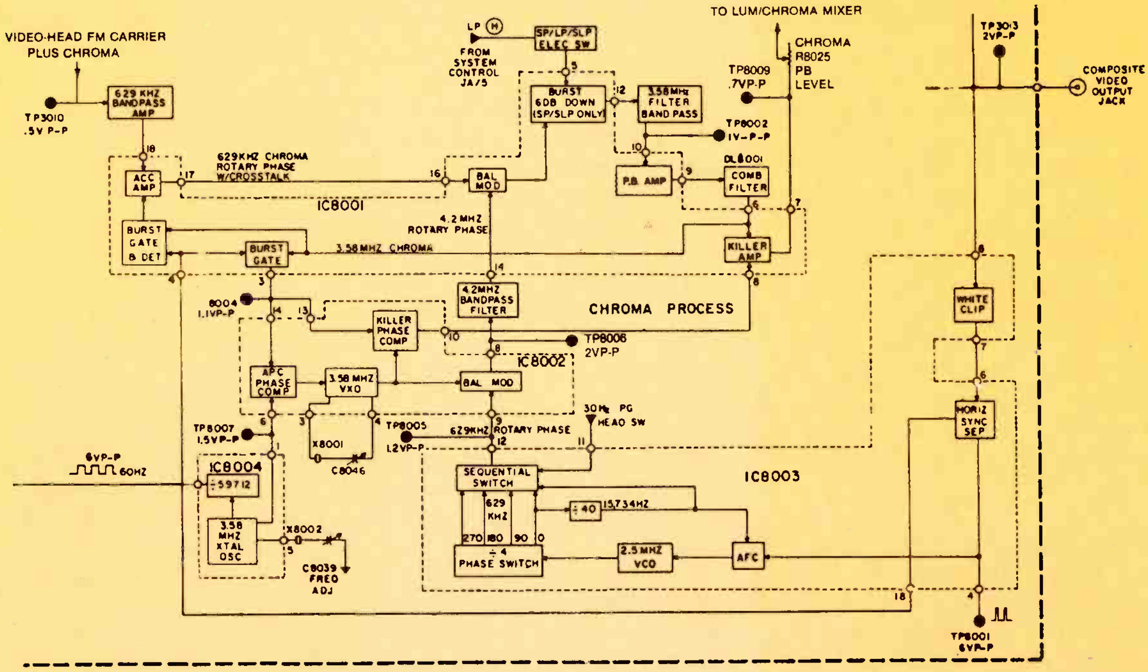
VHS drop-out compensation substitutes a good line of video for one that has a gap in the video waveform. Assume, for example, that the playback is proceeding normally until line 50 is reached, but a section of line 50 is missing. At the beginning of the missing segment, the drop-out compensator (DOC) instantly substitutes the same part of line 49 for the remainder of that line, before switching back to normal line sequence. Line 49 has been traveling through a precision delay line that delays the signal by one horizontal line of video (1HLD, as it is abbreviated in the Figure 8 schematic).

The VHS DOC has a detector, a delay line, and an electronic switch that is controlled by the detector. Output signal from the FM mixer amplifier constantly is feeding the delay line's input. When no drop-out occurs the signal from the delay line's output is not used. But when the detector identifies a drop-out, the switch closes and feeds the delay-line output back to the input of the FM mixer amplifier. Thus, the previous non-defective line of video has been substituted for one having missing video.

Output of the delay line also feeds a separate FM demodulator (in IC3004) that is used only for drop-outs. The delayed luminance signal is mixed with the signal that has traveled the normal signal path, then both are applied to the noise canceler mixer (Figure 9). This provides better resolution during a drop-out condition.

From TP3011, the signal travels two paths. One path is through a highpass filter, and the other is to a mixer amplifier. The signal at the highpass filter (Figure 8) is limited to remove amplitude variations from the FM signal, which then is mixed with the normal signal that feeds the limiter FM demodulator. The demodulator output at TP3016 is the demodulated FM signal that is free of amplitude variations. The lowpass filter removes high-frequency noises and any sidebands that have been produced. The luminance playback level is adjusted by R3088 (Figure 9) and the 30Hz PG pulses are added to eliminate the effects of FM interleave recording in LP and SLP modes.

Two noise-cancel circuits are used to improve the overall signal-to-noise ratio (SNR) in the signal. One cancels low-frequency noises, and the second cancels high-frequency noises. The output signal of the high-frequency canceler travels two paths, one to a highpass filter and one to the mixer. Output of the highpass



VHS CHROMA PLAYBACK

Figure 10

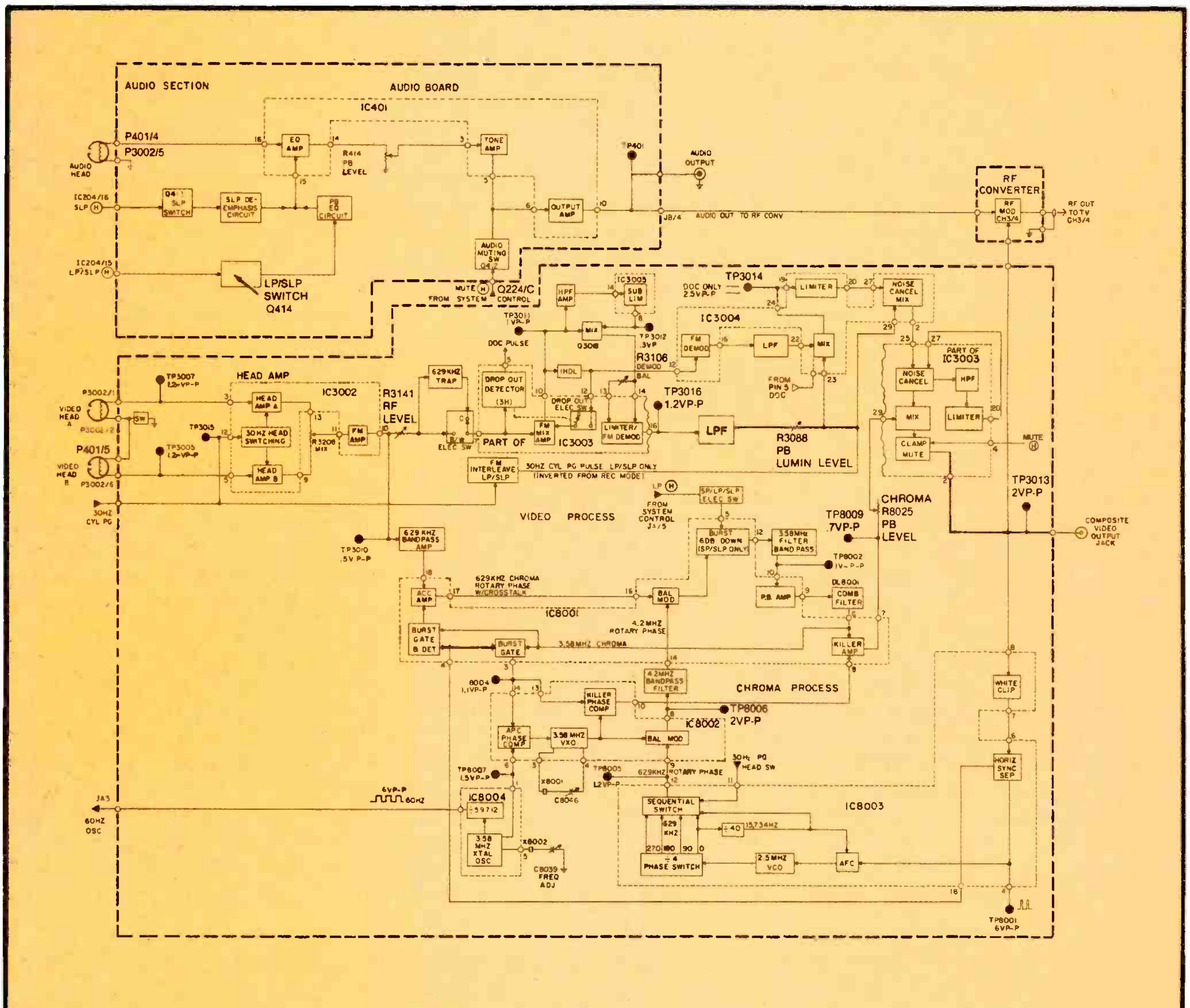


Figure 11

filter is limited and the front edge of horizontal sync pulses is added. Then the signal is fed back into the noise canceler and mixed with the incoming signal, thereby canceling any high-frequency noise. The noise-free luminance signal is sent to the mixer and combined with 3.58MHz chroma to produce the complete color signal. Output of the mixer is applied to a muting circuit where the signal can be muted during speed changes of the tape.

