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THE PROFESSIONAL MAGAZINE FOR ELECTRONICS AND COMPUTER SERVICING

ELECTRONIC Servicing & Technology

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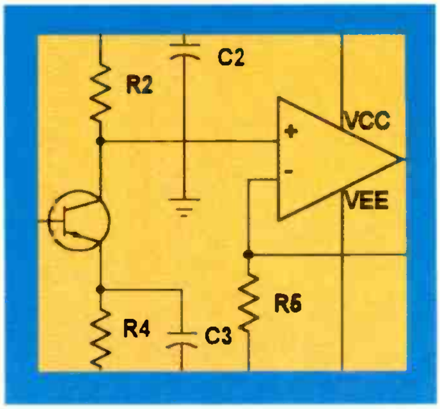

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ON THE COVER

Servicing philosophy swings back and forth between the concept of isolating faults down to the component level and the concept of finding and replacing the defective module or circuit board. Each concept has its adherents and its detractors and its advantages and disadvantages. However, it's always useful for a technician to possess the skills to be able to troubleshoot in enough detail to pinpoint the problem component, even if in a particular case it turns out to be more efficient to replace the entire circuit board or module. (Photo courtesy Thomson Consumer Electronics).

EDITORIAL

The logic of logic

An interesting thing happened when component manufacturers began manufacturing integrated circuits. People began thinking of circuits in terms of functional blocks, rather than in terms of individual components. Of course, that's not to say that since that time that all engineers or technicians think of all circuits in terms of functional blocks. Many circuits don't lend themselves to that kind of treatment.

In many cases, however, rather than troubling about what components an IC package contains, the technician only cares about whether its inputs and outputs are correct. After all, even if he could determine if R3, or Q7 within the circuit was bad, he can't get inside to fix it. If the IC is bad, it will have to be replaced.

The change in thought process from components to functional blocks is especially pronounced in the area of logic circuits. Early in the computer era, computer manufacturers began offering logic circuit packages; products like "quad two-input NAND gate," or "quad two-input NOR gate." Each of these devices contained four of the gates in a single package. In fact the so-called 54/74 series of integrated circuit packages consisted largely of logic circuits packaged in functional blocks such as this.

Given this type of component, the computer designer was freed of the necessity of worrying about how individual components, or combinations of components, behaved. He merely had to provide the correct supply voltages and combine the logic devices in the proper manner in order to create the circuit he desired.

Actually, in many cases this makes the job of the technician easier as well. Instead of having to worry about the correct responses of a resistor, capacitor or inductor to electrical phenomena, or having to remember the value of the emitter to collector voltage drop in a silicon transistor, the technician now merely has to make sure that the inputs, outputs and supply voltages to an integrated circuit are as specified. If they are not, he has to determine if the problem is caused by an incorrect supply voltage or a problem with the source of the input signal, or caused by the device itself.

Fortunately for the designer, logic circuits are extremely versatile. For example, as the article "Isolating logic faults at the component level," in this issue states, "Most logic used nowadays is positive convention. In positive logic, the more posi-

"...the concept of "duality" exists in logic. There is a positive way and a negative way of saying the same thing."

tive voltage will represent a binary 1 or "True" or "High" state. Also, in current logic, a true, asserted, 1 state, or closed switch is represented by 20mA, and a 0 or off, or inactive, or open switch by 0mA. It is agreed, however, that when using the High (H) and Low (L) system, the H is always the more positive voltage and the L is always the more negative voltage."

However, as the same author points out, the concept of "duality" exists in logic. There is a positive way and a negative way of saying the same thing. That's why duality gates are called negative logic gates. He further cautions readers not to confuse the duality concept with negative logic convention. Duality simply means that a particular circuit may be represented as either an OR or an AND function.

Actually, as the author points out, a physical gate can be represented by any of four symbols if both positive and negative logic conventions are used.

Unfortunately, all of this versatility for the designer makes things more confusing for the technician, just as it is in the

"Of course, as long as we're consistent about the convention, it doesn't matter how we think of the circuit, when we perform the calculations, they'll turn out to be correct."

case of the current convention. Some technicians were taught to think of current in a dc circuit as flowing from the positive pole of the battery. Other technicians were taught to think of current as the flow of electrons from the negative pole of the battery. Of course, as long as we're consistent about the convention, it doesn't matter how we think of the circuit, when we perform the calculations, they'll turn out to be correct.

The same is true in the case of logic symbols. Regardless of whether the gates were designed to operate on positive supply voltages or negative supply voltages, and whether the logic functions are realized using a particular gate or its dual, the end result is the same. We just have to be careful to apply the rules of logic correctly in order to know what's going on, and what might be going wrong.

Electronics in general, and consumer electronics in particular, are increasingly based on digital circuitry. The signal for DTV systems, the satellite to home television systems, employs a digital signal. Soon broadcast television, including HDTV will follow suit. Troubleshooting of these devices will increasingly require a knowledge of the operation of digital circuits, including logic devices. It will, therefore, become increasingly important that technicians apply the correct logic when dealing with logic devices.

Nils Conrad Persson

December ends 1997 audio year with expected bang

Audio sales ended the year on the up beat, according to figures released by the Consumer Electronics Manufacturers Association. Overall December audio shipments rose six percent to $525 million for the period. Total 1997 audio sales were $7.7 billion, one percent less than last year's total sales.

December offered expected good news in audio system sales, with dollar volume soaring 26 percent. Compact systems kept up their status as the driving force all year with total sales for 1997 at $1.4 billion, a 22 percent gain compared to the same figures in 1996. Home theater-in-a-box systems eclipsed rack sale system sales by bringing in $282 million. The entire audio systems market rose 16 percent to $2 billion, compared to last year's figure.

Aftermarket mobile sound sales remained steady, bringing in another $1.8 billion in December. In this category, CD players were by far the brightest light, selling $613 million in units throughout 1997, representing a jump of 18 percent compared to last year.

Home radios and boomboxes thumped into the lead for portable audio figures, with each product's sales rising four percent and two percent, respectively, in 1997. The portable audio market rose nine percent in December, compared to its performance last year.

The audio separates market showed an increase in receiver sales in December, climbing five percent over last year. The separate components sector brought in $1.6 billion in 1997 sales.

CEMA report on digital radio with FCC

Concluding its six-year evaluation of Digital Audio Radio (DAR) systems, the Consumer Electronics Manufacturers Association (CEMA) filed its final report with the Federal Communications Commission (FCC) last week. The report, "Technical Evaluations of Digital Audio Radio Systems: Laboratory and Field Test Results, System Performance, Conclusions," is available from the FCC and through CEMA's web site, www.cemacity.org/works/pubs/dar.htm.

The DAR Subcommittee examined nine proposed technologies for broadcast digital audio radio. Of all the systems tested, only the Eureka-147/DAB system offers the audio quality and signal robustness performance that listeners would expect from a new DAR service in all reception environments. The other systems had significant problems:

1. The IBOC (in-band, on-channel) systems as presented and tested are not feasible at this time due to deficient performance in the areas studied: audio quality, performance with channel impairments, RF compatibility and extent of coverage.

2. The IBAC (in-band, adjacent-channel) system cannot be deployed due to interference with the current spectrum occupancy of the FM band.

3. The VOA/JPL (Voice of America/Jet Propulsion Labs) system at S-band frequencies is subject to continuous and/or repeated outages due to blockage. It is not clear that this could be totally remedied.

"Despite these results, last spring we halted advocacy of the adoption of any system at the request of the broadcasters who said they needed more time to correct the flaws of the IBOC system. We look forward to the demonstration in the near future of a system that will work," said Gary Shapiro, CEMA president.

CEMA is a sector of the Electronics Industries Association (EIA), the 74-year-old Arlington, Virginia-based trade association representing al facets of electronics manufacturing. CEMA represents U.S. manufacturers of audio, video, accessories, mobile electronics, communication, information and multimedia products which are sold through consumer channels.

CEMA unveils DTV certification logo at 1998 international CES

Icon Signifies Compliance with ATSC digital TV standard

The Consumer Electronics Manufacturers Association (CEMA) and the Advanced Television Systems Committee (ATSC) have unveiled a new logo for the DTV Receiver Certification Program. The new logo will be displayed on television sets, computers and other consumer devices to signify to consumers that the product they are about to purchase will be capable of receiving and presenting for display all ATSC video formats.

A CEMA/ATSC certification program, which will be administered by CEMA, will allow manufacturers to assess their products for conformance to the ATSC standard. ATSC will establish the conformance standards and compliance testing procedures.

"The new DTV certification logo is part of our efforts to minimize consumer confusion in the digital TV marketplace. This logo signifies to consumers that the products carrying this label will work with all the ATSC video formats," said Gary Shapiro, president of CEMA.

The ATSC, established in 1982, is an international organization developing voluntary technical standards for the entire spectrum of advanced television systems. The ATSC membership is composed of approximately 130 companies and organizations from the television, computer, telecommunications, and motion picture industries.

Home theater becomes more affordable for families

Home theaters are becoming even more affordable for families, according to new data from the Consumer Electronics Manufacturers Association (CEMA). While dollar sales of home theater products * in 1997 reached $8.2 billion; a slight drop from the $8.3 billion generated in the previous year, many of the essential components of home theater systems sold more units than ever before. Overall unit sales of home theater products rose five percent.

Showing an impressive 14 percent increase, the number of home theater households continued to expand from 13

(Continued on page 60)

Tools catalog

Jensen has just re-issued its 300-page, full color Master Catalog, offering full lines of products for the worldwide electronic/electrical industries. In addition to the company's tool kits, this catalog covers test equipment, specialty hand tools, wire and cable, power tools and measurement, soldering, storage and handling, work stations and static control, lighting and vacuum cleaners, and accessories for computers, networks and telecommunications. This latest edition includes many new items, such as: power drills, a reciprocating saw, test meters, a stereo inspection microscope, a paging system, multipurpose scissor tool, the latest torx driver sets, and more.

Circle (100) on Reply Card

Semiconductor and relay cross reference

Philips ECG introduces its Semiconductor and Relay Cross Reference for Windows on 1.44M diskettes.

Over 4,000 ECG semiconductor replacements cross to approximately 300,000 industry part numbers, and 775 ECG relay replacements cross to approximately 60,000 industry parts numbers.

In addition to crossing industry part numbers, the Instant Cross program displays the full Semiconductor and Relay device description, case style, and a reference to any special or general notes that may apply. Another feature of the software permits the user to select from a number of font sizes for easy viewing.

The program contains the same cross reference database as published in the ECG Semiconductor Master Replacement Guide (ET-2762), now in its 17th edition and the 8th Edition Relay Guide (ET-2700-1). The product line comprising this database includes replacements for transistors, IC's, SCR's, TRIAC's, rectifiers, diodes, optoelectronic devices, solid state relays, general purposes relays, timer relays, optical sensors and many other devices.

Circle (101) on Reply Card

Fiber optic training booklet

Fiber U, Fotec's fiber optic training program called *The Fiber U Guide to Fiber Optic Training*. The booklet has been written for both students and instructors, offering information on how to choose a fiber optic training program to attend as well as how to run one.

Because the company has been frequently asked for advice on choosing courses by those interested in learning fiber optics and how to start teaching one by instructors, they have written this booklet to provide guidelines for both.

For the student, the booklet offers advice on how to choose a course, evaluating the material, format and instructor. For the instructor, the booklet offers advice on how to structure a course, find appropriate materials for teaching and even set up a classroom for the course. Fiber U programs for students and instructors are described also.

Circle (102) on Reply Card

Tool/toolkit/test equipment catalog

Techni-Tool's al new 1998 color catalog includes a selection of hard-to-find tools, tool kits, production aids, test equipment and computer accessories. The catalog is filled with more than 16,000 items from over 650 manufacturers, including electro-mechanical and assembly devices, electronic and telecommunication tools, production tools, custom tool kits, bio-medical-related-tools and field service tool kits. The catalog carries a full line of items for aerospace production, computer maintenance and surface mount technology, as well as a complete line of ESD, static control and cleanroom items.

Circle (103) on Reply Card

Technical support newsletter

Sencore, Inc. has announced that Sencore News #182 is now available. This issue discusses what's necessary for businesses to stay competitive in the service industry. New servicing challenges are forcing service centers to stay current with training and test equipment. The company's new training seminars and schedule are also listed in this issue.

This technical publication, printed six times a year is designed to help electronic servicers (owners and operators) with informative articles and troubleshooting tips spread throughout each issue.

Circle (104) on Reply Card

Anniversary catalog

Jameco Electronics has released their twenty-fifth anniversary catalog featuring 5,000 ICs, components, tools, test equipment and computer products for OEMs,. engineers, educators and service/repair technicians.

In addition to new memory chips, embedded development boards, tools, hobby kits and power supplies, the catalog's 270 new product additions include full lines from manufacturers such as Panamax, DTK Computer, Shaxon, Wavetek and Velleman.

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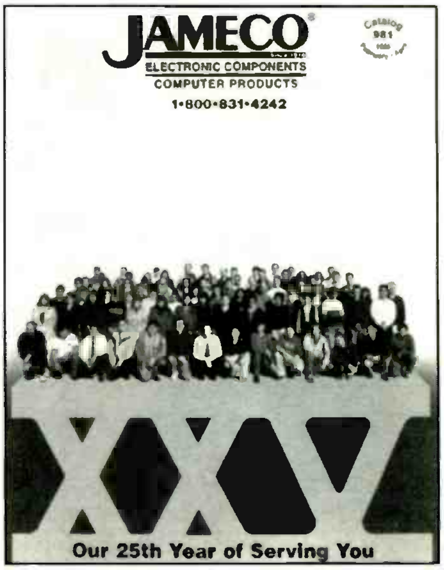

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Isolating logic faults at the component level

by Tom S. Jones

After using various digital instruments such as logic analyzers, computer diagnostics, and signature analyzers when dealing with digital circuits, final troubleshooting procedures include signal injection, tracing, and disturbance tests to isolate the defective component. Regardless of the method used to discover the general location of a digital fault, final component isolation usually comes down to a decision between two or more integrated circuits which share common connections. An understanding of digital theory, integrated circuit fault modes, and applicable troubleshooting techniques will help when diagnosing faults in digital logic circuits.

Interpreting logic

While *digital* represents quantities in multiple discrete increments, *logic* implies that a decision is made based on supplied information. Most logic used nowadays is positive convention. In positive logic, the more positive voltage will represent a binary 1 or "True" or "High" state. Also, in current logic, a true, asserted, 1 state, or closed switch is represented by 20mA, and a 0 or off, or inactive, or open switch by 0mA. It is agreed, however, that when using the High (H) and Low (L) system, the H is always the more positive voltage and the L is always the more negative voltage. Figure 1 contrasts logic conventions.

Data books usually refer to specific logic circuits formed in an integrated circuit with positive logic convention. So a positive logic, 2-input OR gate will require one or more "more positive" voltage inputs to obtain a "more positive" voltage output. A positive logic two-input AND will require two "more positive" voltage inputs to obtain a "more positive" output voltage (Figure 2). In a logic diagram, if a straight line terminates on a gate, input or output, it means a logic high state satisfies or asserts that point. A circle indicates that a logic low satisfies or asserts that point. Referring to the OR symbol, say that there was a low on A and a high on B. According to the symbol lines (no circles on this gate) terminating on this gate and the knowledge that it is an ANY gate, there will be a High output. However, Low inputs on both lines will yield a low output because the gate is not

Jones is electronics applications engineer at Enercon Industries, Menomonee Falls, WI.

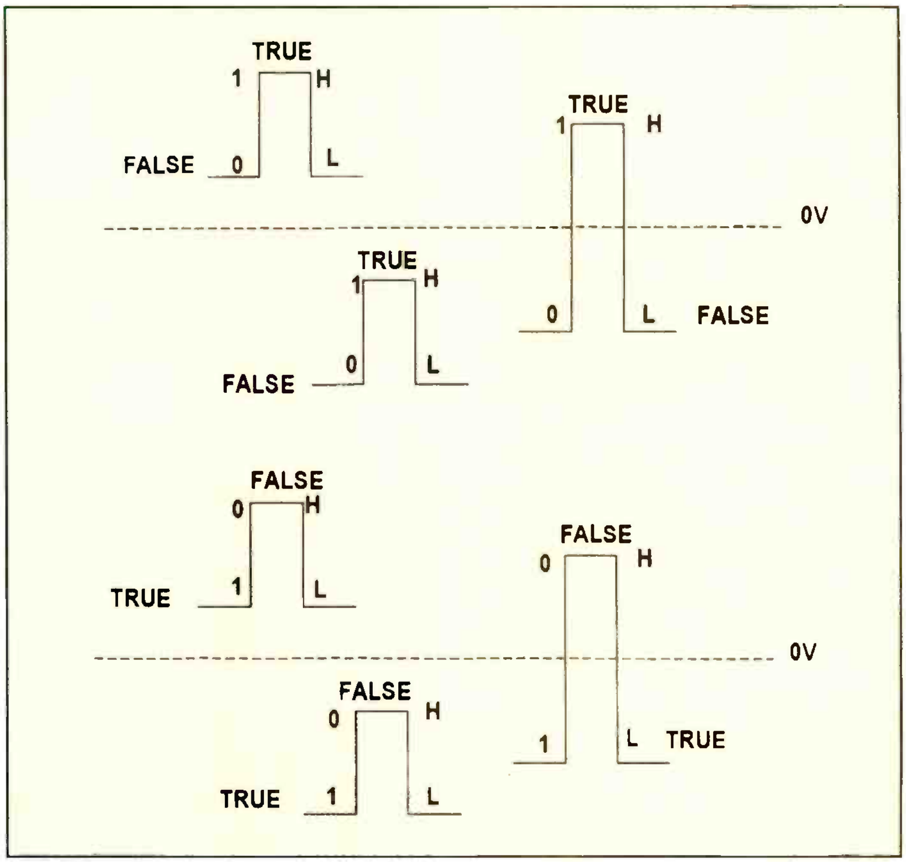


Figure 1. Logic conventions describe the arbitrary values we assign (1,0, True, False, etc.) to the hardwired system voltage swings.

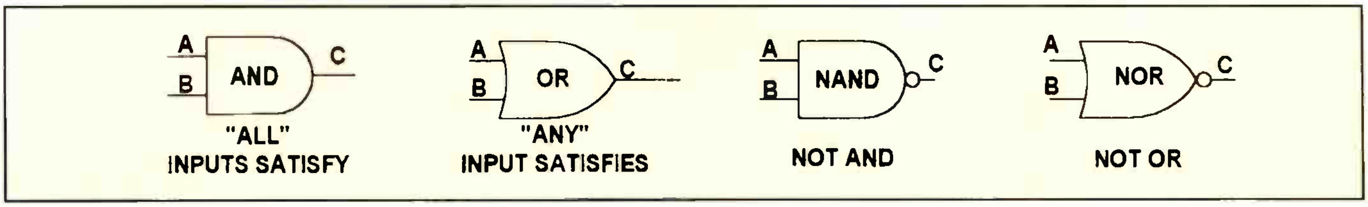
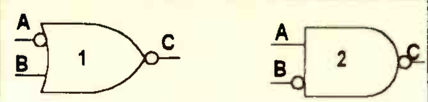


Figure 2. An AND gate requires signals at all inputs in order to produce an output. An OR gate requires a signal at any input to produce an output. NAND and NOR are the netation of AND and OR respectively.



A	B	C
0	0	1
0	1	1
1	0	0
1	1	1

Figure 3A. The gate at the right is the logical "dual" of the gate at left. To form the dual of any gate, change AND to OR (or vice versa) and put lines where there were circles and circles where there were lines.

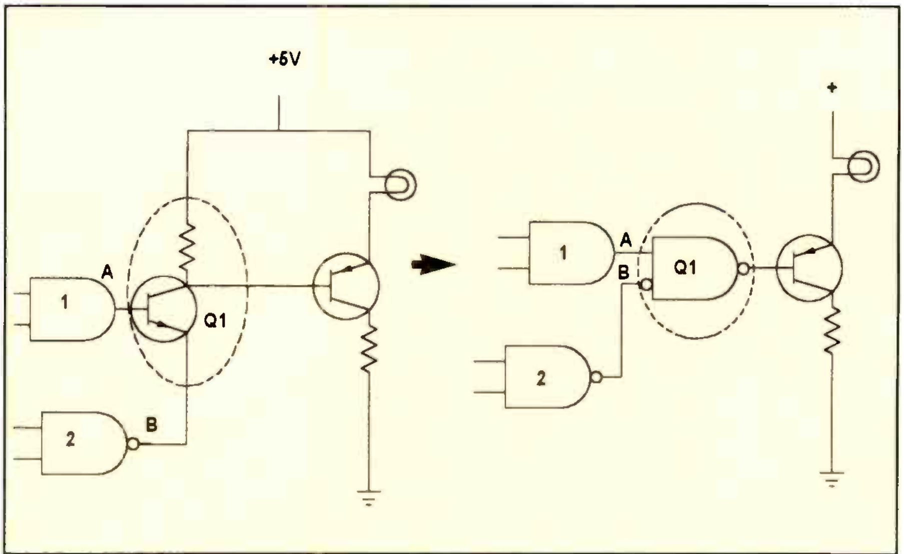


Figure 3B. The logic gate circled in the drawing at the right is the equivalent of the transistor circuit circled in the drawing at the left. A H at the base of the transistor, AND a L at the emitter produces **a** L output.

