THE MAGAZINE FOR CONSUMER ELECTRONICS SERVICING PROFESSIONALS

ELECTRONIC T.M.
Servicing & Technology

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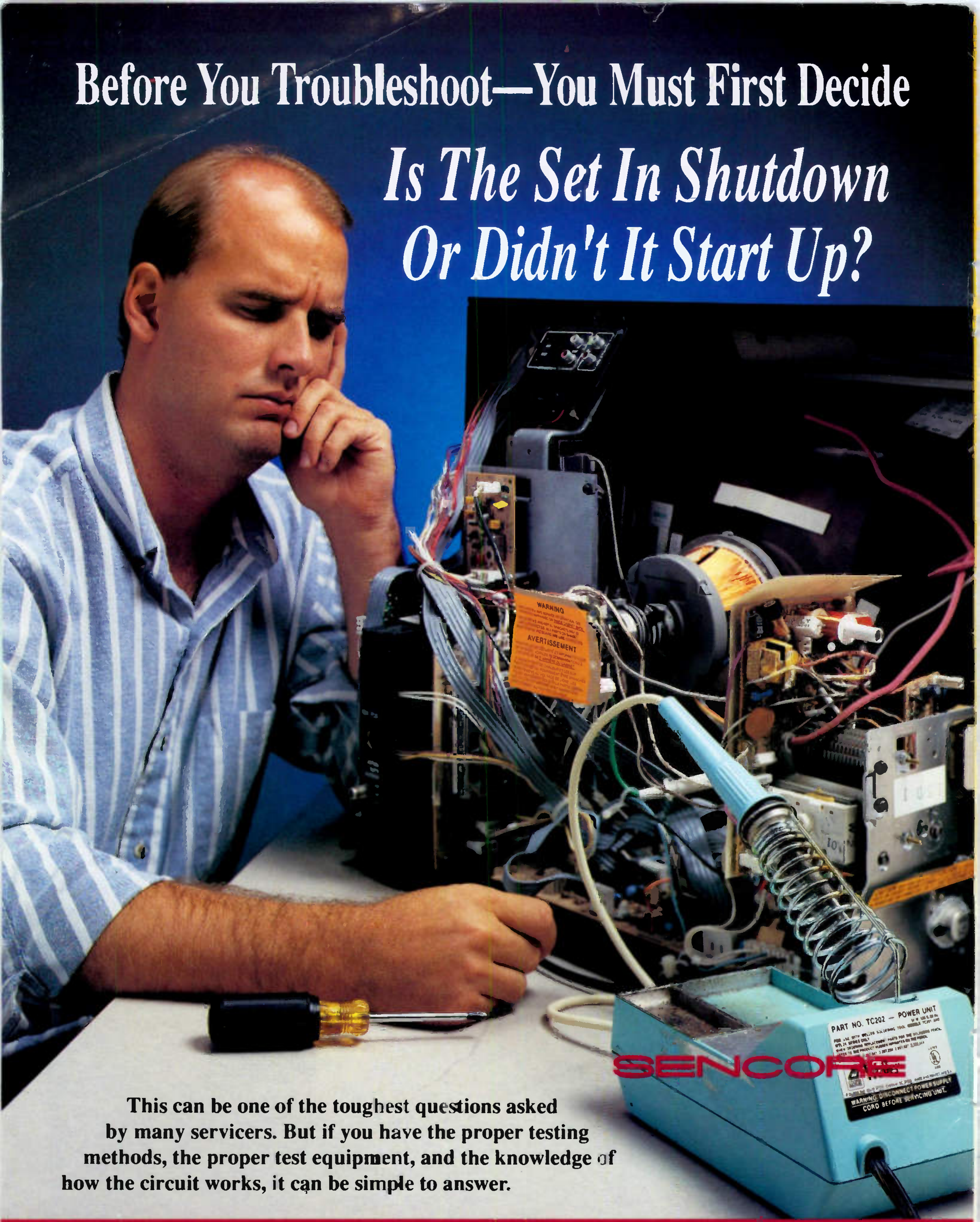
Service center management software

VCR theory, troubleshooting and adjustment

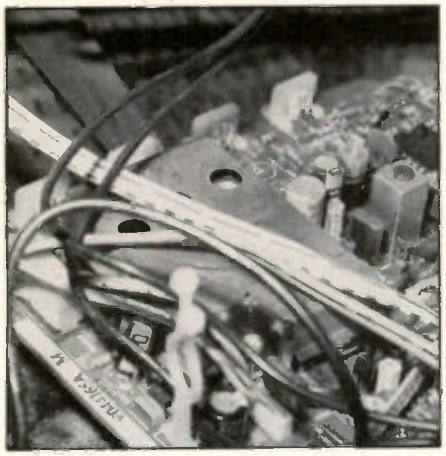
Servicing IF and video circuits



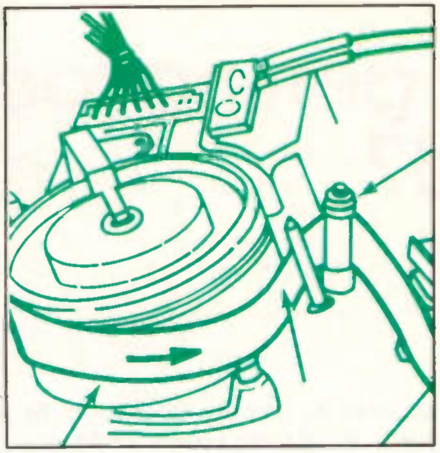
WARNING
AVERTISSEMENT
PART NO. TC202 — POWER UNIT
SENCORE
WARNING: DISCONNECT POWER SUPPLY CORD BEFORE SERVICING UNIT.