Chroma processing during playback

Head amplifier FM/chroma signals from TP3010 are passed through a 629kHz bandpass filter that removes everything except the 629kHz AM chroma signal that is sent on to the ACC amplifier. From there on, the playback circuit operation is identical to the recording operation with the following exceptions:

- The 629kHz chroma signal and the 4.2MHz CW carrier are inputs to the balanced modulator, producing an output of 3.58MHz chroma at TP8002. A comb filter farther downstream removes chroma crosstalk (Figure 10).
- In the SP and SLP modes, the burst is decreased 6dB to compensate for the +6dB increase used during recording, bringing the burst to the standard amplitude.
- The chroma signal that is applied to the burst gates is taken from the comb filter output.
- The 3.58MHz crystal oscillator (shown at the bottom of Figure 11) provides the reference signal for the APC phase-compensator circuit.

Figure 11 shows the entire block diagram of the playback system. This should make clear the interconnection of all separate circuits.

Troubleshooting

The first step of troubleshooting a VHS machine should be determining if the problem exists in playback or recording, or in both playback and recording. Use a known-good VCR and a known-good pre-recorded VHS tape. *Caution:* Don't use a VHS alignment tape to test a VCR deck. The tape is expensive and can be damaged by a defective machine. Always use an NTSC signal when making *signal* adjustments in these VCRs, because a 100 percent white signal is imperative when the white clip adjustment is made. Use these block diagrams to locate areas of suspicion. ES&T

PART 3

Interpreting waveforms

By Carl Babcoke, CET

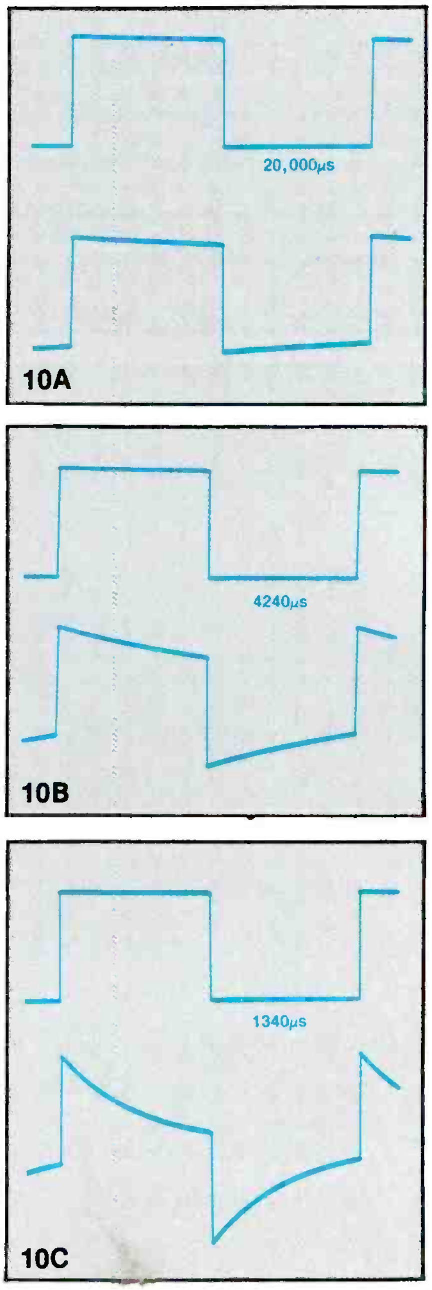
When you're troubleshooting a unit, waveforms can tell you a lot about the condition of the circuits–if you know what to look for. This is the third and final installment of a series written to help you understand the effects of circuit components on waveshapes.

Highpass filters and square waves

Figure 10 shows six dual-trace waveforms illustrating a wide range of highpass filter effects from almost none (Figure 10A) to extensive (Figure 10F) when square waves are passed through filters having various time constants. In all cases, the top trace shows the incoming square waves for reference. The precision 20KΩ resistor and many capacitor values from the lowpass filters were used in the Figure 10G circuit. Included with the other information is a table showing the sine wave frequency responses of six time-constant filters. These will help you estimate the frequency response of amplifiers according to the amount of square-wave integration.

Notice the tilted tops and bottoms in Figure 10A. It has been taught that these tilts indicate a decrease of low-frequency response, and that is true. But how much decrease and at what frequencies? Perhaps a typical first reaction is to believe a drastic reduction of lower frequencies, because the tilts are very noticeable.

However, the sine wave frequency-response table (in Figure 10) shows good low-frequency audio response, with the 20Hz response (for example) down only 0.9dB, which is acceptable for all but the most exacting audio applications. Remember, 20Hz is more than 3 octaves (a musical octave is the interval between one frequency and double or half that frequency) *below* the 200Hz square-wave test frequency. Also, the slight loss of bass response will not be noticed with most speaker systems (even those with woofers up to 12-inch sizes) because those systems seldom reproduce anything below about 55Hz.



Therefore, the tilted square waves must be considered as a very sensitive indicator (not measurement) of low-frequency response, revealing the slightest decrease of low-frequency response, even far below the repetitive frequency.

Estimates of the frequency responses of unknown audio circuits can be obtained by comparing its 200Hz square-wave tilts or charge/discharge curves with those in Figure 10. When similar conditions are found, the sine wave frequency response for that highpass filter (which probably is capacitive coupling between stages) can be estimated by comparison with the one-cycle time of the waveform. This test works only for time constants longer than those giving the classical capacitor-voltage-discharging curve (Figure 10D) where the curve reaches zero by the end of the positive peak.

In Figure 10D, the curve reached zero by (or before) the end of the square wave's positive peak. The same virtual zero point was reached in Figure 10E at about halfway across the positive peak. Therefore, this time constant should be about half of the one-time-constant of Figure 10D. Actually, Figure 10D was produced by 245μs which is 49% of the 500μs in Figure 10D. Figure 10F was measured in the same way, with the voltage-discharge curve covering about an eighth of the positive peak. This figures to approximately 62.5μs time constant, whereas the curve was produced by 56μs. Although the visual method does not provide perfect accuracy, it does give useful ballpark figures. Of course, better accuracy can be obtained if the positive peak is expanded by the scope so it covers the entire scope screen.

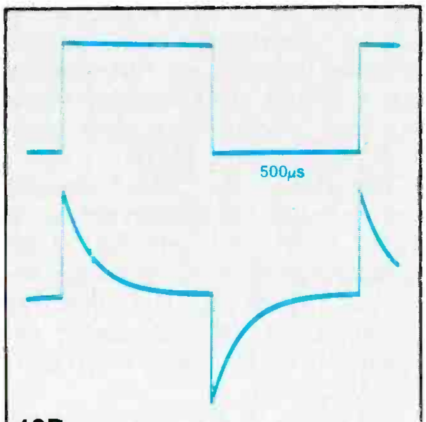
Multiple time constants

Actual audio equipment (such as an AM/FM-stereo radio) has more than one time-constant filter in it. Resistance-coupled audio stages usually have a highpass filter that

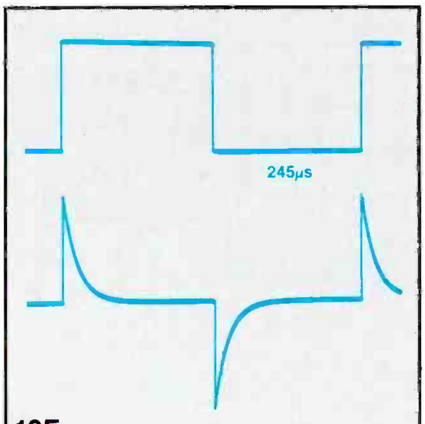
FREQUENCY RESPONSE FOR TIME-CONSTANT HIGHPASS FILTERS

SINEWAVE TEST FREQUENCY	ALL READINGS IN DECIBELS FIGURE NUMBERS A	B	C	D	E	F
20Hz	−0.9	−6.4	−15.7	−23.8	−30.5	−40
40Hz	−0.3	−2.7	−9.6	−17.8	−24.5	−37
60Hz	−0.2	−1.4	−6.9	−14.7	−21.4	−33.5
100Hz	0	−0.7	−3.9	−10.1	−16.8	−29
150Hz	0	−0.3	−2.2	−7.3	−13.8	−25.7
200Hz	0	−0.2	−1.4	−5.4	−11.3	−23.4
400Hz	0	−0.1	−0.5	−2.3	−6.1	−17.5
800Hz	0	0	−0.2	−0.9	−2.8	−11.8
1600Hz	0	0	0	−0.4	−5.6	−7.4
3200Hz	0	0	0	−0.2	−0.5	−3.1
6400Hz	0	0	0	−0.1	−0.3	−1.7
12,800Hz	0	0	0	−0.1	−0.2	−1.1
16,000Hz	0	0	0	0	−0.1	−0.5
	40TC	8.5TC	2.7TC	1TC	0.5TC	0.11TC

