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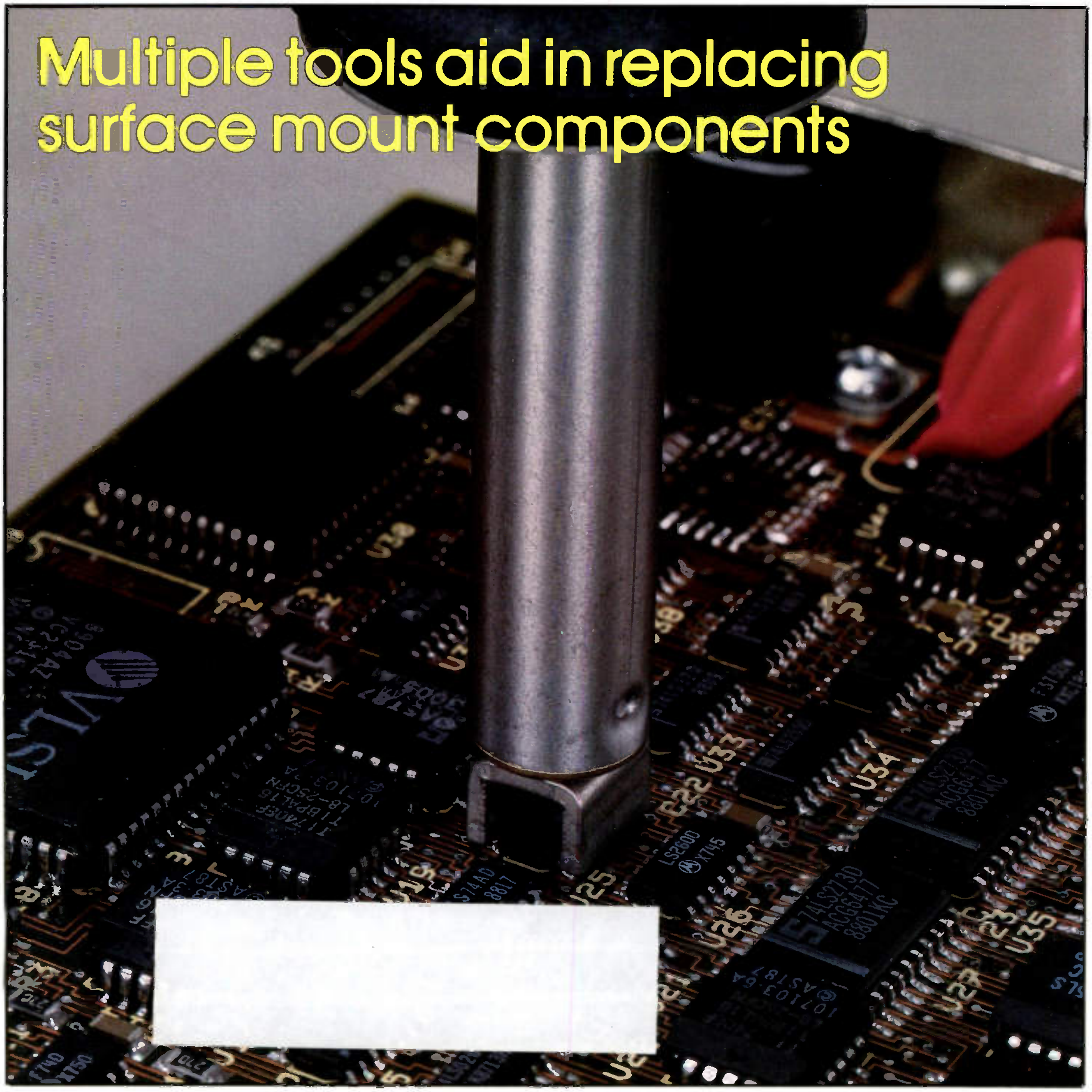
Understanding bipolar transistors - Part II

Servicing TV width and linearity problems

Multiple tools aid in replacing surface mount components



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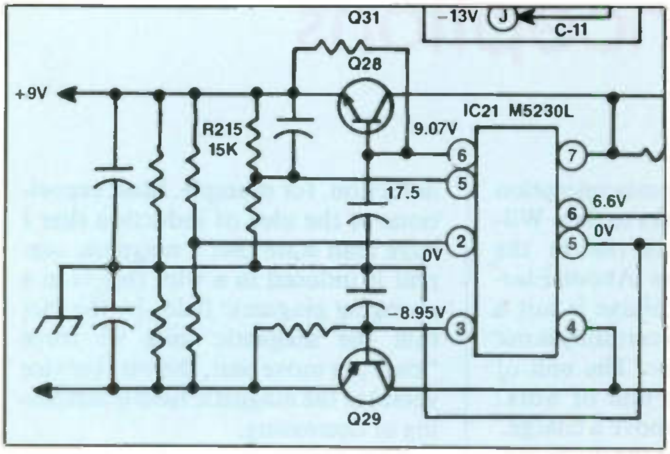

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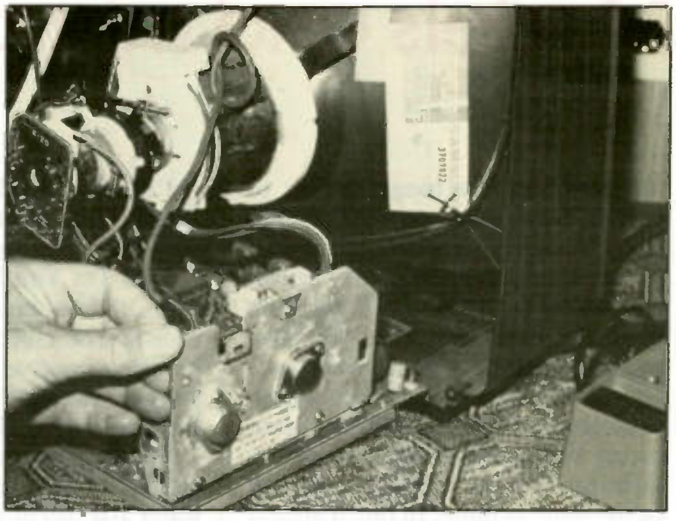

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ON THE COVER

When you're working on a mechanical problem, it may be possible to get by with an adjustable wrench, or a pair of pliers and a screwdriver but you'll get more done with less damage to yourself and the product you're working on if you use a tool kit with a selection of the right tools. The same principle applies to soldering and desoldering components mounted on a pc board. *(Photo courtesy PACE).*

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Models and misconceptions

Electronics is a tough subject to master. No one has ever seen an electron. Electrical parameters can only be measured with some kind of instrument. You can't see what's going on in an electronic circuit, so you have to visualize, in your mind, what's going on. And that's one of the biggest problems in learning and communicating about electronics. Your mental image of what's going on may not be the same as mine. In fact it almost certainly isn't. And because electronics is so abstract we have to resort to models and analogies to get a handle on it.

Of course, the most well known model, or analogy, is the classic water analogy. It's a wonderful analogy to use to visualize what's going on in an electronic circuit. An electronic circuit can be looked at as though it's a closed plumbing system. Let's consider a simple circuit in which we have a battery and a resistor in series, connected, of course, by wires.

The water analogy of this system is as follows: consider the voltage source to be a pump, consider the wires to be pipes, and the resistor would be a narrower piece of pipe. The flow of water through the system is analogous to the current, and the pressure drop across the narrower pipe is analogous to the voltage drop across the resistor.

An analogy such as this one allows us to form a mental concept of what would otherwise be difficult, if not impossible to grasp. It is therefore very useful to use such analogies and models. But there is serious danger that once the analogy has been applied, once the model has been constructed, the person using the model will forget that it is just a model, and believe that that's really how the electronic circuitry operates. Once that happens, all kinds of confusion and misconcepts can result. In fact, even the geniuses who have developed the science of electricity and electronics have been known to contribute to the confusion.

I'd like to dispel one misconception for starters, with thanks to Sam Wilson for pointing this out in the "What Do You Know About Electronics?" column. Voltage is not a pressure, or a force. It certainly is not an *electromotive force*. The unit of voltage, the volt, is a unit of work: the work required to move a charge.

To further point out the inadequacies of models, let's go back to the water analogy of an electrical circuit. The model as we constructed it has analogues for voltage, current, wires, resistance. What would the hydraulic equivalent of an inductor be, or a capacitor? What would a water transformer look like, and how would it work?

I can still remember using models when I was going through engineering school. In those dim and distant days the class was introduced to the piecewise-linear model of the vacuum tube. given the characteristic curves of a vacuum tube, it was possible to construct a model consisting of several diodes, a controlled current source, and several resistors. If the model was properly constructed, on paper of course, the characteristic curve was a series of straight lines that closely approximated the actual characteristic curve of the vacuum tube.

The idea was great. The piecewise-linear model made it possible to study the characteristics of the vacuum tube with something approaching mathematical rigor. The math was horrendous, though. The biggest problem with this model approach was that somehow many of the students lost sight of the fact that this was just a model and really had the feeling that within that glass, plastic and metal device was an assembly of the components that made up the model.

Another problem with the study of electricity and electronics is that many of the topics are taught in a slightly off the mark manner, which leads to a slightly incorrect notion of the theory of how things work. Take induction, for example. Most expositions of the idea of induction that I have read state that a magnetic current is induced in a wire that is in a changing magnetic field, by the fact that the magnetic lines of force "cut", or move past, the wire (or vice versa) as the magnetic field is increasing or decreasing.

That notion works, but it is not quite correct. The current is induced in the wire because the magnetic field in the portion of space where the wire is located is increasing or decreasing. It is the increase or decrease in the magnetic field at the wire that causes the induced current, not any "cutting" of the wire by the magnetic field. It's a small point, but an important point, and on occasion, the explanation of a phenomenon that depends on magnetic induction becomes confused because of the incorrect mental picture of what's happening.

It cannot be overemphasized that the understanding that many of us have of how electricity and electronics work is clouded by this kind of confusion we have between the model and the real world, and by some of the slight misconceptions we may have been taught. The first reaction that many of us have when we are faced with a discussion of electronics that is at odds with our preconceived notions is to dismiss the new idea. It may be that it is our preconceived notions that are wrong, and not the new information. Any time a new idea in electricity or electronics jangles, we should question the old information on which we built our view of the subject, as well as the new information to determine which is faulty. Otherwise we cling doggedly to the misconceptions we learned early on, and that means that we stop learning.

Nils Conrad Persson

IESA/ETA-I Regional technician training conference

The Indiana Electronic Service Association President John Blaydone announces the ISEA annual fall convention, Nov. 8 and 9, 1991 at the ITT Technical Institute in Indianapolis Indiana.

The IESA/ETA-I Regional conference will feature two days of electronic seminars for technicians and shop owners.

The IESA will present electronics technology and servicing seminars covering: lasers, fiber optics communications, computers, laser disk flyers, switching power supplies, TV and VCR basics and test equipment. The seminars will be held Friday and Saturday, November 8 and 9, 1991.

The ETA-I and SDC will also present a Business Management Seminar. This is an opportunity for business owners, managers and technicians dealing with the public to learn profitable business methods. By the time this eight hour seminar is over, participants will know how to use their financial records to assure that they are on the right path towards operating their business profitability and efficiently.

Technicians will have the opportunity to become Certified Electronics Technicians. The Certified Satellite Installers exam will be given by ETA-I and Indiana State testing will be given by the Indiana Professional Licensing Agency on Friday, November 8, 1991 at 7:00 p.m.

NESDA/ISCET enters supreme court tiff; files as friend of court in behalf of independent servicers

The National Electronics Sales & Service Dealers Association (NESDA) and International Society of Certified Electronics Technicians (ISCET) have moved decisively to help defend, in court, the future of independent service. The dealers' and technicians' organizations, based in Fort Worth TX, are filing a joint Friend of the Court Brief on behalf of Image Technical Services (ITS) Inc. et. al. vs. Eastman Kodak Co.

The NESDA/ISCET Brief is being filed by noted antitrust attorney Ron Katz of the San Francisco law office of New York-based Coudert Brothers.

Kodak is one of several manufacturers using tactics that NESDA/ISCET claim would establish a defacto monopoly on the servicing of their brand of product. In 1987, Kodak refused to sell service literature and repair parts for Kodak printers and copiers to ITS and other independent service companies in California. Those services sued Kodak, charging restraint of trade. After a split decision in two lower courts, the case is now scheduled for a U.S. Supreme Court hearing in late 1991 or early 1992. Companies and other entities which have sided with Kodak include Digital Equipment Corp., General Electric (not Thompson or GE Service), Hewlett Packard, UniSys, Wang, and the U.S. Justice Dept., and several major national automotive and computer manufacturers' trade associations.

In addition to participating in the Friend of the Court Brief, NESDA/ISCET officials plan to exert intense lobbying influence at the Justice Dept. in Washington DC.

NESDA/ISCET continues to support, in principle the additional Friend of the Court Brief filed by the California State Electronics Association and is assisting CSEA in the collection of funds to offset their legal expenses.

Literature

Corporate newsletter published by Anritsu Corporation

Anritsu has made available its free corporate newsletter, Anritsu News. This four-color newsletter, published eight times a year, focuses on presenting an array of marketing and technical articles.

The newsletter has three distinct sections which are entitled management, special feature, and technical review. The management section focuses on philosophies that Anritsu employs in the workplace. The special feature section deals with a subject relevant to Anritsu's market that is written by a prominent authority on that topic. The technical review concentrates on an Anritsu product and provides detailed features and specifications. The last page of the newsletter details any newsworthy information on Anritsu overseas subsidiaries.

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Electrical/HVAC-R service equipment catalog

The Electrical/HVAC-R service equipment catalog from John Fluke Mfg. Co., Inc. is now available. The 15-page catalog features an extensive line of multimeters, thermometers and accessories for the electrical service industry.

Highlighted in this year's catalog is the 20 Series II family of digital multimeters. The 20 Series II retains the features found in the original line of meters while adding increased accuracy and measurement capability. The catalog also provides descriptions and photos of the Model 70 analog/digital multimeter, the 80 Series handheld DMMs and the 51/52 digital thermometers, as well as several selection guides for the products and accessories.

Circle (65) on Reply Card

Spec sheet describes 2-in-1 instruments

Complete electrical and mechanical specifications plus key features, of the FG-500 Series of sweep/function generators from American Reliance Inc., are displayed and detailed in a two-page spec sheet. The FG-506 offers a 6MHz sweep/function generator while the FG-513 provides a 13 MHz sweep/function generator. Both have an intelligent 100MHz frequency counter.

Key features common to both units are: sine, square, triangle, ramp synchronous clock, and dc outputs; 6-1/2 digit frequency counter with attenuation and low pass filter; linear and logarithmic sweeps; adjustable symmetry/duty cycle; continuous triggered, gated, clock and external frequency modes; period or frequency read-out; and TCXO crystal stabilized time base (optional). This spec sheet displays the operation of the units, and their mechanical and electrical specifications. Both units are microprocessor-based providing menu-driven front panel controls for setting waveform outputs and operation modes.

Circle (72) on Reply Card

Distributor catalog features new instruments

The latest edition of the Fluke Distributor Products Catalog, featuring new digital multimeters with increased measurement capability and accuracy, is now available. The 20-page catalog contains photos and information on the full line of Fluke handheld and benchtop multimeters, digital thermometers and accessories, plus specifications on the Philips line of timer/counter, frequency counters, DMMS and RCL, meters all available through authorized Fluke distributors.

New to this year's catalog is an expanded and improved version of the 70 Series DMMs. The new 70 Series II adds increased measurement capability and accuracy to the broad range of features offered on the original family of meters.

The catalog provides easy-to-use selection guides for meters, counters and thermometers and an accessory compatibility chart, which allows for a quick check of multimeter/accessory and multimeter/test leads compatibility. ■

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Understanding bipolar transistors - Part II

By Carl Babcoke

The first part of this article was published in the August 1991 issue. It considered transistors as consisting of two diodes connected back to back. As that segment pointed out, there are advantages to understanding transistors in taking that approach, but it is misleading. In this segment, we consider transistors as they actually are. It's a little more complicated, but presents a true picture of how they actually operate.

In Part 1, we examined the methods and results of testing a small transistor as if it were two separate diodes stacked together. This is a very helpful concept for the rapid testing of transistor junctions (actually, they *are* diodes.

If ohmmeter tests show one or more transistor junctions open, shorted or excessively leaky, that transistor is defective, and no complicated tests of it as a complete transistor can improve that diagnosis. However, not all questions about the conditions of transistors can be answered so easily. Therefore, it's time to leave the ohmmeter.

Tests of whole transistors

Transistor tests discussed here are of two general types: 1) static tests of transistor junctions individually; and 2) dynamic or operational with-signal tests between input (base) and output (collector). Examples of both will be described and illustrated.

Sweeping one junction

The test is a hybrid that checks only one junction at a time by using a dynamic-sweep method. As shown in Figure 1, a junction is swept with 60Hz voltage, producing a straight line across the scope screen. But diode conduction adds a right-angle on the end of the line. The simple testing circuit is easy to construct. Your can even mount the complete circuit on the case of the 6.3Vac transformer.

Many typical good and bad waveforms are shown via photographs from a scope screen. Each waveform is explained.

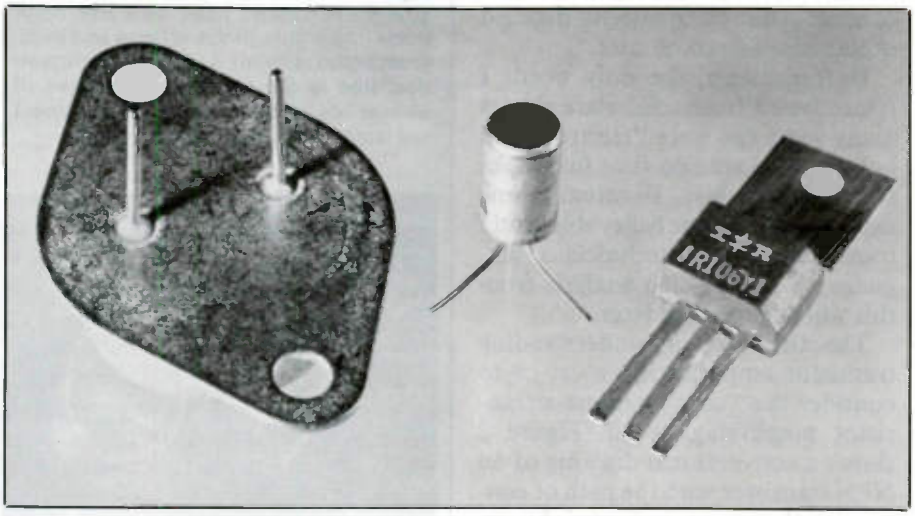
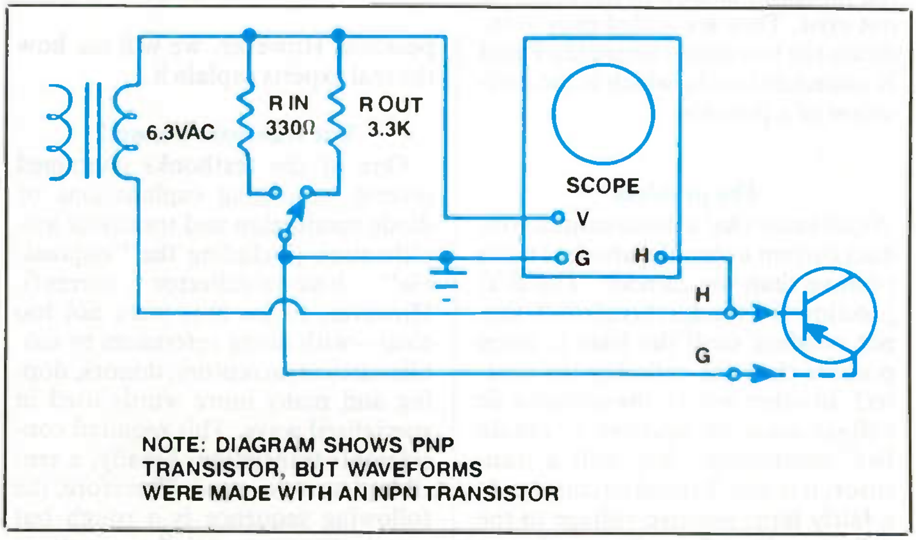


Photo 1. Bipolar transistors come in a variety of package styles and sizes.



NOTE: DIAGRAM SHOWS PNP TRANSISTOR, BUT WAVEFORMS WERE MADE WITH AN NPN TRANSISTOR

Figure 1. You can learn a lot about bipolar transistor characteristics by stimulating them with a low-voltage ac waveform and observing the response using a setup similar to this one. Use the 330Ω switch position for in-circuit measurements, and the 3.3k position for out-of-circuit measurements.

Babcoke, now deceased, was Consumer Electronics Servicing Consultant for Electronic Servicing & Technology until February 1989.

Simplified transistor theory

Many times it will be helpful to have a working knowledge of basic transistor theory. First, some background. The name transistor was coined from the two words "transfer-resistor" (*trans*fer-re*sistor) which describe the basic operation of a transistor as: obtaining power gain by transferring* the effects of current *changes* in a low-impedance base circuit to a higher-impedance collector circuit, when both have about the same current. However, this simple concept is not clear without detailed explanations to come later.

Unfortunately, the only words I remembered from solid-state classes many years ago were "electrons and holes." So I studied four textbooks for days and days. Eventually, one explanation became believable, and I translated it into technicians language. A step-by-step analysis from this will be presented later.

The first step in understanding transistor amplification must be to consider the "case" *against* a transistor amplifying at all. Figure 2 shows a conventional drawing of an NPN transistor with the path of *conventional current indicated by arrows.* Also, locations of the two junctions are added, using diode symbols. Each junction is between P and N materials, as shown in Figure 3. When drawn correctly, the junction lines are between the diode anode's triangle (the transistor base) and the diode cathode's slab (the transistor emitter or collector). Notice: those lines that pass through the junctions and on to the edges do not exist. They are added only to indicate the two places where the P and N materials touch, which is the definition of a junction.

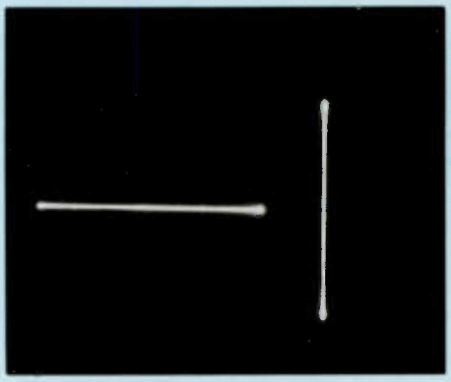


Figure 1A. At left in this photo, the long straight horizontal lines indicates *open* leads (maximum probe voltage and minimum probe current). At right, the long vertical line is the characteristic curve of *Shorted* test leads (maximum probe current and minimum probe voltage).

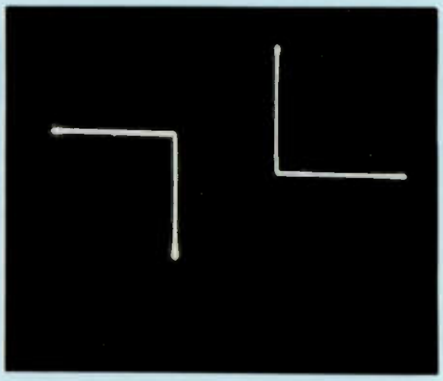


Figure 1B. A 90° angle that opens out to the lower left (shown at left in this photo) indicates a good NPN diode. On the right of the photo, a 90° angle opening out to the upper right indicates a good PNP diode.

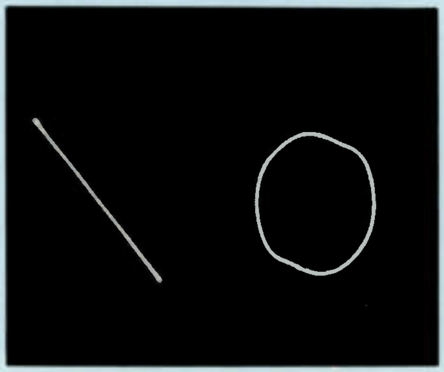


Figure 1E. In-circuit transistor testing will give waveform variations that are introduced by connected components. Resistors in parallel tilt the base lines. The line at the left in this photo tilted about 55° from an imaginary baseline when a 4700Ω resistor was placed across the scope leads. The near-circle at the right was caused by a 0.22μF capacitor.

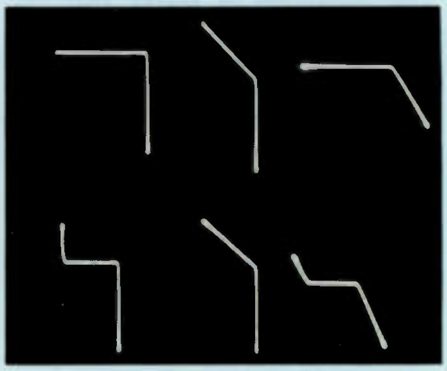


Figure 1F. These photographs show some changes to the two basic silicon-transistor waveforms caused by the addition of series parallel resistance to the B/C junction (top) and the B/E junction (bottom). At the extreme left are the two normal waveforms. In the horizontal center are the two junctions after each was paralleled with a 4700Ω resistor.

The problem

We all know that a diode cannot conduct current unless the anode is more positive than the cathode. The B/C junction is a diode, therefore it cannot conduct until the base is more positive than the collector (or emitter). In other words, the collector dc voltage *must* be negative to obtain B/C conduction. But with a transistor, it is *not*. Typical circuits apply a fairly large positive voltage to the collector. Therefore, the question is: how can the positive collector current pass through (or around) the reverse-biased B/C junction? It seems impossible. However, we will see how the real experts explain it.

The transistor answer?

One of the textbooks contained several interesting explanations of diode conduction and transistor amplification (including the "impossible" base-to-collector current). However, to me they were not too clear—with many references to mobile carriers, acceptors, donors, doping and many more words used in specialized ways. This required considerable translation. Finally, a sensible picture emerged. Therefore, the following sequence is a rough but practical answer to the question: How can NPN transistors amplify?

Two external dc voltages are essential for true transistor operation, although they are seldom mentioned in the explanations. To avoid needless repetition when their use is mentioned later with specific circuits, they are described here (Figure 4). First, the emitter-to-base (E/B) junction of an NPN transistor is forward biased by a negative dc voltage (from an external source) to the "N"-type emitter, and the "P"-type base is grounded. This forward bias *narrows* the electrostatic field that surrounds the E/B junction, thus allowing the electrons to pass through more easily. Notice that a much larger positive voltage (from an external source) is applied to the "N"-type collector, *reverse-biasing* the B/C junction and widening the electrostatic field that surrounds it.

Unfortunately, this almost com-

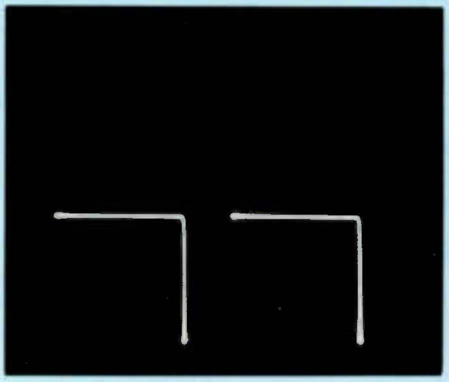


Figure 1C. In the case of germanium transistors, the B/C waveform at the left of the photo, and the B/E waveform at the right, are virtually identical. That's because germanium transistors do not exhibit B/E zenering.

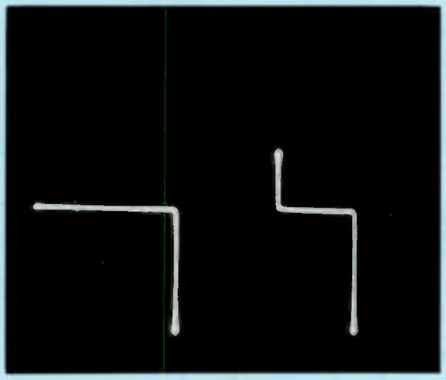


Figure 1D. The waveform at the left opens to the lower left corner in this silicon transistor. From this we know that this is a junction in an NPN transistor. If there were no further information, we wouldn't know if this was B/C or B/E.

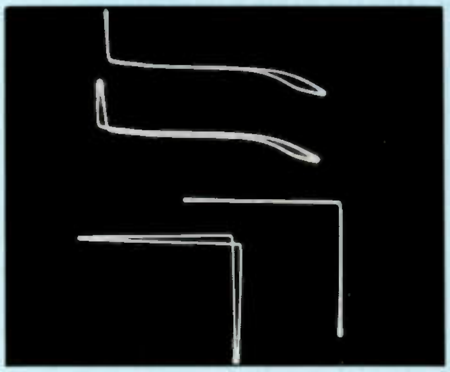


Figure 1G. AC coupling at the signal and sweep inputs to the scope (instead of the recommended dc coupling) separates the twin forward-and-reverse tracing lines, making the waveform more difficult to analyze.

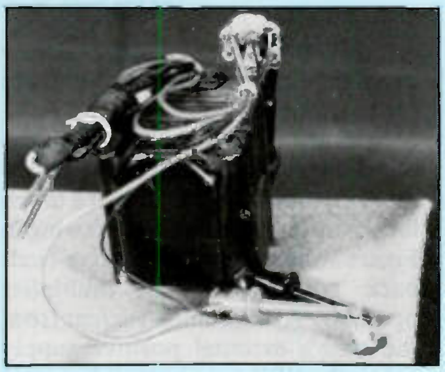


Figure 1H. Construction of the junction tester is easy, requiring only four components plus two hook clips and wire. The transformer can be very small. This is the only one available from the junk box that had a 6.3Vac winding.

pletely blocks passage of electrons through *conventional* methods. (Remember, like charges repel one another; but opposite charges attract each other).

Free electrons from the "N"-type emitter are attracted to a small positive electrostatic voltage on the emitter side of the E/B junction and move there. Although the base side of the E/B junction has a small negative electrostatic field which tends to weakly repel electrons, the electrons overpower the field and keep moving —with strong help from the base's forward bias that first attracts them and then diffuses the electrons across the entire "P"-type base (see Figure 4).

Additional electron movement is aided by the B/C junction's positive electrostatic field which is placed at the optimum point on the collector side of the junction. It pulls electrons into the output area where they first are attracted and then accelerated to the collector's large positive voltage (from an external source) where they are used as the transistor's useful output to an external load. (Later, we will find that this circuit is a *common- base*—or grounded-base type with a current gain of less than one).

Additional information

That previous explanation *appears* to cover all functions. But do you understand now — and are you satisfied with the explanation? No? Well it didn't satisfy me either. I found nothing that would explain reverse conduction of the base/collector diode (B/C junction).

So, I carefully went through the book again, looking for something that made sense. Finally, I found these next four paragraphs.