Contents

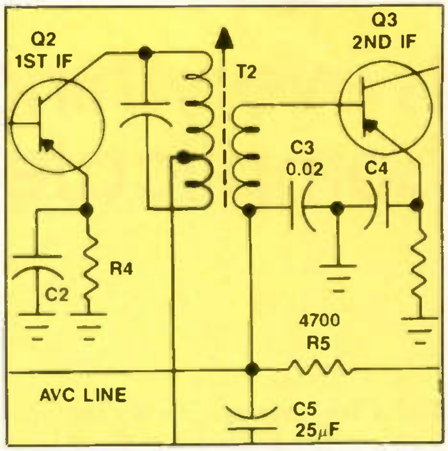
Volume 11, No. 2 February 1991



page 8



page 13



page 22

FEATURES

DEPARTMENTS

ON THE COVER

Servicing of any consumer-electronic product; television, personal computer of VCR, requires that the technician have at his disposal knowledge of how the product operates, product-specific servicing data and information and the proper tools, test equipment and accessories.*(Photo courtesy ITT Pomona).*

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Is everything getting too complicated?

Just a few days ago I was chatting with a service center owner about his business. It's a highly successful service-only company. He's just had the number of telephone lines coming into his facility increased to six in order to handle the increase in volume of calls coming in from customers. In spite of all these lines, he still receives complaints from customers that they received a busy signal when they called.

This increase in the number of calls has occurred in just the past few years. Interestingly, and distressingly, there has been no increase in business corresponding to the increase in the volume of calls.

When this organization performed a little analysis to try to get some idea of the reason for this phenomenon, their conclusion was that many of the phone calls they get are simply because a customer has bought a product that's extremely complex and they need help in operating the sophisticated VCR, camcorder or projection television set that they have just bought.

As an example, this service manager mentioned that some of the projection televisions feature multiple page menus that the purchaser has to step through, just in order to set the unit up. Still more menus await the user when he operates the product.

Unfortunately, the typical consumer lacks either the patience, the sophistication, or both, to go through all the required steps to place the product into proper operation. Even if someone who has bought one of these products is quite sophisticated in the world of high technology, and is able and has the patience to go through the set-up procedure, some of the terms he will encounter in the menu are almost certain to be unfamiliar. When those terms are encountered, the consumer will become frustrated and get on the phone to the nearest service center listed in the paperwork that came with the set.

Part of the problem is simply that the technology has progressed so fast that the perceptions of the user of the products have not had time to catch up with the new realities. For example, most of us, even those who followed the computer revolution closely, are used to having one button or knob perform one function. In today's products with microprocessor control and its attendent menuing, a button may activate one of any of a number of functions depending upon which page of the menu, or line of any page, happens to be active at the time. This can be confusing until the operator has operated the product often enough to become familiar with the procedure. Unfortunately, if the operator doesn't have patience, that may be never.

But the problem of high-tech becoming too difficult does not stop with the consumer. I just read a copy of a bulletin from one large manufacturer of consumer video equipment that states that some of their ultraminiature video equipment is so complex, and requires such highly sophisticated test equipment to adjust and align the product that there are only three service centers in the entire country that are at present qualified and authorized to perform these procedures.

There may be no way to simplify the servicing/adjustment, but it does seem as though there has got to be some way to simplify the customer interface. For example, when the automobile first came on the market, operation required something of an expert. To start the car, it was necessary to manually set the choke, pull out the manual throttle, adjust the spark gap, and turn the crank. Gradually refinements in automotive technology made all of those functions automatic.

The same kind of progression from complex operation to simple took place in radio. Early radios were tuned-RF and required the adjustment of several knobs just to tune in a station. The several batteries that were required to supply power to some early radios gave way to ac powered radios. The radio went from being a complex device that was to be operated only by the head of the house, to a fun product that could be operated by anyone.

More recently there has been some progress in making today's complex consumer electronics products easier to use. For example, programming of a VCR to record a television program at a later time has been simplified in some cases through the use of bar code technology. No doubt further simplifications are in the works.

When technology in consumer products becomes so complicated that almost none of the intended users can understand how to use it, and very few of the people who will be called upon to service it are qualified to perform the service, it's time to take another look at where we're going.

Nils Conrad Persson

Catalog of wireless cable products

A new catalog "Wireless/90" describes microwave filters and accessories for MMDS/ITFS/MDS reception. The book begins with a section on how the wireless cable indsutry evolved, equipment used and the nature of this video delivery system. Details on video aural-combiners, channel combiners, channel group combiners, preselectors and interference filters are contained with test curves and dimension drawings. Appendices also list domestic and international frequencies, other manufacturers and service providers to the industry and a listing of articles printed about wireless cable in the trade press.