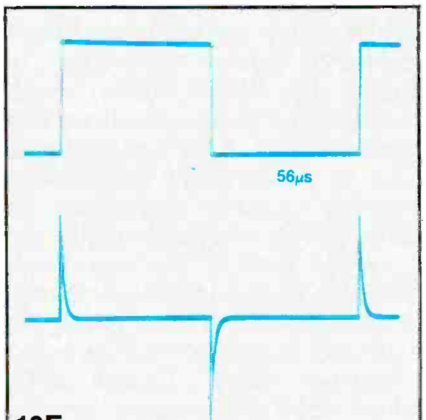
10H



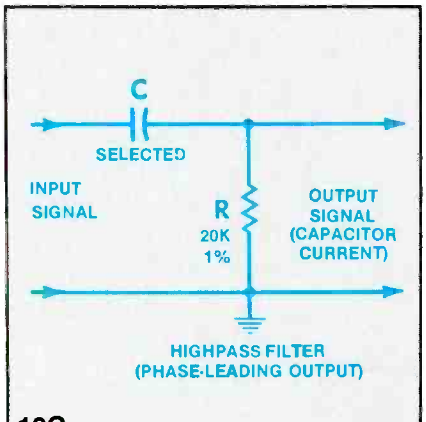
10D



10F



10E



10G

Figure 10. Six different time constants illustrate the effect of highpass filters on square waves. (A) A large 20,000μs time constant tilted top and bottom of the square wave, an indication of decreased low-frequency response, although the sine wave response tested good at low frequencies (see text). (B) Decreasing the time constant to 4240μs tilted the top and bottom even more. Also, the top and bottom lines are not perfectly straight, but appeared to have a slight curvature. (C) A time constant of 1340μs increased the tilt and the curvature of top and bottom. Notice that the rising and falling edges remained the original height, and all corners are sharp, not rounded. (D) Curvature at top and bottom increased when the time constant was changed to 500μs, the value for the classic one-time-constant curve. (E) Decreasing the time constant to 245μs decreased the time for the curve to reach zero. (F) A small 56μs time constant narrowed the positive and negative curves to spikes. Decreasing the time constant would only narrow those spikes, and if carried too far, the spike amplitude would decrease finally. (G) A highpass filter is similar to part of the resistance-capacitance coupling between audio stages. *Notice that the output waveform shows the capacitor current.* (H) The frequency responses of the six highpass filters are listed for comparison with the matching waveforms.

couples two stages together, passing the audio and blocking the unwanted dcV levels. With resistor/capacitor coupling, the highpass action is accidental and sometimes undesirable.

In addition, filters are included to minimize unwanted reception of radio signals. Other filters are called tone controls, sub-sonic filters, loudness controls and other names that hide the existence of time constants in them.

Figure 11 shows several waveforms taken from a typical stereo-radio receiver. Identifications and most information are included with the waveforms.

Admittedly, the actions of several time-constant filters does complicate the analyzing of waveforms that can provide approximate frequency responses. But, a person who routinely tests many audio amplifiers and tape recorders with square waves soon learns which waveform distortions are normal, and others that suggest changing to more complicated tests of higher accuracy, such as spot frequency checks with sine waves.

Square-wave tests can be made in TV video stages, also. However, the results are somewhat erratic because of possible ringing from peaking coils and the loading effects from other circuit components. To have the most value, the substitution of square waves for the usual signal in video stages should be practiced in non-defective receivers ahead of the need.

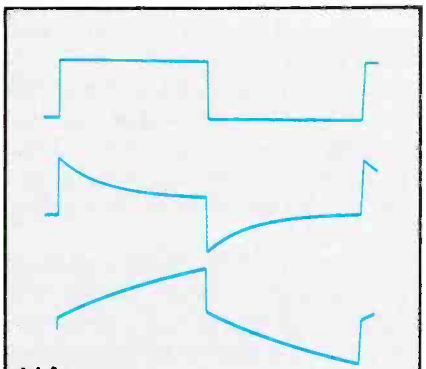
Sine wave to square-wave transition

One simple rule from electronic tradition says: *Capacitor current leads the voltage.* If a person takes that statement literally, he might wonder how current can flow *before* any voltage arrives to push it along. Before trying to explain what is meant, or rewriting the rule to make it apply to other situations, remember the rule originated years ago for use with sine wave electric power.

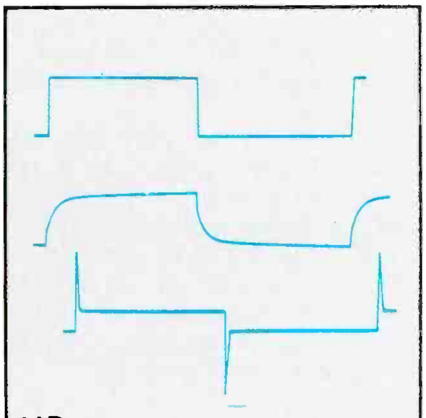
An allied tradition is this: *The phase between capacitor current and capacitor voltage is 90°.* Both rules together say: *Capacitor current leads the capacitor voltage by 90°.*

Another correct statement says: *A capacitor cannot change the signal phase of a circuit more than 90°.* (As a beginner in electronics around 1934, I *heard* the statement as this: "A capacitor changes the signal phase 90°." Several years elapsed before I discovered the 90° was a maximum, not a fixed number.)

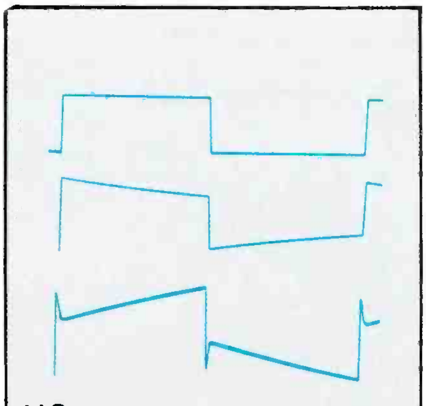
Let's rewrite the rule about current leading the voltage, so it will apply also to lowpass filters and perhaps other specific applications. *Maximum capacitor current precedes maximum capacitor voltage.* The statement certainly is true for the filtered square waves in Figure 5 and Figure 12.



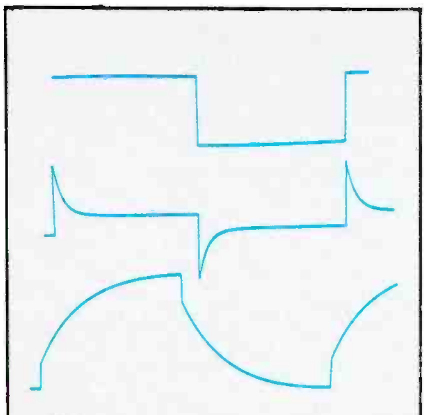
11A



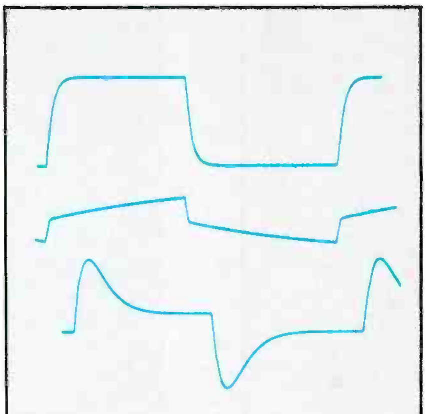
11B



11C



11D



11E

Figure 11. Various tone-control and audio-filter actions are shown here by the changes made to square waves. All waveforms were taken from a medium-quality AM/FM-stereo radio with internal amplifiers of about 35W per channel. (A) The top trace shows the 400Hz square-wave signal at the amplifier speaker terminals (now loaded with an 8Ω resistor), when all tone controls are rotated to flat position. The center trace shows tilt caused by applying maximum bass cut (decrease or attenuation). The bottom trace reveals an opposite tilt produced by maximum bass boost (increase). (B) Again, the top trace shows flat response at 400Hz; the center trace shows voltage capacitor charging/discharging curves from maximum treble cut; and the positive-going and negative-going narrow spikes of extreme differentiation produced by maximum treble boost are shown by the bottom trace. (C) These 400Hz rep rate square waves show absence of tone controls; tilting of the center trace was produced by the subsonic filter that attenuates frequencies below 30Hz; and the bottom trace shows bass boost and some treble boost obtained when the loudness mode was switched on. (D) The input square waves were changed to 80Hz, as shown by the top trace; maximum bass cut (center trace) forms the typical highpass curves on the 80Hz square waves; and maximum bass boost increased the signal level 10dB while tilting the waveform with the right side of the peaks having higher amplitude (lower trace). (E) Square waves of 8kHz have some rounding even with all tone controls in neutral (top trace); treble cut reduced the amplitude and tilted the waveforms to the left (center trace); and maximum treble boost produced highpass filter curves shown by the bottom trace.

However, problems arise with the 90° rule. One cycle is 360°, of course, so the classic capacitor-voltage charging curve in Figure 12 has maximum capacitor current at 0° and maximum voltage at 180° (end of the positive peak). Also, a few glances at the Figure 5 filtered waveforms show current/voltage phases between about 10° and 180°. *Evidently, the 90° current/voltage phase is for sine waves only.*

Another sticky point is raised in Figure 12 during the capacitor-discharging curve. The maximum capacitor current occurs at the same time as the input square wave's falling edge, so maximum current occurs near zero degree phase. However, the maximum capacitor voltage also occurs at the same time, because full positive voltage remained from the previous charging curve. What is wrong?