Four conditions for a practical transistor

1. All "P" and "N" areas must be parts of the *same* solid-state crystal; germanium or silicon.
2. All "P" and "N" areas must be doped to one part in 20 million by either acceptor (for "P" type) or donor (for "N" type) elements, but the base should have *less* doping thus providing fewer electrons in the base so that electrons (holes) on the base side of the emitter/base junction can be accelerated more easily to the collector than to the base material.
3. The number of electrons (holes) that are available for acceleration by the output field of the B/C junction is *determined by the distance the electrons must travel through the base.* Therefore, best efficiency is obtained when the base is very *thin*, perhaps a thousandth of an inch. This helps accelerate most of the base's electrons (holes) into the B/C field and on to become useful current.
4. Although the emitter and collector are always made from the same kind of "P" or "N" material, their size, shape and doping in the silicon crystal are not the same. For efficiency, a larger area is doped for the collector than for the emitter. That's why reversing the emitter and collector pins of a silicon transistor in the circuit gives poor gain and low power.

Also, with silicon transistors, zenering can occur in the original collector wiring. Perhaps you noticed in Part 1 that the base/collector path always gave lower ohmmeter readings than did the base/emitter path. This doping of a larger area for the collector (compared to the emitter) explains the lower B/C ohmmeter readings: the larger doped surfaces reduced the resistances.

All these variations (and probably more) of the three plain silicon slabs are responsible for the formerly impossible *reverse* flow of electronic current from the transistor's positive collector through the C/B junction and to the negative base. Greatly simplified, the action appears to be a combination of *pulling* electrons into the "P" type base, and then *pulling* those electrons out of the base and in-

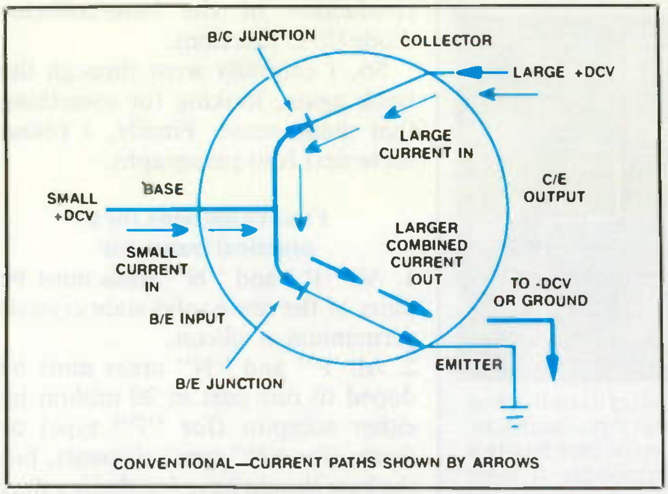


Figure 2. This drawing is the standard schematic symbol for a NPN transistor, but with the location and polarity of the two junctions shown as diode symbols, to give a feel for the transistor's electrical characteristic.

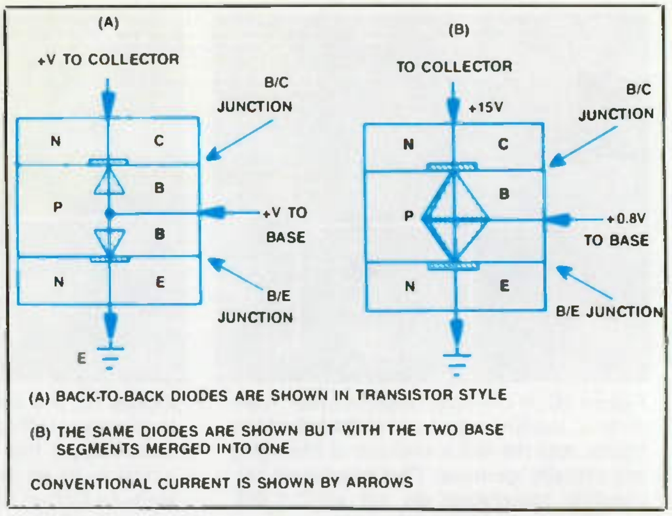


Figure 3. These A and B drawings are electrically the same, but A depicts the concept of a transistor as consisting of two separate diodes back to back, while B depicts the more correct view showing the base sections of the two diodes merged into one.

to the collector material. However, both pulling actions would move very *few* electrons if the base material was as thick as the emitter or collector instead of very thin. Other variations of the slabs also help the transistor action, but they are likely to be proprietary information.

A small input current controls a large output current

Previously, we described transistor amplification as: transferring a current change in a low-impedance circuit to a higher-impedance circuit, when both have about the same dc current. This was demonstrated and proved in Figure 4 where about 98% of the input current appears at the output; and about 2% is used to operate the base circuit. Because the output current was 2% lower than the input current, it would appear that the circuit had no gain, but a small loss.

It should be explained that the base and emitter are the input, and the collector and emitter are the output of the transistor.

There is a small loss of current; however, the overall circuit produced *voltage* gain, because the incoming ac voltage was across a low impedance, while the ac output voltage was across a much higher impedance. These results are typical of common-base circuits: current gain 0.99 (a loss), a voltage gain up to 200, power gain up to 30dB, with an input impedance of 100Ω and an output impedance of about 50KΩ. These results make common-base circuits excellent for some circuits, but not for the majority.

Another circuit has not been explained very often. *A small input current* can produce and control a much larger output current. The drawing in Figure 5 shows how the positive-feedback type of current multiplier operates. When a small current from the base's external positive supply enters the "P"-type base, it becomes a small forward bias that begins the transistor sequence.

Base current travels through the E/B junction and the "N"-type emitter to ground. From ground, the (conventional) current passes through the higher-voltage collector supply and brings a large positive voltage to the "N"-type collector.

Current from the collector passes through the B/C junction to the "P"-type base—where it joins a small positive current from the base's bias supply mentioned before. These two currents merge and pass on through the E/B junction, the emitter, and arrives at the ground.

From ground, the current (in conventional direction) passes through the higher-voltage supply, bringing a large positive voltage to the collector. Larger collector current passes through the B/C junction to the base, where it again is joined by the base's forward-bias current. This combined current flows through the E/B junction, through the emitter and to the ground again.

This is more than a full cycle; after

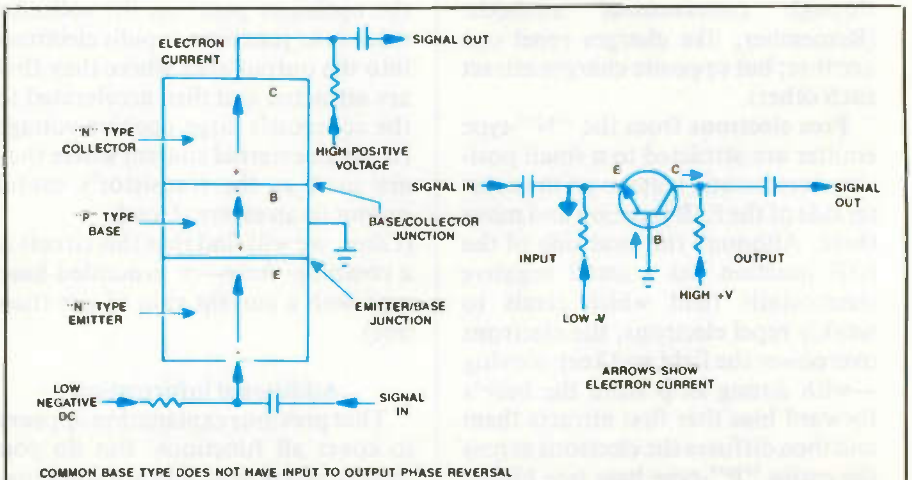


Figure 4. Here is a representation that gives a slight idea of the actual physical construction of the NPN transistor, in a common base configuration, along with the typical schematic representation of the device.

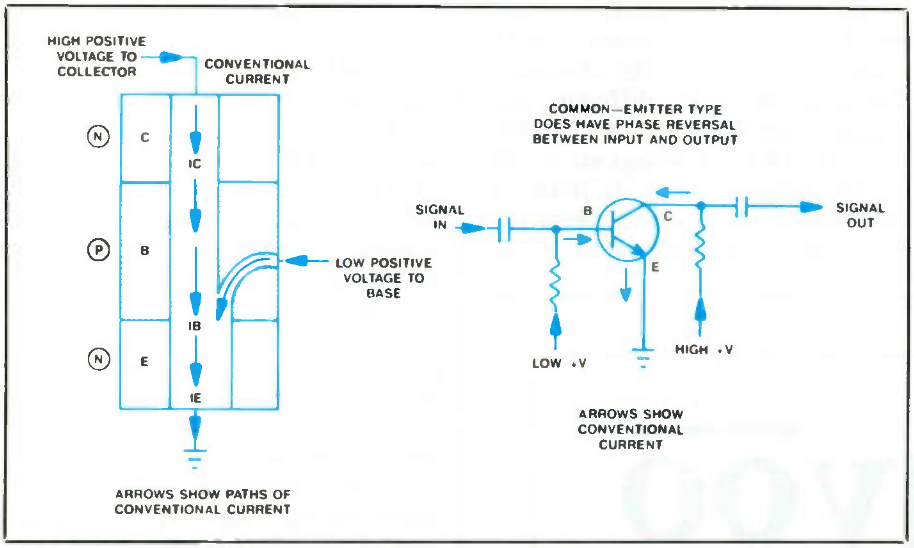


Figure 5. This representation of an NPNM transistor in the common emitter configuration gives the feel for how the collector and base currents add to result in current "gain." When the proper dc bias is applied, this circuit will provide voltage, current, and power gain.

this, the cycle repeats endlessly, so long as power is applied, with the increasing collector current increasing the base's current and forward-bias voltage with each cycle. Then a question arises.

What stops the increase of bias?

If the increase of forward bias is not leveled at some point, the alternate increases of base and collector currents will destroy the transistor. Obviously, all transistors do *not* commit suicide, so an answer must exist. But what and where? No controls, varistors, thermistors or other stabilizing components are used (Figure 5). The text books did not give an answer, but I believe I know. The B/E junction is a diode, and a normal diode is a fair dc-voltage regulator. Therefore, the B/E dc-bias *voltage* is moderately regulated, and cannot rise high enough to allow excessive-current damage, or thermal runaway.

At turn-on, the regenerative increase of base dc voltage occurs so quickly that, when a specific collector voltage is needed, you should start with insufficient base bias and then increase it *gradually* until the desired collector voltage is obtained. Or, if maximum gain is desired, connect a test signal to the base input, monitor the collector signal and adjust the base bias until a maximum-gain *peak* is reached.

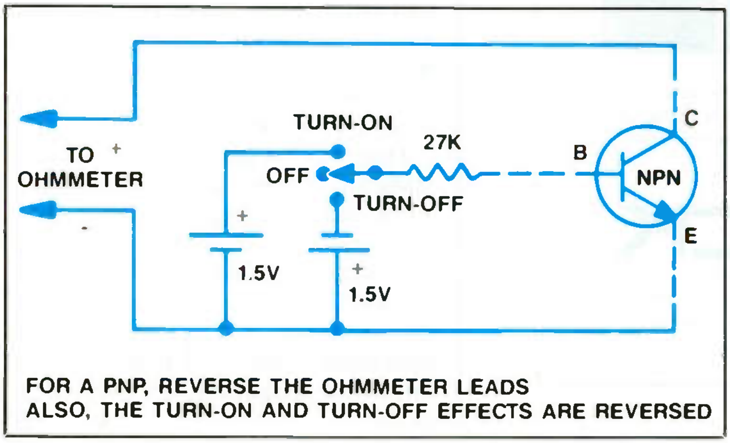
The circuit of Figure 4 is called "common (or grounded) base." The common base configuration gives no current gain, only a moderate voltage gain and provides the same signal phase at the emitter input and the collector output. There is no phase inversion. By contrast, the circuit of Figure 5 is called "common (or grounded) emitter." The common emitter configuration does give a large current gain, a large voltage gain, and *does* invert the phase between the base input and the collector output. Specifically, the grounded-emitter current gain is a high 75, voltage gain is 600 and the output impedance is a high 50K. These specifications, checked against those of the common base show why the common emitter is chosen for most TV designs.

A simple transistor tester

True transistor operation can be proved or disproved most simply by these few readings. And the tests are easy when using an ohmmeter, the transistor to be tested, and a shop-made adapter that has four components plus flexible wire and three hook-type test clips, as shown in the Figure 6A schematic.

These tests could be called bias-on/bias-off because that describes the method of the tests. A moderate

Figure 6A. Use of a simple circuit such as this allows you to measure the "on" resistance of a transistor. See text for details.



FOR A PNP, REVERSE THE OHMMETER LEADS
ALSO, THE TURN-ON AND TURN-OFF EFFECTS ARE REVERSED

Figure 6B.

TURN-ON RESISTANCE READINGS

METER AND RANGE READINGS

SIMPSON 260 (VOM)	
RX1Ω	150Ω
RX100Ω	60Ω
RX10K	SHORT
BECKMAN 310 (DMM)	
200Ω	47.7Ω
20KΩ	440Ω
2MΩ	30KΩ
B&K 388-HD (DMM)	
200Ω	64.9Ω
20KΩ	280Ω
2MΩ	21KΩ

NOTE: THE 27KΩ RESISTOR TESTED 26KΩ, AND THE 1.5V BATTERY TESTED 1.56V

B/E forward bias is applied at the TURN-ON position; zero bias at the OFF position; and an equal reverse bias at the TURN-OFF position. The C/E voltage comes from the ohmmeter, which also displays the C/E resistance, the thing we are measuring.

The Figure 6B table shows C/E resistance readings obtained from one small NPN silicon transistor when connected in turn to the ohmmeter function of three different test meters - one VOM and two DMMs. Only TURN-ON readings are shown by the table because TURN-OFF readings of silicons were opens (infinite ohms), as were all the OFF-position readings.

Start with a TURN-ON test. After a normal reading is obtained, change the switch to the OFF position, where the meter should read infinite ohms (open). But if a reading is obtained, switch to the TURN-OFF switch position and read the ohmmeter. If that reading is the same as the previous OFF reading, the transistor has C/E internal leakage, and the meter shows the resistance. The Figure 6A schematic also can be used to test PNP-polarity transistors. Just reverse the ohmmeter leads at the adapter. Notice: this also reverses the TURN-OFF and TURN-ON functions. In other words, when TURN-ON is needed, use TURN-OFF. And use TURN-ON when TURN-OFF is desired.

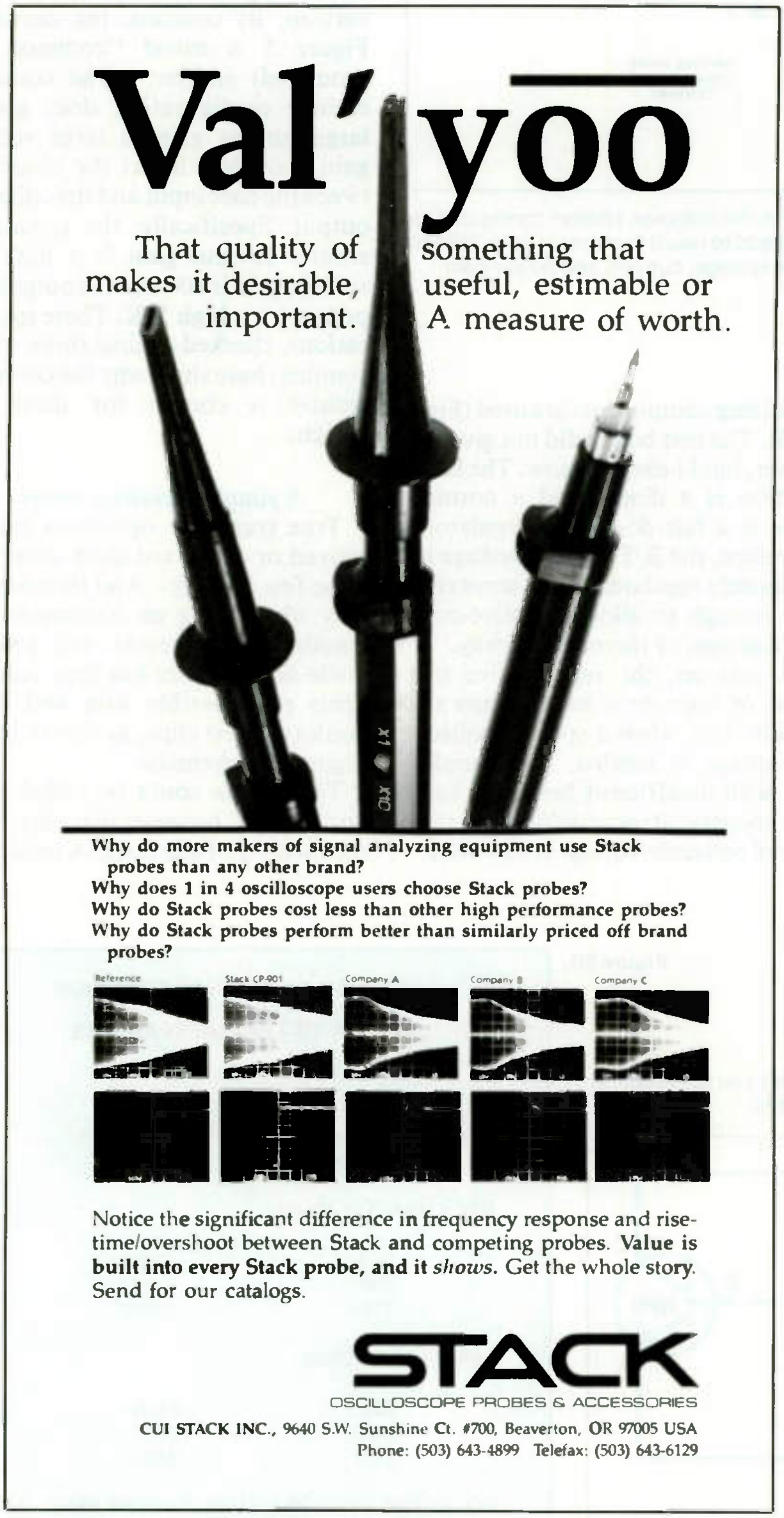
If large quantities of small transistors are to be tested, it might be advisable to wire a 3-pin socket to replace the flexible connecting wires now going to base, emitter and collector.

Normal readings of TURN-ON forward-bias tests show large differences in resistance; there is no standard here. However, experience quickly will teach you the allowable resistance-reading variations of nondefective transistors when compared to the readings of shorts, near shorts and opens or near opens that should arouse suspicion, and perhaps call for further tests. We believe a VOM produces a better spread of resistances; although in Figure 6B, we show for comparisons three ranges each of two good DMMs. Ideally, a seldom-used VOM could be designated for these tests alone.

Experiment to understand

Transistors have always been somewhat baffling to many technicians. They come in two types: PNP and NPN. They can be connected in any of three configurations: common base, common emitter and common collector. They can be used to amplify, regulate or switch.

One way to gain a better understanding of these devices, how they work and how they're applied, is to fabricate a test setup such as the one described here and make your own observations. The result will be a deeper understanding of transistor operation, which will translate into improved diagnostic and servicing skills. ■



Keeping your business healthy in a sick economy

By William J. Lynott

Many years ago, I worked for a boss who made a major contribution to my business education. One lesson in particular has stuck with me over all these years. "Now and then," he told me, "stop and ask yourself whether the task you are performing at that moment will: 1. Increase income; 2. Reduce expenses; or 3. Improve service to the customer. If you can't give a positive 'yes' to at least one of the three, stop what you're doing and get on with something that qualifies."

Simplistic perhaps, but a sound lesson in business economics nevertheless. Like a good steak dinner, it "sticks with you." And when times get a little tough, as they are for many electronics service dealers right now, it's a philosophy that can do a lot to help maintain fiscal health.

We've already discussed the importance of increasing income (marketing) and improving service to customers a number of times in this column. Now let's take a look at that old profit robber, rising expenses.

It is axiomatic in business that good times almost always breed a careless attitude toward the control of expenses. Sales, as they say, cover a multitude of sins. But when times get tough, as they always do, it's the place to look for the largest potential savings.

Clerical expense and other supporting payroll have a way of sneaking up on you when you're not looking. For that reason, it's a good idea to keep a record of the ratio of nontechnical payroll to technical payroll in your business. The idea, of course, is to keep that ratio to the lowest practical minimum. To figure your percentage, just add up all dollars for technician payroll in a given month and divide that figure into the total of all other payroll (including yours if you don't run calls). Then, multiply the result by 100. Here's how that might look:

$$\frac{\text{supporting payroll (\$2,300)}}{\text{technical payroll (\$4,500)}} = .51$$

$$.51 \times 100 = 51$$

Because of the wide range of sizes and types of electronics service organizations, an industry average for supporting payroll ratio would not be of much help. Instead, once you begin to maintain your own records, you can set realistic goals to reduce your own ratio or at least hold the line. Don't worry about getting that ratio too low. In many years of consulting, I have yet to find a service operation in sore need of additional supporting payroll.

How to reduce supporting payroll? Well, for one thing, take a hard look at your office and record keeping systems. Are your files well organized? Have you set a specific time limit for the retention of customer records? Better, have you computerized your customer records?

Look, too for duplicated efforts. Sometimes, the most conscientious of employees will establish "backup" systems, just to be "sure." Paper has become a major villain in the business world, both because of the cost of the stuff itself and the cost of shuffling it back and forth around the office. Records are essential, or course; but *you* must be in control of them, not vice-versa.

One profitable use of records is in keeping track of supplies. Chances are that you don't need to be reminded of the cost of a roll of solder or a box of flashlight batteries. But those items may be costing you more than they should if you aren't keeping accurate records of who-gets-what.

While you don't want to be another Scrooge in the matter of pencils and paper clips, your demonstrated interest in reasonable expense control will almost surely influence your employees in a positive way. I once saw a technician from a local utility give a customer a roll of plastic tape saying "I can pick up another roll or two when I get back to the shop." Not long ago, I borrowed a marking pen from the driver for one of the package delivery services. I used it to address my package and admired how nicely it worked. "Keep it," he insisted, "I have lots of them."

In my opinion, the employers in both of those cases probably take a casual approach to controlling the cost of supplies. As a result, their employees view the subject the same way.

Printed forms are another opportunity to waste expense dollars. Do you really need a five-copy work order? Is there a printed form that could be combined with another? Would a form be just as effective printed on 20-pound bond paper as on heavy stock?

There are, of course, many other expenses in a service business that should be examined carefully. Telephone/fax, utilities, vehicle operating costs, and non-productive technician hours, to name a few of the more important. Each dealer has a unique combination of operating expenses and each must develop his own approach to keeping those expenses in line.

While keeping an eye peeled for unnecessary expenses may not be the most glamorous of pastimes, it can be an important help in keeping the bottom line healthy when times get tough.

Lynott is president of W.J. Lynott Associates a management consulting firm specializing in profitable service management and customer satisfaction research.

A CD repair case history

By Victor Meeldijk

Note: when servicing CD players Electrostatic Discharge (ESD) Control procedures should be followed. This includes using wrist straps, using a grounded soldering iron and working at a static controlled area.

A client brought in a CD player, a Sharp model DX-620, with the stated problem that it did not play, and was probably dropped. Along with the CD player was a compact disc, the operator manual and service manual. I later found out that the unit had already been looked at by someone else who could not determine the cause of the problem.

When I inserted the 12-track disc that was provided into the player, and closed the disc drawer, the track indicator showed the number of tracks on the disc and the time duration of the disc.

When I pressed the Play button, the track indicator showed 01 and the Play Triangle in the display started to blink; an indication that the player was searching for track 01. The player, however, would not lock onto the track and the player stayed permanently in this searching mode.

When I set the player to track 02, the same thing happened, and I could hear the laser pick-up assembly moving, searching for the track. Tracks 3, 4, and 5 also exhibited the same problem, but when I tried track 6, the player worked. Tracks 7 through 12 also worked. I thought that it was possible that the problem might be caused by the disc, so I tried a known good one that had 24 tracks.

This time the player found some of the lower numbered tracks, but only after a lengthy delay. It occurred to me that information on this performance might be of use in isolating the problem, so I recorded all of this data.

Table 1 lists the searching times for each of the disc tracks. Table 2 is a comparison of the search times for the 12 and 24 track compact discs when I tried them on two other CD players. I next tried the Cue and Review modes. I found that if the player had once locked onto a track, and was then put into the Review mode, it could go back to the beginning tracks of the CD, including Track 1, and play them.

TRACK LOCATION TIMES IN INITIAL PLAYER EVALUATION
TRACK NO. TIME TO LOCK ONTO THE TRACK
1. Did not lock after 1 minute (jarring the unit had no effect).
2. Did not lock after 1 minute (jarring the unit had no effect).
3. Did not lock after 1 minute (jarring the unit had no effect).
4. Did not lock after 1 minute (but jarring on the unit caused the system to lock onto the track).
5. Locked after 25 seconds (32 seconds when tried again).
6. Locked after 8 seconds then 10 seconds when retried.
7. Locked after 8 seconds
8. Locked after 7 seconds
9. Locked after 5 seconds
10. Locked after 11 seconds

23. Locked after 2 seconds
24. Locked after 1 second

Table 1.

Visual inspection revealed little

I removed the cover and examined the CD player. I didn't see any internal damage, but the Spin (turntable) Motor was noisy and did not rotate freely. I turned off the player and lubricated the laser assembly rails with a little grease and put a drop of oil at the base of the motor shaft with a precision oiler. I then examined the laser assembly and cleaned the laser object lens with some alcohol. When I tried a disc again I found that the cleaning and lube had had no effect on player performance.

To attain unobstructed access to the laser assembly, I removed the disc holder by pushing on the retaining hook (Figure 1) and removed the disc pressure arm by unscrewing two screws at the rear of the arm. I removed the disc pressure arm and tension springs (Figure 2) and examined the turntable assembly, and checked using a bubble level to see if it was misaligned (Figure 3). The bubble was exactly in the circle. Note, if you attempt this test on a unit, make sure the player itself is on a level surface;

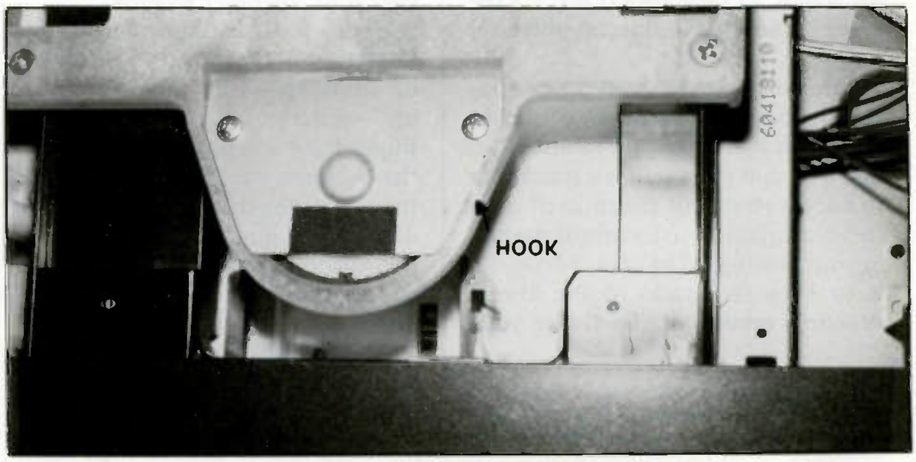


Figure 1. Remove the disc holder by pushing on the retaining hook.

Meeldijk is Reliability/Maintainability Engineering Manager Diagnostic/Retrieval Systems, Inc., Oakland, NJ

COMPARISON OF TRACK LOCK TIMES FOR DIFFERENT PLAYERS

TRACK NO.	REALISTIC PORTABLE CD-3200	HITACHI PLAYER DA-600
24 TRACK CD		
1	5-6 SEC.	5-6 SEC
2	5 SEC	2-4 SEC
3	6 SEC	4 SEC
4	6 SEC	3-4 SEC
5	7 SEC	4 SEC
6	7 SEC	3-5 SEC
7	6 SEC	3-5 SEC
8	7 SEC	4 SEC
9	7 SEC	3-4 SEC
10	7 SEC	3-4 SEC
11	7 SEC	4 SEC
12	10 SEC	4 SEC
12 TRACK CD		
1	3-4 SEC	4 SEC
6	5 SEC	4-5 SEC
12	6 SEC	4-5 SEC
18	7 SEC	4-5 SEC
24	8 SEC	6-7 SEC

Table 2.

otherwise you might misalign a good unit.

At this point I reassembled the mechanism, and examined the eye pattern. The service manual recommends that Ravel's Bolero by Deutsche Grammophone be used to do this but as this was unavailable I used one of the earlier sample CD's.

The eye pattern on track 24 of the CD was according to specifications, but I made a slight adjustment to the X and Y axis controls to see if this would have an effect on the track lock-on problem. To do this SW401, which is held in the "Mechanism Closed Position" has to be closed (Figure 4). This can be done with a piece of tape.

Next, to make the X axis control visible through the slot in the disc pressure arm the player has to be set to a track in the middle of the disc (Figure 5). The disc is then removed from the player to make the adjustment. I marked the original adjustments so that they could be returned to their original positions.

Figure 6 shows the range in which tracks would be found and which would remain in search mode. These adjustments had no effect on player performance, so I reset the adjustments to their original factory positions.

I next tried using some freeze spray to cool some of the IC's to see if this would have some effect on the unit. The performance did not change.

Problems in the power supply

Considering the strange symptoms, I decided to check the power supply for proper outputs and ripple. The +5V output from Q30 was at +4.23V and the −5V output, from Q31, was at −4.27V (refer to the schematic in Figure 7). I noted that the input to IC20 was also low. It was specified to be +13V, but it measured +11.58V. The negative input to IC20 was −13.39V compared to the specified −13V.

While performing these measurements I discovered that filter capacitors C103 and C104 were warm, and C096 was hot. When I replaced the capacitors the player symptoms changed dramatically. For the worse.

With the power switch in the off position I plugged the unit in and immediately the loading motor began to run and the display segments started to rotate, like a moving marquee light display. Pressing the power button had no effect. Checking the bases of Q30 and Q31 revealed that the transistors were always biased on, regardless of the position of the on/off switch.

I removed the replacement capacitors from the circuit and checked them. They were fine. Just to be sure, I put the old capacitors back in, but the bizarre symptoms remained, so I removed them and contacted the Sharp National Parts Center (201-512-0055) for some technical assistance. Once you get through all the customer service representatives and get switched to Audio Tech Assistance you find extremely helpful service people. The individuals I spoke to actually walked me through the schematic, providing hints about common problems associated with this model.

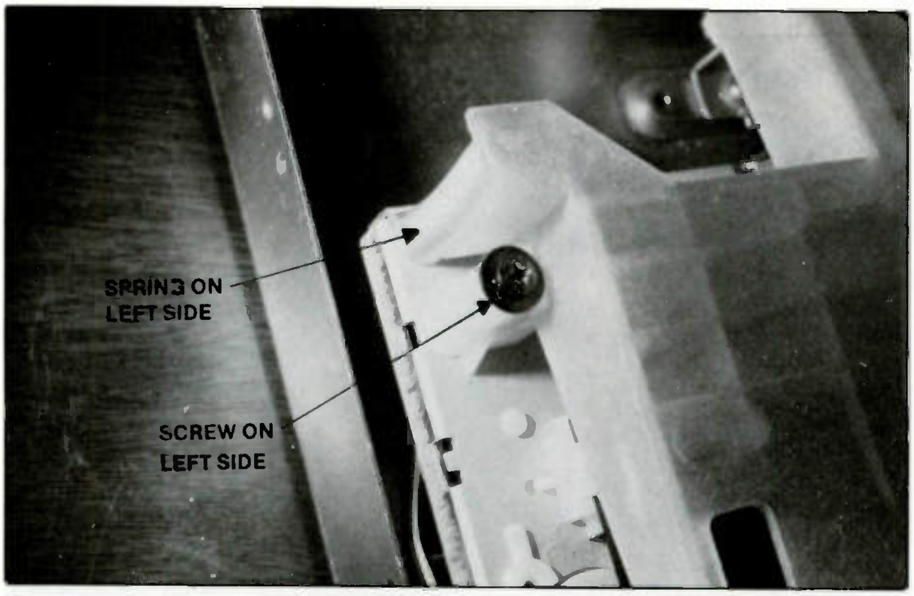


Figure 2. Remove the disc pressure arm by removing two screws and tension springs at the rear of the arm.