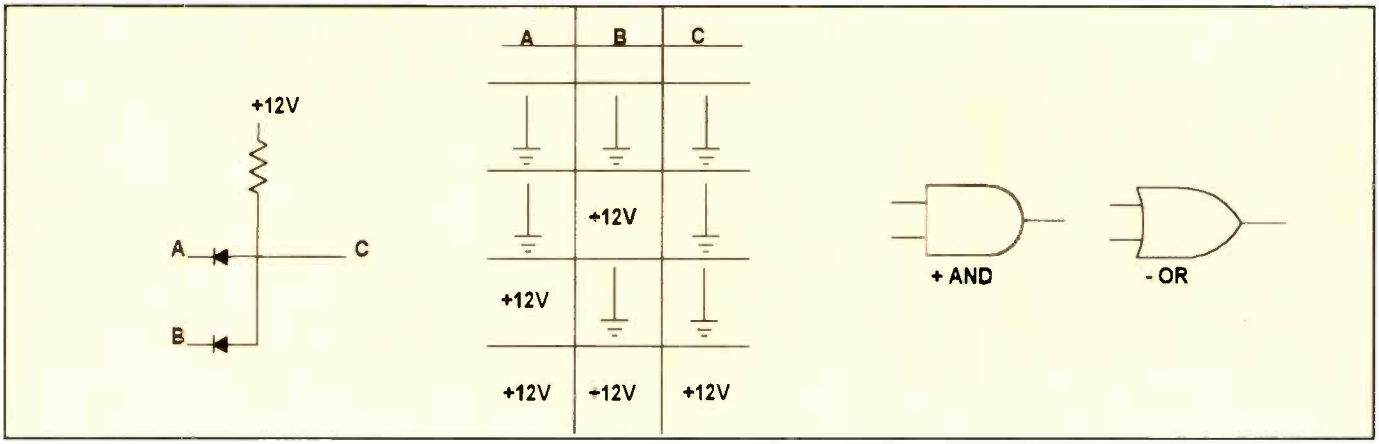
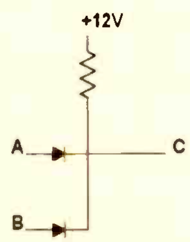


Figure 3C. Either of the logic symbols at the right (+AND or -OR) satisfies the truth table, and so is the logical equivalent of the circuit at left.



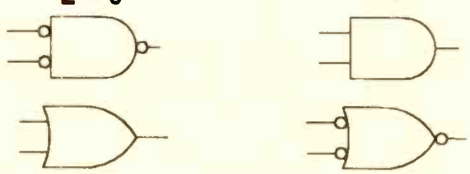
A	B	C
-12V (L)	-12V (L)	-12V (L)
-12V (L)	(H)	(H)
(H)	-12V (L)	(H)
(H)	+12V	+12V

A	B	C
0	0	0
0	1	1
1	0	1
1	1	1

A	B	C
1	1	1
1	0	0
0	1	0
0	0	0

H = 1
L = 0

H = 1
L = 0



STEPS TO DEVELOP SYMBOLS
FROM A DISCRETE CIRCUIT
- DRAW VOLTAGE ONLY TRUTH TABLE
- DRAW AND AS WELL AS OR GATE
- FIND UNIQUE OUTPUT STATE (-12V IN COLUMN C). THIS IS THE AND. DRAW CIRCLES ON INPUT/OUTPUTS IF MORE NEGATIVE VOLTAGE ASSERTS/SATISFIES
- OBSERVE THE OTHER INPUTS AND OUTPUTS. THESE ARE THE OR FUNCTION. DRAW CIRCLES ON INPUTS/OUTPUTS, IF THE MORE NEGATIVE VOLTAGE ACTIVATES/ASSERTS.
- CIRCLES ON INPUTS DENOTE NEGATIVE GATES.

Figure 3D. Follow the steps in this figure to develop a symbol from a discrete circuit.

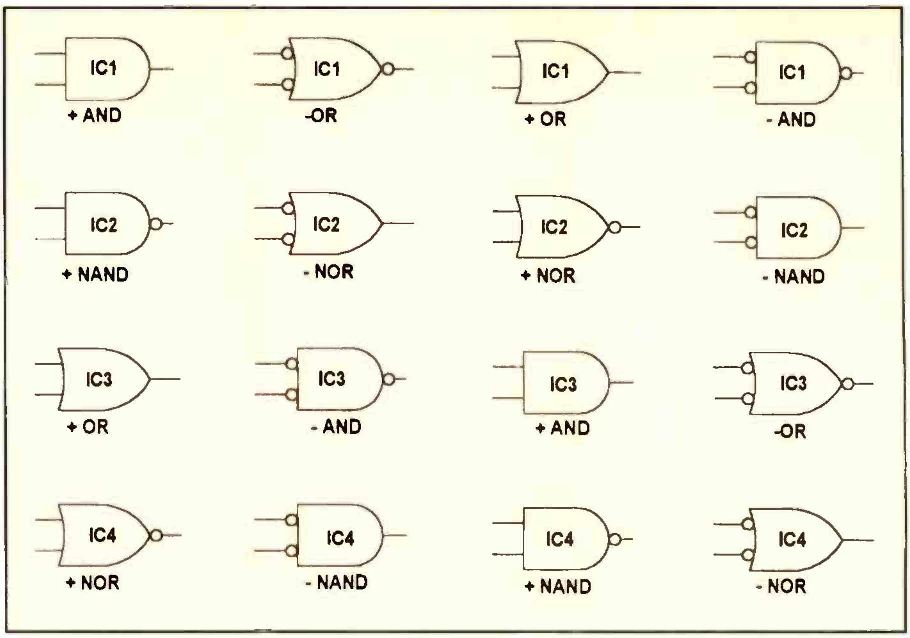


Figure 4A. A physical gate can be represented by any of four symbols if both positive and negative logic conventions are used. A "L" means True (satisfied) on negative gate inputs.

satisfied as drawn. Figures 3A and 3B reveal other symbology to indicate a particular circuit function.

Figure 3C demonstrates the concept of "duality" in logic. There is a positive way and a negative way of saying the same thing. That's why the duality gates are called negative logic gates. Do not confuse them with negative logic convention. Duality simply means that a particular circuit may be represented as either an OR or an AND function. Figure 3D further demonstrates how a logic circuit symbol can be derived from using a voltage truth table and following four simple steps.

Notice that this "duality" applies within a positive or negative convention, and is not the same as logic convention. A particular gate circuit is drawn as positive if it is satisfied by "most positive" voltages activating inputs to produce the desired activated output. Figures 4A and 4B reveal how the same integrated circuit (IC4) will act in "duality" within each logic convention. The actual voltages are the same in each case, and the circuit reacts the same way to the voltages. The circuit, however, cannot be *implemented* in the same manner for both positive and negative logic *conventions*.

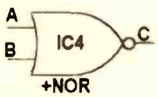
Nowadays, designers generally stay within positive convention, and the logic symbols are drawn in the active state, i.e. if a H signal is needed from an AND gate when two switches are connected to +5V, then the +AND symbol would be used. Conversely, if a L signal were needed, the designer might us a +AND gate with an inverter. If a signal is "active" as a L, like a signal called LIGHTS, then a bar would be drawn over the top of the word LIGHTS to so indicate.

Choose a symbol

Figure 5 demonstrates how "duality" should be used to more rapidly reveal circuit function. In this case, we use a TTL 74LS02, which is listed in the data book as a quad 2-input positive-logic NOR gate IC. The designer uses both positive (NOR) and negative (negative NAND) symbology to better reveal circuit operation. This circuit is used to generate (*key*) the Morse code letter A, which is a dot followed by a dash, the duration of the dash being three times that of the dot. U1A is a gate (electronic switch) which passes a 1KHz tone to the amplifier for the duration of each dot and dash.

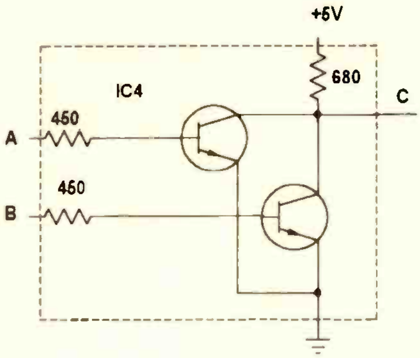
Hearing a distorted output on the dashes in the speaker, one might check at U1A output, where a signal should be observed if the 1KHz tone AND the Morse code letter (the duality function better represents what is going on at this point in the circuit) are arriving at pin 2 and pin 3 respectively at the same time.

Assuming a signal is observed, but the dashes are distorted, next check pin 2 and pin 3 of U1A. Assume a check of pin 2



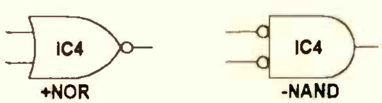
A	B	C
H	H	H
H	L	L
L	H	H
L	L	L

The logic symbol and the truth table at left may be found in a data book. There is only one way to interpret H's and L's. H is the more positive voltage. L is the more negative voltage. The logic symbol is chosen using positive logic convention as is the predominant case nowadays.



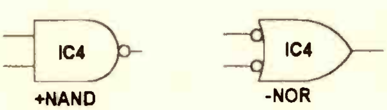
A	B	C
+5V	+5V	ground
+5V	ground	ground
ground	+5V	ground
ground	ground	+5V

The truth table at left is the only truth table for the circuit as shown. Regardless of what symbols replace the +5V and ground symbols on the truth table, the circuit will only respond this way to all possible input combinations. This truth table of voltages does not imply any logic symbol until you apply a definition. See below.



A	B	C
1	1	0
1	0	0
0	1	0
0	0	1

The truth table at left uses positive logic convention, and yields a + NOR (- NAND in duality) function. This is IC 4. The H and L in the table above are replaced with 1 and 0, respectively. H = 1 = MOST +E = +5V



A	B	C
0	0	1
0	1	1
1	0	1
1	1	0

The truth table at left uses negative logic convention and yields a + NAND (- NOR in duality) symbol. This is also IC4. The H's and L's from the truth table above are replaced with 0's and 1's respectively. L = 1 = MOST -E = ground.

Figure 4B. The same integrated circuit (IC4) will act in "duality" within each logic convention. The actual voltages are the same in each case, and the circuit reacts the same way to the voltages. The circuit, however, cannot be implemented in the same manner for both positive and negative logic conventions. Nowadays, designers generally stay within positive convention.

shows that it is normal, but that a check of pin 3 reveals distorted dashes (two holes in the middle of the dash). The output of U1B is probably functioning OK, and perhaps the retriggerable monostable is not filling in the "holes" in the dash. U1B is an OR, so we know that there should be an asserted low output when either input goes positive. If U1B pin 6 is stuck low, the dash would never be filled in, and hence distortion would occur on the code dashes.

Assuming that the input to the monostable is OK, we have isolated the fault to the monostable multivibrator, the trace

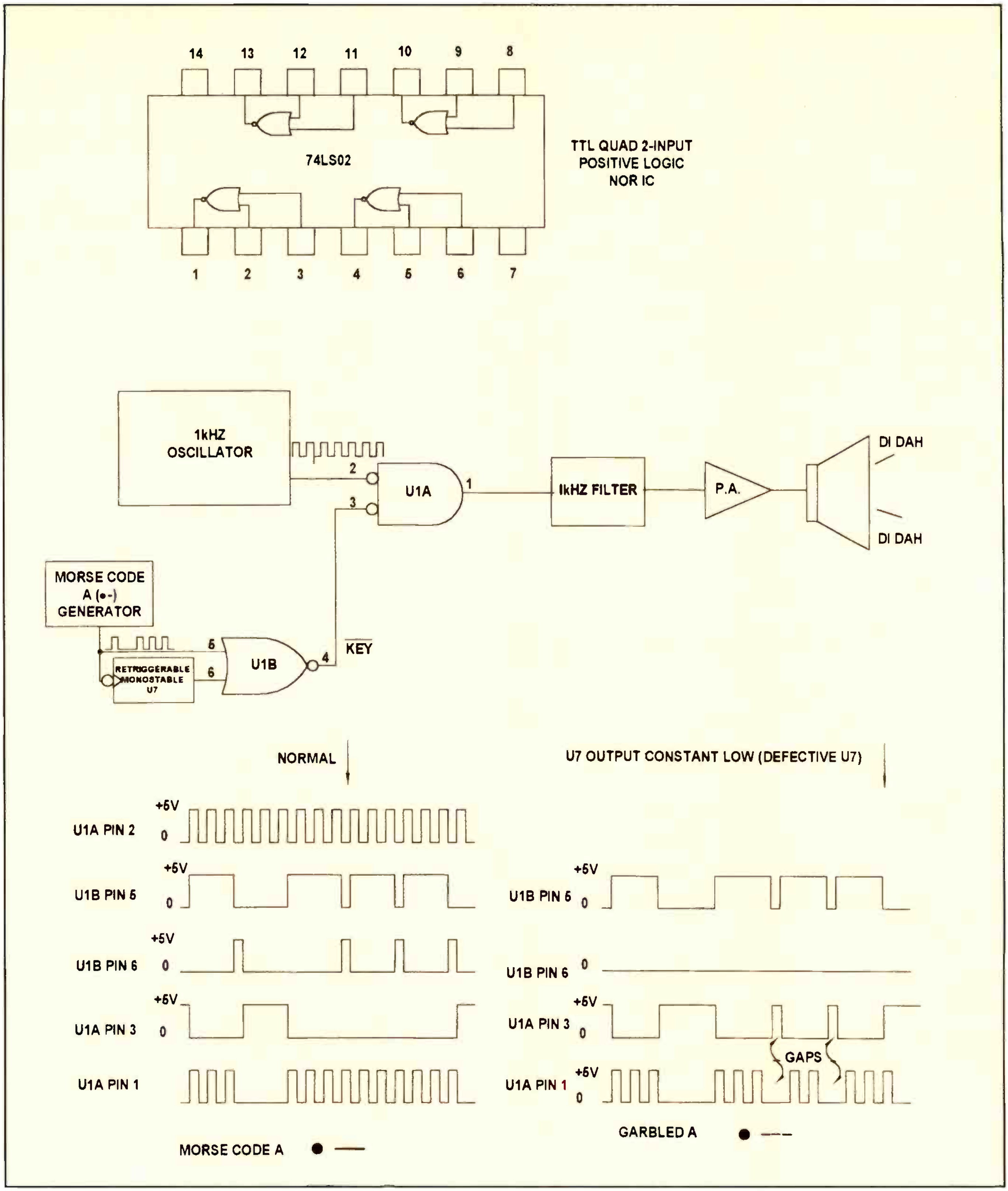


Figure 5. The concept of duality can be used to more rapidly reveal circuit function in order to speed troubleshooting. A distorted output on the dashes in the speaker in this circuit turned out to be caused by U1B pin 6 being stuck low. See the text for a detailed explanation.

between pin 7 of the monostable and the OR input pin 6, and also perhaps the OR gate itself. This is a classic scenario with integrated circuit troubleshooting. Also, notice at this point that gates are level sensitive (voltage amplitude asserts), while the monostable is edge sensitive (triggering on a voltage change): the circle indicates negative and the triangle indicates edge sensitive.

Inputs and outputs

The ideal gate would have no propagation delay and infinite input impedance: that is, no current draw or loading of driving gate output stages. Moreover, it

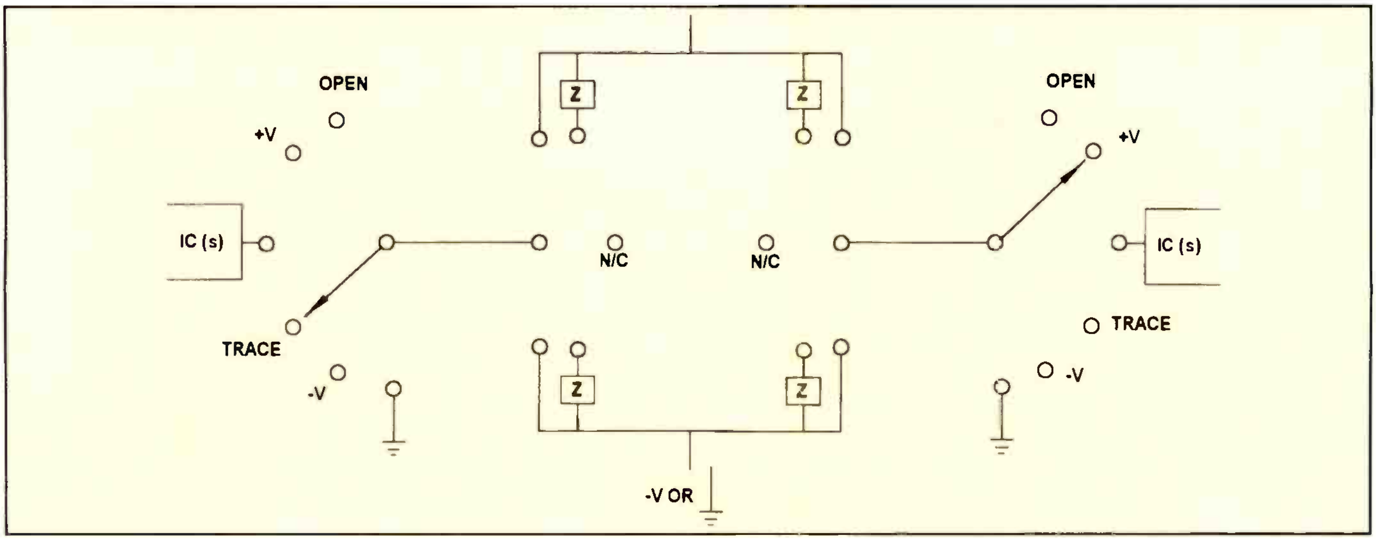


Figure 6. An IC may exhibit any of a number of faults, as suggested here. The impedances within the IC take into account device capacitance. The switches show a range of possible problems in the interconnecting circuits, including the N/C designation for open collector or three state logic, or just an open circuit internal IC fault. The OPEN designates a hairline circuit trace crack and TRACE indicates a short to another trace.

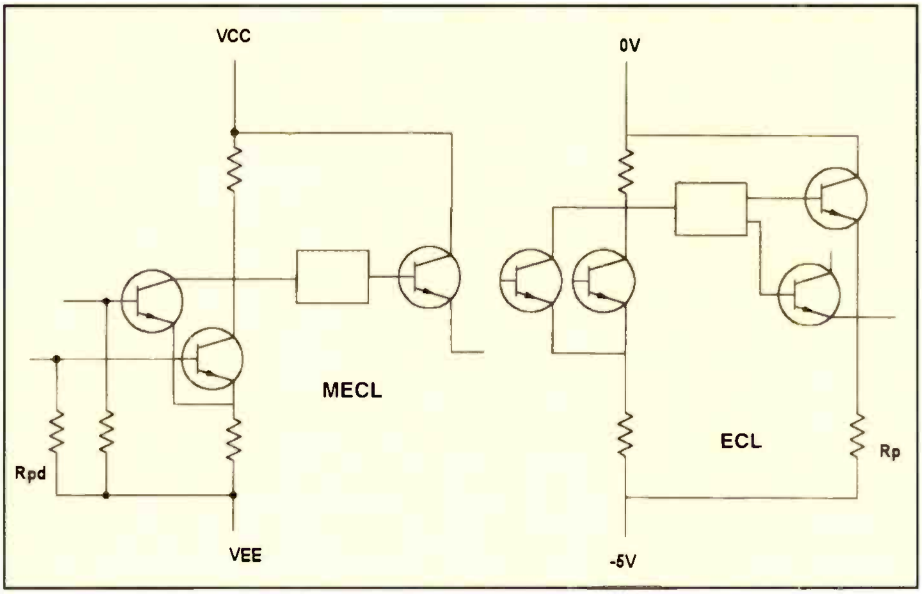


Figure 7. Not all logic uses totem-pole outputs or saturating logic, and inputs and outputs may have pull-down resistors as well. Emitter-coupled logic, also called current mode logic, usually has two complementary outputs which will always be in opposite states. To troubleshoot these unique devices, it helps to be aware of input and output circuits of the ICs you are troubleshooting.

would also feature zero output impedance, which would provide fast, high current delivery with no output voltage drop in output stages. A simple model will serve us well for troubleshooting purposes. Figure 8 reveals possible internal circuitry of common logic families.

Logic fault modes

The impedances within the IC shown in Figure 6 take into account device capacitance. The switches show a range of possibilities for the interconnecting circuits, including the N/C designation for open collector or three state logic, or just an open circuit internal IC fault. The OPEN designates a hairline circuit trace crack and TRACE indicates a short to another trace. Internal to the IC, on the input or output, will be some impedance in normal operation, as represented by Z. CMOS and TTL use totem-pole outputs; i.e. one device supplies a high when on, and the other supplies a low when activated. Figure 7 highlights the fact that not all logic uses totem-pole outputs or saturating logic, and inputs and outputs may have pull-down resistors as well. Emitter-coupled logic, also called current mode logic, usually has two complementary outputs which will always be in opposite states. To troubleshoot these unique devices, it helps to be aware of the nature of input and output circuits of the ICs you are troubleshooting.

It is always important in digital troubleshooting to ensure that the logic voltage is low enough, or high enough, to be considered a valid state. For modern TTL, the states are 0.8V or less and 2V or more. CMOS likes states that are 30 percent or less of supply voltage, and 70 percent or more of supply voltage.

General logic troubleshooting

In a manner similar to analog and discrete component troubleshooting methods, some techniques directly cross over to digital systems. For example, always measure, if possible, on the actual pin of the device. Failure of an IC, like many other components, often causes excessive current to flow, so check for discoloration, or feel the device and compare its temperature to that of similar devices.

A common fault in digital systems is an open bond inside the package. Use a burst of coolant spray on each suspected IC to see if that will cause the circuit to start working again. The freeze spray causes the metal in the package to contract, which may cause the metal bonds to move back into contact with each other momentarily. You can also use a heat gun in a similar manner to see if differential expansion will cause a momentary reconnection of a bond.