Unfortunately, that viewpoint is backward. A negative-going pulse of current must match a negative-going capacitor-voltage curve. Therefore, *the positive voltage at the end of the charging cycle is the new zero for the discharging cycle,* with the curve moving downward (negative-going) to create a negative (upside-down) curve that ends at maximum negative, which is maximum voltage for the negative peak. In other words, consider the voltage at the beginning of the discharge cycle as zero, and the reworded rule states correctly: *Maximum negative current occurs before maximum negative voltage.*

All these curves have similar shapes, so it is not obvious that the capacitor-charging curve and the capacitor-discharging curve are identical, *except the discharging curve is inverted.* One goes from zero to a specific maximum positive, while the other goes from this positive (acting as zero) to true zero (substituting for negative-peak negative).

Current without voltage

Several paragraphs before, some tongue-in-cheek remarks were made about the impossibility of current flowing before the capacitor had voltage to force the

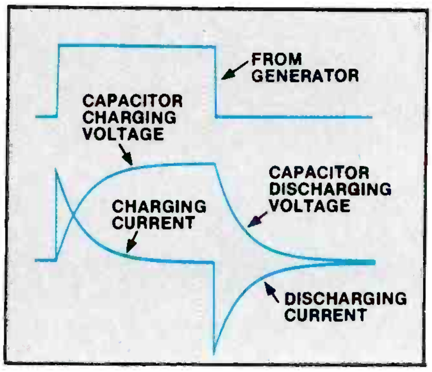


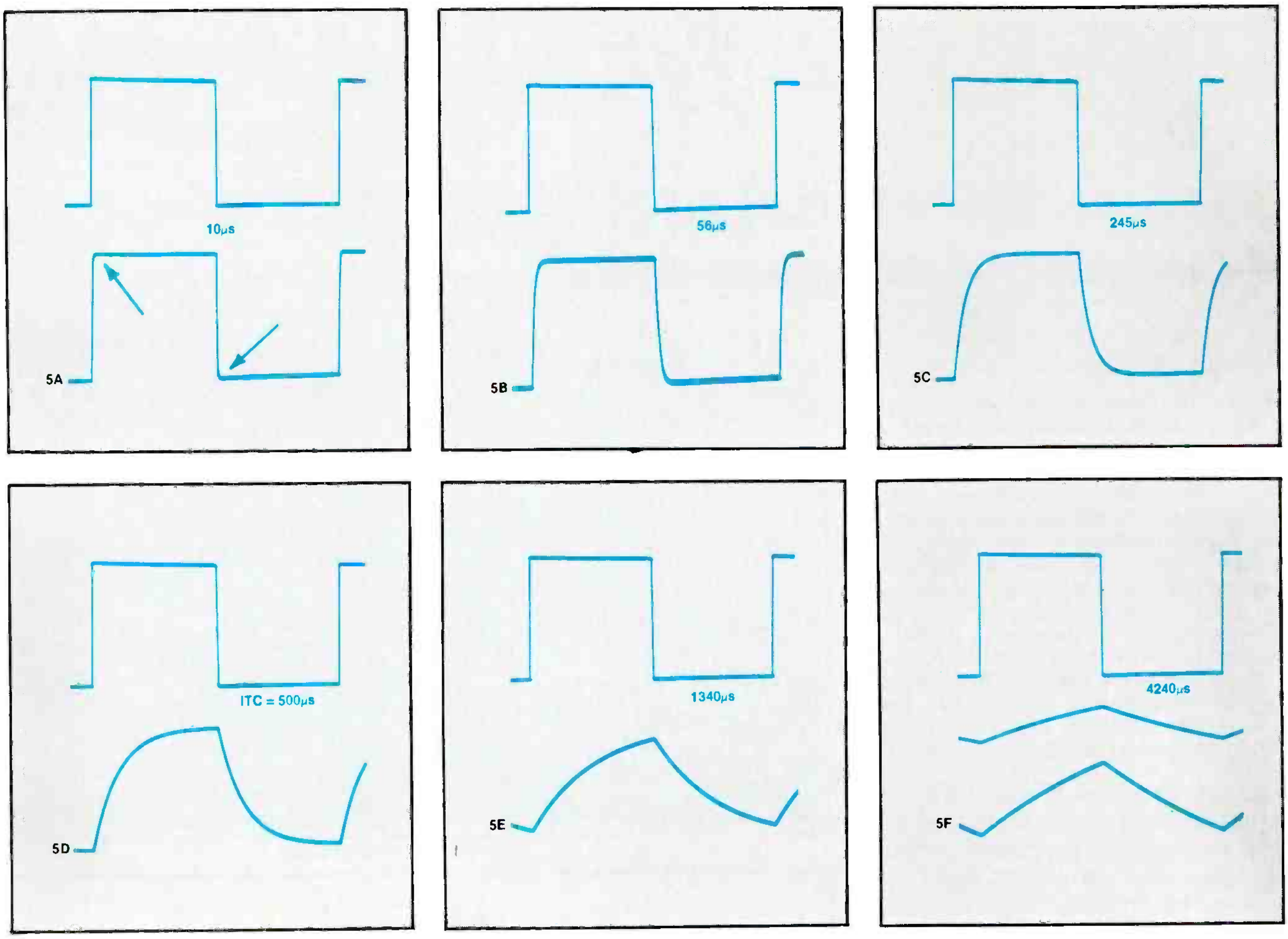
Figure 12. Obviously, the rule about capacitor current leading the capacitor voltage by 90° does not apply to filtered square waves. However, in lowpass filters, maximum current *always* occurs before maximum voltage. That is clear in the capacitor-charging half of square waves. But when the discharging begins, the rule appears to be broken, for this capacitor-discharging curve begins with the maximum positive voltage from the charging mode. As explained in the text, the capacitor current has reversed (call it *negative*), so the discharging curve is identical to the charging curve except it is upside-down.

current. However, it is possible for *capacitor* current to flow without any voltage being present *across* the capacitor. Of course, there is voltage somewhere else in the circuit.

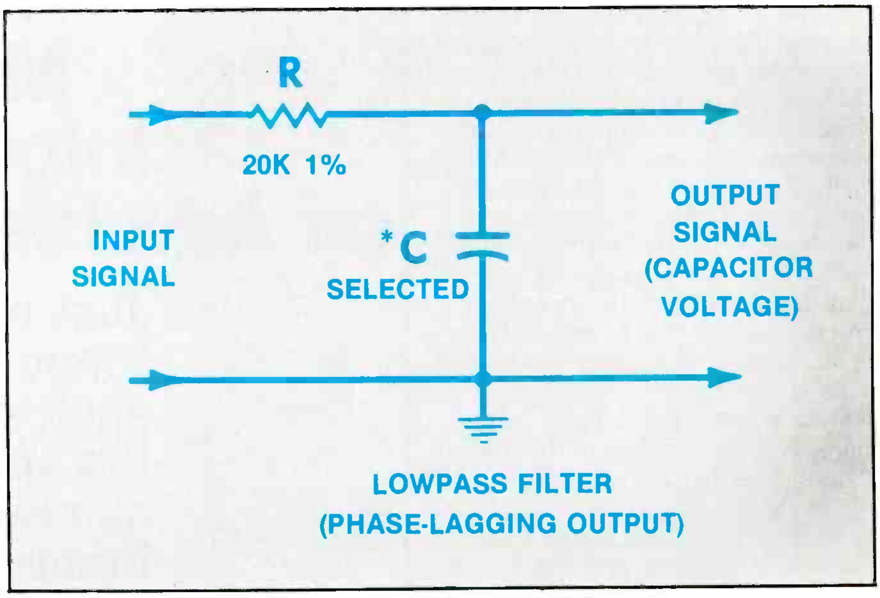
Look at it this way. An uncharged capacitor has zero voltage and zero current. At that time, it is the equivalent of a short circuit. When voltage is applied to the time-constant resistor (Figure 5G), current will flow into the capacitor for a time before any voltage is developed across it. Imagine it as a resistance that changes value to give the characteristic waveform. In other words, the circuit *at first* is a series type with voltage source, resistance, and a short circuit to ground. Given those conditions, current will flow in the short circuit whether or not there is measurable voltage drop across it. Gradually the short changes to a variable resistance and finally to an open circuit when it is completely charged.

Capacitor phase

After the previous tests, we should be in agreement that the 90° phase between capacitor voltage and current must be correct only for sine wave conditions. Over the years, I had checked the



phase shift introduced by resistance/capacitance filters and found it could be varied between almost 0° and 90°. Sometimes I wondered if the phase between a capacitor's voltage and current always was 90°, or if it could be varied by the circuitry around it.



Several lowpass and highpass filters were checked for capacitor phase by adding a 100Ω resistor in series with the capacitor. Connecting one scope channel across the resistor provided a voltage waveform of the current waveform. All filters appeared to have the same 90° phase between capacitor voltage and current. The only questions arose because the capacitor current was very small in some cases, allowing hum and radio carriers to widen the scope trace.