Some unusual approaches to design

If you look at the schematic again you will note some interesting differences in this design versus that of other CD players. First, there are no fuses or transient suppressors in the input circuit of the power supply. The power on/off switch does not switch the power on or off by disconnecting the input ac power; it actually controls a logic signal that goes to inhibit pins of IC20 and IC21 (pin 8, which is shown as going to the start circuit of M5230L [Sharp Part No. VHiM5230L//-1] on page 10 of the service manual). In a manner of speaking, the CD player is never actually "off".

According to the service technicians at Sharp, power turn on/off problems are common with this model. When problems occur, the areas to check are Q50 and Q51 (silicon DTC144N Sharp Part No. VSDTC-144N//-1), Q40 (Silicon NPN 2SC-2603F Sharp part no.VS2SC2603-F-1), D33, D32 and the rest of the "Muting Circuit"(which actually turns the player on and off) and resistors R221, R222 and R230 and R231 (Sharp Part No. RR-XZ1055AFZZ).

Q50 and Q51 are devices that may not be familiar. These are 3 terminal devices that physically look like TO-92 case transistors but are digital transistors and have a logic symbol on the schematic for this CD player, like an inverter. These devices are just transistors with some resistors added to make the device an inverter. If pin 1 is at ground when pin 2 is high, pin 3 will be low. Similarly if pin 2 is low, pin 3 will be high.

The inhibit signals for the voltage regulators come from pin 2 of Q51 (see connection "C" on the schematic). Figure 8 shows some of the different schematic symbols used to denote various digital transistors, also called "Resistor Built-In Transistors"by Panasonic which sells a UNXXXX series of devices similar to the DTC and DTA transistors sold by ROLM Corporation.

The resistors mounted above the circuit card in a white high temperature sleeving (Figure 9), are 1Ω 1/4W fusible resistors. R221 and R222 are located on the input lines to the diode bridge and R230 and R231 are in the 13V output lines on IC20 (in series with pins 7 and 4). These two fusible resistors are not shown on the schematic.

These devices are the protective

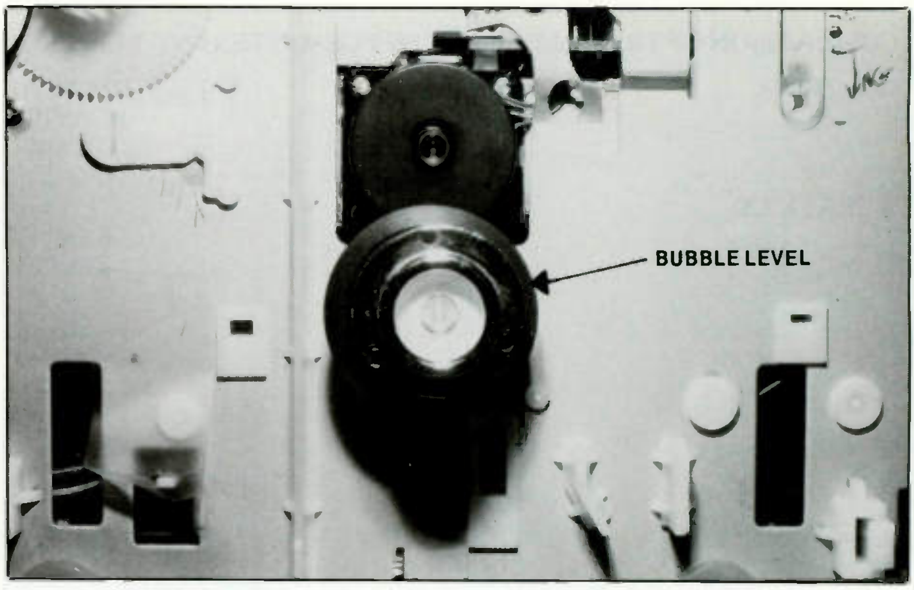


Figure 3. The turntable assembly alignment was checked with a bubble level.

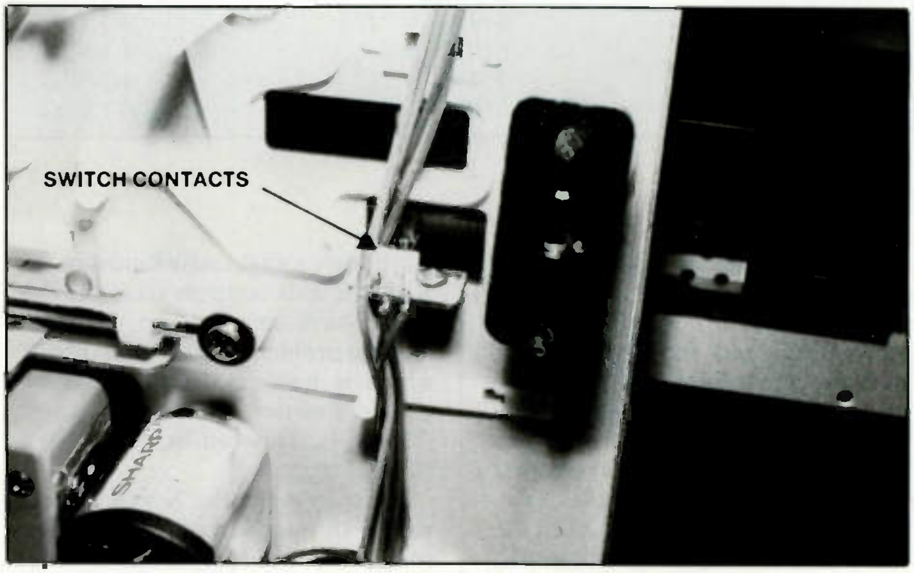


Figure 4. Switch SW401 must be held in the closed position when tests are made.

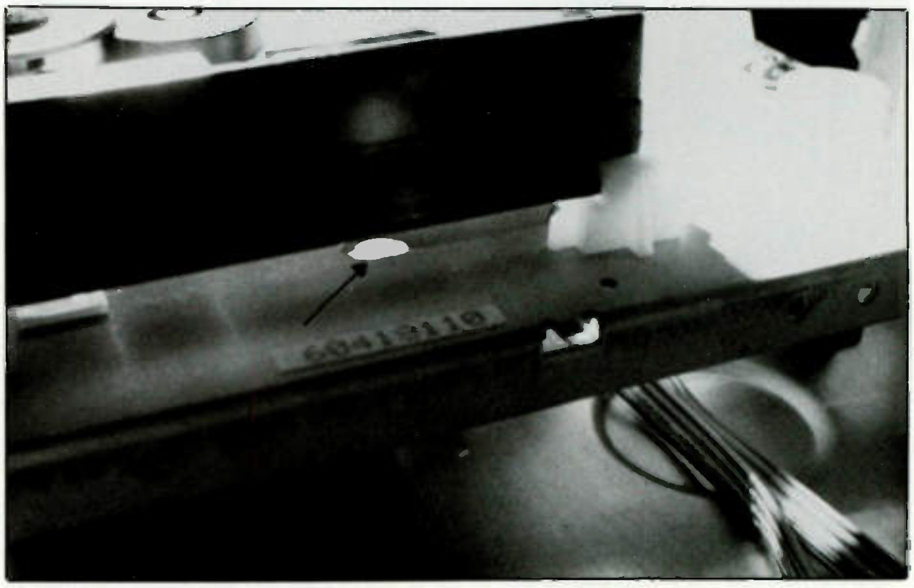


Figure 5. The location of the X axis control.

CHARACTERISTICS OF Q30 (2SD1406Y) AND Q31 (2SB1015Y) AND Q28 (2SC2236Y) AND Q29 (2SA966Y)
2SD1406, HIGH POWER SILICON NPN TRANSISTOR
MAX Pc FREE AIR 25C, 0.20 W/C
Ic MAX 3A
Ib MAX 300mA
BVcbo MAX 60V
BVebo MAX 7V
BVceo MAX 60V
MAX Icbo + Vcb Vcb + 25C 100uA
Bias: Vce 2.0V, Ic 500mA , hFE min is 60, max is 300
Gain Bandwith Product fT 3.0MHz

2SC2603, LOW POWER SILICON NPN TRANSISTOR
MAX COLL. DISS FREE AIR 25C 300mW
Ic MAX 200mA
BVcbo MAX 50V
BVebo MAX 6V
BVceo MAX 50V
MAX Icbo + Vcb Vcb + 25C 100mA
Typical h parameters: Vce 6.0 V, Ic 1mA , hFE min is 90
Gain Bandwith Product ft 200MHz
Common Emitter hoe 5.5n mhos, hie 8.5 ohms, hre 0.0001
Cob 3.5 F

2SA966, LOW POWER SILICON PNP TRANSISTOR
MAX COLL. DISS FREE AIR 25C 900mW
Ic MAX 1.5A
Vcbo MAX 30V
BVebo MAX 5V
Vceo MAX 30V
MAX Icbo + Vcb Vcb + 25C 100nA- Typical h parameters: Vce 5.0V, Ic 500mA , hFE 180
Gain Bandwith Product ft 120MHz
Cob MAX 30pF

2SC2236, LOW POWER SILICON NPN TRANSISTOR
MAX COLL. DISS FREE AIR 25C 900mW
Ic MAX 1.5A
BVcbo MAX 30V
BVebo MAX 5V
BVceo MAX 30V
MAX Icbo + Vcb Vcb + 25C 100nA
Typical h parameters: Vce 5.0V, Ic 500mA , hFE 180
Gain Bandwith Product ft 120 MHz
Cob MAX 30pF

Table 3.

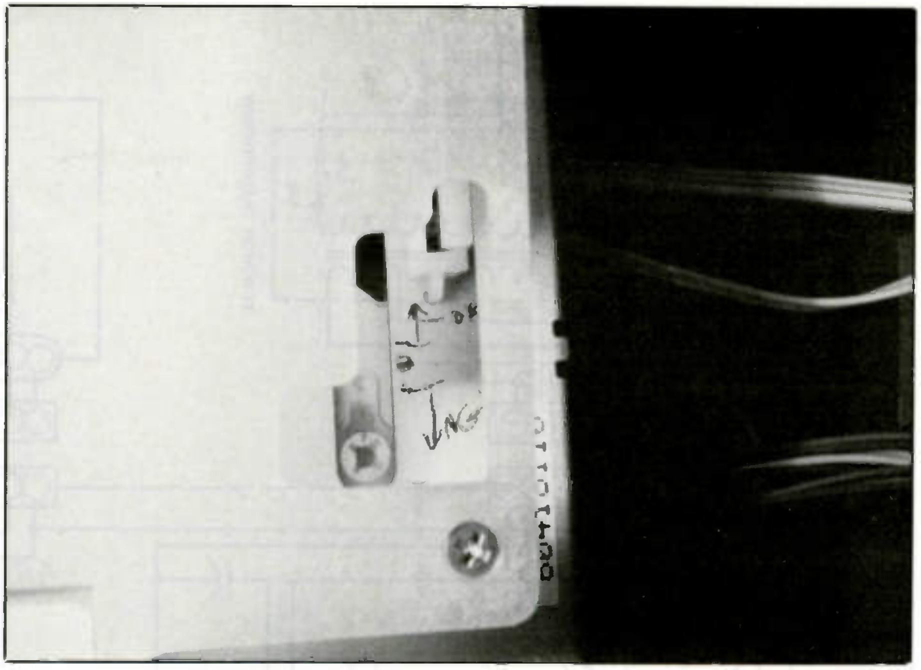


Figure 6. The range in which the CD player would lock on the tracks (OK) and the area where lock-on would not occur (N.G.)

fuses in this design and should be checked when power supply problems are suspected as they might have open circuited. In addition to these omissions on the schematic diagram, there were silk screening errors on the printed circuit card reference designations on this unit. For example Q039 is shown in two places by the silk screening (Figure 10). Obviously the original larger lettering should have been removed when the artwork changed, and the smaller lettered "Q039" was put on the card.

When you look at the power supply section you will also note that there are no adjustment potentiometers for either the 5V or 9V supplies, but their designs are very similar. The output voltages are actually set by R228 for the 5V supply and R215 for the 9V supply (more about this later).

Voltage measurements of the power supply area confirmed that IC20 was not responding to the voltages at pin 8, and transistors Q30 and Q31 were always biased on. I replaced the voltage regulator, a custom part in a single-in-line (SIP) package, with a replacement that was ordered from a Sharp parts distributor. Most parts in CD players are special custom devices that must be ordered from the manufacturer and are not available from general replacement part sources. More about this and the price of various repair parts later.

Replacement of the voltage regulator restored the on/off control; however the display still rotated. I again checked the voltage outputs. The +5V output measured 6.06V and the −5V output was −6.02V.

The base voltage of Q30 was 5.37V (should be 5.7V) and the base voltage of Q31 was −5.41V (should be −5.7V). As mentioned earlier, R228 a 6.2KΩ resistor sets the power supply output. The value of this resistor in fact measured 6.2KΩ, as specified, but I temporarily wired a variable resistor in its place to observe the effects of changing this resistance value on the unit.

Adjusting the resistor to cause an output of 4.51V, on the 5V line caused the display to fade out. When I reduced the voltage to 4.47V the display came back and the segments rotated very fast. Reducing the voltage further to 4.07V caused the segments to rotate very slowly. At these lower voltages the front panel controls did not always respond, but when they did the player would even lock onto track 1 of a CD and play it.

During these tests I noted that the power supply pass transistors were unusually hot, so I replaced them with some equivalent types that were in stock. The characteristics of Q30 and Q31 (along with Q28 and Q29) are shown in Table 3. Any transistors with similar or better ratings can be

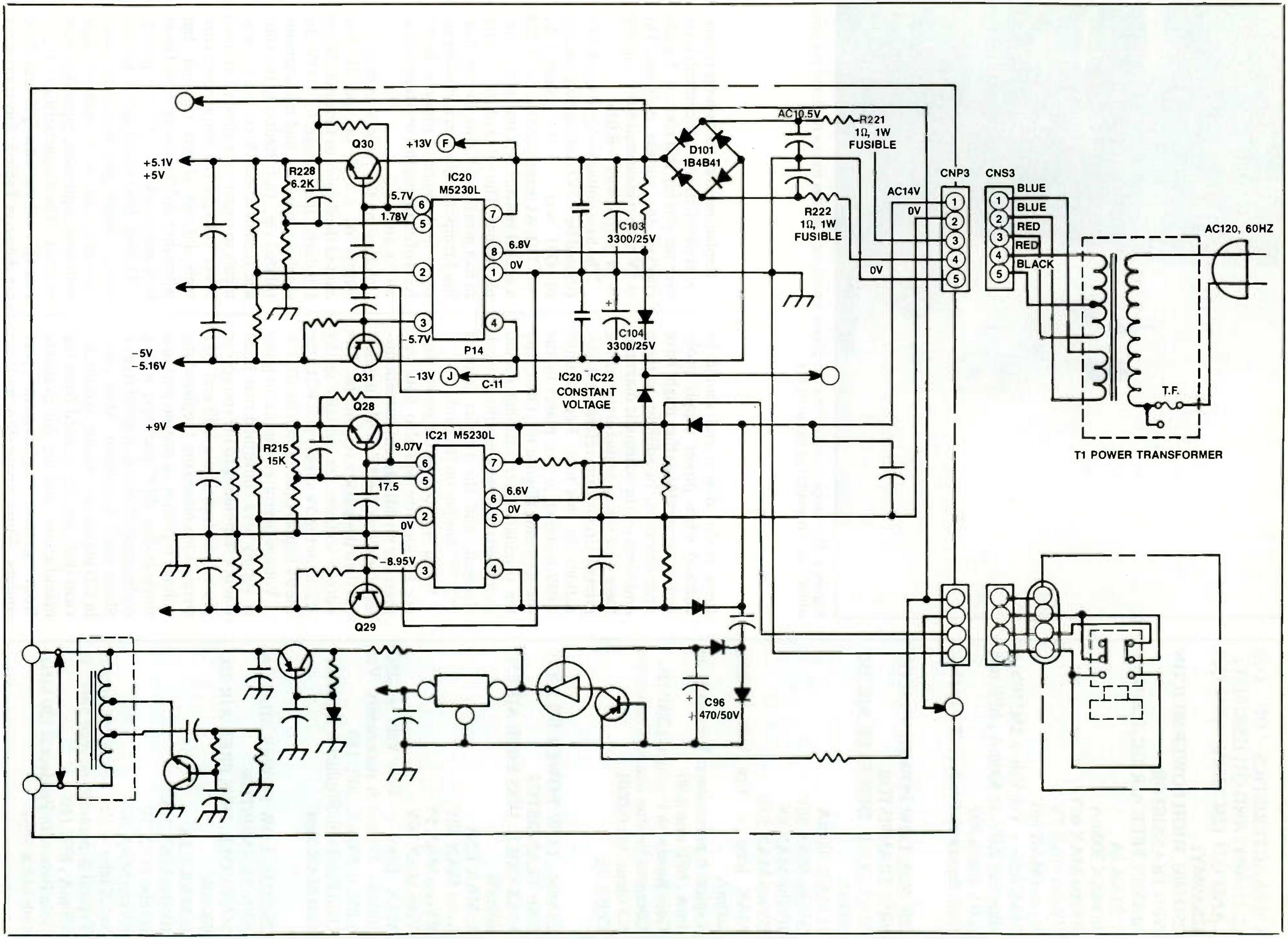


Figure 7. The power supply schematic.

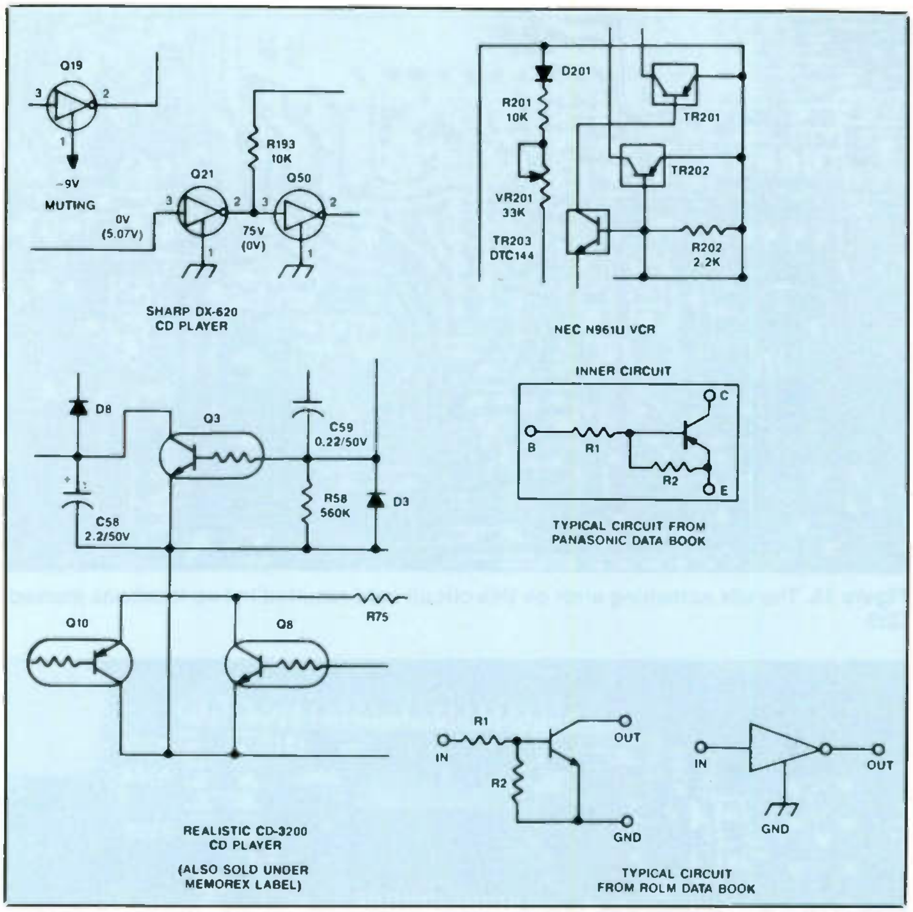


Figure 8. Some typical symbols used to denote digital transistors and a typical specification sheet.

used to replace these devices.

One note of caution, the original manufacturer parts have isolated collector tabs. If your replacements do not, and are put into the circuit, fusible resistors R220 and R221 will blow out. I know, because even though I used mica insulators and an insulating bushing in the transistor mounting holes, the mounting screws still caused a short circuit, opening these resistors.

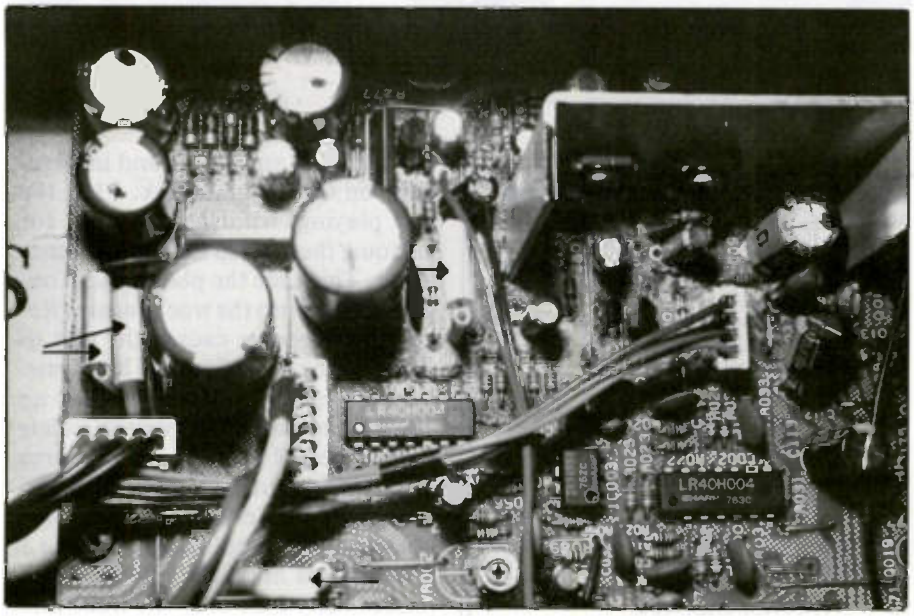


Figure 9. The fusible resistors are mounted above the circuit card in white high temperature sleeving.

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Circle (19) on Reply Card

Before you plug in the player check that the transistor collectors are not shorted together through the heat sink. This applies to Q28 and Q29 also). While I was replacing the transistors, I also changed R228 to a value of 5.52KΩ (I selected two film resistors connected in series to give this value) which trimmed the power supply output to +4.96V and −5.01V.

Correcting the display problem

It is obvious from the schematic that display problems are caused by the control microcomputer IC303. This device, P/N uPD 7502G, (Sharp part number RH-iX1313AFZZ) is a custom 64-pin surface mount device located on the display printed circuit card.

I replaced this device by first placing solder braid on each side of the device to remove the solder from the pins. Next, using a soldering iron with a cone tip and a hobby knife, I heated each pin and lifted them with the knife. This took about 20 minutes.

Alignment of the replacement microcomputer was not necessary as it fits into a hole in the printed circuit card, which automatically aligns the pins (Figure 11). I soldered the pins at the corners of the microcomputer first, and then soldered all the other connections. After all the connections were soldered, I used a magnifying glass to make sure no solder bridges were made between the pins.

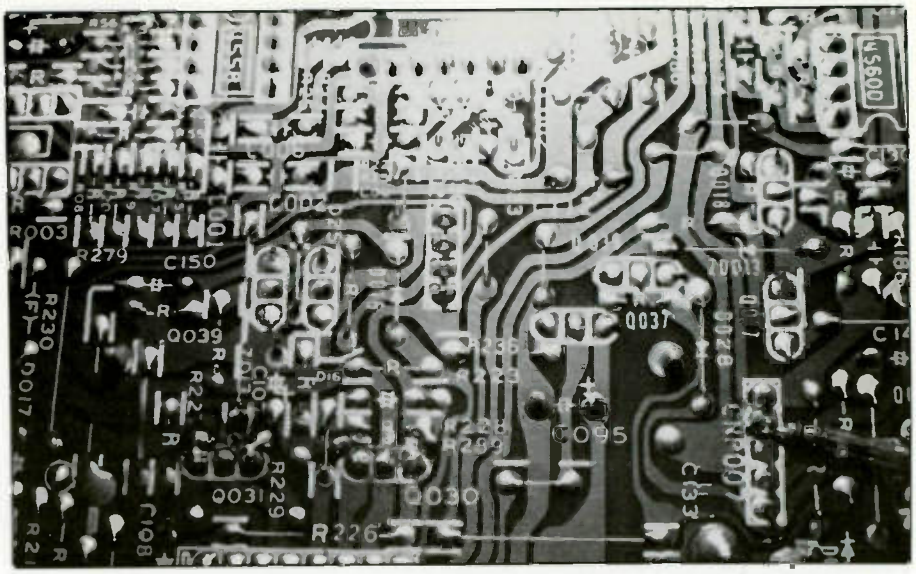

Figure 10. The silk screening error on this circuit card resulted in two locations marked Q39.

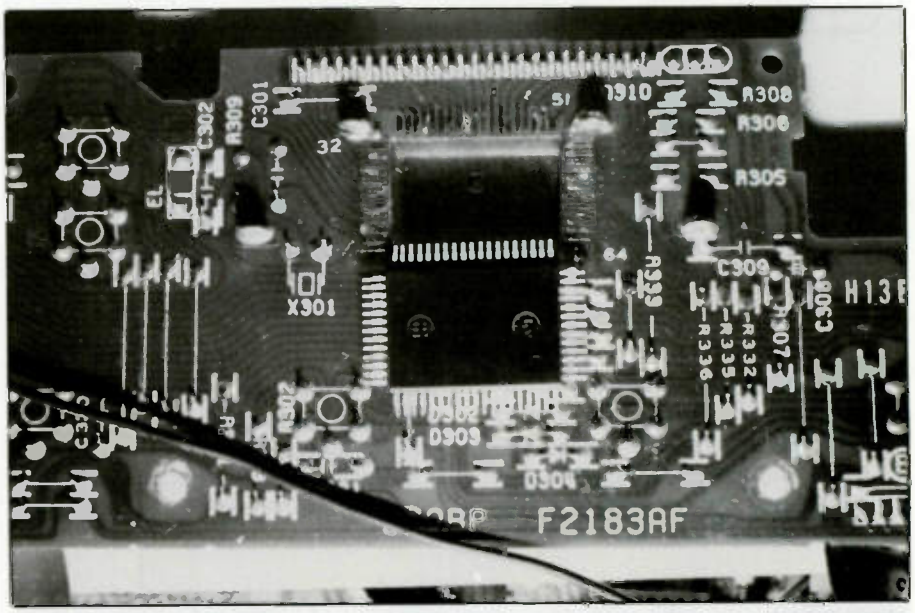

Figure 11. Al gnment of the microcontroller pins is not necessary because of the cutout in the circuit card.

After I replaced the microcomputer, I plugged the unit in and tested it. Track 1 was found in 5 seconds on the 12 track disk and was found in 4 seconds on the 24 track disk. I left the unit playing, with the cover on, for an hour, then tested the performance again. This time the player had trouble locking onto the tracks again. Removing the cover caused the unit to return to the 4 and 5 second lock time.

I allowed the player to heat up again, then used cold spray to isolate the problem. I found a sensitive area around C059, in the VCO control circuit (IC10, the Servo Control IC, was not sensitive to cold). As soon as I sprayed this area, the player would immediately lock onto the track and play. When I removed this capacitor and tested it at room and cold tem-

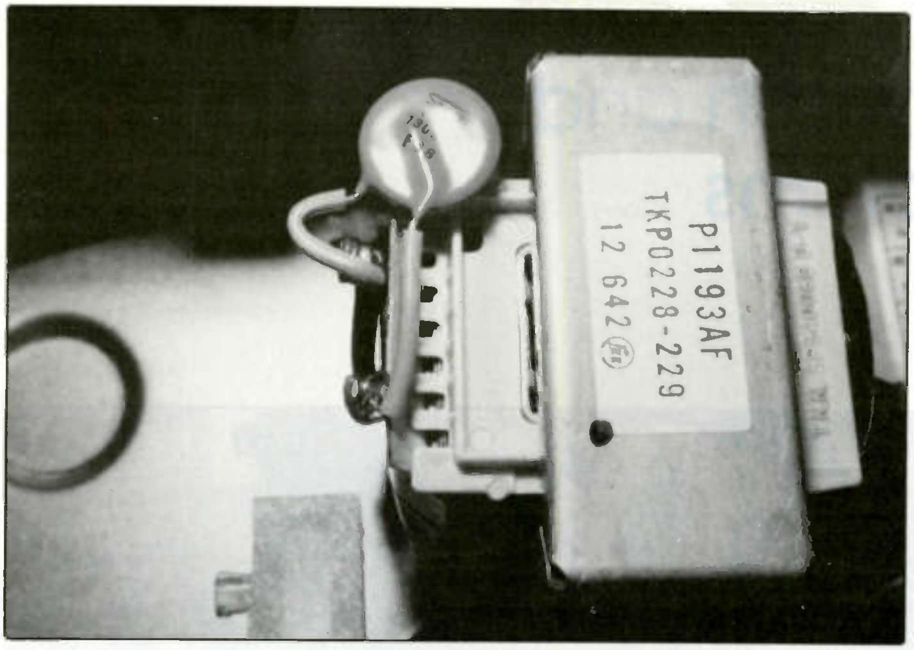

Figure 12. A MOV was added to the input terminals of t1 to prevent voltage transients from causing circuit failures.

peratures, I found that it varied from 0.1023nf to 0.1017nf. This is not a very great change, but in view of the symptoms it caused, I replaced it with another mylar capacitor anyway.

I tested the player again and still found it to be sensitive in this area, by R152 and R157, although the replacement capacitor was not temperature sensitive at all.

Looking at the schematic again showed a VCO adjustment inductor L1 in this circuit. I adjusted this inductor slightly (with TP3 pin 2 GND and Pin 1 set to 4,300.0kHz +5kHz, −0kHz) and tested the player again. The unit now locked on all tracks even after warmup.

I suspect that the faulty parts in the player were caused by voltage transients. To prevent such damage happening in the future, I soldered a metal oxide varistor (MOV) to the ac-line-side terminals of the input transformer (T1) (Figure 12). Finally, I tightened the transit screw to prevent damage to the pick-up during transportation back to the owner (this should be done on all players after repairs are completed, reference Figure 13).

