THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC™

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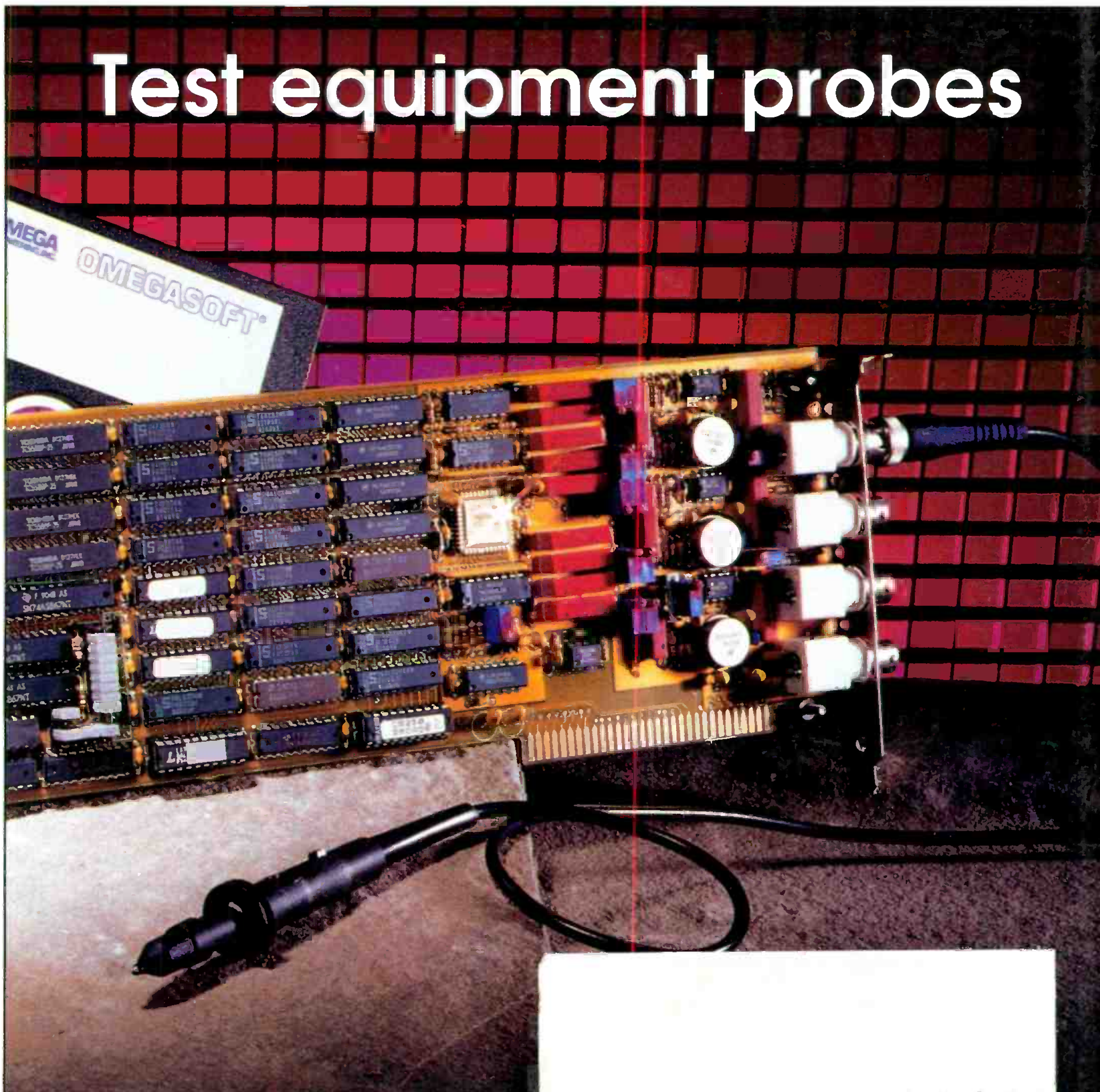
Understanding compact disc troubleshooting concepts

Test equipment probes



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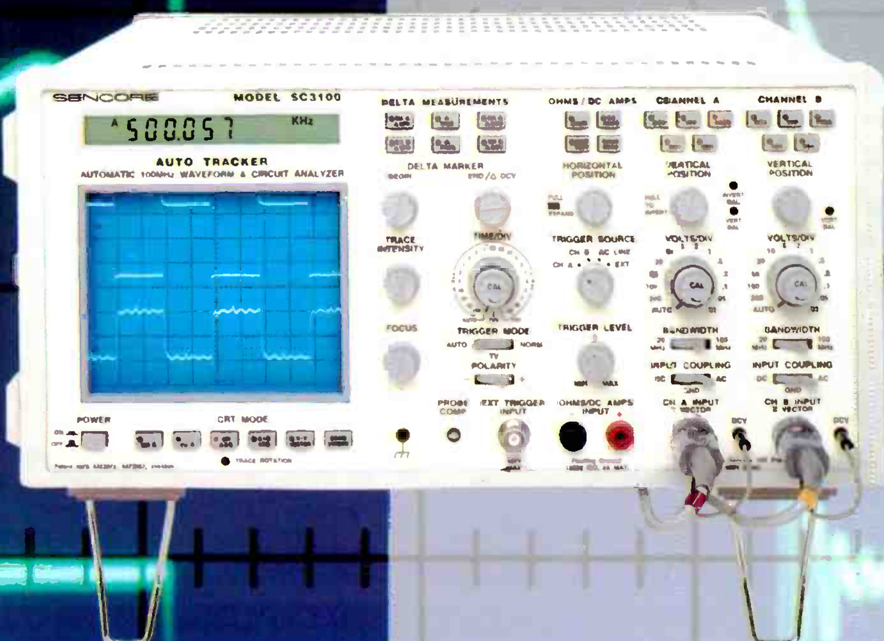

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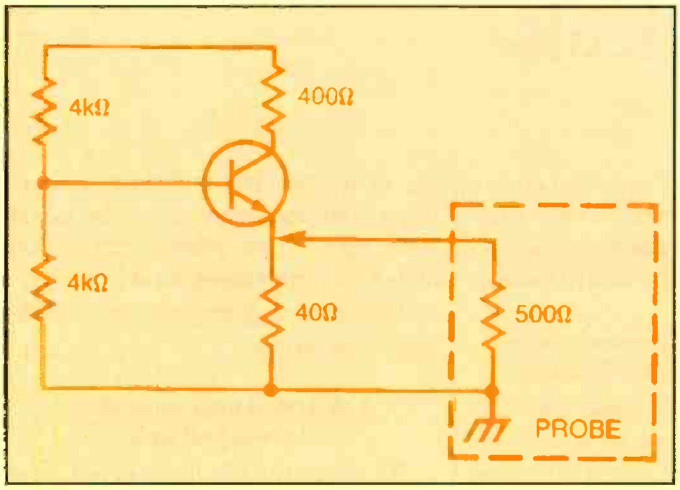

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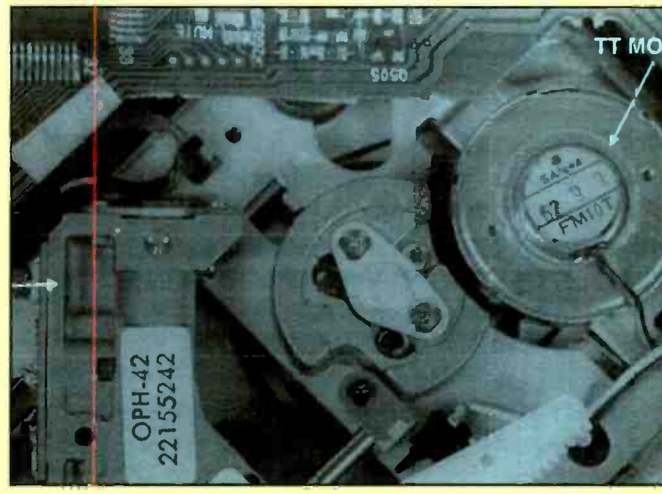

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ON THE COVER

Test equipment probes must be much more than just pieces of wire. A properly chosen probe will conduct the signal from the device being tested to the inputs of the scope or other piece of test equipment accurately and safely, and will provide shielding to keep out stray signals. (Photo courtesy Omega Engineering).

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Details, details, details

When thinking about the equipment we use every day, we tend to take certain items for granted. We tend to think about some things as commodity items, and give little thought to their selection, use and care. But every part of a system, at least a high performance system, has to be carefully designed and manufactured, and users should be attentive to their selection and care.

Take for example, the automobile. Most of us really don't think a great deal about the tires on the car. They're just black rubber things that have to go on the wheels, and that occasionally go flat and have to be replaced.

And when the car isn't going very fast, or won't be driven for a long period of time, or won't be going around corners very quickly, and when it isn't too hot out, and the surface of the road is in good shape, and when it isn't raining, and when there isn't several inches of rain on the roadway, or when there isn't snow, or ice on the road, the *quality* of the tires is not of major importance.

But in general, a tire is doing a lot of things that we really don't realize as we drive down the road. For example, as the tire rolls, the part of the tire that rolls to the bottom becomes flat. As that flat part rolls around toward the top, it becomes round again. That action causes the tire to be constantly flexing. That flexing generates heat that the tire must be designed to deal with. And the faster the car is driven, the greater the heat buildup in the tire.

As you turn a corner, the tire has a tendency to roll, so that if it weren't designed to be stiff enough the tread would roll away from the direction of travel and you'd be riding on the sidewall, and, of course, you'd lose traction. In cases of extreme cornering speeds and inadequate stiffness, the tire would roll right off the rim.

The dangers of hydroplaning in the wet, or losing traction in the snow are pretty obvious. Properly designed tire treads minimize those problems.

And yet, for the most part, most drivers take those tires for granted—until a tire that was of inadequate quality for the type of driving fails, perhaps catastrophically.

Test equipment accessories are sometimes taken for granted

It's pretty much the same with test equipment probes. Most of us who are technical can get pretty excited over a new oscilloscope or DMM that offers some new measurement features, or improved accuracy, or increased ease of use. But when we're thinking about all of those wonderful features, how often do we think about the probes that come with the unit.

We buy the unit without giving any thought to the probes. If we think about it at all, we generally simply expect that the manufacturer will provide probes that are adequate to the tasks that the product is designed to perform. And, that's a pretty good assumption. Test equipment manufacturers know what their products can do and provide an adequate set of probes with the product.

But most things wear out, or break, or become damaged. And test probes have a tendency to do that. They hang there on the bench where they can come into contact with a hot soldering iron. They're subjected to abuse by the technicians who use them. They become abraded by sharp edges on the bench or the equipment they're used to probe. They're dropped, or things are dropped on them.

When the test probes become damaged, they're replaced. Unfortunately, they're not always replaced with test probes of the quality of the originals. Service centers should know the requirements of the products they're testing in order to know the quality of probes they need.

For example, in order to look at digital signals, the probes need to be able to conduct a wide range of frequencies to the oscilloscope inputs. Square corners such as you see on digital signals contain, theoretically, sinewaves of an infinite number of frequencies, including those of many times the frequency of the square wave signal. If the probes attenuate the higher frequency components, the signal will be rounded, giving a distorted rendition of the signal.

A system is only as good as its weakest link

The same principle holds in just about every aspect of life, even, for example, in the worlds of culture and entertainment. Have you ever been to a movie or a play in which all of the parts were played by competent, believable actors, except for one part that was played by someone who was just not very good or seriously miscast. The level of the overall performance is basically set by the performance of that poorest of the performers.

The same is true of a musical performance. Whether you're listening to a symphony, a rock band or a singing group, if one of the musicians or singers is a little flat you're going to hear it and the level of that sound will set the grade that you'll give that group.

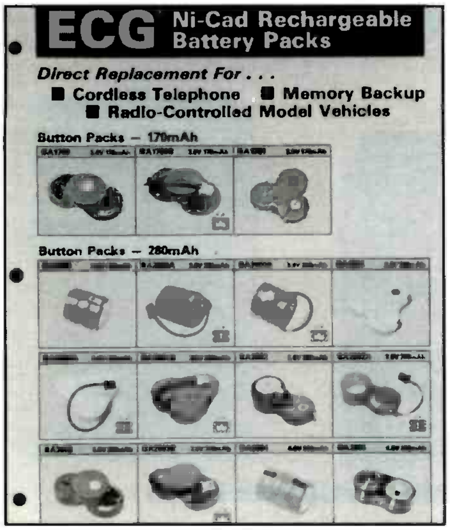
Attention to detail

The only way to be sure that your test equipment will give you the accuracy you need to troubleshoot a product, the only way that you can be sure that your tools will do the job you need them to do, the only way you can be sure that everyone in your organization is contributing positively to the mission of the organization is to know what needs to be done, what level of performance you want or need in getting that mission accomplished, and to select every piece of equipment, every accessory, and especially every individual so that the lowest level of each is of a quality at least as good as the performance that you wish to achieve.

Nils Conrad Persson

Cordless-phone battery line expanded

Philips ECG announces the addition of 18 Ni-Cad rechargeable direct replacement battery packs for cordless telephones.



The newly expanded ECG line now consists of 47 different battery types including AAA, AA, 1/2AA, button and N packs. A new six-page catalog features specifications, illustrations and a cross reference that lists replacements for 63 popular phone brands and almost 700 manufacturers' part/ model numbers.

Circle (1) on Reply Card

1993 products catalog

Chemtronics Inc. now has available its 1993 *Electronics Grade Chemicals, Materials & Supplies* catalog. This catalog features many new specialty chemical products for the electronics industry including several that are CFC-free or have little or no potential to damage the stratospheric ozone layer.

The catalog also features a special section that clearly spells out the new "CFC Labeling Rule" (EPA Rule 40 CFR Part 82 requiring labeling of products made with ozone-depleting substances) along with the implications of this rule for electronics manufacturers and servicers. Also, new to the catalog is a section on adhesives and sealants that are packaged to provide maximum convenience and flexibility in repair and field service applications.

Features of the catalog include color-coded icons that clearly identify product categories, helpful product application tips and cross-reference information from older products to the new alternatives. There are also detailed application and compatibility charts designed to help specialty chemical users more closely match specific needs with the right products as well as information environmental impact.

Circle (2) on Reply Card

ESD workstation brochure

Kalamazoo Technical Furniture has just released a new brochure featuring their line of ESD (electrostatic discharge) controlled workstations. The eight-page, four-color brochure showcases Teclab's static protective workbenches and complete furniture systems.

The brochure highlights the company's multi-level approach to ESD static-controlled workstation system design. Featured are the wide variety of ESD workstation components—hard-surface laminate worksurface material, wrist straps, constant ground fault monitors, dissipative pads, common point ground, grounded chairs and lighting, and more—along with complete workstation systems.

Circle (3) on Reply Card

Free software explains advanced analysis techniques

National Instruments announced today a new free interactive software tutorial that educates users about data analysis and demonstrates advanced analysis techniques for use with LabVIEW graphical programming software or LabWindows automatic code-generating software. Analysis Advisor is an easy-to-use package that guides users through analysis examples with on-line text instructions and describes the important characteristics and benefits of each analysis technique or function.

Analysis Advisor includes four tutorial sessions—Digital Signal Processing, Statistics, Simulation, and Time-Domain Analysis—with detailed demonstrations in each session. A fifth session, Utilities, includes analysis computational benchmarks that run on the PC and a summary of add-on Analysis Toolkits. Users can run benchmarks to time an FFT, sine wave generation, exponential fit, and other analysis functions.

Circle (4) on Reply Card

Catalog 45

The new 1993 catalog from Techni-Tool includes tools, tool kits, test equip-

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Electronic Servicing & Technology is edited for servicing professionals who service consumer electronics equipment. This includes service technicians, field service personnel and avid servicing enthusiasts who repair and maintain audio, video, computer and other consumer electronics equipment.

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Editor wins Friend of Service Award

The National Electronics Service Dealers Association (NESDA) presented the Friend of Service Award to Conrad Persson, Editor of **Electronic Servicing & Technology** magazine, in a ceremony at the Awards Banquet of the National Professional Electronics Conference on August 7, 1993.

The plaque reads: NESDA Friend of Service Award, Presented to Conrad Persson, for contributions to the Betterment of the Independent Electronics Sales and Service Industry. Awarded at the National Professional Electronics Convention, Louisville, KY, August, 1993.

According to the citation read at the presentation, the award was presented because of the contributions that have been made to the service industry by the publication in Electronic Servicing & Technology of articles that describe successful service operations and suggest ways in which other service businesses may diversify in order to remain successful.

Conrad Persson, Editor of *Electronic Servicing & Technology*, at left in photo, accepts the NESDA Friend of Service Award from NESDA officials Susan Frick and Mike Weber

AFSM International announces 22nd annual world conference

The Association For Services Management International (AFSMI) will hold its 22nd annual World Conference and Exhibition in Anaheim, CA at the Anaheim Hilton and Towers from November 14 through 16, 1993. The theme of the conference will be "The Time of Transition."

Sixteen "Sessions of Excellence" will be led by professionals and services industry leaders. The popular and heavily attended sessions cover management, business and marketing themes.

An additional full day of "Services Professional Education" sessions for some of the vertical technical services disciplines (e.g., medical, software, services marketing., etc.) will be held on Saturday, November 13th prior to the conference.

For further information contact AFSM International, 1342 Colonial Boulevard, Suite 25, Fort Myers, Florida 33907; or call 813-275-7887 or 800-333-9786.

First management institute of USA adds speakers

The preparations for the first Management Institute of the United Servicers Association, Inc. continues to add industry speakers. The conference will be held at Ramada Inn's Henry VIII Conference Center in St. Louis, MO, October 15, 16,

(Continued on page 64)

Test equipment probes—Part I

By Vaughn D. Martin

As consumer electronics equipment becomes more technologically advanced, more sophisticated test equipment is required to service it. Oscilloscopes are being offered with greater bandwidth, digital storage capability, and other advanced features. Other types of test and diagnostic equipment such as logic analyzers and frequency counters are increasingly important in diagnostic procedures.

A piece of test equipment is only as good as the weakest link in the system. If the probes being used with a particular piece of test equipment for a particular task are not adequate, the result could be distorted results. And distorted test results could lead the technician in the wrong direction.

This four-part story will take an in-depth look at test equipment probes. Oscilloscope probes will be given the most attention, but the articles will also cover logic analyzer probes, a frequency counter delay equalizing probe, and even a TV/video sync pod probe accessory.

The function of test equipment probes

Probes connect the measurement test points in a DUT (device under test) to the inputs of an oscilloscope or other test instrument. Achieving optimum system performance depends on selecting the proper probe. Connecting a scope and DUT with just wire, would not let you realize the full capabilities of your scope. But let's begin this article considering the characteristics of wire probes, then evolve into an ideal probe, step-by-step, examining all factors, including all design tradeoffs that affect probe performance.

Why not just use wire?

Why not just use a piece of wire as a probe? Good question. There are legitimate reasons for not using a piece of wire or, more correctly, two pieces of wire. Some low bandwidth scopes and special purpose plug-in amplifiers only provide bind-

Martin is Chief Engineer in the Automatic Test system Division at Kelly Air Force Base.

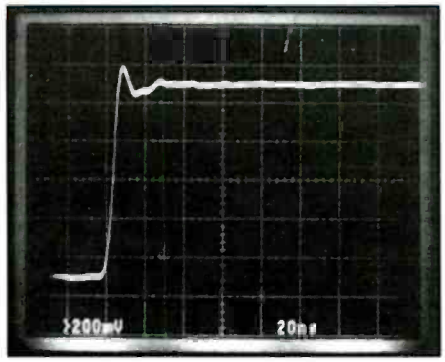


Figure 1. A signal from a 500Ω impedance with a 10MΩ, 10pF probe.

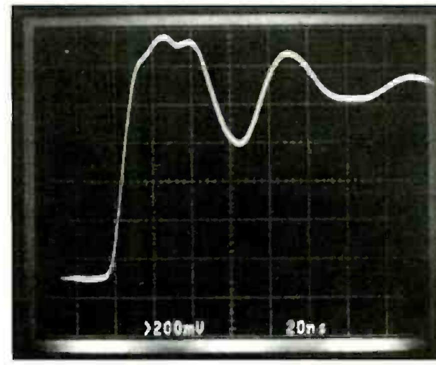
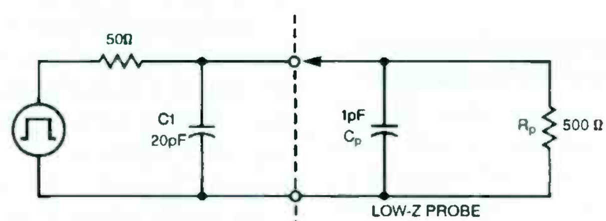


Figure 2. The same signal as in Figure 1 with a 2-meter-long probe. Note the effects of stray capacitance.

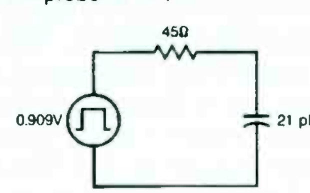
- If a low-R probe were used to measure the signal source, the probe loading circuit would change.
- In this instance R_p would not be 10 times greater than R1 and must be considered.



$V_0 = (500/(500 + 50)) \times V_{in} = .909 \times V_{in}$ (Voltage Divider with R_{source})

$R_{new} = R_{source} \parallel R_{probe} = 50 \parallel 500 = 45\ \Omega$

$C_{new} = C_{source} + C_{probe} = 21\ pF$



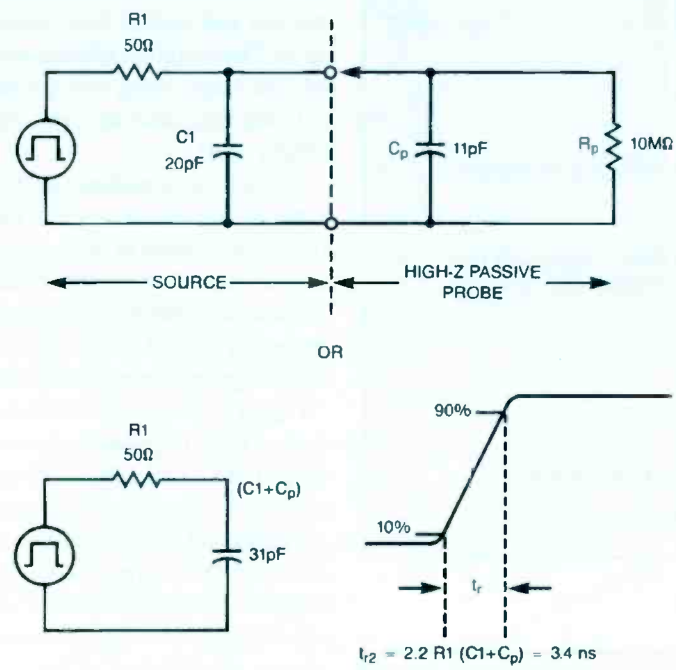
$$t_r = 2.2 \times R_{new}C_{new}$$
$$= 2.2 \times 45\ \Omega \times 21\ pF$$
$$= 2.08\ ns$$

Faster than the risetime without the probe!

But, this decrease in risetime was "bought" at the expense of a loss of approximately 10% of the amplitude.

Figure 3. Loading effects of a low-Z probe.

- If a typical passive probe is used to measure this signal, the probe's specified input capacitance and resistance is added to the circuit.



- Risetime was increased 55% by adding a 10 MΩ, 11 pF probe.
- There is no voltage divider action between R_{source} & R_{in} (probe). Hence amplitude measurement is 100% accurate.

Figure 4. Loading effects of a high-Z probe.

ing post input terminals, a convenient means of attaching wires of various lengths.

DC levels associated with battery operated equipment could be measured. Low frequency (audio) signals from the same equipment and some high output transducers could also be examined. However, this type of connection should be kept away from line operated equipment for two basic reasons: safety and risk of equipment damage.

- Safety: Attachment of hookup wires to line-operated equipment could impose a physical safety hazard, either because the operator might come into contact with the hot side of the line itself, or with internally generated high voltages. In either case, the hookup wire offers you virtually no protection, either at the equipment source or at the scope's binding posts.
- Risk of equipment damage: Two unidentified hookup wires, one signal lead and one ground, could cause havoc in line-operated equipment. If the "ground" wire is attached to any elevated signal in line-operated equipment, various degrees of damage will result simply because both the scope and the equipment are (or should be) on the same three-wire outlet system, and short circuit continuity is completed through one common ground.

Circuit loading

Another reason that a straight piece of wire is not a desirable lead for an oscilloscope is that the oscilloscope might load the circuit to be tested, and therefore distort the measurements. The test equipment (scope and probe) presents a combination of resistance and capacitance to the circuit to which it is connected.

Without the benefit of using an attenuator (10X) probe, the loading on the (DUT) will be 1MΩ (the scope input resistance) and more than 15pF, which is the typical scope input capacitance, plus the stray capacitance of the hookup wire.

Figure 1 shows what a "real world" signal from a 500Ω impedance source looks like when loaded by a 10MΩ, 10pF probe: the scope/probe system is 300MHz, observed risetime is 6nsec.

Figure 2 shows the same signal when it is accessed by two two-meter lengths of hookup wire: loading is 1MΩ (the scope input resistance) and about 20pF (the scope input capacitance, plus the stray capacitance of the wires). Observed risetime has slowed to 10nsec and the transient response of the system has become unusable. Figures 3 and 4 show typical circuit loading for a low-Z and a hi-Z probe respectively (both to be explained shortly).

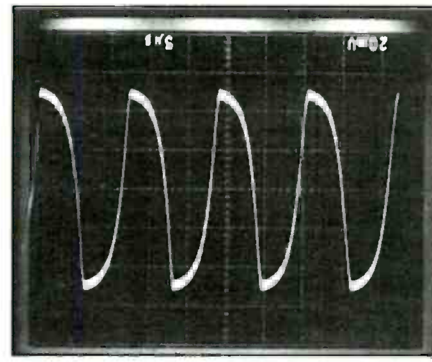


Figure 5. A low-level signal from a high-impedance source.

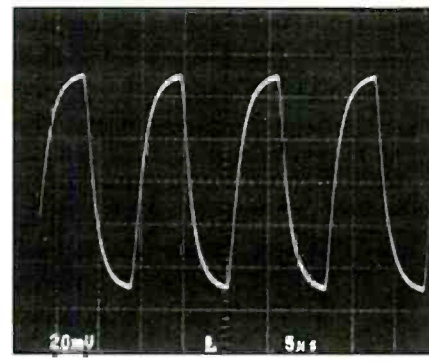


Figure 6. The same signal as in Figure 5 with the bandwidth limit (BW) switch engaged.

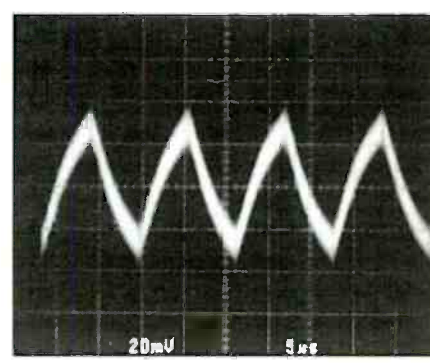
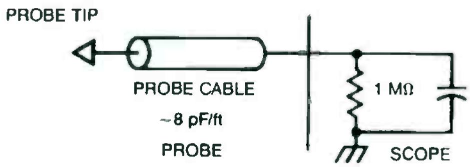


Figure 7. A "fuzzy" signal caused by use of a totally unshielded hookup wire for a probe.



DISADVANTAGES:

- HIGH C_{in}

  $C_{in} = C_{scope} + C_{cable} = 20\text{ pF} + (8\text{pF/ft} \times 5\text{ ft}) = 60\text{ pF}$ (For a 1.5 m probe)

- LOW BANDWIDTH

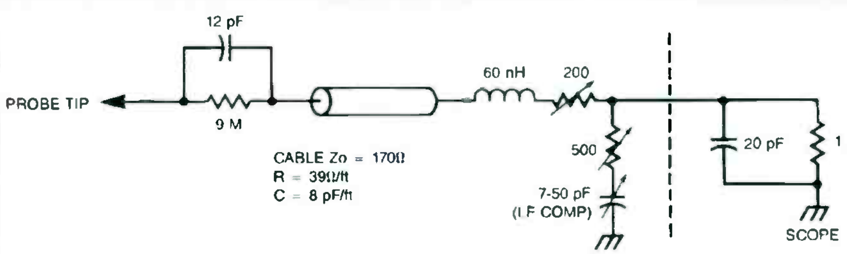
  R_{source} & C_{in} of the probe combine to form a low-pass filter. If R_{source} is only 100Ω, maximum BW will be equal to $1/(2\pi R_{source} C_{in})$ or only 26 MHz for this 1X probe.

ADVANTAGES:

- HIGH R_{in} (1 MΩ)
- GOOD FOR VIEWING LOW-FREQUENCY, LOW-AMPLITUDE SIGNALS

  (Like 60 Hz ripple on the output of a linear power supply.)

Figure 8. A typical 1X probe.



FOR LF COMP:

$R_{tip} \times C_{tip} = R_{scope} \times C_{tot}$

$9\text{ M} \times 12\text{ pF} = 1\text{ M} \times (C_{scope} + C_{cable} + C_{lf\ comp})$

where $C_{cable} = 8\text{ pF/ft} \times$ cable length (ft)

CABLE TERMINATION NETWORK:

60 nH contributes inductive peaking

200 Ω is a first order high-freq termination for the cable

7-50 pF allows padding of C_{tot} for proper lf comp

500 Ω adjusts squareness of front corner

REDUCED LOADING:

$R_{in} = R_{tip} + R_{scope} = 9\text{ M}\Omega + 1\text{ M}\Omega = 10\text{ M}\Omega$

$C_{in} = C_{tip}$ in series with C_{tot}

$1/C_{in} = 1/C_{tip} - 1/C_{tot}$

C_{tip} places a limiting value on C_{in}
(for $C_{tip} = 12\text{ pF}$, $C_{in} \leq 12\text{ pF}$)

This is less than C_{in} of the scope, and 49 pF less than the C_{in} of the 1X probe.

Figure 9. A typical 10X probe.

Susceptibility to external pickup

An unshielded piece of wire acts as an antenna for the pickup of internal fields, such as line frequency interference, electrical noise from fluorescent lamps, radio stations and signals from nearby equipment. These signals are not only injected into the scope along with the desired signal, but can also be injected into the (DUT) itself.

The source impedance of the DUT has a major effect on the level of interference signals developed in the wire. A very low source impedance would tend to shunt any induced voltages to ground, but high frequency signals could still appear at the scope input and mask the desired signal.

Figure 5 shows what a low level signal from a high impedance source (100mV from 100kΩ) looks like when accessed by a 300MHz scope/probe system; loading is 10MΩ and 10pF. This is a true representation of the signal, except the probe resistive loading has reduced the amplitude by about 1%. The observed high-frequency noise is part of the signal at the high impedance test point and would normally be removed by using the BW (bandwidth) limit button on the scope (see Figure 6).

If you were to look at the test point with those two pieces of wire, two things happen (Figure 6): the amplitude drops due to the increased resistive and capacitive loading, and noise is added to the signal because the hookup wire is completely unshielded (Figure 7). Most of the noise you see in the photo is line frequency interference from fluorescent lamps in the test area.

Probably the most annoying effect of using hookup wire to observe high frequency signals is its unpredictability. Any touching or rearrangement of the leads can produce different and nonrepeatable effects on the observed display.

Benefits of using probes

For starters, probes help minimize loading. To a certain extent, all probes load the DUT—the source of the signal you are measuring. Still, probes offer the best means of making the connections needed. A simple piece of wire, as we have just seen, would severely load the DUT. In fact, the DUT might stop functioning altogether.

Probes are designed to minimize loading. Passive, non-attenuating 1X probes

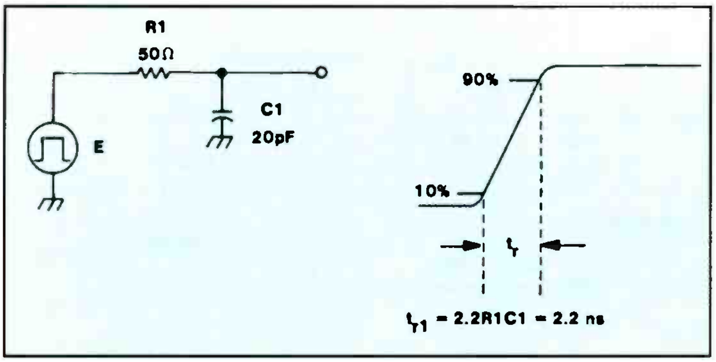


Figure 10. Internal source resistance and capacitance affect the equivalent circuit. At no time can the output risetime be faster than 2.2(RC) or 2.2nsec.

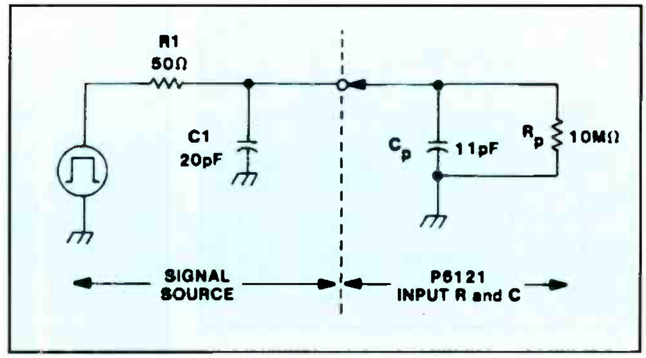


Figure 11. Adding the impedance characteristics of the probe to the circuit under test.