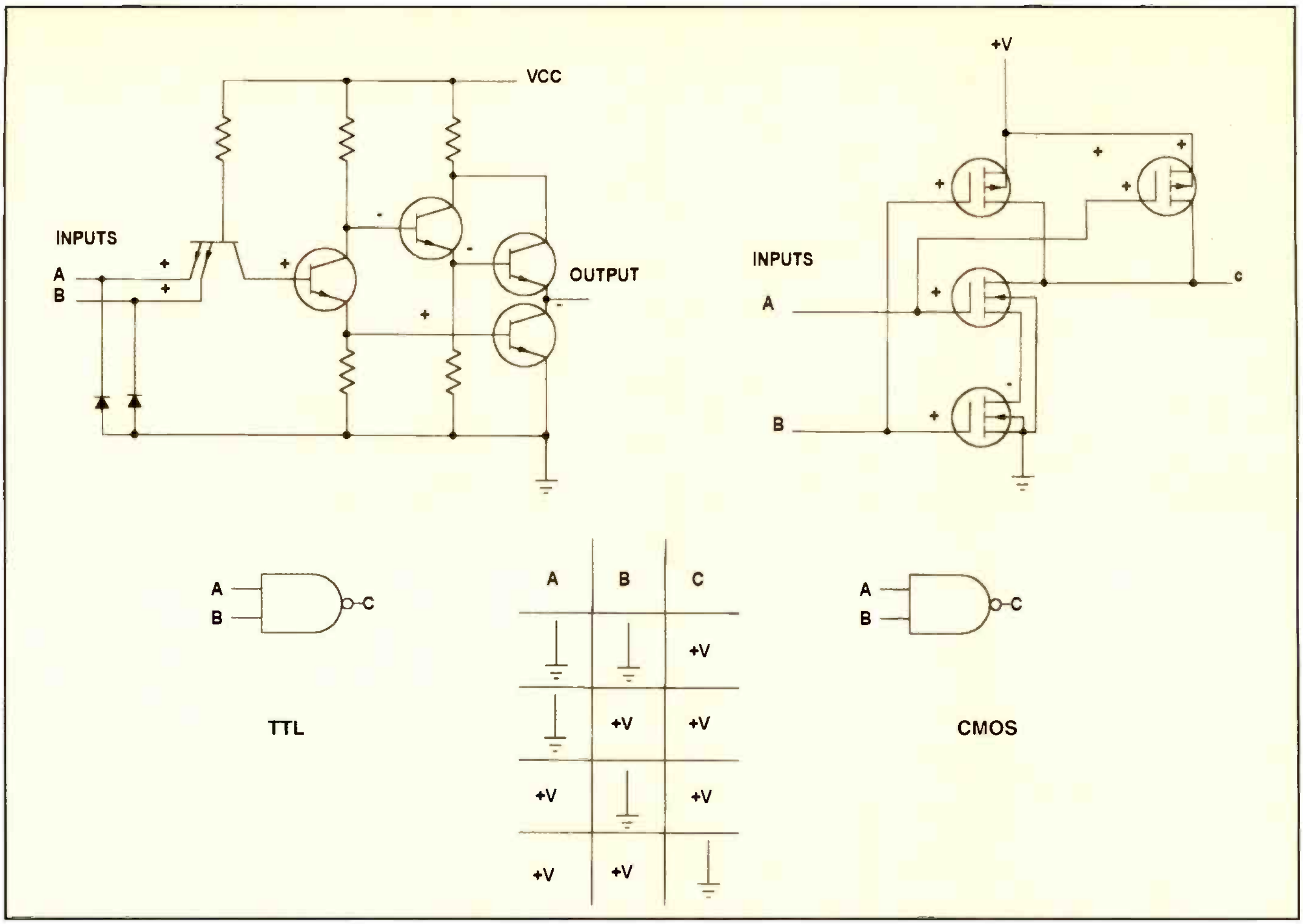


Figure 8. A logic gate may be constructed using TTL (transistor-transistor logic) circuitry, or CMOS.

Unfortunately, the effects of heating or cooling may affect other ICs on the board, and so it may seem that any one of several ICs may be the cause of the problem. However, even if that is the case, if cooling or heating of the circuitry in this manner causes a momentary return of correct operation, you have established that the problem is an open circuit somewhere.

To isolate possible hairline cracks in traces, you might also try shorting across PC traces, or connect voltmeter leads to each end of a trace. If the trace is intact you will measure zero voltage drop. Another technique, in the case of an IC internal open bond, is to piggyback a known-good IC directly on top of the suspected IC to see if normal circuit operation returns. The "disturbance" method of tapping or slightly twisting the printed circuit board to see if this causes a change in any parameters may also provide you with useful information.

If you happen to have replacements for the suspected ICs in stock, you might "shotgun" the problem by replacing the one or two units you suspect of being

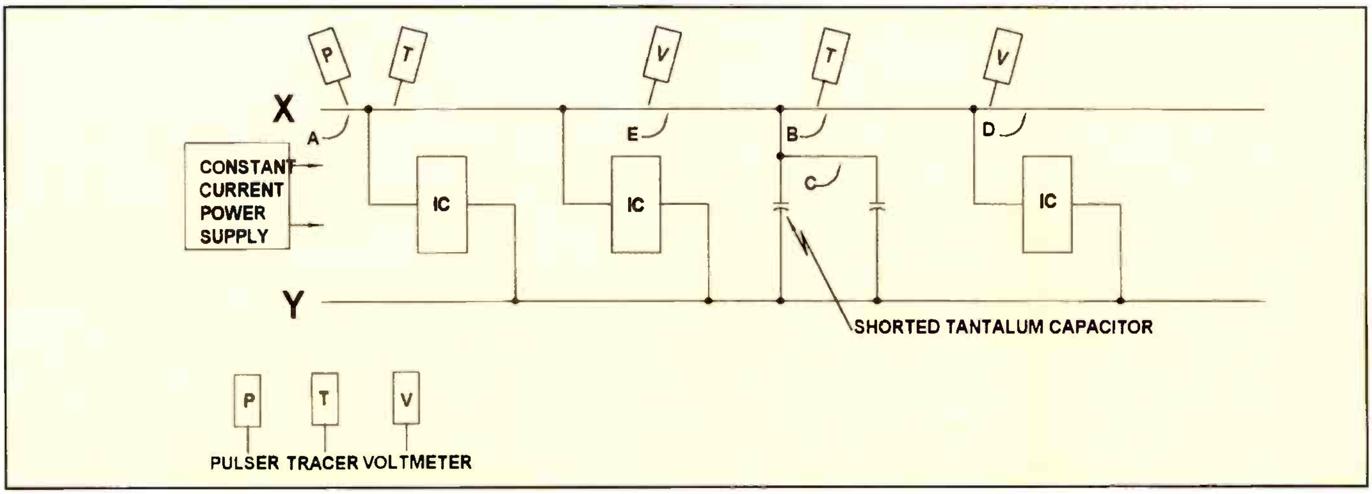


Figure 9. A logic pulser and logic tracer or voltmeter can be used together to isolate problems on power rails.

defective. Another method of temporary substitution is to put the new IC in a wire-wrap IC socket, bow out the socket leads and place it in the spot vacated by the faulty IC. Energize the circuit and test, thus verifying that the new IC solves the problem before soldering it in.

You can also force one of two suspected ICs to fail by connecting it to one of the supply rails through a low resistance resistor and noting the temperature rise. The idea here is that if a trace is constantly held low, the defective IC which is sinking the current will become overheated if you apply V_{CC} through a low-value resistor to the stuck trace.

Another technique is to unsolder all around a pin, so it is not in contact with the foil trace, thus isolating it from the external world, then simply measure the voltage on the pin. Of course, this method will not work with an open collector device that uses an external pull-up resistor on the output as its source of supply.

Using a voltmeter

A sensitive voltmeter capable of resolving microvolts can be used to determine whether the driving IC or the driven IC is constantly pulling a trace or line low. Measure the voltage at each IC pin that is connected to the stuck-low trace. The lowest voltage will be measured on the pin of the IC which is pulling the line low. Also, you might measure the voltage to common on each IC pin at each end of a trace, and, by noting the polarity, determine which way current is flowing. Or, find out the same by noting the polarity of the leads when they are connected to the IC pins at opposite ends of a trace.

Using the oscilloscope

A key point to remember when using the scope to check digital waveforms is that the trigger must occur at the same time as, or just before the pulse you are trying to observe. Also, it is helpful to ground the probe with the ground clip close to the measurement point to avoid distorted waveforms as viewed on the scope. Although scopes are best used for recurring waveforms, they can be and are used to look for activity on a line, as a quick troubleshooting step. It is best to use a 10X probe to avoid spurious signal radiation and possible damage to the IC. Scopes are useful for checking the filtering on the supply lines, as well. By the way, timing parameters rarely become degraded, so don't overanalyze the circuit with an oscilloscope.

Logic pulsers, probes and current tracers

These devices are commonly used to isolate digital faults at the component level in many consumer electronics circuits. These test devices connect to, and derive their power, from the supply rails.

Logic pulsers sense the voltage level at the point of test and then inject a fast rise-time pulse of the opposite state with enough current to override a stuck or shorted gate. They usually feature selectable injection frequencies, although older pulsers require you to press a button to generate a pulse.

Logic probes display the presence of a pulse and the polarity of the pulse. Some have audible tones so you do not have to observe the probe to ascertain whether a signal is present or not.

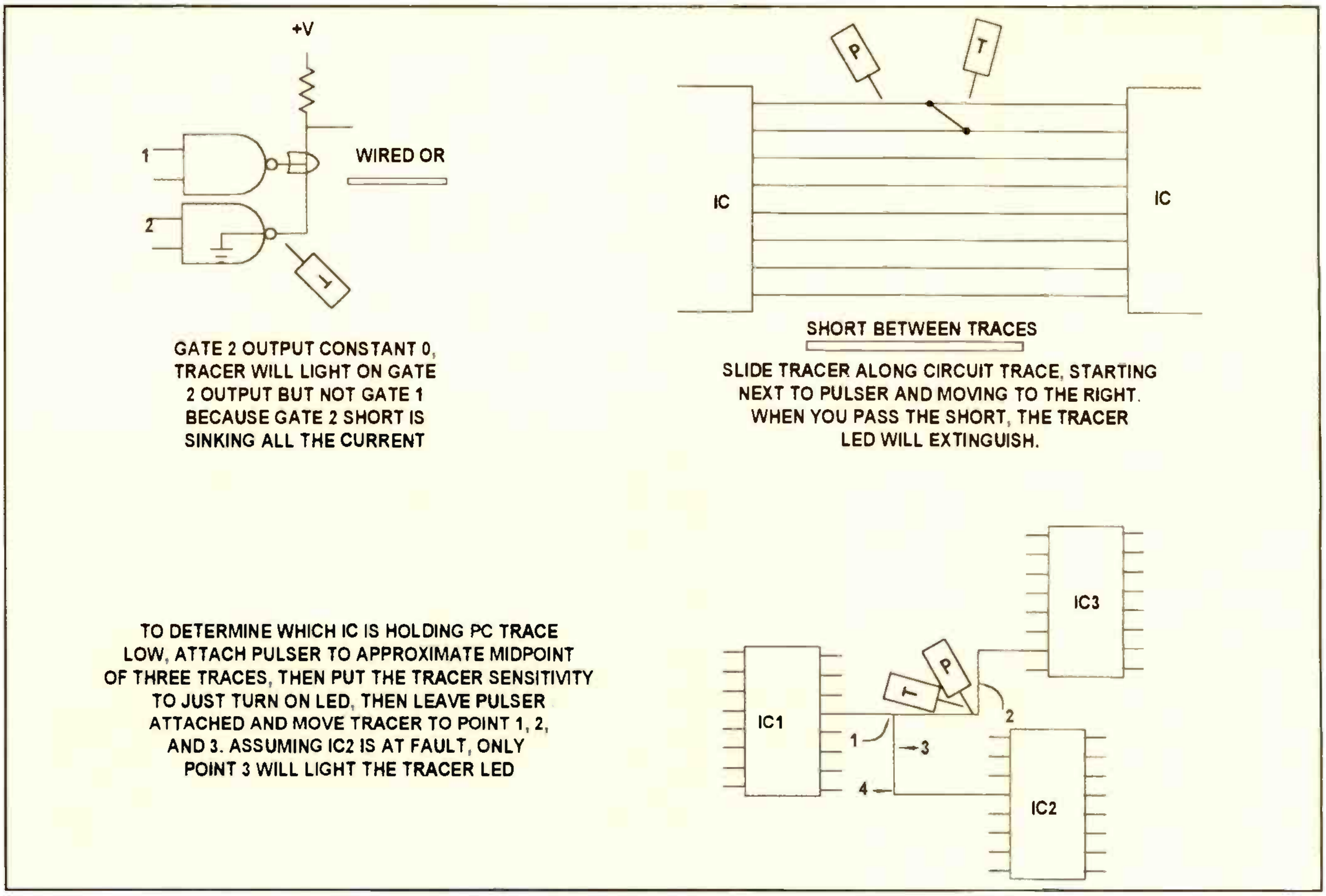


Figure 10. The Logic pulser and tracer can help the technician trace the causes of "stuck" lines.

Current tracers of the "Hall-effect" type sense changes in the magnetic field about a circuit trace, allowing you to zero in on shorts. Put the tip on a place where current is flowing, adjust the sensitivity until the LED just lights, then move along the trace, following the path that keeps the LED on, to trace the current.

Shorts on supply rails

Figure 9 shows techniques for isolating faults on power rails. In each case, the power supply is disconnected. The pulser injects a signal and at point A the tracer LED is on, yet when the tracer is moved to point B, the LED extinguishes. At point C it also extinguishes, thereby isolating the short circuit.

To use a voltmeter, (microvolt sensitivity), connect a constant-current dc power supply to X and Y, and one lead of the voltmeter to the Y terminal, while moving the other lead along the upper supply rail starting at A and working toward B. Just before B is reached, the voltage reading will stop decreasing, indicating little current flow on that side of the connection to the rail. Following the connection down toward the top of the shorted capacitor will show a continual decrease in voltage until you reach the defective capacitor itself.

An additional method to use would be to spray the board with freeze spray, turn on power and watch as the short circuit path defrosts sooner than the others. It must be cautioned that this type of troubleshooting is strenuous on the equipment.

Stuck logic lines

Figure 10 shows methods of using a logic pulser and current tracer to determine which gate is defective. One cautionary note. In the three-IC example, placing the tracer on line 3 indicates that current is flowing in that line. However, you need to check on the pin of the IC to verify, for example, what if there were a short to ground at point 4. If you hadn't investigated such a possibility before, replacing the integrated circuit you would find that you had replaced an IC needlessly, and, furthermore, that you hadn't fixed the problem.

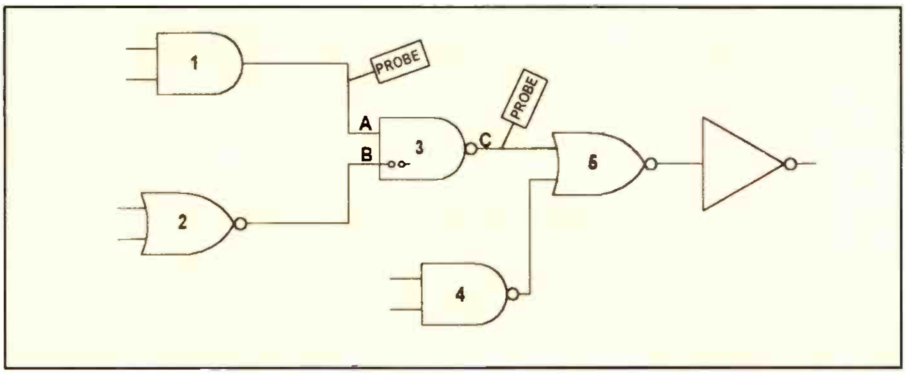


Figure 11. This test to determine the cause of an absence of signal at pin C of gate 3 is performed with original circuit power applied and using the pulser and probe. See the text for details of the procedure.

Exercising gates with logic pulserand probe

Figure 11 displays a test with original circuit power applied and using the pulser and probe. In the course of troubleshooting with a probe, you find gate three has a 0 output on pin C, and input pin A is 1 and pin B is 0. You check the inputs to gates 1 and 2 by using a pulser, while monitoring with the probe at pins A and B of gate 3, and ascertain that the gates feeding gate 3 are operating normally.

Next you pulse gate 3A input and notice with the probe monitoring pin C that it changes states. You then pulse B and notice no change at C. Referring to Figure 6 in this article, you conclude that there is possibly an open circuit on the inside bond of pin B or some other internal electrical fault, which happens to be the problem in our example. Always check the associated circuits tied to the suspect line, or trace, when troubleshooting logic circuits. Just as you will do in analog circuits.

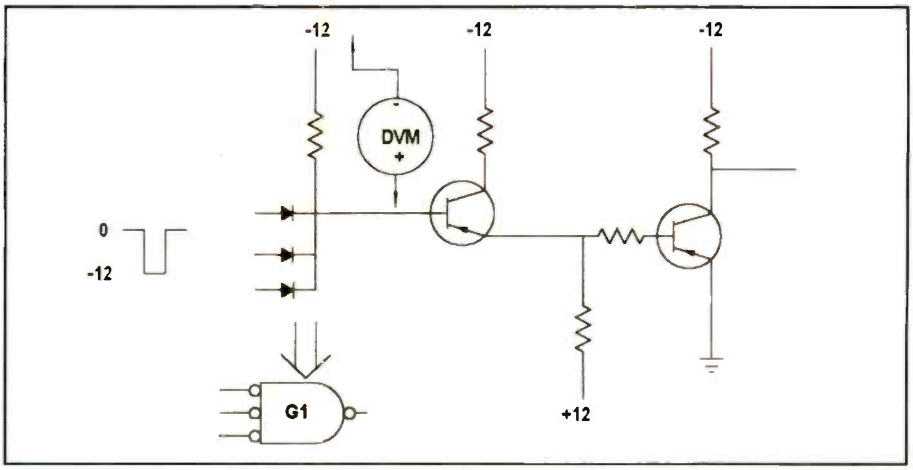


Figure 12. Connecting the DVM backwards in this negative logic circuit allowed the technician to work with it as if it contained the more familiar positive logic. This technique made troubleshooting quicker and less confusing.

Technician logic

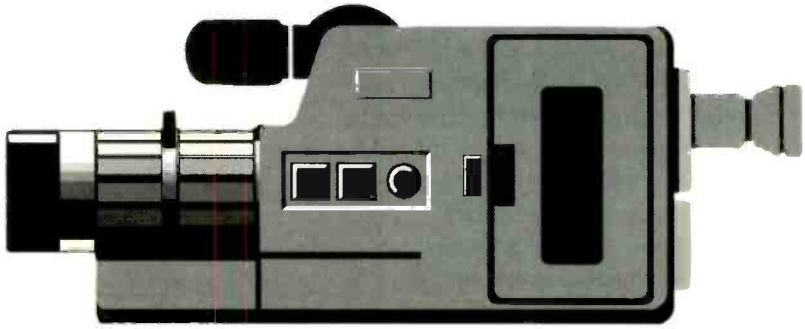
One system I worked on, Figure 12, used hundreds of discrete logic gates with either the negative AND or positive OR symbols, depending on the output desired. The circuitry used -12V and 0V logic levels (the designers called -12V a 1). Since I am accustomed to positive logic convention, I could more easily follow the schematic and trace signals if I saw 0V and +12V for low and high respectively, instead of the 0 and -12V levels. So, by clipping the DVM negative lead to the -12V supply (-12V is now reference), I read near 0V on the inputs and outputs of G1 using the DVM positive lead, when it was asserted, (all inputs -12V, output -12V) and I read about +12V on G1 output when it was not asserted. As previously stated, the circuit is independent of the logic definition, and by using the technique described above you can more easily work on those rare negative logic convention systems.

Good troubleshooting. ■

Camcorder servicing

The basics of camcorders

by the ES&T staff



Camcorders present special challenges to the service center. They're small, and tightly packed with minuscule components. A camcorder is a video camera and videocassette recorder in one. It consists of a number of subsystems: the recorder, the lens system and the image sensor.

Because camcorders are tiny, complex and highly advanced technologically, they're more difficult to service than most other consumer electronics products. Not only that, but it really helps in servicing these devices if the service technician has some idea of how they work, and understands the rudiments of videography. This article is presented as a primer of the operation and uses of the camcorder for the service technician who may be considering camcorder service as an adjunct to the products he is currently servicing.

The image sensor

The image sensor is the part of the camcorder where the visual image is turned into an electronic signal. In early video cameras, before the introduction of the camcorder, the image sensor was a special camera tube. Some examples of camera tubes are the Vidicon, the Saticon and the Newvicon. These sensors were large and heavy and consumed a lot of power. With these tubes, intense light sources caused streaks of light on the image.

Charge-coupled device (CCD)

In modern camcorders, the camera tube has been replaced by a special chip; a semiconductor image sensor: the charge-coupled device (CCD). In small camcorders, the charge-coupled device chip is a round plate measuring about 1/2-inch or 2/3-inch in diameter.

In standard consumer camcorders, the CCD image sensor consists of approximately 300,000 microscopically small light-sensitive elements. In high-end and professional camcorders, the CCD image sensor may consist of up to 500,000 elements. The surface of the image sensor is ordinarily a surface with an area of about 1cm^2.

The camera's lens projects the image that is to be recorded onto the charge-coupled device image sensor. The image projected on the CCD chip causes the cells to be electrically charged. The brighter the light that falls on an area of the image sensor, the greater the charge. This charge image is then converted into an electric current or signal which corresponds to the picture information.

Creation of the video signal

In an image tube camera, the conversion from a light image to an electrical picture signal is performed by means of a high speed electron beam. The beam scans the entire image field of each cell. In the camera tube the electron beam picks up enough electrons for each cell to neutralize the charge generated by the light. This generates a signal that varies proportionally to the information created by the impingement of the light on the tube's photo conductive coating. This is the video signal.

In contrast, the process in a CCD image sensor takes place via a second coating. Every 1/50th of a second the charge image on the sensor is instantaneously transferred to the second layer. During the next 1/50th of a second, as the next image is being built up in the charge carriers, the cells of the second coating are transmitting their charges one by one. This transfer of charge results in a continuous electrical signal, the video signal, in which the direction and amplitude of current are proportional to the charge, and thus, proportional to the light information as well.

The video signal consists of both black and white and color information (Y and C signal). The black and white information (luminance signal Y), consists of the three primary colors: 30% red, 59% green and 11% blue.

Color information

In a professional tube camera, the light is divided into its constituent colors in a prism system, or via a dichroic filter. A dichroic filter uses a thin film on a glass plate to separate the colors. You may have seen an analog of this process when you've seen a rainbow created by a thin film of oil on water. Once the colors have been separated, three camera tubes are used to process the light, one for each of the primary colors.

In a consumer camcorder, only one recording element, the CCD, is used. Stripe filters separate the image into the three primary colors. A complicated matrix circuit generates two color-difference signals from the three primary colors. This color information is ultimately combined with the black and white information into the final video signal.