Repair parts

As I mentioned earlier, most of the parts in the CD player are custom devices that must be ordered from either the manufacturer or an authorized manufacturer parts dealer. At this time there are no generic parts from parts houses available to replace the custom IC's or motors. In any CD repair you must be aware that the cost of some of the parts can exceed the cost of a new CD player, especially if a low end single disc player is being serviced (which when on sale can be as low as $89). Some typical service dealer prices for some replacement parts for the Sharp DX-620 unit are as follows:

Servo Amplifier (IC10) - $35.20

Motor Driver (IC11) - $3.63

Demodulator (IC12) - $45.10

16 Bit D/A Converter (IC13) - $35.20

RAM (IC14) - $11.66

Voltage Regulator SIP (IC20,21) - $4.95

Microcomputer (IC303) - $16.50

Laser Power Control (IC401) - $3.63

LCD Display (LCD301) - $11.66

Disc Holder Open/Close Motor (M401) -$11.66

Spin Motor (M402) -$16.50

Pick-Up Slide Motor (M403) -$11.66

Pick-Up Assembly (228) -$122.86

It is obvious that if the Pick-Up assembly has to be replaced in this model the repair should not be attempted. ■

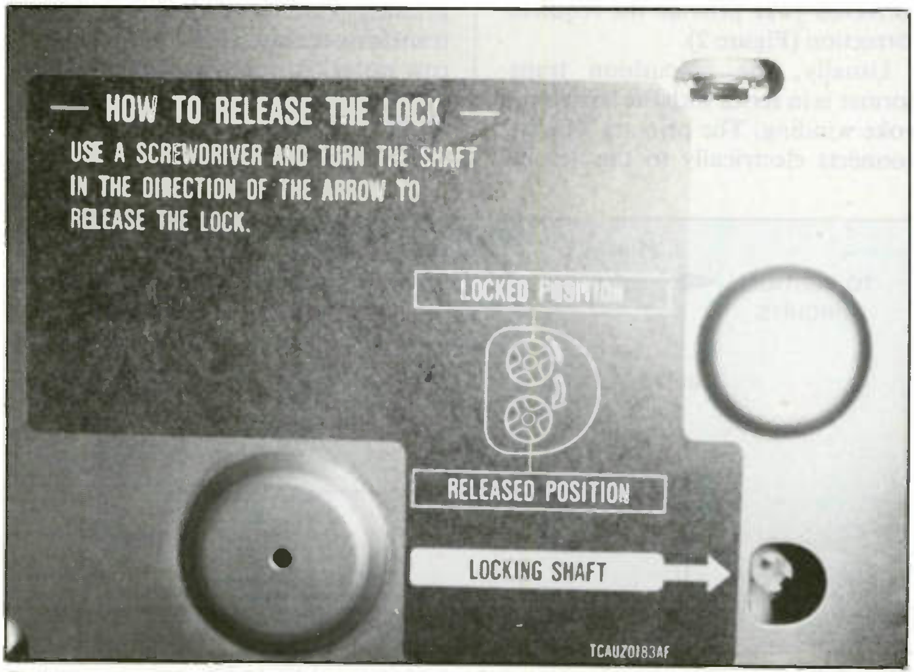

Figure 13. After CD player repairs, the transit screw should be locked.

Servicing TV width and linearity problems

By Homer L. Davidson

Most TV horizontal width and linearity problems are the result of malfunctions in the horizontal output, flyback, yoke and pincushion circuits. Excessive width followed by high voltage shut down may develop when one or more safety or hold-down capacitors become open. Improper width may occur intermittently. Often poor horizontal width and linearity go hand in hand (Figure 1).

A trapezoid-shaped picture pattern in either the horizontal or vertical dimension is a sure sign that there's a problem in the deflection yoke. Shorted turns in the horizontal yoke windings may cause a narrow raster with poor linearity. Usually, shorts between vertical and horizontal yoke windings cause chassis shut down.

If the terminals connecting the pincushion transformer to the circuit board are not properly soldered, the symptom may be intermittent width problems. Shorted turns in the primary windings cause narrow or insufficient width problems. Leaky capacitors and burned resistors within the pincushion circuits cause narrow pictures and poor linearity.

Insufficient horizontal drive voltage and low voltage from the power supply may cause poor width problems. Low voltage from the SCR regulator is another possible cause of narrow pictures.

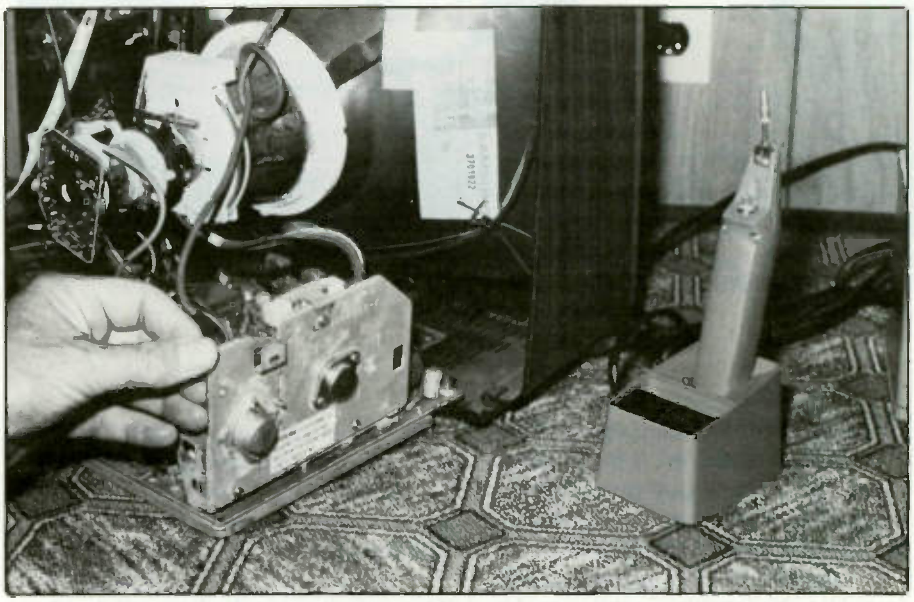

Figure 1. Most width problems are caused by defective components in the horizontal output, yoke and pincushion circuits.

Pincushion circuits

As the TV screen gets larger in size, the pincushion circuits usually increase in complexity. In the RCA 27-inch color chassis, a pincushion correction circuit modulates the horizontal yoke current at a vertical rate to correct for distortion in the raster caused by the physical shape of the face of the picture tube. On smaller screen picture tubes, the pincushion transformer, linearity coil and pin corrected yoke provide the required correction (Figure 2).

Usually, the pincushion transformer is in series with the horizontal yoke winding. The primary winding connects electrically to the vertical yoke winding while the secondary winding is in series with the horizontal yoke. Shorted turns in the primary winding of the pincushion transformer may cause a bowing narrow raster. An open secondary winding, or improperly soldered circuit board connections, cause insufficient width.

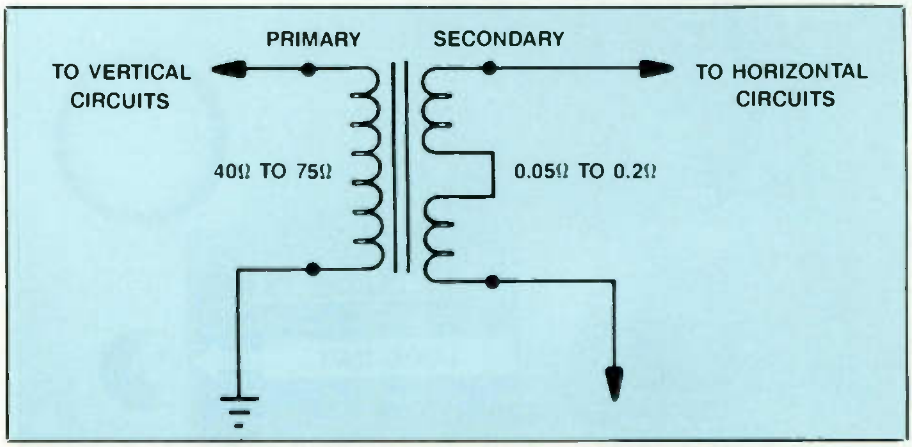

Figure 2. The pincushion transformer may have a primary of 40Ω to 70Ω, and a secondary from 0.05Ω to 0.2Ω.

Davidson is the TV servicing consultant for ES&T.

TV SET	PINCUSHION TRANSFORMER RESISTANCE PRIMARY	SECONDARY
GOLDSTAR CMT-4062	97Ω	0.05Ω
PHILCO E25-6	16Ω	0.40Ω
RCA CTC92	90Ω	0.05Ω
RCA CTC97	75Ω	0.05Ω
RCA CTC107C	44Ω	0.10Ω
SAMPO CS-13CS	42.5Ω	0.04Ω
ZENITH SS2333E3	42Ω	0.03Ω

Figure 3. Random pincushion transformer resistance chart.

Most TV diagrams do not list the resistance of each pincushion winding. A rule of thumb is that usually the primary resistance will be between 40Ω and 90Ω, and the secondary from 0.05Ω to 0.02Ω. The ratio of resistance of the primary winding to the resistance of the secondary winding may be between 40 to 1 and 70 to 1 (Figure 3). Replace the suspected pincushion transformer when the winding cover is scorched or burned. Re-solder all pincushion transformer terminals.

Some pincushion circuits consist of transistors, a linearity coil and a width control instead of a pincushion transformer. In one of these sets, if the horizontal output transistor fails, it may damage the pincushion driver or pin output transistor. Similarly, leaky series connected safety capacitors can damage pincushion transistors.

Samsung TC9800T - Narrow picture

In one Samsung TC9800T that was left for service, the raster had pulled in about one inch on each side of the picture tube. Measurements of high voltage and low voltage in the horizontal circuits were normal. The voltage on the collector pin of Q402 was 87V. I inspected the terminals of T402 and resoldered them, but this did not result in any improvement (Figure 4).

Although the original schematic did not list the nominal resistance values of the primary and secondary pincushion transformer windings, the ratio of the measurements I made was about 40 to 1. Next I checked the deflection yoke and both horizontal and vertical windings seemed normal. L402 and L403 choke coils showed continuity.

An oscilloscope check showed that the waveform on the base of Q402 was normal, and the amplitude of the output waveform at L406 was about 600Vpp. According to the schematic, the amplitude of the output waveform should have been 920Vpp at L406 or pin 10 of the flyback transformer. Q402 then became suspect, but it tested good in the circuit. Neither the flyback nor the deflection yoke appeared to be very warm after a half hour of tests. No doubt some component in the output circuits of the flyback was loading down the voltage at the flyback connection.

In some circuit configurations, if the yoke or pincushion circuits are defective, removing the red lead from the deflection yoke disconnects these circuits. In this case, when the yoke lead was disconnected, the collector voltage shot up to 125V, indicating overloading in those circuits. The increase of collector voltage also eliminated the possibility that there was any overloading in the secondary circuits of the flyback transformer.

Again, the pincushion and yoke circuits were checked for defective components using voltage and resistance tests. L402 appeared to have overheated and was running warm. When I measured C413 for leakage, in circuit, I found 1KΩ across it. At first I thought that this resistance measurement was from the power supply. When I removed C413 (0.36μF) from the circuit and measured it again, I measured a leakage resistance of 1073Ω. Replacing C413 restored the waveform to its correct amplitude, and the narrow picture to its correct width.

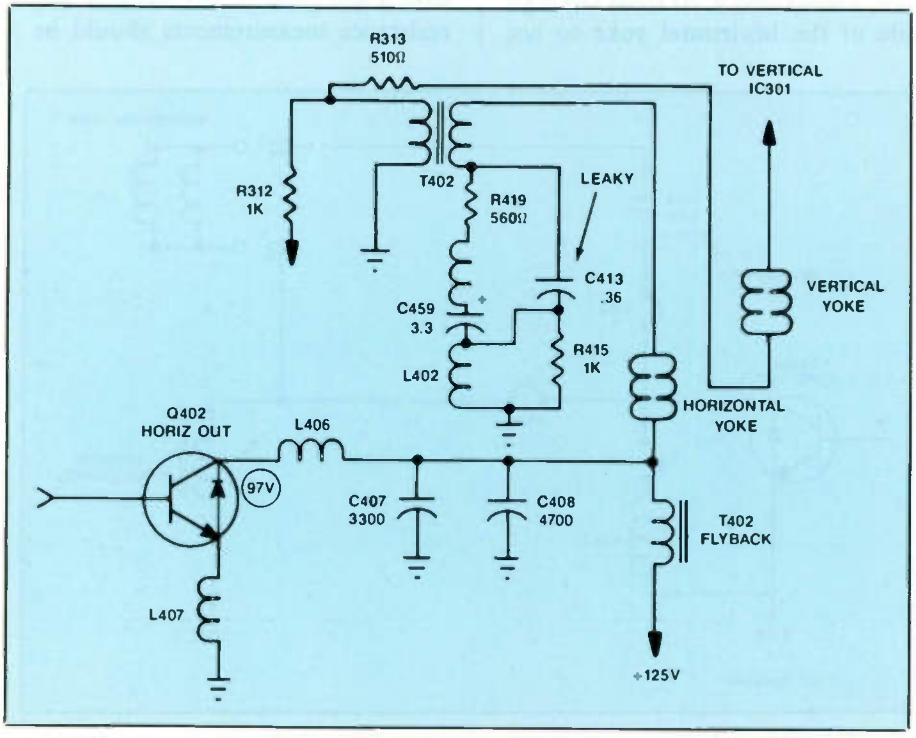

Figure 4. Leaky C413 (0.36μF) capacitor caused a narrow picture in a Samsung TC9800T portable.

Intermittent width - shutdown

The width of the picture in an RCA CTC149 chassis would intermittently become narrow, then return to normal, then the set would go into shutdown. In addition to these symptoms, the chassis kept blowing the low voltage fuse. A DMM diode test between Q4401 and hot ground was normal. When the set was operated with the deflection yoke unplugged, the fuse would hold (Figure 5).

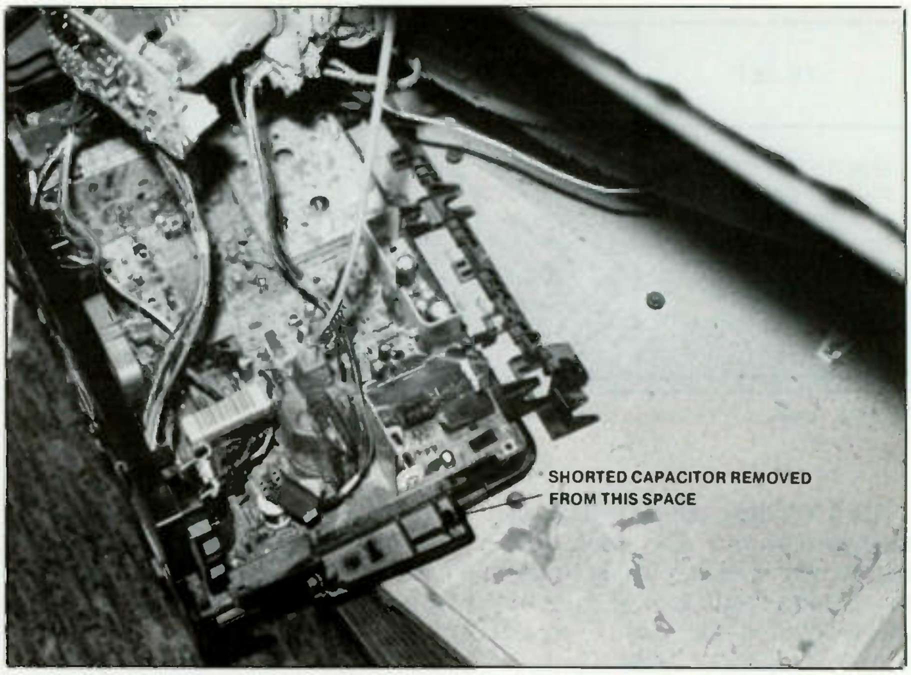

Figure 5. The shorted safety capacitor caused intermittent width before chassis shut down in an RCA CTC 148/149 chassis.

Although the high voltage measured only 13kV with the yoke disconnected, a light white vertical line indicated no horizontal sweep. The normal + 125V was measured at the collector of the horizontal output transistor. Either the deflection yoke or pincushion circuits were defective.

At first I suspected that the deflection yoke was shorting between vertical and horizontal windings. In fact, I measured 4.7Ω from the high side of the horizontal yoke to hot chassis ground. After checking several pincushion components, a closer scrutiny of the schematic indicated that C403 was the component that was most likely causing the problem.

What made the initial measurements quite different was the fact that resistance measurements were originally taken from the chassis cold ground. In this set, however, the horizontal output circuits operate with a hot ground. All voltages and resistance measurements should be

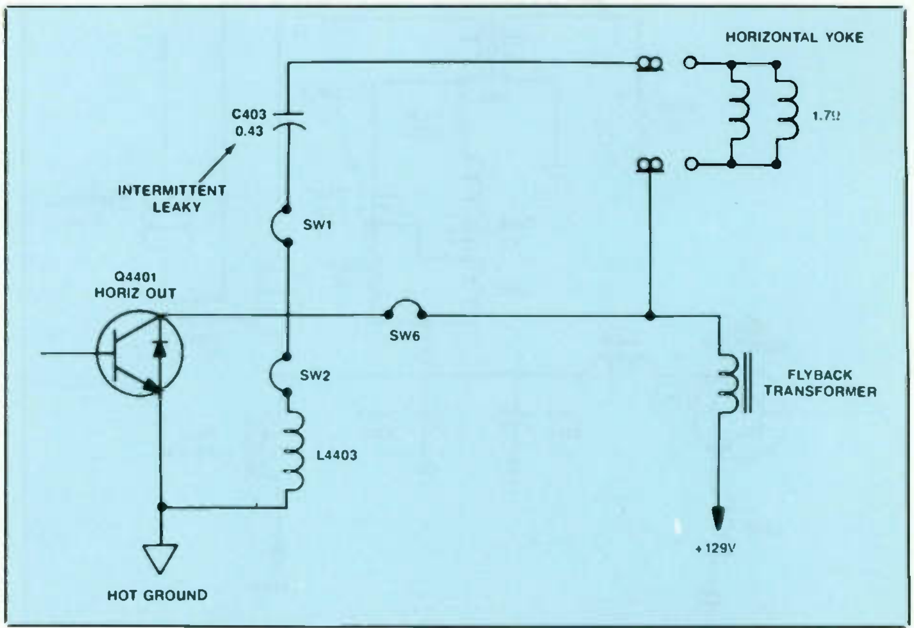

Figure 6. C403 (0.43μF) capacitor was leaky in an RCA CTC 149 chassis, causing intermittent width and shut down.

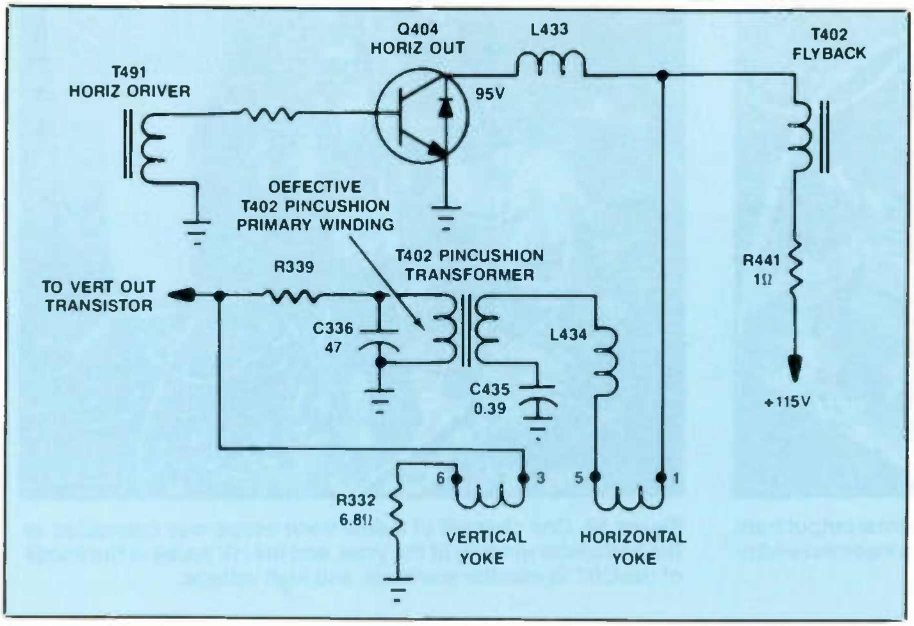

Figure 7. The primary winding of T402 caused a narrow raster in a Goldstar CMT 4442 TV.

made with respect to this ground.

Resistance measurements from both sides of C403 showed low resistance to the hot ground. I unsoldered C403 from the circuit and found that it had a leakage resistance of 4.7Ω (Figure 6). Because this capacitor is part of a safety-related circuit, I replaced it with an exact replacement.

Goldstar CMT 4442 - poor width

A Goldstar CMT 4442 portable TV with poor width and fairly normal high voltage was brought into the service center. The collector voltage of Q404 was a little low (90.1V). Low voltage from the power supply was normal at 115V. Base and collector waveforms were good at Q404 (Figure 7).

A quick check of continuity of the deflection coils showed them to be normal. The secondary winding of the pincushion transformer was good, but the resistance of the primary winding was only 27Ω. The cover of T402 showed no signs of overheating. I disconnected the transformer from the circuit in order to take an out-of-circuit resistance measurement. This reading was also low. A check of the other components in the circuit while the transformer was out of the circuit, proved them to be good. T402 had thus been confirmed to be the problem, so we ordered a replacement (151-100E) through the manufacturer's parts depot.

Intermittent width

The picture on an RCA CTC 120D that we took in for service would pull in at the sides about one inch. The picture was wavy as well. The linearity of the raster was normal from center to the quivering sides. Once it was warm, the chassis would operate normally for hours. The only time the symptoms would reappear was once the chassis was allowed to cool down and turned on again. After the set was operated till it was warm again, the raster returned to normal.

We had plenty of CTC120 circuit diagrams, but none with a separate pincushion board. While going through several RCA schematics, we found that the circuits of the CTC130 and CTC111 chassis were similar. The pincushion circuit board is mounted on top of the TV chassis, right under the neck of the CRT (Figure 8). Because the CTC130 schematic had a separate schematic of the pincushion circuits, we decided to use it for troubleshooting.

I decided to monitor the drive and horizontal output waveforms on Q402. I connected one channel of the dual-trace scope to the base terminal of Q402, and the other channel to the flyback (Figure 9). It actually proved much easier to connect the scope probe to one side of the horizontal winding of the yoke than directly to the flyback. I placed the HV probe under the anode rubber insulator to monitor the HV (Figure 10).

Both the horizontal drive waveform and the horizontal output waveform were normal whether the set was operating normally, or the intermittent change of width occurred. Voltage measurement at the collector flyback circuit did not change when the set malfunctioned intermittently. High voltage was normal at all times. Actually, all symptoms indicated a defective yoke or defective pincushion circuits.

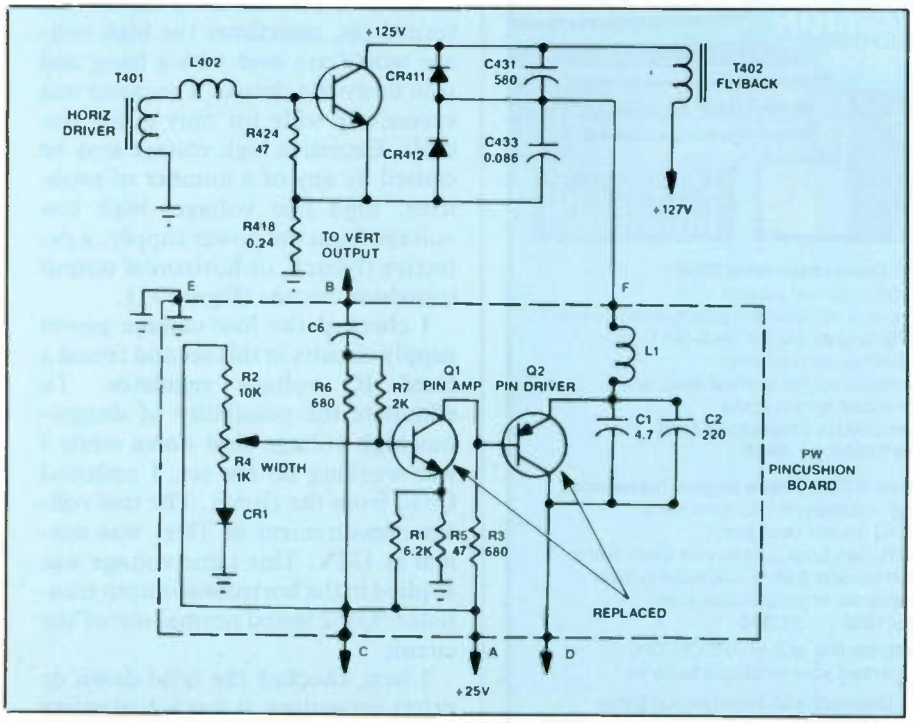

Figure 8. Replacement of both Q1 and Q2 in the pincushion circuits cured a problem of intermittent width in an RCA CTC120D chassis.

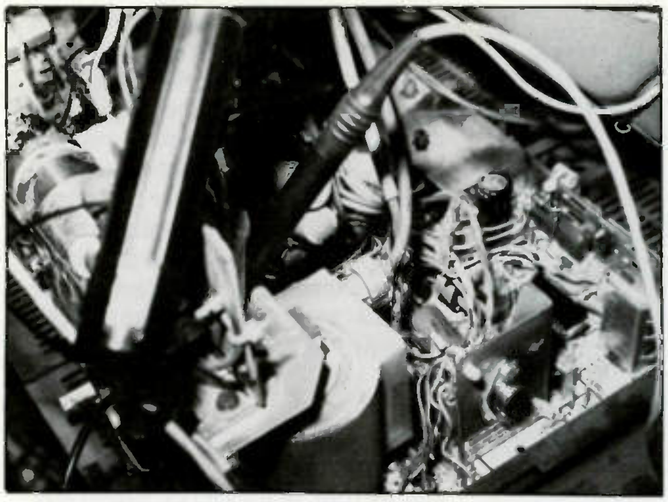

Figure 9. Monitor waveforms at the base of horizontal output transistor and yoke connections when the problem is incorrect width.

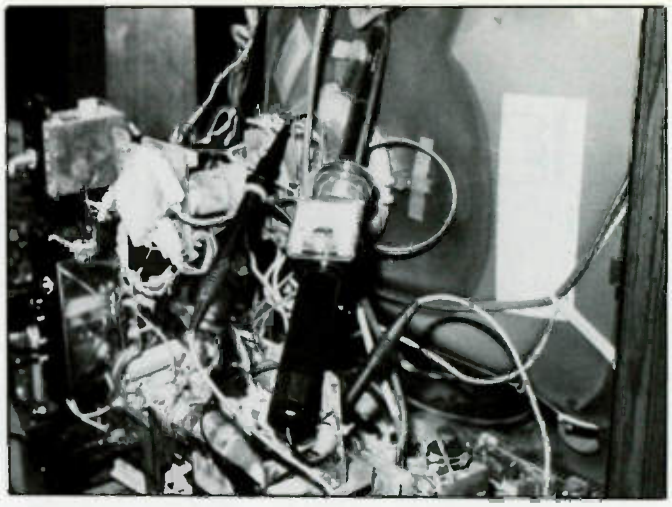

Figure 10. One channel of a dual-trace scope was connected to the horizontal winding of the yoke, and the HV probe at the anode of the CRT to monitor waveform and high voltage.

The primary suspect was a defective pincushion board, because any rough handling of the chassis would cause the width to return to normal. When the set was malfunctioning, just touching the pincushion board with an insulated tool or attempting to spray components on the pincushion board with coolant made the width snap back to normal. Any attempt to adjust the width (R4) would cause the raster to return to normal.

In several other RCA chassis with this type of pincushion circuits I found that the pin driver was leaky. In the CTC 111 chassis when CR411 became leaky, or Q2 was automatically damaged. Each time Q2 was leaky, the low voltage fuse opened up. In this case, Q402, CR411, C425 and pincushion transistor (Q2) were replaced. Replacing only Q2 without replacing the other components resulted in destruction of Q2.

I replaced both Q1 (146847) and Q2 (153350) with exact replacements. While the PW pincushion board was exposed, all solder joints on it were resoldered for good measure. A squirt of cleaning solution was inserted at width control (R4). The chassis was bench tested for four days and is still operating.

Excessive width - shutdown

When a Teknika 3459 model was turned on, sometimes the high voltage would arc over with a bang and shut down the chassis. The raster was excessively wide for only a few seconds. Excessive high voltage may be caused by any of a number of problems: high line voltage, high low voltage from the power supply, a defective flyback, or horizontal output transistor circuits (Figure 11).

I checked the low voltage power supply circuits in this set and found a fixed IC voltage regulator. To eliminate the possibility of dangerous high voltage shut down while I was working on the set, I removed Q352 from the circuit. The low voltage measurement at TP91 was normal at 131V. This same voltage was applied to the horizontal output transistor. Q352 tested normal out of the circuit.

I next checked the hold-down or safety capacitors. It was a dual safety

(Continued on page 37)

ES&T
Manufacturers' schematics
PROFAX

NOVEMBER 1991

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RCA/GE
CTC 166 Color TV Series 3082

VIDEO SCHEMATIC

Product safety should be considered when component replacement is made in any area of an electronics product. A star next to a component symbol number designates components in which safety is of special significance. It is recommended that only exact cataloged parts be used for replacement of these components.

Use of substitute replacement parts that do not have the same safety characteristics as recommended in factory service information may create shock, fire, excessive x-radiation or other hazards.

This schematic is for the use of qualified technicians only. This instrument contains no user-serviceable parts.

The other portions of this schematic may be found on other Profax pages.