Circle (11) on Reply Card

Catalog of electronic, electro-mechanical and computer components

A 1991 catalog of electronic, electro-mechanical and computer related parts and components is available from American Design Components. Geared to meet the needs of hobbyists, computer buffs, small manufacturers, medium and large OEMs, universities, and R&D facilities , this 48 page, fully illustrated catalog is chock full of components and peripherals. Featured are integrated circuits, switches and connectors, power supplies, rechargeable batteries, fans, blowers, and more. Easy indexed for shopping, the catalog also features a large assortment of computer products such as monitors, disk drives, add-on boards, mice, modems and computer systems.

Circle (12) on Reply Card

MCM announces free distribution of its new, 204 page catalog

The MCM catalog contains over 16,000 high-demand parts and components. More than 1100 of them introduced to MCM customers for the first time in this latest edition. Among the categories of products offered are: semiconductors, television parts, computer equipment, power centers and regulators, telephone parts and accessories, connectors, tools, batteries, speakers, VCR parts, audio parts and accessories and more.

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New literature on audio components

Cliff Electronics stocks over 250 audio components that are being used in almost every environment and application throughout the world. Send for the Cliff corporate brochure that covers seven reasons to consider Cliff for your next project. Catalogs provide product documentation on jacket sockets, connectors, cabinet hardware and other audio products.

Circle (14) on Reply Card

Catalog of audio components

Cliff Electronics stocks over 250 audio components that are being used in almost evey environment and application throughout the world. Catalogs provide all the product documentation on jacket sockets, connectors, cabinet hardware and other audio products.

Circle (15) on Reply Card

Test equipment catalog

Emco Electronics, a division of Component Specialties, announces the availability of its new 1990 test equipment catalog. This catalog features analog and digital multimeters, ac clamp meters, signal and square wave generators, oscilloscopes and power supplies.

Circle (16) on Reply Card

1991 UL catalog of standards for safety

Get your free copy of Underwriters Laboratories January 1991 catalog of standards for safety and keep up to date on all of UL's proposed, new, and revised standards. Environmental issues have played an integral part in recent revisions and editions. For example, the Standard for Safety for Steel Underground Tanks for Flammable and Combustible Liquids has been revised to reduce the risk of soil contamination; the new Standard for Safety for Waste Oil Burning Air-Heating Appliances covers products that convert waste oil into useful heat. Ten new standards are included in this issue, covering topics from power limited circuit cables. Order your free copy of the January 1991 catalog from: Underwriters Laboratories ATTN: Publications Stock 333 Pfingsten Rd. Northbrook, IL 60062.

Circle (17) on Reply Card ■

THE MAGAZINE FOR CONSUMER ELECTRONICS SERVICING PROFESSIONALS

ELECTRONIC
Servicing & Technology

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

SALES OFFICE
Electronic Servicing & Technology
76 N. Broadway, Hicksville, NY 11801
516-681-2922; Fax, 516-681-2926
Jonathan Kummer, *Advertising Manager*
Emily Kreutz, *Sales Assistant*

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Gary J. Shapiro appointed group vice president of the Electronic's Industries Association's Consumer Electronics Group

Gary J. Shapiro has been appointed group vice president for the Electronic Industries Association's Consumer Electronics Group (EIA/CEG) succeeding Thomas P. Friel, who resigned to pursue new career opportunities and interests.

Shapiro served as EIA's vice president and general counsel. In his new position he will direct a staff of 55 and will have overall responsibility for the Group's activities including: Marketing Services, Engineering, Government Affairs, member services, product services, communications, consumer affairs as well as the industry's premiere trade shows, the summer and winter consumer electronics shows (CES).

In announcing the promotion, EIA President Peter F. McCloskey stated, "Gary's significant experience as well as his impressive knowledge of the consumer electronics industry make him an excellent choice to lead the CEG into the 90's."

Shapiro began his career at EIA in 1982 as the government and legal advisor to the Consumer Electronics Group and Show. In 1983 he was promoted to staff vice president. Two years later he was appointed EIA assistant general counsel and then promoted to vice president in 1988. In November of 1989 Shapiro was appointed EIA's general counsel. *(Source: The Electronic Industries Association Executive Report to the Electronic Industries.)*

TIA supports Burns' compromise to senate cable bill

The Telecommunications Industry Association (TIA) announced its full support of the amendment proposed by Senator Conrad R. Burns (R-MT) to allow independent telephone companies to provide limited video programming to residential subscribers under certain specific conditions.

Allen R. Frischkorn TIA president, stated that, "Unless Congress changes federal policy as called for in the Burns' amendment, Americans will be denied the benefits of advanced telecommunications well into the twenty-first century." The issue is not the availability or the cost of the technology, Frischkorn said, "The issue is whether the market place will be allowed to determine when and how fiber-to-the-home will be deployed rather than government fiat."