Advantages of using CCDs

The CCD image sensor has a number of advantages. For starters, it is light and small, and so the camcorder that employs a CCD can be light and small. Another advantage is that CCDs don't require a lot of power to operate. Moreover, CCDs provide excellent image quality: the pictures they generate are sharp and have good color quality.

Another important advantage of CCDs, especially in consumer cameras, is that they are more shock resistant than a camera tube, so CCD cameras can take the rough handling that they might suffer at the hands of an enthusiastic amateur.

Additionally, CCD image sensors have a good light sensitivity, but do not cause streaks, blurring or burning in the picture.

The lens

The CCD is a key component of a camcorder, but the quality of the lens is an important determinant of the quality of the pictures from the camcorder. The overall quality of a camcorder, and the price are largely determined by the quality and characteristics of the lens. The lens system is complex. Picture brightness, focus, and sharpness are largely determined by the components and characteristics of the lens: diaphragm, focal distance, lens types, depth-of-field and autofocus.

Diaphragm

In the human eye, the amount of light that enters is adjusted by the iris. If the light is too bright the iris closes up to admit less light to the retina. If the light is too dim, the iris opens wider to admit more light to the retina. In the same way, the light that is allowed to fall on the film of a photo camera, or the image sensor of a video camera is regulated by a device called a diaphragm. If too much light were allowed to come through the lens, the picture would be overexposed. If there were too little light allowed through, the picture would be underexposed and too dark.

In a manual or semiautomatic photo camera, the amount of light is adjusted by the photographer. The various lens opening settings are marked on the lens. In a video camera, the diaphragm that controls the light level operates automatically. In many cases the automatic controller can be switched off, by pressing the button marked IRIS.

If you're called on to service a camera in which the recorded picture is either too bright, or too dim, the problem is probably somewhere in the diaphragm subassembly in the lens, or in the sensor or circuitry that controls the diaphragm.

Focal distance

The design and curvature of a lens determines its focal distance (f); the point at which light beams transmitted by the lens come together and project a clear image on the image sensor. The focal distance is always marked on the lens, for example, f = 50mm. The larger the focal distance, the larger the images will be.

In a video camera the image formed by the lens is a much smaller image (1/2" or 2/3"), than in film cameras. The lenses in video cameras, consequently, have a relatively small focal distance, in the range of 9mm to 12mm, compared to 50mm for a typical 35mm camera.

Depth-of-field

If a customer complains that when he makes videotapes in dim light he has problems with focus, it may be that the problem is a limited "depth of field," and may simply be a characteristic of the photography process about which nothing can be done. If the diaphragm is closed down, as in a bright light situation, the object on which it is focused will, of course, be in focus, but things that are closer to the lens and farther from the lens will also be in focus. This range of distances for which objects are in focus is called the "depth of field."

If, on the other hand, the lens is fully opened, only the object on which the camera is focused will be reproduced sharply. The more the diaphragm is opened, the less depth-of-field extends forward and backward from the object focused on. This means that in the case where there is little light, and the lens is wide open, only limited depth-of-field can be expected. Depth-of-field is not the same as sharpness. An image is always sharp (if you have focused accurately on the object), whether or not there is acceptable depth-of-field. In case of extended depth-of-field, there is increasing sharpness from the front areas to the back areas

Depth-of-field is also related to the focal distance. The longer the focal distance, the narrower the depth-of-field and vice versa. (In other words, the wider the image angle, the greater the depth-of-field). In the telephoto mode the depth-of-field is smallest and must therefore be focused most accurately.

Autofocus

Every camcorder features automatic focusing, or autofocus. Autofocus gets kind of complicated, since it is not only necessary to precisely measure the distance to the object that is to be focused on, but it also needs to determine what the main object is. Then, information needs to be transferred quickly to a motor which needs to bring the lens quickly into the correct position. There are two basic types of autofocus systems: active and passive.

Active autofocus systems

An active autofocus system transmits a signal in order to measure the distance to the object on which the camcorder operator wishes to focus. Most camcorder active autofocus systems were based on infrared (IR). A few camcorders used an ultrasonic autofocus system. Either of these systems is based on the principle of sending out signals in pulses, then measuring the time between transmission of the signal and reception of the reflected signal. This allows the system to determine the distance between the camera and the object of interest. When the distance to the subject is determined, the focus motor is moved accordingly.

IR autofocus has the advantage that it can also be used when there is little light. It is also fast. Disadvantages are that because it is sensitive to infrared light, an IR autofocus system is also sensitive to other sources that emit infrared light, such as an open fire. And while infrared light passes through glass, as does ordinary light, a portion of the beam might be reflected back at the sensor on the camera, causing the lens to focus on the window instead of the object of interest. Conversely, if the object of interest is a black dim surface, the infrared signal might not be reflected back causing the lens to be set to infinity.

Passive autofocus systems

All camcorders currently manufactured use passive autofocus. The principle on which these systems operate is that they will try to create an image on the CCD image sensor that is as sharp as possible. Because the sharpest image possible causes the highest possible frequency of output signal, the system tries to find the highest frequency. Either the lens or the CCD image sensor moves back and forth while the logic in the camera samples the frequency of the output signal to find out at what position it can register the highest possible frequency.

The autofocus system is set up so that the object that is situated in or near the center of the image field is the object on which it will try to focus. In active systems this is realized by focusing the light or sound beam as sharply as possible, and in the case of passive systems, to focus the receiving optics as accurately as possible. If there happen to be two objects near the image center, the autofocus will consider the nearer object to be the one on which it should focus. If the operator wants to focus on the other object, he must switch off the autofocus and focus manually.

Recording mechanism

The recording mechanism of a camcorder works basically in the same way as the recording/playing mechanism of the VCR. The main difference lies in the fact that a camcorder has smaller components and double the number of heads. At present, there are five types of camcorders that use different recording systems.

VHS

The VHS camcorder is designed to be used with standard VHS-cassettes, and therefore is one of the larger-sized camcorders. This camcorder allows for the longest playing times; up to four hours when on the E-240 cassette. Including the battery and the cassette, the weight of this type of camcorder is over four pounds.

VHS-C

VHS-Compact (VHS-C) was designed in order to provide a smaller camcorder, but one able to use the standard VHS cassette. The width of the videotape remained the same (1/2-inch or 12.5mm), as did the tape speed and the tape recording speed: only the size of the cassette became smaller. A VHS-C tape can therefore be played back in any conventional VHS-VCR, using a special adapter. There are also video recorders with a compatible loading system in which either VHS and VHS-C, can be used without an adapter. Because the cassette is much smaller and the tape much shorter, the maximum playing time is 45 minutes in SP-mode (Standard Play). It is also possible to record at half the speed (LP - Long Play, or EP - Extended Play), making the maximum playing time 60 minutes. However, this can only be done at the expense of image and sound quality.

Super-VHS(C)

The Super-VHS(C) system is an improved VHS-C system, providing a resolution of 400 lines, compared to 240 lines for the VHS and VHS-C systems. With this system, the image is much more detailed. VHS-C allows the user to edit and copy tapes without visible quality loss. Only after copying from a second copy recorded tape, do slight quality reductions become noticeable.

A disadvantage of Super VHS-C is that a tape made using this system cannot be played back in a conventional VHS recorder. A tape made in Super VHS-C can only be played back in a S-VHS recorder, using a VHS-C adapter. If there is no S-VHS domestic video recorder available, S-VHS(C) tapes can only be played back via your camcorder or copied on VHS cassette, which means loss of the high quality.

Video-8/8 mm

Video-8 is a completely different system which uses an 8mm videotape. It was necessary to make the tape smaller in order for the camcorder to be small enough to be hand held. Tapes made in the 8mm format cannot be played back on a VHS-VCR, they can be copied to VHS and S-VHS format tapes. The Video-8 system, which was developed specifically for portability purposes, offers better image and sound quality than the VHS-C system. The Video-8 tape also has longer playing times than the VHS-C tapes, 90 minutes compared to 45 minutes (VHS-C). In LP mode, it offers 180 minutes of recording time but with the loss of some quality of the picture.

Hi8

Hi8 is an improvement on the Video-8 system, just as the Super-VHS(C) system is an improvement on VHS-C. As in the Super-VHS system, all improvements relate to increased bandwidth and better separation of color and brightness signals. Hi8 goes further by applying a specially developed Metal Evaporated (Metal-E) tape, ensuring that the image quality is even better than in Super-VHS(C). Hi8 recordings cannot be played back via standard Video-8 equipment.

Viewfinder

An important difference between a camcorder and other cameras is that the image seen by the operator is shown on an electronic viewfinder (EVF) rather than through a lens. In essence, the EVF is a mini-black and white or color tube/LCD screen, with a screen diameter of approximately 2cm. The viewfinder also gives information, via LEDs or in digital figures, on start and stop, under- and over-exposure, white balance, battery status, recording duration, recording time and date, and sometimes on titles that can be entered and recorded on tape.

An extra benefit of the viewfinder is that immediately after the recording session the viewfinder can be used as a monitor to display what is recorded.

This article was prepared on the basis of information found at the Philips-/Magnavox website at http://www.-magnavox.com, and the CEMA website at http://www.cemacity.org.

Servicing audio products

by John A. Ross

An *audio-frequency*, or *A-F*, *amplifier* is found at the last stage of a receiver sound circuit and amplifies only the narrow spectrum of audio frequencies that ranges from 20Hz to 20KHz. Audio output amplifiers should have the following characteristics: High gain; very little distortion within the audio frequency range; high input impedance; and low output impedance.

Modern audio and video receivers feature either transistor or integrated circuit amplifiers in the audio output stage that provide enough gain to drive a 30 percent modulated signal. Transistor-based audio amplifiers usually consist of a two-transistor, push-pull class B or AB output stage and, in small receivers, have an output range of 100mW to 1W. Audio amplifiers incorporated into an integrated circuit have an output power in the range of approximately 2W to 5W.

Audio amplifiers are also classified as power amplifiers. In an audio circuit, the power amplifier drives a high amount of power through a low resistance load with the speaker serving as the load. Although resistances dissipate power, efficient power amplifiers drive the maximum amount of power possible through a load. We can measure the *figure of merit*, or the efficiency, of an amplifier using the following equation:

n = (ac output power / dc input power) x 100%

where n represents the figure of merit. Circuit designers rely on the figure of merit when matching an amplifier with an application in which it will be used.

Amplifier classification

Any amplifier that conducts during the entire 360^{o} of the ac input cycle is a *class A amplifier*. Class B and Class C amplifiers conduct for less than the entire ac input cycle. With a *class B amplifier*, two transistors conduct for 180^{o} of the input cycle. One transistor conducts during the positive alternation of the ac input cycle and the other conducts during the negative alternation of the cycle. The combination of the conduction cycles yields a 360^{o} output waveform.

A *class AB amplifier* is a variation of the class B amplifier. While the class AB amplifier also uses two transistors, conduction occurs only during the portion of the input cycle between 180^{o} and 360^{o}. *Class C amplifiers* use one transistor and conduct for less than 180^{o} of the input cycle. Reactive components in the class C amplifier circuit provide the waveform for the remainder of the cycle.

In terms of efficiency, class A amplifiers have the lowest efficiency with a figure of merit ranging from 25 to 50%. The range depends on the use of RC or transformer coupled circuits. Class B and class AB amplifiers have an efficiency rating of approximately 78.5% while class C amplifiers have a maximum theoretical efficiency of 99%. Audio circuits rely on class B amplifiers because of the good efficiency rating. Although class C amplifiers have near-perfect efficiency, this type of amplifier works only with a tank circuit tuned to either the same frequency or a harmonic of the input signal.

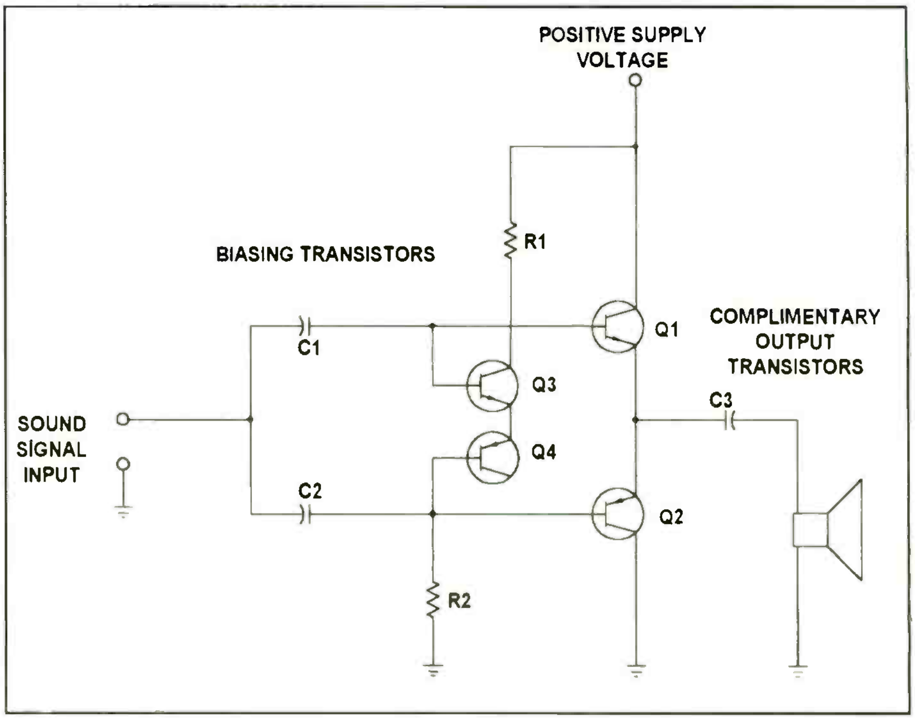


Figure 1. This Class AB audio amplifier circuit uses complimentary output transistors.

A class AB amplifier

The amplifier circuit shown in Figure 1 is configured as a class AB complementary-symmetry amplifier. When studying the circuit, note that one of the output transistors is an NPN transistor and the other is a PNP transistor. With this, two output transistors form a complementary pair and work like two variable resistors that are controlled by the audio signal amplitude. The NPN transistor draws current only during the positive half-wave of the audio signal and the PNP transistor draws current only during the negative half-wave. While complementary- symmetry circuits may use different components for biasing, the use of complementary transistors in the output stage will remain constant.

Transistors Q3 and Q4 provide biasing for the power amplifiers and act as diodes. With the biasing transistors configured in this way, each has a shorted collector-base junction and uses only the emitter-base

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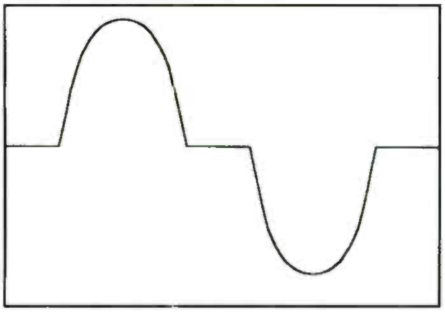


Figure 2. Crossover distortion results in this type of waveform. This type of distortion occurs when neither transistor in a class B amplifier has any forward bias and the output voltage of the amplifier circuit equals zero.

junction in the circuit. Using transistors in this way ensures that the biasing transistors match perfectly with the amplifier transistors. Because a complementary-symmetry amplifier does not require the use of a transformer, the circuit offers a low-cost, low-loss method for amplifying audio frequencies.

Because of the potential for crossover distortion when the two transistors go from conduction into cut-off, the biasing circuit prevents both transistors from entering cut-off during the same interval by maintaining a small amount of forward bias for each transistor. Figure 2 shows the type of waveform produced by crossover distortion. *Crossover distortion* occurs when neither transistor in a class B amplifier has any forward bias and the output voltage of the amplifier circuit equals zero.

Crossover distortion

Applying a small amount of dc bias voltage to the push-pull configuration allows collector current to flow for more than one alternation of the applied signal but not for the time of one complete cycle. Under these circumstances, the circuit operates as a class AB amplifier and produces a linear output that contains no distortion. Figure 3 shows the audio frequency sine wave produced by the combination of a class AB amplifier and the application of the dc bias voltage.

The drawback caused by the need for added dc bias is the potential for *thermal runaway*. Often, power transistors are destroyed when an excessive forward bias voltage combines with junction leakage to produce progressively higher currents. With a fixed base current, the collector current increases. This higher- than-normal internal current causes the transistor to overheat which, in turn, breaks down the internal resistance of the device. As the cycle of increased heating and increased current production continues, the transistor eventually destroys itself.

As Figure 3 has shown, one transistor of the class AB pair begins to conduct before the other has stopped conducting. For a brief time period, a path between power and ground exists through the transistors. To eliminate the thermal runaway problem, class AB amplifiers utilize a matched pair of transistors that have identical electrical and thermal characteristics. The use of a matched pair allows the same dc current to flow through both transistors and the same collector voltage to split equally between the two transistors.

In addition, the biasing circuit establishes a quasi-complementary-symmetry configuration. With this configuration, the complementary-symmetry section of the amplifier appears before the actual output stage. Rather than use a matched pair of high-cost output transistors, the circuit uses a matched pair of biasing transistors. Going back to Figure 1, the circuit consisting of transistors Q2 and Q3 provides the correct amount of forward bias for output transistors Q4 and Q5.

The circuit shown in Figure 1 also provides an example of the amount of power dissipated in the resistances of a power amplifier circuit. Current flows through and voltage is applied across each resistor. Thus, using the power equation, or $P = I^2R$, we can find the amount of power dissipated by each resistor. When we compare the sum of the dissipation amounts against the total power drawn by the amplifier, we have the total amount of power going to the load.

Every transistor has a maximum power dissipation rating. When selecting a replacement transistor for a power amplifier application, verify that the power dissipated by the transistor in the circuit does not exceed the rating of the replacement transistor. The $P_{D(max)}$, or maximum power dissipation rating of a transistor indicates the maximum amount of power in mW that a transistor can dissipate. For class B and class AB amplifiers, the maximum power dissipation rating equals:

$$P_{D(max)} = V^2{}_{PP} / 40R_L$$

where V_{PP} equals the peak-to-peak load voltage.

Variations in class AB circuit amplifier designs

Although Figure 1 shows a popular class AB amplifier design, other types of class AB amplifiers also exist. Other popular designs include the diode-biased class AB amplifier, the Darlington complementary-symmetry amplifier, and the split-supply class AB amplifier. Each alternative offers characteristics that may be more useful for specific amplifier designs. Figures 4A, B, and C illustrate the different class AB amplifier circuits.

The diode-biased amplifier illustrated in Figure 4A uses two diodes to match the characteristic base-emitter voltage values of the output transistors. While class B amplifiers normally operate at cutoff, the addition of the diodes biases the transistors above cutoff. With both amplifiers operating above cutoff and conducting between 180° and 360° of the waveform, the circuit has the response shown in Figure 3 and begins to operate in the class AB range. Thus, because of the matched characteristics, this variation of the cir-

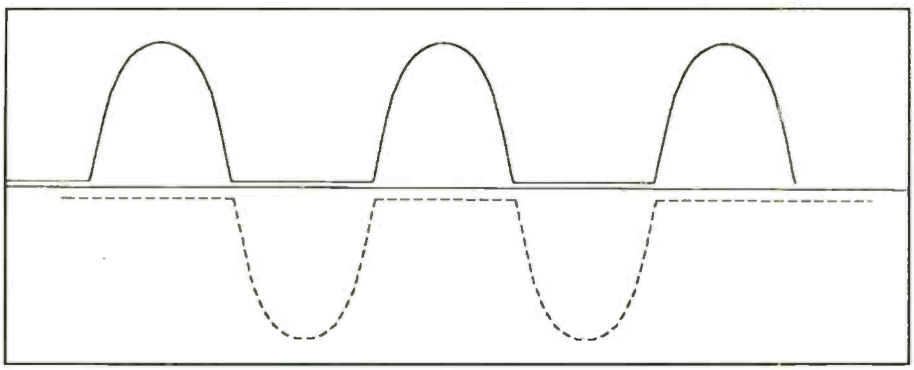


Figure 3. This drawing shows the audio frequency sine wave produced by the combination of a class AB amplifier and the application of the dc bias voltage.