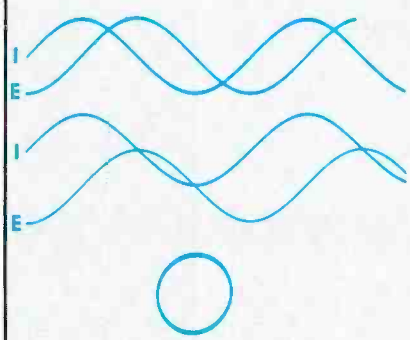
Finally, a 0.22μF capacitor was connected in series with a 100Ω resistor and the two wired across the audio generator's output. The phase was 90° (Figure 13). Regardless of the circuit around a capacitor, capacitor current and capacitor voltage have a phase difference of 90°.

Summary

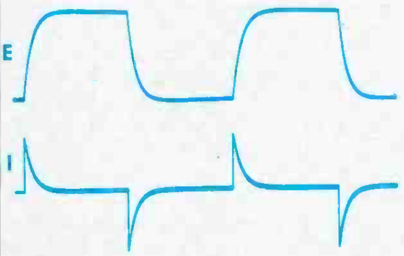
Some time-constant filters are designed into circuits. These filters must be understood so the symptoms of a bad component can be recognized. Other time constants might be added (by defective circuit components), thus adding filtering that is not desired.

Secondly, it is valuable in many cases to know what pulses and square waves become when integrated and differentiated. For example, when a sawtooth waveform is produced by integrating a pulse waveform, the presence of pulses indicates an open integrating capacitor.

A full understanding of time-constant actions can explain how the same capacitor can function as a bypass, a coupling capacitor or a filter capacitor. Time constants also explain capacitive reactance. Briefly, capacitance reactance causes a capacitor's apparent ac impedance to change according to the applied frequency. A capacitor will have a lower impedance at higher frequencies than at low frequencies. An uncharged capacitor acts as a short circuit (while it has no voltage and no current), but a charged capacitor virtually is an open circuit (full voltage and no current). Therefore, the apparent impedance of a capacitor depends on the percentage of each cycle that it is uncharged (and can pass the signal) compared to the time it

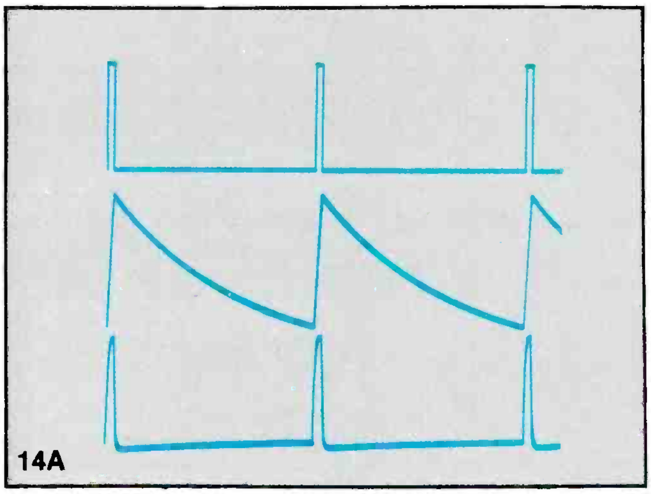


13A



13B

Figure 13. These waveforms prove that capacitor current leads the capacitor voltage by 90° when sine waves are involved. (A) At the top are dual-trace sine wave waveforms showing current (I) leading the voltage (E) by 90°. The center waveforms are the same, but one is moved down to show how the 90° points of the two sine waves intersect. Finally, a 90° phase difference is shown by the X/Y graph circle. (B) The voltage (top) and current (bottom trace) waveforms show short time-constant lowpass (top) and highpass (bottom) curves when square waves are used. Both sine waves and square waves were applied directly to a 0.22μF capacitor in series with a 100Ω resistor. Voltage waveforms were taken directly across the capacitor and the capacitor-current waveforms were scoped across the small-value resistor.



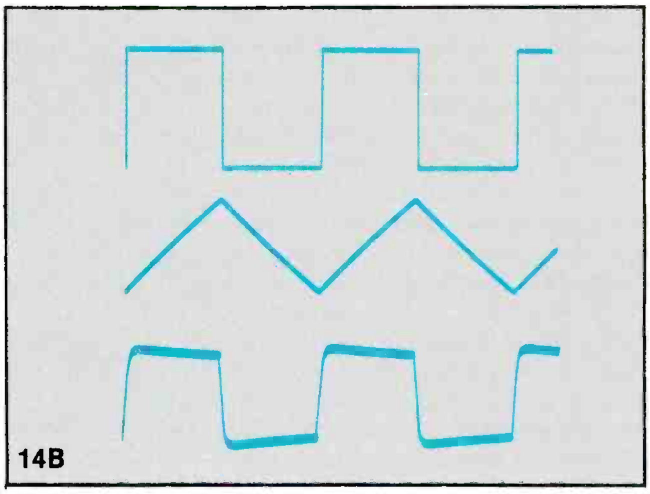


Figure 14. These waveforms answer the question: If a lowpass filter integrator makes sawteeth out of pulses (or triangles out of square waves), can the original waveform be obtained by using a complementary highpass filter? The answer is yes. (A) Three scope traces show the transition from pulses (top trace) to sawteeth (center trace) following a lowpass filter, and the bottom trace shows the pulse's approximate waveform after the signal went through a highpass filter. (B) Square waves (top trace) become triangles (center trace) after a lowpass filter, while the triangles become square waves (bottom trace) again after passing through a highpass filter. Incidentally, both filters were used simultaneously, giving the center and bottom waveforms on dual-trace mode. These are strong time-constant filters that cause a large loss of amplitude, and some problems were experienced with pickup of hum and RF carriers along with the final weak waveforms. If amplification had been used between the two filters to cancel the filter losses, and more care given to selection of filter-component values, it should have been possible to show *identical* waveforms for input and output pulses and square waves.

is charged (and acting as an open circuit).

The following basic truths were discussed in Part 1 (December 1983), Part 2 (May 1984) or in this article:

- When pulses are integrated by passing through a strong lowpass filter, the output waveform shows sawteeth. The rise time of each sawtooth is equal to the duration (width) of the input pulse. Filtering that is strong enough to produce linear sawteeth reduces their amplitude to just a few percent of the input pulse amplitude.
- When pulses are differentiated by a strong highpass filter, the output signal has a base line nothing but one narrow positive-going spike for each input square-wave leading edge, and one narrow negative-going spike for each input square-wave trailing edge.
- When square waves are integrated by a strong lowpass filter, the resulting output waveform shows triangles. (Triangles can be differentiated into square waves.)
- When square waves are differentiated by passing through a strong highpass filter, the output has a base line with nothing but one positive-going parabolic spike for each input square-wave leading edge, and one negative-going parabolic spike for each input square-wave trailing edge.
- Output of a lowpass filter is the time-constant capacitor's *voltage* waveform.
- Output of a highpass filter is the time-constant capacitor's *current* waveform.
- When a pulse or square wave is changed by any type of time-constant filter, the bent lines always have a parabolic shape, either a full parabola or a section of a parabola.
- Many lowpass filters have output waveforms of lower amplitude than the input signal amplitude. Many highpass filters tilt the waveform so the output waveform has a higher overall amplitude than the input pulse or square wave amplitude.
- Waveform changes of pulses and square waves from time-constant filters can be reversed. For example, a lowpass filter makes sawteeth from pulses and triangles from square waves. If these sawteeth and triangles are passed through an appropriate highpass filter, the output waveforms will be pulses and square waves, respectively. Figure 14 shows waveforms obtained this way, from a lowpass filter and a highpass filter wired in series to provide two filtered waveforms simultaneously.

Other predictable waveform changes occur when diodes are added to time-constant circuits. After all, a rectifier diode changes the operation of a bypass capacitor to a peak-reading filter capacitor. 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.