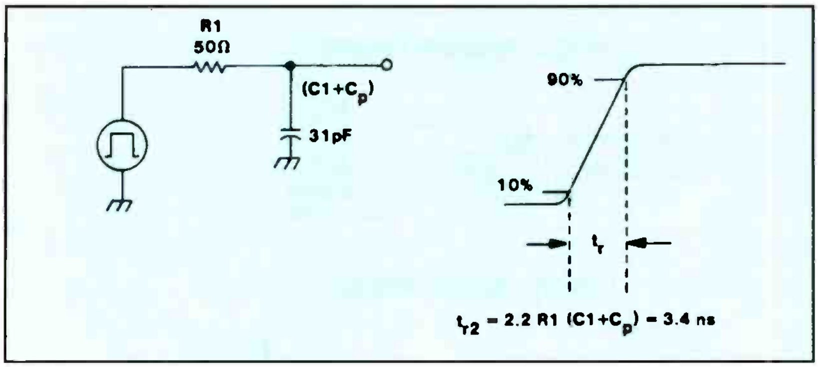


Figure 12. Observing how a probe affects risetime.

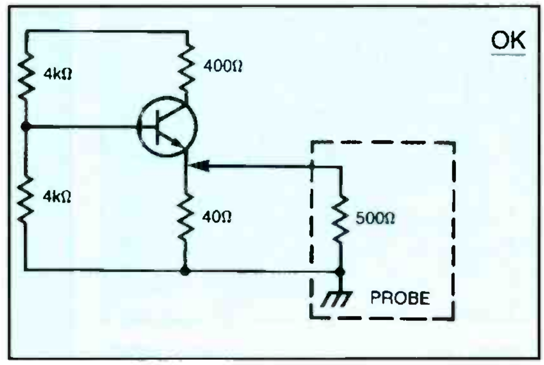


Figure 13. An example of when using a low-Z probe is appropriate.

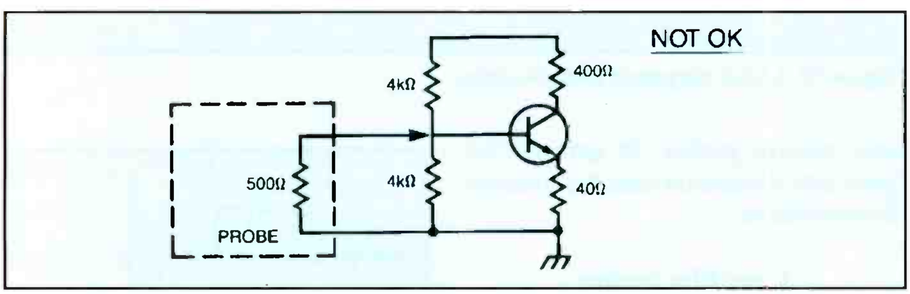


Figure 14. An example of when using a low-Z probe is not appropriate.

offer the highest capacitive loading of any probe type. Even passive 1X probes, however, are designed to keep loading as low as possible (Figure 8).

Probes extend a scope's signal amplitude handling capability. Besides reducing capacitive and resistive loading, a standard passive 10X (ten times attenuation) probe extends the on-screen viewability of signal amplitudes by a factor of ten (Figure 9).

A typical scope minimum sensitivity is 5V/division. Assuming an eight-division vertical graticule, a 1X probe (or a direct connection) would allow on-screen viewing of 40Vpp maximum. The standard 10X passive probe provides 400Vpp viewing. Following the same reasoning, a 100X probe should allow 4kV on-screen viewing. However, most 100X probes are rated at 1.5kV to limit power dissipation in the probe itself.

Check the specs

Bandwidth is the probe specification most users look at first, but plenty of other features also help to determine which probe is right for a given application. Circuit loading, signal aberrations, probe dynamic range, probe dimensions, environmental degradation and ground-path effects will all affect the probe selection process.

How probes affect measurement

Probes affect measurements by loading the circuit that you are examining. The loading effect is generally stated in terms of impedance at some specific frequency, and is made up of a combination of resistance and capacitance.

• Source impedance. Obviously, source impedance will have a large impact on the net effect of any specific probe loading. For example, a device under test with a near zero output impedance would not be affected in terms of amplitude or risetime to any significant degree by the use of a typical 10X passive probe. However, the same probe connected to a high impedance test point, such as the collector of a transistor, could affect the risetime and amplitude of the signal.

• Capacitive loading. To illustrate capacitive loading, let's take a pulse generator with a very fast risetime. If the initial risetime was assumed to be zero (tr = 0), the output tr of the generator would be limited by the associated resistance and capacitance of the generator. This *integration network* produces an output risetime equal to 2.2(RC). This limitation is derived from the universal time-constant curve of a capacitor.

Figure 10 shows the effect of source resistance and capacitance on the equivalent circuit. At no time can the output rise-

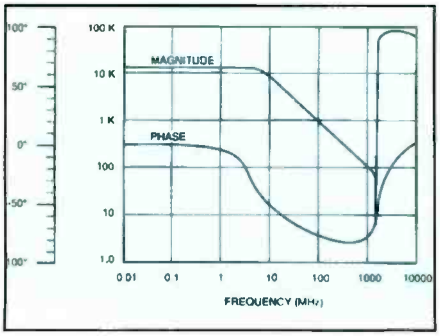


Figure 15a. An impedance vs frequency graph of an active probe.

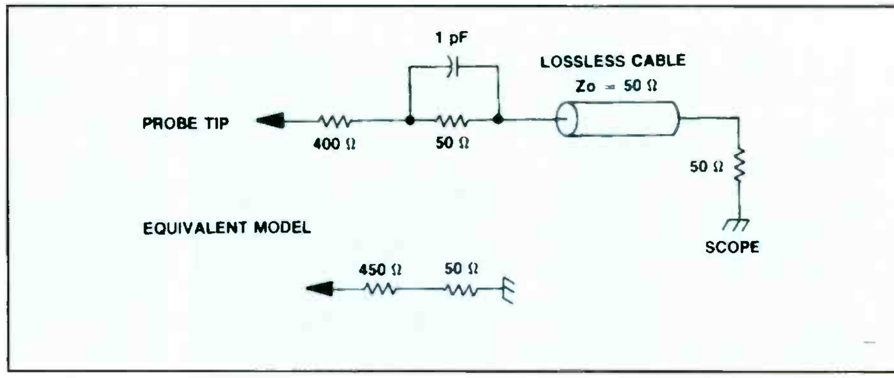


Figure 16. An illustration of how a low-Z probe offers low tip capacitance.

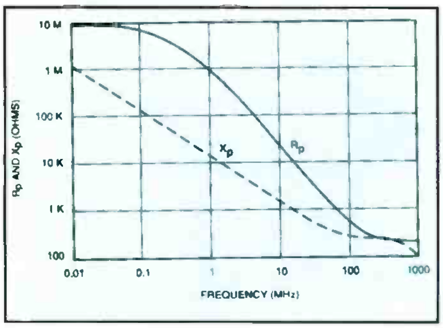


Figure 15b. An impedance vs frequency graph of a passive probe.

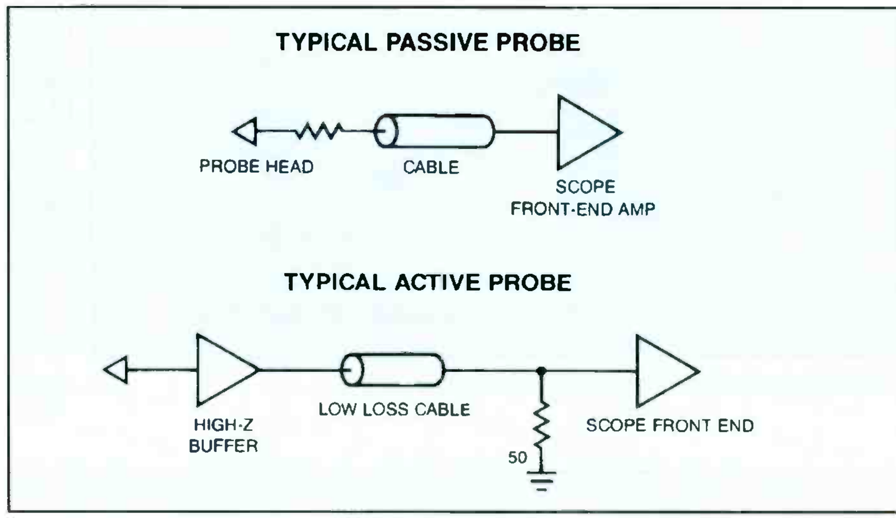


Figure 17. A block diagram of an active probe.

time be faster than 2.2(RC) or 2.2nsec.

If a typical probe were used to measure this signal, the probe's specified input capacitance and resistance would be added to the circuit as shown in Figure 11. Because the probe's 10MΩ resistance is much greater than the generator's 50Ω output resistance, it can be ignored.

Figure 12 shows the equivalent circuit of the generator and probe, applying the 2.2(RC) formula again. The actual risetime has slowed from 2.2nsec. to 3.4nsec.

Percentage change in risetime due to the added probe tip capacitance:

$\%\ change = |(tr_2 - tr_1)/tr_1| \times 100$
$= |(3.4-2.2)/2.2| \times 100$
$= 55\%$

Another way of estimating the effect of probe tip capacitance is to take the ratio of the probe tip capacitance (marked on the probe compensation box) to the known or estimated source capacitance.

Using the same values:

$[C(probe\ tip)/C_1] \times 100$
$= [11pF/20pF] \times 100 = 55\%$

Any added capacitance slows the source risetime when using high impedance passive probes. In general, the greater the attenuation ratio, the lower the tip capacitance.

Capacitive loading

When probing continuous wave (CW) signals, the probe's capacitive reactance at the operating frequency must be taken into account. The total impedance as seen at the probe tip is designated Rp, and is a function of frequency. In addition to the capacitive and resistive elements, designed-in inductive elements serve to off-

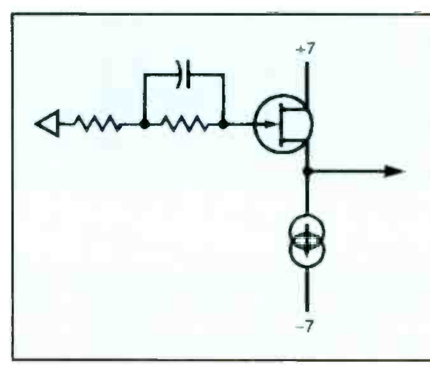


Figure 18. A typical FET front end of an active probe.

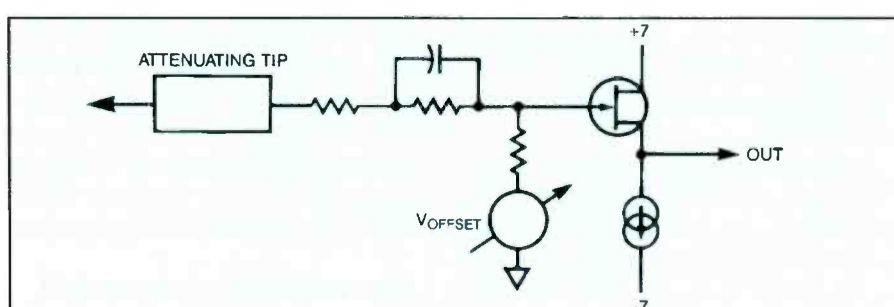


Figure 19. An improved front end of an active probe.

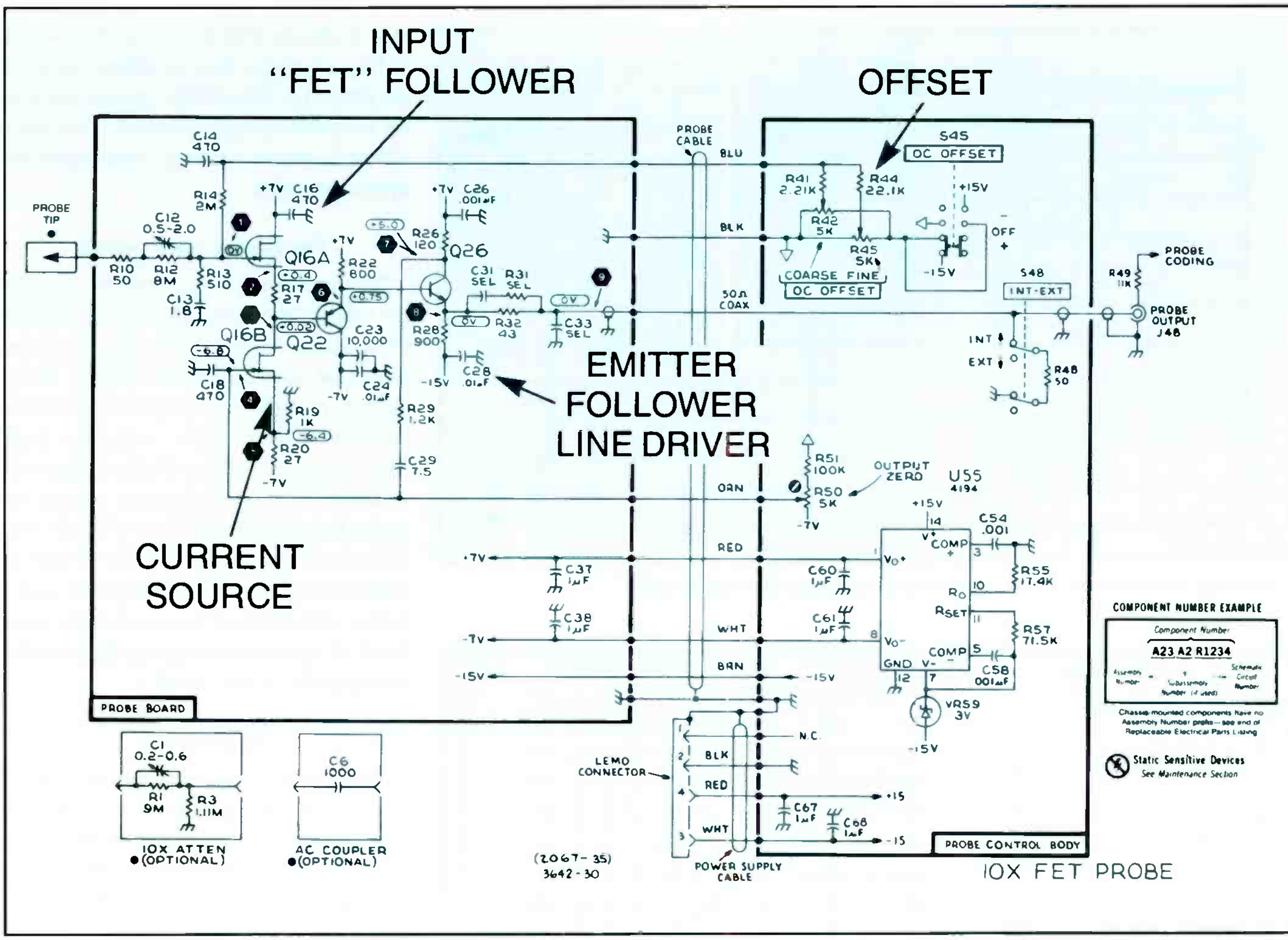


Figure 20. A schematic of a commercially-available active probe.

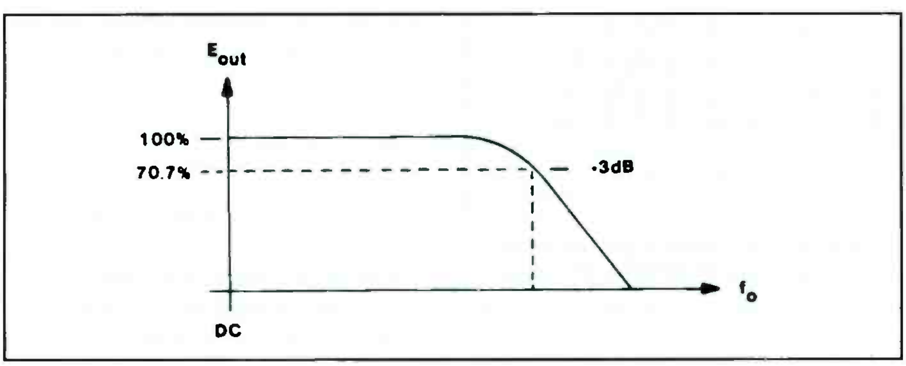


Figure 21. A typical response of an oscilloscope system.

set the pure capacitive loading to some degree. Figures 13 and 14 show uses of low-Z probes.

Curves showing typical input impedance vs frequency, or typical Xp and Rp vs frequency are included in most probe instruction manuals. Figure 15A shows the typical input impedance and phase relationship vs frequency of one active probe. Note the 10kΩ input impedance is maintained to almost 10MHz by careful design of the associated resistive, capacitive and inductive elements.

Figure 15B shows a plot of Xp and Rp vs frequency for a typical 10MΩ passive probe. The dotted line (Xp) shows capacitive reactance vs frequency. The total loading is again offset by careful design of the associated R, C and L elements.

If you do not already have access to the information and need a worst-case guide to probe loading, use this formula:

$Xp = 1/2\pi FC$, where

Xp = capacitive reactance in Ω
F = operating frequency
C = probe tip capacitance

For example, a standard passive 10MΩ probe would have a tip capacitive reactance (Xp) of about 290Ω at 50MHz.

Depending, of course, on the source impedance, this loading could have a major effect on the signal amplitude (by simple divider action), and even on the operation of the circuit being measured.

Resistive loading

For all practical purposes, a 10X, 10MΩ passive probe has little effect on today's circuitry in terms of resistive loading. However, they do carry a tradeoff in terms of relatively high capacitive loading previously discussed.

Low-Z passive probes

A "low Z" passive probe offers very low tip capacitance at the expense of very high resistive loading. A typical 10X "50Ω" probe has an input C of about 1pF and a resistive loading of 500Ω. Figure

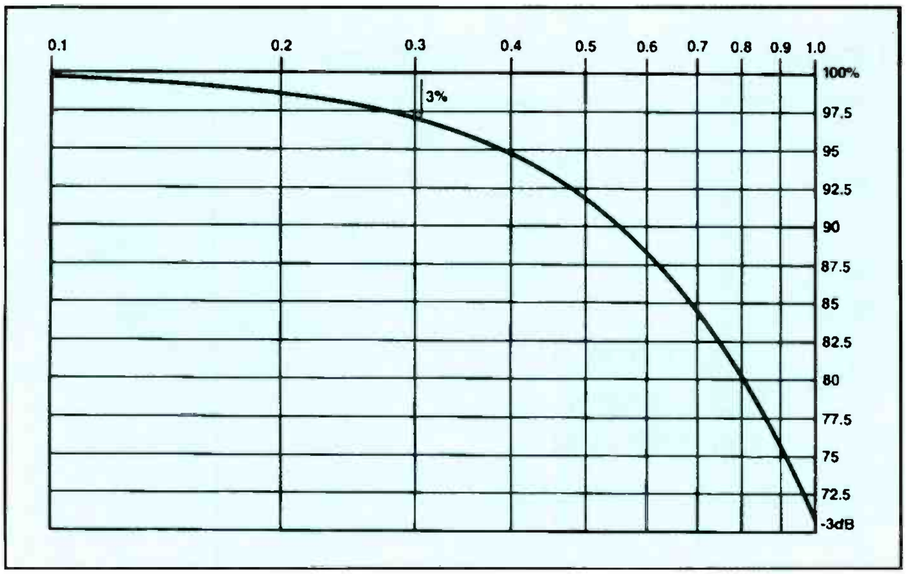
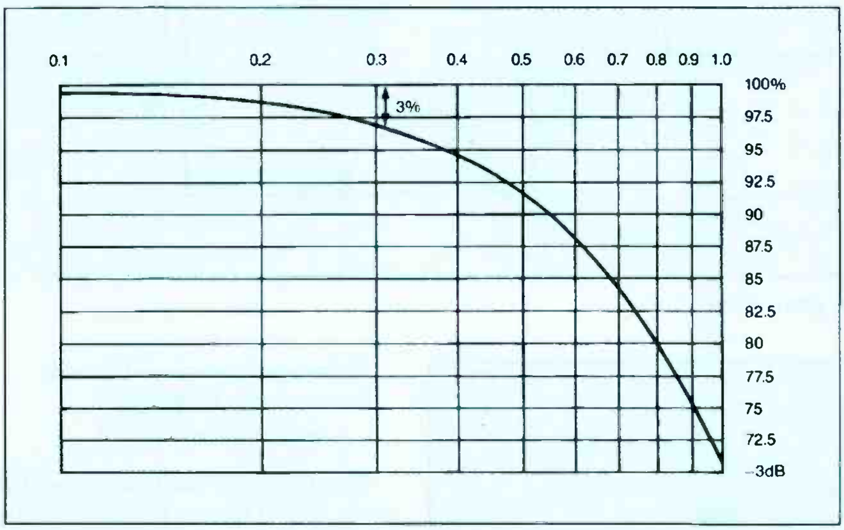


Figure 22. An expanded view of the -3dB area of an oscilloscope system.



Amplitude accuracy degraded to −3% at only 0.3 of normalized bandwidth. Therefore, a 350 MHz system is 3% accurate to only (.3)(350 MHz) = 105 MHz.

Figure 23. Amplitude accuracy vs normalized frequency.

16 shows the circuit and equivalent model of this type of probe.

This configuration shows a high frequency 10X voltage divider because, from transmission line theory, all that the 450Ω tip resistor sees looking into the cable is a pure 50Ω resistance, no C or L component. No low frequency compensation is necessary because it is not a capacitive divider.

Low Z probes are typically high bandwidth (up to 3.5GHz and risetimes up to 100ps) and are best suited for making risetime and transit-time measurements. They can, however, affect the pulse amplitude by simple resistive divider action between the source and the load (probe).

Because of its resistive loading effects, this type of probe performs best on 50Ω or lower impedance circuits under test. These probes operate into 50Ω scope inputs only. They are typically teamed up with fast (500MHz to 1GHz) real time scopes or with scopes employing the sampling principle.

Bias-offset probes

A bias/offset probe is a special kind of low-Z design with the capability of providing a variable bias or offset voltage at the probe tip. Bias/Offset probes are useful for probing high speed ECL circuitry, where resistive loading could upset the operating point.

The best of both worlds

From the foregoing, it can be seen that the totally "non-invasive" probe does not exist. However, one type of probe comes close: the active probe. In general, active probes provide low resistance loading (10MΩ) with very low capacitive loading (1pF to 2pF). They do have trade-offs in terms of limited dynamic range, but under the right conditions, offer the best of both worlds (Figures 17, 18, 19 and 20: a block diagram, the front end of such a probe, an improved front end and a schematic of an actual commercially available active probe, respectively).

Bandwidth

Bandwidth is the range of frequencies between the two points on an amplitude versus frequency curve where the amplitude of the signal is down 3dB from a starting (reference) level. Figure 21 shows a typical response curve of an oscilloscope system. Scope vertical amplifiers are designed for a Gaussian roll-off at the high end. With this type of response, risetime is approximately related to bandwidth by the following equation:

Tr=0.35/Bandwidth

or, Risetime = 350/Bandwidth(MHz)

Note the measurement system is 3dB (30%) down in amplitude accuracy at the specified bandwidth limit. Figure 22 shows an expanded portion of the -3dB area. The horizontal scale shows the input frequency derating factor necessary to obtain accuracies better than 30% for a specific bandwidth scope.

For example, with no derating, a "100 MHz" scope will have up to a 30% amplitude error at 100MHz (1.0 on the graph). If amplitude accuracy is to be better than 3%, the input frequency must be limited to about 30MHz (100 MHz/3).

For making amplitude measurements within 3% at a specific frequency, choose a scope with at least four times the specified bandwidth, as a general rule of thumb (Figure 23).

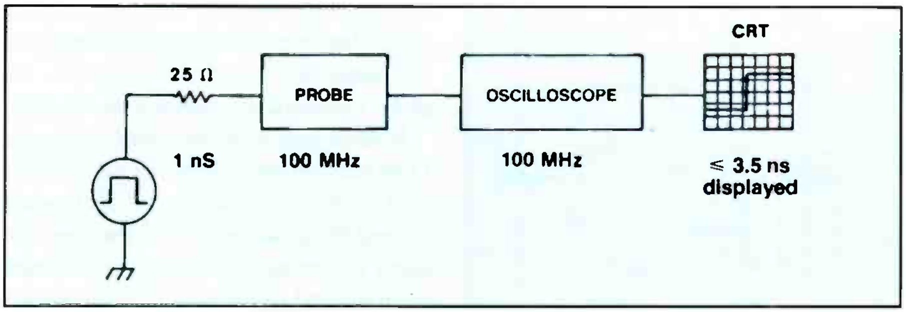


Figure 24. An equivalent circuit of a typical test setup.

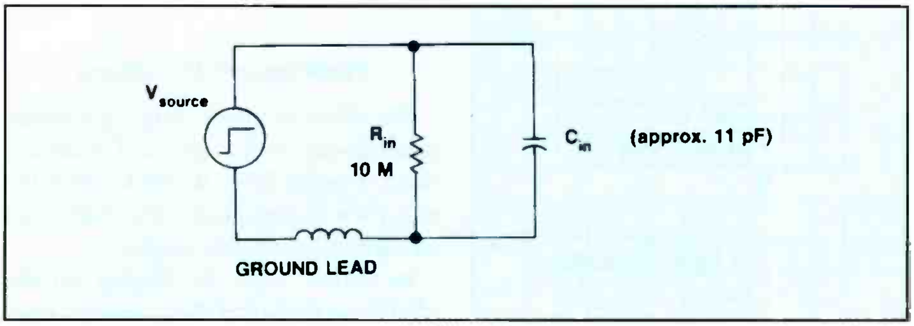


Figure 25. Effects of ground lead inductance.

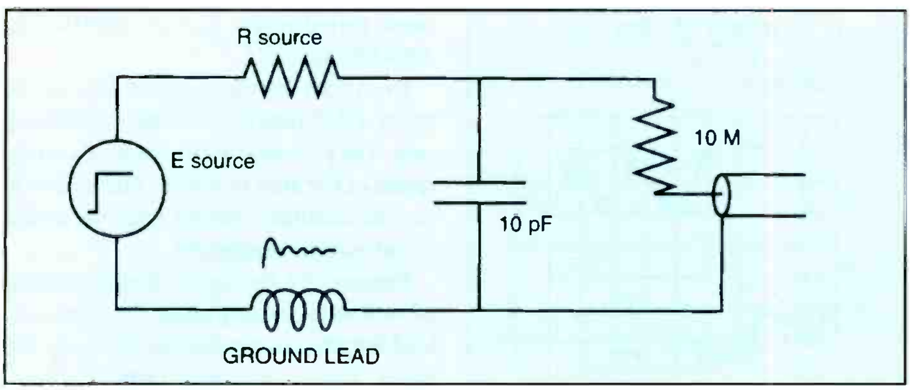


Figure 26. An equivalent circuit of a typical passive probe connected to a source, including ground lead inductance.

Probe bandwidth

All probes are ranked by bandwidth, just as scopes or amplifiers are. To determine the risetime of the scope/probe system, apply the square root of the sum of the squares formula. This formula states:

$$T_r = \sqrt{(Tr^2 \text{ displayed} - Tr^2 \text{ source})}$$

Passive probes do not follow this rule and should not be included in the square root of the sum of the squares formula. Most manufacturers provide a probe bandwidth ranking system specifying the bandwidth (frequency range) over which the probe performs within its specified limits. These limits include: total aberrations, risetime and swept bandwidth.

Both the source and the measurement system should be specified when checking probe specifications. In general, a "100 MHz" probe provides 100MHz performance (-3dB) when used on a compatible 100MHz scope. That is, it provides full scope bandwidth at the probe tip. However, not all probe/scope systems can follow this general rule.

Test methods

As with all specifications, matching test methods must be employed to obtain specified performance. With bandwidth and risetime measurements, it is essential to connect the probe to a properly terminated source. One manufacturer, for example, specifies a 50Ω source terminated in 50Ω, making this a 25Ω source impedance. Furthermore, the probe must be connected to the source via a proper probe tip to BNC adapter (Figure 24).

Scope bandwidth at the probe tip?

Most manufacturers of general purpose oscilloscopes with standard accessory probes in the package, promise and deliver the advertised scope bandwidth at the probe tip.

However, not all high performance scopes can offer this performance even when used with their recommended passive probes. This is because even the highest impedance passive probes are limited to about 300MHz to 350MHz, while still meeting their other specifications. This performance is only obtainable under strictly controlled, and industry recognized conditions; which states that the signal must originate from a 50Ω back-terminated source (25Ω), and the probe must be connected to the source by a probe tip to BNC (or other) adapter.

This method ensures the shortest ground path and necessary low impedance to drive the probe's input capacitance, and to provide the specified bandwidth at the signal acquisition point—the probe tip. Real-world signals rarely originate from 25Ω sources, so less than optimum transient response and bandwidth should be expected when measuring higher impedance circuits.

How ground leads affect measurements

A ground lead is a wire providing a local ground-return path when you are measuring any signal. An inadequate ground lead (one that is too long or too high in inductance) can reduce the fidelity of the high-frequency portion of the displayed signal (Figure 25).

What grounding system to use

When making any measurement, some form of ground path is required to make a basic two-terminal connection to the DUT. If you want to check the presence or absence of signals from low-frequency equipment, and if the equipment is line-powered and plugged into the same outlet system as the scope, then the common 3-wire ground system provides the signal ground return. This indirect route adds inductance in the signal path. It can also produce ringing and noise on the displayed signal and is not recommended.

When making any kind of absolute measurement, such as amplitude, risetime or time delay, you should use the shortest grounding path possible, consistent with the need to move the probe among test points. The ultimate grounding system is an in-circuit ECB- (etched circuit board) to-probe-tip adapter. You can purchase these for miniature, compact or subminiature probe configurations.

Figure 26 shows an equivalent circuit of a typical passive probe connected to a source. The ground lead L and C form a series resonant circuit with only 10MΩ for damping. When hit with a pulse, it will ring. Also, excessive L in the ground lead will limit the charging current to C, the probe's capacitance, limiting the risetime.

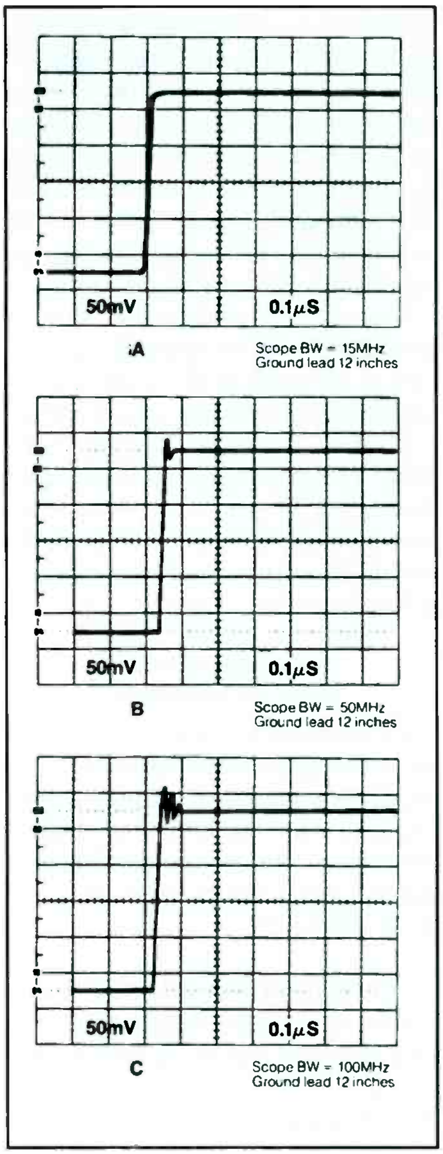


Figure 27. Effects of ground lead inductance on oscilloscopes of various bandwidths. A. BW = 15MHz and ground lead = 12 inches. B. BW = 50MHz and ground lead = 12 inches. C. BW = 100MHz and ground lead = 12 inches.

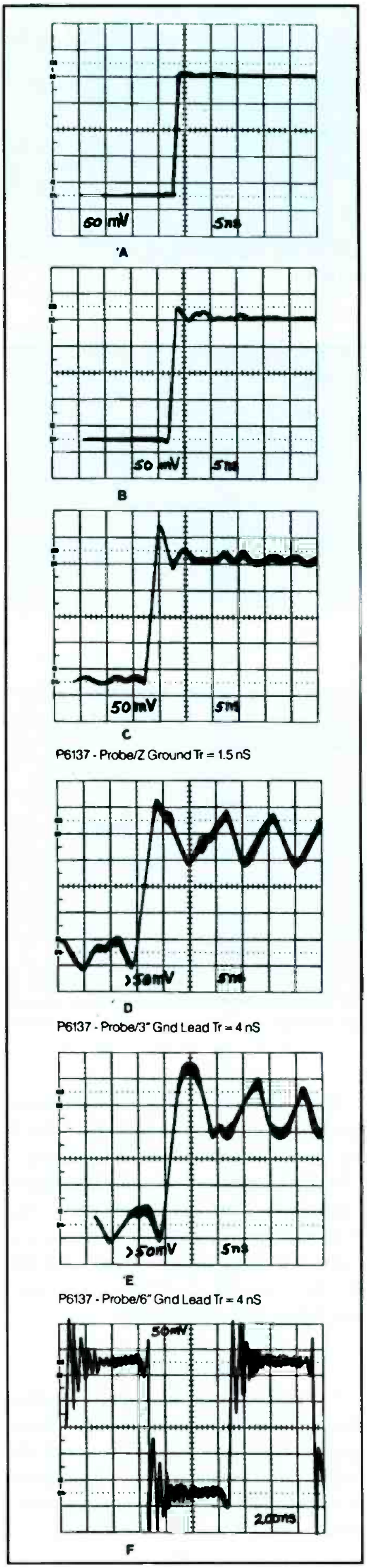


Figure 28. An optimal impedance match, minimizing ground lead effects. ➤

Without going into the mathematics, an 11pF passive probe with a 6-inch ground lead would ring at about 140MHz when excited by a fast pulse. As the ring frequency increases, it tends to get outside the passband of the scope and is greatly attenuated. To increase the ring frequency, use the shortest ground lead possible and use a probe with the lowest input C.