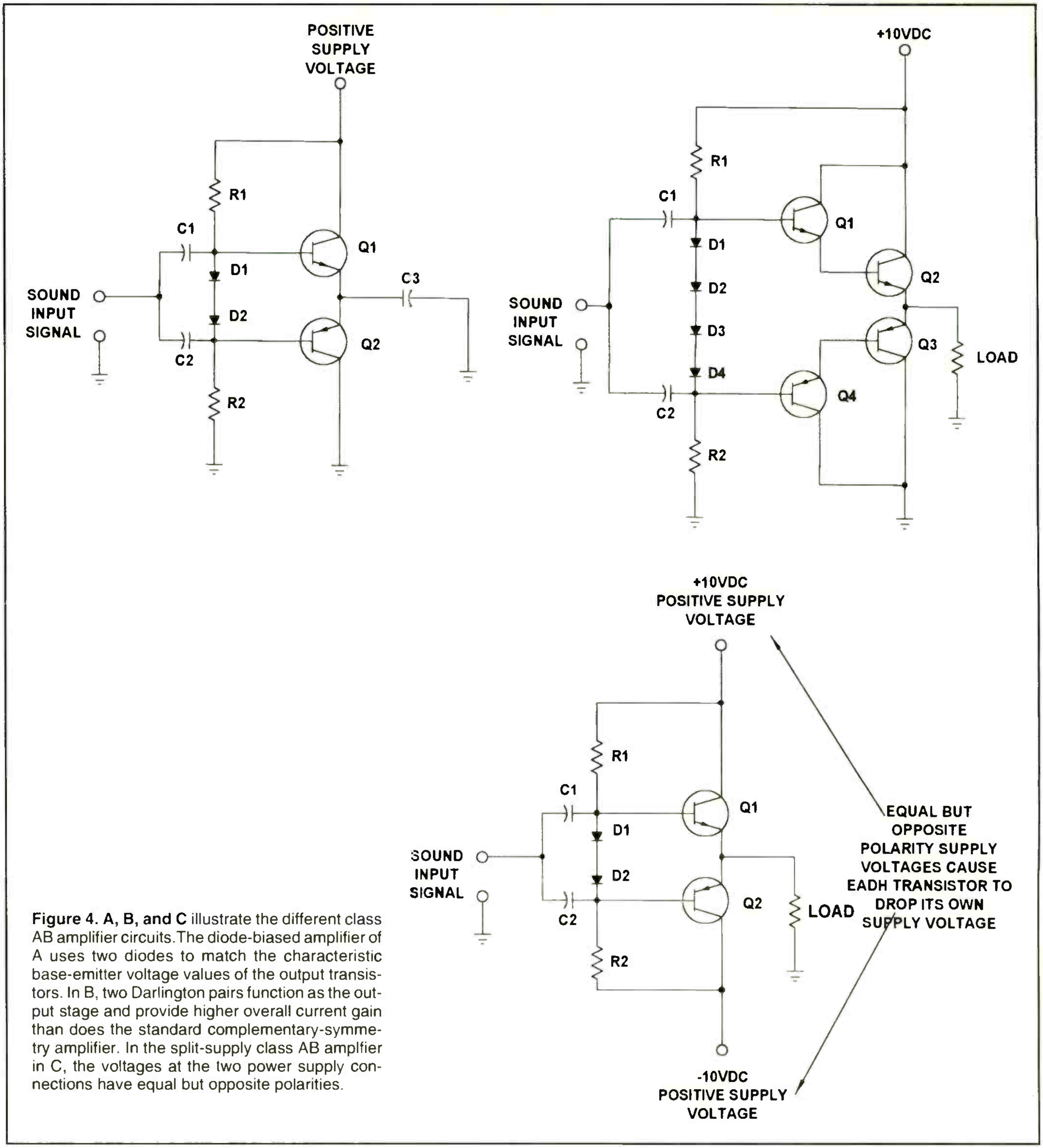


Figure 4. A, B, and C illustrate the different class AB amplifier circuits.The diode-biased amplifier of A uses two diodes to match the characteristic base-emitter voltage values of the output transistors. In B, two Darlington pairs function as the output stage and provide higher overall current gain than does the standard complementary-symmetry amplifier. In the split-supply class AB amplfier in C, the voltages at the two power supply connections have equal but opposite polarities.

cuit eliminates the chance for thermal runaway or crossover distortion.

Darlington pairs

In the circuit of Figure 4B, two Darlington pairs function as the output stage and provide higher overall current gain than the standard complementary-symmetry amplifier. Although both transistors of a Darlington pair are usually packaged in the same case, the term actually describes the configuration of the two output transistors. The first transistor of the pair acts as an input amplifier for the second transistor. Because the dc and ac beta values of the pair equals the product of the individual transistor betas, the Darlington pair has an extremely high beta. With the emitter of the first transistor connected to the base of the second, the base current of the first is multiplied by the beta of the second.

Usually, a Darlington complementary-symmetry amplifier is used for applications that require high load power. Because of the use of an input amplifier, which the Darlington configuration provides, the transistor pair has better stability, high current gain, and a high input

(Continued on page 39)

impedance. The four diodes shown in the diagram provide biasing at the bases of Q1 and Q3 and compensate for the base-emitter voltage required for each Darlington pair.

In the *split-supply class AB amplfier* shown in Figure 4C, the two power supply connections have equal but opposite polarities. By using matched power supplies, each amplifier drops its own supply voltage. This allows the output of the class AB amplifier to center around zero volts rather than the division of the supply voltage.

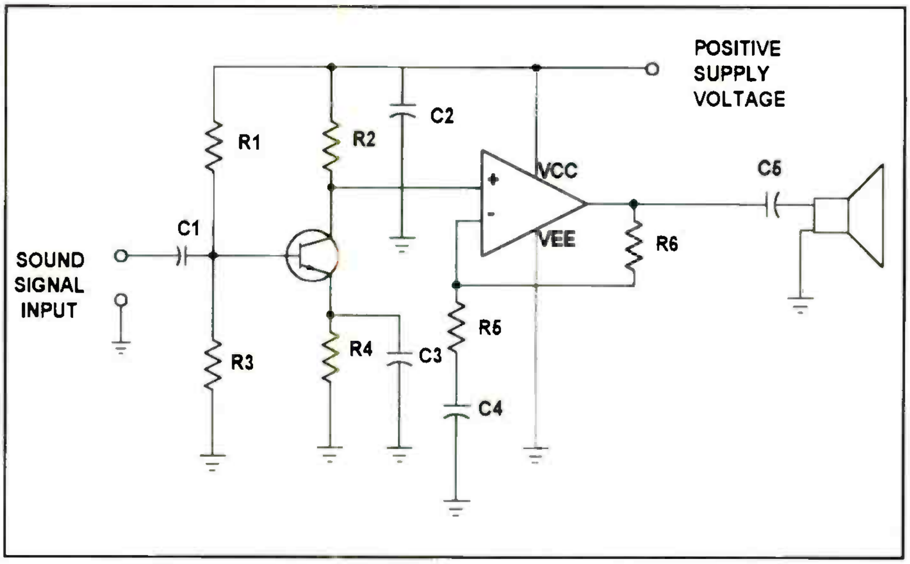


Figure 5. This is the schematic diagram for an audio amplifier found within a single IC package and based on an operational amplifier. The operational amplifier provides a combination of high input impedance, low output impedance, and low noise distortion.

Integrated circuit audio amplifiers

Figure 5 shows the schematic diagram for an audio amplifier found within a single IC package and based on an operational amplifier. The op-amp provides a combination of high input impedance, low output impedance, and low noise distortion. With the low output impedance and low noise distortion, the amplifier provides optimum coupling to the speaker with minimum distortion in the audio frequency range.

In the circuit, the grounding of the operational amplifier negative supply voltage input through capacitor C5, a coupling capacitor, limits the amplifier output to a specific range. Grounding the supply in this way places the reference for the speaker close to ground, and, because of its location in the bias supply voltage line, protects transistor Q1 from transient current. Without the capacitor in that location, current could feed back from the operational amplifier through the power supply and to the transistor.

Newer sound channel designs enclose the complete audio system into one or two integrated circuits. Figure 6 shows the schematic/block diagram for the sound processing system for a Sylvania model 19C5 television. In the Figure, IC111 handles the amplification of the 4.5MHz sound i.f .signal, provides limiting, detects the FM audio signal, and controls the level of the signal before coupling it to IC121, the audio output IC.

As the figure shows, the composite video signal travels from pin 12 of IC51, the video i.f. processing IC, through a coupling capacitor and to a 4.5MHz high-pass filter. From there, the 4.5MHz sound i.f. signal travels to a 4.5MHz buffer transistor and then to T110, a sound input transformer. After arriving at pin 14 of IC111, the 4.5MHz is amplified, limited, detected, and coupled to the IC121. The +12Vdc voltage supply seen at pin 11 of IC1 and the Q36 collector circuit has its source at the integrated flyback transformer.

Moving to pin 5 of the sound i.f. IC, a voltage divider controls the volume. R114, the audio preset control, compensates for any variations within the sound i.f. IC by controlling the audio level when the volume control is set to its minimum level. The controlled audio signal couples from pin eight of IC111 through a 1(F capacitor to pin nine of IC121.

Troubleshooting audio circuits

If we consider the audio stage as something that provides the power to mechanically move a speaker cone, then troubleshooting the stage may seem easier. With audio frequencies, the stage generates power throughout a range from 20Hz to 20kHz. Any time that a stage provides power, it also becomes exposed to the possibility of a short or an overload. Either condition can cause symptoms such as blown fuses, open resistors, and shorted power transistors to surface.

As a rule, always look for one of these three basic problems when troubleshooting audio circuits:

1. The bias current may have risen to a high level and caused a higher-than-normal voltage drop across the emitter resistors in a transistor-based amplifier circuit. Under normal operating conditions, the voltage drop will stay within the 10mV to 30mV range. With a high bias current, the voltage drop may measure as high as 10V. Too much bias current will cause the amplifier to heat while too little bias current will cause distortion at low volumes.

2. Consider high-frequency oscillation as a possible problem. If high-frequency oscillation exists, the amplifier will get unusually hot with no applied signal and will have a low emitter voltage. More than likely, high-frequency oscillation will also cause hum and decrease the amount of power at the speaker.

3. Finally, clipping may occur at different signal levels and may be seen at the top and bottom of the output waveform.

As with all troubleshooting efforts, working with the audio section requires a logical approach and basic knowledge about the circuit operation. For example, if the speakers, fuses, and connections appear in working order, measure the power supply voltage. At the pre-amplifier stage, filters minimize hum and noise while providing a very stable supply voltage. DC voltages at the driver and power amplifier stages connect directly to capacitors that smooth any ripple.

After verifying the presence of the correct supply voltage, use common signal injection and tracing techniques to determine where the fault exists. With the audio stages, we can inject an audio fre-

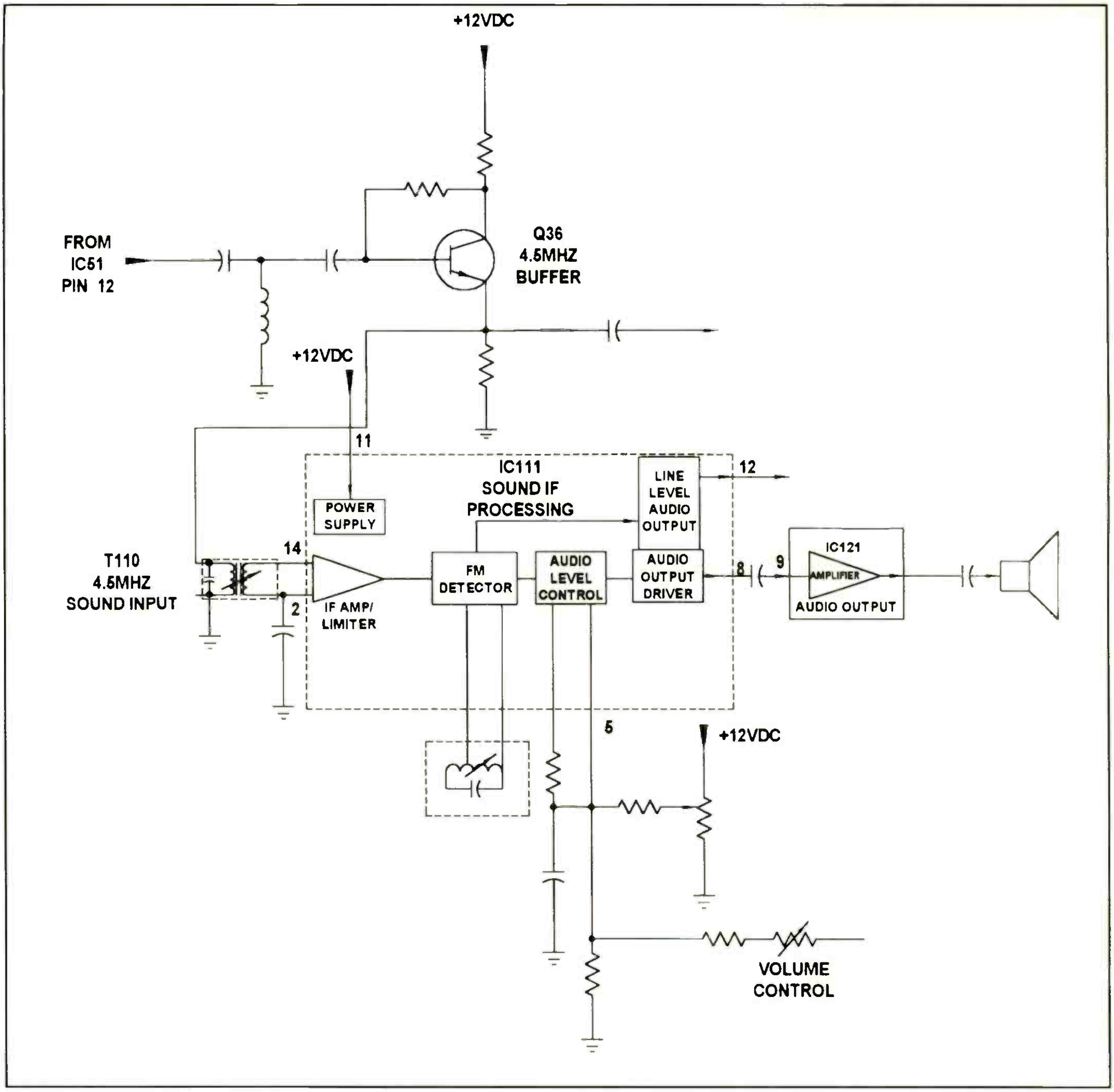


Figure 6. This is the schematic/block diagram for the sound processing system of a Sylvania model 19C5 television. IC111 handles the amplification of the 4.5MHz sound i.f. signal, provides limiting, detects the FM audio signal, and controls the level of the signal before coupling it to IC121, the audio output IC.

quency at the beginning of the stage and check for the presence of a signal at the output of the stage. Usually, the schematic will indicate a good point for injecting the substitute signal.

Applying test equipment to the problem

Troubleshooting audio amplifier problems requires four basic pieces of test equipment. An isolation transformer will protect you, your test equipment, and the equipment under test. The use of a variable transformer will allow the testing of an amplifier under different voltage conditions and will allow the gradual application of power. An oscilloscope, multimeter, and an audio frequency generator provide the equipment necessary for checking both the input and output signals, component and stage voltages; setting the bias, and for finding high frequency oscillations.

When injecting a signal into an audio channel, use an audio or function generator to supply either a 3kHz square or sine wave. In addition, connect either an 8Ω or a 10Ω resistor across the stereo speaker terminals as a load. The wattage rating of the resistor chosen as a load should match the power output of the amplifier. For transistor amplifiers, connect the audio or function generator to the first audio transistor. Integrated circuit audio channels will require a connection to the pre-amp portion of the circuit.

Then, clip a test lead from the generator probe to the input channel. By using an oscilloscope, you can monitor the performance of the audio channel while injecting the test signal. Set the variable sweep control of the oscilloscope for a steady waveform and adjust the input signal so that a stable waveform appears. When injecting a sine wave into the circuit, the shape of the sine wave should not change as the signal progresses from the input to the output of the amplifier.

Squarewave response

Depending on the shape and amplitude of the waveform at the output of each stage, the injection of a square wave signal can tell you about the type of problem occurring within the circuit and disclose the source of the problem. For example, a square wave with a rounded leading edge indicates the loss of high frequency response in the amplifier stage. Using a square wave as an input signal also allows the technician to test for internal oscillation, or ringing. Ringing may occur any time that a defective component, such as an output transformer, introduces oscillation into an amplifier circuit. Figure 7 shows several square waves and the corresponding problem as indicated by the shape of the waveform.

Using a square wave input signal allows a technician to verify that the amplifier passes all the harmonic components of the fundamental frequency and that it has sufficient bandwidth. When injecting and monitoring a square wave, check the amplifier response at a range of low and high frequencies. As Figure 7 shows, the waveform will appear differently for poor low frequency or poor high frequency response conditions. For example, the waveform at an amplifier output for an injected low-frequency signal may show a perfect square wave while the waveform for an injected high frequency signal may show some rounding at the edges.

However, some rounding of the square wave is permissible at the higher frequencies. Even when the amplifier is not up-to-standard, it may continue to produce excellent sound. This occurs because response is measured relative to a repetitive frequency. An amplifier would need an extremely wide frequency response of 10,000Hz to 200,000Hz to produce a perfect square wave. On the hand, a severely-rounded square wave, which almost resembles a sine wave, indicates that the circuit has excessive high frequency attenuation and that the amplifier has eliminated most of the harmonics associated with the fundamental frequency.

Monitor the amplitude

As with many of our tests, we can check the overall response of the circuit by monitoring the amplitude of the injected signal from the output of the circuit back to the first input stage. For example, a known-bad circuit may have a strong output signal with the injection occurring at the volume control. However, moving the injection point further away from the output may disclose that the next stage has a defect. When injecting the signal, remember to keep the the signal generator input signal to a low level. An overly-strong input signal can overdrive the amplifier undergoing the test and distort the waveform found at the output of the amplifier.

Even if no schematic is available, we know that a preamplifier, or low-noise amplifier, increases the signal level between 0.7Vdc and 1Vdc. In addition, we also know that a driver stage provides enough power to drive the next stage and that the power amplifier drives a speaker. Yet, as you move a signal generator toward the speaker terminals, the amplitude of the output signal will decrease because the number of amplifier stages between the injection point and the speaker has decreased. This knowledge tells us what to expect when we apply test equipment to the troubleshooting process.

An audio amplifier test setup

Figure 8 shows a typical test set-up needed for checking the performance of an audio amplifier. Moving from left to right, an audio frequency generator that has a frequency range of 10Hz to 20kHz works as a signal source. The generator supplies an adjustable output voltage that ranges between 0.5mV and 2V. While the oscilloscope provides a method for monitoring the output signal, we can measure the output voltage with a multimeter.

In addition, we can use the oscilloscope to check for noise in the audio channel. Checking the voltages at the pre-amplifier with an oscilloscope can disclose the source of the noise. In many instances, active components in the signal path can develop characteristics that generate

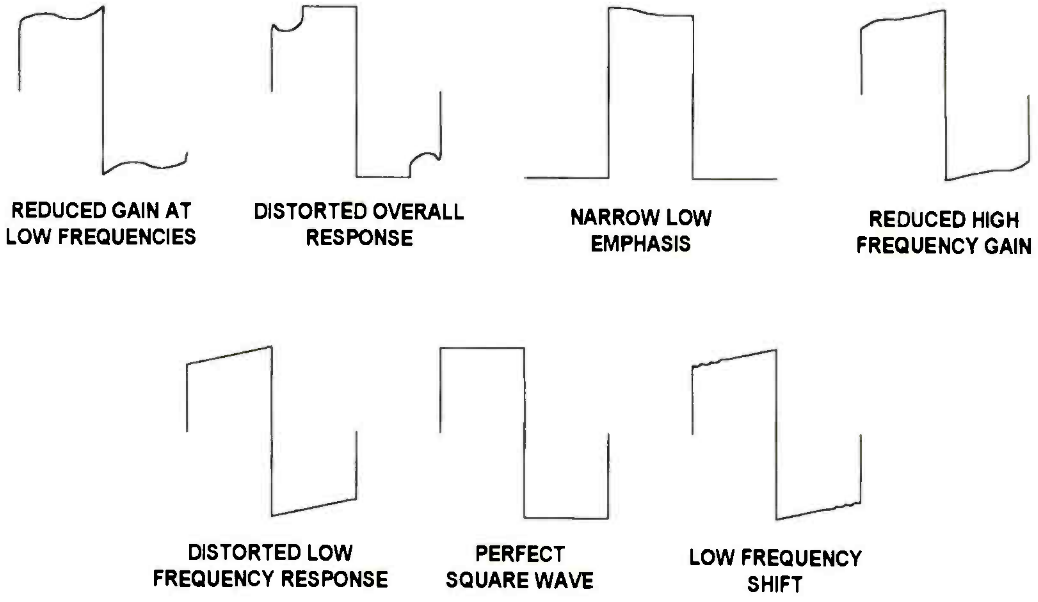


Figure 7. Using a square wave substitute input signal allows a technician to verify that the amplifier passes all the harmonic components of the fundamental frequency of the waveform and that it has sufficient bandwidth.

noise. In others, an overloaded amplifier stage can produce distortion.

Whenever an output transistor or integrated circuit becomes leaky, the problem condition will introduce distortion into the signal. Injecting a signal into the audio channel stage-by-stage should allow you to narrow the troubleshooting process. At this point, you can use your knowledge about transistors or integrated circuits to find the faulty stage. Distortion at the output but not the input of either a transistor or integrated circuit audio channel points towards that stage.

If the amplifier stages utilize capacitor coupling, always check the output capacitors. Many times, a dried electrolytic capacitor in the output stage will either badly distort the signal or cut the amount of power delivered to the speaker. Under normal circumstances, an increase in frequency will cause the capacitive reactance of a capacitor to decrease and the circuit current to increase. When an electrolytic capacitor dries, the internal resistance of the capacitor increases, dissipates additional power, and cuts the ability of the circuit to reproduce high frequencies.

One quick method for checking for a dried electrolytic capacitor involves measuring the voltage drop across the capacitor. In a normally-operating circuit, the voltage drop decreases to a negligible value as the frequency increases. A circuit operating with a defective coupling capacitor will have a larger voltage drop. Because of the increased power dissipation within the capacitor, the part may also feel hot to the touch.

Troubleshooting transistor amplifier circuits

Class B and AB amplifiers pose some interesting troubleshooting problems because of the use of two transistors in the output and biasing stages. Either of the two transistors can develop a shorted or open junction or have intermittent operating characteristics. The most common fault associated with amplifier circuits is "no output signal." Often, this type of problem leads technicians on a fruitless search for a defective output transistor.

Often, simple time-tested checks such as signal injection and tracing will point toward the problem. More than likely, though, we will need to apply our knowledge of amplifier circuits to our troubleshooting efforts. Class AB amplifiers draw very little idle current. As a signal is applied, the amount of current increases. When the amplifier is operated in class A mode, the circuit draws a small amount of quiescent current to minimize distortion at low output power. When operating in class B mode and at a higher output power, the amount of current drawn from the power supply depends on the amount of output power.

In addition, each active component of a class AB amplifier amplifies only a half wave of the audio signal. The half-waves of the output signal combine at the output stage of the amplifier. Both of these factors affect what we might see if we monitor the audio stages with an oscilloscope or multimeter.

Along with these factors, we should also remember that audio output stages usually do not rely on an output transformer. Some transformerless power stages will have positive and negative supply voltages while others will rely on a "center voltage" for both power transistors. The center voltage at each transistor always equals half of the supply voltage. In all situations, because a dc voltage will harm a speaker cone, you should see 0Vdc at the output. From a troubleshooting perspective, we can begin to look for a very high dc voltage at the output as one fault indicator or a very low or negative voltage at the positive supply as another.