CAPEHART/SPECTRICON
7000A/4000A 2244-1

GENERAL ELECTRIC
Chassis XM-F 2247-1

JC PENNEY
685-2079-00 2243-1
685-2045J-10/051J-10/081J-00,
685-4005J-30/011J-30/012J-30,
685-4202J-00/212J-00/213J-00/214J-00 2246-1
685-1043-00 2248-1
685-2074-00 2249-1

MAGNAVOX
Chassis 25C105-00AA, BA/106-00AA, BA/107-00AA, BA/108-00AA/109-00AA, BA/112-00AA, BA/113-00AA, BA/115-00AA, BA, CA, DA/116-00AA/118-00AA, BA/121-00AA 2245-1

RCA
Chassis CTC111W 2244-2
EJR330S 2248-4
FJC423S 2248-5
GJC650T/654H, L/658P, GJR639PR/751TR/ 756HR/759PR 2248-6

REALISTIC
SCR-10 (14-780) 2248-3

SEARS
562.42630350/51 2243-2
564.43220350/3320350/3420350/3520350 2248-2
564.43720350/3720351/3730351/3820350/ 3820351/3920350/3920351 2249-2

SONY
Chassis SCC-453A-A,B-A 2238-3
Chassis SCC-266J-A/-453C-A 2241-1
Chassis SCC-470J-A 2247-2

SYLVANIA
Chassis 12M101-00AA 2245-2

TG&Y
E-4816 2241-2
E-4814 2242-2

WARDS
GEN-11285A 2230-3
GEN-12394E,F,G 2235-2
GGV-12924E/934D/954C 2237-2
GEN-12325A,B,C,D,E 2246-2

Products

VCR head cleaner

Two VCR head cleaners–model AV009 for all VHS systems and model AV010 for Beta systems–are available from *RCA*. These cleaners are a non-abrasive, lint-free, non-woven, cloth-cleaning surface in a cassette and a head-cleaner spray to clean the entire tape path. The cleaning tape is sprayed with the head cleaner;

the cassette is inserted into the VCR and run in play mode for 10 seconds. A fresh-cleaning surface for the next cleaning is automatically exposed. The RCA VCR head cleaner does not wear the heads or leave any residue and cleans 95 to 100 percent of the dirt, dust, and oxide residue from all the video heads, tape guides, and the entire tape path.

Circle (80) on Reply Card

Desoldering system

Two human-engineered, self-contained systems for the fast, spike-safe desoldering and temperature controlled soldering of electronic assemblies are available from *PACE*. These Micro Bench Top Systems have the "instant rise," rotary carbon vane pump. Vacuum rise time is now instantaneous, which ensures the non-destructive removal of any solder joint. The system has a low voltage, lightweight, pencil-grip handpiece with integral finger-tip actuation, which permits more precise operator control.

The systems feature a variable air pressure control and linear temperature controls for adjusting accurate tip temperature setting. Fast heat-up and instantaneous recovery increase operation efficiency and higher productivity. Both systems use the PACE

VisiFilter, a system designed to provide effective filtration of toxic and/or noxious particles. The MBT-200 and MBT-100 are packaged in a heat resistant, non-corrosive, extruded aluminum case with rounded corners and rolled edges to ensure user and work surface safety.

Circle (81) on Reply Card

Digital multimeter

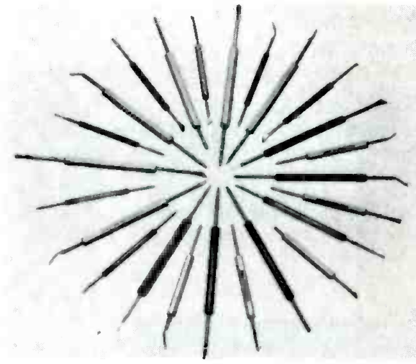
A 3½-digit, auto/manual-ranging, hand-held digital multimeter featuring 0.7 percent dc volt accuracy, diode test, audible continuity check and 10A current range has been introduced by *B&K-Precision/Dynascan.* Model 2804 provides auto-ranging or step-through manual ranging for all volt and ohm measurements and manual ranging on amp measurements. Dc voltage ranges are

200mV, 2000mV, 20V, 200V and 1000V. Ac voltage ranges are 2000mV, 20V, 200V and 750V. Input impedance is 10MΩ and ohm ranges are 200Ω, 2000Ω, 20KΩ, 200KΩ, 2000KΩ and 20MΩ. Dc and ac amp ranges are 200mA and 10A. The diode test measures the forward voltage drop of a semiconductor junction at 0.6mA. Continuity checks are annunciated by an audible tone.

Circle (82) on Reply Card

Precision tools

Desco Industries is offering 24 different styles of soldering aid tools that are made from stainless steel to provide durability, resistance to corrosion, resistance to solder sticking and non flaking.



Each tool configuration is available with either a hardwood or plastic handle to suit every taste and environment. The tools are part of Desco's line of precision tools for the repair, assembly and testing of electronic circuits.

Circle (83) on Reply Card

Electronic hardware

Twelve new electronic hardware products have been introduced by *E.F. Johnson Company.* Low-profile horizontal test jacks that are designed for test points and antenna connectors use a copper aluminum alloy developed by Johnson. The jack mounts in PC boards in .052-inch diameter holes on .410-inch centers. Needle-tipped test probes, uninsulated or insulated with a UL approved self-extinguishing nylon, will pierce corrosion or plating for positive contact. The probes have removable chucks for easy replacement of broken needles.

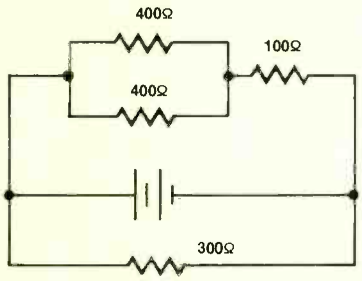
Two miniature banana jacks and

(Continued on page 61)

Answers to quiz

(From page 16)

1. *A.* If you redraw the circuit you get the figure shown here. The parallel resistive branches have identical resistance values, so they will have equal currents. The current through the 100Ω resistor equals the current through the 300Ω resistor.



2. *D.*
3. *C.* Among other things, Hall devices are used for measuring magnetic field strength.
4. *E.*
5. *A.* Diamagnetic materials are repelled by a magnetic field.
6. *C.* The circuit is actually a balanced Wheatstone bridge. As such, the center 50Ω resistor is the same as an open circuit, leaving two parallel 100Ω paths. The equivalent resistance is 50Ω.
7. *B.* The resistors are used to equalize the *reverse* voltage. That makes it possible to connect the diodes across a higher peak-inverse voltage than either diode is rated for.
8. *B.* Bifilar windings are used to make non-inductive wirewound resistors.
9. *B.* This type of question is often missed. When the switch is opened, the inductor tries to keep the current flowing. So, the induced voltage is in series with the battery voltage. In the circuit marked B there are *two* voltage drops: one across the switch and the other across the resistor. Therefore, the induced voltage must be higher to overcome that resistance and maintain the current. This theory explains why a resistor is placed *in series* with a spark plug to get a hotter spark in an automobile engine. In the ignition circuit there is a capacitor (condenser) across the switch (which is actually the breaker points in the distributor).
10. *B.* When the load is heavy, less filtering is needed, so the swinging choke adjusts to the load.

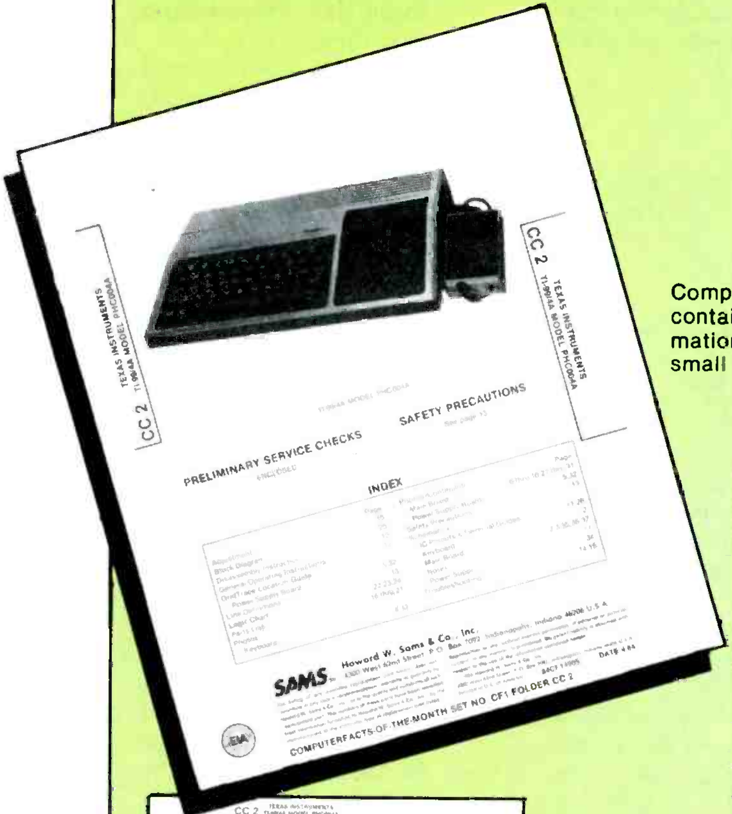
At last, a source of computer servicing information

Trying to repair a piece of complex electronic equipment without servicing information is a lot like taking a trip without a road map. You might get to your destination or you might not.

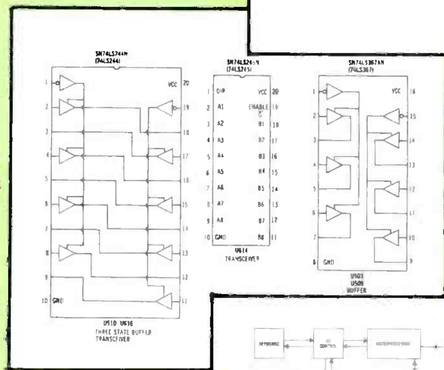
Many people who have tried to fix computers have been frustrated because for one reason or another they couldn't locate a schematic, block diagram, IC pinouts, parts list or other necessary servicing information.