A study commissioned by TIA and performed by Hal Selander of Braxton Associates was released, in conjunction with Senator Burns' press announcement. The study reviews and interprets economic assessments of fiber-to-the subscribers. The report concludes that fiber is "stalled on the way to the home" because there is now no incentive under current law for telcos to install broadband switched network to residences.

With current restrictions on video programming, they simply have no revenue flows available to offset the higher first-installed cost of switched broadband fiber systems to the home. Frischkorn said, Why would the telcos invest in more expensive technology when they're unsure about whether they'll ever be able to use it?"

As fas as cost is concerned, the Braxton study reveals that once the deployment of fiber systems to the home begins, the cost of such systems will fall dramatically. This is due to the so called "experience curve" effect, which results in cost reduction with accumulated production volume. "So the cost issue," Frischkorn said, "is not how much it will cost to wire the nation with fiber, but rather how much additional cost is involved in deploying enough systems to reduce the cost to the level of existing technology." Braxton calls this the "strategic investment." After it is made, fiber will be deployed in the normal cost of building and maintaining the network. Frischkorn said, "This strategic investment is surprisingly small." Braxton found that the strategic investment for narrowband fiber-to-the-curb systems that are upgradable to broadband is only $80 per subscriber through 1998 or only $7 billion. This is outstanding compared to the $450 billion figure used by fiber opponents.

The Burns ammendment will "jump start" the deployment of fiber, according to Frischkorn. It will remove the uncertainty facing the independent telcos and give them a financial basis for initating deployment. This will hasten the strategic investment, hasten the process of cost reduction inherent in the experience curve, and accelerate the rate of deployment of fiber to the home. *(Source: The Electronic Industries Association Executive Report to the Electronic Industries.)*

Video equipment sales reach new heights

Sales to dealers of color TVs projection TVs, VCRs and camcorders peaked in September according to new statistics released by the Electronic Industries Association's Consumer Electronics Group (EIA/CEG).

After a five month slowdown, monthly color television sales crossed the two million mark for the first time this year since March. A monthly total of 2,644,994 units sold translated into a .5 percent increase over the last year's record-breaking figures. Sales of projection TVs also soared during the month with more than 52,000 units sold for a 27.6 percent increase over September. "Camcorders were by far the star performers during September with an increase of 40.3 percent over last year's comparable figures," said Gary J. Shapiro, vice president of EIA's Consumer Electronics Group. EIA conducts programs for the collection of data on production, sales, and other industry activity by way of market activity reports, special reports and surveys, research and analysis services and liaison activities with the government and other associations. ■

Base pricing on your cost of doing business

By William J. Lynott

One of the most crucial tasks for an electronics service dealer is setting his service rates. But no matter how carefully and professionally you set your fees, the service job hasn't been completed until the proper charge has been collected from the customer. And that's where many service dealers are losing out.

It's no secret that most people are less than fond of paying for intangibles. Unlike, say, a new coat, a service call cannot be held in the customer's hand, touched, eaten, or worn to church. When the job is done, all your customer has to show for her money is the same product she had before the repair became necessary. Given this fact, and what we know about human nature, it's no surprise that many servicers have lost money at one time or another through their failure to collect the full amount due on some service jobs.

The cause I see most often for this is a failure on the part of management to convince their own technicians that the company's service rates are fair and reasonable. Over the years, I have had many technicians confide in me their feelings that they were being required to charge unreasonable rates for their work. Some even said they often felt "guilty" when they presented the bill for their work.

Inevitably, if things reach this point, some technicians will compensate by "hedging" on the quoted service rates. That is, alter the description of the work done on the work order, thus enabling them to charge the customer less than the full amount due.

That solves two problems quite nicely, for the technician. It tempers his guilt feelings, and lessens the chance that he'll have to defend his charge to an irate customer. After all, he reasons, the company doesn't need the money as badly as the customer does. Or does it?

Let's say that your operating statement tells you that your service business is bringing in a respectable 10% net profit. Now take the case where one of your techs is about to tote up the bill for a towering customer with a decidedly unfriendly manner. The proper change comes to $68 but our friendly technician takes one look at that threatening hulk and decides that $68 is too much after all. A few scribblings on his work order and, voila, the total now comes out to an easier-to-swallow $55.

The technician is happy. The customer has gotten a bargain. And you don't even know that you've been had. Your potential profit of $6.80 (10% of $68) has disappeared and you've actually lost money on the job.

It doesn't take much imagination to figure out the eventual result if that scenario were played out often enough.

And so, adopting a professional and accurate method for setting your service rates is only half the job. If

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

your employees don't have confidence in the integrity of your rate structure, or if you haven't trained them well in the need for charging the proper amounts, the chances are high that your company is not collecting money it has honestly earned.

Unfortunately, many service dealers have difficulty bringing themselves to believe that such a thing could happen in their "little families." From my experience, that attitude is a sure guarantee that it is happening, or eventually will be.

Here are some things you can do to minimize the likelihood of this nasty profit leak in your organization. None are difficult and all are consistent with sound business management principles.

Most important, your pricing structure must be based on your costs of doing business, and fairly calculated. A sloppy attitude in setting your service rates cannot be hidden from your technicians. And it guarantees that they will look with disdain on the rate structure you are asking them to implement.