Probe ground lead effects

The effect of inappropriate grounding methods can be demonstrated in several ways. Figures 27A, B and C show the effect of a 12-inch ground lead when used on various bandwidth scopes.

In Figure 27A, the display on the 15MHz scope looks OK because the ringing aberrations are beyond the passband of the instrument and are greatly attenuated. Figures 27B and C show what the same signal looks like on 50MHz and 100MHz scopes.

Even with the shortest ground lead, the probe-DUT interface has the potential to ring. The potential to ring depends on the speed of the step function. The ability to see the resultant ringing depends on the scope system bandwidth.

Figures 28A through F show the effects of various grounding methods and ground lead lengths on the display of a very fast pulse. This is the most critical way of looking at ground lead effects: we used a fast pulse, with a risetime of about 70ps and a fast (400MHz) scope with a matching probe.

Figure 28A shows the input pulse under optimum conditions when using 50Ω coax cable. The scope has an input impedance of 50Ω, the cable is 50Ω, and the source impedance is 50Ω. Displayed risetime is 1nsec.

Figure 28B shows the same signal when using the scope-probe combination under the most optimum conditions. A BNC to probe adapter or an in-circuit test jack provides a coaxial ground that surrounds the probe ground ring. This system provides the shortest probe ground connection available, displayed risetime is 1 nsec.

Part II examines how the design and type of probe affects your measurements.

Understanding compact disc troubleshooting concepts—Part 1

By Marcel R. Rialland

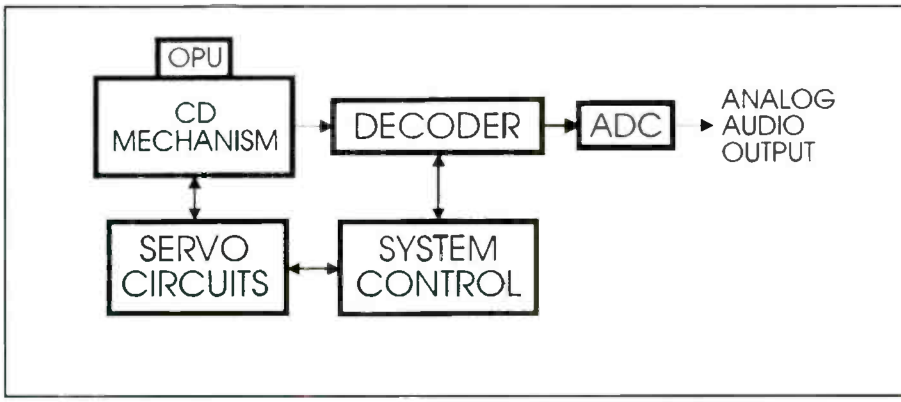


Figure 1. CD player block diagram.

Compact disc technology was introduced in 1982, with the idea of greatly improving audio recordings. The compact disc has now become a widely accepted medium for audio recordings. Because of its large storage capacity, the compact disc is now used for applications other than audio; including CD-ROM (compact disc read-only memory), photo-CD, and CDI (compact disc interactive).

Laser Vision is also becoming more popular and new developments in optical recording devices, such as Sony's Mini Disc, have recently been introduced. All this new technology means expanded opportunities and challenges for the service technician.

The troubleshooting challenge

Troubleshooting compact disc players (or other laser read and write systems) can be quite a challenge. A thorough knowledge of the theory of operation can help a technician become more effective in diagnosing compact disc player faults. Also, there are some tools, test jigs, test discs, and test equipment (oscilloscope and DVM) that are needed to simplify service procedures.

The required equipment is usually listed in the service manual; which is also needed to service a compact disc player. The service manual contains service procedures, such as how to enter the test modes that assist in diagnosing the player. In many players, the test modes are used to check the condition of the laser pen (optical pick-up unit) as well as the status of the servo circuits.

Basic CD operation

The simplified block diagram, shown in Figure 1, illustrates the process of reading and decoding a compact disc. This process must be followed in all CD systems. First there must be a means of retrieving the data from the disc. This is accomplished by the optical pick-up unit (OPU), which is part of the CD mechanism. The CD mechanism provides the means for the OPU to track the disc.

Normally the spindle or turntable, which is used to spin the disc, is also part of the CD Mechanism. The position of the OPU, focus, tracking, and the data retrieval rate (spindle motor speed) are controlled by the servo circuits. The system control block controls the status of the servo system (including the start-up sequence), and interprets and initiates commands received via the remote control or local keypad.

The data from the disc must also be decoded. At the least, decoding includes: EFM demodulation, deinterleaving, error correction, interpolating unrecoverable data, digital to analog conversion, and filtering. Most of these processes are performed by the LSI ICs and there is little that a technician can do about what goes on internally. However, there are signals (clock and data) as well as control lines that one should be familiar with in order to become proficient in troubleshooting the CD player.

The data includes more than just digital audio samples. The data also includes

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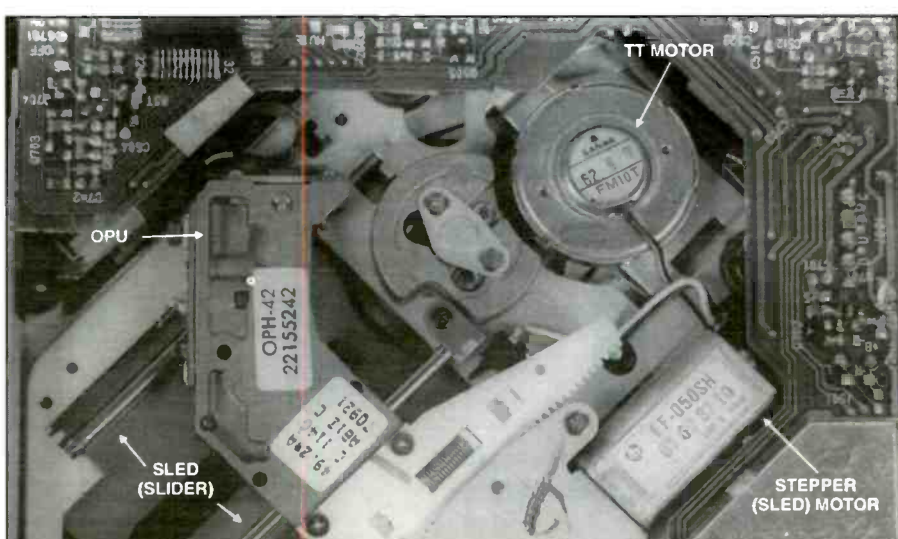

Figure 2. Three-beam servo CD mechanism (bottom view).

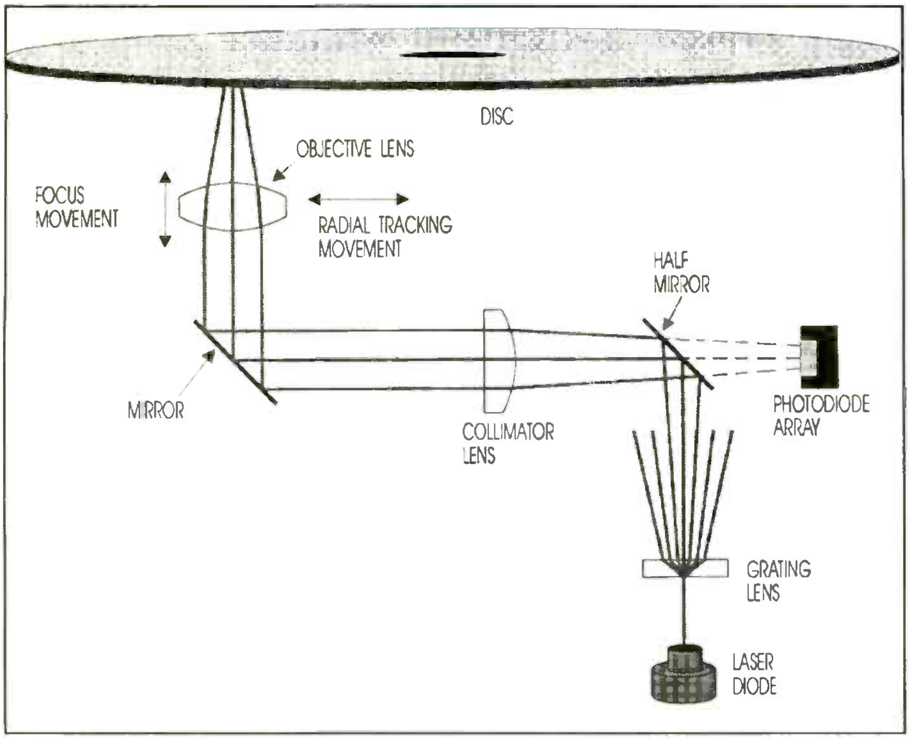

Figure 3. Three-beam optical pick-up unit.

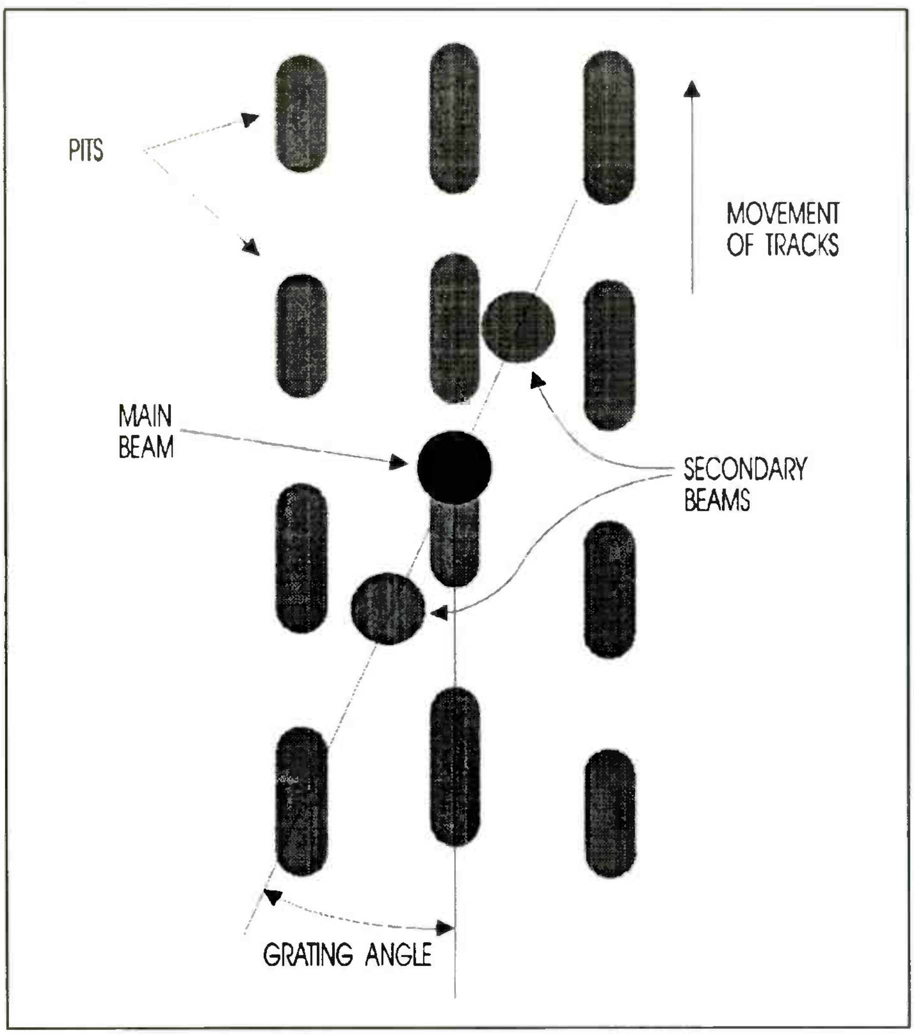

Figure 4. Grating angle.

parity bits (data for detecting errors), and control and display symbols. The decoder deinterleaves the data and uses the parity bits to recover unreliable data.

The control and display information is retrieved and used by the system control circuit for controlling the CD player system, and for displaying data related to the disc that is playing, such as elapsed time and the current track. The right and left audio 16-bit samples are converted to analog audio by the analog to digital converter (ADC).

Two types of servo systems

There are basically two types of servo systems, the single beam system and the three beam system. Most CD players contain three servo loops: the spindle (turntable) servo, focus servo, and tracking servo (radial tracking).

In addition, the laser beam intensity is controlled by a feedback control circuit. The servo loops must be operating before the data from the disc can even be retrieved (read) and decoded. The three beam system is examined in this article.

The three beam servo system

The bottom view of a CD mechanism for a three-beam servo system is shown in Figure 2. The CD mechanism can be divided into three main sections corresponding to their respective servo circuits: focus, turntable and tracking.

The focus servo circuit controls the focus movement of the objective lens (the objective lens is not shown).

The turntable servo (TT servo) controls the speed of the turntable motor.

As the compact disc spins, the tracking servo causes the OPU to follow the track. The tracking servo controls the position of the OPU in two ways: one for small (high frequency) radial corrections caused by the eccentricity of the disc and one for greater (low frequency) tracking corrections as the OPU tracks across the disc.

The first servo controls the movement of the OPU via radial tracking coils which control only the radial movement of the OPU. This loop allows fast response to the tracking servo. The second moves the entire OPU assembly on a sled via a stepper (sled) motor and gears.

The optical pick-up

The optical pick-up unit is a complex electromechanical device designed to op-

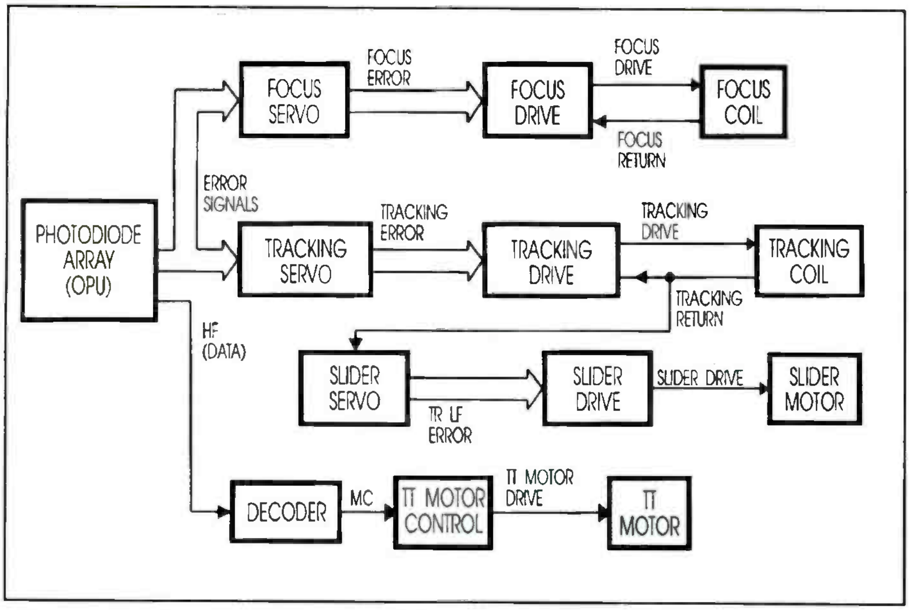

Figure 5. Three-beam servo system block diagram.

tically read and track the compact disc's spiral tracks. As illustrated in Figure 3, the three-beam optical pick-up unit is generally composed of lenses, mirrors, a laser diode and photodiodes.

A single beam, emitted from a laser diode, is split into several beams of which only three are used; the three in the center. The center or main beam is the most intense beam used for focus and reading the pits on the disc. The secondary or radial beams are used strictly for tracking.

The light bundle (three beams) is reflected by the half mirror toward the collimator lens (all three beams are placed in parallel by the collimator lens). The beams are then directed by another mirror up through the objective lens.

When the player is placed in a service mode to initiate a start-up, the lens can be seen moving up and down several times. The OPU should also move inward to locate the lead-in track.

If a disc is detected, the light bundle (modulated by the pits in the disc) is reflected back through the objective lens, mirror, and the collimator lens. Some of the reflected, modulated light bundle passes straight through the half mirror to strike the photodiode array.

Alignment is critical

The alignment (grating angle) of the three beams is very critical in the three-beam optical pick-up system as shown in Figure 4. An improper grating angle results in poor tracking or, in severe cases, tracking may not be possible at all.

In many cases, the grating angle is factory set and cannot be adjusted. Where there is an adjustment, the manufacturer's grating angle adjustment procedure as outlined in the service manual must be followed. Normally the adjustment is only made when replacing the optical pick-up unit.

The three beam servo block diagram is shown in Figure 5. The photodiodes provide focus and tracking error signals to the focus and tracking servo circuits. The focus error signal is developed by the focus servo circuit and is fed to the focus drive circuit. The focus drive provides the drive signal to the focus coil on the compact disc mechanism (CDM) to keep the laser beam focused on the disc.

The tracking servo circuit

The tracking servo circuit similarly receives tracking error signals from the photodiodes and develops the tracking (TR) error signal. The tracking error signal is fed to the tracking drive circuit, which applies drive to the tracking coil on the pick-up mechanism.

The coil provides the tracking (TR) return to the tracking drive and to the slider servo circuits. The slider servo provides low frequency (LF) tracking corrections. The TR LF (tracking low frequency) error signal is sent to the slider drive circuit to drive the slider motor.

The rotational speed of the turntable (TT) motor is controlled by detecting the data (detected from the HF) coming into the decoder block. This is done in the process of bit clock regeneration and decoding the incoming data. The decoder develops the motor control (MC) signal to regulate the speed of the motor and thus keep the demodulated data coming at the correct speed (4.3218 Mb per second).

Starting the disc

Every CD player must go through a start-up procedure in order to start playing a CD. It is important to know the start-up sequence when troubleshooting a condition where the disc will not play. The start-up sequence is initiated by the microprocessor when it receives a command to detect the presence of a CD or to start playing the disc.

The start-up initiates as follows (note: some of the steps occur simultaneously):

1. Turn the laser diode on.
2. Focus the laser beam (the objective lens will move up and down until focus is achieved).
3. Start the disc turntable motor (TT servo locks when data is detected).
4. Move OPU to the lead-in track and read the table of contents.

Although there are variations in the start-up sequence between makes and models, all CD systems must find focus and find the control and display data (especially the table of contents in the lead-in track) to play a disc.

Once the CD starts, all the servos remain locked, until a jump track command (skip track or fast forward or reverse) is received. In this case, the servo microprocessor works with the tracking servo to allow skipping of tracks until the desired selection has been located.

A laser power meter can be used to check the status of the laser beam. The laser power meter is also used to adjust the laser power level following the service manual's instructions for the unit under test. This check or adjustment is usually performed while the player is in the service mode.

In some players, the intensity of the laser diode is measured by checking a reference voltage in the laser diode control circuit. This voltage is proportional to the intensity of the laser diode.

Part two will take a closer look at some troubleshooting techniques for the three-beam servo circuit and introduce the single-beam servo system. ■

Principles of switching power supplies

By The ES&T Staff

This article is partly based on the service manual for the RCA CTC176 color television set by Thomson Consumer Electronics. The schematic diagram for the power supply of this set is reproduced within this article as Figure 3. However, for a broader view, refer to the Profax schematic diagram in this issue, which is the schematic diagram for this set.

The function of a power supply

The purpose of a power supply is to convert the input power line voltage, in the United States 120V at 60Hz, into one or more dc voltages that are required to operate the various circuits in an electronics product.

Historically, power supplies have been linear. That is, they consist of a transformer to step the voltage down to the desired value, a rectifier to convert the ac to dc, and a series pass element to regulate the voltage so that it remains near the desired value in spite of fluctuations in the input voltage, or changes in the load (Figure 1).

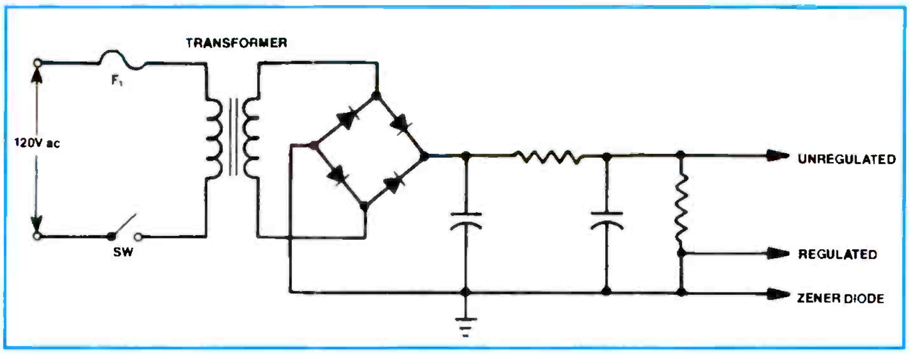

Figure 1. A linear power supply consists of a transformer to step the voltage down to the desired value, a rectifier to convert the ac to dc, and a series pass element to regulate the voltage.

Such power supplies worked fine for many years, but they had disadvantages. For one thing, they required large, heavy transformers to handle the currents at 60Hz. That means large costs for transformers and added weight of the product.

Furthermore, the regulation components consumed power (losses) which resulted in waste.

The switching power supply

For many years, given the state of electronics technology and the cost of components, series pass voltage regulation was the most practical and efficient method of achieving voltage regulation.

With the advent of high-speed switching semiconductor components, engineers began to investigate the possibility of regulating the voltage output of power supplies in a new way. Instead of regulating voltage by dropping some of it across a pass transistor, or other component, which dissipates power as it regulates, it might be possible to switch the supply power in and out of the circuit, and regulate the voltage in that manner.

When the load is low and the line voltage is within specs, the power into the supply is switched in by the switching element only for brief periods of time. When the load on the supply is high, or the line voltage is low, or both, the switch remains closed longer so that more energy can flow in during a given interval.

Thus, in most switching power supplies, the switching frequency is higher at light loads and lower at heavier loads. The switching frequency is lower at heavier loads because the switch must remain closed for longer periods of time in order to allow more energy to flow into the power supply.

A simple switcher

In one of the most basic examples of a switching power supply (Figure 2), a transistor switch applies the unregulated voltage across an inductor for brief periods of

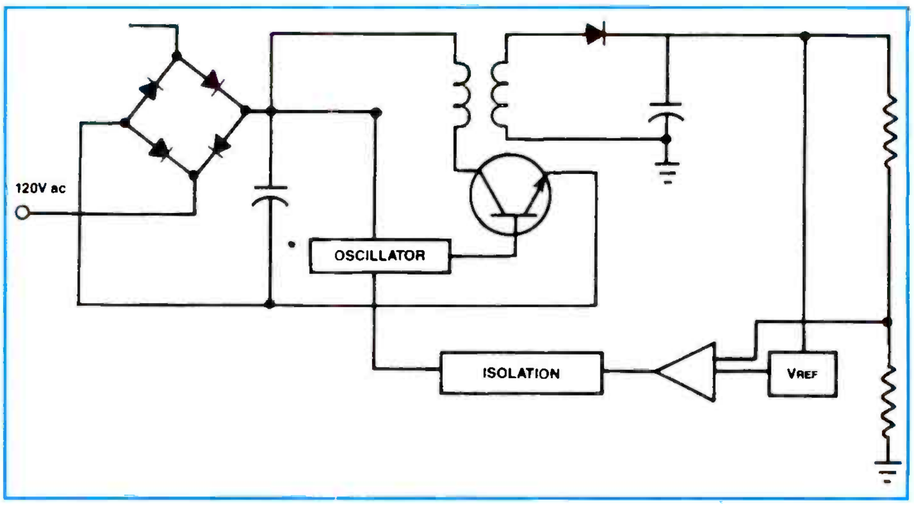

Figure 2. In this switching power supply, a transistor applies the unregulated voltage across an inductor intermittently. The current in the inductor increases when the transistor is on. The energy represented by this increase in current is stored in a magnetic field. This energy is then transferred to a filter capacitor in the output circuit.

time. The current in the inductor increases during each period when the transistor is on. The energy represented by this increase in current is stored in the inductor's magnetic field.

The energy thus stored in the inductor's magnetic field is then transferred to a filter capacitor, which is in the output circuit.

The capacitor serves as the component that outputs the power supply's voltage to the load circuit. It is also a filter which smooths the dc output.

Gaining an understanding of switchers

A lot of technicians have difficulty understanding switchers, and troubleshooting them. Much of this problem stems from the fact that there is not a single switching power supply circuit, but an almost infinite variety of such circuits, depending on the manufacturer, the nature of the product that the supply is used in, and the state of advancement of electronic circuit/component technology when the supply was designed and built.

The key to understanding switchers, then, is to recognize the general principle of the units, as stated earlier, and to read the manufacturer's literature, if available, to see how the supply in a particular product applies this principle.

Of course, troubleshooting a switching power supply that's not functioning presents problems of a complexity that you just don't encounter in linear supplies. But an understanding of the nature of these circuits will make troubleshooting considerably easier.

A real world switcher

The power supply in the RCA CTC176 color television (Figure 3) uses a variable frequency, variable pulse width (switching) regulator. U4101, the hybrid IC, contains most of the regulator circuit components, including the power switching FET.

When power is first applied to the set, approximately 150Vdc is developed by the bridge rectifier diodes and filter capacitor. This voltage is applied through the primary winding of T4101 pins 1 and 3 into U4101 pins 11 and 12.

Pins 11 and 12 are the drain of the power FET. This FET is internal to U4101. The source of the FET is connected to pins 8 and 9 of the IC. R4124 is connected between the junction of pins 8 and 9 and

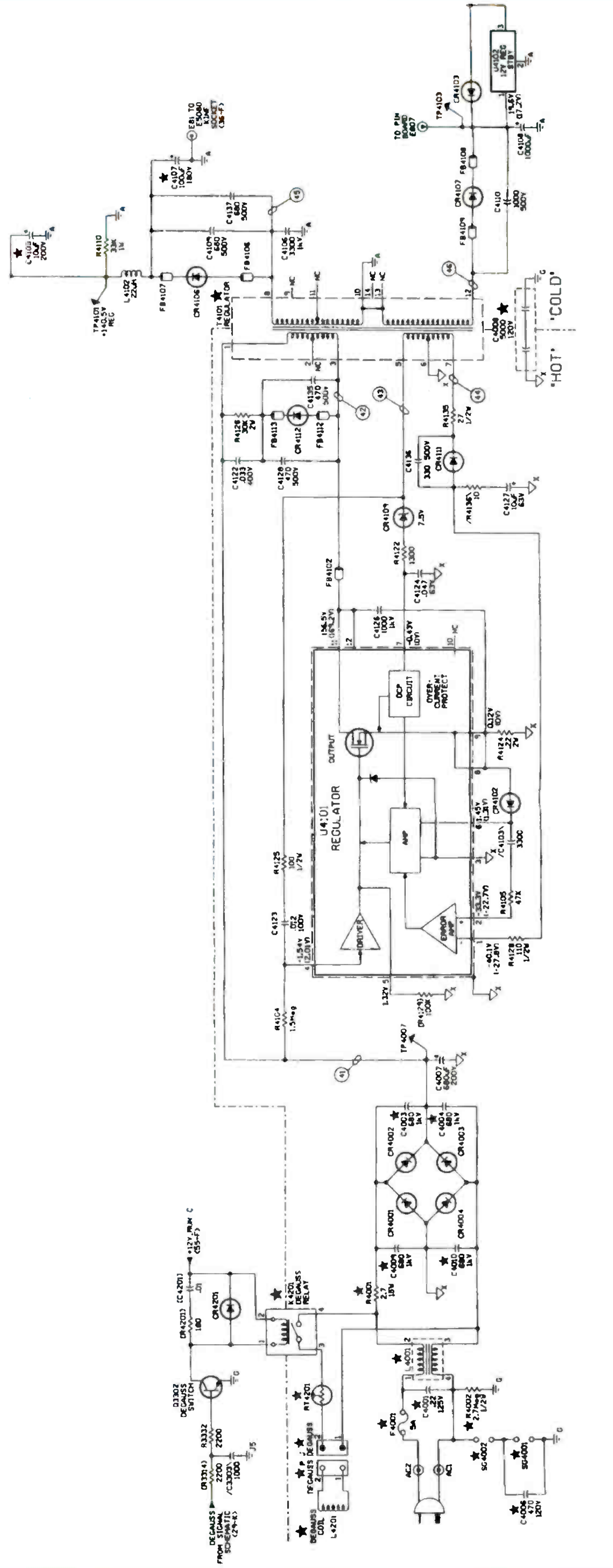

Figure 3. The power supply in the RCA CTC176 color television uses a variable frequency, variable pulse width (switching) regulator. U4101, the hybrid IC, contains most of the regulator circuit components, including the power switching FET.

ground. R4104, the start-up resistor, provides bias to the gate of the FET through pin 4 of U4101 to turn the FET on.

When the FET is turned on, the drain current flows through the primary winding of transformer T4101 through the FET to ground. Current flowing in the primary induces a voltage on the winding between pins 5 and 6 on the transformer. This voltage is coupled from pin 5 through R4125 and C4123 into pin 4 of U4101.

Pin 4 of U4101 is connected internally to the gate of the FET. The polarity of the voltage is such that it turns the FET on harder. As more current flows, a larger voltage is built up on R4124, the FET source resistor.

The overcurrent protection circuit

Eventually, the voltage will be large enough to turn on the overcurrent protection circuit (OCP) internal to U4101. This will cause the FET to turn off.

When the FET turns off, current in the primary windings of T4101 ceases, and the collapsing magnetic field induces current in the secondary windings, charging filter capacitors C4107 and C4108.

Once the voltage sensed by the OCP circuit has dropped sufficiently, the FET will again begin to conduct.

This sequence repeats for several cycles until stable oscillation begins. The frequency of oscillation will vary with load from approximately 100KHz at standby to 38KHz at full load.

Regulating the voltage

The feedback winding between pins 5 and 7 on T4101 is tightly coupled to the secondary windings. The voltage on the feedback winding tends to follow the voltage changes on the secondary windings.

The voltage developed on pin 7 of T4101 is rectified by CR4111 and filtered by C4127. This negative voltage is applied to pin 1 of U4101.

Internal to U4101 is a precision voltage reference, trimmed to –40.5V ± 0.5V. The error amp acts to make the voltage on pin 1 of U4101 equal to the reference voltage.

If the load on the secondaries increases and the voltage drops, the voltage developed at pin 7 of T4101 would decrease. When the pin 7 voltage decreases, the error amp output signal causes the FET to stay on longer thus increasing the output voltage. In this way, the IC is able to hold the output of the supply constant with varying line voltages and loads.

Overcurrent protection

If an excessive load is placed on the power supply outputs, the on time of the FET will increase. This will result in more current through the FET and source resistor R4124. A voltage drop will be developed proportional to the current and this voltage will be applied to the overcurrent protection circuit internal to U4101.

This circuit is also connected to pin 7. A capacitor, C4124, is connected to pin 7. As the current increases, it will charge C4124 and turn on the overcurrent protection circuit. This will turn off the FET. Increasing the value of C4124 would increase the overcurrent protection trip point.

Other parts of the power supply

The network composed of C4122, C4128, R4126 and CR4112 is a snubber network used to reduce the high voltage spike developed when the FET turns off.

C4103 and R4105 are part of a compensation network which tends to stabilize the supply from parasitic oscillations.

R4129 is an ESD protection resistor for the gate of the FET.

R4122 and CR4109 help stabilize the overcurrent protection with line voltage variations.

All of the ferrite beads are for RFI emission reduction.

C4107, L4102 and C4105 form a filter network to reduce the ripple in the REG B+ and to reduce high frequency switching noise.

The secondary windings of T4101 provide standby voltages of +12V and +5V plus a regulated +140.5V supply used to power the horizontal deflection circuit.

Troubleshooting

Finding problems with this power supply circuit is a fairly straightforward task. The most important voltage to measure is the one found on pin 1 of U4101. It should be -40.5V ± 0.5V. If this voltage is correct, it is very probable that the IC is working correctly and any incorrect output voltages are caused by abnormal loads.

As the output loads increase, the output voltages drop and the frequency of oscillation will decrease. With high enough loads, the frequency will be in the audible range. If the outputs are shorted, the supply will shut down until the problem causing the short is corrected.

Under no-load conditions, the REG B+ voltage will rise and the supply will go into a "burst" mode where there is a series of drive pulses at an audible rate. Note: it is not recommended that the supply be run without loads as the REG B+ output capacitors may be stressed by over-voltage.