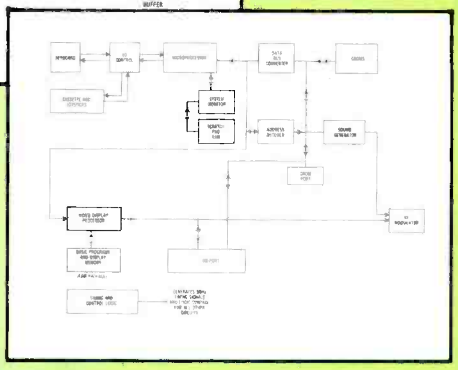
Howard W. Sams & Company, publishers of Photofact folders that contain complete servicing information on specific brands and models of televisions, have announced the availability of Computerfacts, servicing information for computers.

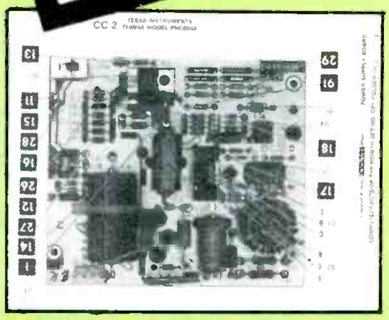
The first entries in this new product line, released in April, are packages on the Apple II, II+ and TI 99/4A computers and the Rana Elite Three disk drive. The index for the TI 99/4A, as an example,



Computerfacts booklet contains detailed information on servicing of small computers.







Circuitrace photos like this (left) help identify circuit components and connections. Block diagrams illustrate device interconnection, assist in understanding operation, locating faults. Complete IC pinout and terminal guide information is given.

Computerfacts publishing schedule for 1984.

April
- Apple II, II+ .... Computer
- TI-99/4A .... Computer
- Rana Elite Three .... Disk Drive

May
- Commodore VIC 20 .... Computer
- Epson MX 80 FT .... Printer
- Panasonic CT-1310M .... Monitor
- Hitachi CM-1481 .... Monitor

June
- Commodore 64 .... Computer
- Apple .... Disk Drive
- Epson MX 100 .... Printer

July
- Osborne 1/1A .... Self-Contained System
- Zenith .... Monochrome Monitor
- Panasonic CT-135MG .... Monitor

August
- IBM PC .... Computer
- Hayes .... Modem
- Okidata .... Printer

September
- ATARI 800 .... Computer
- C ITOH .... Printer
- IBM .... Color Monitor
- Apple .... Monochrome Monitor

October
- Franklin Ace 1000 .... Computer
- Rana Elite One .... Disk Drive
- NEC .... Printer

November
- Apple IIe .... Computer
- Diablo .... Terminal
- Zenith .... B/W Monitor
- NEC .... Color Monitor

December
- Epson QX10 .... Self-Contained System
- IBM .... Monochrome Monitor
- Commodore .... Color Monitor

lists the following information features:

- Adjustment
- Block diagrams
- Disassembly instructions
- General operating instructions
- Grid trace location guide for the power supply board
- Line (address, data, etc.) definitions
- Logic chart
- Parts list
- Photos
  - Keyboard
  - Main board
  - Power supply board
- Safety precautions
- Schematics
  - IC pinouts and terminal guides
  - Keyboard
  - Main board
  - Notes
  - Power supply
- Troubleshooting

CC	All central processing units
DD	Disk drives and other memory devices
CMD	Modems and local area network productions
CMT	Monitors
CP	Printers
CT	Terminals
CSCS	All computers that are self-contained incorporating a monitor, disk drive and CPU in one unit

According to preliminary information, Computerfacts will be presented in booklet format with numbered pages. An index will be on the front cover. The actual size and number of pages of any one booklet will depend upon the complexity of the product covered. Current plans call for all major manufacturers to be featured including Apple, Atari, Commodore, Epson, Hayes, IBM, Osborne, NEC and Texas Instruments.

Computerfacts will be available through electronics distributors, electronics retailers and computer stores. The accompanying table shows the names and coding for these booklets.

For anyone who might be interested in building a complete library, Sams offers a Computerfacts Standing Order Program that features at least three new Computerfacts each month: one each for a computer, a disk or modem and a printer or terminal. ES&T

(Continued from page 58)
three miniature banana plugs may be used for riveting to panels or PC boards, and the solder turret jacks also enable rapid attachment of wires. The solder-type miniature banana plugs are available in

rivet types with or without turrets, and a standard type with threaded stud. Standard insulated or uninsulated alligator clips are also available. The collars of the clips will accommodate a standard banana plug.

Circle (84) on Reply Card

Satellite dish

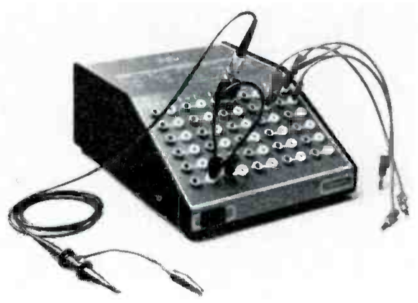
A 10-foot perforated aluminum satellite TV antenna from *Winegard* delivers 39.5dB gain to provide quality reception in most parts of the continental United States. Model SC-1018 complies with FCC 2-degree spacing requirements, with a beamwidth (at −3dBi test points) of 1.6 degrees. The .040-gauge perforated aluminum unit uses extruded aluminum in its eight support ribs and rim for extra strength. Though rugged, the dish weighs 92 pounds and is designed for quick set-up. A special antenna feature is the anodized finish, which makes it impervious to all weather conditions and corrosion. Included with the dish is a heavy-duty, pedestal-type polar mount. Wind survival is rated at 125 mph.

Circle (85) on Reply Card

Power supply

The model PPS-1000 multi-output ac power supply from *Pantera Corporation* allows a designer to emulate virtually any voltage/current combination he desires, simply by rearranging output jacks. Several different outputs can be generated simultaneously, eliminating the need for numerous prototype transformers.

Thousands of voltage/current configurations are feasible through 30 separate outputs, allowing a total output of more than 300 watts. A total of 186 volts



is possible. Units can be added in parallel if additional power is needed. All outputs are independently isolated and overload protected. Because all outputs are independently isolated, balanced center tap arrangements are easily simulated. Voltage is regulated within 3 percent on all outputs.

Circle (86) on Reply Card

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Readers' Exchange

For sale: Eico 944 flyback transformer and yoke tester. Like-new condition. Complete with cables and manual, $40; Jackson model TVG-2 TV signal generator with manual, no cables, $60 or best offer, not working. *Alfred Weiss, Route 2, Box 25, Moffat, CO 81143; 303-256-4262.*

For sale: Heathkit IG28 color signal generator, $35; Knight KG 625 VTVM, $20; Eico 950 bridge and comparator, $15 with manuals, good operating condition. *A. Orjias, 1650 Airport Rd., Montrose, CO 81401; 303-249-4995.*

For sale: 2 meters as new with batteries. 1) Hickok model LX304 digital multimeter, $50 with leads and information; Eico multimeter model 30A3, $15. Shipped UPS collect, or buy both with no shipping. *L.M. Morrish, 3113 Primrose Drive, Hendersonville, NC 28739; 704-692-7139.*

For sale: Heath IT-3120 transistor, FET & SCR tester, mint condition with manual and test leads, $70 postpaid. *Bob Kramer, 919 Grove St., Aurora, IL 60505; 312-898-8946.*

Needed: Schematic for TV set model C-2000SR made by United. Also need flyback transformer for same or where to obtain one. *Kenneth J. Sponholz, Ken's TV & CB, 166 Gary Lane, Cheektowaga, NY 14227.*

For sale: Antique and obsolete radio and TV tubes; also radio and TV knobs, 100 to package, assorted; color and b&w yokes. Also need input transformer for Philco radio model 20, listed as #21 on chassis. *Troch's, 290 Main St., Spotswood, NJ 08884; 201-251-3042.*

For sale: Heath Vectorscope model IO-101, $85; Eico flyback and yoke tester, model 944, $45; Heath FET/transistor tester, model IT-121 (like model IT-3120), $45; or all three for $155. *Dennis Jaques, 235 Hull St., Coldwater, MI 49036.*

Needed: Service manuals for Bearcat scanner model 200, Kenwood KX-1030 cassette deck and Fidelity Electronics chess challenger model CCX, or company that sells such manuals. *Karl Hendricks, 1011 W. B, N. Platte, NE 69101.*

For sale: 31 Sams 916-1739, 417 Sams 3-894, CB 8 & 12, 31 AR 1-181, Tab Books, Zenith 2, Sylvania, RCA 1 & 2, Admiral 2. Best offer for any one or all. Send SASE for complete list. *Donald Lewis, Route 1, Box 308, Central City, NE 68826.*

Needed: One IC, #IC21/46-5002-21 Philco part #, or replacement #HEPC6077P Motorola #, for Philco TV model C9263 BPC-1, chassis #3C R41. *Tabor TV, Box 56, Killdeer, ND 58640; 701-764-5017.*