Once your prices are properly set, sit down with your technicians and brief them on the hows and whys of setting service rates. You don't need to bore them with a lot of statistical analyses (nor divulge any confidential company data). Simply acquaint them with the many hidden costs involved in running your business. Unfortunately, technicians (and often customers) have a tendency to conclude that hourly charges should be set at the technicians wage rate, "plus a little for profit."

In reality, an hourly charge of from two and one-half to as much as four times average technicians' wage rates are needed to generate a satisfactory profit in most types of service operations. Too often, technicians simply don't know this.

Once your technicians are knowledgeable about the costs of service, they will be in a position to deal with customers with more confidence. In turn, you will be in a better position to ask for their help in collecting the full amount due for every service job. Years ago, one service dealer I knew had excellent results in this area by appealing to the pride of his technicians. "You are professionals," he frequently reminded them. "You want to be treated and paid as professionals. Don't demean your profession by indicating that your work isn't worth the going rate.

And sound service management calls for screening completed work orders. Comparing time spent on the job with descriptions on the work order will often alert the trained eye to discrepencies that could mean lost service income.

Because human nature tends to work against us in the matter of collecting properly for completed service, bulldog tenacity is your best insurance against this unkind assault on your bottom line. ■

Servicing IF and video circuits

By Homer Davidson

In the first solid-state TV chassis, the IF and video circuits were made up of transistors. Today, the IF and video circuits include integrated circuits. The IF signal starts at the output of the VHF-UHF tuner assembly (Figure 1).

To determine if the tuner or IF circuits are defective, a tuner substitute may be used in place of the suspected tuner. Connect the output cable of the tuner subber to the IF input and tune in a station (Figure 2). If the subber tunes in the various TV bands, it's a good indication that the IF and video circuits are operating and the tuner is bad. Check the IF and video circuits if no stations can be tuned in. Remember, the IF and video circuits can be signal traced like the audio circuits.

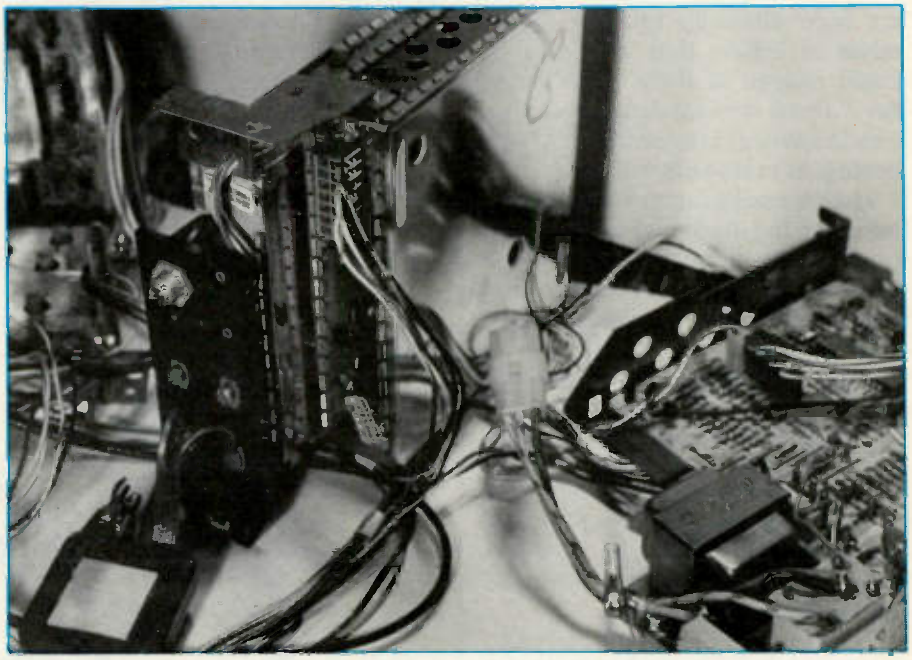


Figure 1. Remove the IF cable from the tuner module or varactor tuner to determine if the tuner or IF-video stages are defective.

Signal tracing with the broadcast signal

You can trace a signal through the IF and video circuits using either the standard broadcast signal, or a signal dot-bar generator as the source. Connect a demodulator probe to the scope input and probe from one end of the circuits to the other, using the scope as indicator. Some technicians use the broadcast signal because it requires only connecting the TV set to the TV antenna or cable.