If pin 1 of U4101 is shorted, the REG B+ output voltage will be low (approximately 30V). If pin 1 is open, the REG B+ voltage will rise to over 200V.

In all cases, the voltage on pin 1 of U4101 should be checked for -40.5V ± 0.5V. This is the best indication that U4101 is operating correctly. It is normal for the REG B+ voltage to rise 4 or 5 volts when the supply is in the standby mode.

Consult the literature

Unfortunately, it's a fact of life that switching power supplies are more varied in design and more complex than are linear power supplies. The fact that frequently switching power supplies are largely contained in an IC package for which only a block diagram is given adds to the difficulty of understanding and troubleshooting them.

The mode of operation of linear power supplies was usually fairly straightforward, and a study of the circuit itself and its schematic diagram would lead to an understanding of the circuit operation. With a given switcher, the operating principles may not be obvious, and it may be necessary to obtain a detailed explanation from the manufacturer's literature.

As with any other complex, sophisticated electronics circuitry, the more you study switching power supplies, and the more variations you see, the clearer the operation of the circuits will become. ■

CD Alignments

By Sheldon Fingerman

Maybe you are already repairing CD players, or just contemplating whether to get into it. As with servicing any product, one of your prime concerns is reducing callbacks. One way to minimize callbacks is to follow the manufacturer's alignment procedures. Over the long haul, the money saved by a service center in reduced callbacks could very well cover the cost of any extra equipment needed.

Another reason for checking the alignment of a CD player as part of a service routine is that specs seem to drift over time. You will find that proper alignment will not only solve some annoying problems, but will usually shorten disc access time as well.

It's really amazing how much faster a CD player can jump from track to track after proper alignment. Since deterioration of disc access time occurs over a long period of time, the customer will not only be happy that their player is fixed, but will wonder what you did to "hot-rod" it.

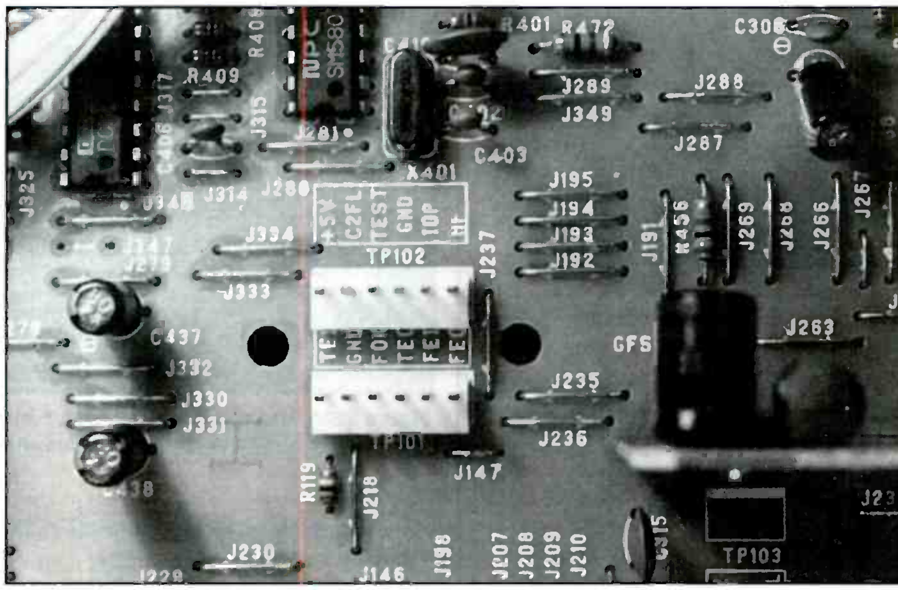

Figure 1. An example of connector type test points on the Denon DCM 777: all grouped together, easy to get to, and well labeled.

CD alignment equipment

The pieces of equipment needed to align most players are a dual-trace scope, an audio generator, a frequency counter, and a specific test disc. Although most manufacturers call for a scope of 100MHz or more, around 50MHz or 60MHz seems to work fine. The frequency counter must read at least 50MHz, and the test disc may have to be purchased from the manufacturer. Some luxury items that are nice to have are a laser power meter and a "torture" disc.

If you're contemplating working on CD players, and you do not have a frequency counter or an audio generator, one of the newer generators with a built-in counter (for use internally or externally) may be just what you are looking for.

Test discs

Some test discs are universally used among several manufacturers, with alignment specs given for the different discs. A test disc from another manufacturer will usually work just fine, but it is strongly recommended that you use a test disc from the manufacturer of the product you're aligning.

Keep in mind, however, that it should never be necessary to turn a pot very much for any adjustment. If you're using another manufacturer's test disc and you find yourself having to turn adjustment pots excessively, the problem may be the wrong test disc, or a symptom of a problem relating to that particular alignment. If you are using the wrong disc you will never know which it is.

It should be noted that in communicating with technical support, my experience has been that many of the support technicians didn't seem overly concerned that I was using another manufacturer's test disc. Most of these discs contain a variety of music (no special test tones that I can discern), and a lot of tracks, and run the information right out to the edge of the disc. You'll have to draw your own conclusions from your own experience.

Service literature

When working on CD players, a service manual is really more of a necessity than a luxury. With the price of some service manuals on the high side, especially for non-authorized service centers, you may be tempted to wing it. If all of the adjustment points and test points are well labeled, it may be worth a try. You should, however, mark all of the adjustment pots before you touch any of them so that you can return them to their original positions—just in case.

Remember, the player should function better, not worse, when you are through.

Many of the newer carousel (turntable) type CD players require removal of the entire loading drawer to gain access to the adjustment points. This usually takes only a few minutes with the proper instructions.

As you are probably aware from servicing other devices, many different models by the same manufacturer are very similar, and a manual from one may be transposed to another. CD players are no different, so you may be able to spread the cost of one manual out over several other models.

Special tools fall into the same category. If you're pretty sure that this is the only CD player of this type, which would be easier to service with a special tool, that you will be servicing, you might be able to get by with the tools you have. But if you know that you can spread the cost of a special tool over several repairs, and it

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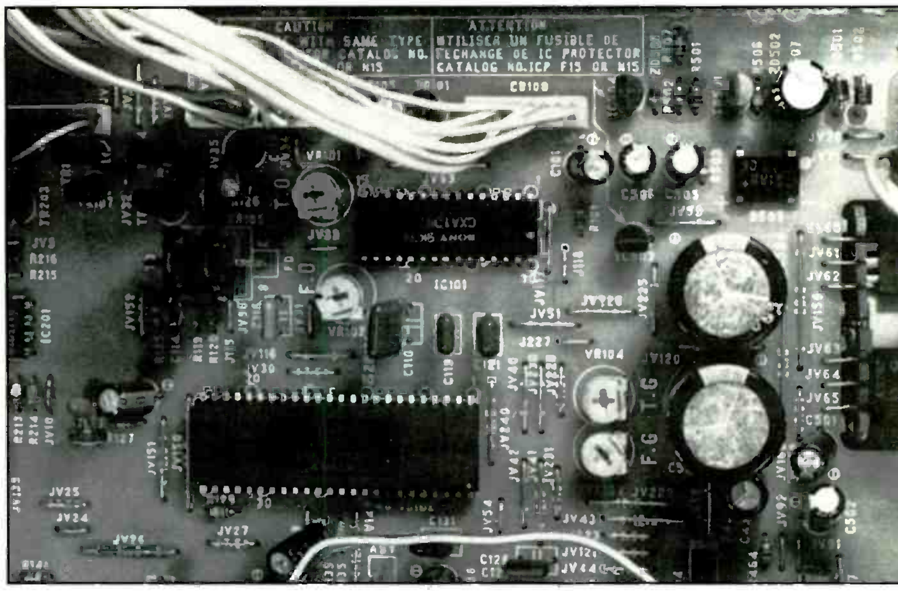


Figure 2. An example of well labeled adjustment pots. Focus offset (FO), tracking offset (TO), focus gain (FG), and tracking gain (TG) can be easily spotted on this circuit board.

will make your servicing more efficient, it may be worth the expenditure.

Some CD player servicing precautions

Before beginning you should take some precautions into account. The service manual will warn you against looking at the laser beam, and tell you not to put the laser diode in your mouth. I can understand why it might be necessary to warn you that you should not put your eyeball up against the laser lens (someone who isn't aware of the danger to eyesight might be tempted to look at it to see if they can tell if it's working), but why anyone would feel compelled to eat the laser diode is beyond me. Other, and more realistic concerns are warnings about proper handling of the laser assembly, and antistatic precautions.

Become familiar with the procedures

Read all of the alignment procedures before you start. This will give you a chance to see if you need any special tools or if you have to make any "filters," and let you explore the circuit board for all of the test and adjustment points (Figure 1). Some of them may be labeled so clearly that you hardly need the manual at all; others may be extremely obscure (Figure

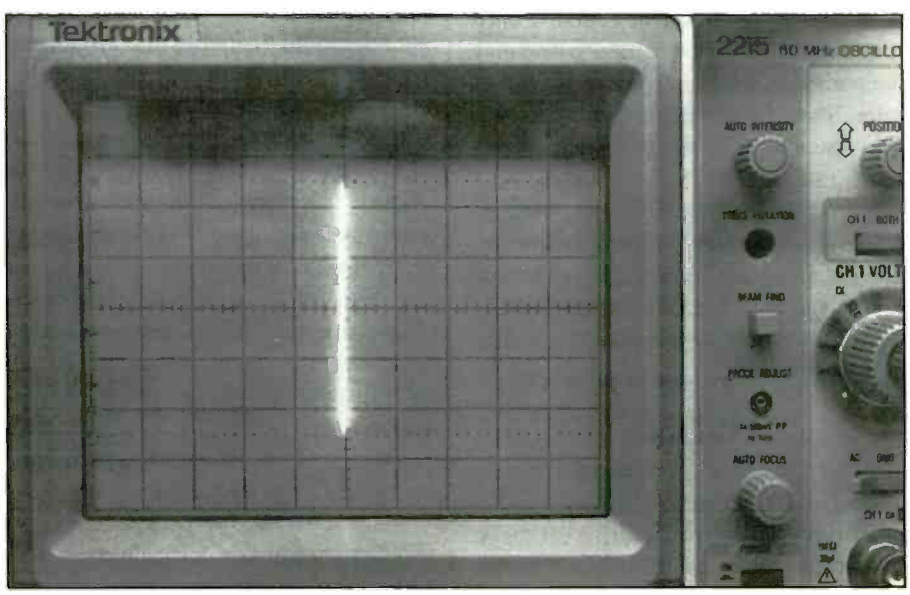


Figure 3. The tracking offset waveform compressed into a single vertical line. Using this method makes it a snap to determine if it's symmetrical about the zero point.

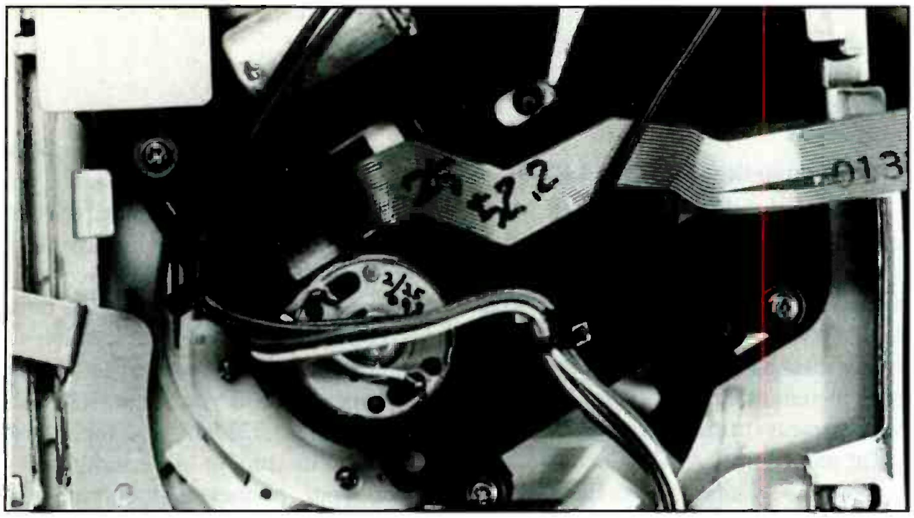


Figure 4. The pointer points to the grating adjustment on the Denon and similar multidisc players. This type of player has the laser assembly aimed downward. The disc is loaded information side up.

2). It's easy to figure that a pot labeled TG is tracking gain, and a test point labeled GND is ground. Labels like VR102 and TP1 aren't going to get you very far without the proper manual.

While we're on the subject of manuals, we have all seen more than one error in service literature. Most manuals are translated into English from another language. From some of the errors I've encountered, I've always felt that the same person who did the translation also proof read it. If you try a procedure that doesn't work, and you've double checked everything, the problem may be that there is an error in the manual.

A couple of methods seem to work for me when this happens. First, read ahead. Maybe you're supposed to be on test point 3, even though the manual says 2. Later, in that same procedure the manual may read, ". . . and be sure to remove the jumper from test point 3..." This would tell you that maybe 3 was the proper test point. In most such cases that I've run into, this cleared up the situation.

Second, if all the test points are lined up, resembling a connector, and numbered like a connector, they are usually labeled as well. It is not uncommon to find that the pin numbers are labeled in an order that's the reverse of the order printed in the manual's instructions.

If the instructions tell you to connect the ground of your scope to pin 5 (GND) of a 5 pin connector, but pin 5 is labeled TEO, check pin 1. If it is labeled GND, either the labels are wrong, or the manual is wrong. Use an ohmmeter to determine which pin is actually ground, and using that as a reference continue on. When in doubt, I've found that the labels on the circuit board are usually more correct than the pin numbers that are called out in the manual.

Labels can also help you when making connections. For adjusting Focus Gain you will have to both read, and inject a signal. You will be adjusting control FG, and attaching your probes to FEI and FEO. When tracing connections remember the I in FEI stand for Input, and the O in FEO stands for output. Obviously, you would not inject a signal into an output.

Using a filter

Most CD players require some kind of "filter" for proper adjustment, and you will have to make one. They are usually composed of a resistor and capacitor, or just a resistor. If another manufacturer calls for values different from those for a filter you have already made, the one you have will probably work fine.

The reason for the filter is to reduce the amount of "fuzz" in the waveforms. Try viewing some of the waveforms with and without the filter. You will quickly see why it is such a necessity.

Aligning the Denon DCM 777

This article will use a Denon DCM 777 as an example, with references to general alignments and problems found on other players. The Denon DCM 777 is a cartridge type multidisc player, sharing many mechanical components with Pioneer models of the same type. The service manual is easy to understand, and the alignment procedures are well documented.

Before beginning alignments you will have to place the player in the test/service mode. On this Denon you enter the service mode by shorting two pins together when powering up the player. Disc number 1 will appear in the display (0 if no cartridge is present) and you can now remove the short. The player will now stay in service mode until you turn the power off. If you do turn the player off at any time during the alignments, you will have to follow that procedure again if you want to put it back in service mode.

Different players use different procedures for placing them in service mode. Some players require that you leave a jumper in place; others require that you press and hold one or two buttons on the front panel when the unit is turned on. Like models use the same procedures.

Once in service mode you can manually switch different circuits on and off. Numbers will either be displayed, or in some cases not displayed on the front panel, indicating what test mode you are in.

The laser pickup

It is not uncommon to find that some players allow you to switch the laser off and on to see if it's functioning properly, or to adjust the output. If you do not have a laser power meter, checking the laser may be as simple as dimming the lights in the shop and cautiously looking at the lens from a distance of at least a foot, and preferably several feet, and at an angle to the direction of the beam. The beam can be easily seen at an angle quite a distance from the laser assembly.

Although the laser is fairly weak, observe proper precautions that are in the manual, and do not peer into it like a microscope. If you can see no light emitting from the laser (in a darkened room), and you are sure that the player is in the right test mode, there may be a problem with the laser.

Making the adjustments

The first alignment on the Denon DCM 777 is the PLL adjustment. Before you can get the proper frequency, the test points ASY and GND3 will have to be connected with a jumper. The frequency you are looking for is 4.32MHz. If those two points are not connected together via a jumper, you will never even get close to the proper specs. If you are having problems getting 4.32MHz, and the adjustment is at its stop, or close to it, double check your jumper and connections. Also, this measurement is taken through a 10:1 scope probe, not only on the Denon, but on many other brands as well.

The next three adjustments: Tracking DC Offset, RF Offset, and Focus Offset are easily adjusted with a DVM. You can be as much as 50mV off on these adjustments, so as in horseshoes, close counts.

Tracking Offset is adjusted with a scope, using the filter that is called for. Again, this filter is easily constructed and is invaluable in seeing clear waveforms. Although you may have to deviate your scope settings slightly from what is called for, you should see a clear waveform just like the one pictured. Don't forget to switch your scope to dc.

A trick, given to me by Yamaha Technical Support, is to compress the wave into a simple vertical line (Figure 3). Although the normal waveform is clear, it is in constant motion and difficult to get a handle on. One vertical stripe is a snap to adjust.

Adjusting the gains

Focus Gain is adjusted using a pair of filters, a frequency generator, a frequency counter, and a scope. A handful of small hook type connectors can be invaluable here. If you get confused as to where to inject the signal from the generator, once again remember the meaning of the O and the I; FEO (Focus Error OUT) and FEI (Focus Error IN). The generator goes to the input. It is usually best if you make the last connection the positive lead from the signal generator, with the player in the proper mode and the disc spinning.

Tracking Gain is adjusted almost exactly like Focus Gain, using the Lissajous waveform once again. The Denon manual gives scope settings for both Focus Gain and Tracking Gain. You will find that if your scope has V/div settings for both 10:1 and 1:1 probes, you should use the 1:1 setting with a 10:1 probe.

Virtually all alignment instructions will have you confirm Tracking Offset at some point. Once again, this is an easy alignment, especially if you remember to compress the waveform.

Denon completes their adjustments at this point, having you continue only if you are experiencing problems. Tangential adjustment, or aligning for the optimum Eye Pattern, is fairly simple. The Grating adjustment is not.

The Grating adjustment

The Grating adjustment is probably the most difficult alignment to get right—on any player (Figure 4). And if this adjustment is not correct, the CD player will not play at all. Most new players can be adjusted with a simple screwdriver, but many cannot. Investing in costly alignment tools will greatly reduce your profitability, unless you can be assured they will be used again.

Second, the Grating adjustment is extremely difficult even with the right tools. The main problems are that the adjustment is minute, and that it is difficult to differentiate between the null point of the waveform, and the (exactly as it is translated) "Waveform of not null point."

The Grating adjustment aligns the beams in a "3 beam" laser assembly. A player that won't accept discs may only need a Grating adjustment, assuming the motor and laser circuits are operating properly. Low amplitude of this waveform may indicate a laser problem.

Checking your work

When all alignments have been completed, turn off the power and remove any jumpers and probes still attached. When you power up, the player should return to normal operating mode. If you have one, a "torture disc" can be used to check out your work.

A torture disc is one of those discs with built-in dirt spots, scratches, and fingerprints. Philips manufactures a set of two discs, one with flaws, and one without (for reference). Although pricey, around $100, these discs can be an invaluable diagnostic tool.

If the customer complains of only one or two discs being a problem, make sure they bring the discs in with the repair. If the discs are clean with no major scratches, and you can duplicate the problem with these CDs, playing them after the player has been serviced will help confirm that you have indeed solved the problem, assuming the discs play fine on another player.

A few thoughts

You'd be amazed how many customers don't realize that the "business" side of a CD is the side without writing on it. Yes, all their discs are clean, just on the wrong side. Also, some players, like the Denon DCM 777, accept discs upside down (music side up). Both the Denon and Pioneer cartridge type players share the same transport assembly, and load the same way. Although they are both very good products, neither will play a disc that has been loaded label side up.

Mechanical problems

Remember the good old days of records (LPs)? Remember how you sometimes had to enlarge the hole to get the record to fit on the spindle? Well, some CDs have the same problem. They don't sit properly on the CD "turntable," and have to be gently reamed out. Since everything that goes on inside the player is hidden from view, you can't see that the disc is not sitting flat in the clamper assembly.

Waveforms that pulsate vertically may indicate a bent spindle. Waveforms that pulsate horizontally, like a "Slinky," may be an indication of a motor (speed) problem. And waveforms that will not reach proper amplitude may indicate some sort of laser problem.

You may want to check for service bulletins. The Denon DCM 777 had a problem with intermittent disc access. The problem is solved by replacing R144 (68K ohms) with a 91K resistor. This modifies the feedback circuit driving the spindle motor, allowing the CD to "spin up" faster. If the problem still persists, a new motor may be required.

This information is portable

Alignments on other models are very similar, although the labels and order of adjustments may not be the same. For example, on a particular Yamaha player the PLL adjustment is called VCO Freerun. Yet, you are still looking for a reading of 4.32MHz, and you still are required to use a 10:1 probe.

The more you do these adjustments the easier they get. You will soon begin to see the similarities from one brand to the next, and when you come across one of those really vague service manuals, your previous experience will go a long way.

Experience will also teach you what waveforms to look for when evaluating problems, regardless of the manufacturer or the absence of a manual. It's a great feeling to be able to tell your customers what the problem is, without having to repair the unit first.

Although proper alignment will add time to any repair, I'm reminded of an old saying, "We can never seem to find the time to do it right, but we always have the time to do it over again."

Servicing and adjustment procedures for the Denon DCM 777 compact disc player

The Denon DCM 777 CD player contains a microcomputer that includes all of the programs to perform servicing for each servo adjustment.

To activate the service program, perform the following steps:

1. Turn the power off.
2. Short circuit pins 3 and 4 of TP 102.
3. Turn the power on. The indication "Disc No. 1" will show on the display.
4. Remove the short circuit.

When the unit has been placed in the service mode by following the above steps, the operating controls will not function normally, but will only operate for servicing. When the service program is invoked, the laser pickup will move to the optimum position.

The only controls that are used during normal service procedures are EJECT, STOP, PLAY AND PAUSE. The use of these buttons for service will be described here. All of the other buttons are reserved for factory use, for specific functions such as checking the IC. Operation of these buttons during service could result in incorrect function of the CD player.

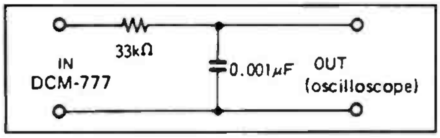


Figure 5. Connect the oscilloscope to the CD player through this filter network for making all adjustments, except where directed otherwise.

If you accidentally push any of these buttons, immediately turn power off and activate the service program again. You should also never use the remote control when the service program is activated.

Note that in a number of the adjustment procedures following, the first step is "Set the unit to test mode." If the unit is already in test mode, you, of course, don't have to go through that procedure again.

Preparations for making the adjustments

Before moving any of the adjustment controls, first adjust, if necessary, the turntable height, the laser pickup system and the spindle motor system. The super linear convertor in this unit ordinarily requires no adjustments.

The equipment required to perform the adjustments are:

- Dual-trace oscilloscope (100MHz or greater bandwidth)
- Adjustment disc (33CA-1094)
- Low frequency oscillator: 10Hz to 10kHz, 0Vpp to 3Vpp
- Frequency counter readable to over 5MHz
- Filter network for measurement (see Figure 5)

Place the unit in service mode as described earlier, then set the adjustment controls (VR102 to VR106) to the positions shown in Figure 6. Make the adjustments in the following order:

1. PLL
2. Tracking dc offset
3. RF offset
4. Tracking offset
5. Focus gain
6. Focus offset
7. Tracking gain
8. Tracking dc offset
9. Tracking offset

PLL (phase lock loop) adjustment

- Set the unit to test mode.
- Confirm that the display shows "Disc No. 1."

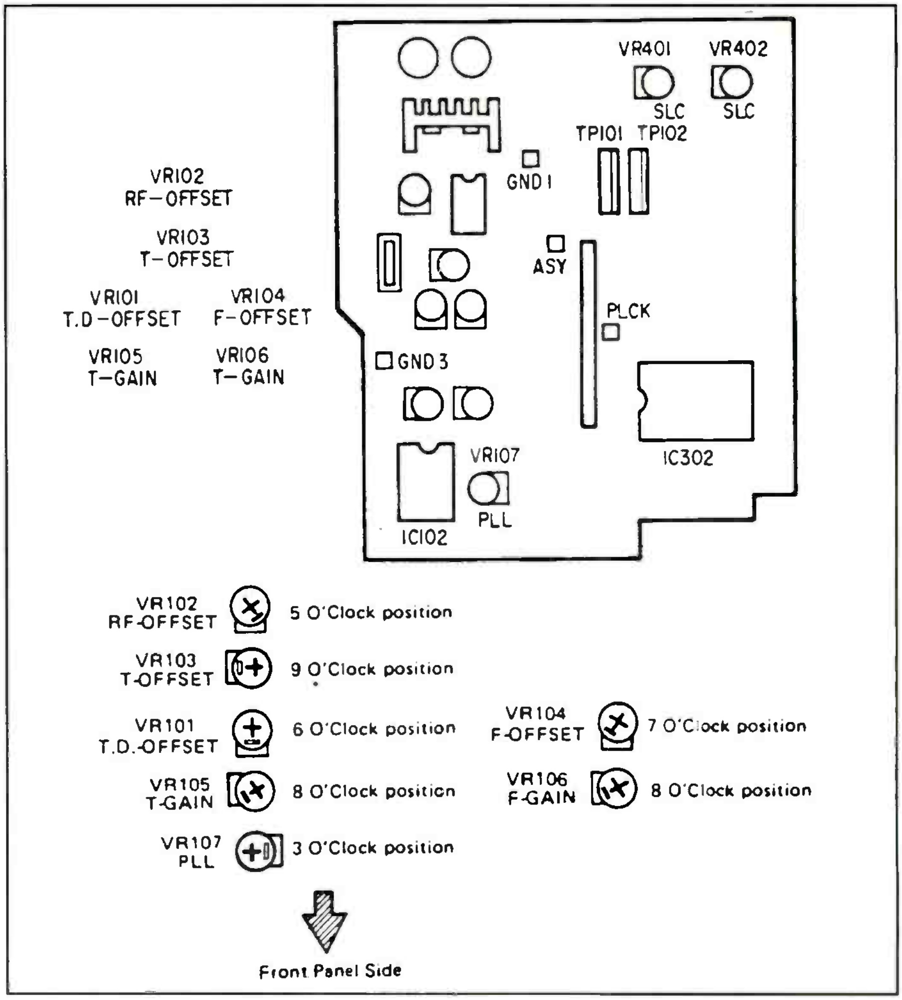


Figure 6. The PC board outline, along with the callouts to the left, give an idea of the position of the adjustment pots. The illustrations below the PC board show the correct initial positions of these pots.

- Connect the ASY to "GND 3" for grounding.
- Connect the positive side of the frequency counter to test point "PLCK" (phase lock) using a 10:1 oscilloscope probe, and the negative side to "GND 1."
- Rotate the PLL VR (variable resistor) to obtain an indication of 4.32MHz ± 10kHz on the counter.
- Disconnect the ASY from the ground.
- Disconnect the frequency counter grounding jumper.

Tracking dc offset adjustment

- Set the unit to test mode.
- Confirm that the display shows "Disc No. 1."
- Set the VR103 (Tracking offset, or T.O. ADJ) to a position 45 degrees clockwise from its mechanical center position.
- Adjust the VR101 (Tracking dc offset, or T.D. ADJ) until the voltage at pin 3 of TP101 (TEO) measures 0V ± 50mV.

RF offset adjustment

- Press the Stop button.
- Confirm that the display on the CD player shows "Disc No. 1."
- Adjust the VR102 (RF offset adjustment) until the voltage at pin 1 of TP 102 is 100mV ± 50mV.

Tracking offset adjustment

After you have completed this adjustment, readjust the Tracking dc offset.

- Set the unit to test mode.
- Insert the adjustment disc into the magazine and insert the magazine into the CD player.
- Press the Stop button and confirm that the display shows "Disc No. 1."
- Set Channel 1 of the oscilloscope for 50mV/div, and ground the input. Adjust the vertical position, if necessary, to make sure that the trace is at the 0 position.
- Set Channel 2 of the oscilloscope to 5ms/div.
- Press the Play button. The disc will be pulled out of the tray and begin to revolve.
- Check to see that the display now shows "Disc No. 2."

(Continued on page 41)

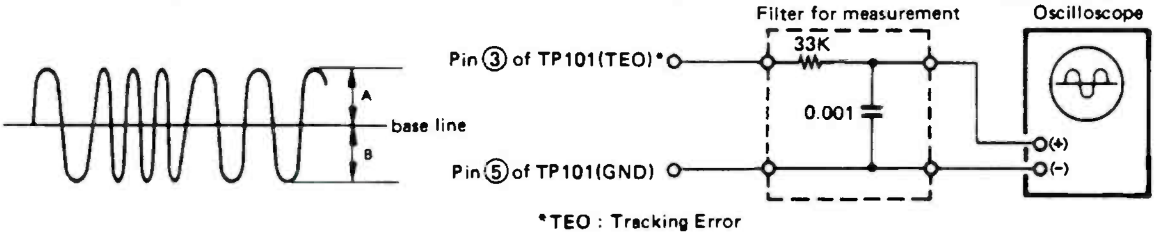
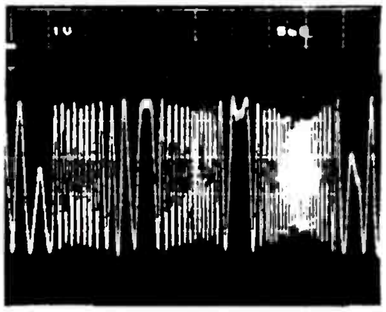
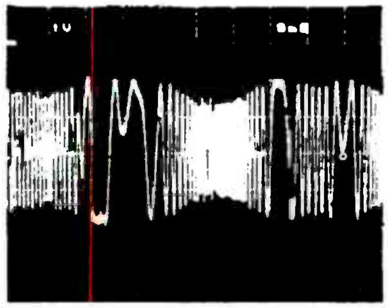


Figure A Tracking offset adjustment



DC component exists



DC component not exist

Figure 7. Connect the oscilloscope to the CD player as shown here to adjust tracking offset. Adjust the pot so that the amplitudes of the signal above and below the oscilloscope's baseline are equal.

• Using a 10:1 probe, connect the oscilloscope as shown in Figure 7.

• Adjust VR103 to make A and B equal in height. That is, the signal amplitude should be symmetrical about the vertical zero position. This will minimize the dc component of the signal.

Focus gain adjustment

• Set the oscilloscope Channel 1 to 20mV/div, and connect a 10:1 probe to the input of Channel 1.

• Set the oscilloscope Channel 2 to 50mV/div.

• Connect the oscilloscope, the audio

Function of the operating controls in service mode				
Name	**Function**	**Description Indication**	**Disc No.**	**Used for**
Eject	Ejection of Magazine	Be sure to take out the magazine when the system is in stop mode (Disc No. indication 1).	—	Taking out magazine
Stop	Stopping of System Movement	Push this key when the servo adjustment is completed, or to perform readjustment.	1	Tracking D.C Offset (VR101) RF offset adjustment (VR102) PLL adjustment (VR107) Focus offset adjustment (VR104)
Play	Focus Servo Turns ON Spindle Servo Turns ON	Turning on the focus servo to revolve disc.	2	Tracking offset adjustment (VR103)
Pause	All servos— Focus, Tracking, Slide, Spindle turn ON.	Turning on all servos to shift the unit in play mode.	3	Focus gain adjustment (VR106) Tracking gain adjustment (VR105)

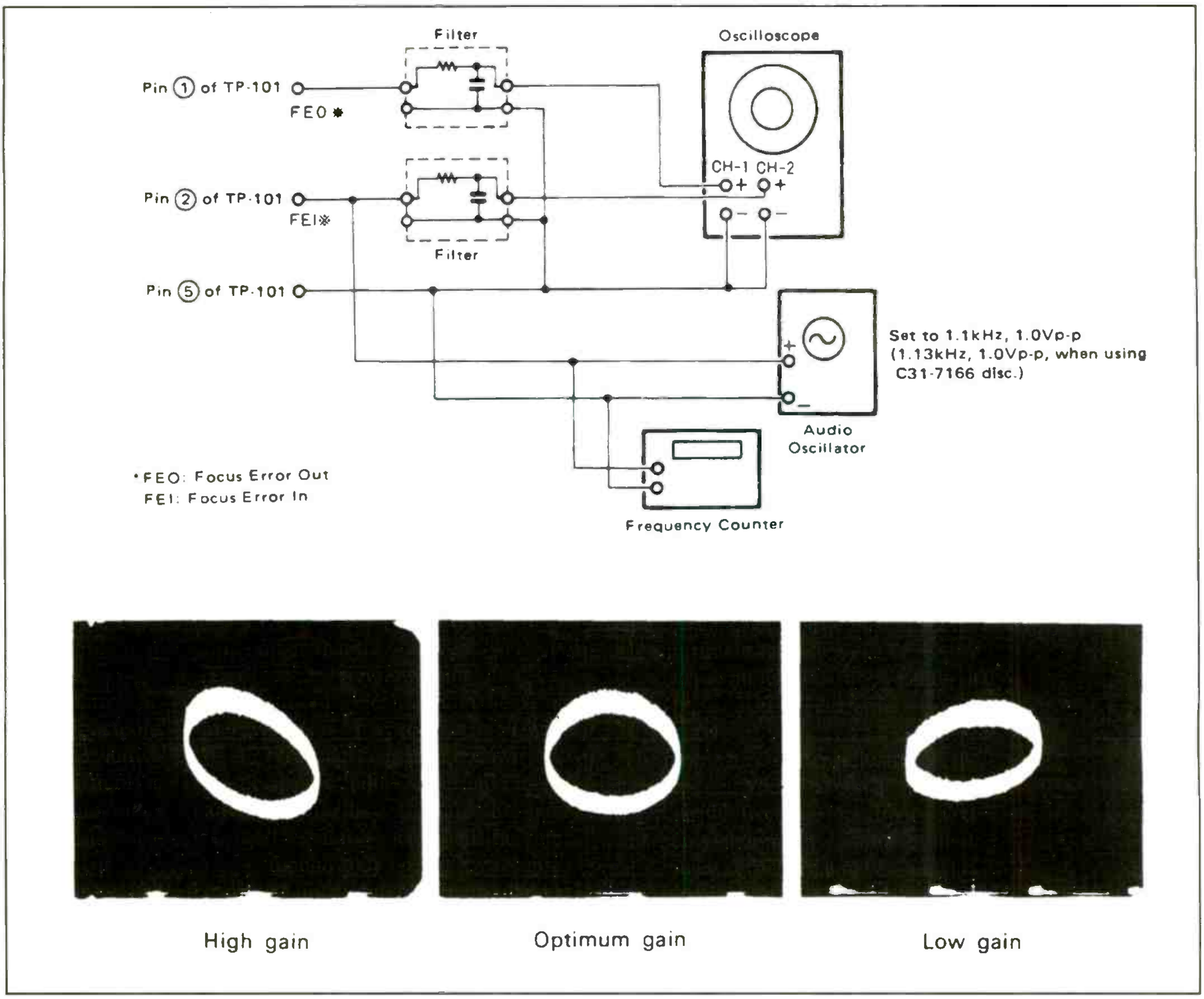


Figure 8. For the focus gain adjustment, connect the oscilloscope, the audio oscillator and the frequency counter to the CD player as shown here. Adjust VR106 so that the Lissajous pattern is symmetrical about the X and Y axes.

oscillator, and the frequency counter to the CD player as shown in Figure 8.