Needed: The RP-1 board (video playback and record amplifier board) part #809-42 (old #804-770) for a Zenith videorecorder model #VR9700J. *Peter C. Tukker, 6321 Sherrian St., Douglasville, GA 30135.*

For sale: Sams Photofact car radio repair manuals #1 through #137, $1 per manual plus postage. *John Brouzakis, Route 3, Box 602B, Charleroi, PA 15022; 412-483-3072.*

For sale: Several used Heathkit, Eico test instruments. Best offer. Excellent condition, manuals and leads included. *Al Altigieri, 539 Bernard St., E. Meadow, NY 11554; 516-542-0780.*

For sale: Model TV50 genometer, $25, Sencore CR143 CRT tester, $40, Sencore SS137 sweep circuit analyzer, $50; or all for $100, plus shipping. All items complete with manuals and leads. *Lloyd E. O'Brien Sr., P.O. Box 105, Springfield, WV 26763.*

Needed: TV schematics (1970 on), complete sets preferred, would prefer to buy from someone in California, Oregon, Nevada or Arizona so I can pick them up myself. *Frank Eichler, P.O. Box 1116, Mt. Shasta, CA 96067; 916-926-5443.*

For sale: One Quasar SF module and one Sencore SM158 sweep aligner. Best offer for either or both. *Larry P. Huckeba, 5 Northside Drive, Newnan, GA 30263.*

Wanted: Good used yoke, Sylvania #51-27761-1 (for model C34W/chassis D11-1). Also good used or new horizontal output transformer, Toshiba #AZ-9122 (for model C3A). *Henry Herling, 6723 Breezy Point Road, Oconomowoc, WI 53066.*

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WANTED: Used CTR rebuilding machine, Raymond Mailhot, 107 W. 5th Ave., La Sarre, Quebec, Canada J9Z-1K5. 4-84-3t

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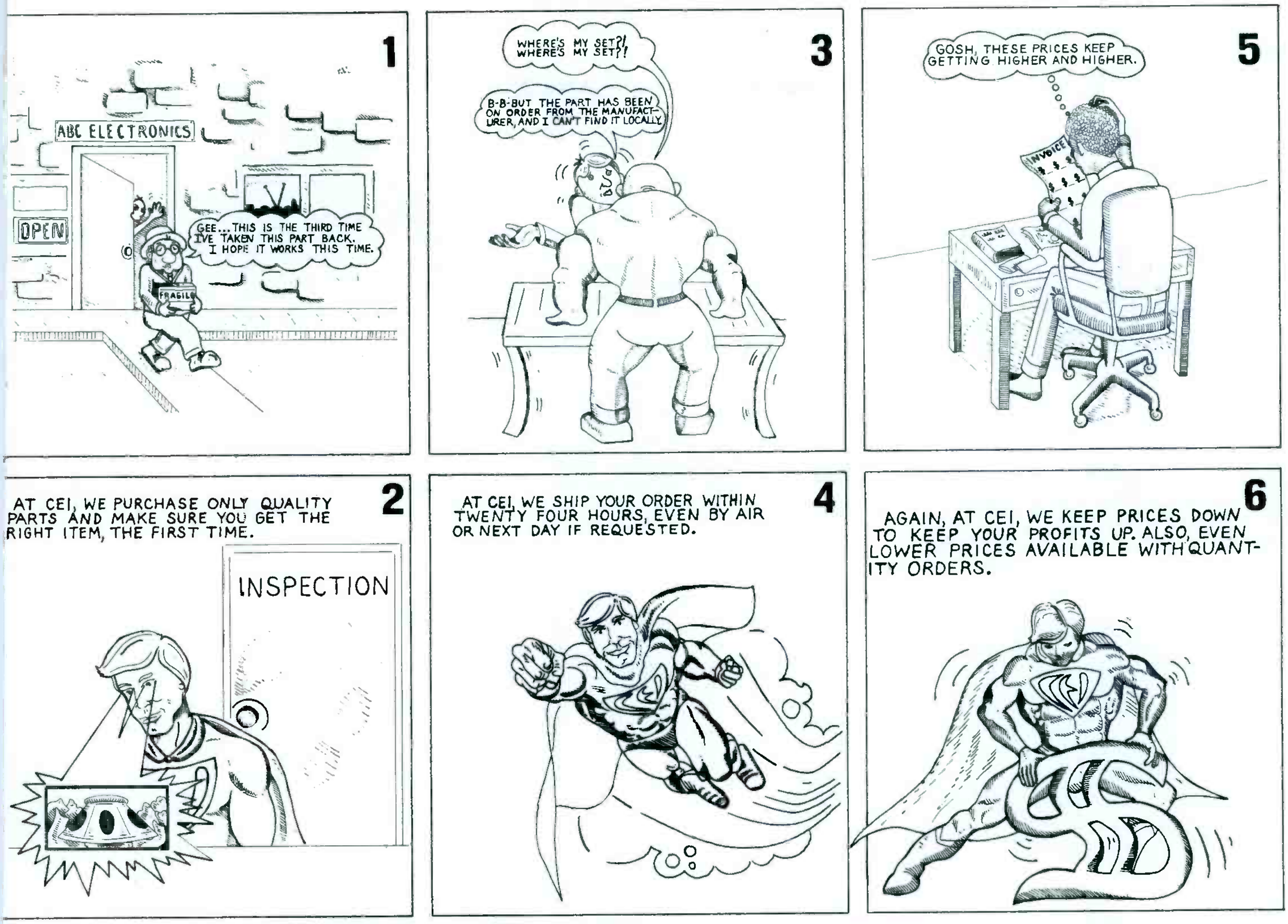

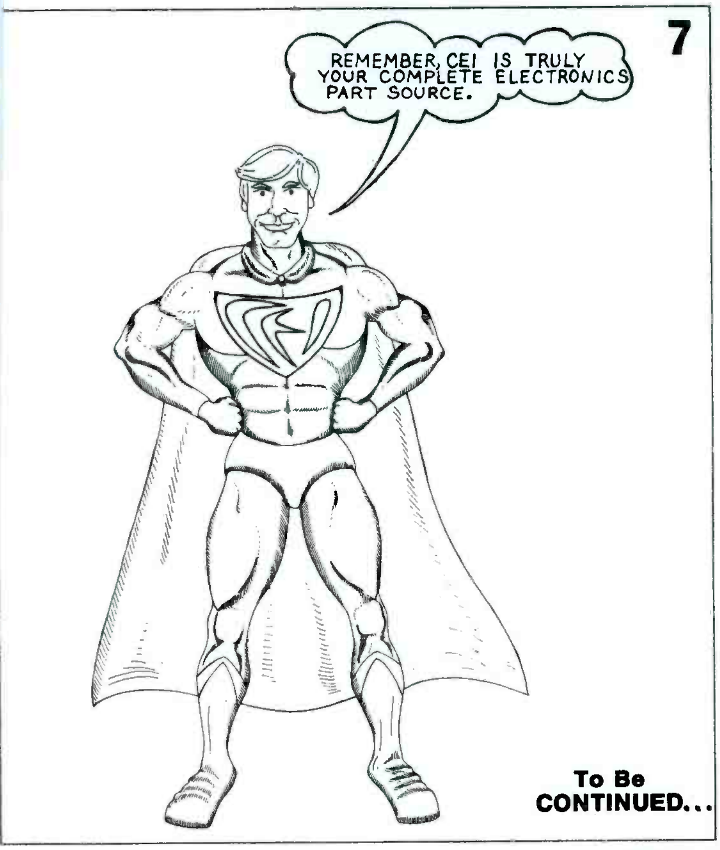

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The people who gave you the Video Service Standard of the 70's. Now Introduce the all new standard for the 80's—MODEL VA62.

Cut your video service time in half

The Sencore VA48 TV Analyzer, introduced in 1976, quickly became the industry standard for video service. It is now used by more than 22,000 technicians nationwide who have averaged an overall 54% reduction in service time, according to a recent survey of VA48 owners.

But Times Change: Today's video circuits include projection TV, 4-head VCRs, SAW filters, comb filters, integrated flybacks, cable-ready tuners, and many more circuits you just can't service effectively with the VA48. That's why we now have the VA62—the only video analyzer that equips you for all of these new video circuits—and then some.

In a Nutshell: Here's what makes the VA62 unique:

- It's a TV analyzer—Fully updated for the latest circuits.
- It's a VCR analyzer—Makes VCR analyzing a snap (using two inexpensive accessories) . . . and it meets all manufacturers' requirements.
- It's cable-ready—Test all the latest digital tuners.
- It has unique patterns—Special test patterns, plus standard patterns simplify troubleshooting.
- It's obsolete proof—It can be updated as needed for new circuits or formats . . . quickly and inexpensively.

Guaranteed Results: The VA62 can cut your service time in half on all video circuits—new and old. We guarantee it or we'll refund your money at the end of 30 days.

Update Today: If you're ready to update your bench to service the new circuits of the 80's, write or call toll-free today for a complete color brochure.

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