Check the sound channel

Before focusing on only the output stages, check the sound channel for the correct input signal from the previous stages, the correct supply voltages, and good ground connections. After confirming the presence of the signal, voltage, and ground connections, disconnect the load from the circuit and recheck the voltage and signal characteristics. At times, the

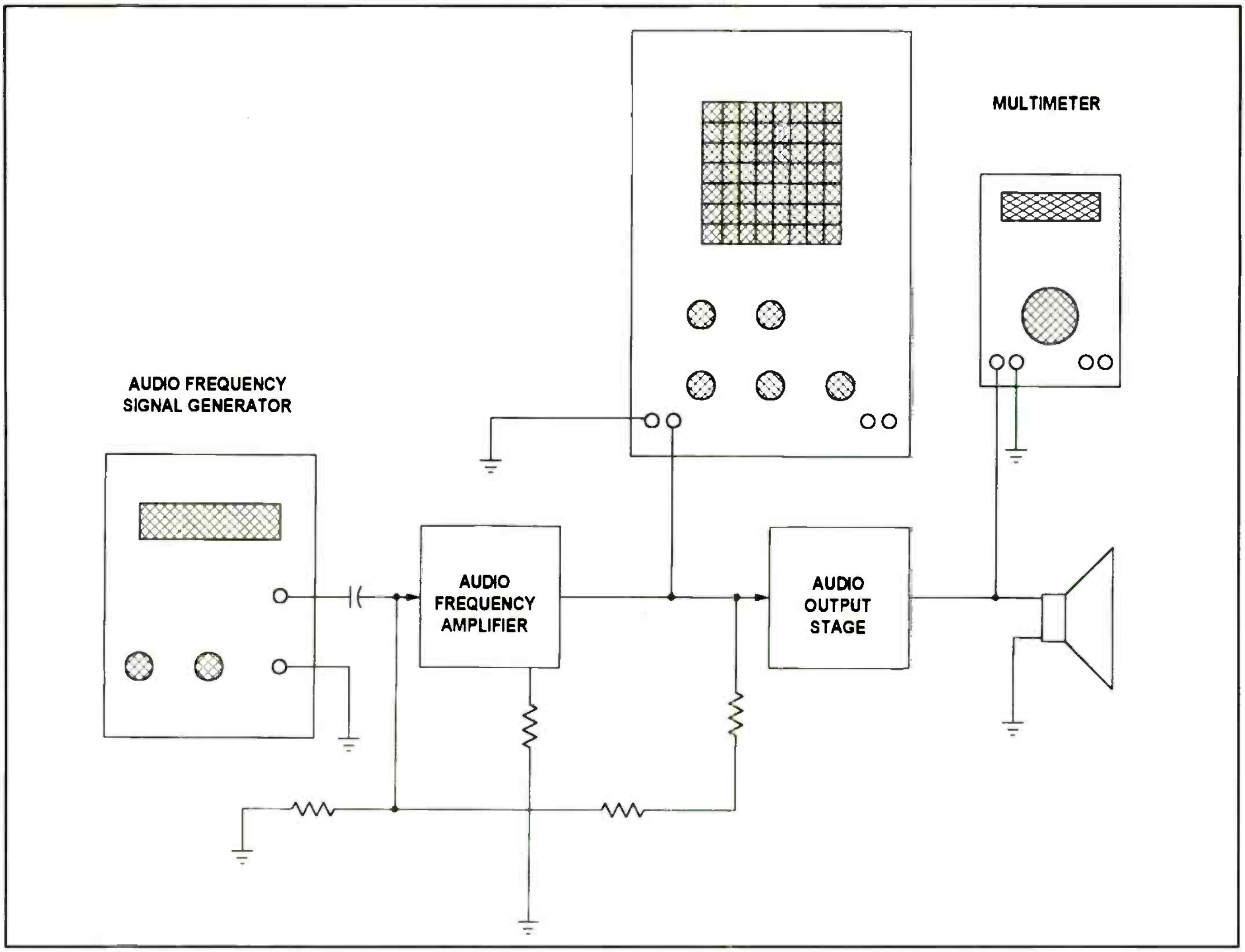


Figure 8. A test set-up such as this allows the technician to check the performance of an audio amplifier. The audio frequency generator has a frequency range of 10Hz to 20kHz and supplies an adjustable output voltage that ranges between 0.5mV and 2V. DThe oscilloscope provides a method for monitoring the output signal. The multimeter provides for measurement of the output voltage at the load resistor. In addition, the oscilloscope can be used to check for noise in the audio channel.

load can prevent an amplifier from working by adding additional loading. In this case, you would check for a shorted load.

If all these circuit checks point to the amplifier, disconnect the ac signal source, or the output of the previous stage, from the output stage. To do this, either desolder a connecting wire or remove the coupling component that connects the two stages. Either method will isolate the output stage. After isolating the output stage, check the voltages at the base, emitter, and collector terminals of each transistor. Also, check for an even distribution of voltages at the voltage dividers. Figure 9 illustrates the voltage check-points.

A leaky transistor will have lower-than-normal voltages at both the collector and base. Along with those checks, verify that the transistor has the correct forward bias between the base and emitter terminals. A leaky transistor will have an improper forward bias. Many times, though, the base or emitter bias resistors can change value and cause the amplifier to appear leaky.

An overload or shorted output will cause a power transistor to short. To find which power transistor has shorted, check the resistance between the collector and emitter of each transistor. Furthermore, check the corresponding driver transistor.

Table 1 — Component Level Troubleshooting for a Class AB Amplifier

Symptoms Check Component:

- ***Voltages found at Test Points 1 and 2 will be closer to the source R2 has opened.***
- ***The voltage at Test Point 3 will be higher than normal.***

- ***Voltages found at Test Points 1 and 2 are close to zero. The R1 has opened.***
- ***The voltage at Test Point 3 is lower than normal.***

- ***Voltages found at Test Points 4 and 5 are normal. The voltage Q1 is open.***
- ***The voltage at Test Point 3 is very low.***

- ***Voltages found at Test Points 4 and 5 are normal. The voltage Q2 is open.***
- ***The voltage at Test Point 3 is very high.***

Test Your Electronics Knowledge

by J. A. Sam Wilson

Determine which of the following statements are correct.

1. One knot equals 6080 feet.
   A. Correct
   B. Not correct

2. An op amp filter that uses two capacitors is a second order filter.
   A. Correct
   B. Not correct

3. The area of a circle is equal to $\pi D^2/2$.
   A. Correct
   B. Not correct

4. A two-input NAND can be used as a voltage comparator for different voltage levels.
   A. Correct
   B. Not correct

5. Morse code was invented by Samuel Morse.
   A. Correct
   B. Not correct

6. Hydrogen is a magnetic gas.
   A. Correct
   B. Not correct

7. MAD in antisubmarine warfare stands for More Advanced Device.
   A. Correct
   B. Not correct

8. An FM detector can be used for a phase modulated signal.
   A. Correct
   B. Not correct

9. To change a keystroke on the keyboard of a computer to a code the computer can understand requires the use of a decoder.
   A. Correct
   B. Not correct

10. In some applications a light emitting diode can be used as a light sensor.
    A. Correct
    B. Not correct

(Answers on page 60)

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

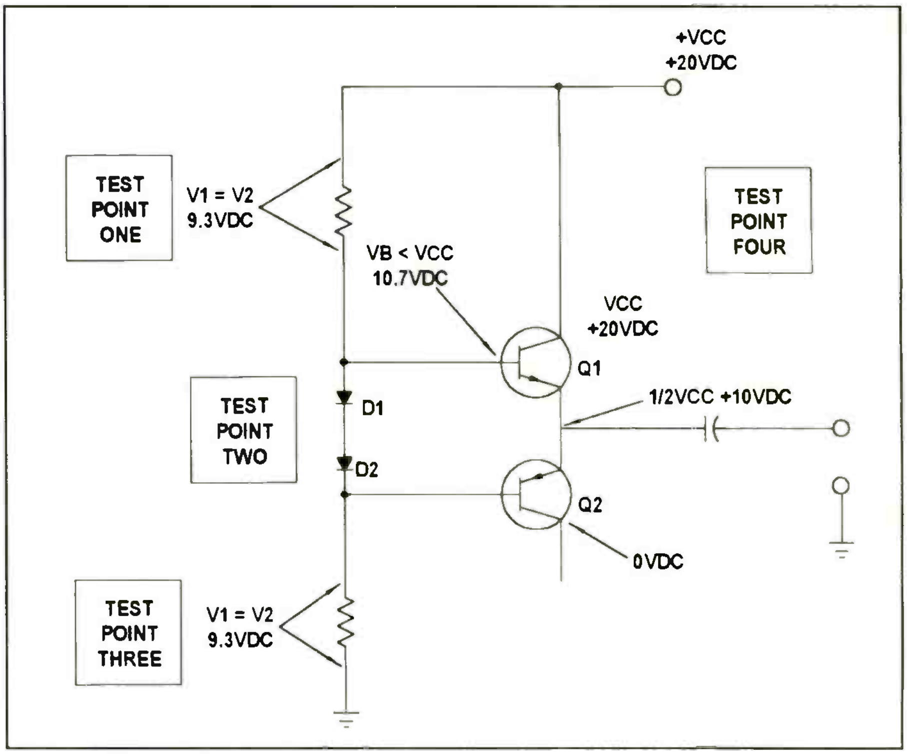


Figure 9. If you have isolated the cause of an audio problem to the output stage, check the voltages at the base, emitter, and collector terminals of each transistor. Also, check for an even distribution of voltages at the voltage dividers. The check-points are shown here.

Many times, a breakdown within the emitter-base or collector-base junctions of the power transistor will cause both the output transistor and the driver transistor to overload. Generally, the driver transistor will have an emitter-base short. As a final rule-of-thumb, if the symptoms direct your efforts towards one amplifier transistor, replace both transistors. More than likely, a defect in one transistor has damaged the other.

Each of the voltage checks tells us about the current operating conditions of the circuit and allows us to pinpoint the problem area. Table 1 lists some of the common symptoms and faults found with transistor AB amplifiers. The component numbers listed in the table correspond with the numbers listed in Figure 9. Normal voltage readings for the table are taken from the schematic drawing for the particular circuit.

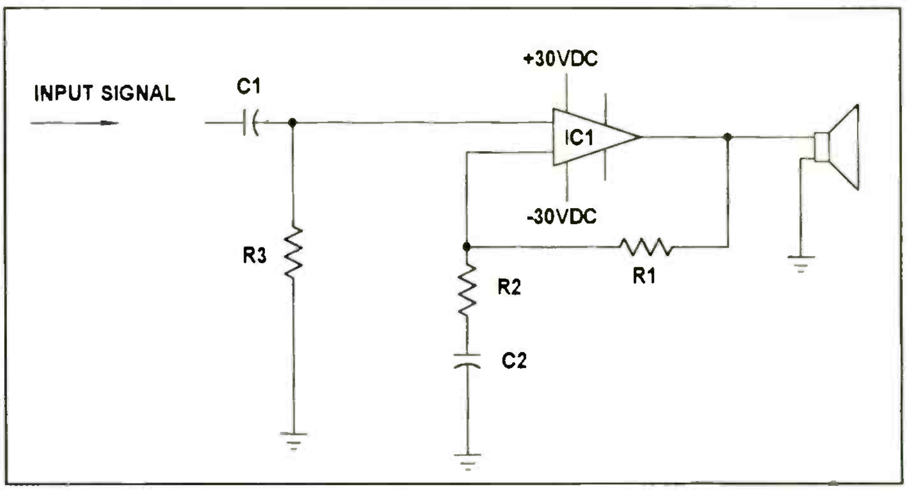


Figure 10. Because of the level of integration seen in IC-based sound circuits, the search for a problem solution is limited to only a few points. The application of basic signal tracing skills and voltage checks will often disclose the source of the problem. A knowledge about feedback and gain helps.

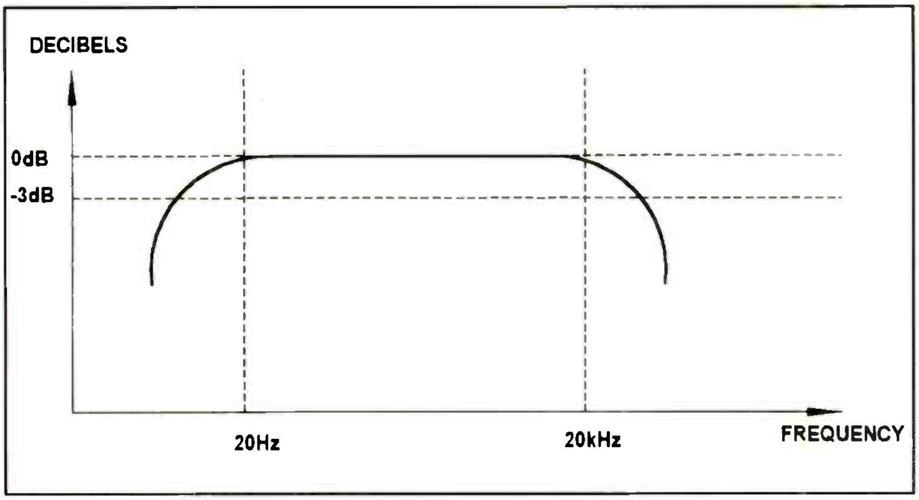


Figure 11. A good audio amplifier will have a flat frequency response for frequencies ranging from 20Hz to 20kHz.

Troubleshooting integrated circuit amplifiers

Because of the level of integration seen in IC-based sound circuits, the search for a problem solution is limited to only a few points. The application of basic signal tracing skills and voltage checks will often disclose the source of the problem.

As Figure 10 shows, we can apply our knowledge about feedback and gain while checking the circuit from output to input. In the figure, R1 is in a negative feedback path. The combination of R1 and R2 determine the gain of the power amplifier while resistor R3 stabilizes the output voltage.

First, with a signal applied to the receiver, check for an audio signal at the output of the audio amplifier. Next, check for the correct voltage at the source voltage connection of the IC. If those two checks provide no hint for a solution, move your efforts to the IC terminals that connect to the volume control.

Checking stereo amplifiers

One of the nice things about troubleshooting stereo amplifiers is that every stage has two identical signal channels. If one channel fails, the other channel works as a reference for verifying the presence of dc voltages and audio frequency signals. For this reason, we can use a dual-channel oscilloscope to compare the performance of the audio channels with each other. So that you can maintain accurate measurements, adjust the amplifier balance control for even balance between the two channels and adjust the oscilloscope gain controls for each channel to the same levels. In addition, adjust the variable sweep control of the oscilloscope so that you can see two stable waveforms on the oscilloscope display.

At times, a change in the frequency response of one channel will cause that channel to produce distorted, low-quality sound. Using an oscilloscope, compare the frequency response of both channels with the curve shown in Figure 11. A good amplifier will have a flat frequency response for frequencies ranging from 20Hz to 20kHz. As with the monaural sound channel, we can also use the oscilloscope and a signal generator to monitor the progress of an injected signal through an audio channel.

When the frequency response of one channel decreases, inject a 400Hz square wave into the input of the audio stage and use an oscilloscope to check the shape of the signal at the stage output. Checking the frequency response then involves setting the generator to reference value 1000Hz and the output signal to a value below the maximum output power. At this point, the volume control should be set to the minimum level.

Switching the signal generator frequency from 20Hz to 20kHz should not cause the output voltage to change by more than 1dB. As mentioned, the frequency response should remain flat. The amplifier should begin to symmetrically clip the positive and negative peaks of a sinewave at the output as the input voltage increases. The key phrase here is "symmetrically clip." If the oscilloscope shows less-than-symmetrical clipping, one amplifier does not have the proper frequency response.

After checking the response of the distorted channel, begin to narrow your search by checking for bad electrolytic capacitors in the amplifier line. As mentioned, a bad coupling capacitor will harm the frequency response of an amplifier stage. When using signal injection in an effort to find the bad component, bypass both the pre-amplifier and the tone control, and consider the point where the signal begins to clip. An amplifier that has poor frequency response will have an output signal that begins to clip at a low output power setting.

Example one: Weak or distorted sound

One of the most commonly reported problems with audio circuits involves weak or distorted sound. We can use our troubleshooting skills and our knowledge about audio circuits to narrow the search for the problem to a small area. In this case, we will use signal injection and voltage tests to find why the monaural sound circuit of a late model television produces a somewhat muffled output that the customer describes as "underwater music."

Because this description verifies that both the desired audio and the background noise are weak, we know that the signal path for the audio signals is not completely open. Therefore, we can limit our search to components that may develop a *leaky* condition. An open path, sometimes caused by an open coupling capacitor, in this area would weaken the desired signal but not the background noise.

We start our troubleshooting by injecting a 1V audio signal at the input to the audio stages. Given the layout of the circuit board, we can use the volume control, rather than the output of the audio detector, as a convenient test point. Injecting an audio signal at this point and with the control set to mid-point should cause the speaker to produce a loud tone.

With a loud tone produced through injection at this point, we can then move our test back to the sound i.f. stage and inject a 4.5MHz FM signal. Here, we find that the signal injection produces only a weak tone at the speaker. Even without the benefit of a schematic, we know that a typical sound i.f. stage will produce approximately 4Vdc to 5Vdc at its output. Usually, a transistor in this section will provide a gain of 10. Finding less than 1V at the sound i.f. output, we know that a fault exists within this circuit.

To narrow the search even further, we can measure the resistance of each transistor base to ground. Lower than normal resistance readings indicate a leaky component in the circuit. Because electrolytic capacitors often become leaky, we can concentrate on a electrolytic capacitor found in the emitter circuit of the sound i.f. transistor has become leaky. However, replacing the capacitor does not completely clear the problem. Another check of the transistor shows that the semiconductor has also developed a leaky condition. Replacement of that component restored normal audio to the receiver.

Example two: No sound

Another common audio circuit failure involves a "no sound" condition. Again, we can use signal injection and a few voltage checks to find the source of the problem. For this problem, injecting a 4.5MHz signal at the sound i.f. amplifier and an audio signal at the volume control conveniently divides the circuit into halves. With the circuit passing the 4.5MHz injected signal but not the audio signal, we know that the problem lies within the audio amplifier stages.

To narrow the search even further, we can inject a low-level audio signal at the base of each transistor while listening for a tone at the speaker. After using this technique to eliminate most components, we can measure the voltages at the stage most in question. Because checks of the transistor voltages produced normal readings, we can proceed to components in the amplifier circuit. In this instance, an open emitter bypass capacitor all but eliminated the amplifier stage gain.

Summary

The two examples shown in this summary are basic applications of the troubleshooting skills described in this article. Solving the problems shown in the examples becomes a matter of employing logical troubleshooting techniques and applying test equipment to the symptoms. Some of the techniques include careful observation, waveform comparison, voltage and resistance measurements, and component substitution. In addition, troubleshooting the audio problems requires knowledge about how the amplifiers operate and how components in the amplifier stages can affect that operation.

Reader survey results: Appliances

by the ES&T Staff

In every monthly issue of this magazine, we enclose a Survey Card in which we ask readers to provide some information that will help us to learn more about them. Some of the surveys are designed to help us understand what kinds of problems they are facing in running their service businesses, others just to find out more about what kinds of products they are servicing, and still other surveys are designed to help in planning the editorial content of future issues.

Appliances

One question that has concerned us recently is that of appliance servicing. There are a number of reasons for this. For one thing, many appliances today have electronic circuitry in them, and if the consumer electronics bus (CEBus) ever becomes a reality in homes generally, appliances and other devices in homes will be sharing information with each other electronically. Secondly, within the past few years, a consumer electronics service organization and an appliance service organization combined into a single organization. And third, many consumer electronics service centers are finding it necessary to branch out into other areas.

To try to find out readers' feelings in this area, we included a survey card on the subject in the November 1997 issue (Figure 1). The results were interesting, and we are still considering the implications, if any, to future coverage in **ES&T**.

ES&T READER SURVEY November 1997

Appliances

Consumer electronic servicing and appliance servicing have traditionally been very separate pursuits. However, recently several factors are combining to bring the two worlds together. For one thing many appliances now contain electronic circuitry, and this will be an increasing trend. Another factor signalling increasing commonality of the two servicing pursuits is the merger a few years ago of the National Electronic Service Dealers Association with the National Institute of Appliance Servicers.

In an effort to obtain some clues as to how **ES&T** should treat this new reality, we ask readers to provide us with responses to the following questions.

1. For which of the following products does your service center provide servicing?

Consumer electronic products	Appliances
☐ TV/Video	☐ Refrigerator/Freezer
☐ Audio/radio	☐ Air Conditioning
☐ Microwave Oven	☐ Dish Washer
☐ Personal Computer	☐ Washer
☐ PC Monitors	☐ Dryer
☐ Video games	☐ Small Applainces
☐ Other ________	☐ Other________

2. Would you like to see articles on appliance servicing in **ES&T**? ☐ Yes ☐ No

3. If the answer to question number 2 was yes, please describe the types of articles you would like to see. ________________

Figure 1. November 1997 reader survey card.

The results

The results of the survey were striking, and frankly, unexpected. One of the questions on the survey was "Would you like to see articles on appliance servicing in **ES&T**?" We received 96 survey cards back. The opinion on this question was almost evenly divided. Of the respondents, 43 answered "Yes" to this question and 39 answered "No." Four more respondents didn't answer that question.

Of course, as we have taken pains to point out in past articles about these surveys, the nature of the survey is such that the responses are not statistically significant, and so can't be considered to be representative of the magazine's readership as a whole. Still they're interesting.

Another somewhat surprising aspect of this survey is that the answers to the question about interest in seeing appliance servicing articles is that it did not strictly reflect whether or not a service center was servicing appliances or not, although it was weighted in that direction. Of the 43 respondents who indicate that they would like to see appliance servicing articles, 22 are currently servicing appliances. But that means that 21 respondents who are not currently servicing appliances would like to see such articles.

Of the 39 respondents who are not interested in seeing appliance servicing articles, four of them are currently involved in servicing those products. Of the four "don't cares", one indicated that they currently service appliances.