• Press the Pause button on the compact disc player.

• Set the audio oscillator output to 1.1kHz, 1.0Vpp. If you're using C31-7166 disc, set the oscillator output to 1.13kHz, 1.0Vpp.

• Set the oscilloscope to X-Y mode in order to observe the Lissajous pattern.

• Make sure that both channels are set to dc input.

• Adjust VR106 so that the Lissajous pattern is as close to symmetrical about both the X and Y axis as possible (the closer to symmetrical the pattern, the closer the phase difference between pin 1 and pin 2 is to 90 degrees).

Focus offset adjustment

• Set the unit to test mode.

• Confirm that the compact disc player display shows "Disc No. 1."

• Adjust the VR104 (Focus offset adjustment) until the voltage at pin 1 of TP 101 is 0V ± 50mV.

Tracking gain adjustment

The tracking gain adjustment is performed in much the same way as is the focus gain adjustment.

• Set the oscilloscope Channel 1 to 50mV/div, and connect a 10:1 probe to the input of Channel 1.

• Set Channel 2 to 20mV/div.

• Connect the oscilloscope, the audio oscillator, and the frequency counter to the CD player as shown in Figure 9.

• Press the Pause button on the compact disc player.

• Incorrect operation sometimes occurs if the oscillator is connected before the servo is actuated. If this happens, disconnect the oscillator, press the Stop button on the CD player, then push the Pause button to actuate the servo again. Finally, reconnect the oscillator.

• Set the audio oscillator output to 2.6kHz, 2.0Vpp. If you're using C31-7166 disc, set the oscillator output to 3.0kHz, 2.0Vpp.

• Set the oscilloscope to X-Y mode in order to observe the Lissajous pattern.

• Adjust VR105 so that the Lissajous pattern is as close to symmetrical about both the X and Y axes as possible (the closer to symmetrical the pattern, the closer the phase difference between pin 1 and pin 2 is to 90 degrees).

Confirmation of tracking offset

• Adjust tracking dc offset again.

• Adjust tracking offset again.

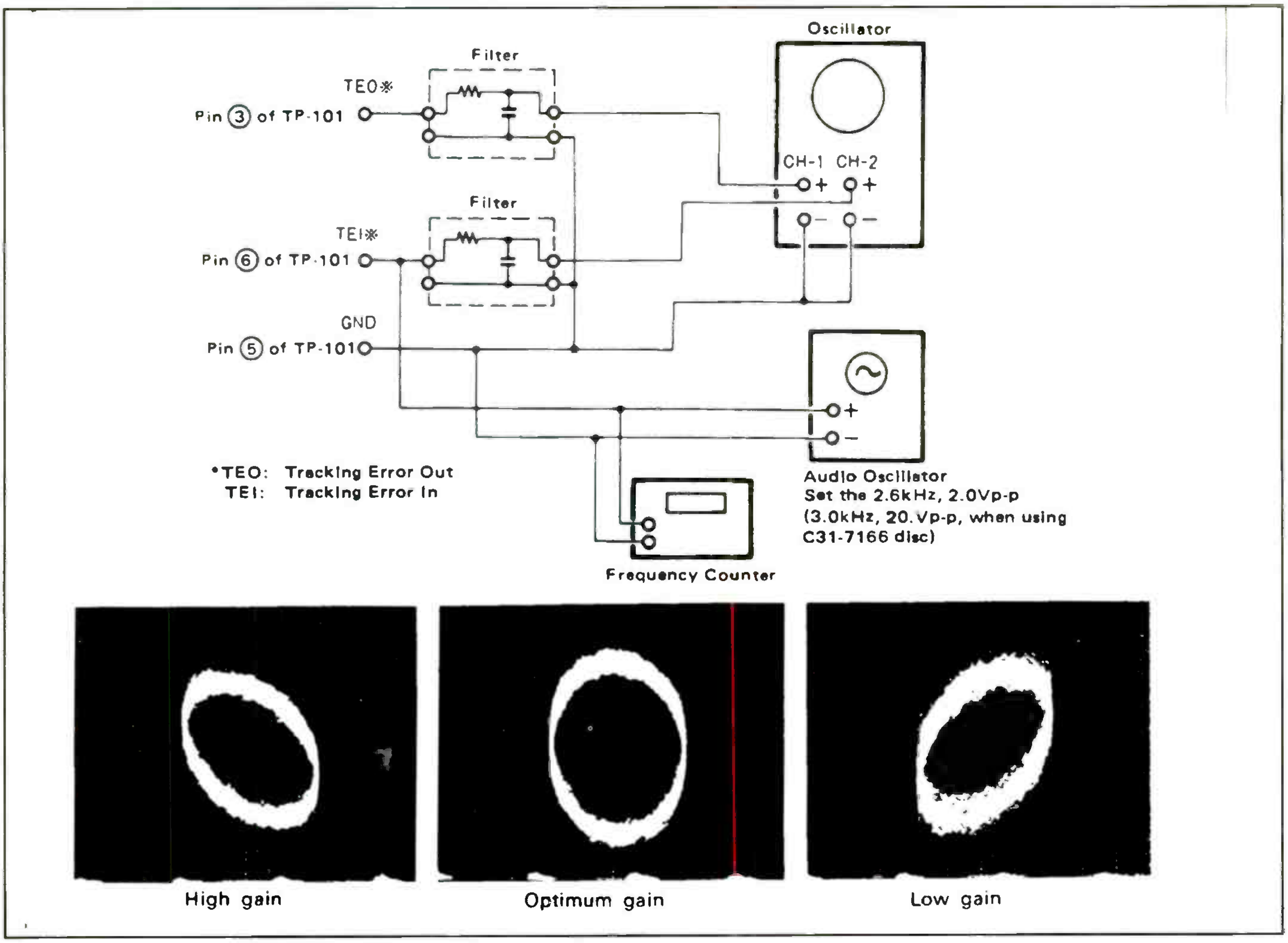


Figure 9. Connect the oscilloscope, the audio oscillator and the frequency counter as shown here to adjust the tracking gain. Adjust VR105 so that the Lissajous pattern is symmetrical about the X and Y axes.

• Press the Stop button.

• Press the Play button to confirm that the disc starts revolution. Sometimes pressing the Play button will not have any effect. If that happens, press the Play button again. Make sure that the display shows "Disc No. 2."

• Confirm that the waveform is symmetrical about the baseline. The height of the waveform above the baseline and the height of the waveform below the baseline must be within 5% of each other.

• If the difference in height exceeds 5%, adjust VR103 to correct this problem.

Adjustments are finished

At this point, all adjustments have been made. Press the Stop button to stop revolution, and press the Eject button to disengage the magazine and remove the adjustment disc.

If you are unable to properly perform

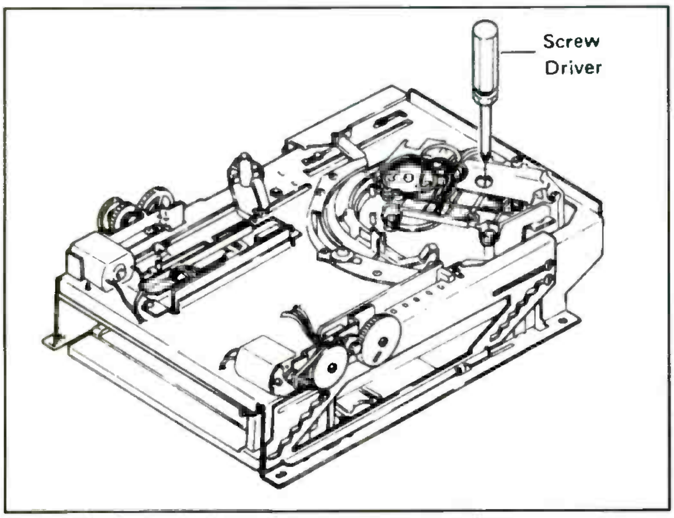
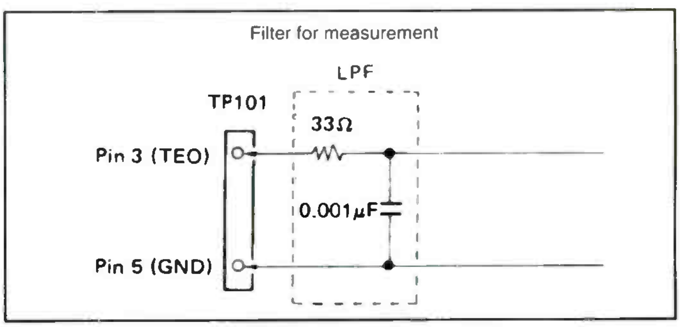


Figure 10. The grating adjustment screw may be reached by inserting a screwdriver through the oval hole in the upper side of the servo mechanism.

Figure 11. For the grating adjustment, observe the waveform at pin 3 (TEO) of TP101 on an oscilloscope. Connect the oscilloscope through a filter such as this one.



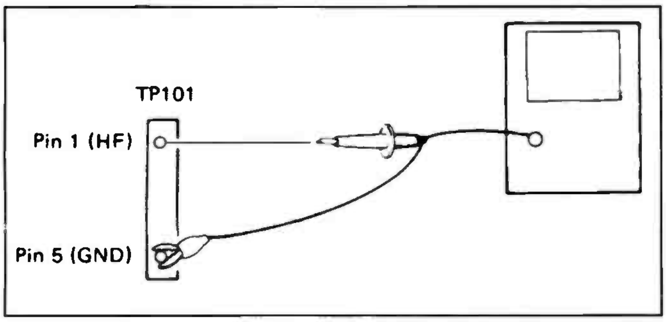


Figure 12: Observe the RF output at pin 1 (HF) of TP101 with the oscilloscope.

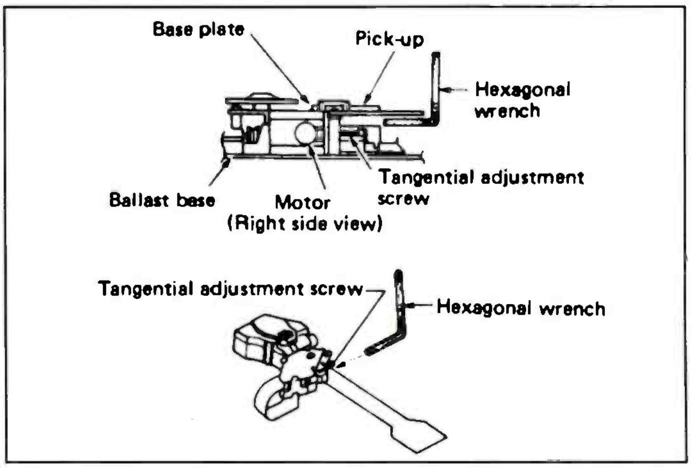


Figure 13. Adjust the tangential adjustment screw until the eye pattern becomes clear.

any of the servo adjustments after correcting a malfunction or replacing the laser pickup, it may be necessary to perform a grating adjustment first.

Grating adjustment

• Set the CD player to service mode.

• Press the Play button to activate the Focus and Spindle servos.

• Shift the pickup toward the center of the disc by pressing the Automatic Search Fwd button so that the grating adjustment screw of the pickup can be seen through the oval hole in the upper side of the servomechanism (Figure 10).

• Insert a screwdriver into the adjustment hole from the upper side of the mechanism, and confirm that the grating screw turns.

• Observe the waveform at pin 3 TEO (tracking error) of TP101 with an oscilloscope. Measure the signal through a 4kHz cutoff low pass filter (Figure 11).

• Turn the screw until you reach the point of minimum amplitude (null point).

• Slowly turn the screwdriver counterclockwise from the null point and adjust until the waveform (tracking error signal) just reaches its maximum amplitude. Don't press too hard on the screwdriver when making this adjustment, or the pickup may move toward the center of the disc, making this adjustment difficult.

• Finally, with the oscilloscope connected directly to the test point (without the 4kHz filter in the circuit), confirm that the tracking error signal (when the pickup is moved toward the disc center) and the peak-to-peak voltage of the tracking error signal at the outer circumference of the disc are not greatly different. If this difference exceeds about 10%, readjust by turning the grating screw to the maximum error amplitude point.

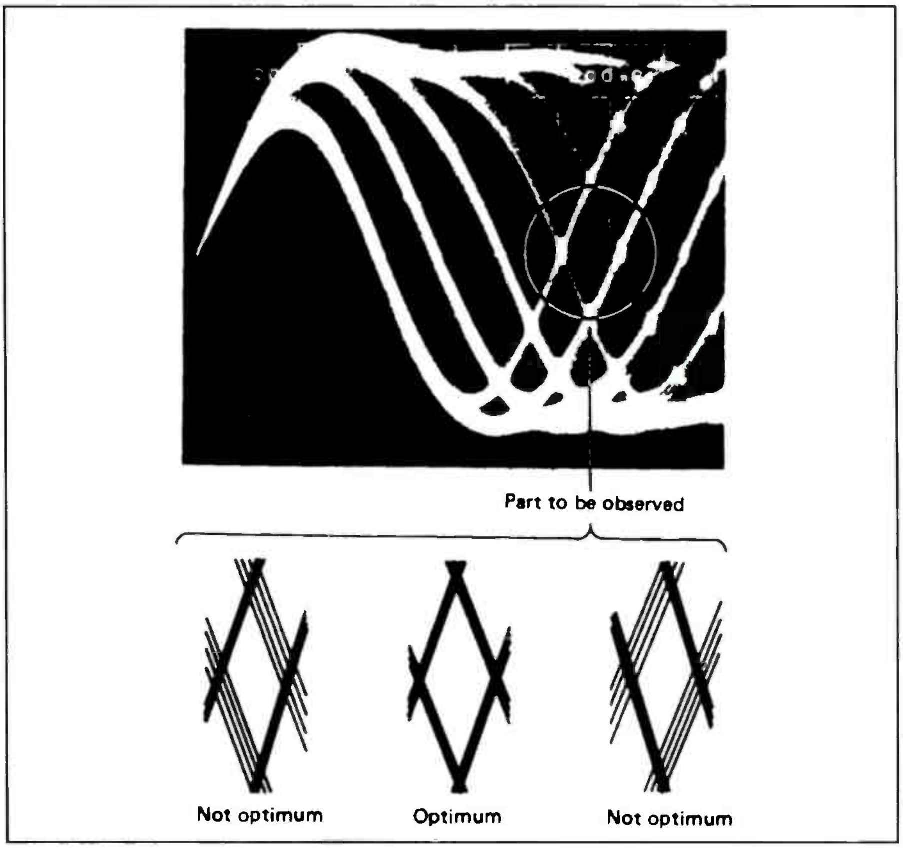


Figure 14. When the grating adjustment is correct, the eye pattern should be clear, as shown here.

Tangential adjustment

• Set Channel 1 of the oscilloscope to 20mV/div, and connect a 10:1 probe to the Channel 1 input.

• Set Channel 2 to 0.2μs/div.

• Insert the test disc into the compact disc player.

• Invoke the service mode.

• Shift the pickup toward the center of the disc by pressing the Automatic Search Fwd button.

• Press the Pause key. This will activate all servos.

• Observe the RF output at pin 1 (HF) of TP101 with the oscilloscope (Figure 12), and adjust the tangential screw (Figure 13) until the eye pattern becomes clear (Figure 14).

• The correct point for this adjustment is the point midway between the point where the eye pattern deteriorates by turning the tangential screw clockwise, and the point where the eye pattern deteriorates by turning the screw clockwise. As a criterion, the overall waveform is clear and the lines that define one of the diamond shapes within the eye pattern should be relatively fine. During this adjustment, hold the hexagonal wrench vertically so that it doesn't exert downward pressure on the pickup as you turn it. ■

Test Your Electronics Knowledge

Questions from past issues

By J. A. Sam Wilson

Are you keeping up with the technology? You are if you're reading ES&T magazine. Here is a short review. All questions are related to the January and February '93 issues. Specific references are given with the answers.

1. Unlike traditional filters which consist entirely of passive components, active filters utilize
 A. non-linear amplifiers.
 B. linear amplifiers.

2. Which of the following is often used to provide active low-frequency attenuation for high-pass filters?
 A. differentiating circuit
 B. integrating circuit

3. Which of these filter networks has been the tone control workhorse for years?
 A. reverse slope
 B. bandwidth clipping
 C. Baxandall circuit
 D. current feedback

4. The equation dB = 20log(V2/V1) can be used
 A. anytime.
 B. only when the input and output impedances are the same.
 C. only if the input and output currents are the same.
 D. only when the input and output voltages are the same.

5. According to owners of some large service centers, the number of house calls per day necessary for a decent profit is
 A. 4 to 6.
 B. 6 to 8.
 C. 8 to 10.
 D. 10 to 12.

6. In order to be profitable, an on-site service of consumer electronic equipment should be completed in (how much time?)

____

7. There are three things you should do before making any tests in a microwave high-voltage circuit. They are:

____

____

____

8. An ac meter can be connected across the primary of the HV transformer in a microwave oven to determine if the primary circuits are normal. In place of the ac meter you can use a

____

9. Is the following statement correct? "Regarding VCR troubleshooting, if any part of the playback picture is clear the trouble is not the video heads."
 A. The statement is correct.
 B. The statement is not correct.

10. Just when you thought digital tape was the medium of the future, here comes DCC. What do the letters DCC stand for?

____

(Answers on page 54)

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

Tuner and control problems

By Homer L. Davidson

Symptoms such as a snowy picture, a white and dark raster, erratic or intermittent picture all point to a defective tuning system. In early TV sets, the mechanical tuner consisted of a wafer or turret type tuner controlled by a manually turned tuning knob.

In today's sets, the tuning section may include such circuits as a control system, prescaler, band switching, microcomputer, AIU and CITAC tuning controllers.

RCA's digital control systems

In RCA's CTC140 chassis, the digital tuning control system consists of a system control microcomputer, U3100, an analog interface unit (AIU), U3300, and a band switching IC, U3600 (see Figure 1). The AIU controls the tuning operation. The system control microcomputer, U3100, is controlled by a keyboard or remote control to select the correct station.

The system control microcomputer in this set sends the channel information to the AIU, U3300. The AIU supplies band switching information to the op-amp/band-switch IC, U3600. The band switch IC provides tuning voltage to a varactor-tuned oscillator in the tuner assembly.

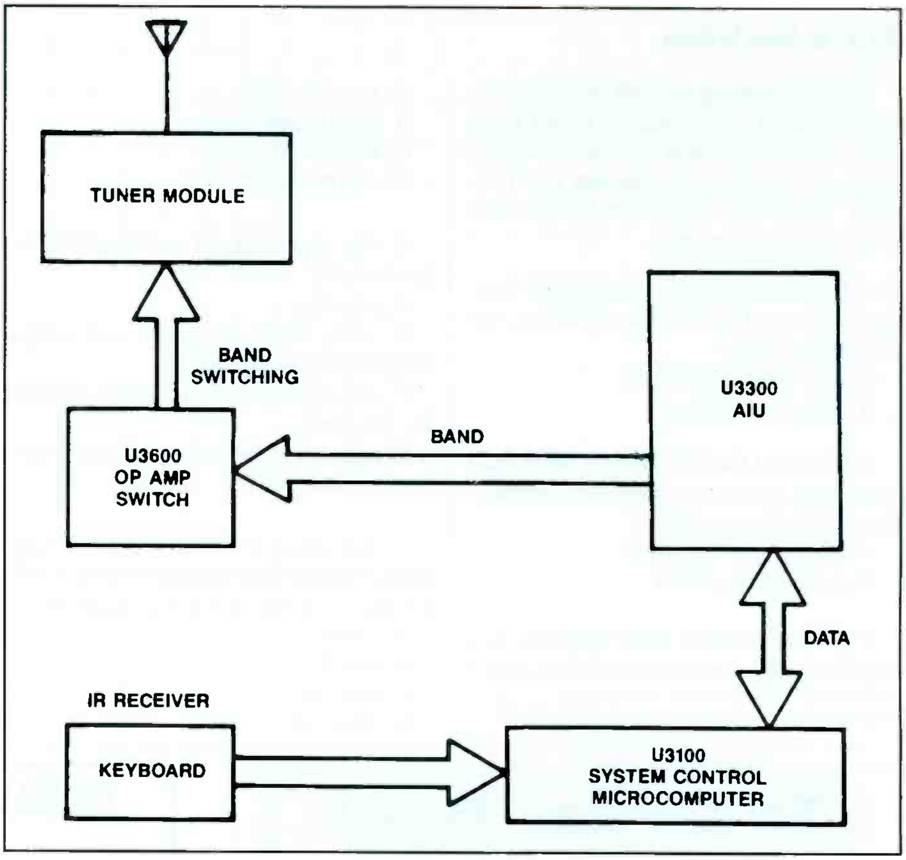


Figure 1. The system control IC, U3100, in RCA's CTC140 chassis, controls U3300 and band switching IC, U3600, which supplies a tuning voltage to the tuner assembly to select the correct channel.

Sylvania's B1 series tuning system

The Sylvania TS-17 tuning system has a microcomputer, computer interface tuning and control IC (CITAC) and varactor tuner. This tuning system may be controlled via a remote control or through controls on the set. The tuning system selects channels in a number of ways: by scanning or random access from the remote control, or by scanning or random access from the on-set keyboard.

Most TV microcomputer control systems are alive at all times, supplied with standby voltage. The CITAC controls band switching and channel tuning (Figure 2).

In this system, the microcomputer, IC302, receives the control signal from the on-set keyboard or from the remote control system, and controls IC301. IC-301 sends a control voltage to the UHF/VHF varactor tuner.

Some of these U/V tuners may actually have as many as 152 channel, cable-ready control systems.

As with other control systems, while the RCA and Sylvania tuning systems may be based on different components the control system results are the same: the control system provides a change in voltage to the varactor tuner, which in turn, tunes in the selected channel.

The manual tuner

Until remote control TV systems were introduced, manually-operated wafer or turret type tuners were used in every TV chassis. The manual tuner was controlled with a tuning knob, which changed channels and also switched in the UHF tuner.

The manual ultra-high-frequency (UHF) tuner is located under or on top of the very-high-frequency (VHF) tuner, and is also rotated manually (Figure 3). Some of these tuners are still found in a few low-priced TV receivers, especially monochrome models.

In time, the silver contacts of the mechanical tuner become tarnished or dirty. When these tuners become dirty, they require cleaning. To clean a mechanical tuner, spray cleaning fluid inside the switch contacts, and rotate the tuning knob.

Another tuner-related problem encountered with mechanical tuners is caused by the RF transistor when it becomes defective. When the RF transistor is defective, it causes snow in the picture.

If it is not possible to tune in stations the problem may be a defective oscillator or mixer transistor.

Some technicians replace the RF tran-

Davidson is a TV servicing consultant for **ES&T**.

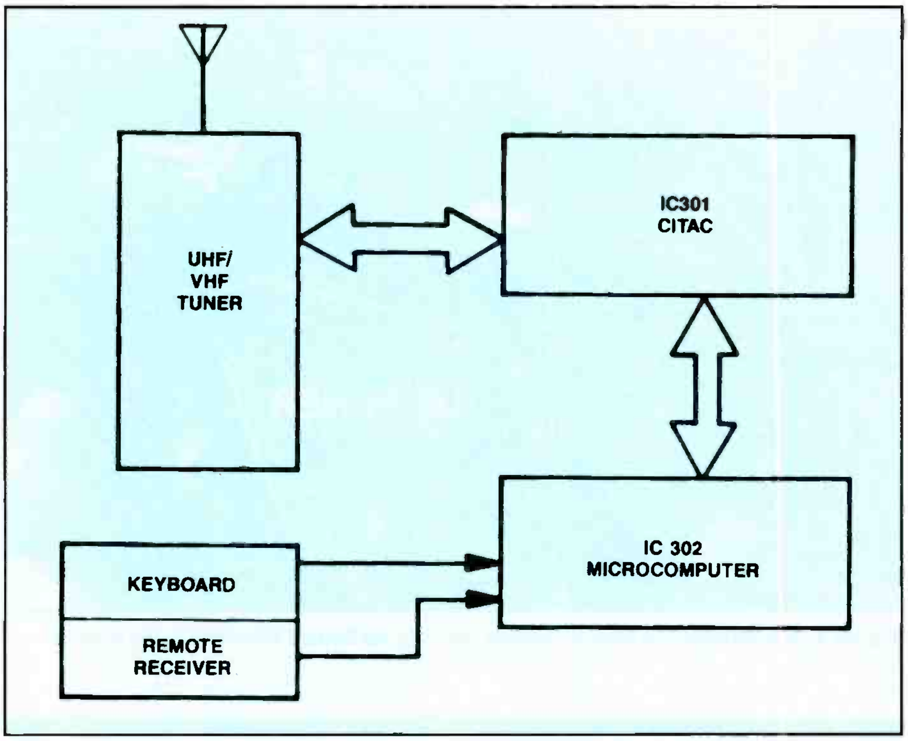


Figure 2. In the Sylvania TS-17 tuning system, microcomputer IC302 controls data to IC301, which provides local oscillator tuning voltage to the U/V tuner.

sistor if it is easily accessible. Most tuners, however are sent to a service depot to be remanufactured.

Varactor tuners

When the voltage applied to a varactor diode is changed, the capacitance across the diode changes. In effect, the varactor diode is a semiconductor-type voltage-variable capacitor.

In varactor tuning, the frequency of an oscillator consisting of an inductor and a varactor diode is controlled by changing the voltage across the diode, which alters its capacitance. The varactor diode takes the place of the variable capacitor ordinarily used to tune the oscillator.

In sets with mechanical tuners, the tuner is usually at the right side of the front of the TV. That's because it makes sense to locate the tuner directly behind the tuning control knob.

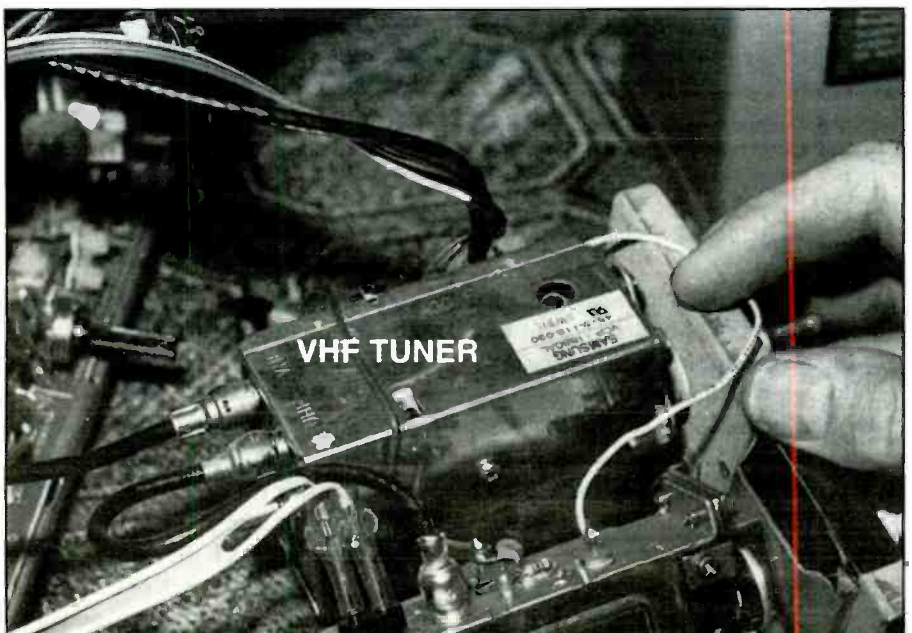


Figure 3. The mechanical turret or wafer tuner requires periodic cleaning of the switching contacts.

Today, you may find the varactor U/V tuner anywhere in the set, even in the middle of the chassis (Figure 4). A varactor tuner can be mounted any place, as long as the control system changes the tuning voltage applied to the varactor tuner.

The varactor tuner has no moving parts, so cleaning it is not a concern. But varactor tuners do experience tuning problems. A defective varactor tuner may cause a snowy picture or drifting of the channel off frequency, or may fail to tune stations in.

You may find surface mounted components (abbreviated SMD; for surface-mount device) in the latest varactor tuners. These SMDs are found on the pc wiring or foil side. You may need a magnifying glass to see them (Figure 5). The large tuning components are found on the side of the pc board opposite the wiring.

Repairing these small tuners is difficult and time consuming, unless the problem is caused by something obvious, like poor soldered joints, loose terminals, or connected wiring. Be careful when soldering suspected terminals, to avoid damaging SMD diodes and transistors. If the set is in warranty, send the tuner to the manufacturer. If the set is out of warranty, send the tuner to a tuner service depot.

Tuner modules

In many sets, the tuner and control circuits are in separate modules. Although TV sets are no longer being manufactured with modular circuits, you still may encounter a few sets that have tuner modules. You can easily determine which of the modules is the tuning module: it's the one with the antenna and IF cable attached to it. The control module will have several plug-in type wire harnesses (Figure 6).

When the symptom is a snowy picture or raster, or if you can't tune in a station, simply remove two or more metal screws, and the IF cable, and pull out the tuner module and install a replacement. Sometimes both modules must be replaced when damaged by lightning.

The defective module can be sent into a tuner service station for an exchange or for servicing.

Replace the control module when stations cannot be selected or if there are no control features.

Tuner subber

The tuner subber may be used to determine if the tuner is defective, control circuits are defective, or the chassis is causing the snowy raster or picture. Actually, the solid-state subbers are nothing more than a channel 2 to 13 tuner operating from a battery source.

Simply connect or plug in the subber to the IF cable of the TV chassis in place of the TV's tuner. Connect the antenna lead to the tuner subber and tune in a station (Figure 7).

If the subber tunes in all stations connected to the IF cable, you may assume that the chassis is normal and that the tuner is defective. When the picture tuned in by a known-good substitute tuner is snowy, or if you can't tune in a picture at all, check the IF and AGC circuits of the TV chassis.

Although some tuner subbers may be collecting dust on a shelf of the service bench, they are still effective and an easy method to tell if the tuner or chassis is defective, even in the latest TV chassis using varactor tuning.

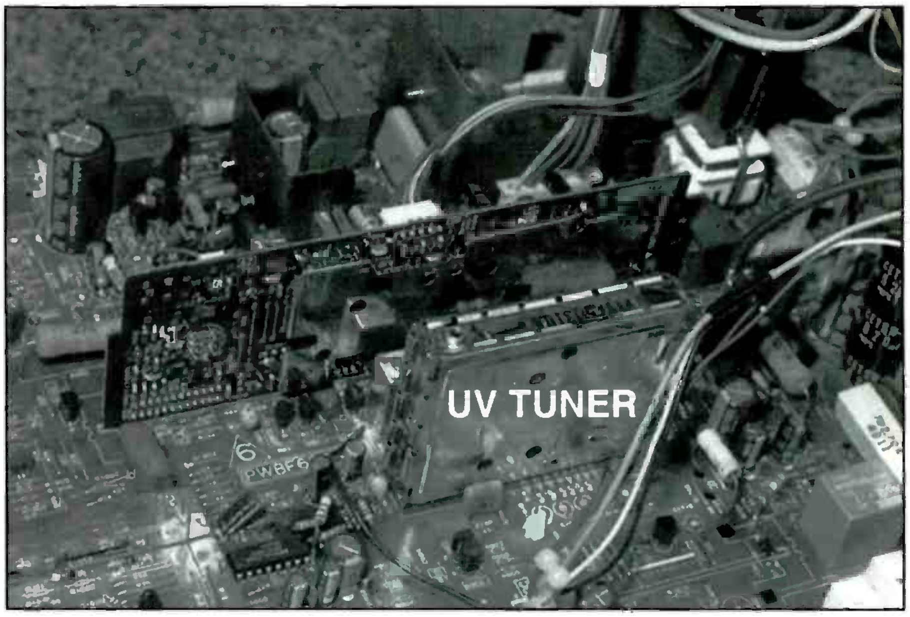


Figure 4. The varactor U/V tuner in modern sets may be located anywhere in the chassis.