Start signal tracing with the scope probe at the collector of the first IF transistor. Most scopes do not have enough sensitivity to check the IF signal at the IF input cable. Notice that the signal is very weak at the first IF stage. Now check the IF signal through the preamp and to the video input IC terminals (Figure 3). When the signal appears at the input of a stage, but is absent at the output,

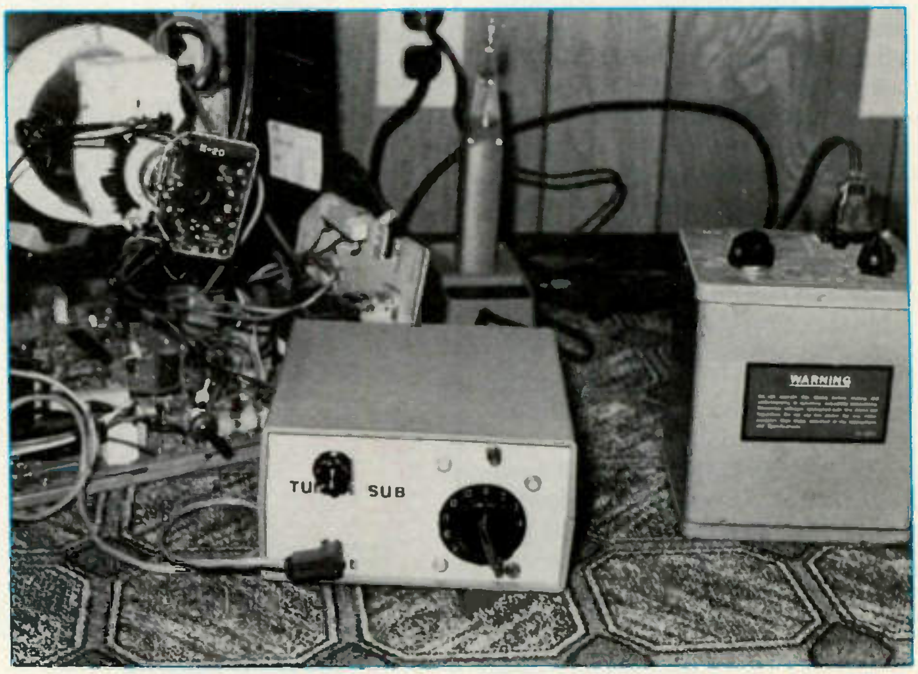


Figure 2. Connect the tuner subber to the IF cable or clip it across the IF circuit. Try to tune a live channel to determine if the tuner is defective.

Davidson is a TV servicing consultant for ES&T.

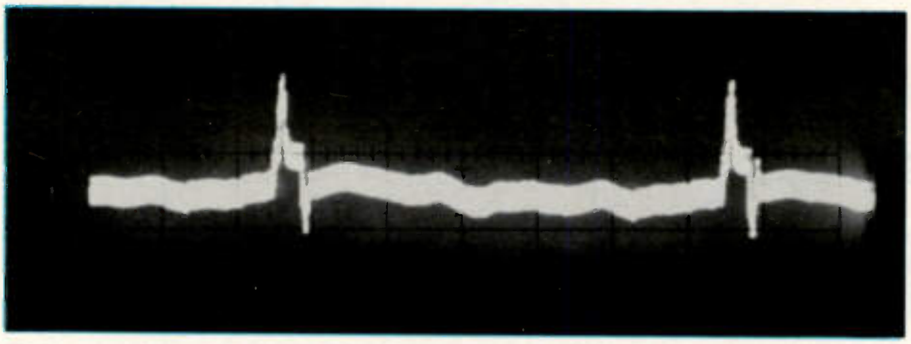


Figure 3. Here is a broadcast IF signal waveform taken at the collector terminal of the IF input amp, before it reaches the SAW filter.

check the components in that stage for defects.

Signal tracing with dot-bar generator

To signal trace with a dot-bar generator, connect the dot-bar generator to the antenna terminals in place of the antenna or cable signal. The dot-bar generator provides a more stable IF signal for checking the gain of each IF stage. The dot-bar generator waveforms are found throughout the TV schematic in the Sams Photofacts.

Check for a loss of signal after each IF or IC stage to determine if the IF and video circuits are defective. If the problem is in the IF or video circuits, a snowy or white picture without normal sound is likely to be the symptom. If you have a snowy or white picture but normal audio is heard, suspect the video and picture tube circuits.

No sound - snowy - white raster

I was working on a Goldstar CMT-2132 in which neither picture nor sound could be tuned in. I connected a tuner subber but noted no change in the symptoms. Using the broadcast signal, I signal traced the IF stages with the scope. Very little signal was found on the base of Q101, and no signal was found at the collector terminal.

DC voltage measurements at the terminals of Q101 were quite high. In fact, the collector voltage had increased above the supply voltage source (12.7V). A reading of 0V at the emitter terminal indicated that Q101 was open (Figure 4). Checking Q101 in the circuit verified that the transistor was open.

It's best to replace IF and video transistors with exact replacements when possible. Because I didn't have a KTC388A transistor in stock, I substituted a SK3132. Always try to replace IF transistors with one that has the same length of leads and replace in the same position.