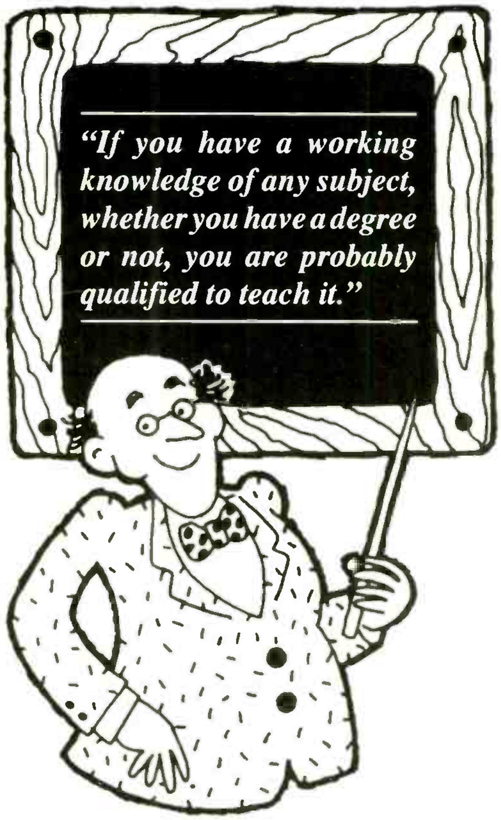
What to do with this information

Because the results of the survey are not definitive, and because there is so much information in the world of consumer electronics service that needs to be published, this magazine is not going to rush to cover appliance service. However, because of the electronic nature of microwave ovens, we have and will continue to report on how to service those products.

On the other hand, much is happening in the area of appliances and they are increasingly incorporating electronic circuits. The staff of this magazine will continue to monitor the situation as regards appliance servicing and will continue to provide servicing articles that are most useful to the greatest number of readers.

Teaching at community colleges and vocational schools

By Sheldon Fingerman



Time to get up and go to school. Only this time you're the teacher, and you can't wait to get there.

Community colleges and vocational schools are always looking for qualified instructors. What does qualified mean? If you have a working knowledge of any subject, whether you have a degree or not, you are probably qualified to teach it.

Since most local colleges cater to the communities they are in, you may find that schools located in the mountains will offer courses in mountain rescue, while schools located near a beach will offer courses in lifesaving. On the other hand, large metropolitan areas offer a variety of curricula catering to students from all over the country. Vocational schools generally fall into those categories, and subjects like electronics, auto repair, and computer training are often included.

Computers

Computers are big right now, so if that's your specialty there may be a position already waiting for you. Almost any specialty relating to business is always in demand, and many schools are open to suggestions on just about any subject area you can think of.

Electronic servicing

Schools that teach electronic servicing are the perfect way for a student to turn his or her favorite hobby into a paying profession, much like a lot of us did. Although many of us learned by the seats of our pants, these schools allow students to gain the kind of knowledge only someone who has been in the field can teach.

Sure, getting the basics and theory down will help immensely when it comes to solving problems, but only someone like yourself knows that R123 is the cause for virtually every case of vertical sync problems in a particular brand of set. Or, that company "A" requires you to replace all of the output transistors in one channel of a particular stereo when it fails. And, what about that special "trick" you know to test bad capacitors. Academics may be able to teach someone how to find these problems, but only those in the field can pass on years of real hands-on experience to these students.

Fingerman is an electronics and computer consultant and servicing technician.

How to begin

How do you begin teaching? The first step is to find the nearest community college or vocational school. Call ahead and make an appointment with one of the supervisors who covers your specialty. Be sure to put together some kind of an outline covering how and what you plan to teach. You may be required to prove that you have experience in the subject you plan to teach, and you may be required to obtain some kind of vocational teaching credential. But, once you have been accepted, the school will usually take care of any credentials you might need.

Certification exams are rarely required for working professionals and others who have been in a particular field for a long time. Some kind of teaching experience is a plus, but not always necessary. If you supervise other technicians, or train your employees that may be all you will need.

Most computer professionals already do some consulting, training, and tutoring, and isn't that teaching? When you think about it, if you can explain, clearly, how to set the clock on a VCR, you are probably doing better than a lot of the teachers out there now.

Are teaching jobs hard to get?

How tough is it to get these jobs? "I just asked," says one part-time instructor who teaches telecommunications at a prestigious university. "Had I known this beforehand I would have applied a long time ago." He also proclaims, "Schools are always looking for people who have been out there and done it."

Cathy Markuson, program director at Colorado Mountain College, Glenwood Springs, CO, confirms what this instructor says, "People in an industry who can share real world experiences know what employers really want."

As for myself, I teach computer related courses at the local community college. My background, and the fact that I have a local business was enough to get me in the door.

Believe it or not, teaching skiing for a couple years helped as well. I think they liked the fact that the ski school gave me the students who couldn't walk and chew gum at the same time.

If you don't have patience, teaching isn't for you. But, if you have no patience you probably wouldn't be involved in electronic servicing.

Once I was accepted, the school took care of all the paperwork and certification I needed. They were even able to work the classes I teach around my busy schedule. People who are still working in a particular field are often sought-after commodities, and most schools will try very hard to work with your schedule.

Why would you want to teach?

Now, if you've read this far you are probably asking yourself why anyone would want to do this. For one, it's a great way to network and meet others in your field, and experts in other fields. Again, people who teach in technical fields tend to do so because they enjoy the subject.

You will often get a chance to pick others' brains, and even learn from your students. I've had students come up with some very creative solutions to software problems I never would have thought of.

If you are currently working, or run your own business, teaching gives you the chance to do something a little different. It usually has little effect on your normal day-to-day business, and you might even pick up a few new customers.

You also get to pass your knowledge on to your students, and give them a good start in their careers. You may even get the opportunity to pick off the best students to work in your own service center. After all, they learned everything they know from the best. Right?

If you're looking for a job, or retired

If you're between jobs, why not use teaching to make a few bucks. yes, you do get paid, and meet people who can probably help you find another job. Teaching, or having taught, is a great feather in your cap when you're job hunting. And, you might even enjoy teaching so much you'll decide to do it on a full-time basis, assuming there is a full-time job available at a local school.

If you're retired, or thinking of retiring, teaching is a great way to pass on years of real-world experience to others, and enjoy an extremely rewarding experience yourself. There are a lot of wonderful things in life, and a pat on the back from a student for a job well done has to be placed somewhere near the top. Trust me, hearing, "Thank you. I really enjoyed your class," is just as, if not more rewarding than fixing the worst "dog" that ever came across your bench.

Another benefit is simply the academic experience. I had the opportunity to speak with one retiree who teaches at a junior college in Maryland. He boasts that hanging around all those young people keeps him feeling and looking a lot younger than his years.

Besides, it's invigorating

I can certainly attest to the fact that life can be a bore at times. Going to the same job day after day, with the same people every day, can get to you after awhile. As a teacher, each class offers up a group of fresh new faces to deal with. They present you with new questions, new answers to those questions, and most of all new opportunities.

Teaching isn't easy. It requires a degree of commitment, not only in terms of time, but to the students and the school. However, I've found it to be lots of fun, and well worth the effort.

As a child, going to school was often a real chore. As an instructor at a local college or vocational school, going to school can be one of the most rewarding experiences of your life. ■

Touch tone decoder for product testing

Viking Electronics introduces the DM-4 Touch Tone Decoder. For use in service departments, the decoder allows the technician to check all types of telephone dialing devices. The unit will record up to 14 digits, so service personnel can check the operation of extended dialing features of the equipment they are servicing. It will also display the * and # symbols.

In security applications, the decoder can be used to detect pass codes, location or identification numbers for emergency phones, or any other security related situation where identification is required.

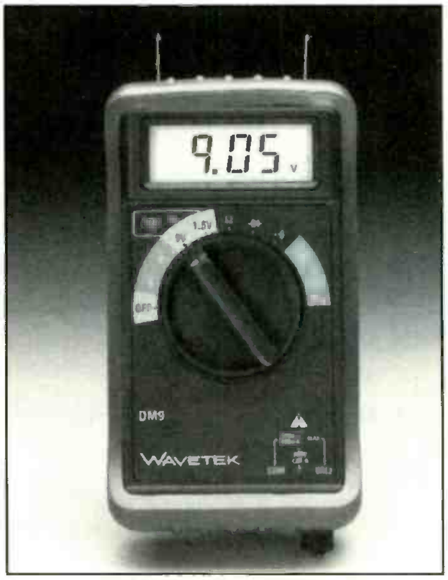
Circle (107) on Reply Card

High performance oscilloscope probes

ITT Pomona Electronics introduces a new line of oscilloscope probes specifically designed to match the bandwidth of the oscilloscope. The new probes have been developed to perform to the highest standards of accuracy and reliability, according to the manufacturer.

These probes are designed, rated and specified to match the bandwidth of the particular instrument. The result is a probe frequency response that can essentially be considered transparent. Only an oscilloscope probe specifically tailored to have a frequency response/bandwidth that matches the bandwidth of its companion oscilloscope and which includes adequate compensation circuitry and overall shielding can provide the signal integrity and minimum loading of the signal source, according to the manufacturer. When used with instruments with 1MΩ input resistance, the probes can handle frequencies up to 300MHz. The probes are rated 600V (dc+Peakac).

Circle (108) on Reply Card



Autoranging tester

Wavetek's pocket-sized meter, the DM9 is a full featured, autoranging, compact digital multimeter (DMM). The meter may be used for the field service tool case and as a service center meter for basic electronic and electrical troubleshooting, test and measurement. Measurement capabilities include ac, dc, resistance, continuity, diodes and special 1.5V and 9V battery testing. The unit comes standard with safety test leads and protective rubber holster.

Key measurement capacities include ac/dc to 600V, dc current to 400mA, high resolution of 4000 count digital display and fast continuity check tone. Additional features include its EN610101 Design safety rating and battery test function with special go/no go LEDs (green when good, red when bad).

Circle (109) on Reply Card

Memory tester

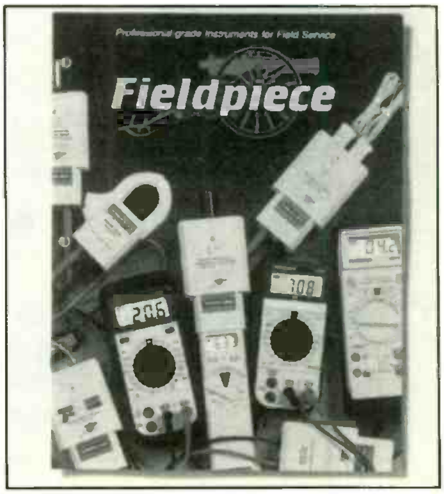
Aristo Computers announces the SIMCHECK II se, memory tester.

The product's advanced architecture and fast 32-bit processor gives users the power to test today's and tomorrow's large memory devices. The unit is a stand-alone portable unit that accurately tests all popular EDO, Fast Page Mode, and ECC SIMM modules with sizes up to 32GB, at a 2nS to 3nS resolution. Four voltage regulators provide a full range of 2.7V to 5.75V functional tests. Optional adapters support most types of memory cards and DIMMs, including the new 168-pin SDRAM DIMMs.

Circle (110) on Reply Card

Instruments catalog

Fieldpiece Instruments announces the immediate availability of their 1998 comprehensive catalog. The new, full-color catalog offers a complete selection of heavy-duty instruments and accessories for HVAC, electrical, and electronic applications, including the newly designed Fieldpiece Model ATIR1 Non-contact Infra-Red Temperature Head and



the cost effective Model ARH2 accessory head that measures both RH% and ambient air temperature.

The catalog highlights Fieldpiece Instruments' complete line of Heavy Duty DMMs and accessories which provide maximum functionality, A complete selection of interchangeable accessory heads are featured for measurement of most parameters needed by field service technicians. Information on probes and cases for field service instruments is included as well.

The fieldpiece Fieldpack Test Kits are offered, providing field service and plant technicians complete test solutions and convenience for most applications. Detailed specifications are provided on the several Heavy-Duty DMMs including the popular HB74, a variety of Test Lead Sets, Thermocouple accessories and other Fieldpack kits.

Circle (111) on Reply Card

Multimeter

Extech's 4 1/2 digit true RMS multimeter, Model 380285, measures dc voltage with a basic accuracy of ±0.1%. Measuring capabilties include voltage, ac/dc current, resistance, capacitance, frequency, and F/C temperature plus audible continuity and diode test. The meter displays up to 20,000 counts with a 42 segment bar graph. A Max/Min recording/recall mode is equipped with an audible beep when a new Max or Min value has been recorded. Data hold freezes the reading for viewing at a later time. Reference values can be programmed along with high/low limits for repetitive tests or inventory checks. Auto Power Odd saves battery life. Complies with CE safety standards. Complete with test leads, temperature probe, 9V battery, and protective holster.

Circle (112) on Reply Card

Exhaust light reduces fumes

Light fixtures from *O.C. White* remove, absorb, or disperse soldering smoke and fumes to make workstations and work areas safe and pleasant. These products, incorporating illuminated magnifiers, and/or chrcoal filtration are equipped with fans and lamps that operate independently of each other for control.

Four combinations provide flexibility:

- Exhaust-A-Lite: Illuminated Maginifier removes smoke as it illuminates to eliminate potential hazard of toxic fumes.
- Exhaust-Mag: Provides 3 diopter magnification, fume removal, and illumination.
- Exhaust-Fan 475 CFM: Eliminates solder fumes, welding fumes or other irritating air-borne particles.
- ESD Safe Absorber: Removes noxious fumes that cause headaches and nausea.

Circle (113) on Reply Card

What Do You Know About Electronics?

Going beyond the electron model

by Sam Wilson

When students enter the subject of electronics they are usually given a description of the electron based upon models. That usually causes some frustration because it doesn't show them how to take a computer apart and put it back together again, and, it doesn't show them how to design a television receiver. There is a tendency to skip rapidly through electron theory and get on with "the meat of the subject".

Let me assure you that a knowledge of atoms, electrons and atomic nuclei is very important for understanding the operation of some kinds of electronic devices. I will review a few of those devices in this article.

Let's take a quick look at the electron and other basic particles. If you take a grain of salt and divide it, and, divide it again and again and again (etc.) you will come to the smallest division in which you still have salt. That smallest division is a salt molecule. Divide that molecule one more time and you get two atoms: the elements sodium and chlorine (NaCl). (By the way, both are poisons.)

If you divide a grain of sugar down to the point where you can't divide it again and still have sugar you have a molecule. Divide that molecule again and you get three kinds of atoms: carbon, hydrogen and oxygen ($C_{12}H_{22}O_{11}$).

There are only 92 basic kinds of atoms and everything on earth is made up of those atoms. More types of atoms are made in the lab, but only 92 are found out of the lab. The subscripts given with the atoms show how many of each type of atom is used to make up the molecule. The most basic atom is hydrogen which has one electron circling a proton nucleus.

The electron in an atom does *not* circle the nucleus like the earth goes around the sun. Instead, it goes around the nucleus to form a shell. When you wind a ball of string you rotate the ball so that the string forms a shell around the ball. That is the way the electron goes around the nucleus of the atom. The electron moves so fast that the shell it forms cannot be (easily) penetrated. The next more complicated atom is helium with two protons in the nucleus and two electrons circling in approximately the same shell. It is important to understand that the first shell is completely filled when it has two electrons. You will never find an atom in its natural state with more than two electrons in the first shell.

Wilson is the electronics theory consultant for ES&T.

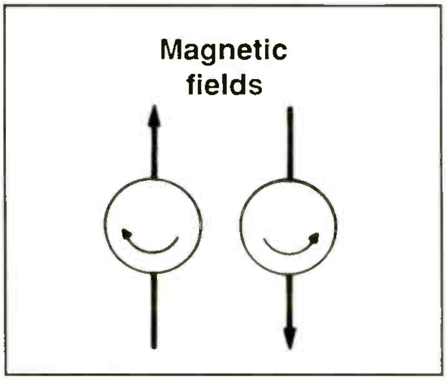


Figure 1. The opposite spins of these electrons are compensated, so their magnetic fields cancel each other out.

The electrons in the shells and the protons in the nucleus spin on their axis and that creates magnetic fields. The magnetic fields of the electrons and the protons in the nucleus of most atoms are said to be "compensated" (Figure 1). In other words they cancel as in the helium atom. However, the magnetic fields of hydrogen cannot be compensated.

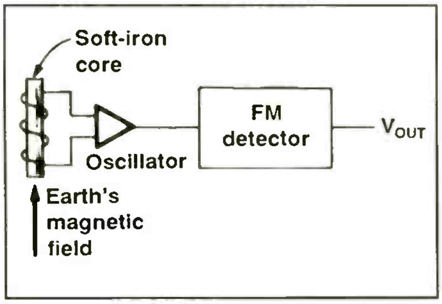


Figure 2. An anomaly in the earth's magnetic field is sensed by this basic magnetometer.

Don't worry. I'm not going to go through all 92 elements, but the two atoms we have discussed are enough to show how our first electronic device operates.

Let me add something to what I've said. Lithium has three electrons. Since the first shell is filled with two electrons the second shell is started with one electron. It is a very unstable material. Eight electrons are needed to fill the second shell.

There is a basic rule that says a magnetic material is one that has an uncompensated spin in an inner shell. That explains why you can't magnetize a wooden broomstick; it does not have an atom in its makeup with an uncompensated spin in an inner shell.

Question: From what has been said about atoms, would you say that hydrogen is a magnetic gas?

Answer: Yes. Hydrogen is a weakly-magnetic gas.

An analysis of the nuclear precession magnetometer

The word nuclear as used here means that it pertains to the nuclei of atoms. It does not mean that we're talking about a radiatioactive material like radium.

According to the World Book Dictionary, "precession" means the rotation of a spinning rigid body that has been tapped from its vertical axis by external torques acting on it. This phenomenon is illustrated by the wobble of a top.

A magnetometer is used to measure magnetic anomalies. Using the same dictionary, an anomaly is an irregularity. For example, a submarine causes irregularities, or anomalies, in the earth's magnetic field. Those irregularities can be sensed by an airborne magnetometer.

Early versions of airborne magnetometers used a coil with a soft iron center (Figure 2). In flight it was aligned with the earth's magnetic field. Normally, that inductance was a fixed value.

When an airplane or blimp flew over a submarine, that sub created a magnetic anomaly in the earth's magnetic field.

That changed the inductance of the coil. (An anomaly in this case was an apparent change in the earth's magnetic field strength.) The inductance change was sensed as a change in an LC oscillator frequency. So, the airplane sensed the presence of the submarine, or iron deposit, or sunken ship, or whatever.

In some metal detectors the coil is also used in an oscillator circuit. When metal is detected the oscillator frequency is changed because the inductance is changed. A basic FM detector detects the frequency change and the operator notices a deflection of a meter or an LED light in the metal detector circuit. When that happens the operator has located buried treasure, or, a tin can, or, whatever.

The nuclear precession magnetometer works on a different principle. A magnetic gas is located in a chamber with two external magnetic fields (Figure 3). The nucleus of the magnetic gas is first aligned in one direction by the electromagnetic field due to a dc current. Then, that electromagnetic field is turned off and the time it takes for the nucleus to align with the earth's magnetic field is measured. If there is an apparent change in the strength of the earth's magnetic field due to an anomaly there is a corresponding change in the erection time.

By electronically switching the electromagnetic field ON and OFF the varying magnetic field induces an ac current in a sensing coil. The frequency of that coil voltage can be used to measure the erection time. T = 1/f.

I am being careful to give the general theory of electronic devices in this article. I don't want to step all over a patent or U.S. Government submarine detector.

The nuclear precession magnetometer I just described is so sensitive that it can detect the presence of buried iron ore in a dense forest from a satellite hundreds of miles above the earth.

I have been told that Magnetic Resonance Imaging (MRI) used in hospitals works on the same basic principle except that the nuclear magnetic field does not react to the earth's magnetic field in a gas chamber. Instead, it erects to the weak magnetic fields of hydrogen atoms in the human body. John Q Public would never submit to tests by equipment with the name "nuclear" in its title. As you know a little knowledge is a dangerous thing. In fact, the "littler" the knowledge the more dangerous it is. Thus, the name MRI.

It is common practice to refer to an electron as if it is a small negative particle. However, physicists who know about such things tell us that an electron changes back and forth between particle and a small bundle of energy. They also tell us that at any time it can be one or the other and it isn't possible to tell which it is. That is called the "uncertainty principle" and it indirectly applies to all measurements. I'll discuss that in the next addition of "What Do You Know About Electronics".

What do we mean by "energy?"

Before we proceed, let's make sure we are talking about the same thing when we use the word energy. In science, energy is the capacity to do work. In the field of science it is *not* something you get when you eat a candy bar. Work is always a force multiplied by a distance. Energy and work are measured in the same units.

There are two kinds of energy: potential and kinetic. Potential energy is the energy a body has by virtue of its position. Kinetic energy is energy a body has by virtue of its motion. A brick sitting on a table has potential energy. If it falls off the table its potential energy is converted to kinetic energy as it is falling. When it hits the ground its kinetic energy is converted to heat energy. Energy cannot be created or destroyed, but, it can be converted from one form to another. Example: kinetic energy to heat energy.

You can think of an electron in its shell as having a certain amount of energy. If its energy level is raised it moves farther away from its nucleus. For example, if you heat a filament in a vacuum-tube diode the electrons in the filament increase their distance from the nucleus. Given enough heat, they can achieve enough energy to escape from the filament.

So, you can increase the energy level of an electron in a material by heating it. You can also increase its energy by shining a bright light on it, or, by accelerating it with a positive/negative voltage, or other accelerating source.

In an x-ray machine, electrons are emitted by a cathode. They are accelerated to a very high speed by a high positive voltage. When the electrons slam into the anode they must give up their kinetic

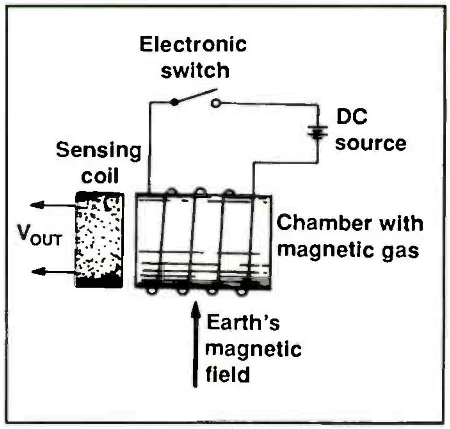


Figure 3. The basic principle of a magnetic anomaly detector (MAD) system is based on nuclear precession.

energy. Remember: energy cannot be destroyed (or, created). So, the kinetic energy of the electrons is converted to x-ray energy (Figure 4).