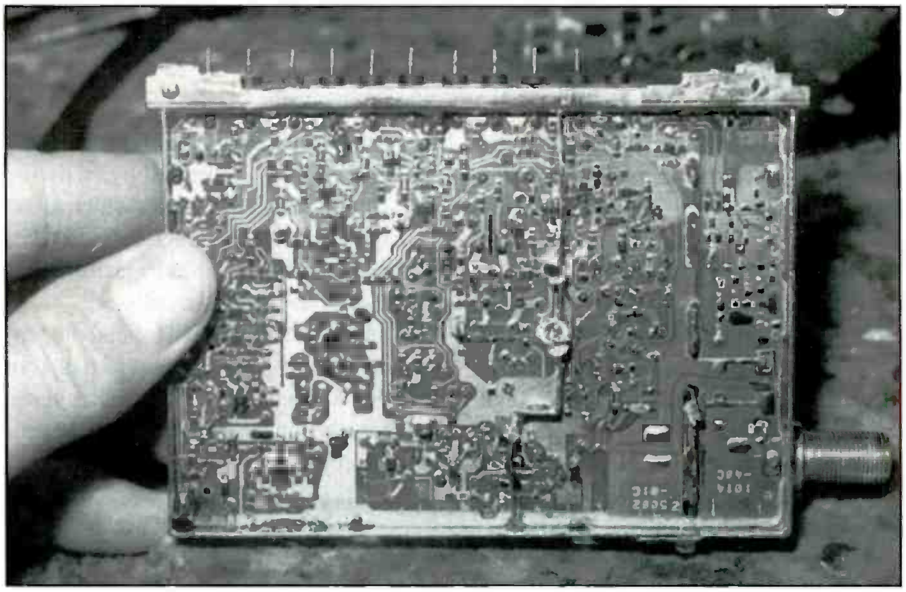


Figure 5. Surface mounted devices (SMD) are located on the pc foil side of the small U/V tuner. Larger, through-hole components are mounted on the other side of the board.

Locating the defective tuner

When the symptom is a snowy picture, no stations tuned in or drifting off channel, the source of the problem can be isolated by checking the dc supply voltage, and the AGC, and substituting a tuner subber for the suspected tuner. Simply measure the supply voltage, V_{CC}, and the tuning voltage applied to the local oscillator circuits within the varactor tuner.

After checking the B+ voltage (+12V in Figure 8), locate the tuning voltage supplied by the band switch, prescaler, or microcomputer control to the varactor tuner. Check to see if the voltage changes as different stations and channels are selected (pin 5). This voltage will vary from 0.5V to 35V.

For instance, when the set is tuned to channel 2 the voltage is around 2.6V. The voltage applied to the varactor diode to tune in channel 3 is about 4.3V. The voltage for channel 6 is about 11.5V. If you measure 0V, or voltages of the wrong value on the tuning oscillator pins, suspect the control circuits.

These voltages may not be the same in the tuning control systems of sets made by other manufacturers. You can use an external voltage source to pin down whether the tuner or the controller is the defective section. Use a bench power supply to inject a variable dc voltage at the tuning voltage pin of a suspected varactor tuner.

In the case of this set, I connected the variable power supply voltage to pin 5 (see Figure 8) and slowly raised the voltage. I connected the positive lead to pin 5 and the negative to common chassis ground. When you're using a bench power supply to substitute for the varactor tuning voltage, do not vary the voltage over 35V.

If stations are tuned in up and down the tuning range as you vary the voltage, suspect a controlling circuit. When no stations can be tuned in with the external variable power supply, replace the defective varactor tuner. If stations drift off frequency, check the AFT circuits. If the AFT is working properly, replace the tuner.

Checking tuner control

If you don't find any variable voltage at the tuning oscillator pin of the tuner assembly, suspect a defective controller, band switching, prescaler or tuning control IC circuit. Check the supply voltage pin upon each band switch or tuning control IC. Measure all voltages supplied to the U/V varactor tuner.

Test for low and high VHF voltages,

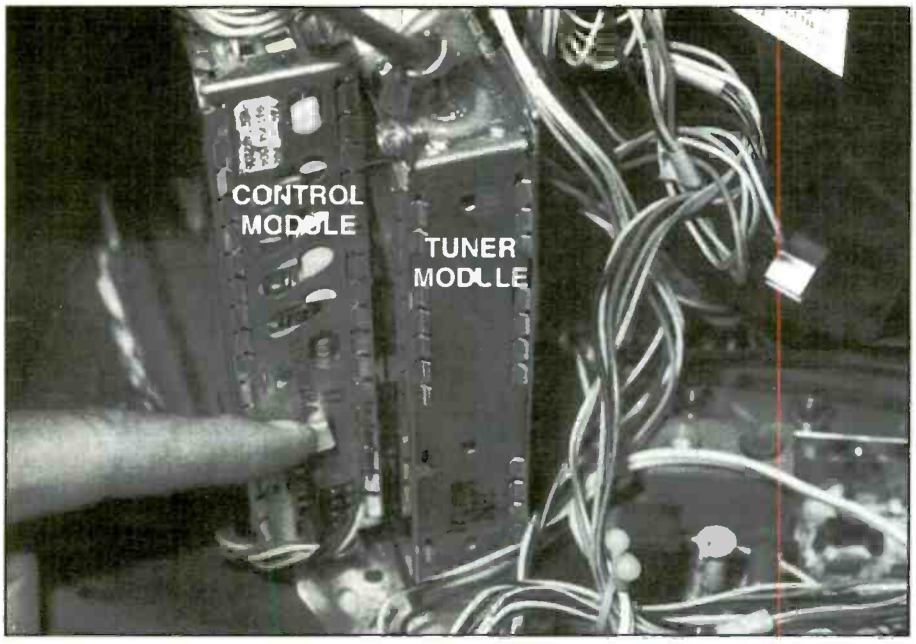


Figure 6. The defective tuner module may be easily located: it's the one with antenna and IF cable connected to it.

UHF and cable channel voltages upon the microcomputer interface tuning and control IC. Band switching charts that indicate a low and high voltage source at each band pin terminals may be found in the service literature.

Scope the phase pulses, data and clock waveforms while tuning in the channels. Simply replace the control module if normal voltage applied to the tuner causes the tuner to appear normal. If you replace the switching control IC, the band switch IC, or the system control microcomputer chip, use an exact replacement.

Snowy picture in RCA CTC156 chassis

In one RCA CTC156 portable TV that I was working on, the raster was snowy. I couldn't tune in a channel. The first step I took was to measure the tuning voltage at pin 5 of the tuner while attempting to tune in several channels.

The voltage at pin 5 or pin 9 of the band

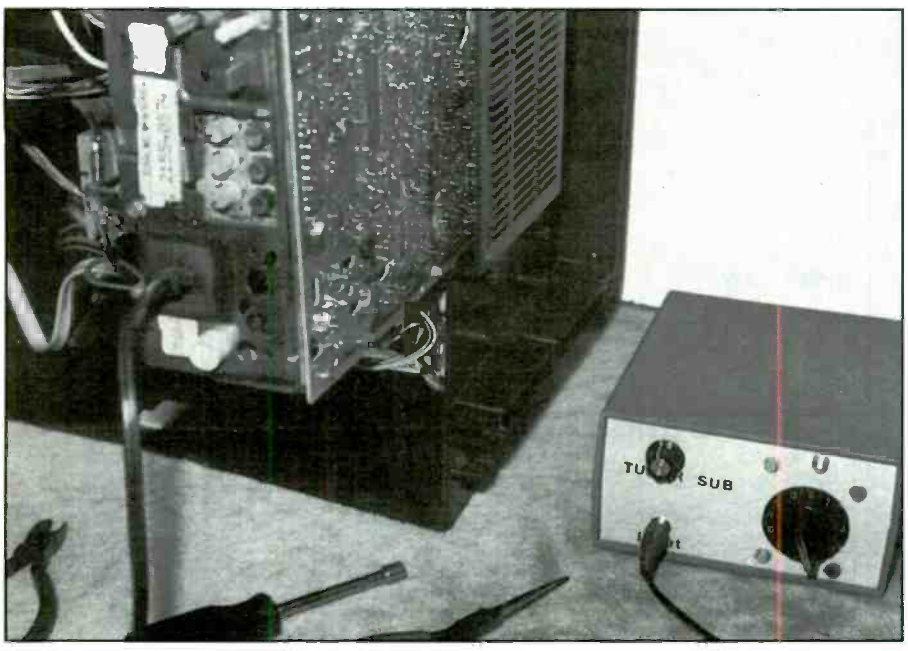


Figure 7. The tuner-subber can be used to determine if a tuner-related problem is actually caused by the tuner or the chassis or if the control circuits are defective.

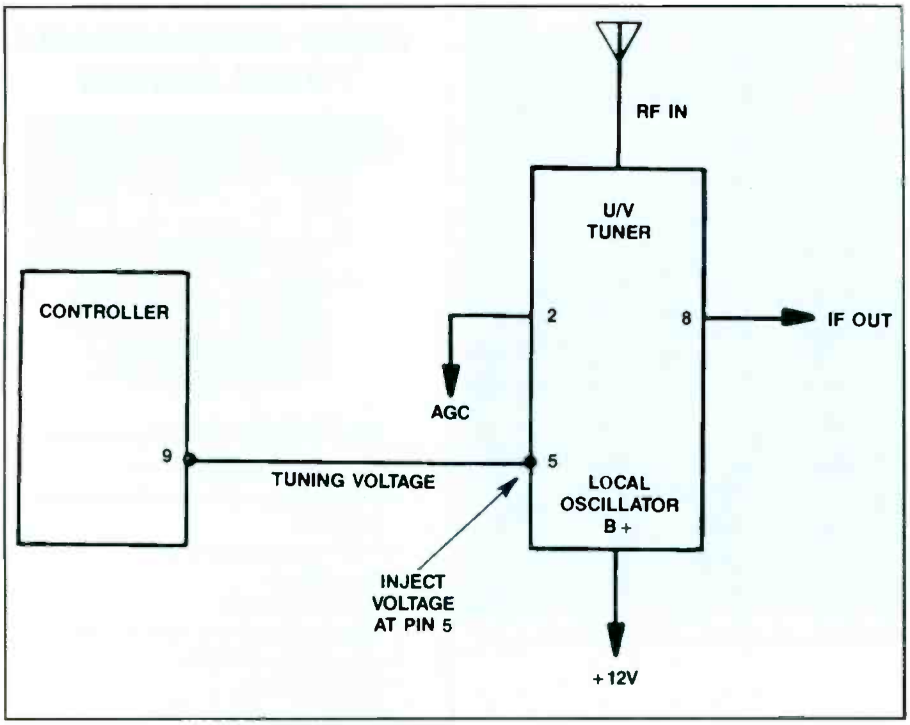


Figure 8. When no local oscillator voltage is found on pin 5 of the U/V tuner, apply 0Vdc to 35Vdc from an external supply to pin 5 to determine if the tuner is functioning.

switch IC (U3600) didn't change significantly as I attempted to tune in a channel. The tuning voltage can also be found at test point TP3608 (Figure 9). Remember the tuning voltages on different channels will vary slightly in different tuners and control circuits.

To verify that the tuner was normal, I injected variable dc voltage from an external low-voltage power supply at pin 5 on the tuner. Several VHF stations could be seen as the voltage was raised and lowered. This confirmed that the tuner assembly was good.

Either the band switching IC (U3600) or tuning control IC (U3300) was defective, since no local oscillator voltage was measured at pin 9 of the band switch IC. A voltage measurement of the supply at pin 12 was 11.8V and pin 10 was a little low (28.8V).

The system control circuits seemed to be normal, except for tuning in the various channels. The tuning control IC voltages, band signals and phase pulses seemed normal while changing the channels.

Although the +33V supply source at pin 10 was a little low, all other voltages and waveforms were normal at the input terminals of the bandswitching IC. All signs pointed to U3600 as the source of the problem, so I replaced it with an exact replacement. The set operated perfectly once the replacement part was installed.

Erratic tuner control

One customer complained that recently the tuning control in a Sylvania 20B1 chassis had become erratic. By the time the set was brought to me, the set could be turned on by the keyboard or the remote, but there was no picture or sound. I removed the back cover of the chassis to get at the microcomputer and tuner control. The U/V tuner is located at the back to make voltage measurements easy.

I measured the voltage at each tuner terminal. There was no voltage at the local oscillator pin, or at High VHF or Low VHF on pins 2, 3 and 7 (Figure 10). The 5Vdc and 13Vdc supply voltages were correct at pins 14 and 6 respectively. The AGC voltage at pin 5 measured 9.9V,

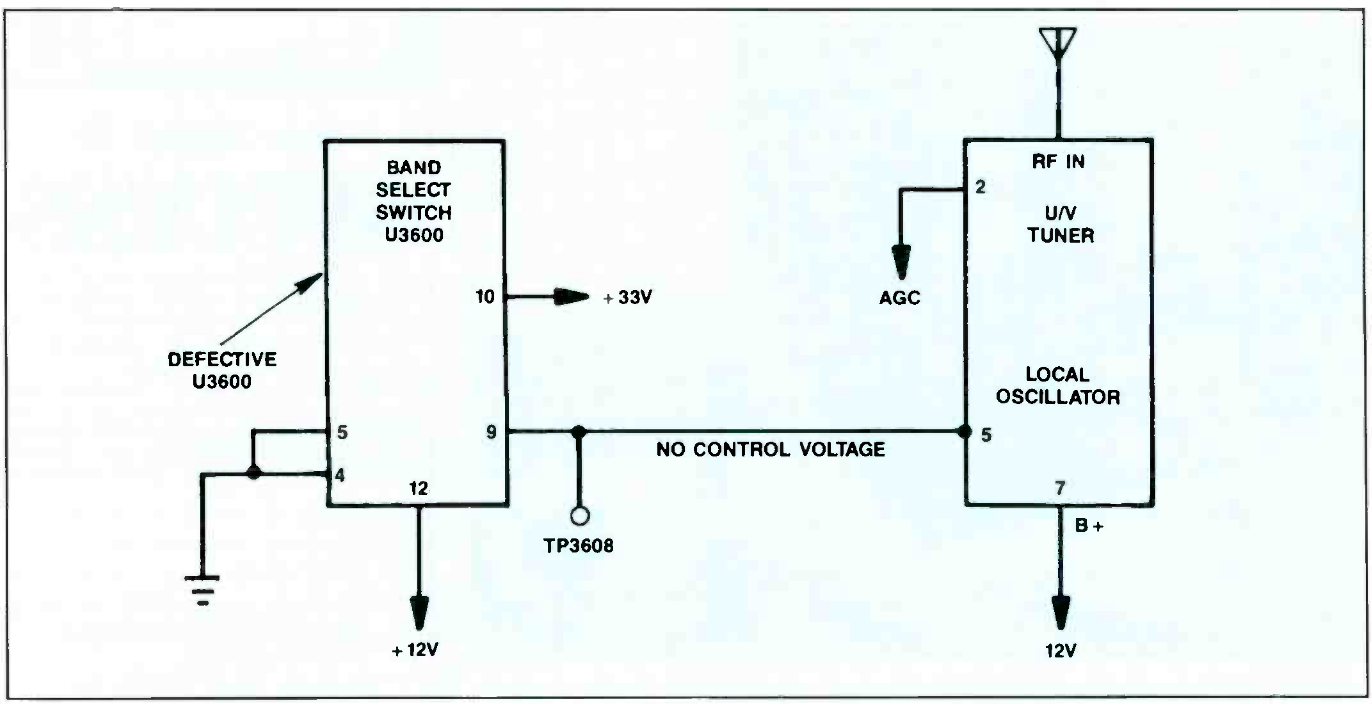


Figure 9. No control voltage was found on pin 5 of the tuner or pin 9 of the bandswitching IC, U3600, in this RCA CTC156 chassis.

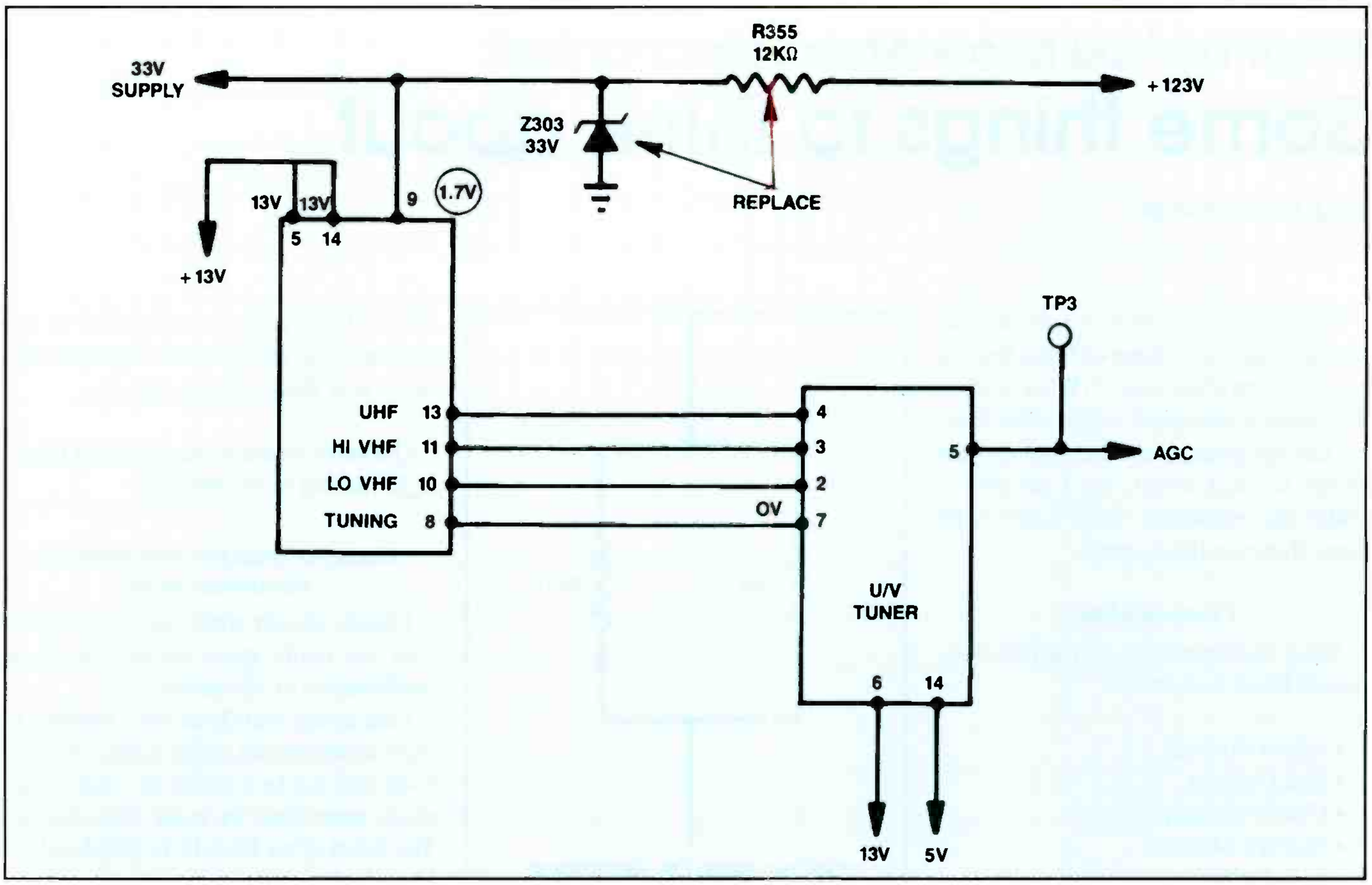


Figure 10. Z303 and R335 in this Sylvania 25B1 chassis were defective, making it impossible to tune in a station.

indicating that it was not receiving a signal. This voltage should measure around 4.8V with normal signal.

Since there was no tuning voltage, I went next to the tuning control, IC301. A normal 13V was found at pins 5 and 14, but the voltage at pin 9 was very low. Upon checking the schematic, I found that pin 8 should have a supply voltage of +33V, from a 12KΩ resistor (R335) and from the 123V source.

I assumed IC301 had internal leakage, or R335 and zener diode Z303 were defective. Z303 showed signs of overheating, and R335 was burned. A quick resistance test across Z303 indicated high leakage. I removed the zener diode from the circuit. It tested bad again out of circuit. Replacing Z303 and R335 restored the set to normal operation.

Channel drifting in RCA CTC146E chassis

In this fairly new 13-inch RCA TV portable, the stations would remain normal for about an hour and then drift off frequency. Sometimes turning the set off and back on would restore the channels to normal. Other times it would not.

The local oscillator control pin voltage remained normal when the channels drifted, no matter what channel was selected. This suggested that the problem was a defective tuner.

Suspect a defective tuner or UHF control when VHF stations are normal but you can't tune any UHF channels. Replace a drifting tuner with exact part number.

Conclusion

Whenever you suspect tuning problems in a set with varactor-diode tuning, check the tuning control voltage being applied to the local oscillator of the tuner assembly for correct tuning voltage. If no voltage, or an incorrect voltage is found, suspect the controller or band switching IC circuits.

Apply dc voltage from an external supply to the tuner to determine if the tuner is defective. Always measure the dc power source (V_{CC}) supplied to each IC component and tuner.

When the picture is snowy, but the voltage on the local oscillator pin is normal, suspect a defective tuner. Station drifting off channel may be caused by a defective tuner or AFT circuits. Defective tuners may be sent to a service depot to be remanufactured. ■

What Do You Know About Electronics?
Some things to think about

By J.A. Sam Wilson

One of the types of letters I get from readers discusses the content of What Do You Know About Electronics? (WDYKAE?). The general statement is that some readers like the column because it gives them things to think about. So, I decided to make an occasional WDYKAE? with some things to think about.

Commonalities

What characteristics do the following people have in common?

- Albert Einstein
- Ben Franklin
- Charlie Chaplin
- Marilyn Monroe
- Judy Garland

Of course, there are several things they have in common: They are all dead, they were all famous, and, they are all people.

Here is something to think about: They were all left handed.

Most people know that a human does not have *a* brain. We all have two separate brains and they are often identified as the *left hemisphere* and the *right hemisphere*. The left side of your brain (or, left hemisphere) controls the right side of your body and the right hemisphere controls your left side.

More important, there are characteristics associated with which side of your brain is dominant. If the left side of your brain is dominant you are likely to be:

- right handed
- adept at verbal skills such as using words to name and describe things
- good at figuring things out step-by-step and part-by-part
- good at taking a small bit of information and using it to represent the whole
- skilled at using numbers
- able to draw logical conclusions
- good at math and logic
- good at drawing conclusions based upon facts and reason

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

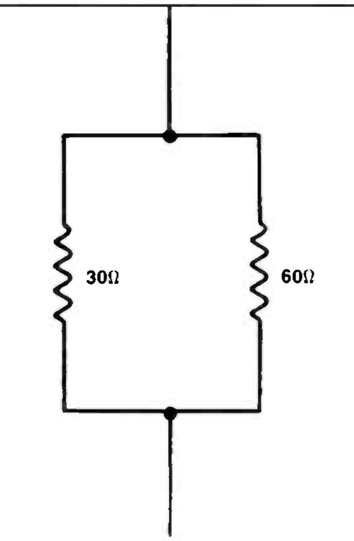


Figure 1. Find the equivalent resistance (R_{eq}) of the two resistors in parallel.

If the right side of your brain is dominant you are likely to be:

- left handed
- non-verbal with a minimum connection between things and words
- able to relate things as they are at the present moment
- without a strong sense of time
- willing to suspend judgements
- able to see things as they are in relationship to each other
- able to make leaps of insight—often based upon incomplete patterns
- able to see all things at once

This is not a bunch of hocus-pocus and black-magic thinking. You can find the very-well documented scientific basis of the above in a fascinating book titled *Drawing on The Right Side of the Brain* by Betty Edwards, published by the Putnam Publishing Group, copyright 1989.

Think of the characteristics of left-handed people in relation to Albert Einstein. I have pointed out a number of times in WDYKAE? that he was not the world's greatest mathematician and that he often preferred to solve problems graphically. One of his greatest contributions to science was his ability to incorporate time into a new theory of the universe.

Question: Is the writer of WDYKAE? right-handed or left-handed?

Excerpts from my new book on electronics math

I know already what you are thinking: "Do we really need another book on mathematics of electronics?"

I am aware that there are a number of well-written books on the subject. But my book will not be a repeat of what has already been done by some fine authors. The thrust of my book is the graphical solutions of problems in electronics.

You may be surprised to learn that many of the problems in electronics that you suffered through in school can be easily solved by drawing lines on paper. I am talking about problems in algebra, trigonometry, analytic geometry, and differential and integral calculus.

When I was teaching I made it a point to mix a few graphical solutions into the required problems in the textbooks. I wanted to see if the graphical solutions were acceptable to the students. I was pleasantly surprised by students who wanted to know why we couldn't go further with that procedure. The answer, of course, is that those courses had already been outlined and instructors were required to follow those outlines.

Bias against graphical solutions

I was not surprised by the reaction of professors who taught in the same school. They were dead set against the idea. To many mathematics teachers and professors graphical solutions is one step below the game of Drop the Handkerchief in kindergarten.

Let me tell you about a brilliant graphical solution to a child's homework problem. I know I've told this story before, but, please don't stop me. It is one of my favorite stories and I want to hear it again.

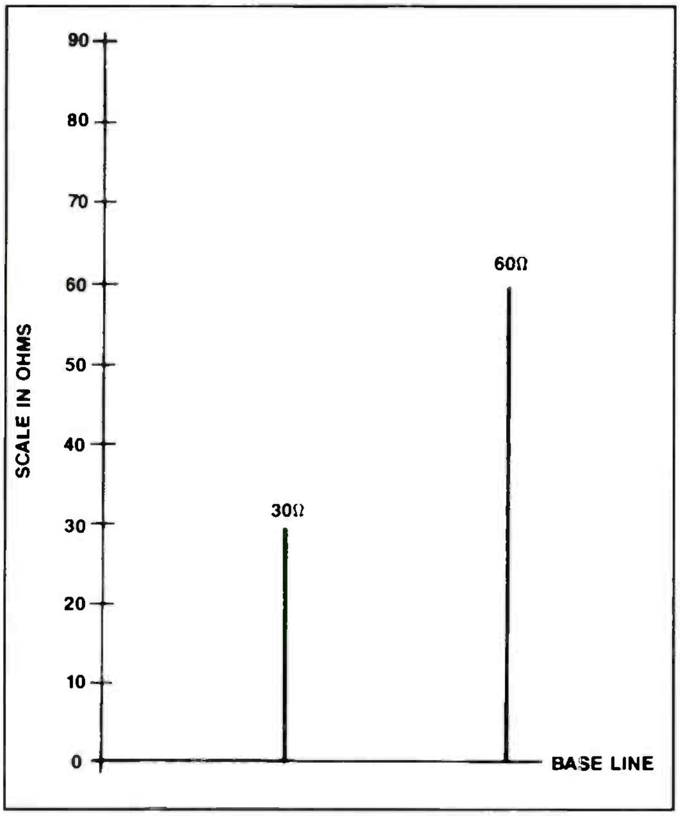


Figure 2. The values of the resistors in Figure 1 may be represented by the lengths of lines.

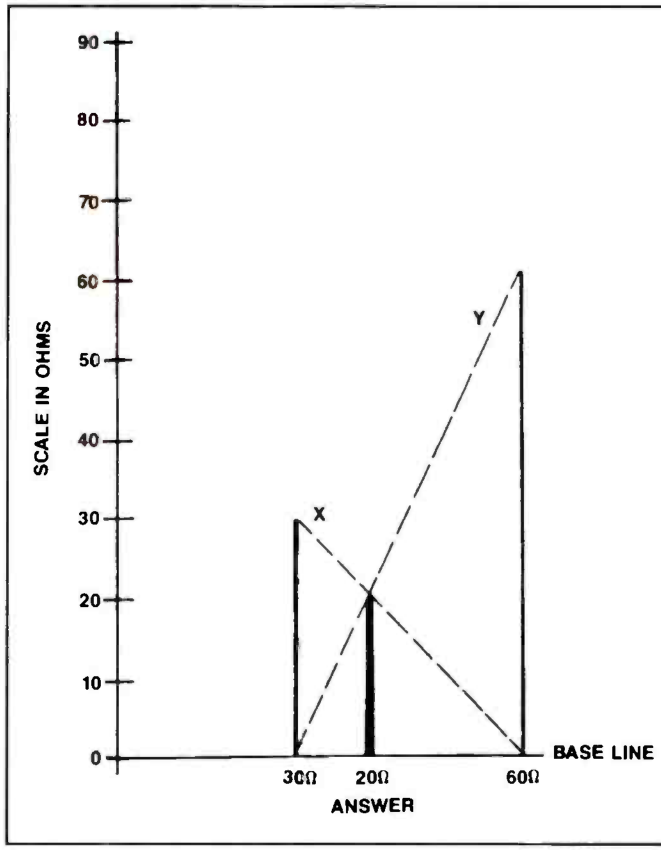


Figure 3. To find the value of resistance (R_{eq}) that is equivalent to the parallel combination of the resistors whose values are represented by the lengths of the two lines in Figure 2, draw lines "x" and "y," as shown, and measure the vertical distance from the baseline to the intersection of those two lines.

A little girl in grade school sent one of her homework problems to Einstein. She said she knew he was the only person who could solve it. Einstein was a gracious person and he sent a graphical solution to the problem. This story (and the solution) was printed in a Los Angeles newspaper.

A few days later a high school math teacher sent a strong criticism saying the graphical solution wasn't valid—regardless, Einstein had the right answer.

I am not going to go any further with that story. I've said enough already. If I go any further I'll start screaming.

Anyway, at that time I figured if Einstein preferred a simple graphical solution it would certainly be worth looking at. Since that time I have been collecting graphical solutions to problems in electronics. Now I'm about half way finished with the book and I've decided to give some examples in the next few WDYKAE? columns.

Parallel resistor solutions

Consider the two parallel resistors in Figure 1. The problem is to find the parallel equivalent resistance (R_{eq}) of the combination. There are several ways to solve the problem mathematically, and here are two:

$$1/R_{eq} = 1/R_1 + 1/R_2$$

and

$$R_{eq} = (R_1)(R_2) \div (R_1 + R_2)$$

Both equations are easy to solve with a calculator. Just to prove a point, let me show how the problem can be solved graphically. It is best to use a piece of graph paper for this solution. Refer to Figure 2.

Two lines are drawn on the graph paper to represent the two resistance values. Pick a convenient scale to represent those values. It does not matter how far apart the lines are drawn, but they must be drawn on the same base line.

Figure 3 shows how the problem is solved. From the top of each resistor line draw lines 'x' and 'y'. This is clearly shown in Figure 3. From the intersection of lines 'x' and 'y' drop a perpendicular line to the base line. That perpendicular is called R_{eq} in the illustration. Measure the length of that perpendicular on the same scale as used for R_1 and R_2.

It is a lot harder to explain the procedure than it is to show it. That is true for many graphical solutions.

From the graphical solution it is very clear that the equivalent resistance is smaller than the value of either resistor.

If there are three resistors in parallel, you simply use the solution of the first two for one of the two resistor lines. Draw a resistor line for the third resistor a convenient distance. Then, draw the solution.

A harder problem

Now, let's change the problem to see if we can solve one that is a little bit more difficult. Once again, we will use a graphical solution.

Refer to Figure 4. One resistor value is given. The problem is to find what value of parallel resistance will give an equivalent resistance value of 30Ω.

Before you go any further, solve that problem mathematically.

The graphical solution is shown in Figure 5. Here is the procedure:

Step 1—Draw R_1 and R_{eq} to scale on the same base line.

Test your electronics knowledge

Answers to the quiz

(from page 45)

Questions 1 and 2 are from an article in the January '93 issue of ES&T. The article is titled "Basics of Active Filtering" by Dale C. Shackelford.

1. B

2. A

3. C. From an article titled "The Digital Pot" by Vaughn D. Martin. It was in the January issue of ES&T.

4. B. From "Test Your Electronics Knowledge" by Sam Wilson. See the January '93 issue of ES&T.

5. C.

6. Less than an hour.

Questions 7 and 8 are from an article titled "Troubleshooting Microwave Oven High Voltage Circuits" by Homer Davidson. It was in the February '93 issue of ES&T.

7. * Take off your watch.
   * Make sure the oven is unplugg ed
   * Discharge the HV capacitor

8. 40W pigtail socket light bulb.

9. A. From "Troubleshooting Tips" submitted by Ken Dias (page 55) in the February issue of ES&T.

10. Digital Compact Cassette. From an article titled "Digital Compact Cassette" by John Shepler in the February 1993 issue of ES&T.