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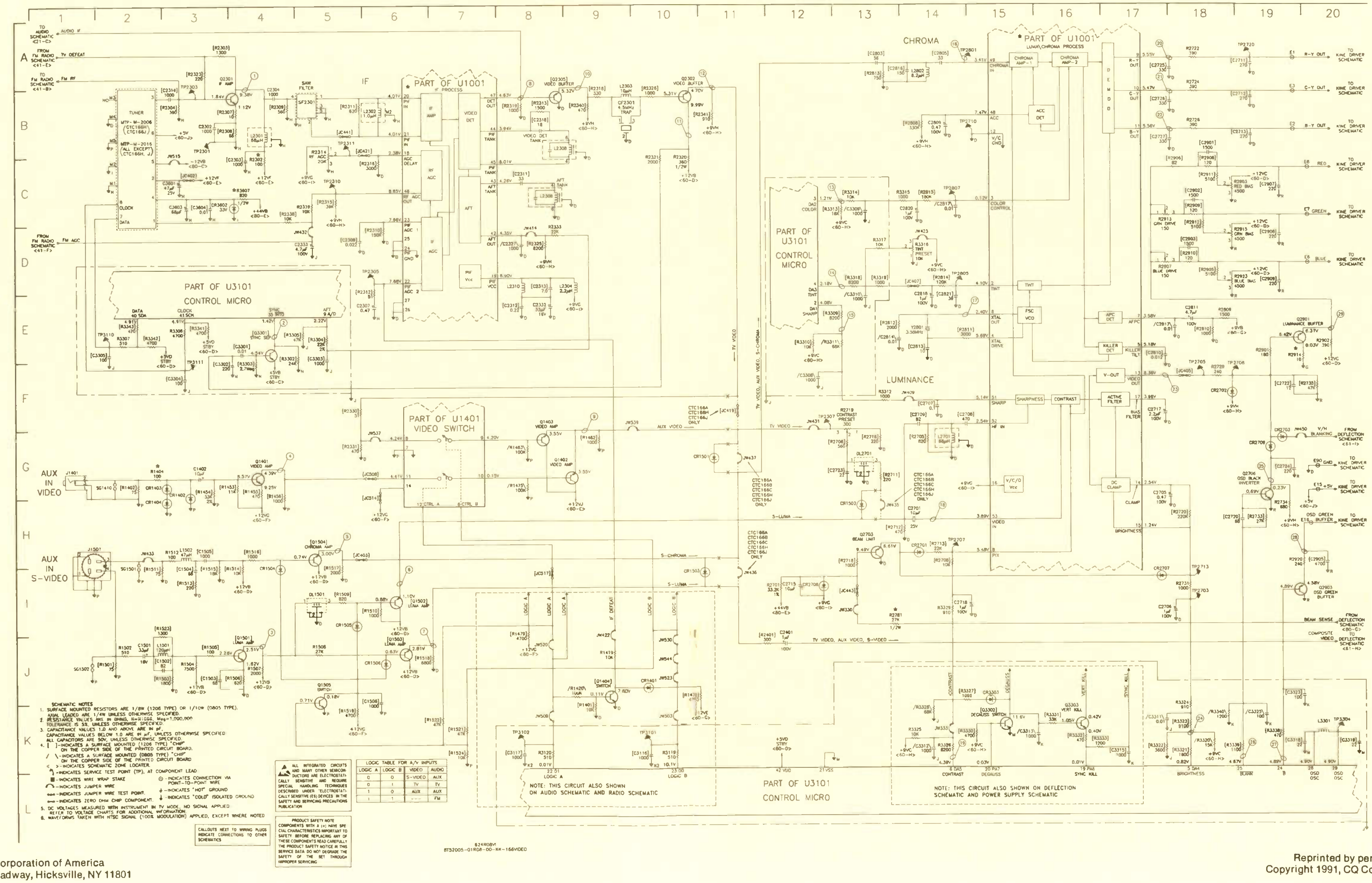
The other portions of this schematic may be found on other Profax pages.

All integrated circuits and many other semiconductors are electrostatically sensitive and require special handling techniques.



SCHEMATIC NOTES
1. SURFACE MOUNTED RESISTORS ARE 1/8W (1206 TYPE) OR 1/10W (0805 TYPE). AXIAL LEADED ARE 1/4W UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES ARE IN OHMS, K=1000, Meg=1,000,000 TOLERANCE IS 5% UNLESS OTHERWISE SPECIFIED.
3. CAPACITANCE VALUES 1.0 AND ABOVE ARE IN pF. CAPACITANCE VALUES BELOW 1.0 ARE IN µF, UNLESS OTHERWISE SPECIFIED. ALL CAPACITORS ARE 50V, UNLESS OTHERWISE SPECIFIED.
4. [ ]-INDICATES A SURFACE MOUNTED (1206 TYPE) "CHIP" ON THE COPPER SIDE OF THE PRINTED CIRCUIT BOARD.
/ \-INDICATES A SURFACE MOUNTED (0805 TYPE) "CHIP" ON THE COPPER SIDE OF THE PRINTED CIRCUIT BOARD
< >-INDICATES SCHEMATIC ZONE LOCATER.
-INDICATES SERVICE TEST POINT (TP), AT COMPONENT LEAD
■-INDICATES WIRE WRAP STAKE
⊙-INDICATES CONNECTION VIA POINT-TO-POINT WIRE
-INDICATES JUMPER WIRE
-INDICATES "HOT" GROUND
-INDICATES JUMPER WIRE TEST POINT.
-INDICATES "COLD" ISOLATED GROUND
-INDICATES ZERO OHM CHIP COMPONENT.
5. DC VOLTAGES MEASURED WITH INSTRUMENT IN TV MODE, NO SIGNAL APPLIED REFER TO VOLTAGE CHARTS FOR ADDITIONAL INFORMATION.
6. WAVEFORMS TAKEN WITH NTSC SIGNAL (100% MODULATION) APPLIED, EXCEPT WHERE NOTED

CALLOUTS NEXT TO WIRING PLUGS INDICATE CONNECTIONS TO OTHER SCHEMATICS

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PRODUCT SAFETY NOTE
COMPONENTS WITH A (*) HAVE SPECIAL CHARACTERISTICS IMPORTANT TO SAFETY. BEFORE REPLACING ANY OF THESE COMPONENTS READ CAREFULLY THE PRODUCT SAFETY NOTICE IN THIS SERVICE DATA. DO NOT DEGRADE THE SAFETY OF THE SET THROUGH IMPROPER SERVICING

LOGIC TABLE FOR A/V INPUTS

LOGIC A	LOGIC B	VIDEO	AUDIO
0	0	S-VIDEO	AUX
0	1	TV	TV
1	0	AUX	AUX
1	1	---	FM

NOTE: THIS CIRCUIT ALSO SHOWN ON AUDIO SCHEMATIC AND RADIO SCHEMATIC

NOTE: THIS CIRCUIT ALSO SHOWN ON DEFLECTION SCHEMATIC AND POWER SUPPLY SCHEMATIC

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FRONT PANEL SCHEMATIC

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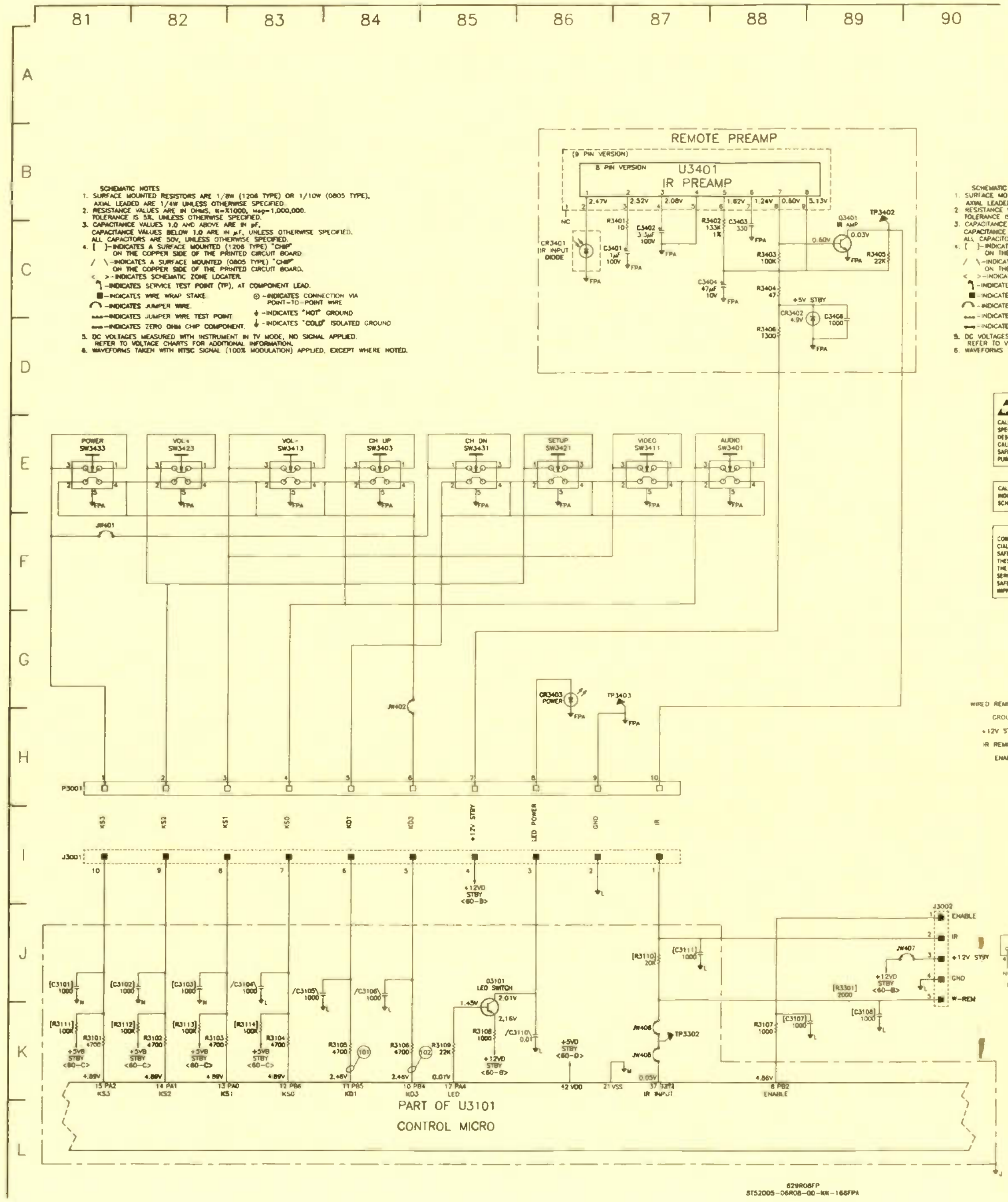
All integrated circuits and many other semiconductors are electrostatically sensitive and require special handling techniques.



SCHEMATIC NOTES
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-INDICATES "COLD" ISOLATED GROUND
5. DC VOLTAGES MEASURED WITH INSTRUMENT IN TV MODE, NO SIGNAL APPLIED. REFER TO VOLTAGE CHARTS FOR ADDITIONAL INFORMATION.
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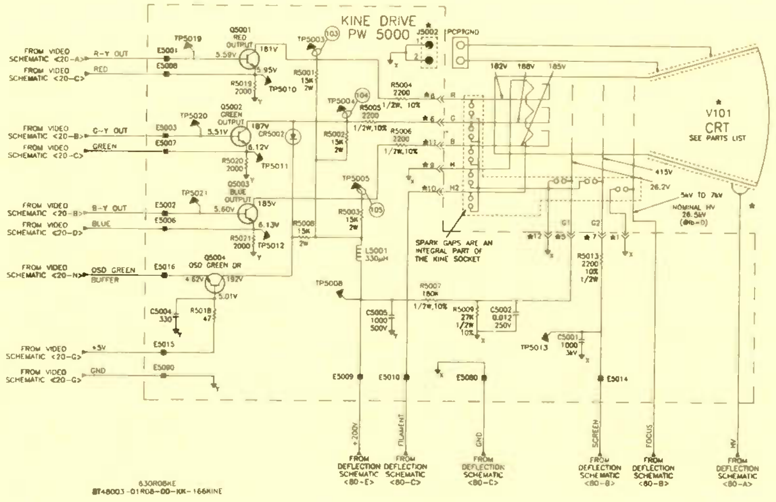
PRODUCT SAFETY NOTE
COMPONENTS WITH A (★) HAVE SPECIAL CHARACTERISTICS IMPORTANT TO SAFETY. BEFORE REPLACING ANY OF THESE COMPONENTS READ CAREFULLY THE PRODUCT SAFETY NOTICE IN THIS SERVICE DATA. DO NOT DEGRADE THE SAFETY OF THE SET THROUGH IMPROPER SERVICING



REMOTE RECEIVER SCHEMATIC

SCHEMATIC NOTES
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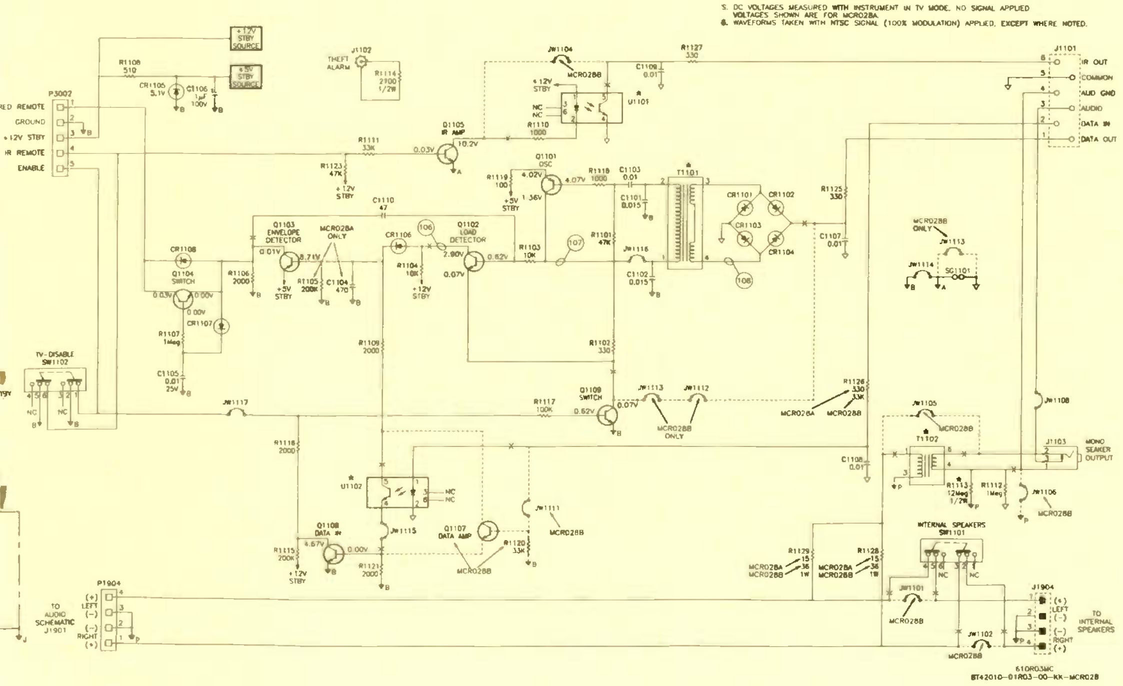
5. DC VOLTAGES MEASURED WITH INSTRUMENT IN TV MODE, NO SIGNAL APPLIED. VOLTAGES SHOWN ARE FOR MCR028A.
6. WAVEFORMS TAKEN WITH NTSC SIGNAL (100% MODULATION) APPLIED, EXCEPT WHERE NOTED.



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AUDIO SCHEMATIC

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ES&T Manufacturers schematics PROFAX 3082

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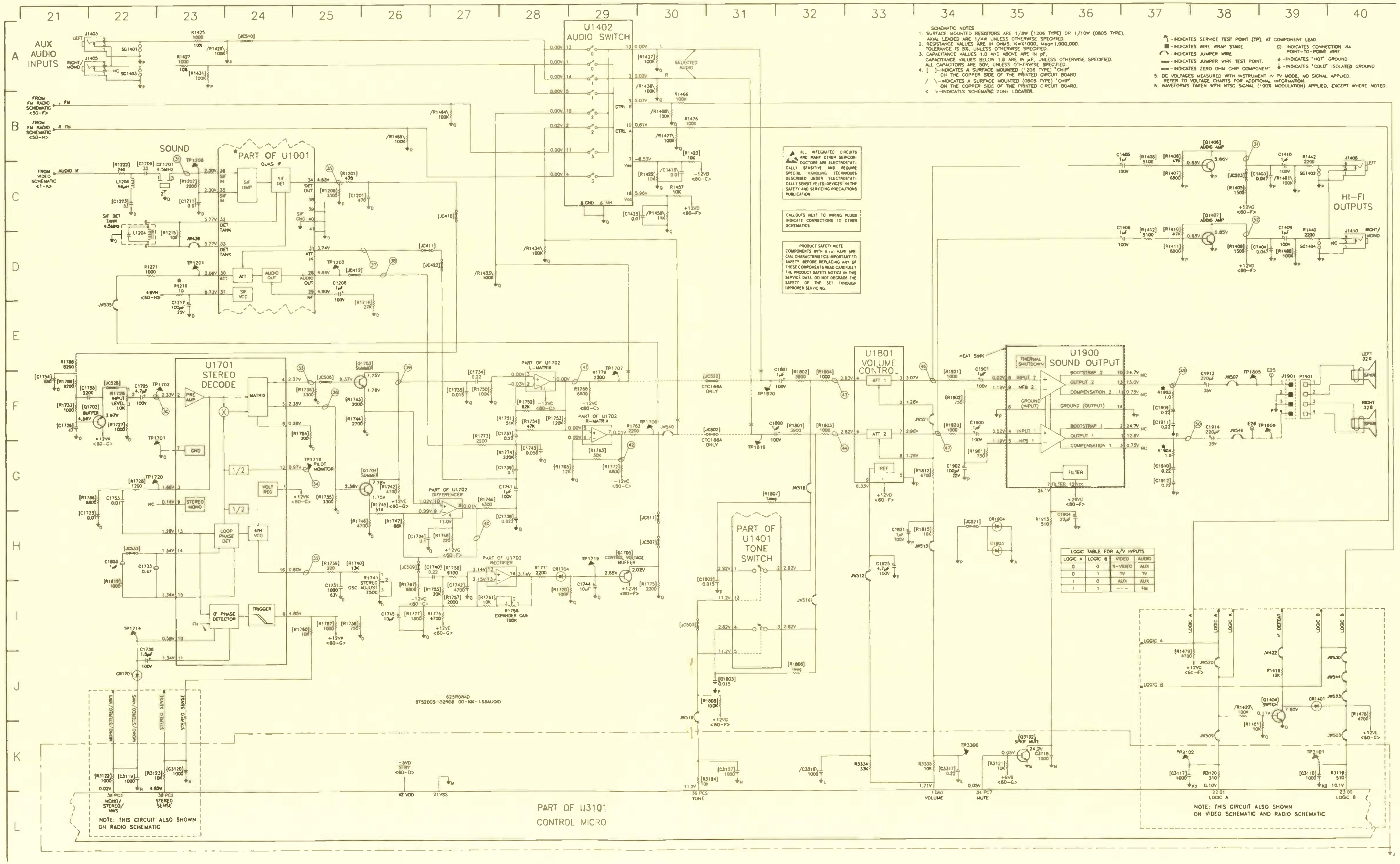

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RCA/GE
CTC 166
COLOR TV

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NOVEMBER 1991

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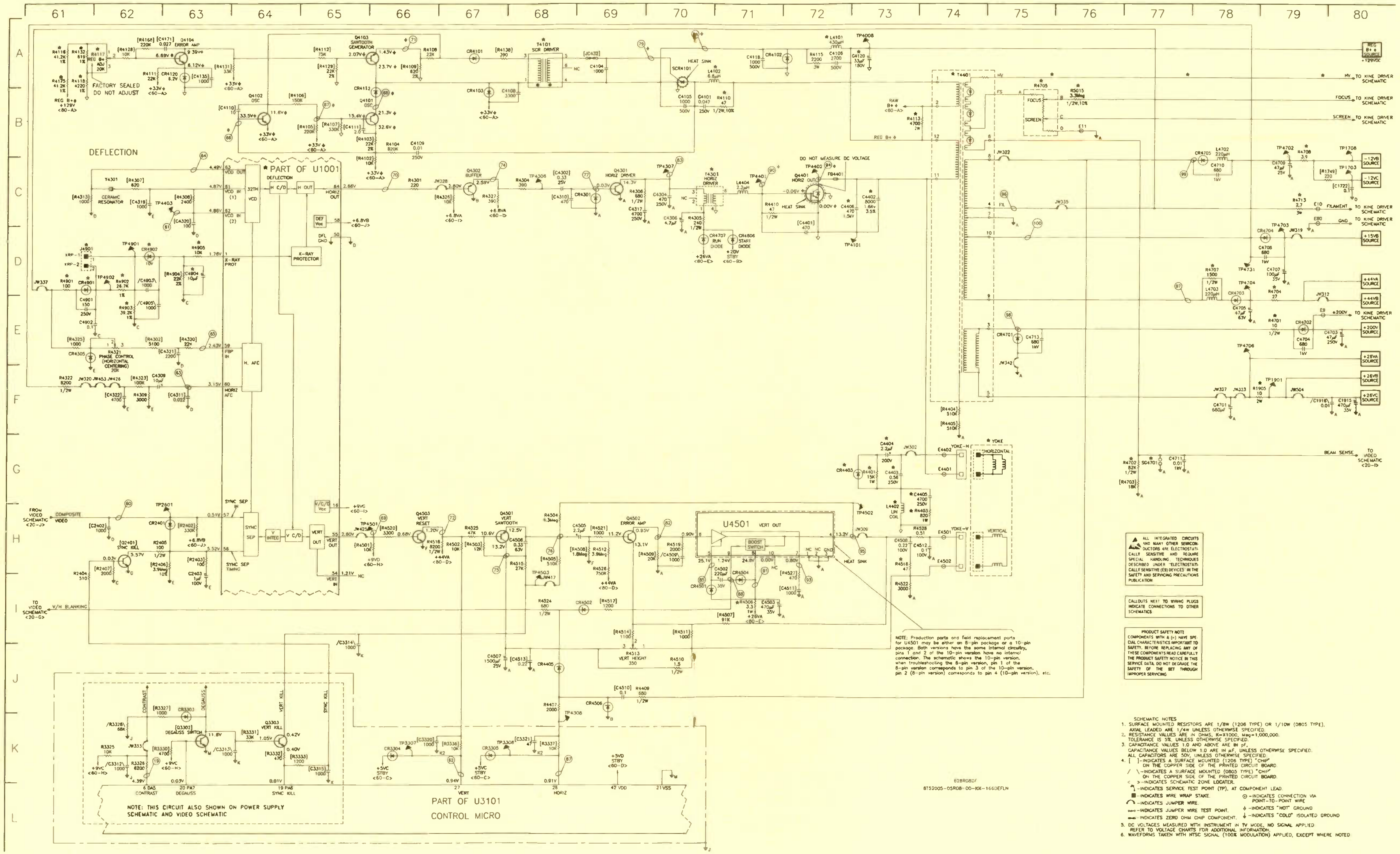

NOTE: Production parts and field replacement parts for U4501 may be either an 8-pin package or a 10-pin package. Both versions have the same internal circuitry, pins 1 and 2 of the 10-pin version have no internal connection. The schematic shows the 10-pin version. when troubleshooting the 8-pin version, pin 1 of the 8-pin version corresponds to pin 3 of the 10-pin version, pin 2 (8-pin version) corresponds to pin 4 (10-pin version), etc.

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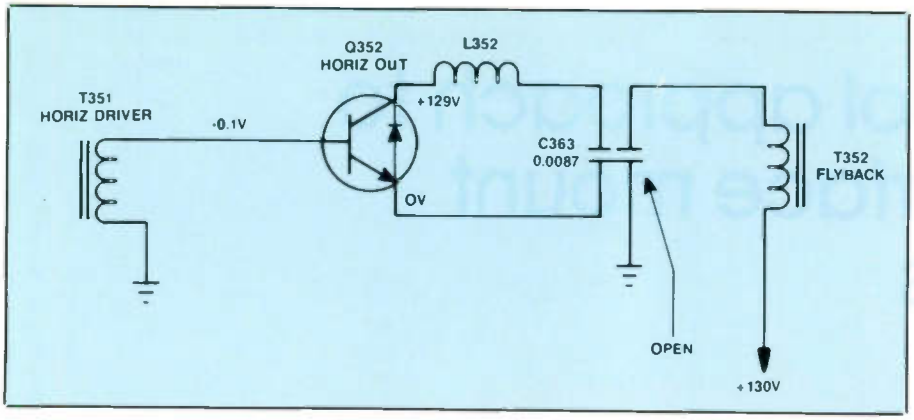


Figure 11. "Old faithful" C363 opened in a Teknika 3459 portable, producing excessive width and HV shut down.

capacitor, the kind many technicians refer to as "old faithful." Back several years ago these capacitors were noted for open or poor internal connections. As I suspected, this capacitor, C363 (0.0087), was open. I replaced it with a 0.0086, 1.6kV universal safety capacitor. Now the HV measured 24.2kV, even when the brightness control was turned clear down.

RCA CTC159 - bowed picture

The picture was really bowed out in one RCA 27-inch color set. No doubt trouble existed in the deflection yoke, horizontal output or pincushion circuits. In this circuit, the pincushion correction circuit modulates the horizontal yoke current at a vertical rate to correct any distortions. Since the picture was bowed out, I went directly to the pincushion circuits.

The schematic shows that the primary winding of the pincushion transformer is in series with the horizontal yoke assembly (Figure 12). By modulating the current through the pin transformer, some of the regulator B+ voltage appears across the yoke and changes the width. The width increases as more B+ appears across the yoke winding.

Because there are several diodes and transistors in the pincushion circuits, I started checking transistors by making tests in the circuit with the diode test of the DMM. All transistors were good, except Q4806 and Q4804. Q4804 was leaky and Q4806 was open. Sometimes, when the horizontal output transistor (Q4401) becomes leaky the pin output transistor (Q4804) shorts out.

When several turns of the horizontal deflection yoke winding short, Q4804 may run hot. Just remove the yoke plug and feel if the transistor is red hot. Readjustment of the width control may be necessary after transistor replacement. Both transistors were replaced with original part numbers.

Conclusion

Remember, the deflection yoke can cause poor width or bowed pictures. To isolate a possible shorted component in the pincushion circuits, remove the yoke plug or the red lead. Check intermittent width symptoms by monitoring the base drive voltage and collector waveforms of the horizontal output transistor. Monitor the high voltage at the CRT. ■

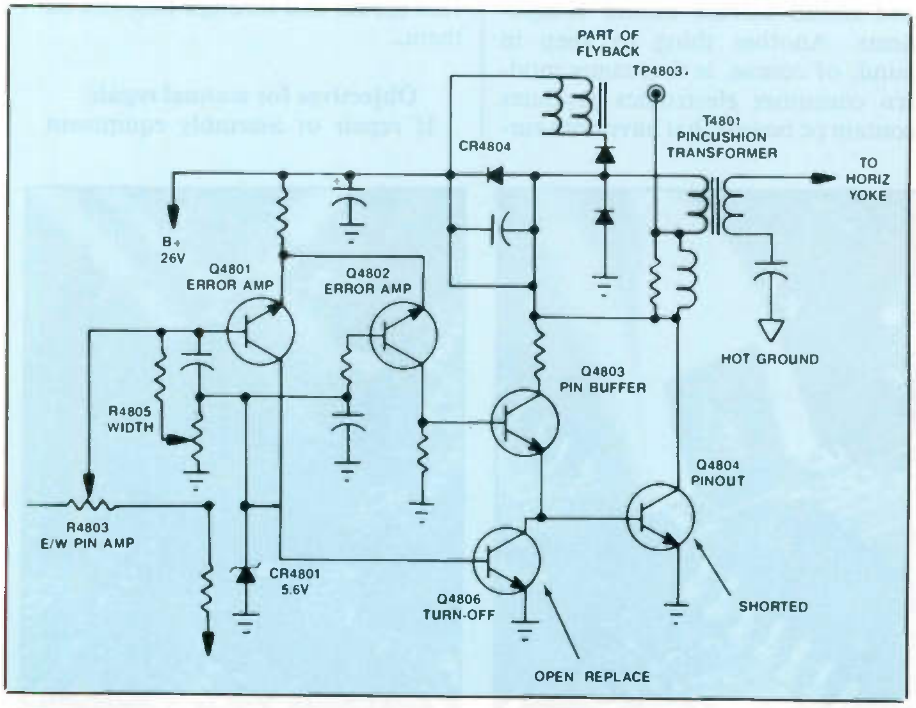


Figure 12. Replacement of the pin out (Q4804) and turn-off transistor (Q4806) cured a bowed raster in an RCA CTC159 chassis.

A multiple tool approach to replacing surface mount components

By Louis Abbagnaro

The introduction of surface mount technology created new assembly and repair problems and challenges. A new set of processing steps and techniques had to be developed to handle surface mount devices because of their mounting characteristics, smaller lead size, greater lead count and other factors. These steps are summarized in Table 1.

Through-hole technology went through an evolutionary stage during which the tools and techniques for assembly and repair were developed. In the manual assembly area, the most notable advance was the progression of the soldering iron from a relatively uncontrolled and bulky device to a modern closed-loop, lightweight handpiece. In the repair area, the major advancement was the continuous vacuum desoldering handpiece which revolutionized component removal.

A similar evolution in tools and techniques has already taken place in surface mount production assembly. A completely new set of automated manufacturing equipment is now used in production. For example, infrared and vapor-phase reflow systems have generally replaced wave soldering, which was standard in through- hole applications. Likewise, solder creams have become the successor for molten solder. The same progression has been taking place in surface mount manual assembly and repair.

This article will focus on the changes in manual assembly and repair by describing and evaluating various techniques used to remove and install surface mount components. Another thing to keep in mind, of course, is that many modern consumer electronics products contain pc boards that have both surface mount and through-hole ICs on them.

Major steps in thru hole and surface mount assembly and repair processes.

ORIGINAL ASSEMBLY

THRU HOLE	SURFACE MOUNT
1. INSERT COMPONENT IN HOLE	1. APPLY SOLDER PASTE
2. WAVE SOLDER	2. TARGET, ALIGN AND PLACE COMPONENT
3. CLEAN PC ASSEMBLY	3. REFLOW PC ASSEMBLY
	4. CLEAN PC ASSEMBLY

REPAIR

THRU HOLE	SURFACE MOUNT
1. DESOLDER OLD COMPONENT	1. UNSOLDER OLD COMPONENT
2. REMOVE OLD COMPONENT	2. REMOVE OLD SOLDER
3. CLEAN PC ASSEMBLY	3. CLEAN PC ASSEMBLY
4. INSERT NEW COMPONENT	4. TIN PADS AND LEADS OR APPLY SOLDER PASTE
5. SOLDER NEW COMPONENT	5. TARGET, ALIGN AND PLACE NEW COMPONENT
6. CLEAN PC ASSEMBLY	6. REFLOW NEW COMPONENT
	7. CLEAN PC ASSEMBLY

TABLE 1

Objectives for manual repair

If repair or assembly equipment

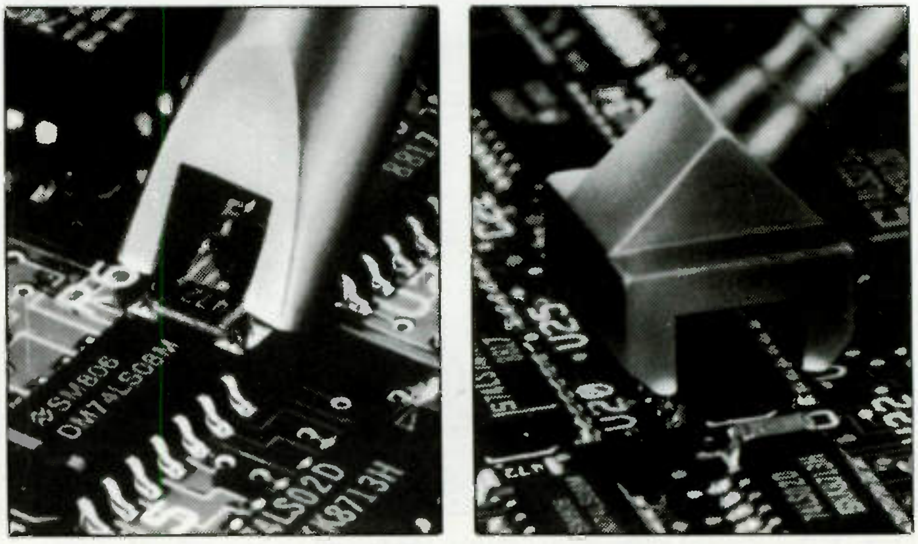


Figure 1. Chip and soic tips for use with standard soldering iron.