Testing SAW filter network

Although the SAW (Surface Acoustic Wave) filter assembly very seldom causes problems, sometimes a transducer will become cracked if the TV set is roughly handled. This device can be tested with resistance measurement and a crystal checker. The SAW filter, which eliminates the IF interstage tuned circuits in the sets in which it's used, is located in a round metal container. The SAW fil-

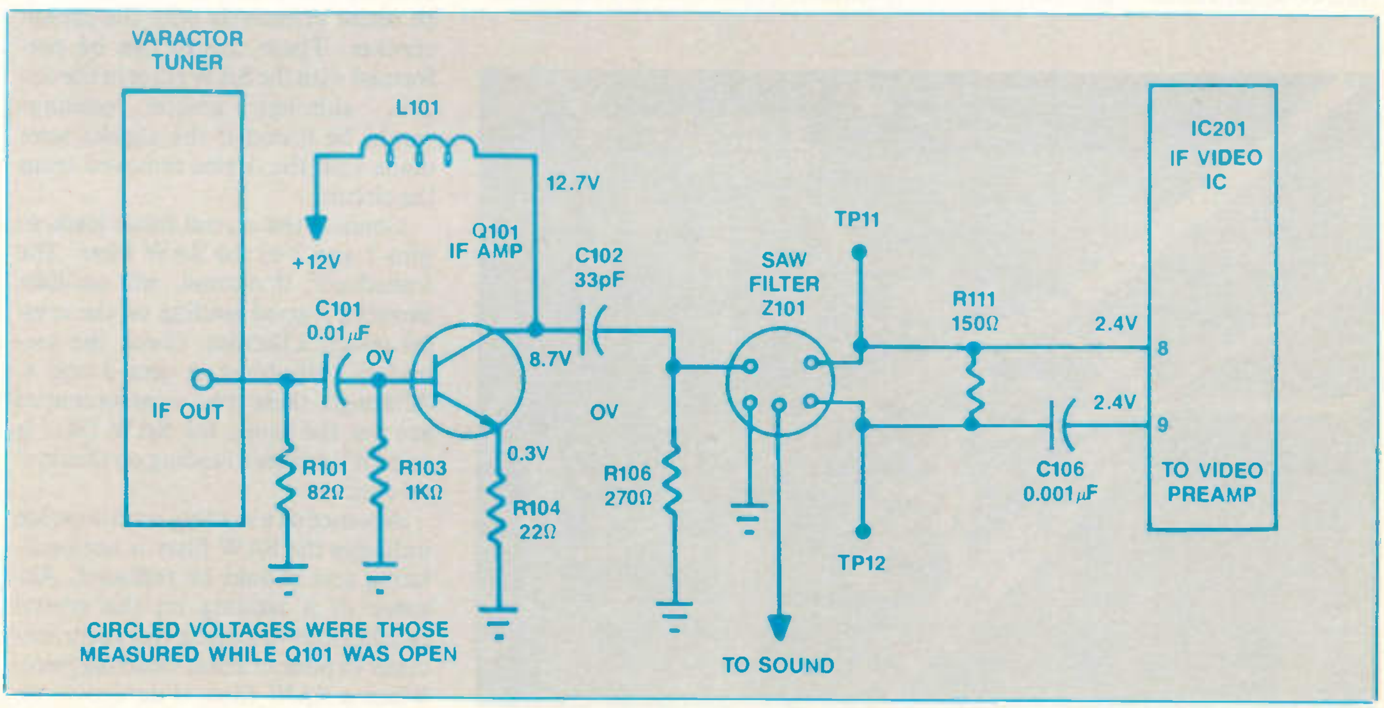


Figure 4. In a Goldstar CMT-2132 TV set there was no waveform at the collector terminal of Q101 when measured with the demodulator probe and scope. Further examination revealed that Q101 was open.