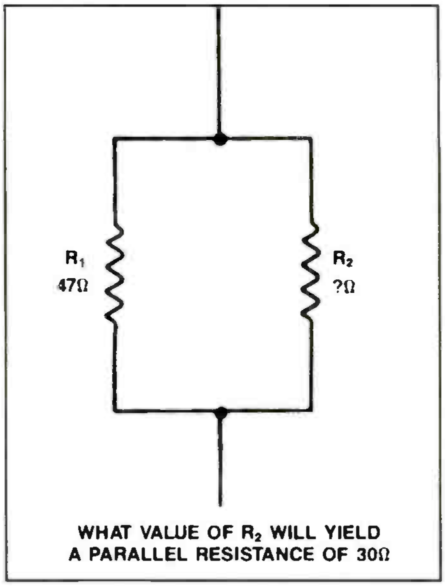


Figure 4. How do you proceed graphically if you have a given value of resistor, and wish to find the value of resistor to parallel it with in order to produce a specified equivalent resistance?

Step 2—Draw line 'x' and line 'y' so that they cross.

Step 3—Draw a vertical line from where 'x' meets the base line to line 'y'. The line for this step is shown in Figure 5. (R_2 = 83Ω.)

I submit that the graphical solution is easier than the math solution in this case. This is especially true for students who are just beginning.

Answer to left-right brain dominant author

When I was a small child many parents felt it important not to let anyone learn to write with their left hand. Their reasoning was that a left-handed person was at a great disadvantage in the world. To carry out my right-hand training, everyone was told to punish my left hand if it tried to take over. To that end, they would smack the palm of my left hand with a ruler whenever I tried to write with it.

One teacher had a very special approach. She would grab my left hand and shake it until there wasn't any blood left in it. Sometimes she would shake my hand so hard that there were standing waves in my arm. School was a lot harder in those days.

Experts say that the above procedure can cause a person to stutter.

I am now a right-handed person but there is still a trace of being left-handed. For example, I am ambidextrose. I can put sugar in my coffee with either hand ■

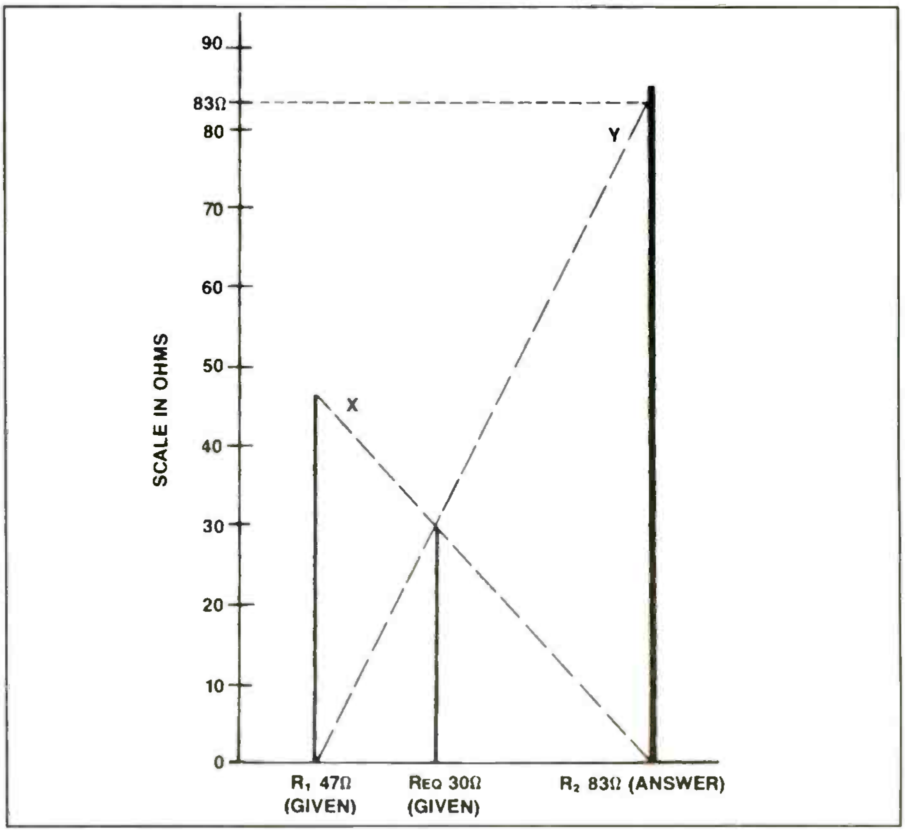
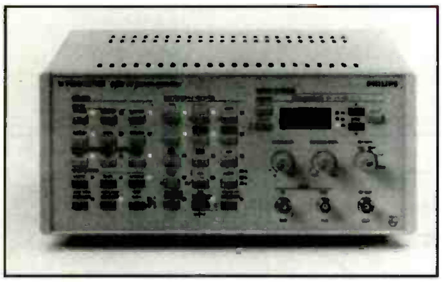


Figure 5. To find the unknown resistor value of the problem of Figure 4, draw R_1 and R_{eq} to scale on the same baseline, draw crossing lines "x" and "y," and measure the length of the vertical line from the point where x meets the baseline to y.



Multistandard TV signal generator supports closed captioning

Fluke Corporation announces the addition of its new PM5418 Video Pattern Generator from Philips. The unit contains all the signals needed for TV, VCR and monitor testing, including more than 100 video test patterns for NTSC, PAL and SECAM video standards.

The unit, which is part of the PM5410 family, offers a wide choice of TV test signals, according to the company. It offers both Caption and Text modes in either of two operating channels. The closed caption information is present in line 21 of the NTSC video signal. The -TNX and -TNS(I) versions offer factory pre-coded closed caption data with a selection of eight different types of information. Selection of the required test option is done in a similar way to the PDC/VPS system.

The generator also features high-precision, digitally-generated patterns for geometry alignment, 16:9 and 4:3 aspect ratio patterns, special patterns for VCR and 100 Hz IDTV (Improved Definition TV) testing, and mono, stereo and NICAM sound test signals. In addition, the unit also contains test configurations for Teletext TOP.FLOF, VPT and Antiope test signals, easily programmable PDC (Program Delivery Control), VPS and Closed Caption test signals. The unit, which is IEEE-488 programmable, offers full RF coverage from 32 to 900MHz with internal/external modulation, RGB, Y/C (S-VHS/Hi-8), CVBS and audio outputs.

Circle (50) on Reply Card

Replacement series library

The 1993 Replacement Series D.A.T.A. Digest library from *D.A.T.A.* contains comprehensive coverage on alternate sources and replacements for integrated circuits and discrete semiconductors. The library consists of three publications—Alternate Sources and Replacements (ICs), Direct Alternate Sources and Replacements (discretes) and Suggested Replacements (discretes).

Each DIGEST presents replacement/alternate source components in an easy-to-use format. Alternate Sources and Re-

placements contains information on both alternate sources and suggested replacements for integrated circuits, while data for discrete semiconductors is divided into two publications: Direct Alternate Sources and Replacements, which contains alternate sources and Suggested Replacements, which lists replacement devices. A Manufacturer Directory referencing address information for all manufacturers included is provided as well.

In addition to the Replacement Series library, the company offers the Discontinued Devices library. Composed of two publications, Discontinued Discrete Semiconductors and Discontinued Integrated Circuits, the library provides the most thorough information on over 427,300 discontinued discrete and integrated circuit devices dating back to 1956. Up to 20 technical parameters are covered on each device and information is presented in an easy-to-use format.

Circle (51) on Reply Card

Self-diagnostic ESD soldering station

Weller introduces the MC5001, a microprocessor-controlled ESD soldering station with self-diagnostic capabilities that allow the station to determine which tool is connected at turn-on. Stations are available with a 40W, 20W, or 42W soldering iron, and tip style changes are input on the keypad as a memory function.

Tip temperature can be set from 350F to 830F in one-degree intervals, while average tip temperature at idle is plus or

minus 5F. A programmable operator lock out prevents accidental or intentional change of temperature setting and a setback feature automatically moves tip temperature back to 350F to extend tip life.

The internal memory retains stored parameters, including set temperature, tip style, display mode, station and tool calibration. This memory remains even when the station is turned off or unplugged.

Circle (52) on Reply Card

True RMS multimeter with computer interface

Extech Instruments introduces a high accuracy true RMS multimeter with built in RS-232 interface. This unit offers a large easy-to-read 3-3/4 digit LCD display, along with a 40-segment bar graph for visual aid. Numerous input ranges are standard for ac/dc voltage, ac/dc current,

resistance, and frequency along with inputs for diode and continuity checks. Important features include data hold, min/max memory, audible and visual function indication and overload protection. This economical unit measures just 6.4 x 3.1 x 1.2 inches and may be used for both handheld and benchtop use. Comes complete with 9V battery, set of heavy duty test leads, and built-in stand.

Circle (53) on Reply Card

CMOS battery failure

By David Presnell

CMOS RAM (Complementary Metal-Oxide Semiconductor Random-Access Memory) (pronounced "see-moss") is a small area of memory that contains valuable information needed by the computer's BIOS ROM (Basic Input/Output System Read Only Memory) to start the computer. The CMOS RAM holds current date and time information, floppy drive information, hard drive types, memory configuration, and monitor and I/O card types.

Because this information will be different for different computer systems, and may need to be changed from time to time, it is in RAM, so that it may be altered. It would be tedious, however, if the user had to enter the date and time and the identification information for disk drives and other hardware every time he turned on the computer. For this reason, this area of RAM is powered by a battery, so that it maintains the information in it, even when the computer is turned off (Figure 1).

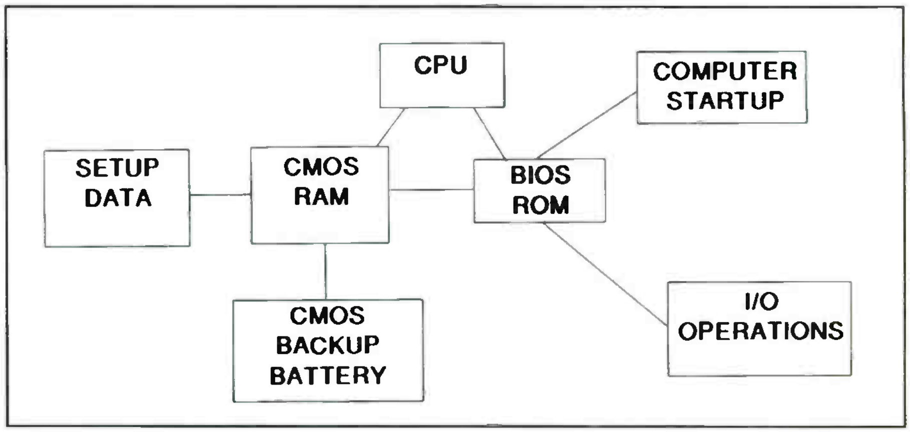


Figure 1. CMOS RAM is a small area of memory that contains valuable information needed by the computer's BIOS ROM (Basic input/output System Read Only Memory) to start the computer. This area of RAM is powered by a battery, so that it maintains the information in it, even when the computer is turned off.

The Setup program

The software that allows the user to enter this system configuration information into the computer is called the Setup program (Figure 2). Some computers allow the user to invoke the setup program during initial powerup. For example, one system puts the message "FOR SETUP, PRESS <DEL>." If the user presses the Delete key when this message appears, the setup screen appears.

In another type of computer, the user can invoke setup at any time by pressing the Ctrl-Alt-Delete keys simultaneously. Refer to the literature supplied with the computer if the method of invoking the setup program isn't obvious.

The setup program is generally manufactured or burned into the ROM BIOS chip, although some computers, (mostly IBM AT's), do not have the setup program on the ROM BIOS chip. With these systems the program is located on a floppy disk, usually bootable, called a setup disk, diagnostics disk, or an equivalent.

CMOS RAM requiring setup is present on AT, 286 and higher computers; however, XT and PC machines may have a clock card installed with a ROM chip, CMOS RAM chip, and a lithium battery for maintaining the data in CMOS RAM.

Some advanced CMOS setup programs offer the ability to personalize a system with the drive to boot from, password setup, extended and expanded memory setup, enable shadow ROM functions, and other advanced setup options.

The BIOS ROM

The BIOS ROM chip is the key that starts the computer's engine running. When you power on the computer, the supply powers up all the components of the mother board. Immediately the BIOS takes over as commander of operations.

The BIOS is a ROM-based program (called firmware) that performs specific I/O (Input/Output) operations, initializes most of the computer hardware checks on the location of hardware, including I/O cards, ports and memory, runs basic diagnostics on the system (in most cases), and looks for and communicates with DOS (Disk Operating System) software.

BIOS ROM performs many other startup procedures, but its final goal is to force the computer to recognize and use DOS. All ROM chips are not created equal. You will find different levels of ROM programming depending on the ROM manufacturer; however, the goal still remains the same.

Once the BIOS ROM program has done its job and located the DOS program, which must be either on a floppy disk or on the boot sector of a hard drive, the BIOS turns the job of handling disk drives over to DOS. BIOS continues to handle computer hardware I/O operations. DOS takes over all disk drives and waits for the user to run application programs, the end use of the computer.

Setup requires exact information

The computer has to be told every move to make, specifically. Thus, the burned in BIOS ROM program must know exactly what hardware is plugged into the computer. You cannot tell the BIOS that you simply have a hard drive, but you must tell it exactly what type of hard drive you have installed.

If you tell BIOS that you have a 40MB hard drive installed, when in fact you have an 80MB, the computer will go right on thinking it only has 40MB available for use and that's exactly what you will get.

You can tell the BIOS what is onboard and customize the computer by using the CMOS setup program (or bios setup program) mentioned above. Remember that a program supplies the necessary instructions (algorithm) that does something with the data supplied by the user. Thus, the BIOS ROM is an unchangeable set of instructions that looks for user entered data to respond to.

Presnell is owner of an independent computer servicing business, and a freelance technical writer.

STANDARD CMOS SETUP PROGRAM

```
Date (mm/date/year): Fri, Mar 1, 1984          Base Memory : 640 KB
Time (hour/min/sec): 12 : 10 : 20               Ext memory:  0 KB
Daylight Saving     : Disabled
Hard Disk C: Type   : 17               Cyln  Head  WPCom  LZone  Sect  Size
Hard Disk D: Type   : Not Installed    977   5     300    977    17    41MB
Floppy Drive A:     : 1.2 MB, 5 1/4
Floppy Drive B:     : Not Installed
Primary Display     : VGA/EGA
Keyboard            : Installed

ESC: Exit   Arrow keys: Sel   F2/F3:Color   F10: save & exit
```

Figure 2. The software that allows the user to enter the system configuration information into the computer is called the Setup program (Figure 2).

The CMOS backup battery

The CMOS RAM backup battery that maintains CMOS RAM is usually the lithium type. Because the CMOS uses little power to preserve its data, the battery backup works quite well until the battery goes dead. In older XT and PC machines, setup was performed by changing motherboard mounted switches and jumpers.

These batteries occasionally outlast the motherboard they reside on. However, most will fail within three to five years depending on use and type. Most of the batteries are 3.6V installed directly on the motherboard close to the keyboard connector. Some are plugged in via a 2-pin connector and wire to an external battery pack, usually 6V. Many modern IBM compatible motherboards allow use of the board mounted battery or an external (to the motherboard) battery by changing a jumper setting on the motherboard.

Think battery

As technicians respond to day to day service calls, it's all too easy to look for the complex rather than the simple. Many computer technical manuals go into great depth on the seemingly complex hardware problems. However, when the CMOS backup battery is mentioned, (if at all), usually you're told to simply replace it. If life were only that simple.

Future installments of Computer Corner, will describe some of the many symptoms caused by a failing CMOS battery, share a case history with you, tell you how to replace the battery and get the system back up and running, and discuss how to avoid this problem in the future. ■

Servicing musical instrument electronics

By Ron C. Johnson

In past articles I've suggested a number of ways you and your shop could use expertise you already have to diversify into new areas. Your test setup, personnel and skills are transferable from one service area of electronics to another. Moving into a new area really isn't all that difficult. The trick is to find an area that's profitable. One of the goals of this column is to help you do that.

Since traditional consumer electronic servicing includes audio equipment such as tuners, receivers and power amplifiers, servicing musical instrument electronics is just a small step away. In this issue I'd like to talk about some technical and some non-technical aspects of musical instrument electronic servicing that may be of help to you.

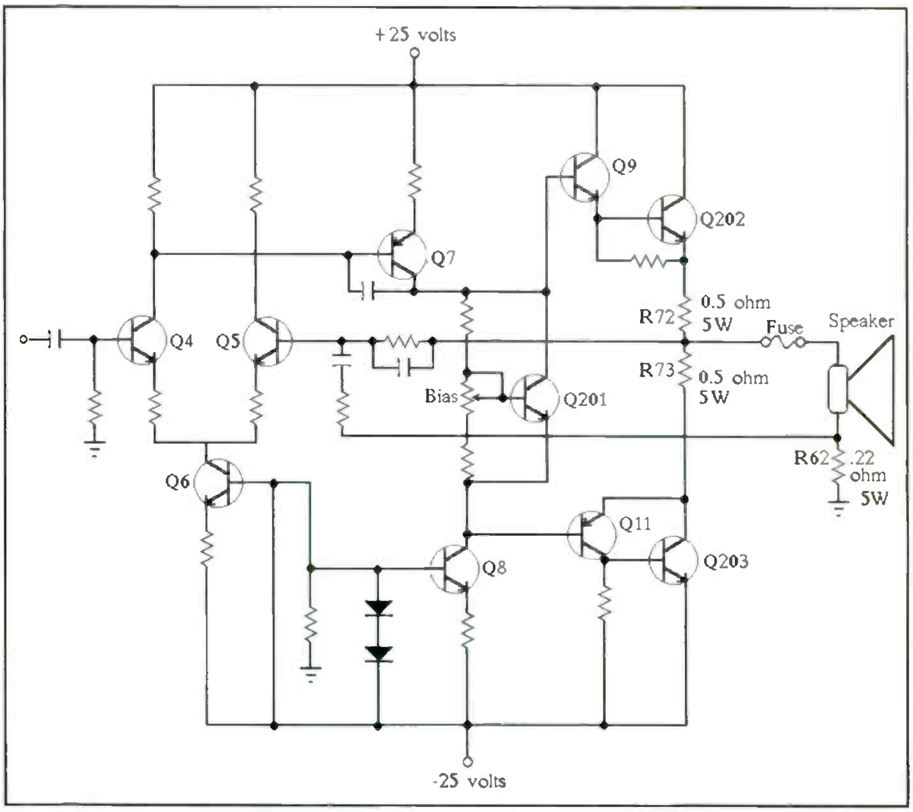


Figure 1. The output stage of a typical musical instrument amplifier. This one, out of a Fender guitar amp, has been around for a few years, and hasn't changed much.

A list of the equipment

In case you're not the musical type and are not familiar with the kind of equipment you'll find in a music store, here's a short list.

Musical instrument amplifiers for guitars, basses, synthesizers, etc. are the main items to be found here. Guitar amps usually have a built in speaker system and the electronics are all over the map: transistor amps, linear power blocks, and even tube amps which deliver that special sound (some would say distortion) desired by musicians.

Another big area is sound reinforcement systems. Sound systems are often rented to bands. A typical sound system consists of sound mixers, equalizers, and effects (digital delays, reverbs, etc.) as well as heavy duty power amps and large speakers. System rentals take a lot of abuse from moving and from rough usage which can provide you with ongoing service work.

Synthesizers of all shapes and descriptions require service from time to time. Again, these are sometimes rented, and therefore often require repair. The level of technology in synthesizers is pretty high and can be a real challenge. MIDI, a serial communication system between synthesizers, is the heart of the latest equipment. You may have come across MIDI in personal computers that have multimedia options. Building or repairing custom MIDI interfaces and cables can add to your service income.

Electric guitars are being manufactured with an assortment of specialty pickups, active electronics and synthesizer interfaces. There is quite a bit of special knowledge required here but it can be found in a few good books on the subject. Mechanical repairs to the guitars (and other instruments) can provide some work too, if you have the expertise to do it.

Fixing the cables

Cable repairs can keep you busy as well. Sound systems use "snakes," multiconductor cables for running multiple microphone lines from the mixing board to the stage. These get beat up and need work regularly, especially the connectors on each end. You can also build and sell them in your spare time. Building snakes isn't difficult but you need to keep costs down to be competitive.

Most music stores also sell and rent recording equipment, usually special multitrack recorders. Some of these recorders use cassettes, others use video tape cartridges, and some are reel to reel. Your ex-

Johnson is a journeyman electronics servicing technician and an instructor of technology at the Northern Alberta Institute of Technology in Edmonton, Alberta, Canada.

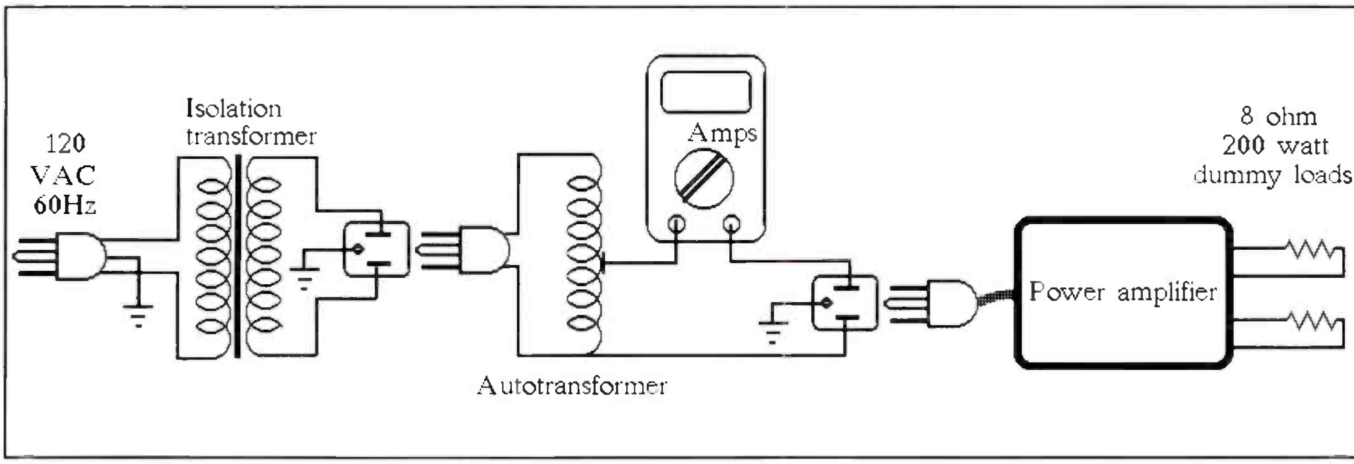


Figure 2. Use this set up to apply power to a direct coupled amp once you have completed servicing it. An isolation transformer feeds a variable transformer, and a special ac power cord (you make up) allows you to monitor ac current. You bring up the ac voltage slowly, watching the ac current.

pertise in VCR's and audio cassettes can be useful here.

Business considerations

Before we go on to talk about some of the technical aspects of doing this kind of work, some other business considerations are important. First, if the store is large, or if it is part of a chain, it may have its own service center and service personnel. The ones that don't, probably contract the service to a company such as yours, or they have somebody who comes in part time to do it.

If you find a music store that needs someone to perform their service, you'll have to decide whether to send one of your technicians to work at the music store or have somebody haul all the repairs back to your service center. This is no trivial matter. Often the music store wants service done at its location because some of this stuff is big and heavy.

We all know that it's difficult to make service calls profitable and this is no exception. Travel time to and from the store, acquiring parts, down time waiting for store personnel and other delays can erode your profit margin.

You need to get some questions settled at the outset of your relationship with the music store. For example, can you charge for checking out equipment that proves out as being good? It's important that you are organized and have a clear understanding with the music store.

If you have a work area in the store, is it yours exclusively? Some stores do speaker reconing and guitar adjustments but no electronics. When I was doing this kind of work I often came in on my assigned day to find the work area a mess. The store didn't like me charging them to clean it up but somebody had to do it. The final straw came when I found a pair of my needle nose pliers stuck to the workbench with spilled speaker cement all over them. The store and I parted company not long afterwards.

Technical considerations

Let's zero in on the technical end of musical instrument repairs and see some of the similarities and differences between what you're doing now and what you're likely to find.

Musical instrument (MI) power amplifiers have some similarities to the ones you see regularly. The heart of a consumer stereo system is the power amp that takes signals from a preamp or receiver and drives the speaker system. The same is true of MI amplifiers. Guitar amps, for instance, usually have two channels of preamplification and an output driver. Sound system amps usually have one or two line level inputs to the power amp section.

While a typical consumer stereo amp is generally designed to be mass produced, MI amps have the added requirement of being ruggedly built to hold up under hauling them around, dropping them and driving them beyond their design limits. A number of other features further differentiate them from consumer amps. For instance, MI amps have built in reverb circuits, tremolo, special filters, compressors and other effects. For now, let's take a look at the power amplifier section itself.

The musical instrument power amplifier

Some of the amplifiers you repair now may be capable of fairly high power output, but chances are most of the stuff you see is relatively low power and uses hybrid power ICs in the final stage. Hybrid power ICs are used in some of the smaller practice amps and a few of the larger ones, but by and large you'll still find a lot of the good old Class AB push-push amplifiers. A few of the newer amplifiers use VMOS FETs in their outputs, but, in my experience, being a bit unstable, they have never really caught on. They tend to fail catastrophically, taking out several components at once.

You might be surprised at how many guitar amps still use tubes. Some of them use tubes throughout while others only use them in one or two stages. There's something about tube amps that musicians like. Although tube circuits do create some harmonic distortion, they cause less intermodulation distortion than solid state circuits. The result is a smoother sound, or so say the musicians.

A real-world MI amplifier

Figure 1 shows the output stage of a typical musical instrument amplifier.

This one is out of a Fender guitar amp, has been around for a few years, and hasn't changed much. I'll use it to point out some of the more common problems with this kind of amp.

This is a direct coupled Class AB amplifier that puts out about 40W RMS. Notice the final output transistors, Q202 and Q203 are both NPN with 0.5Ω, 5W resistors between them. This is called a quasi-complementary symmetry amplifier. If an amp like this fails, usually one or both of the output transistors will short out.

If you encounter an amp like this one that's not working, always check the two resistors, R72 and R73, as they will often open up, and usually there is no visual indication that they carried excessive current. Another resistor to keep an eye on is R62, the 0.22Ω, 5W resistor that connects the speaker to ground.

Now take a look at the differential input stage to the amp (Q4 and Q5). The input signal is applied to the base of Q4 and a negative feedback signal is applied to Q5. The feedback signal comes from the junction of R72 and R73, which is also the actual amplifier output to the speaker. The dc level at this point should be zero volts; the output current to the speaker should swing positive and negative around this point. The feedback voltage from this point reduces the overall gain of the circuit and minimizes distortion. It also serves to work against thermal runaway in the output stage.

Bipolar transistors drop in resistance as they increase in temperature. This causes more current to flow which causes them to get hotter. In this case, if more current flows, the dc voltage at the output tries to climb. This voltage is applied to the differential input stage and turns Q5 on harder. As Q5 turns on Q4 turns off, increasing the voltage applied to Q7, and so on through the circuit acting against the original shift in dc operating point and stopping thermal runaway.

The point is that, if one component fails, it changes the dc bias throughout the circuit and can drive the output to saturation. One nasty consequence is dc voltage applied to the coil of the speaker. This does interesting things to the geometry of the cone. Another consequence is the shorted transistors and open resistors mentioned earlier.

Servicing a direct coupled amplifier

The difficult part of repairing these kinds of failures is finding all the damaged components and replacing them at once. If you don't, powering up the amp may blow up the brand new parts you just installed. You can hope that thoroughly checking all the semiconductors will catch all of the problems but I've become a bit nervous about flipping the power back on in cases like this.

One method of testing to see if a fault still exists is to make up a power cord with a low wattage light bulb in series with the hot conductor. When you turn on the power, if the amp is still faulty and tries to draw lots of current, the bulb will light up brightly. The initial high resistance of the bulb may limit the inrush current enough to save the parts you have installed, if you turn off the power quickly enough—maybe—hopefully.

A better way to check your work is to use the setup shown in Figure 2. An isolation transformer feeds a variable transformer and a special ac power cord (you make up) that allows you to monitor ac current. You bring up the ac voltage slowly, watching the ac current. Most of these amps will draw less than 1Aac with no signal applied. If the current keeps on rising through about 1A as you increase the voltage something is probably still faulty in the circuit. Shut it down and start over.

By the way, the load shown is a dummy speaker load made up of two 200W, 8Ω resistors mounted on standoffs on a board. This is useful once you get the amp working to check for crossover distortion and symmetrical clipping at full output.

The unfortunate part of troubleshooting a circuit like this is that you seldom get a small problem with it. If one component changes the dc bias, everything goes out of line. Even a shorted capacitor will cause this kind of problem.

The finishing touches

Once the amp is working, the only other consideration is the bias adjustment. The bias pot is what makes the amp Class AB instead of Class B. Its job is to bias Q201 on so that a fixed voltage is applied from the base of Q9 to the base of Q11. This voltage will just begin to turn on those transistors, as well as the output drivers, Q202 and Q203.

With a small base current flowing already, any ac signal applied will be amplified linearly. Without this, crossover distortion would result. Q8 is a current source (its emitter current is fixed by the two diodes from its base to the negative rail). Keeping the current through the bias circuit constant stops signal fluctuations from changing the bias voltage.

There are a couple of ways to adjust the bias pot. One crude method is, with an input signal driving the amp, monitor the signal across the dummy load and adjust the pot for no visible crossover distortion. I'm sure you can guess how accurate that might be. A better way would be, with no input signal or load, to measure the voltage across the emitter resistor, R73, and adjust for about 12mV (about 25mA emitter current). Better yet, use a distortion analyzer and adjust for the specification given for the amplifier.

After-service testing

Once the amp is working and the bias is set, about the only other check would be to apply a signal and check the output waveform across the dummy load. As you increase the input there should be no visible crossover distortion, and, when the output waveform reaches the power supply rails, clipping should occur on both peaks at the same time. For more critical checks you'll need a distortion analyzer or another specialized noise measuring equipment.

There is a real variety of interesting technology to work on in the musical instrument field and money to be made doing it. In addition to rental repairs and repairs to customers' equipment, warranty repairs are available. By making contact with equipment manufacturers through the music store you can become the authorized warranty center for the brands handled by that store and eventually widen your market to include others. As usual, good business sense and constant attention to the bottom line are just as important as technical ability.

In a future installment, I'll take a look at some other aspects of musical instrument servicing with some more tips on the technical end of the job. ■

Business Corner

Will Total Quality Management work for you?—Part 3

By John A. Ross

In Business Corner, for the past two months we have been looking at the management theory called Total Quality Management. As Deming's Point 1 shows, an organization that maintains a consistent commitment to purpose has a better chance of achieving success. The second point in Total Quality Management requires that the organization adopt the new philosophy and management must awaken to the challenge, learn their responsibilities, and take on leadership for change. In this installment, we'll talk about point 3.

Ross is a technical writer and microcomputer consultant for Ft. Hays State University, Hays, KS.

TQM Point 3

The third TQM point is *cease reliance on mass inspection to achieve quality. Eliminate the need for inspection on a mass basis by building quality into the product in the first place. Build quality into the product from the start.*

Of all the TQM points, point three may be the easiest to achieve. As we service televisions, VCR's or computers, we can apply quality from the beginning to the end of the service process. The difference between an excellent job and a poor job is often only a few minutes—and return business or referrals through satisfied customers. Indeed, the few minutes required to do an excellent job often eliminate the necessity for re-doing the job.

Building quality into service also means, if possible, completing the job the first time. Understandably, the need for additional parts or other circumstances may prevent "first-time" job completion. Many of us have the best intentions when we putt off the completion of a job until

Microcomputer Services Quality First Checklist

Date________ Office__________ User____________

Operating and Applications Software

1) Autoexec. bat________
Path _____ Prompt _______ Screen saver _____ Windows Mode _____
2) Config.sys ______
Buffers _____ Files _____ Device Drivers ______
Memory Manager _____ Smart.drv _____ Ramdrive ______
3) Menu Access _____ 4) Windows Access _____ 5) Data Path ______
6) Color _____ 7) Graphics Driver(s) _____ 8) User Changes _____
9) Printer Driver(s) _____ 10) Icons _____ 11) Manual
12) Error Messages ______________________________

System Hardware

Hard Drive	Floppy Drive	Memory
1) BIOS compatibility______	1) Disk Read______	1) Read/Write ______
2) Norton Disk Doctor ______	2) Disk Setup ______	2) Parity______
3) Cables ______	3) Cables ______	**Printer**
4) Fasteners ______	4) Fasteners ______	1) Feed______
5) DOS ______	5) Format ______	2) Quality ______
6) Applications ______	**BIOS**	3) Prt Screen ______
7) Boot ______	1) Configuration______	4) Software ______

I have performed the above tests while installing ______________. If you require further assistance, please call me at 4021.
Microcomputer Services Signature ______________________.

Figure 1. The checklist establishes a routine for service personnel.

the next day. Unfortunately, we may not make it back because of other work or simply because going back is inconvenient. For your customers, the fact that you or your employees did not return affects their opinion of your business. Above all, if you or your employees cannot return to a customer site for some reason, explain the reasons for the delay to the customer.