Abbagnaro is Vice President and General Manager of Pace Incorporated.

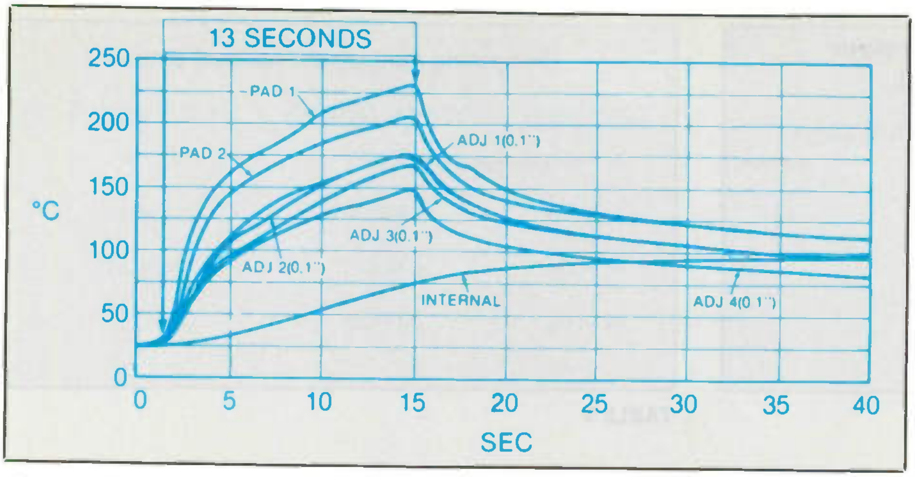


Figure 2. Removal of 67 pin flatpack with hand-held 4 sided convective tool.

were to be used only for one pc assembly and one or two components, or some similarly limited use, it could be specialized and automated. Normally, though, most equipment for manual and semi-automated assembly or repair must be designed for use in many different kinds of applications, as illustrated by Table 2. On the basis of this set of requirements, a set of goals for any piece of surface mount fabrication/repair equipment can be developed. There are three primary goals for this equipment: versatility, control of the process parameters and component safety.

Versatility

The ideal manual system would be able to install or remove any component. The equipment that comes closest to this aim is the one that is most versatile in all the areas described in Table 2.

A versatile manual system would be small enough to put on any bench, and would not require special services such as shop compressed air or a high current line. Likewise, it would be simple enough so that an operator can use it with no special training, or a minimum of special training.

Finally, if a piece of equipment is so expensive that it is out of the question for a small or medium size company to buy it, it can't be considered to be truly versatile.

Control of process parameters

Repair of pc boards is actually more difficult than manufacturing because the board comes to the service facility fully assembled and needs to be carefully de-manufactured before being re-manufactured. The concept of process control in repair is often talked about but not generally given the attention it truly deserves.

To guarantee that manual or semi-automated processes take place in a controlled manner means that the following conditions must be met:

- There must be a well-defined set of relatively simple steps in the process. If the number of steps is too large the operator may inadvertently omit one or more of them.
- The steps must be easily and consistently carried out by trained operators with reasonable skill levels. Even the best set of steps will not lead to process control if the steps are too difficult to be achieved.
- The tools used by the operators must be designed with process control and human dexterity in mind, and ideally should minimize critical aspects of the tasks. This further guarantees that the task can be accomplished at a reasonable skill level. In fact, as the design of the equipment improves, the reliance on critical human skills should be reduced.
- Safety - Simply stated, the assembly or repair process must cause no physical or thermal damage to the component, the pc board, or any of the adjacent components. When semiconductor devices pass through an infrared or vapor phase reflow cycle during manufacture, the chip within the package normally reaches temperatures of 200C or more. Tab components and other assemblies that

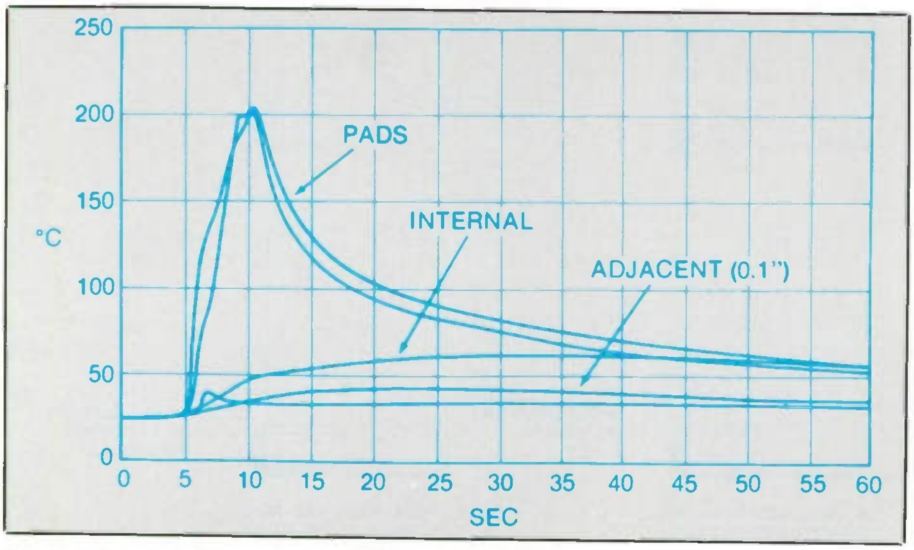


Figure 3. Removal of 67 pin flatpack with hand-held conductive tool with built-in vacuum pick.

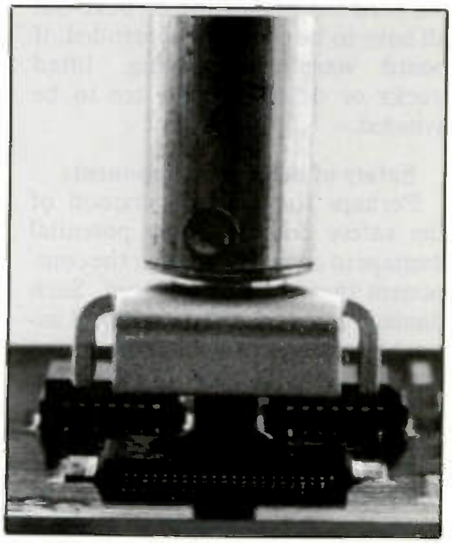


Figure 4. Conductive tool with built in vacuum pick.

Areas where SMD manual assembly or repair equipment is utilized.

1. REPAIR OF PRODUCTION FAULTS
2. DEPOT REPAIR
3. FIELD SERVICE
4. DESIGN CHANGES
5. PROTOTYPE DEVELOPMENT
6. SHORT RUN PRODUCTION

TABLE 2

Comparing component removal times.

COMPONENT	THERMAL TWEEZER	SOLDERING IRON TIP
20 PLCC	2-4 SEC	-----
44 PLCC	4-6 SEC	15-20 SEC
68 PLCC	5-10 SEC	55-60 SEC
84 PLCC	7-12 SEC	-----

TABLE 3

use solder in the chip attachment process may limit maximum chip temperatures to 150C during production to prevent damage to the component assemblies.

Hot bar, laser or other similar techniques are frequently being used to assure staying below 150C during production. These maximum component chip temperatures serve as useful guidelines for the appropriate manual assembly or repair processes to suit the same family of semiconductor devices.

Other components, such as ceramic chip capacitors, may be able to withstand relatively high temperatures, but if the temperature rises too quickly, they'll be damaged by thermal shock. Process techniques in both assembly and repair should therefore include some method of preheating to safely install or remove these devices.

Depending upon the composition of the substrate material (the pc board and wiring), the rate of heat delivery, the type of tools used and the need for preheating or bake-out all have to be carefully controlled, if board warping, measling, lifted tracks or other damage are to be avoided.

Safety of adjacent components

Perhaps the least understood of the safety criteria is the potential damage to components near the component that is being replaced. Such damage can occur if the manual assembly or repair task is not carried out correctly. Generally, the repair process should insure that adjacent solder pad temperatures are kept below 150C to insure that these solder joints are not degraded by the formation of intermetallic growth, or crystallization and embrittlement. In fact, this consideration is one of the critical factors in determining which repair techniques are best suited for a specific component removal or installation.

Approaches to surface mount repair

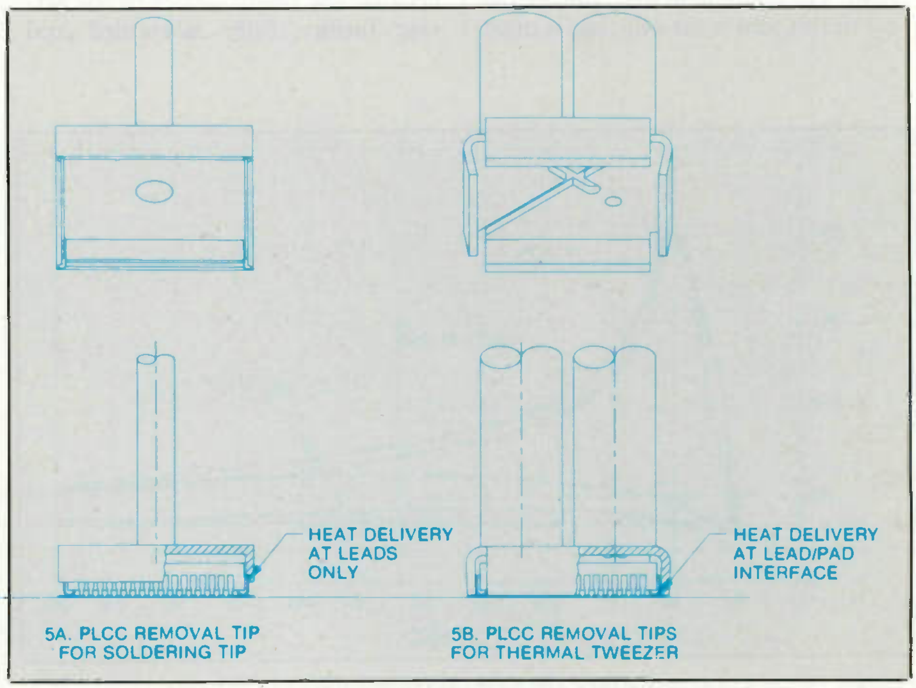
In recent years, two approaches have been popular for manual assembly and repair, and more recently a third approach has evolved: the large machine, the single tool and the multiple tool approach.

Large machine approach

In the early days of surface mount development, the design and repair tasks at first seemed difficult if not insurmountable. Only a few years ago there was a continual debate about all the problems of handling 50 mil component spacing. Now the debate is about 25 mil or smaller spacing, and 50 mil parts are accepted as commonplace by most manufacturers.

The early impression of difficulty led many manufacturers to assume that manual assembly or repair tasks could no longer be handled by human operators, and led to the development of many specialized hot gas and hot bar placement and removal stations for surface mount assembly and repair. These machines satisfied most of the acceptance criteria: they could handle a wide variety of components, they allowed a controlled process approach to assembly and repair with easily defined and repeatable steps that could be followed by trained operators with reasonable skill levels, and they didn't cause damage to other components or to the pc board or wiring.

As the development of surface



5A. PLCC REMOVAL TIP FOR SOLDERING TIP

5B. PLCC REMOVAL TIPS FOR THERMAL TWEEZER

Figure 5. Comparing PLCC removal devices.

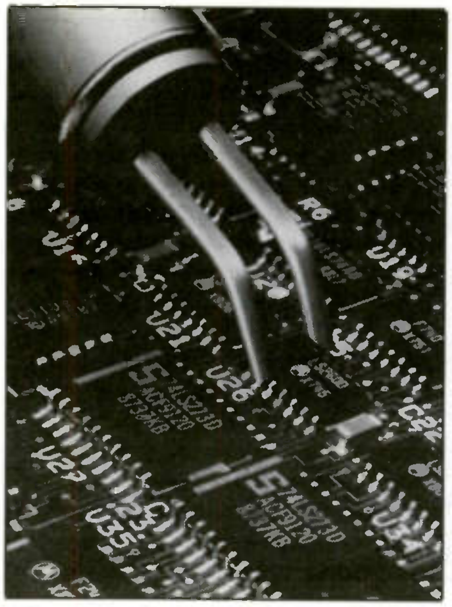


Figure 6. Replacement of soic with convective mini hot jet with focused bifurcated tip.

mount technology has progressed, the concept of a large machine as the only way to do the job has been challenged. It has been proven in many instances that human operators with hand tools can repair surface mount boards as well as hot gas or hot bar machines can.

The single hand tool approach

The soldering iron was quickly applied to surface mount tasks by adding special tips that allowed the handpiece to evolve from a single point (i.e., solder joint) to a multi-point reflow tool. Tips for the removal of chip components and small-outline ICs (SOICs) quickly evolved and are shown in Figure 1. When the tip fit the task, the application worked well and both process control and safety parameters were satisfied.

In other cases, adaptation of the soldering iron didn't work very well. For example, tips for conventional soldering irons have been developed for the removal of plastic leaded chip carriers (PLCCs). In this application, however, no provision has been made for providing the best delivery of heat to the lead/land area or lifting of the component after reflow. Use of such limited tools often lead to poorly made solder joints or component damage.

Hot air as the single tool

Another approach in recent years has been the use of hand-held hot air handpieces as a universal tool for removing and replacing all surface mount components. The tool has some valuable uses, but doesn't always meet safety and process control requirements. For example, many of the hand-held systems don't have the vacuum pick-up capability of larger machine systems. In this case, it takes two hands to remove the component. This may seem trivial, but it often makes it considerably more difficult to remove the component.

The most critical limitation of the hand held hot air approach, however, is safety. The air temperature, time of reflow, and direction of air flow are often poorly controlled, heating nearby components to excessively high temperatures. Frequently the tool is used carelessly and the circuit board is overheated, producing warping or measling. Figure 2, thermal data on the reflow of a flatpack using a hand-held air tool, illustrates an example of improper component removal. It clearly shows that adjacent components 0.10 inches away exceeded the 150C guideline. While it is possible to remove the component safely, the conditions in Figure 2 can occur unless the tool is used with absolute precision. Maintaining this precision is possible but not easy, even for trained operators.

The multiple tool approach

This approach is based on the old sound principle of using the appropriate method to suit the specific job. It basically includes a set of handpieces designed to safely accomplish specific tasks in much the same manner as a garage mechanic uses a full set of specific tools to repair a car. Each tool has a defined purpose and is specifically designed to carry out that purpose. In order to select the tools, some basic thermal guidelines are followed.

Conductive heating

The first guideline to selecting the tools is to use conductive heating devices for component removal and specific installations. Hand-held, conductive (heating by contact) tools are better at targeting heat on the solder joints than comparable convective (heating by gas/air flow) tools. This generally means that conductive devices can be used by operators for multi-leaded component removal without unduly heating adjacent components.

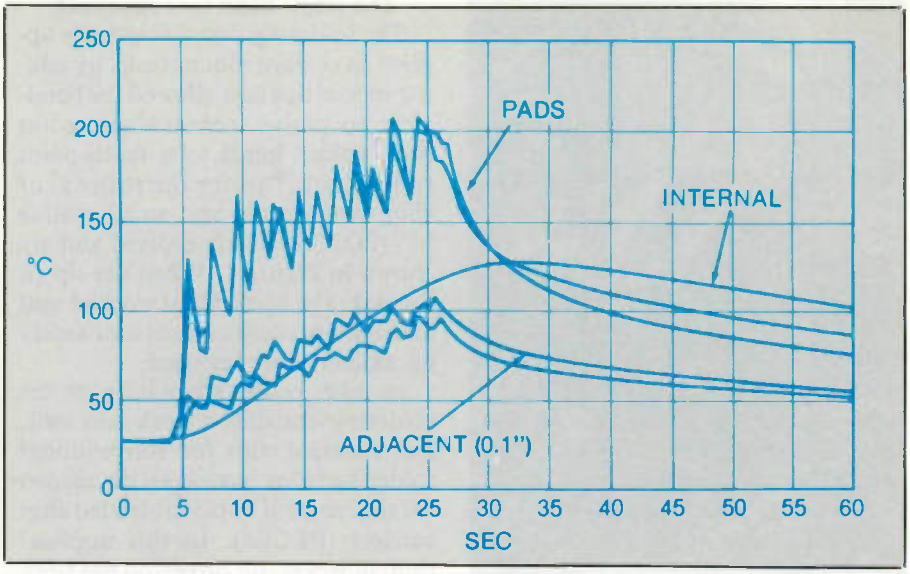
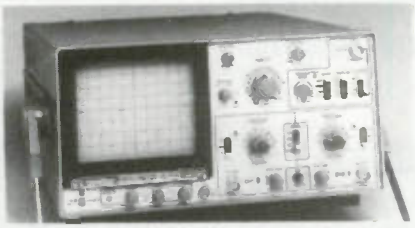


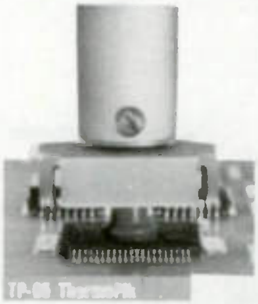
Figure 7. Mini hot jet replacement of soic.

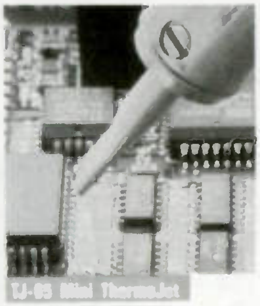
Contrast the unsafe convective removal in Figure 2 with the removal of the same component in Figure 3 using the conductive device shown in Figure 4. The conductive device quickly removed the component while transferring very little heat to adjacent components 0.10 inches away, and did it so quickly that the internal chip temperature remains quite low.

Single point tools

Single point, conductive tools are also usable for component installation and many special tips are used for this purpose. With practice, the task can be accomplished by most operators. In many instances, however, such as with surface mount sockets whose leads are hidden, and fine pitch quad flatpacks, solder







TASK	PREFERRED HANDPIECE	TIP
REMOVE CHIP COMPONENTS	SOLDERING IRON	CHIP TIPS
REMOVE SOICs	SOLDERING IRON	SOIC TIPS
REMOVE PLCCs	THERMAL TWEEZER	PLCC TIPS
REMOVE LCCs	THERMAL TWEEZER	LCC TIPS
REMOVE FLATPACKS/PQFPs	THERMAL PICK HANDPIECE	FLATPACK TIPS
THRU HOLE REMOVAL	DESOLDERING	SIZED TO PAD
SURFACE MOUNT SOLDER CLEAN UP	FLO DESOLDERING	FLO TIP
SURFACE MOUNT PAD TINNING	SOLDERING IRON	TINNING TIP
COMPONENT REPLACEMENT WITH SOLDER PASTE	THERMAL JET	SMALL FOCUSED TIP
COMPONENT REPLACEMENT WITH SOLDER	SOLDERING IRON	MINI TIPS

TABLE 4

bridges or inadvertent damage to the plastic portion of the package can occur. In such cases, fine point convective tools often work better.

Use tools that heat the right spots

The handpieces must be properly designed for the specific application and aim heat at the lead/land interfaces. For example, Figure 5 shows two conductive tools for the removal of PLCCs. The device shown in Figure 5A merely fits into an ordinary soldering iron, and attempts to slip over the component. Because of the need to clear the top of the PLCC body, the best this device can do is to provide heat at the shoulder of the leads which is eventually carried down to the pad area. The process, as might be expected is slow.

In Figure 5B, the use of heated tweezers allows the tip to be slipped over a component and then squeezed together to direct heat much more directly and quickly into the lead/land area. The performance comparison between these two approaches is shown in Table 3. Note that the tweezer often removes even the larger PLCC packages in less than 10 seconds, whereas the soldering iron adapted tip requires nearly a minute for the same task.

Hot air for replacing components

Convective tools have advantages in component replacement, because they don't touch the component. To minimize the danger of overheating adjacent components, the heating system must be focused. It should also provide heat only on demand to avoid inadvertent damage while preparing to replace a component. Figure 6 shows a focused convective tool replacing an SOIC using a scanning technique and Figure 7 shows the thermal characteristics of the reflow process. Again, the process is delivering heat in a controlled manner and causes no damage to either the component, substrate or the adjacent devices.

Operator friendly tools

The specific tools must be designed with both the user and the application in mind. Removal tools should not only properly heat the component, but should also be able to lift the component after reflow. For flatpacks, a vacuum pick built into the handpiece does this, while for PLCCs, the tweezer design heats and lifts. For smaller components such as chip devices or SOICs, a special tip in a soldering iron (such as shown in Figure 1) or tweezer tips may be used. With the soldering iron tips, the surface tension of the solder between the tip and component is usually adequate to lift the component away with the tool once reflow occurs.

With hot air tools, air flow should be slow enough to avoid blowing the parts around.

The tool selection

Which specific combination of tools works best is a matter for debate, and some alternatives to the following list might be suggested. A combination that is being used successfully in process-controlled applications is listed in Table 4. It contains the following elements:

- A high-quality, closed-loop soldering iron for through-hole soldering, and removal of chip and SOIC components.
- A solder extractor, for normal desoldering applications.
- A specialized continuous-vacuum desoldering handpiece to remove old solder from surface mount lands.
- A thermal tweezer for PLCC and LCCC removal. This device may also be used for removal of chip and SOIC components.
- A thermal heating device with a built-in vacuum pick for the removal of extended lead components.
- A low velocity hot air device for the installation of all types of surface mount components.

The right tool for the job

Repairing a printed circuit board that has both surface mount and through-hole ICs may require more than a soldering iron, but present too much variety for use of an automated machine. In such a case, consider the multiple tool approach. You may assemble your own set of tools or consult with soldering equipment manufacturers to see what is available in an integrated soldering/desoldering system. ■

Figure 8.

Protecting circuits from line voltage transients

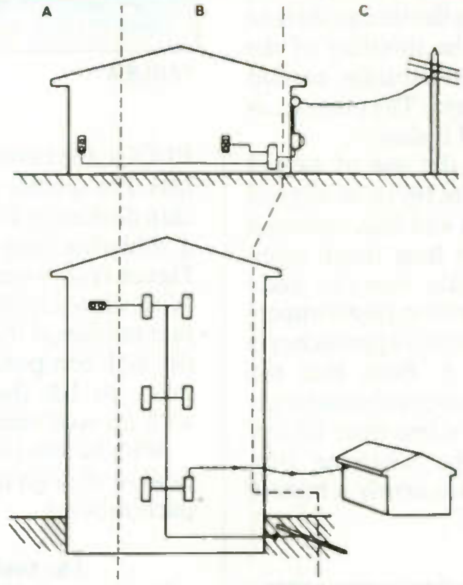
By the ES&T Staff

Based on a booklet published by Intermatic, a manufacturer of transient voltage suppression devices.

Modern solid-state electronics components have provided our age with communications, control and computing capabilities that seem miraculous: instantaneous visual and verbal communication from any place on earth, powerful computers that can be carried around, theaters in any home. The extremely small size of the components that make these miracles possible has at the same time made these marvelous products highly susceptible to damage whenever there's a high-energy transient on the power line that feeds it.

Any time a large motor switches off, or lightning strikes near a power line, or sometimes when the power company is switching from one generator or transformer to another, a brief surge or spike of voltage much higher than the nominal line voltage is created and travels along the line. If this transient overvoltage travels down a line to which an electronics product: TV, VCR, personal computer, is connected, it might damage some of the sensitive components in the product.

Depending on the severity of the transient, the damage might be so slight that the product will continue operating normally while the component gradually deteriorates until the product fails, unexplainably. Or, in the case of a lightning strike, the damage might be so sudden and so violent that the product quite literally goes up in smoke.



Location Categories

A. Outlets and Long Branch Circuits
 All outlets at more than 10 m (30 ft.) from Category B with wires #14-10.
 All outlets at more than 20 m (60 ft.) from Category C with wires #14-10.
B. Major Feeders with Short Branch Circuits
 Distribution panel devices.
 Bus and feeder systems in industrial plants.
 Heavy appliance outlets with "short" connections to the service entrance.
 Lighting systems in commercial buildings.
C. Outside and Service Entrance
 Service drop from pole to building entrance.
 Run between meter and distribution panel.
 Overhead line to detached building.
 Underground lines to well pumps.

Figure 1.

Transient voltage surge suppression (TVSS)

The electronics industry was quick to recognize the problem of damage due to line voltage transients, and has responded with products that will suppress these transients before they reach sensitive electronics products. There are a number of ways to achieve this suppression. Some of these methods are more effective than others. This article discusses some of the components that are used to suppress voltage transients.

Also discussed are the methods used to test these products to see how well they work, and the standards that have been generated by responsible agencies against which these suppression devices are tested.

This information is presented here to make consumer electronics servicing technicians aware of the theory of operation of transient surge suppression devices, and of how they're tested to be sure they work.

Suppression devices

Voltage transient suppressors use electronic devices that are able to change quickly from non-conduction to conduction when the voltage applied to them exceeds a certain design value. The devices in common use today are diodes, MOVs and gas-discharge tubes. Each of these devices has specific characteristics that suit it more or less for surge suppression. In some surge suppression devices, more than one of these components are used.

Transient surge components

Three basic families of protection components are available and used in the transient voltage surge suppression (TVSS) industry today: the silicon avalanche diode (SAD), metal oxide varistor (MOV), and the gas tube. The SAD and the MOV are clamping devices. A clamping device limits the amount of power that can pass. In the case of both the SAD and the MOV, both devices are turned on and turned off at predetermined voltage levels, clamping that part of a TVS that exceeds the predetermined voltage level. A gas tube is a crowbar device. After it turns on, it will exhibit a negative resistance. In effect it acts in the same manner as a crowbar placed across the terminals of a battery.

Silicon avalanche diode (SAD)

The SAD is constructed so that the diode will allow current to flow in one direction and oppose the flow in the opposite direction. When the reverse voltage reaches a predetermined point, the SAD will avalanche in the reverse direction, presenting an extremely low impedance current path.

The silicon avalanche diode is an extremely fast acting component, but as in all natural situations, something else must be traded off for the speed. The SAD is limited in its ability to dissipate heat, a major effect of current flow. The largest commercially used SAD is rated at 1500W, equal to a 1.5 Joule device.

In order to handle the large amounts of power associated with certain categories of transient surges, a large number of SADs must be incorporated into the circuit. This requirement for many components to do a proper job also slows down the reaction time of the device by adding capacitance to the circuit. The true reaction time of a Category B SAD TVS device is approximately between 1ns and 5ns. The characteristics of the SAD make it ideal for protecting data and logic circuits.

Metal oxide varistor (MOV)

The metal oxide varistor (MOV) is the most commonly used transient voltage surge suppression component in the industry. Like the SAD, the MOV is a clamping device, reacting to predetermined voltage levels. The MOV is slower than the SAD, but is still considered as a very fast acting component. Unlike the SAD, the MOV has a very good ability to dissipate the heat associated with heavy current flow.

The size of an MOV is a good indicator of its ability to handle power. In general, the larger the MOV, the more power it can handle. MOVs can absorb a portion of the transient surge energy by converting it directly to heat energy and radiating it to the surrounding environment. This ability to radiate heat energy gives the MOV unique capabilities in the field of transient surge suppression. Reaction times of some TVS devices range from 1ns to over 50ns, depending on size and proprietary designs.

Spark gap devices and gas tubes

A spark gap is as simple as two bare wires placed a short distance apart. When the voltage potential between the two reaches a high enough point, an arc or flashover will occur. Very large amounts of current can be conducted by a spark gap device. The spark gap is a crude device, and there is no true way to regulate the point at which the flashover will occur because of the uncontrollable differences in atmospheric conditions.

A gas tube consists of two or three bare wires called electrodes, that are spaced at a specific distance and housed in a sealed container. The atmosphere in the container is a combination of rarified gasses, with exact qualities of pressure, ionization and conductivity. The gas tube can be constructed so that current and voltage characteristics are repeatable. The gas tube is a crowbar device and will continue to conduct as long as sufficient current is available. Additional electronic components must be placed in the TVSS circuitry with a gas tube to prevent it from interfering with power or the signal on the line that it is protecting.

Like the spark gap, the gas tube is able to handle very large amounts of current for its size. Compared with the SAD and MOV, the gas tube is slow; reaction time occurring between around 1μsec to over 1msec.

Gas tubes are manufactured in several sizes and configurations. A gas tube may have two or three electrodes, and in some cases, the shell or container serves as an electrode. Gas tubes can have glass, ceramic or metal shells.

Other components

Inductors, capacitors and resistors are electronic components that are used in many TVSS devices to complement or enhance the action of the three basic families of TVS components. While both the inductor and the resistor can act upon a transient surge waveform, they cannot by themselves clamp the voltage or suppress the energy. Resistors are used primarily to limit current flow, and as a result, are incorporated in most TVS circuits that use SADs. Resistors are also used to force a gas tube to turn off before it interferes with the power or signal on the lines it is protecting. In both cases, the resistor serves in the role of support component, allowing the suppression component to perform its function better.

Inductors are used in TVSS circuits for several functions, including component isolation and current limiting. Like the resistor, the inductor serves to assist the suppression components. In addition, inductors can be used to filter radio frequency interference (RFI) and electromagnetic interference (EMI).

Inductors store energy in the form of electromagnetic energy, and oppose changes in current flow. In some cases, an indiscriminately placed inductor will actually create transient surges where none existed. Great care must be taken when designing EMI/RFI filter circuits that contain inductors. In the world of switching power supplies, EMI/RFI appears to be a diminishing hazard, and most sensitive equipment can survive and function very well with proper TVSS protection and no EMI/RFI protection.

Capacitors are not transient surge suppression devices. They are misused sometimes to alter the appearance of a suppressed waveform, but it must be remembered that a capacitor is a storage device. Any energy that is stored from a TVS must be discharged back into the line at some point. If a capacitor is placed in a TVSS circuit incorrectly, it has the potential to do more harm than good.

Standards

A standard represents the consensus of opinions of an expert group that defines the level of performance that a certain class of products should meet. Transient voltage surge suppression standards are not a statement of what the industry thinks is happening in nature, but rather what they think may be directly affecting equipment. TVSS standards consider the effect of the electrical power distribution network upon a transient when maximum parameters are stated.

In other words, the effect of a transient on the power line will be most severe when it reaches the service entrance of, say, a home, but its severity will be reduced once it has traveled along light gauge wires for a few feet. The severity of a transient would be expected to be reduced even further after it has traveled along light gauge wires for a longer distance.

The ability of a suppression device that is to be installed at the service entrance to suppress transients would therefore have to be greater than the ability of a suppression device farther downstream in the power distribution network in the house.

The standard provides for a simulation of occurrences and establishes a benchmark for testing. A standard allows for the construction of test equipment and provides uniformity for both quantitative and qualitative testing of products.

Real world transients are not neat, clean and easily read waveforms. In the real world, transients tend to occur in groups of variations, overlapping each other and creating a very indistinct waveform. In order to identify certain types of transients, monitoring equipment is modified to ignore some of the less intense transients.

In the testing laboratory, specially constructed equipment is used to generate transients of uniform waveform and intensity to allow test engineers to replicate test conditions. It is assumed that a transient suppressor that will protect equipment from maximum intensity or catastrophic transients will also protect from smaller or less intense transients.