Now examine the color picture tube with a 30,000V accelerating voltage. Electrons from the gun achieve a very high speed and that means a high kinetic energy. When the electrons strike the face of the cathode ray tube they give up their kinetic energy the same way as in the x-ray tube; that is, they convert their energy to a form of X-rays.

At one time X-rays in color TV sets were a serious problem. Not only X-rays from the color picture tube, but also in the high-voltage rectifier. By using a special glass for the pix tube face, and, lowering the accelerating voltage to about 30,000V, the color TV is now considered to be safe. The high-voltage rectifiers are shielded and the lowered rectifier voltage reduces those X-rays to a safe level.

Lasers and LEDs

The energy level of electrons can also be raised with light waves. That is done

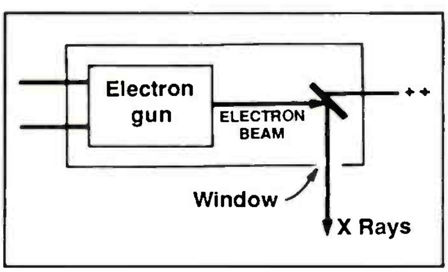


Figure 4. In an x-ray machine, electrons emitted by a cathode are accelerated to a very high speed by a high positive voltage. When the electrons slam into the anode their kinetic energy is converted to x-ray energy.

in the laser. The first laser was made with a translucent ruby cylinder. High-intensity light from a Xenon tube raises the electron energy levels in the ruby (Figure 5).

An important feature of the Xenon light is that it can be turned off very quickly. That enables all of the electrons in the ruby material to return to a lower energy level at the same instant and they all gave up their energy at the same instant. The energy given up is in the form of laser light.

The light waves from the laser are coherent. In other words, they are all in phase. That gives laser light its great strength. Another feature of the coherent laser light is that it can be sharply focused. One of the first uses of laser light was to light a small area on the dark side of the moon with a sharply-focused laser beam. From that historical laser we have progressed to diode lasers and lasers made with many other materials.

In order to get electrons across the depletion barrier in a laser diode it is necessary to raise their energy level. Once across that barrier they give up their added energy in the laser diode in the form of laser light. The barrier in laser diodes is very thin and there is a window in the diode that allows the laser light to escape from the diode (Figure 6). As with the ruby laser, the light waves of the laser diode are coherent. Laser diodes are used to retrieve information from a compact disk.

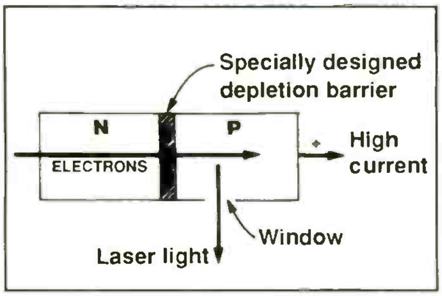


Figure 5. The first laser was made with a translucent ruby cylinder. High-intensity light from a Xenon tube raises the electron energy levels in the ruby. When the light is abruptly turned off, all of the electrons in the ruby material return to a lower energy level at the same instant and they all gave up their energy at the same instant. The energy given up is in the form of laser light.

Light-emitting diodes (LEDs) also produce light when electrons cross the depletion region. However, the light waves thus emitted are not coherent due to the different depletion region.

A little knowledge

Of course it's not absolutely essential to know the kinds of things discussed in this article in order to take a compact disk player apart and replace the laser diode. But it does increase the technician's understanding of how these products work, and thus aids in the diagnosis. ■

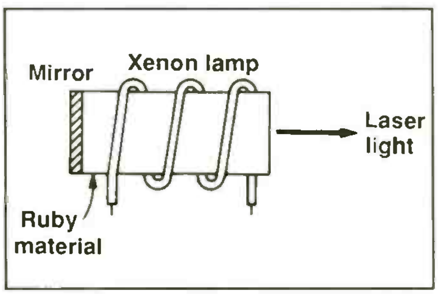


Figure 6. In order to get electrons across the depletion barrier in a laser diode it is necessary to raise their energy level. Once across that barrier the electrons give up their added energy in the in the form of laser light.

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June 19-21, 1998
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CES Mobile Electronics
June 19-21, 1998
Atlantic City, NJ
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June 24-28, 1998
Colorado Springs, Colorado
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NESDA 48th/ISCET 28th/NIAS 6th Annual
August 10-15, 1998
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CeBit Home Electronics '98
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Hanover Germany
609-987-1202

PCS 98
September 23-25, 1998
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Personal Computer & Electronics Expo
October 15-18, 1998
Uniondale L.I., NY
800-886-8000

PCS 99
September 22-24, 1999
New Orleans, LA
703-739-0300

***RadioScience Observing: Volume 1*, by Joseph J. Carr, PROMPT Publications, 336 pages, paperback $29.95.**

Among the hottest topics right now are those related to radio - radio astronomy, propagation studies, whistler and spheric hunting, searching for solar flares using very low frequency radio, and related subjects. In *RadioScience Observing*, you will find chapters on all of these topics and more. The main focus of the book is the amateur scientist who has a special interest in radio. It is also designed to appeal to amateur radio enthusiasts, shortwave listeners, scanner band receiver owners, and other radio hobbyists. This book comes with a CD-ROM containing numerous examples of radio frequencies so you can learn to identify them. Is also contains detailed information about the sun, planets, and other planetary bodies so you can learn more about the natural radio signal generators of our solar system and beyond.

PROMPT Publications, 2647 Waterfront Parkway E. Drive, Indianapolis, IN 46214-2041

***Howard W. Sams & Co. Complete Camcorder Troubleshooting and Repair*, by Joseph Desposito & Kevin Garabedian, PROMPT Publications, 240 pages, paperback $29.95**

The camcorder's circuits process video and audio signals, run recording mechanisms for storing analog information onto videotape, supply power to the machine, and perform many more tasks that can tax and wear out the electronics. This book starts by examining camcorder troubleshooting procedures, then moves into more advanced repair techniques. *Complete Camcorder Troubleshooting and Repair* also contains seven real-life case studies, focusing on a particular model of camcorder with a specific problem. With photographs and captions used in the case studies, it will be as if you were looking over the shoulder of a professional technician and listening to his thoughts during the repair process.

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***1998 Computer Monitor Troubleshooting Tips*, by M.I. Technologies, Inc., PROMPT Publications, 336 pages, paperback $49.95**

Computer Monitor Troubleshooting Tips contains over 2,000 troubleshooting and repair tips listed by manufacturer name and model number. It features such major brand names as Apple, Acer, Compaq, Dell, Gateway, IBM, Packard Bell, NEC, Zenith, and many more. Value-added specials include repair procedures for the KD1700 series monitor including free schematics and the parts list valued at $45. In addition, free FCC number identification software, valued at $50, is included so readers can cross-reference their model information to the original manufacturer and contact information. Also contained in this book is an overview of how VGA monitors work, an overview of EEPROM repair, an overview of ESR in-circuit capacitor testers, and international monitor manufacturer contact listings.

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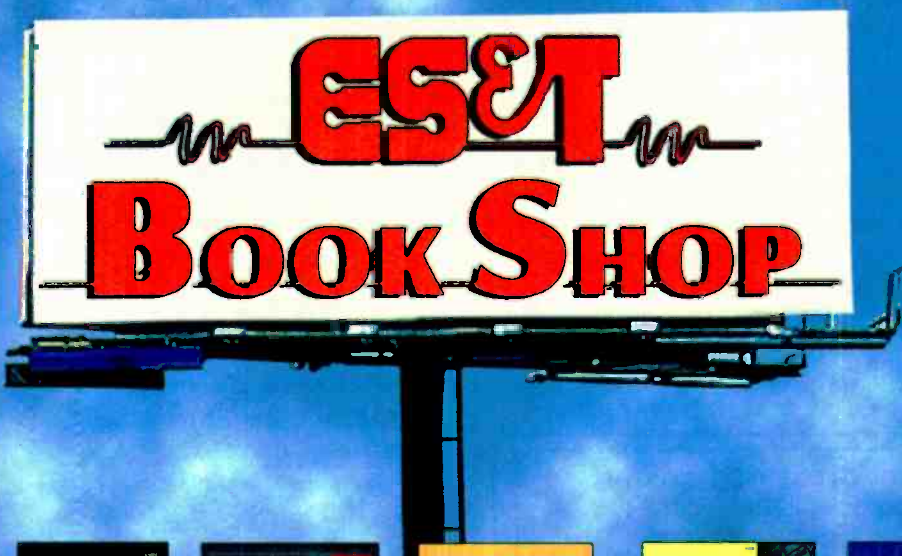

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Please mail your orders to: Electronic Servicing & Technology, 76 North Broadway, Hicksville, New York 11801-9962 **FAX 516-681-2926** million in 1996 to 14.8 million in 1997. CEMA predicts another 1.8 million households will buy a home theater system in 1998. As home theater families begin to replace their analog components with new digital video products, CEMA estimates that the home theater market should reach more than $11 billion in sales by the year 2000.

While dollar sales of home theater video fell three percent in 1997, unit sales of video products rose seven percent. Stereo VCR prices fell dramatically in response to the powerful new presence of the DVD player, introduced in March of 1997. Consequently, unit sales of stereo VCRs shot up 19 percent. Even after the price erosion, VCR dollar sales still managed to grow two percent to $1.4 billion. Prices also dropped for projection TVs which fell four percent in dollar sales, but increased three percent in unit sales in 1997.

Sales of audio-related home theater products topped $1 billion, growing seven percent for 1997 solely on the strength of home-theater-in-a-box shipments which generated $282 million in revenues.

* Direct-view color TVs 25" & over, DVD players, laserdisc players, projection TVs, Hi-Fi Stereo VCRs, surround-sound processors, amps and receivers, subwoofers, center channel speakers and surround-sound speakers sold as separate units or as multi-speaker packages and home theater-in-a-box.

"Millennium Bug" for electronic data interchange (EDI)

The Electronic Industry Data Exchange Association (EIDX), a part of the Electronic Industries Association (EIA) today released a series of recommendations designed to help those in the industry working on possible solutions for the "Year 2000" (Y2K) challenges.

In announcing the recommendations, Ron McAlpine of AMP Inc., President of the EIDX Board of Directors, stated, "No one has invented a single technological "fix" for solving the Y2K issue, but EIDX featured the "Year 2000" question as its theme for its annual conference held earlier in the year. Based on presentations and discussions at that meeting, we are offering to the industry our position and best thoughts on this critical issue."

Based on its comprehensive analysis of the issue, The EIDX Board of Directors released the following recommendations on specific areas in EDI such as:

- Use of dates with century
- Date Conversions-parsing and windowing.
- X12 Version 4010 Re-cast
- Communication with Trading Partners.

The Group series of detailed recommendations in the area of EDI are posted on their website www.eidx.org.

Test Your Electronics Knowledge

Answers to Test *(from page 44)*

1. B - A knot is a speed, not a distance.
2. A - (by definition)
3. B - $(\pi D^2/4)$ or $\pi(D/2)^2$ or πr^2
4. B
5. B - It was invented by his assistant - Alfred Vail.
6. A - As explained in WDYKAE? in this issue.
7. B - (Magnetic Anomaly Detector)
8. A
9. B - An encoder is needed
10. A - (Discussed in a previous issue and verified by Bruce Hagen of Ohio).

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VCR test equipment, $400.00. Beltron 8080A picture tube checker/rejuvenator, $500.00. Bird wattmeter model 4431, with seven elements, $600.00. All new. *Contact: Martin E. Wiedenbeck, 716-434-7395.*

Hickok variable ac isolation transformer includes metal case and storage trays, $100.00 plus shipping. Heathkit condenser checker model c-3, $35.00. *Contact: Harold Klotzle, 773 Midland Avenue, Ravena, OH 44266, 330-297-1155.*

Sencore equipment for VA62 or VA62A analyzer. NT64 NTSC pattern generator, $150.00. VC63 VCR test accessory, $150.00. EX231 accessory jack expander, $40.00. All for $300.00. Never used, in original boxes with manuals and connectors. You pay shipping. *Contact: Gerald, 252-745-4493, 252-745-5707.*

B&K 970 transistor radio analyst. Has an AM and FM signal generator power supply. Six instruments in one case, with manual and leads. $95.00 plus UPS. *Contact: Daniel Seidler, 3721 W. 80 Street, Chicago, IL 60652-2415, 773-284-8221.*

Merit & Meissner - Thordarson coils. Howard Sams, tube substitution handbooks Vol 2-19. *Contact: Ann Bichanich, 15 1/2 Lake Street, Chisholm, MN 55719.*

Three Normande German radios one wood - two plastic. Nice condition. BOC record changer/turntable, $60.00. 22 volumes of Sams Photofacts, covers folders 1 to 500, $300.00 plus shipping. Riders volume 1 to 17, $250.00 plus shipping. *Contact: Maurer Television, 295 S. 4th Street, Lebanon, PA 17042.*

Sencore SC3100, LC53, TF46, SCR250. Protek 506 multimeter with PC interface cable, HP330B, GE1396B tone burst generator. Lambda dual power supply 0 to 18Vdc 5.2A. Kepco power supply 0 to 55Vdc 20 amp. Bruel & Kjaer. *Contact: 612-869-4963.*

READERS' EXCHANGE

Pace solder/desolder station, EPROM duplication system, EPROM/PAL development kit and various new NTE/ECG components, $950.00 OBO. *Contact: 860-632-5577*

Lighted sign, 5 x 6, double-sided with three line marquee and complete letter kit. It reads "RNR Electronics" in black and blue on yellow with a red atom graphic. Good condition. Photos available. Paid $2500.00, asking $800.00. *Contact: Richard, 254-442-1944.*

Heathkit condenser checker, $35.00. Hickok variable ac isolation transformer 0V to 120V ac. Includes steel case and storage drawers. $100.00 plus shipping. *Contact: Harold Klotzle, 773 Midland Avenue, Ravenna, OH 44266-2530, 330-297-1155.*

Sencore CR31 CRT tester rejuvenator with manuals and sockets. $150.00 plus shipping. *Contact: Denny's TV, 603-641-5793.*

Free for local pick-up only, San Diego area. Ten years of **ES&T** back issues. *Contact: 619-582-1728.*

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Sencore VA62 with VC63, $1000.00; SC3100, $2000.00; PR57, $300.00. All probes, manuals and schematics. In excellent condition. *Contact: Frank, 813-546-7060.*

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Globe capacitance meter 3001, measures 1/10 farad. Good condition, manual, $90.00. Heath flyback tester, $35.00. *Contact: Sid, 510-357-3788.*

Electronic Servicing & Technology magazine, five complete years 1993-1997, 60 issues all for $35.00 plus postage. *Contact: Daniel Seidler, 3721 W. 80 Street, Chicago, IL 60652-2415, 773-284-8221.*

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Mitsubishi model CK-3513R TV, part 350P34709 switch mode transformer. *Contact: Winfield Nelson, 316-652-8817.*

Mitsubishi VCR model HSU-32, need front cabinet part 701B201060, new or used. Sylvania TV E34 chassis, need horizontal/vertical. Processing IC part612363-1. ECG/NTE 852 or equivalent. Reasonably priced. Can use 1 - 25 of them. *Contact: Peter Mirich, 124 Thompsonville Road, McMurray, PA 15317, 724-941-5358.*

Service manual or schematic for AKAI model M-10 tape recorder. *Contact: Irvin Sydnor, 806 Meetinghouse Road, Boothwyn, PA 19061-3504, 610-485-5916.*

Carver CD player model DTL-200MK2 service manual. No longer available from Carver Corporation. *Contact: Earl Friedman, 27 N.E. 5th Avenue, Hialeah, FL 33010-5014, 305-884-2175.*

1952 Terminal radio catalog. Will pay reasonable fee for original or photocopy. *Contact: Tom Cadwallader, ProSound Service Co., 1372 Bryn Mawr Lane, Rockford, IL 61107, 815-399-0773, Fax: 815-399-0663, e-mail: Prosound4@worldnet.att.net.*

Heathkit SG1271, SP2718 test equipment and a HW2036 radio. 10 or 15MHz dual trace scopes. Units can be working or non-working as long as parts are there. Send list and asking price. *Contact: Mike Helton, CET, 2708 May Drive, Burlington, NC 27215.*

Jerrold line amplifier SRD-A series 2, schematic and any other information. *Contact: Richard Gilman, PO Box 633, King City, CA 93930, 408-385-9248.*

Emerson, Panasonic VCR service manuals. *Contact: Ed Herbert, 410 N. Third Street, Minersville, PA 17954.*

Curtis Mathes model A2668RL schematic or service manual for color TV. Colortyme model 3R15M color TV. Pioneer model SA9000 amplifier. Will photocopy and return. *Contact: D.L.E. 10003 Greenwood Avenue North, Seattle, WA 98133, 206-782-6344.*

Marantz model 2500 power transformer, receiver or chassis with transformer or company willing to rewind coils of the original transformer. *Contact: John, 787-895-3857.*

Sams photofacts, complete set going back 10 to 15 years. Full multi-year sets of factory service manuals for major brands of consumer video and audio. *Contact: Jeremy Wolfson, 612-473-6222, 612-404-2900.*

Technics SP10MKIIA or III turntables (manuals, parts, etc.), older tube-type processing equipment. *Contact: 612-869-4963.*

AKAI tape recorder model GX400D.SS schematic. Will pay anything within reason. *Contact: Joe A. Perry, 764 Linda Lou, San Antonio, TX 78223-1258, 210-532-3447.*

Magnavox VR8209AV01, need EVF (complete) and microphone. Sony SLV575UC VCR, need remote control transmitter. Symphonic ST191B TV, need tuner P/N UVE50-AW54D (Emerson part). *Contact: Anchor VCR & TV, 541-884-5985.*

Fisher VCR service manuals. *Contact: Ed Herbert, 410 N. Third Street, Minersville, PA 17954.*

COMING NEXT MONTH IN ELECTRONIC Servicing & Technology

UPDATES

Test Equipment Update

Test Probe Update

Cross Reference Update

June will be the month for updates. The **Test Equipment Update** will describe the use of test equipment to check out local area networks. The **Test Probe Update** will discuss a variety of probe problems and solutions, and will highlight some new probe applications. There will also be a **Cross Reference Update** that will describe the many and varied cross references available to service technicians and will suggest which ones might be the first to consult in a particular situation.

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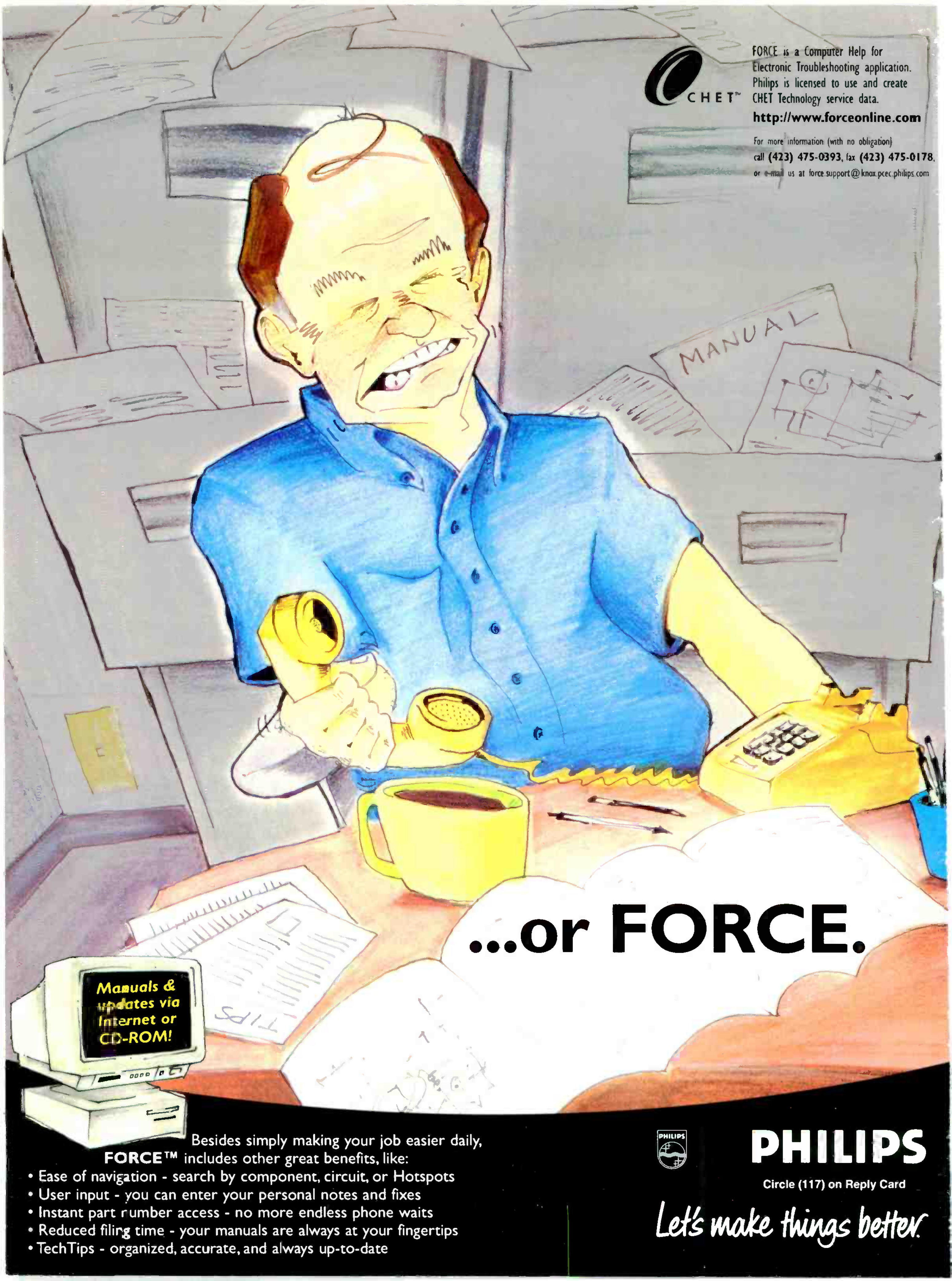
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