Establish routines

Building quality into the repair process can be accomplished by establishing routines. When you or your employees begin a repair task, start the task by writing a repair checklist. Other service calls, the need for parts, or visitors often interrupt the progress of a repair. A checklist can work as a device for recording your progress on a given job through every one of its stages. At the end of the repair, provide a copy of the checklist for your customer. The checklist assures the customer that you have taken a formal, sequential approach to the repair and establishes a repair record for each item.

Total Quality Management has become a mission at our university. To achieve TQM at the service level, the Microcomputer Services office implemented a scheduling system, customer contacts, and a Quality First checklist. Even though the university office only provides services for other university staff and faculty, some of their initiatives may work as models for your service operation.

Handling customer contacts

Customer contacts to the office are made through phone messages and electronic mail. In all cases, the office staff translates the contact into a written, numbered work order which becomes the first stage of the process. With the work order in hand, the office manager places the task into the office work schedule and assigns it to a particular staff member. After scheduling the task, the manager informs the customer about the scheduled day and time, the assignment of the task to the staff member, and explains that all times are tentative. The last, qualifying statement accounts for unforeseen delays that are a part of the service business.

All this accomplishes several things. Translating the customer's call into a written work order creates a paper trail for the manager and the staff member. After completing the task, staff members ask the customer to sign the work order. For the manager, staff member, and, most important, the customer, this signifies the completion of the work order.

Placing the task into the office work schedule allows the manager and staff to see the progress for the day. For the customer, the scheduling illustrates an organized effort by the office staff. As expected, though, the daily schedule is disrupted by jobs that take longer than anticipated. In that event, the manager calls the customers and reschedules the repair.

Using a checklist

As mentioned, the office also implemented a "Quality First" checklist. The checklist, Figure 1, establishes a routine for service personnel. Although this checklist is tailored for computer service, something like it might be useful for any service facility. Often, difficult-to-diagnose problems seem to send service personnel in circles. When it's used during the repair process, the checklist allows service personnel to keep track of their activities. For the customer, it also provides a sense of organization and process.

Aside from building quality into the service process from the start, the moves made by the Microcomputer Services office at this university also have enhanced communication with their customers. Time-consuming return calls have nearly been eliminated. Customers have become more aware of the workload encountered by the service personnel and more tolerant of necessary delays. As a result, customer complaints have dropped substantially. ■

and 17, 1993. Mr. Bill Henry, a well-known humorist and motivational speaker, will keynote the meeting at the welcoming dinner on Friday, October 15. Two technical sessions on Appliances and Electronics will be presented on Saturday, October 16 concurrent with the many business subjects. David Borsani, President of A Complete Appliance Service, Cleveland, OH, will present his Yellow Page Advertising program. "Computers and Your Business," will be presented by Sharon McCarney, President of Advanced Retail systems. Other topics are; "Handling the Difficult Customer," presented by Regis O'Neil, Best Service Co., Pittsburgh, PA. "Your Cost of Doing Business and Your Related Rate Structure," will be presented by David Ashton.

Various "Table Topics" will be addressed on both Saturday and Sunday. One very special topic "Spouses as Partners" for women only will be co-chaired by Sue Niedzielko, All Brand Service, Naperville, IL and Kathy Beecher, American Appliance & Microwave, Coon Rapids, MN. Other important service subjects such as selling service contracts, how E.D.I. will effect your business, and having a flat rate system will be discussed.

The United Servicers Association, a not-for-profit association, is dedicated to serving and providing services to the independent service industry.

For registration information on the Management Institute and special airline fares, call 800-432-0972.

EIA announces agreement reached to produce first annual CES South America

The Electronic Industries Association and Guazzelli Associados, a major trade show producer in Brazil, announced that they have signed an agreement to produce the first annual CES South America in Sao Paulo, Brazil next August.

The Feira Internacional de Eletro e Eletronicos Para Consumo—CES South America (or CES South America—Consumer Electronics and Home Appliances Show) will be held on Wednesday, August 3 through Sunday, August 7, 1994 at the Parque Anhembi Convention Center. The first two days of the Show will include a consumer electronics conference program (10:00 a.m. to 4:00 p.m.) focusing on issues of importance to South American CES retailers, distributors, manufacturers and exhibitors. Exhibit hours will be from 2:00 p.m. to 10:00 p.m. all five days. (These are traditional trade show hours in Brazil.)

Product categories represented at the Show will include audio and video hardware and software, auto sound and security, home office, multimedia, cellular, videogames, high-end audio, home security, telephones, personal electronics, photographic, home, personal and small appliances, healthcare, antennas, cable providers, retail resources and publications. The Show is expected to attract 30,000 trade attendees, approximately 150 exhibitors and a large South American press contingent.

EIA responds to FCC's ATV second report and order

The Electronic Industries Association's Advanced Television Committee (EIA/ATV) has submitted a series of comments in response to the Federal Communications Commission's (FCC) Second Report and Order of May 8, 1992.

The Committee comprises a broad spectrum of electronics enterprises with strong, but diverse, interests in the implementation of advanced television ("ATV") in the U.S.

The Committee vigorously supports the FCC's continuing efforts to formulate public policy for ATV.

In its comments EIA's ATV Committee highlighted the following points:

• The Committee supports the decision to limit initial eligibility for ATV channels to existing broadcasters.

• It agrees that "definite application and construction deadlines" are essential to bringing ATV to the American public quickly, and it supports the two- and three-year deadlines adopted by the Commission.

• The Committee supports the Commission's action with respect to the full range of spectrum issues, including broadcast auxiliary services, coordination with Canada and Mexico, and the treatment of low-power television and translator services.

• It agrees with the Commission's determination that NTSC should be discontinued, nationwide, on a single date. Although the Committee believes that it is premature to establish a firm date at this time, if the Commission decides to do so it should reiterate its firm commitment to a review of this matter in 1998, when more information is available.

• Predictions about the availability and costs of ATV receivers, downconverters, and broadcast equipment are necessarily speculative, but "guesstimates" are possible. First-generation ATV receivers will likely command a 100 to 300 percent premium over comparable NTSC receivers, but this will decline over time.

• Concerning simulcasting, the Committee believes the Commission should recognize the importance, especially in the early years of the transition, of allowing broadcasters to exercise their creativity in ways which stimulate consumer interest in ATV and help to develop the market for ATV receivers. On a related point, the Committee suggests the Commission consider establishing minimum requirements for the proportion of programming on ATV channels that is of true HDTV quality (as opposed to upconverted NTSC).

• The Committee believes the Commission must remain vigilant to ensure that patent licensing does not become an obstacle to the manufacture of ATV equipment. Full documentation of the system and placement of the standard into the public domain are also essential to permit full competition in the manufacture of ATV equipment.

• The Committee believes it is extremely important that the Commission conduct a thorough review of transition issues in 1998. This approach will allow for such "mid-course corrections" as may be advisable in light of the much greater information that will be available at that time.

• The Committee supports the efforts of the Commission and the Advisory Committee concerning "compatibility," to ensure the suitability of the terrestrial ATV broadcast standard for use in other video delivery media, such as cable, telecommunications, and satellite, and with computer applications. In the development of consumer acceptance of ATV, it will be especially important that the ATV be compatible with, and carried by, cable.

• Encryption, captioning, and extensibility issues all warrant continued attention by the FCC Advisory Committee and the Commission.

• The Committee is aware of no additional technologies which have reached the point of development and promise that they merit alteration of the Advisory Committee's existing test plans. The door should not be closed on refinement or combination of superior features of the systems currently under consideration.

NARDA and NASD oppose Citicorp lifetime warranties

NARDA and NASD, its service dealer subsidiary, have announced their opposition to a plan by Citicorp, New York, to offer lifetime warranties on products purchased with Citibank credit cards.

"Independent dealers know what they have to pay either to a third party for a service agreement or what they have to escrow themselves," says Con Maloney, NARDA president and a Jackson, MS, retailer. "Based on those understandings, I really question whether Citicorp will be able for an extended period of time to continue this program.

"It further makes it appear that the service agreements as sold by merchants are not a legitimate value, because if Citicorp is going to give them away free, then they must not cost much," Maloney maintains. "In truth, we know differently."

"One has to question the ethics, if not the legality, of such a program," says Ed Knodle, executive director of the association of consumer electronics and appliance dealers.

Among NARDA's objections to the plan is its maximum claim of $1,000 and the maximum annual claim total per cardholder of $2,500. The association also objects to the $10 million aggregate limit on the entire program, which means when the program reaches its limit, it presumably will end and strand consumers without the warranties they were promised.

NARDA and NASD also object to the warranties because they only are effective for the expected service life of a product as set by Citicorp, not its actual lifetime. For a refrigerator, it only is 10 years.

"Apparently, Citicorp did not do enough market research on service warranties before announcing this program," Knodle says. "If they had, they would have learned of the many other third-party administrators who have failed because of high claim payments. The $10 million aggregate would not have been enough for some of these failed companies, and they had much smaller customer bases than Citicorp does.

"This program not only threatens the profitability of many of our members, it also has the potential to further destroy the integrity of the extended service business as a whole," Knodle continues. "We should not let this be introduced without voicing our objections and concerns." NARDA and NASD's legal counsel has written a letter to the attorney general of New York and other states raising legal questions about the program. The associations also have written directly to John Reed, Citicorp's board chairman, and Christopher Steffans, Citicorp president.

"If independent appliance dealers are concerned, they need to voice those concerns to Citicorp directly or perhaps to a corresponding bank that may do business with Citicorp," Maloney says.

Referring to Hoover's multimillion-dollar escrow established to fund a recent promotional offer for free airplane tickets, Maloney cautions, "Sometimes what people think sounds like a good promotion may well be a very bad promotion and may come back and hurt them a lot more than it will help."

"It is our hope that once Citicorp carefully re-examines the program, they will decide to cancel it," says Knodle.

NARDA, the National Association of Retail Dealers of America, represents dealers of appliances, consumer electronics, computers, furniture and other merchandise. Its service subsidiary called NASD, the National Association of Service Dealers, represents independent service dealers and the service managers of NARDA retailers.

Literature *(from page 4)*

ment and computer accessories. *Catalog 45* contains more than 18,000 items from over 850 manufacturers. Included is a 16-page insert of new items, which adds more products from electro-mechanical assembly devices to electronic, telecommunications and field service tool kits. The catalog includes a full-line of items for aerospace production, computer maintenance and the fast growing field of surface mount technology, as well as a line of ESD, static control and clean room items.

Circle (5) on Reply Card

Brochure helps users differentiate among software products

National Instruments recently announced a new four-page, full-color brochure titled *How to Select Your Instrumentation Software*, that highlights LabVIEW graphical programming software for Windows-based PCs, Sun SPARCstations, and Macintosh computers and LabWindows automatic code-generation software for DOS-based PCs. The free brochure assists engineers and scientists in determining their needs, then selecting the proper software for automating their instrumentation applications.

The two software products simplify the development of application programs without sacrificing flexibility and ease of use. With these software packages, users can build custom display panels to present data with a wide variety of graphs, strip charts, and controls. Data acquisition (DAQ) libraries control over 300 GPIB, VXI, and RS-232 instruments, as well as the company's plug-in DAQ, digital signal processing, and signal conditioning hardware.

Both packages have similar capabilities, but differ in programming technology.

Circle (7) on Reply Card

Capacitors and accessories cross reference

Philips ECG introduces the new ECG Capacitors and Accessories Cross reference guide.

The new publication cross references over 8,000 capacitors and accessories manufacturers' part numbers for 36 competitive brands to the ECG brand replacement part number. Coverage includes aluminum electrolytics, ceramic disk, tantalum, memory back-up, motor run and motor start capacitors.

Circle (6) on Reply Card

Readers' Exchange

Readers' Exchange has been reinstated as a free service.

The following restrictions apply to Readers' Exchange:

• Only individual readers may use Readers' Exchange, and items must be restricted to those that are ordinarily associated with consumer electronics as a business or hobby. If you're in business to sell the item(s) you want to offer for sale, the appropriate place for your message is in a paid advertisement, not Readers' Exchange.

• Readers' Exchange items must be restricted to no more than three items each for wanted and for sale, and may be no more than approximately four magazine column lines in length (about 20 words).

• All submissions must be typed or printed clearly!

Send your Readers' Exchange submissions to:

Readers' Exchange
Electronic Servicing & Technology
76 N. Broadway
Hicksville, NY 11801

WANTED

Novice technician looking for self-training courses/books on TV/VCR servicing such as Philips, Heathkit's TV ET-4001 and VCR ET-4010 manuals (no tools, TV, VCR, etc.). Send description and price to *Lewis Suttles, 613 Monroe, Jacksonville, TX 75766.*

Variable transformer output 0-120 VAC 2.5 amp used O.K. Also, Sharp IC X0212CE.4G. *George T. Fogelman, 1201 Idlewilde El Paso, TX 79925. 915-778-0997. AT&T collect.*

Computer electronics courses by Heathkit, or others. Will pay about 1/3 original cost for Heathkit courses such as; Microcomputer Professor P.C. Introductory Course, MS-DOS Course, WordPerfect Course, Lotus 1-2-3 Course, Artificial Intelligence and Expert Systems Course. MS-DOS is most important. *S.O. Sellers, 7308 Franklin Drive, Rock Creek, Bessemer, AL 35023.*

Convergence board for Philco E25-6 Chassis. Must be complete and undamaged. *Call 1-800-925-7389 or write David Riskin, 119 Rockland Center, Box 258, Nanuet, NY 10954.*

Service manual or schematic for Luxman stereo model R1120, and STV3H diodes (2) for Pioneer stereo model SX-550. *Main TV, 615 9th Ave., Longmont, CO 80501. 303-776-6955.*

Schematic/service manual for EICO 239 Solid State FET-TVM and owner's manual/schematic for B&K 1230 Digital I.C. Color Generator. Will pay reasonable cost for copies. *T.T. Walton, 3403 Crestmont, Midland, TX 79707.*

Handheld copy-machine (Radio Shack similar). Uses thermal strips 2 1/2 wide. Working/not/other. *Please call! 1-800-440-2447.*

Service manual/schematic and parts information for Nintendo and Super Nintendo. Willing to pay reasonable copying costs, or will copy and return. Send info *to: Mike Carter, 12565 Twilight Ln., Jacksonville, FL 32225.*

Ultrasonic remote control unit for 1977 RCA Colortrak console TV, Model #GB938SDA. *T. Dashiell, 593 South 10th St., Noblesville, IN 46060. 317-963-6927.*

Instructional books and videos on VCRs, TVs, microwaves, radios, etc. Call *Nick 717-383-3975.*

IFR 500 service monitor, or similar model of communication test equipment. *Bill Gardiner, 328 Canterbury Dr., Pittsburgh, PA. 15238.*

Two-flyback tranformer Sylvania No. 50-3017134-05. *Brown's TV, P.O. Box 146, Peterstown, WV 24963. 304-753-9549.*

Complete service manual for Bogen Single Channel FM-Wireless Intercom, Model WI-1B. Will pay for copying or buy. *Ed Herman, 1462 East 35th Street, Brooklyn, NY 11234.*

Radio Shack Chip #276-1761 MOS, dual 512 stage audio delay line, also known as SAD-1024. *Call 805-733-0618. Leave Message.*

B&K 470 CRT checker adapter socket CR-42; Fisher VCR service manuals. *ED Herbert, 410 N. Third St., Minersville, PA 17954.*

Sams Photofacts above 2400. Any number and condition. *S.C. Von Tersch, 1555 Kane St., Klamath Falls, OR 97603. 503-883-3694.*

FOR SALE

FC71 frequency counter 10Hz-1GHz, Chrystal check direct/LO cap (x10) probe, RF pickup loop, dummy load, ac adapter/charger, $500.00. *307-283-1960.*

Sencore VA62 UVA and VC63 TA with manuals, cables, original carton. $1500.00. Plus shipping. *M. Meckling, Box 131, Fairview, KS 66425. 913-467-3921/8431.*

B&K 1077B TV analyst with leads, test patterns, and manual. $95.00 or best offer. *G. Inman, 330 Vanbauren Ave. No., Hopkins, MN 55343. 612-933-8006.*

B&K 490 CRT/Video display restorer/ analyzer. Paid $1095.00 in '92. Will take $600 UPS-COD. Money back guarantee. *703-566-2265.*

TV-VCR test equipment—Sencore, RCA, Tentel, B&K, Sams Photofacts 1-2676 (few missing) w/cabinets—brand name repair parts. Sacrifice $12,500.00. Tecumseh, MI. *517-423-7233.*

Sencore SC61 Waveform analyzer, bought new and never used. *Wanda Wiegers, 12303 North 70th, Lincoln, NE 68517. 402-467-2102.*

Complete shop of parts, major manufacturers service literature. Sell for fraction of cost. TV, sound, VCR, microwave., *Robert Haan, 2885 E. Beltline N.E., Grand Rapids, MI 49505.*

B&K 1470 15 MHz oscilloscope. $75.00. Needs repair. B&K will rebuild for $135.00 B&K 1474 30 MHz oscilloscope. Excellent condition. One probe and all manuals. $300.00. Other equipment also available. *Dave, 612-762-1212 days.*

B&K 1570, 80MHz, dual time base, quad trace oscilloscope, 10:1 leads and all manuals. Must sell, $950.00 or best offer. *912-283-4309-Phillip, after 6:00.*

Simpson meter and B&K tester and rejuvenator $50.00 for both including shipping. *M.E. Andrews Jr., P.O. Box 91, Exeter, RI 02822.*

7904 Tektronix scope 500MHz with two 7A26, one 7B53A, one 7B92, plus cart. Like new. New over $20,000.00. Take it for $1,500. *Andy, 914-236-4773.*

Sencore VA62A & VC63 $1800.00 plus UPS. *AG Tennenbaum, PO Box 110, E. Rockaway, NY 11518. 516-887-0057.*

2,000 receiving tubes for radio and TV. Will sell outright or trade for Sencore VC-93, SC3100, VG91. *Blasig TV Service, 70 W. Dudley Town Rd., Bloomfield, Ct. 06002. 203-242-4015.*

Riders 1 through 16. Sams Photofacts 1-1079. Radio Auto Service manuals. *Write Jay's, 15 1/2 W. Lake St., Chisholm, MN 55719. 218-254-4421.*

Motorola solid-state dc multimeter (VTVM) with RF probe and test leads/ power cord. $40.00. *Joe Smith, 8429 Livingston Way, Juneau, AK 99801. Phone/ Fax 907-789-5017.*

Heath IB-2A Impedance Bridge, in good condition. $45.00 includes manual & shipping. *Robert Kramer, 919 Grove St., Aurora, IL 60505. 708-898-8946.*

Sencore SC-61 Waveform analyzer, like new, in box. $2195.00 or best offer. Cost $3295.00 will ship COD write. *Rob Denton, 3913 Doris Dr., Ama, TX, 79109. 806-353-3493 message.*

Numerous hard-to-find parts; receiving tubes, new/used; Sams from $1.00 and up. *Stanley's TV. 801-722-4108. 55 No. 300 E. (123-10) Roosevelt, UT 84066.*

475 new tubes. 720 good used tubes. Miscellaneous, new & used TV parts. Best offer. Send an SASE for list. Hethkit sweep generator. Model TS-4A. $25.00. *305-771-2125 N.E., 63 Court. Ft. Lauderdale, FL 33308. Ask for George.*

1000's of factory (NOT Sams) service manuals, bulletins, updates, 1978-present; Tektronix, Philips, Fluke, Tentel, Heath test equipment; office equipment; more! *SASE to Dave Burd, 14 Penn Estates, E. Stroudsburg, PA 18301. 717-424-5245.*

MOT test set model S 1056 for MOT. Trans & Rec. 25TO 960 MC $25.00. B&K color gen. model 1246. $35.00. Also, 300 boxed radio & TV tubes. $100.00. *708-516-2909. J. Driscoll, 115 Erin Dr., Cary, IL 60013.*

Distributor goes out of business. 5500 new boxed tubes for sale. All offers considered. May take Sencore equipment for part trade. Also have rare Quasar VC60 and VC120 old style video cassettes in box. *Bob Nelson, 602-855-5400.*

Sencore SR68 Stereo TV readout. $300.00. Data Precision 938 portable digital cap. meter, $75.00. Both in excellent condition. *Dave's Electronics, P.O. Box 151, Poway, CA 92074-0151.* ■

Classified

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

By-the word. $1.65 per word, per insertion, pre-paid Minimum charge is $35 per insertion. Initials and abbreviations count as full words. Indicate free category heading (For Sale, Business Opportunities, Miscellaneous, Wanted). Blind ads (replies sent to ES&T for forwarding) are $40 additional. No agency discounts are allowed for classified advertising by the word. Contact Emily Kreutz at 516-681-2922 to place your classified ad (by-the-word). Mastercard, VISA, American Express and Discover are accepted for FAX or mail orders.

Per column Inch (classified Display): $235 per column inch, per insertion, with frequency discounts available, 1" minimum, billed at 1/4" increments after that 10" maximum per ad. Blind ads are $40 additional. Reader Service Number $25 additional to cover processing and handling costs. (Free to 4-inch or larger ads.) For more information regarding classified display advertising please call 516-681-2922. Optional color (determined by magazine) $150 additional per insertion.

Send your order, materials and payments to:
Electronic Servicing & Technology
76 North Broadway
Hicksville, New York 11801
Attn: Emily Kreutz
Phone: 516-681-2922
FAX: 516-681-2926

FOR SALE

REMEMBER, It's not the quantity of TIPS but the Quality of Solutions that makes the difference. Our 10,000 TECH-TIPS cover VCR-VCP-TV/VCR Combo CD/LD-FAX-Camcorder/VHS/SVH/C/8MM/ Camera-Stereo TV Monitors/TV/Computer-Rear/ Overhead Projection Amplifiers-Microwave-Satellite. Our program is actual day to day repairs, written by technicians for technicians. No need for you to spend time updating your data base or paper binders. We send you a complete revised program at each update of your choice (computer or paper format). Outside technicians & students love the portability and say it is a must for the field where time is very critical. As an added extra, we provide you with an FCC ID Cross reference list which saves the expense of purchasing service manuals you may already have and just don't know it. Also, when you join our ongoing program we will send you a key to streamlining your company into profitability overnight! (We actually did it!) **CALL NOW (800) 474-3588 FOR A "FREE" DEMONSTRATION DISK OR PAPER FORMAT** or mail request to **TV-MAN SALES & SERVICE, 8614 SR-84, Ft. Lauderdale, FL 33324.**

Tech ReSource, a computerized directory of over 650 total listings of consumer electronic part distributors in over 90 manufacturer and other categories. IBM compatible 3-1/2" or 5-1/4". Mastercard/Visa **1-800-580-4562 $34.95.** Brochure available. M.C. **Humphrey** & Co. P.O. Box 1414, Noblesville, IN 46060.

Video Analyzer For Sale: Sencore VA62 used 1 year, very good condition, ACC, Inc. $2,000 OBO Myles: Daytime 515-752-0960.

RCA 176342/176343 TUNER CURE! Repair easily to component level. For complete instructions send $20.00: **TEK Enterprises** 212 Marabou Dr. Newark, DE 19702.

MONITOR REPAIR SOFTWARE. Designed for the bench technician, fast easy to use, eliminates costly testers. Write or call for details. Fessenden Technologies, 116 North Third Street, Ozark, MO 65721 (417) 485-2501.

****** The TIP COMPUTER PROGRAM **** One of the LARGEST tip databases in the COUNTRY — over 12,000 tips!!! HIGH QUALITY, PROFESSIONAL SOLUTIONS with up to 8 LINES of problem solving information** (not just 1 line like in other programs). Special **DATA EXCHANGE** feature **INCLUDED with every program,** allows Service Centers with the TIP Program to exchange tips via diskettes. **PRINT** any tip. **EASY** to operate — **ANYONE** can use the TIP Program. This is the **BEST** technical tip database program on the market today. If you want to use only one tip program — **this is the TIP Program to buy.** Used by National Association Members & Officers. **CALL NOW!!! (516) 643-7740** HIGHER INTELLIGENCE SOFTWARE, 60 Farmington Lane, Melville, NY 11747

REDUCED 85%. Diehl Mark III $69, Diehl Mark V Horizontal circuit tester $179. New. Conductive coating for remote control keypads $9.99 ppd. WEEC, 2805 University Ave., Madison, WI 53705. 608-238-4629, 608-233-9741.

VHS-VCR Repair Solution Sets I, II, III IV, V, VI, VII, VIII. Each contains 150 symptoms and cures, updated cross reference chart, free assistance, $11.95 each, all eight $79.95. Schematics available. Visa/MC. Eagle Electronics, 52053 Locks Lane, Granger, IN 46530.

CABLE TV DESCRAMBLERS/ CONVERTERS Wholesale Outlet. All major brands. Money back guarantee. 1 year warranty. **THE CABLE CONNECTION 800-764-5400. DEALERS WELCOME.**

TV/VCR REPAIR SOLUTIONS: 1,000 VCR printed $83. 5¼" IBM disk $72. 5,400 TV prints $135. Disks $113. 1,000 latest TV $54. Electronic Solutions, 407 W. Ave. "N", San Angelo, TX 76903.

The Dog Catcher 2.1 is a computer based repair tips program. The best program for newer models. The best value. Updated monthly. Our tips come from a network of technicians who currently use The Dog Catcher. The Dog Catcher 2.1 is available through November 1993 at the introductory price of $99.95. Call us at 1-800-967-5924 for more information.

Earn $$$ Repairing Zenith TV's To Component Level—110 module cures 9-90 thru 9-1119. **Guaranteed effective** and reliable cost cutting symptom/cure format. Big profit potential. $10/sample, $100 for all: **ZMEX**, 807 Queen Palm Lane, Sarasota, FL 34243.

TV–VCR SHOPS: A program of over 2800 fixes on disk. Only $99.95. TECH-DAT, 212 Earth Row, Waynesville, MO 65583. Call 1-800-280-2100. VISA & M/C.

USED TEST EQUIPMENT FOR SALE: Including **Sencore** *Computer Monitor Analyzer, CM 2000 *Universal Video Generator VG-91, *Stereo Power Amp PA-81, *Variable Transformer PR-57, *CRT Restorer CR-70; **Tentel** *VCR Gauges; **Huntron** *Tracker. Call or write for a price sheet and complete list of available equipment. L. Lunsford, P.O. Box 471043, Aurora, CO 80047-1043. 303-693-9759

TV CASE HISTORIES: Booklet with 1,750+ histories. Satisfaction assured. Only $35 (first-class shipping add $1.50). Mikes Repair Service, P.O. Box 217, Aberdeen Proving Ground, MD 21005. Same mailing address 29 years. Send SASE for samples.

TVA-92 - TV video analyzer and VG-91 - video generator. Excellent condition under warranty $3,300. CR-70 - CRT restorer $900, 3 months old. Paul Farrow (217) 446-1147

BUSINESS OPPORTUNITIES

MOVE TO SUNNY SOUTH FLORIDA: A Turn of the key guarantees minimum take home of $100,000. Owner retiring. Fully staffed in largest growth area of Ft. Lauderdale. Established 12 years, no competition. Authorized 15 major brands. 100 percent computerized. Simple to operate business. Owner financing available. Call for details 305-474-2677.

ESTABLISHED 15 YEARS authorized service center: good location, great potential. authorized 17 major brands, 100% computerized, well equipped with tools and schematics. Call 212-447-7562

TV-VCR SHOP FOR SALE—FULLY EQUIPPED IN GOOD HIGH INCOME AREA—32 years same location—Step in and make money immediately call for details southern Calif. 909-684-9393.

Busy TV VCR Computer Repair Shop: Owner Retiring. Call for Details. Days 305-961-1011 Eve 305-891-8749.

MOVE TO SOUTHERN CALIFORNIA. Growing high desert community TV/VCR shop. Good visibility, no smog, low crime. $15,000 takes all. Call George, (805) 948-4144.

WANTED

EXPERIENCED ELECTRONIC TECHNICIAN - VCR Television repair - factory trained a strong help. Live in the beautiful Smoky Mountains near lakes and waterfalls. Very good pay - full time. Modern store - "top of the line" equipment. Call Dave, Mountain Electronics, Glenville, NC (704) 743-2810.

Advertiser's Index

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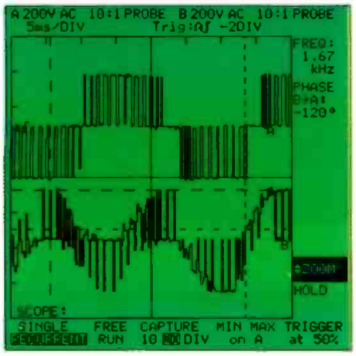
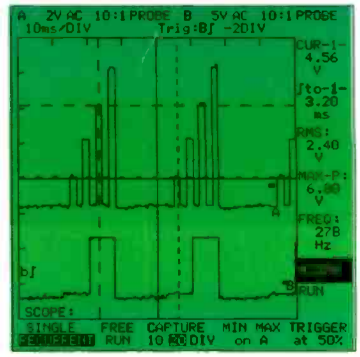
A DAY IN THE LIFE OF SCOPEMETER®.

6:42 AM, Motor in #2 shaft overheating.
Dual channel shows incorrect drive signal.

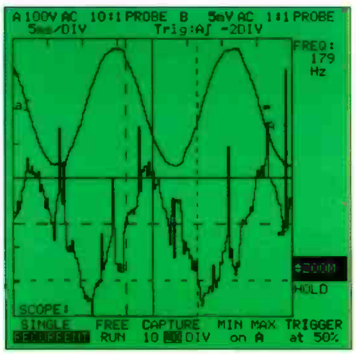


8:23 AM, Security Monitor not working.
3-1/2-digit DMM indicates bad ground.

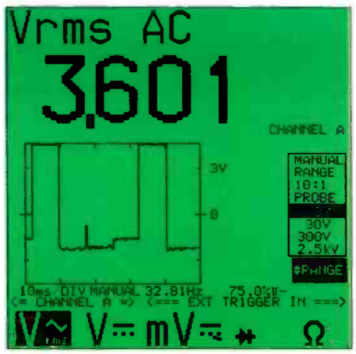
9:25 AM, Conveyor Stepper Control fails.
Cursors help find broken sync connection.



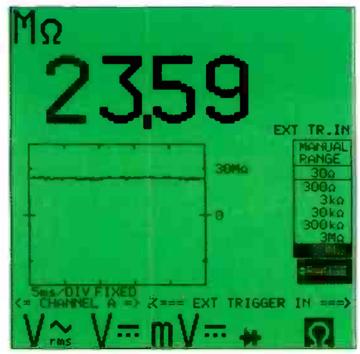
10:57 AM, Intermittent Auditorium lighting.
Waveform shows too much noise.



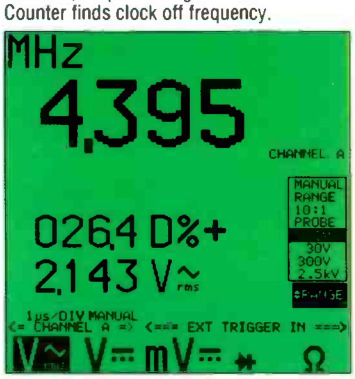
11:17 AM, 5V Control Signal is bad.
Scope display reveals -DC offset.



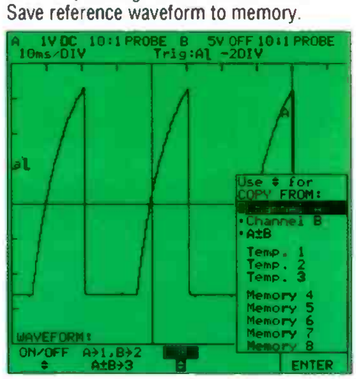
12:58 PM, Air Conditioner overheating.
Resistance shows corroded connection.



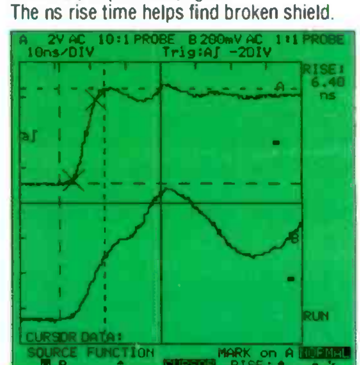
1:22 PM, Copier toning uneven.
Counter finds clock off frequency.



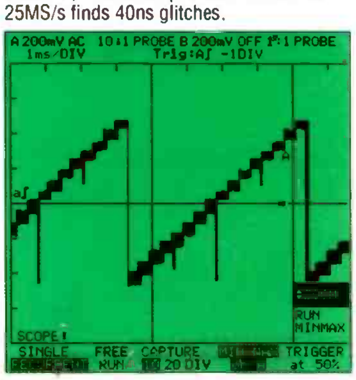
2:14 PM, Testing Power Inverter loads.
Save reference waveform to memory.



3:12 PM, Copier fails, again!
The ns rise time helps find broken shield.



4:05 PM, Salesman presents demo board.
25MS/s finds 40ns glitches.



From the roof top to the basement, indoors and out, the ScopeMeter test tool works wherever you work. The sealed, ruggedized case is designed for hand-held use. The backlit screen works in both bright sun and low light conditions. And the logical control panel makes operation simple. So, make your day a little easier. Call **1-800-44-FLUKE** and ask how the ScopeMeter test tool can help you save time and frustration with electrical problems, on the go.

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