IEEE 587-1980

IEEE (Institute of Electronic and Electrical Engineers) 587-1980 is one of the benchmark standards used by the transient suppression industry. This standard does not publish methods of testing, but it defines the waveform, intensity and physical locations of transient surges. This standard establishes three categories of building environment and the associated transients that are most likely to be encountered in each of the environments. The transients are defined by their maximum intensities (see Figure 1).

Category A is defined as outlets and long branch circuits. It encompasses all outlets located more than 30 feet from Category B with wire gauges 10 through 14.

Category B is defined as major feeders and short branch circuits. This category encompasses distribution panel devices, bus and feeder systems and heavy appliances outlets with short connections to the service entrance.

Category C is defined as the outside and service entrance. It is made up of the service drop from pole to building entrance, overhead lines to detached buildings, and underground lines to well pumps.

ANSI (American National Standards Institute) C62.41 reaffirms the waveforms and the categories as defined in IEEE 587-1980. The standard is written as a combination of both of the standards.

ANSII/IEEE 62.41

ANSI/IEEE 62.41 establishes the relationship between waveform, intensities and locations. Figure 2 shows the Category A ring wave. The Category A ring wave is a decaying oscillatory wave with a maximum open circuit peak of 6000V. The wave decays at a 40% rate on each successive peak. The Category A wave has a short circuit amperage availability of 200A.

Category B, short branch circuits, exhibits the same oscillatory decaying ringwave as Category A, but with a larger short circuit current availability. The Category B ringwave can have up to 500A of available short circuit current. The waveform is the same as shown in Figure 2.

In addition to the ringwave, Category B introduces the concept of an impulse. A very fast rising voltage waveform coupled with a current waveform. The maximum expected waveform is again 6000V open circuit, while the short circuit current availability is 3000A. Figure 2A and 2B show the two waveforms.

It should be pointed out that the 3000A of available current do not exist at a 6KV potential. The voltage waveform can be seen when the transient is imposed on a high impedance circuit, while the current waveform is the result of a transient imposition on a low impedance circuit. The conversion from the voltage waveform to the current waveform occurs at the speed of the surge suppression device. The change in circuit impedance is brought about by the action of the surge suppression device as described in the sections above on surge suppression components.

UL 1449-1987

UL 1449-1987 was a large step within the transient surge suppression industry to establish not only levels of potential encountered surges, but to define testing procedures for transient suppression devices. UL 1449 marked the first time that a testing organization defined specific parameters for qualitative testing, with a highly regulated regimen for the public reporting of the test results.

The standard established a series of requirements for surge suppression products designed for repeated limiting of transient voltage surges on 50Hz or 60Hz circuits. It further limits the coverage to products intended for indoor use, for connection on the load side of the service disconnect, and in circuits not exceeding 600Vrms. The standard specifically states that it covers transient voltage surge suppressors that are essentially voltage-sensitive breakdown or clamping-type devices, such as varistors, avalanche diodes and gas tubes.

UL 1449 lists specific requirements regarding construction such as enclosure construction, protection against corrosion, insulation materials, internal wiring and grounding. In the performance section, the standard lists over one dozen tests that must be accomplished in order for a product to be listed. In addition to transient surge suppression tests are temperature, duty-cycle, leakage current, grounding continuity, overvoltage, and others.

The principal transient surge related tests are the Voltage Withstand Test and the Transient Voltage Suppression Test. In each test, three samples of the suppressor under test are subjected to the defined voltage tests. Table 1 is a copy of the UL Table 24.2, listing the waveform test parameters according to product type. An average of the "maximum peak let-through voltage" from the twenty-four Duty-Cycle impulses is used to determine the suppressor rating.

UL 1449, section 37, Ratings, states "the transient suppression voltage rating shall be a voltage level as specified in Table 37.1 that is equal or greater than the suppressed voltage measured during testing. If a suppressor incorporates transient suppression between several terminals, that is, line-line, line- neutral, line-ground, neutral-ground, several suppression ratings shall be provided."

When you're looking for a plug strip that will offer suppression of transient devices, make that it is UL listed for compliance with this standard. If you buy a product that calls itself a suppression device, but carries a UL listing for some other standard, it's possible that the device passed testing as a wiring device but not as a suppression device.

Always consider transient voltage suppression

While manufacturers of consumer electronics products today make every effort to design products that are reliable and will operate satisfactorily when connected to the power line, the susceptibility of the solid state devices that constitute the circuitry of these products means that transients on the power line will damage or destroy some of these products unless some kind of suppression device is used.

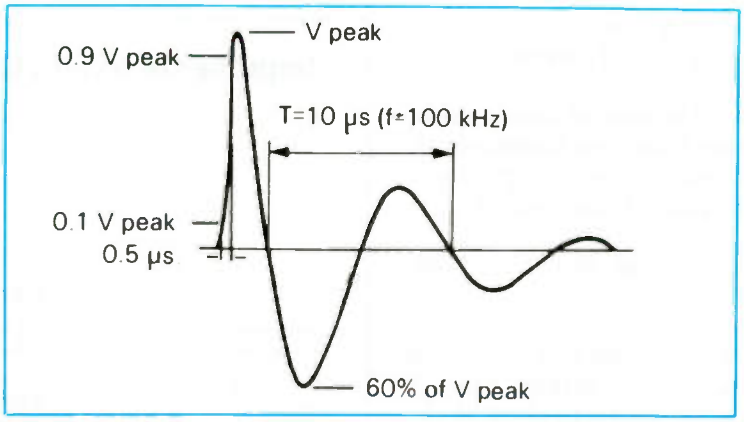


Figure 2.

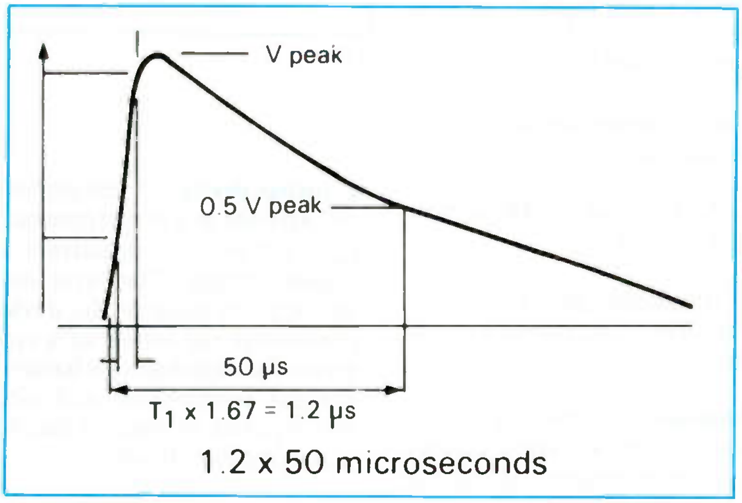


Figure 2A.

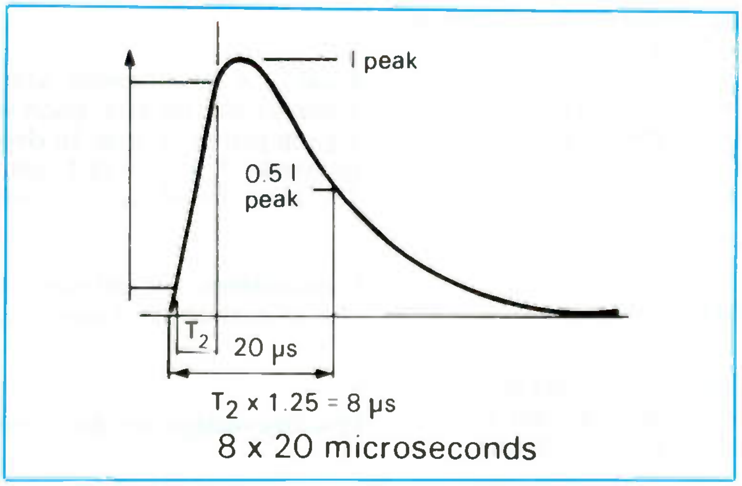


Figure 2B.

A technician who is well informed on the operation of these suppression devices will be able to advise clients on what kind of devices offer the needed protection.

Glossary

Alternating current (ac) - Current in which the direction of flow of electrons changes periodically. In the U.S., the rate of change is 60 times per second.

Ammeter - A device calibrated to measure the flow of current.

Ampere - The unit of measurement for current flow. One ampere equals one coulomb of electrons passing a point in a circuit in one second.

ANSI - American National Standards Institute

Atom - The smallest part into which an element can be divided and still maintain the characteristics of the element.

Capacitance - The ability to store an electrical charge. The unit of measurement is the farad.

Capacitor - A device that can store an electrical charge.

Choke - An inductor used to oppose changes in current flow.

Circuit - A complete path for current to flow from one terminal of a power source to another.

Circuit breaker - An automatic protective device that will allow current to flow under normal conditions, but will open the circuit under abnormal conditions to prevent damage from excessive current.

Clamping device - A component whose action is triggered by a predetermined voltage. A clamping device will activate (turn on) and deactivate (turn off) at specific predetermined voltages.

Coil - See inductor

Condenser - See capacitor

Conductance - The ability to conduct or carry current. The unit of measurement is the mho, or Siemens.

Conductor - A material with the ability to conduct electrical current. Copper is a commonly used electrical conductor.

Coulomb - The Coulomb is the basic unit of measurement of electron quantity. 6,250,000,000,000,000,000 electrons, or in scientific notation 6.25×10^{18} equal one coulomb.

Impulse Generator Characteristics Vs. Product Type

		Impulse[a]	
		Amplitude[b]	
		I	II
Product	Waveform	Voltage Withstand, Transient Voltage Suppression	Duty Cycle
Cord-Connected and Direct Plug-in	1.2 x 50 uS 8.0 x 20 uS	6 kV 500 A	6 kV 125 A
Permanently-Connected	1.2 x 50 uS 8.0 x 20 uS	6 kV 3 kA	6 kV 750 A

[a] Combination voltage/current surge with open-circuit voltage and short circuit current as specified.

[b] Open circuit voltage/short-circuit current levels applied during testing.

Table 1

Crowbar device - A component that will activate at a predetermined voltage, but will not deactivate at the trigger voltage. The term crowbar was applied because the device approximates the action of a crowbar across the terminals of a battery. Additional components and circuitry are required to prevent pulling the signal or power to zero.

Current - The flow of electrons through a conductor. Current is measured in amperes.

Cycle - A phenomenon that can repeat itself in the same order within a given period of time. In electrical terminology, a wave that completes 360: regardless of the point of origin.

Direct current - Current in which the flow of electrons is in one direction only.

Effective voltage - See RMS voltage

Electricity - The flow of electrons through materials and devices.

Electromagnetic field - A field of force produced around a conductor whenever there is current flowing through it.

Electron - A negatively charged particle surrounding the nucleus of an atom. The nucleus and the electrons combine to give an atom its chemical and electrical properties.

Element - One of over one hundred different substances which are the building blocks of all matter. An element cannot be divided into simpler substances by chemical means.

Energy - The ability to do work. The unit of measure of energy is the joule.

Farad - The unit of measure of capacitance. One farad is the ability to store one coulomb at a potential of one volt.

Frequency - The number of cycles or completed alternations per unit time of a wave or oscillation. The time unit is one second. The abbreviation is f.

Fuse - A protective device that will allow current to flow in a circuit under normal conditions, but will open to prevent current flow under abnormal current conditions. A fuse usually contains material with a low melting point which opens when the current passing through it exceeds the rated ampere value.

Gas tube - A surge suppression component that is made up of two or three electrodes in a sealed envelope that contains a rarified gas. A gas tube is a crowbar device.

Giga - Metric prefix meaning billion or 10^9. The abbreviation is G.

Ground - A voltage reference point which may be connected to earth ground.

Henry - The unit of measurement for inductance. A one henry coil produces 1V when the current through it is changing at the rate of 1A per second.

Hertz - The unit of measurement for frequency, used when the occurrence is more than one cycle per second. 60 cycles per second would be identified as 60 hertz. The abbreviation is Hz.

IEC - International Electrotechnical Commission

IEEE - Institute of Electrical and Electronic Engineers

Inductance - The ability of a coil to store energy and oppose changes in current flowing through it.

Inductor - A number of turns of wire wrapped around a core used to provide inductance in a circuit. Also called a coil.

Insulator - A material of low conductivity used to isolate and/or support a charged conductor. Glass and porcelain are examples of insulators.

Joule - The unit of measure of energy equal to one watt-second. 3,600,000 joules equal one kilowatthour.

Junction - A connection of two or more components or materials.

Kilo - Metric prefix meaning thousand or 10^3. The abbreviation is k.

Leakage current - The small electron flow between components, circuits or conductors due to the fact that an insulator is not a perfect nonconductor.

Load - A device that receives electrical energy from a source, draws current and/or provides opposition to current, requires voltage, or dissipates power. Resistors, light bulbs, and electric motors are examples of loads.

Loop - A closed path for current to flow in a circuit. A complete or closed circuit.

Magnetic flux - Magnetic lines of force in or around a material or conductor.

Mega - Metric prefix meaning million or 10^6 The abbreviation is the letter Mμ. A lower-case u is often used.

Metal oxide varistor - A solid-state surge suppression component that can handle large amounts of current and reacts in the low nanosecond time range.

Milli - Metric prefix meaning one-thousandth, or 10^{-3}. The abbreviation is m.

MOV - See metal oxide varistor.

Nano - Metric prefix meaning one billionth, or 10^{-9}. The abbreviation is n.

NEMA - National Electrical Manufacturers Association.

Ohm - The unit of measurement of resistance equal to the resistance in a conductor in which one volt of potential produces a current flow of one ampere.

Ohmmeter - An instrument used to measure resistance.

Open circuit - An interruption in a circuit that causes an incomplete path for current flow.

Oscilloscope - An electronic instrument that can visually display varying electrical signals as a function of time. Oscilloscopes are often used to measure voltage, current, and frequency.

Parallel circuit - A circuit that has two or more paths or branches for current to flow.

Peak amplitude - The maximum positive or negative deviation or value of an electrical signal from the zero reference level.

Peak-to-peak amplitude - The distance or value between an ac signal's maximum positive and maximum negative peaks.

Percent - The ratio of one part to the whole expressed as a function of 100.

Phase - Term used to describe the hot line or lines in ac power. The term is properly used to describe the relative positions of ac quantities in time reference to each other.

Phosphorescence - The property of a material to emit light after being struck by electrons.

Pico - Metric prefix meaning one trillionth, or 10^{-12}. The abbreviation is p.

Polarity - See voltage polarity.

Power - The rate at which work is performed or heat is generated. Power is measured in watts. The abbreviation is P.

Power dissipation - The ability of a component to disperse power, usually in the form of heat energy. The rating of a component's ability to dissipate power.

Relay - A switch or combination of switches activated by an electromagnetic coil.

Resistance - The opposition to current flow. Resistance can be thought of as electrical friction because it opposes electron flow and generates heat. The symbol is R, and the unit of measurement is the ohm.

Resistor - An electrical and electronic component that has a predetermined measurable opposition to a current flow.

RMS - See root mean square.

Root mean square - The square root of the mean (average) of squared values. A method of calculating the effective value of a waveform, such as a voltage waveform that varies around a zero value and so has a zero average value.

RMS voltage - Applied to an ac sinewave, the rms value is also known as the effective voltage and is .707 times the peak voltage.

Scientific notation - A type of shorthand used to keep track of decimal places which utilizes powers of the number 10. The form for scientific notation is D.DD X 10^n, where D represents the first three significant digits, and n represents a positive or negative number that is the exponent or power of ten. As a specific example, 18,000 might be expressed as 1.8 X 10^4.

Series circuit - A circuit that has only one path for current to flow through.

Short circuit - A path with very little or no resistance to the flow of current.

Shunt - A term which means to parallel. In electronics, the term is used to indicate a low resistance parallel circuit often used to divert current.

Silicon avalanche diode - A solid-state surge suppression component that is extremely fast, but lacks the ability to handle heavy current.

Trigger - An event that initiates a reaction.

Trigger voltage - The voltage level required to initiate a component or circuit response.

UL - Underwriters Laboratories.

Volt - The unit of measurement of electrical potential. One volt will cause one ampere to flow through a conductor with a resistance of one ohm. The abbreviation is V.

Voltage - Potential difference expressed in volts. The symbol is E.

Voltage drop - The change in voltage between two points in a circuit caused by current flow through components within the circuit. Voltage drop is measured in volts.

Voltmeter - A calibrated instrument for measuring the potential difference between two points.

Watts - The unit of measurement of power equivalent to one joule per second. A watt is equal to the power in a circuit in which a current of one amp flows at a potential of one volt. The abbreviation is W.

Waveform - The graphic depiction of a progressive disturbance propagated from point to point. ■

Computer Corner

A couple of servicing tips

By the ES&T staff

Servicing personal computers can be a good way for a consumer electronics servicing organization to expand the scope of their operations. However, because personal computers have only recently become a consumer product, many of the servicing tips and ideas that help make servicing more efficient aren't generally available among the consumer electronics servicing community.

In an effort to make a start at correcting this lack, we present here a couple of tips that were made available to us by National Advancement Corp. (NAC) of Santa Ana, CA.

PS/2 built-in diagnostics

The IBM PS/2 personal computer comes complete with some built in diagnostics for reporting system problems. Logic on the motherboard reports errors displayed as hexadecimal code. Using a standard breakout box, you can observe the hexadecimal readout, and if you have a list of what those codes are, you can determine the nature and location of the problem.

If a problem has occurred in a PS/2 computer and you wish to check the error code to determine what the problem might be, first, turn the computer off and then connect a breakout box to the built-in parallel port of the PS/2. Be sure that your breakout box has lights on pins 2 through 9. Use pin 25 as ground. Once the breakout box is connected, turn the system on.

When the system is first turned on, it goes through a self test. This is called the power-on self test, or POST. If an error occurs during this power-on self test, the test will stop and the hexadecimal code that describes the nature of the error will be displayed on the LEDs on the breakout box. Figure 1 lists five of the most common of these errors.

PIN	ERROR
23456789	
oooo*ooo	First 512K RAM in real mode
ooooooo	Processor self-test
o**ooo*o	NMI error
oo**o**o	Setup configuration error
*ooo*ooo	Halt system if memory test error

Legend * = pin on or lit
o = pin off or unlit

Figure 1. The IBM PS/2 personal computer offers built in diagnostics that can be read by plugging a breakout box into the built-in parallel port and then turning the power on. These error codes, which you may read on the LEDs of the breakout box, are five of the most common encountered.

It is possible to obtain a list of these errors from IBM. If you encounter an error that is not listed in this short list, NAC will provide you with the error description. They will not provide you with a full list of the errors, as that is part of what they provide, for a fee, in the courses they offer. You can reach NAC at 800-832-4787, or 800-443-3384 in California.

Color monitor problems

The IBM 8514 monitor is manufactured by Panasonic, a division of Matsushita Electric. To solve 80% of the problems with this monitor (according to NAC), do the following:

1. Check Q560 (2S1849) and Q571 (2SD1850). Replace them if they test out bad. If these transistors are good, or if replacing them does not solve the problem.
2. Replace C825 (47μF +25V), C810 (22μF 235V), C832(100μF +25V) and C865 (10μF +50V).

If the problem persists:

3. Replace the flyback

Test your electronics knowledge

By Sam Wilson, CET

The questions in this TYEK are from articles that appeared in **ES&T** between January and October 1990. These are very easy questions so you will likely score high.

1. The letter I in PIN diode stands for

A. Implied
B. Inter
C. Inner
D. (None of these choices are correct)

2. The circuit of Figure 1 was given in an article titled "Thyristors from A to Z" by Lambert C. Huneault. The article was in the February 1990 issue of **ES&T.** As explained in the article, if there is an internal (anode/cathode) short in the SCR and the FM stereo lamp will be:

A. ON all the time.
B. OFF all the time.
C. destroyed

3. When a customer's radio, which glitches and distorts at home, works just fine in the shop, one of the first things to suspect is

A. AGC
B. RFI
C. BFO
D. AFC

4. The symbol in Figure 2 is for a ________.

5. The time rate of doing work is called ________.

6. Regarding frequency counters, time base stability and resolution determine ________.

7. Noise caused by the random movement of electrons across a potential barrier, such as a transistor or vacuum tube, is called ________.

8. A rapid variation in signal strength of a signal being received from a mobile 2-way radio unit is called fading.

Wilson is the electronics theory consultant for **ES&T**

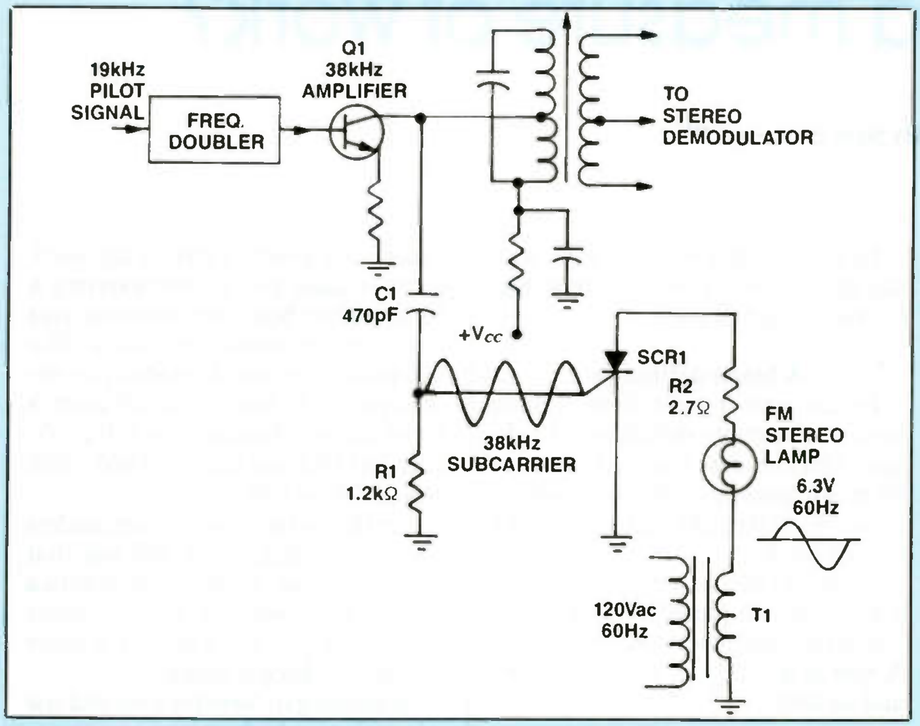


Figure 1

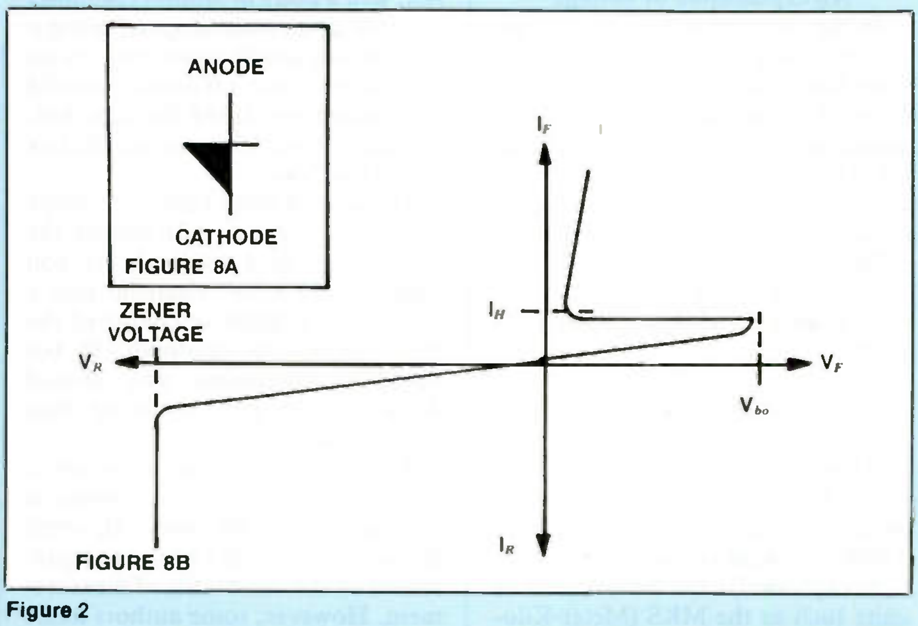


Figure 2

9. From an article titled "Servicing Modems," by Glenn R. Patsch—if you cannot get a dial tone, but do see the RD (Receive Data) and SD (Send Data) lights flash, suspect the ________.

10. A bathtub curve is described in an article titled "10 Steps to Prevent Equipment Failure," by John Shepler. The curve show that:
A. Most failures occur right away when the equipment is first used.
B. Failured approach 100% when age begins to take its toll.
C. (Both choices are correct).
D. Neither choice is correct).

(Answers on page 58)

What do you know about electronics?

Did you know that the volt is a measure of work?

By Sam Wilson, CET

In this article I will continue with the discussion of voltage that was started in the last issue.

A better definition

In the past I have been a little careless about my definition of voltage. Alert readers have asked me to be more specific. The complaint is about my statement that *voltage is a unit of work*.

Actually, the statement should be *a volt is a unit* period. It is a difference of potential between two points. A volt is a unit just like an ampere and an ohm.

An explanation of voltage

In the last article I spent time explaining what a voltage is *not*. It is not a force, nor is it an electromotive force. If it was any kind of force you would need to know how far a resistor is from the source of voltage before you could calculate the amount of current through that resistor.

Before I go any further, I have to review the meaning of the term *work* as it is used in science. In equation form:

$$WORK = W = Fs$$

Where F is the force exerted on some object and s is the distance the object moves as a result of that force. All of the entries in the equation have to be expressed in the same system of units such as the MKS (Meter-Kilogram-Second) system of the British system (Foot-Pound-Second). For example, if the force is in pounds and the distance is in feet, then, the work as expressed in pound-feet.

If you push a box across a floor the work you do is easily calculated by multiplying the force you use by the distance you move it. However, if you carry the box horizonally between two points there is no work done because you are not exerting a force on the box. (this assumes you have already started the box). The two points are not the starting or ending points.) I know that will cause a lot of concern because you will probably feel like you have worked when you carry the box.

I am likely to get mail from readers on that subject. They will say that you have to get the box started with a force. However, in the scientific sense once you get it started it takes no force to keep it going.

According to Newton's second law of motion: *a body at rest remains at rest, and a body in motion continues to move at a constant speed along a straight line unless acted upon by an unbalanced force.* Of course, you did work when you lifted the box, but, you do not work in moving the box across the floor.

The second thing I want to review is the term *unit charge*. In science, the unit charge is a coulomb. If you squeeze 6.25 x 10^{18} electrons into a ball the total negative charge of the ball will be one coulomb. In the following discussion you should think of the unit as being that negative ball.

The third thing I want to review is the term *energy*. In science *energy is the capacity to do work*. In some literature energy and work are represented by the same units of measurement. However, some authors make a valiant effort to avoid confusion by changing the names of the units a little bit. For example, the call of the unit of work (in the British System) "foot-pounds" and the unit of energy "pounds-feet." I don't want to go into that any further - at least not at this time. Just remember the above definition of energy.

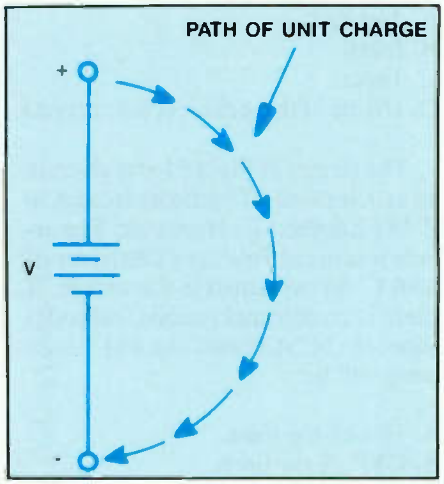


Figure 1.

Having reviewed those points, we can proceed with the true meaning of voltage. Consider the battery (shown schematically) in Figure 1. Assume you are going to move a unit charge from the positive terminal to the negative terminal along a path shown by the broken line.

You are going to have to exert a force on the unit (negative) charge to get it away from the positive terminal because unlike charges attract.

Like wise, you will have to do work on the unit charge to force it to move to the negative terminal because like charges repel.

So, you have to exert a force on the unit charge to move it through the distance shown by the broken line. *Voltage is the amount of work done in moving a unit charge from a point of higher potential to a point of lower potential.* The positive voltage is considered to be the point of higher potential and the negative terminal is assumed to be the point of lower potential. That is the true meaning of voltage.

Now, suppose you decide to move the unit charge along a different path as shown by the second broken line in

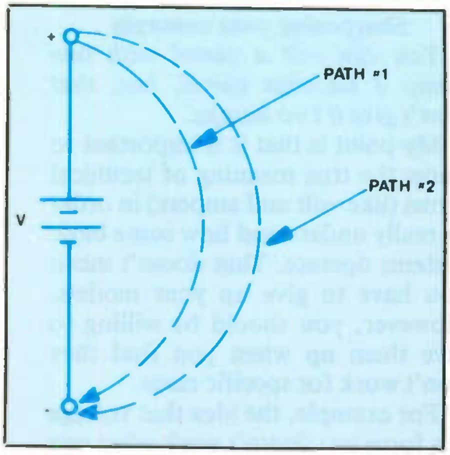


Figure 2.

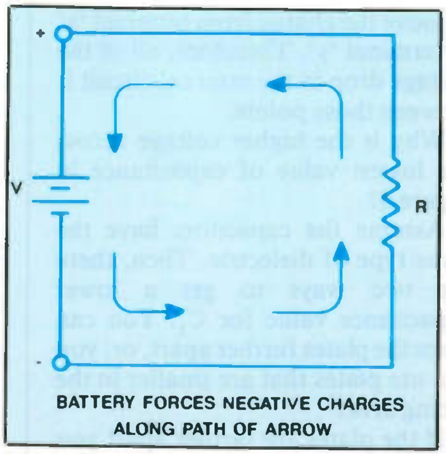


Figure 3.

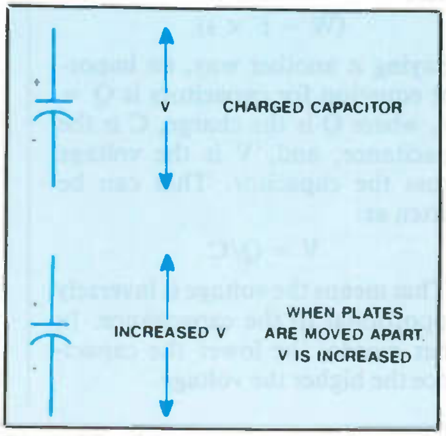


Figure 4.

Figure 2. The average amount of force will be lower along the way, but, the distance is greater. The work done (force times distance) in moving the unit charge along the two paths is the same.

Let me give some arbitrary numbers to demonstrate that point. Suppose the average force is 10 units and the distance is 2 units for path #1. (See Figure 2.) Then:

$$W = Fs = 10 \times 2 = 20$$

Now suppose the average force is only 2 units but the distance is 10 units when you move the unit charge along path -2. Now the work done in moving the unit charge is:

$$W = Fs = 2 \times 10 = 20$$

You do exactly the same amount of work in both cases, so, the voltage between the points is the same in both case. This is a very important point:

The work done in moving a unit charge from a higher potential to a lower potential is the same for a voltage source regardless of which path you take. That is why voltage is expressed as the work done in moving a unit charge from one point to another.

You have, no doubt, heard that a battery is a source of electric energy. That simply means it has the ability to do work. For example, it can move a negative charge from the negative terminal to the positive terminal. This is illustrated in Figure 3. In this case the resistor offers the opposition to the motion of the negative charge.

In the same way, a charged capacitor is a source of stored energy. It can also move a negative charge around a circuit.

When you move the plates of a charged capacitor apart, as shown in Figure 4, you must do work. The plates are oppositely charged so they are attracted to each other. To move the plates apart you must overcome that attraction. So, you exert a force through a distance. You are doing work. That work shows up as an increase in the stored energy.

In other words, the voltage across the capacitor *increases*. Putting it another way, it would take a greater amount of work to move a unit charge from the positive plate to the negative plate after the plates have been moved apart.

Suppose you move a unit charge from the positive terminal to the negative terminal in the circuit of Figure 5. You do not need to exert a force to move the charge from one plate of the capacitor to the other. The capacitor is uncharged, so, the potential on both of its plates is the same.

You do, however, have to do work

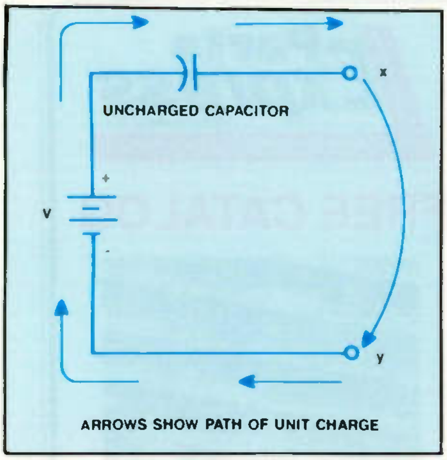


Figure 5.

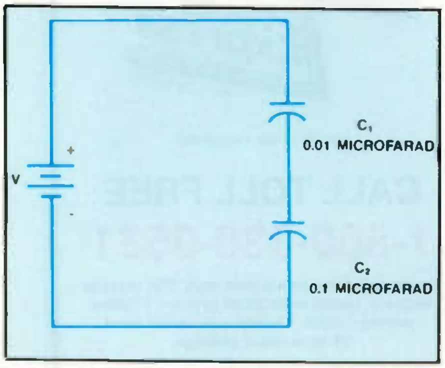


Figure 6.

to move the charge from terminal 'x' to terminal 'y'. Therefore, all of the voltage drop in the external circuit is between those points.

Why is the higher voltage across the lowest value of capacitance in Figure 6?

Assume the capacitors have the same type of dielectric. Then, there are two ways to get a lower capacitance value for C_1. You can place the plates further apart, or, you can use plates that are smaller in the facing area.

If the plates are farther apart you have to go a longer distance to move a unit charge from one plate to the other.

$$(W = F \times s).$$

Saying it another way, an important equation for capacitors is $Q = CV$, where Q is the charge, C is the capacitance, and, V is the voltage across the capacitor. That can be written as:

$$V = Q/C$$

That means the voltage is inversely proportional to the capacitance. In other words, the lower the capacitance the higher the voltage.

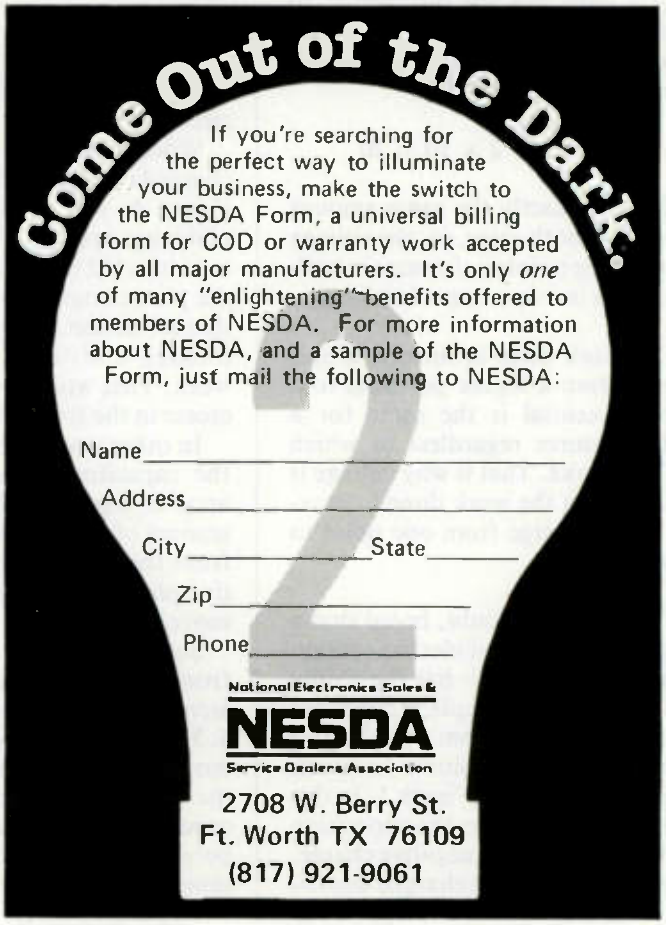
Sharpening your concepts

You can call a camel with one hump a Bactrian camel, but, that won't give it two humps.

My point is that it is important to know the true meaning of tecnhical terms (like volt and ampere) in order to really understand how some basic systems operate. That doesn't mean you have to give up your models. However, you should be willing to give them up when you find they don't work for specific cases.

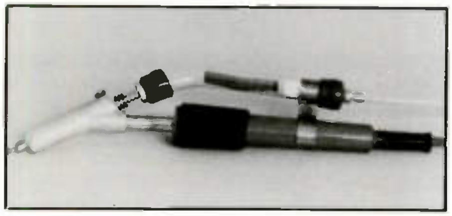
For example, the idea that voltage is a force just doesn't work when you are trying to understand how a parametric amplifier works. The idea that a capacitor is charged by poking electrons into one plate and sucking them out of the other just doesn't help to explain how a capacitor can be charged by using an electret.

In those specific cases, be willing to recognize that the models we use to understand some facets of electronics are just that: models. They enhance, nd make concrete our understanding of certain aspects of electronics, but electronics doesn't *really* work the way the models imply that it does. ■



Desoldering iron

Pat Dooley Company's recent renovation of the PD-900 desoldering iron solves all desoldering/rework needs with one tool. The iron now accepts both through-hole desoldering tips and surface mount leads (made to specifications). The tool conforms to all ESD standards and is user-friendly. The tool comes with either an air-operated vacuum pump or a portable electric motor pump.



Circle (61) on Reply Card

Kit features heat tools and soldering tip

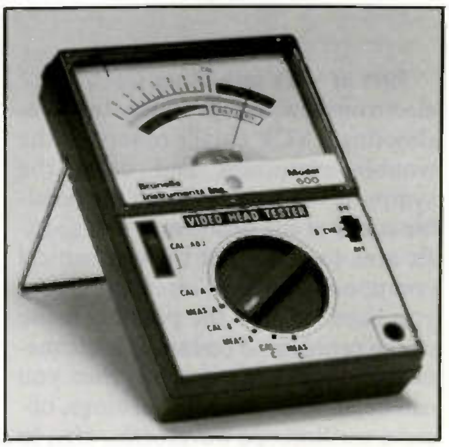
Portasol Inc. now has their new tip and accessories kit, Model TB-10, which features a blow torch, hot blower, hot knife and 1.0mm fine point soldering tip. These tips are designed for exclusive use with the Portasol cordless, refillable, butane gas powered heat tools (Models P-1 & P-1K). The tip and accessories kit features a durable storage case made of an impact resistant plastic. The compact storage case protects the tips from accidental damage and fits easily into a tool box or tool kit case. The TB-10 includes a blow torch which generates a precise, micro-flame with a temperature of 1300C, a hot blower which produces a focused, flameless heat of up to 450C, and the hot knife with a range up to 450C.

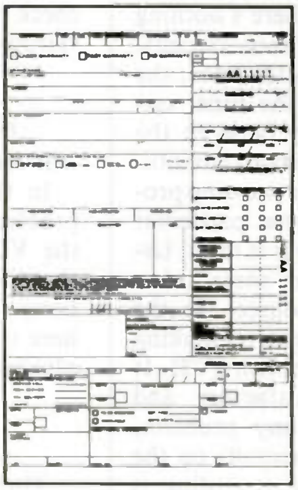
Circle (62) on Reply Card

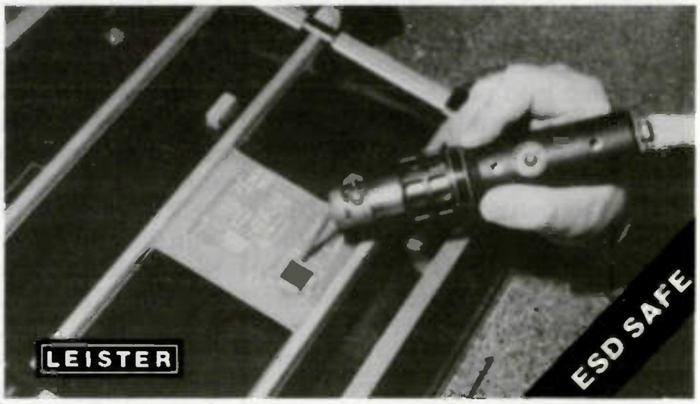
Video Head Tester

Brunelle Instruments announces the model 600 video head tester. The unit is an analog tester used for determining the amount of wear and condition of a video head. It is available for testing either Beta or VHS type of heads, is lightweight, portable, battery operated, and has three ranges of measurement to cover all types of VCR heads.

Circle (63) on Reply Card







What is that VCR trying to tell you?

By the ES&T staff

Just as with any other electronic/electromechanical product, troubleshooting a VCR entails observing the trouble symptoms and using the symptoms to narrow down the possible cause of the problem/s to a specific area (or areas) of the mechanical components of the circuitry. Once you have isolated the possible cause of the problem to certain specific mechanical areas of circuitry, then you can begin to take DMM readings, observe oscilloscope waveforms, etc., to determine what specific component is the cause of the problem.

Noise in the picture

As an example of the VCR troubleshooting procedure, let's consider the situation where the picture is noisy during playback of a video tape. The first step to take in diagnosing such a situation is to play back a known good tape to determine if the problem is in fact with the VCR, or if the problem is one tape.

Once you have determined that the problem is in fact in the VCR, the next question to ask is "Is the entire screen covered with noise?" If the answer to that question is yes, then the problem could very well be the video heads, or associated circuitry. However, and this has been emphasized many times here in the past, if any part of the screen shows a clean picture, the problem is *not* in the video heads.

Isolating the problem

Assuming that you have ruled out the video heads as the cause of the problem, the next step is to narrow the possible cause of the problem. The first in doing so is to play back tapes that have been recorded on the machine that's having problems, as well as tapes that have been recorded on another machine. You will observe one of these possible outcomes when you play these tapes: 1. the problem will occur only when you play back tapes that were recorded on the problem VCR; 2. the problem will occur only when you play back tapes that were recorded on another machine; 3, the problem will occur no matter what VCR the tape was recorded on.

Problem occurs only on self-recorded tapes

If the problem occurs only when you play back tapes that were recorded on the VCR that's having problems, that means that the unit plays back prerecorded tapes just fine. That being the case, there's nothing wrong with the playback circuits. This leaves two places to check: the recording circuits or the tuner circuits and the circuitry between the VCR's tuner and the record circuits.

In this case, there is a two-step process to determining what particular portion of the circuitry is at fault. Using another VCR, or some other known-good video source, as the source of the video signal, try making a recording ont he problem VCR. If the recording is satisfactory and plays back without any problem, check out the tuning circuits on the problem VCR. If the recording is bad, you now know you made a bad recording from a perfectly good video signal. The problem must be in the record circuits.

Problem occurs only with prerecorded tapes

If the problem occurs with tapes that were recorded on another machine, but not with self-recorded tapes, it's almost a sure thing that the problem is a compatibility problem, caused by some kind of irregularity in the tape path, or some kind of problem in the timing circuits. The reason is this: the VCR both records and plays back, so all of the circuitry associated with those functions must be operating properly.

When we've eliminated the record and playback circuits from suspicion, that leaves the timing circuitry and the mechanical tape path as possible culprits. The next step in resolving this kind of problem is to perform a thorough visual examination of the tape path, clean and lube it according to the manufacturer's specifications if indicated, check the tape tension, check the shape and multitude of the various timing signals.

Problem occurs with both self-recorded and prerecorded tapes

In this case, there's definitely a problem in the playback portion of the VCR. It's possible, of course, that there are problems in other portions of the VCR, but the first step here is to pinpoint the cause of the playback and cure it.

The diagnostic process

Three things are necessary to the success of the kind of diagnostic process described here: 1. an in-depth knowledge of the construction and operation of the equipment being diagnosed; 2. a logical and well thought out approach to interpreting the symptoms; 3. practice at performing the diagnosis. ■

Digital signal processing

By John Shepler

The world of audio electronics is steadily shifting from analog to digital. Today, digital audio is compact discs and DAT tape recorders. Soon, digital audio will include DAB (Digital Audio Broadcasting) and perhaps even all-digital television. Tuners, amplifiers, recorders, and accessories will perform their functions digitally. You'll need to add a new term to your audio dictionary: Digital Signal Processing.

Digital Signal Processing or DSP is a term that covers several techniques. There are really special purpose microprocessors that have been designed strictly to perform mathematical operations on continuous signals like audio, TV, or radar. More common microprocessors, like the Intel 80486 or Motorola 68040, are intended for logic and general purpose computing.

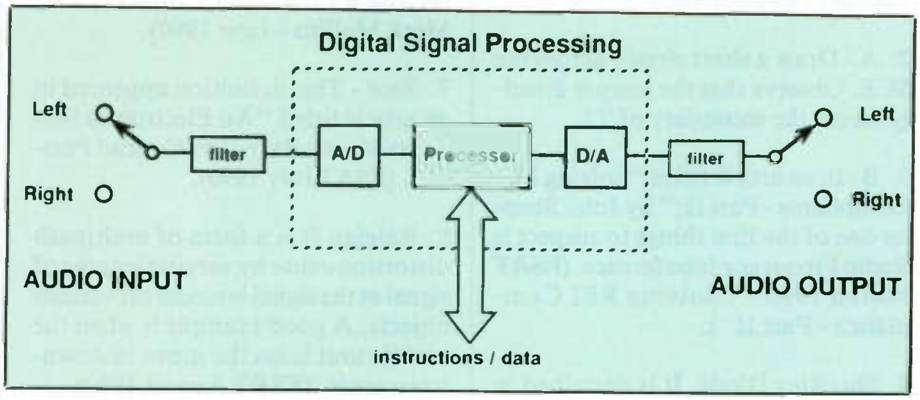


Figure 1. DSP for stereo audio.

What makes a DSP (Digital Signal Processor) chip special? A DSP is optimized for high speed. It has to be.

If two channels of digital audio are sampled at 44.1kHz, then the DSP has to operate on a new input value every 11.3 microseconds. That's not much time between samples to do any number crunching.

Figure 1 shows how DSP is incorporated into an audio system. We'll assume the audio is analog at the inputs and outputs of the processor; the most common arrangement today. The first function is to convert the analog signal to digital data. This is done with an A/D converter. The converter is actually taking snapshots or samples of the constantly varying analog signal. If the snap-

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Shepler is an electronics engineering manager and broadcast consultant. He has more than twenty years experience in all phases of electronics.

Test your electronics knowledge

Answers to the quiz *(from page 51)*

1. D - The I stands for Intrinsic. The total acronym stands for Positive-Intrinsic-Negative. It refers to the way the diode is constructed. **(ES&T January 1990 -"TYEK").**

2. A - Draw a short circuit across the SCR. Observe that the lamp is directly across the secondary of T1.

3. B - In an article titled "Solving RFI Complaints - Part II," by John Shepler one of the first things to suspect is Radio Frequency Interference. **(ES&T March 1990 - "Solving RFI Complaints - Part II").**

4. Shockley Diode. It is described in an article titled "Thyristors from A to Z - Part II" **(ES&T April 1990).** It is defined as a PNPN 2 -terminal thyristor. It is also called a Four-Layer Diode (FLD).

5. It is called power (by definition). (TYEK - May 1990)

6. Accuracy of measurement. ("Selecting a Low-Cost Counter," by Mark Mullins - June 1990).

7. Shot - This definition appeared in an article titled "An Electronics Servicers Vocabulary," by Conrad Persson. **(ES&TJuly 1990).**

8. Raleigh It is a form of multipath distortion cause by varying lengths of signal as the signal bounces off various objects. A good example is when the mobile unit is on the move in downtown areas. **(ES&T August 1990).**

9. Phone line jack - **(ES&T - October 1990).**

10. C - **(ES&T October 1990).**

shots are taken at least twice as fast as the highest audio frequency, then no information is lost. The idea is similar to movies and television, which are really individual pictures displayed so fast that the motion appears continuous.

The digital samples are 12 to 16 bit binary numbers. The processor reads these numbers from the A/D and manipulates them to create such effects as filtering, delay and echo, compression and limiting, and noise reduction. It's all done with mathematics. A typical digital filter has several multiples and additions, with constants that determine if the filter boosts or cuts treble or bass.

The next step is to recreate the analog audio. This is done by a D/A converter that takes the processed digital samples, and creates analog voltages at the same rate as the numbers are changing. These samples are smoothed with a low pass filter and output to an audio amplifier.

Earlier it was stated that the term DSP can be applied to more than one technique. On slow signals such as low fidelity audio, computer sound, or servo controls, a microprocessor chip can serve as the processor. Software is written in assembly or C language to perform the filtering and other processing functions. This is still called digital signal processing.

Be aware that some audio equipment contains digital control circuitry for reel motor control, MIDI music interface, remote volume control, and so on. This also might be advertised as digital signal processing, although the audio signal is not being manipulated in digital format.

DSP using specialized integrated circuits is the trend for the nineties. The advantage is that a single processor with memory and converters provides more functions with fewer components than a chassis full of op-amps and capacitors. As the volume of use increases, the price on these components will drop and you will see them applied in nearly all stereo equipment.

Another feature that DSP makes possible is the all-digital audio system. Since CDs and digital broadcasts are already in numerical format, there is no need to convert the signal to analog until it reaches the speakers or headphones. Future stereo system components may have standard digital inputs and outputs instead of the present audio connectors. ■

Classified

Classified advertising is available by the word or per column inch.

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FOR SALE

REPAIR MANAGEMENT SOFTWARE: for IBM PC's. Repair tracking, inventory, reports, billing, maillist, more. Demo disk $15. CAHILL ELECTRONICS, PO Box 568, Kingston, NH 03848. 10-91-3t

PHOTOFACTS: Folders under #1400, $5.00. Above #1400, $7.00, sent same day first class postpaid. Allen Loeb, 414 Chestnut Lane, East Meadow, NY 11554. 516-481-4380. 11-91-5t

SENCORE VA61: video analyzer, manual, less test leads, excellent, $1575; ST66 stereo TV analyzer, manual, less test leads, excellent, $375. Bob Grove, PO Box 98, Brasstown, NC 28902. 11-91-1t

VHS-VCR REPAIR SOLUTIONS SETS I,II,III,IV,V,VI. Each contains 150 symptoms and cures, updated cross reference chart, free assistance, $11.95 each all six $59.95. Eagle Electronics, 52053 Locks Lane, Granger, IN 46530. 10-91-3t

TV TOUGH DOGS 300 symptoms and cures. Send $10.95 to Davis TV, 11772 Old Fashion Way, Garden Grove, CA 92640. 10-91-2t

ATTENTION VCR SERVICE CENTERS: 1000 VCR symptoms/cures from experience and manufacturers publications. Computer printout $90. Guaranteed satisfaction. VCR Tuneup Center, 43 James Avenue, Redwood City, CA 94063 or call 1-800-777-7883. Mastercard and Visa accepted. 11-91-15t

SENCORE: testing equipment, new in box, never used. Phone 714-837-4173; before 2 pm. P.S.T. or send L.S.A.S.E. for list. A.J.M. 25432-2nd Street, El Toro, CA 92630. 11-91-1t

NEW EQUIPMENT: Sencore waveform analyzer model SC-61 (60 MHz). Sencore variable transformer Model PR-57, Both $2,900. O.H. Vaughan. 205-544-1648, leave message. 205-881-2566. 11-91-1t

YOU'VE TRIED THE REST NOW GET THE BEST! Don't waste money on inferior tech tips. Get the best tips money can buy! Send $99 for printout containing over 650 TV tips covering over 300 model numbers and 20 manufacturers. Get the most complete, up-to-date tech tips over your phone line by using the best on-line service available. Over 2500 tips covering TVs, VCRs, Camcorders, listing over 800 models and 50 mfgs. New tips entered daily. Send a SASE for sample printout and more information. T.I.P.S., PO Box 1681, Forest Park, GA 30051-1681. 11-91-1t

FOR SALE: 8 TECHNICIANS AND THEIR TRAINING. 5000: **ACTUAL CURRENT "TECHNICIAN" TECH-TIP REPORTS:** Symptoms, Cures & Part Numbers. 1987 Through 1991. TV-VCR-CD-LD-CAMERA-CAMCORDER-PROJECTION-STEREO-AMPLIFIERS-SATELLITE-MICROWAVE-CASSETTES-PHONO-ETC. We service All Consumer Electronics and Factory Authorized for 36 Major Manufacturers. If it came through our doors, it's on it's way to "YOURS"! FOR OUR BOTTOM PRICE SEND $15.00 FOR DEMO DISK OR $10.00 PRINTED FORM. $70.00 per 1000 data-base disk price or $350.00 for 5000, Printed form add $5.00 Per 1000 Tips. Annual updating available. AMEX-M/C-VISA & CHECKS, 2-Wks Delivery 305-474-2677 Factory Service 8614 SR-84, Ft. Lauderdale, FL 33324. 8-91-12t

COMPUTER AIDED TV/VCR REPAIR SOLUTIONS: 5¼" IBM Compatible disks. 1,000 VCR, Printout $55, Disks $51. 3,500 TV, Printout $95, Disks $91 (Hardrive). Time saver. Add to or quick scan by model, chassis or stage. Electronic Solutions, 407 W. Ave. "N", San Angelo, TX 76903. 8-91-6t

ESTATE: Sencore, System Donner, etc: Oscilloscope, UHF, CB, Waveform analyzer, 50 pieces. SASE for price list to Electronics, PO Box 252, Glenridge, NJ 07028 or call 201-783-9733. 11-91-1t

MISCELLANEOUS

CAMCORDER REPAIR: Don't turn away good profits let our experienced technicians provide your shop with complete camcorder repair service. Also, VCR, "Tough Dogs." Call 1-800-846-4648. Edington VCR/TV, 204 North Kimble Drive, Bloomington, IN 47404. 9-91-6t

Readers' Exchange

WANTED

Service manuals for Kenwood model "KD3100" turn table and Smith Corona Model "Mark X" typewriter. Will copy and return. *Ted Lietzau 15669 Couzens East Detroit, MI 48021 (313) 777-5661.*

Operations literature for Sencore Yoke and Flyback tester model -YF33. *Guy D'Amico 1770 Ft. St. Lincoln Park, MI 48186, (313) 381-7800.*

Parts, test equipment, SAMS photofacts (-170, -1473) old radio and TV tubes) from a 1960, 70's service shop). Owner recently deceased. *Clark's TV Box 68, Jeffersonville, NY 12478, (914) 482-5030.*

Compute! Magazines will pay a reasonable price. *Jack Grossman 98-17 HOR. HDG. Corona, NY 11368, (718) 271-2775.*

Flyback transformer for "leading edge" monitor DR 1240 part number; TMF 2000 (will pay). *Joe LaGuardia 1521 Flamingo Ct, Homestead, FL 33035.*

Tuner module (used) MUV005A RCA CTC 108C model FGR 450 W. *George at collect AT&T only (915) 778-0997.*

Volume control for a Bradford Model 89193 stereo. *Paul Capito 637 West 21 St., Erie, PA 16502.*

Schematic for Bell Audio model PR 200. *Mike's Repair PO Box 503 Baraboo, WI 53913 (608) 356-6525.*

Service schematics and/or service manuals for an APT Holman model stereo pre-amplifier. *Ronnie Day, 2623 Treeview Dr., Arlington, TX 76016, or call (817) 429-2918.*

Schematic diagram and or repair manual for RGB SYNCO color monitor model CM-1416 by Shinlee Corp. *Max Yoder (703) 241-0142; 6512. Truman Lane; F.C., VA 22043.*

Schematic for EMC (Electronic Music Corp.) Mix/Amplifier Model PA600. *Richard Plante, P.O. Box 1345, North Conway, N.H. 03860.*

Photofacts over #2000. Please send numbers available and price wanted. *Nancy Hauver, 34 Burlington Ave. Rochester, NY 14619.*

Pontiometer controls for a Bradford model 89193 stereo receiver or the address where I can get these parts. *Paul Capito 637 West 21st St. Erie. PA 16502.*

Power transformer for Zenith model 860 AM radio. Org part number 95-234. State price and terms. *Century Electronics 18044 Wallingford North Seattle, WA 98133, (206) 546-3043.*

Schematic for B&K oscilloscope model #1450. Will copy and return or pay for copy. *Gerard O'Gara 11 Crag Lane, Levitown, NY 11756 (516) 731-4075.*

Power transformer, #3000010 for Schaevitz MCD model S-11-A oscilloscope. Service manual for Crate Technology MacCrate 2824 hard drive. *Michael Ames, 7 Hyatt St., Cortland, NY 13045.*

FOR SALE

RCA 19" color test jig Mo. 10J106 with HOKV, picture tube. Rating new condition used only three times 125 plus shipping. *Hank Gehring PO Box 454 Torrance CA 90508 (213) 320-4125.*

Sencore LC77 Auto Z analyzer -recalibrated a few months ago. Also a Hitachi Dual Trace model 422 Oscilloscope. Like new in the box $500.00. *Alex Minelli 718 Michigan St, Hibbing MN 55746.*

B&K CRT resotrer with univ. adapter $450.00. B&K color bar generator $300.00. Weller desoldering DS600 $250.00. *Electro Tech 677 E. Main, Ventura CA (805) 648-5417.*

Three brand new CRT's for Sony projection system part #'s SD186 or 8-738-352-05 or 8-738-351-05. Still in the boxes call (218) 751-2620. *Dan 1430 Paul Bunyan Dr. NW, Bemidji, MN 56601 (218) 751-2620.*

Sams manuals 1150-2130 and 2593-2767, B&K 1472B O scope, B&K 467 CRT restorer/analyzer. $3000 for all (715) 259-7977.

Beckman scope digital readout and cursors #9202 asking $550.00. Heath CRT checker and rejuvinator $175.00 (602) 985-6336.

Sams photofacts #1 to #1500 $1250.00 plus shipping. Sams Audio Radio Services Vol 17 to 340 $850.00 plus shipping. New and used vaccum tubes 4000 to choose from $1.00 each older used test equipment—make an offer. *Ed Krivaner (515) 673-5846.*

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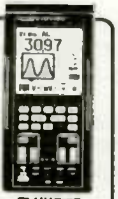

FLUKE 97
AUTHORIZED DEALER

Circle (7) on Reply Card

Advertisers' Index

Company	Page Number	Reader Service Number	Advertiser Hotline
B & K Precision	24	1	312/889-1448
Brian R. White Co.	55	22	707/462-9795
Brunelle Instruments	60	2	800/567-3506
C & S Sales	IBC	3	800/292-7711
CUI Stack, Inc.	10	4	503/643-4899
Circuit City	60	23	800/285-TECH
Electro Tool, Inc.	42	5	800/772-3455
Iscet	17		817/921-9101
International Components Corporation	60	6	800/645-9154
Kelvin Electronics	60	7	516/349-7620
Klein Tools	54	8	
NESDA	54,55		817/921-9061
NTE Inc.	BC	75	800/631-1250
National Advancement Corporation	58	24	800/832-4787
Pace, Inc.	41	10	301/490-9860
Parts Express	53	11	513/222-0173
Philips ECG	3	12,13	800/225-8326
Premium Parts +	60	14	800/558-9572
Print Products International	42	15	301/587-7824
Reztek	18	16	714/454-9204
Sencore	IFC	66	800/SEN-CORE
Sperry Tech	60	17	800/228-4338
Tentel	57	18	800/538-6894
Viejo Publications	17,37,53	19,20,21	800/537-0589

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(Portable Real-time Digital Storage Oscilloscopes)

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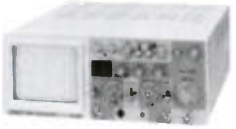
VC-6045 - 100MHz, 40MS/s	$2,995
VC-6145 - 100MHz, 100MS/s	$4,495

RSO's from Hitachi feature roll mode, averaging, save memory, smoothing, interpolation, pretriggering, cursor measurements. These scopes enable more accurate, simplier observation of complex waveforms, in addition to such functions as hardcopy via a plotter interface and waveform transfer via the RS-232C interface. Enjoy the comfort of analog and the power to digital.

25MHz Elenco Oscilloscope



$349
S-1325

- Dual Trace
- 1mV Sensitivity
- 6" CRT
- X-Y Operation
- TV Sync
- (2) 1x, 10x Probes included

SPECIAL BUY

V-212 - 20MHz Scope $425

Hitachi Portable Scopes

DC to 50MHz, 2-Channel, DC offset function, Alternate magnifier function

V-525 - CRT Readout, Cursor Meas.	$995
V-523 - Delayed Sweep	$975
V-522 - Basic Model	$875
V-422 - 40MHz	$775
V-223 - 20MHz delayed sweep	$695
V-222 - 20MHz deluxe	$625

PRICE BREAKTHRU

20MHz Digital Storage Oscilloscope

- Analog/Digital Scope
- 2K word per channel memory
- 10MS/s sampling rate
- State-of-art technology
- Includes probes

DS2D3
$795

HITACHI COMPACT SERIES SCOPES

This series provides many new functions such as CRT Readout, Cursor measurements (V-1085/1065A/665A), Frequency Ctr. (V-1085), Sweeptime Autoranging, Delayed sweep and Tripper Lock using a 6-inch CRT. You don't feel the compactness in terms of performance and operation.

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V-665A - 60MHz, DT, w/cursor	$1,345
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Elenco 40MHz Dual Trace

Good to 50MHz

$495
S-1340

- High luminance 6" CRT
- 1mV Sensitivity
- 10KV Acceleration Voltage
- 17ns Rise Time
- X-Y Operation
- Includes (2) 1x, 10x Probes

All scopes include probes, schematics, operators manual and 3 year (2 yrs for Elenco scopes) world wide warranty on parts & labor. Many accessories available for all Hitachi scopes. Call or write for complete specifications on these and many other fine oscilloscopes. **1x, 10x Scope Probes: P-1 65MHz $19.95, P-2 100MHz $26.95**

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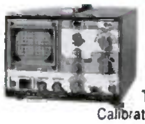

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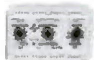
Function Generator Blox



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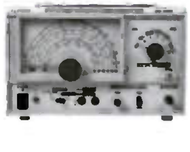

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- +5VDC @ 1 Amp
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