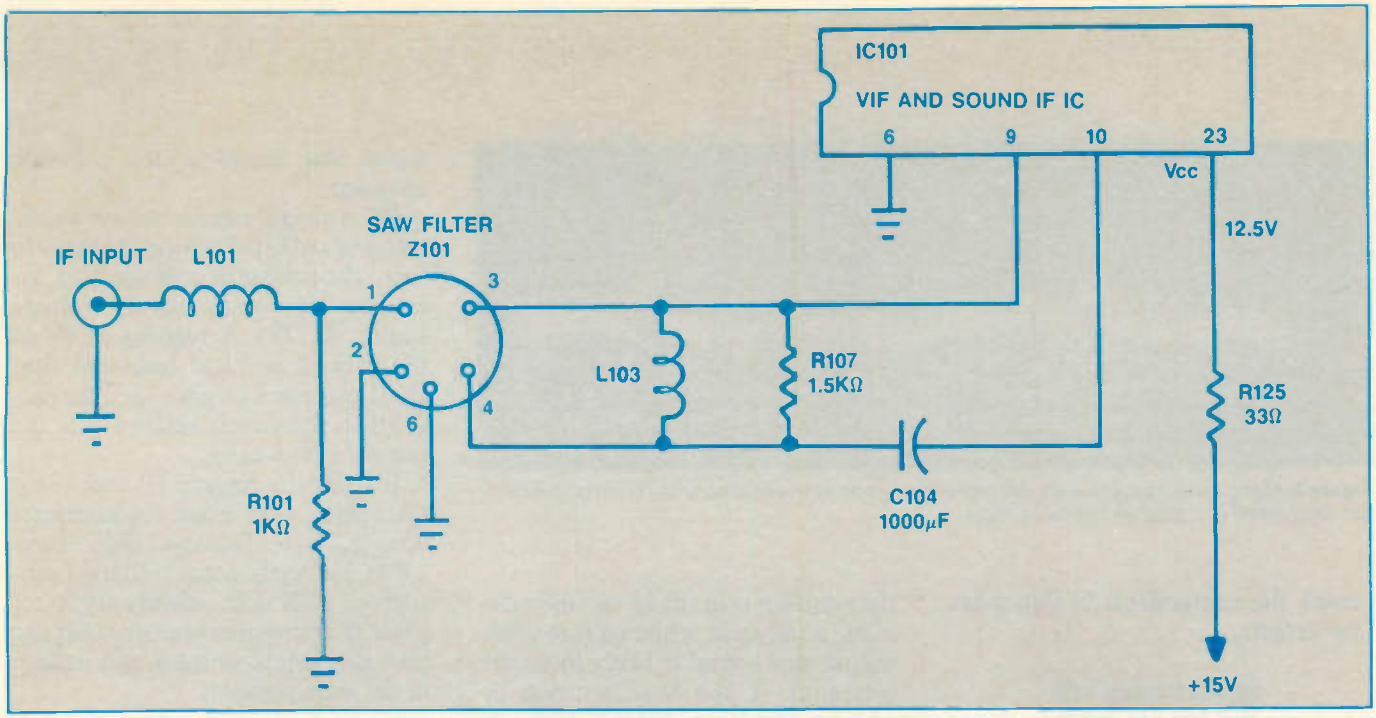


Figure 5. The SAW filter may be located between IF amp and VIF IC which has an internal preamp IF stage. A SAW filter which is suspected of being defective may be checked with the crystal checker.

ter generates the proper IF responses without interstage transformers.

The SAW filter is made up of piezoelectric material onto which are plated two pairs of transducer electrodes, one as input transducer and the other as output transducer. The IF frequency response is determined at the time of manufacture and cannot be adjusted, as there are no outside adjustments as on the early IF transformers. The SAW filter may be located at the IF input or after the IF transistor preamp stage (Figure 5).

Terminals 1, 2, 3 and 4 can be checked with ohmmeter continuity measurements. If the SAW filter is good, you should measure infinite resistance between any two numbered terminals, or between any numbered terminal and common ground, with the exception of pin 1 which will measure 1KΩ through R101 to ground. Remove the device from the circuit for more accurate readings.

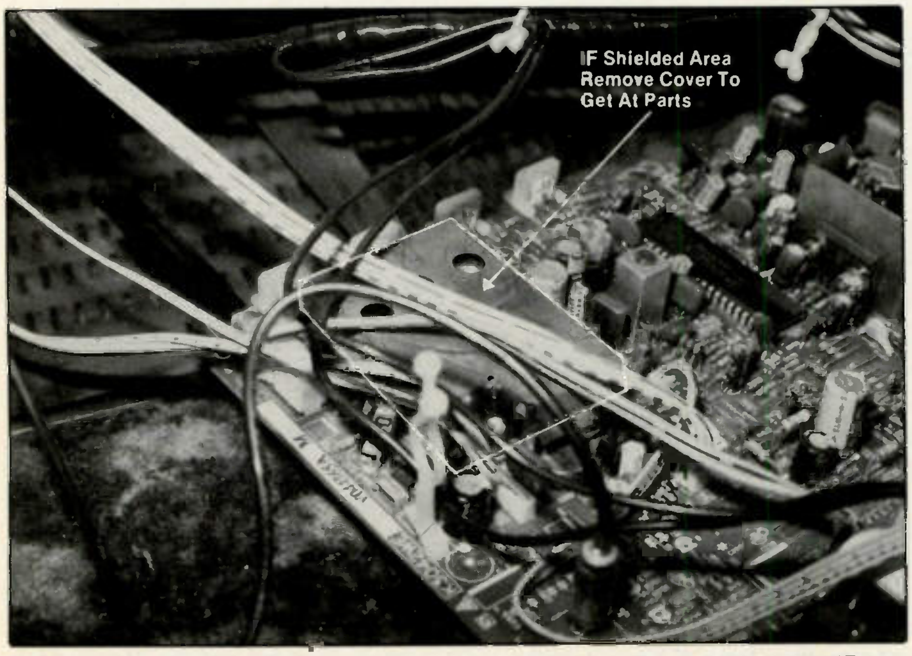


Figure 6. Often, the IF circuits are found under a shielded cover in the TV set. The IF transistor and IC components may be separate, or all in one large IC processor.

Of course resistance measurements do not indicate if the device is oscillating. Because the SAW filter is made up of piezoelectric material, each input and output transducer can be tested effectively with the crystal checker. These checks can be performed with the SAW filter in the circuit, although greater readings would be found if the checks were made with the device removed from the circuit.

Connect the crystal tester leads to pins 1 and 2 of the SAW filter. The transducer, if normal, will oscillate showing a good reading on the crystal tester. Likewise, check the secondary transducer at pins 3 and 4. Although these two measurements are not the same, the SAW filter is good if it causes a reading on the crystal checker.

Absence of a reading on either side indicates the SAW filter is not oscillating and should be replaced. Absence of a reading on the crystal checker may indicate a cracked transducer or poor internal soldering joint. When a SAW filter is defective, always replace with the exact part number.

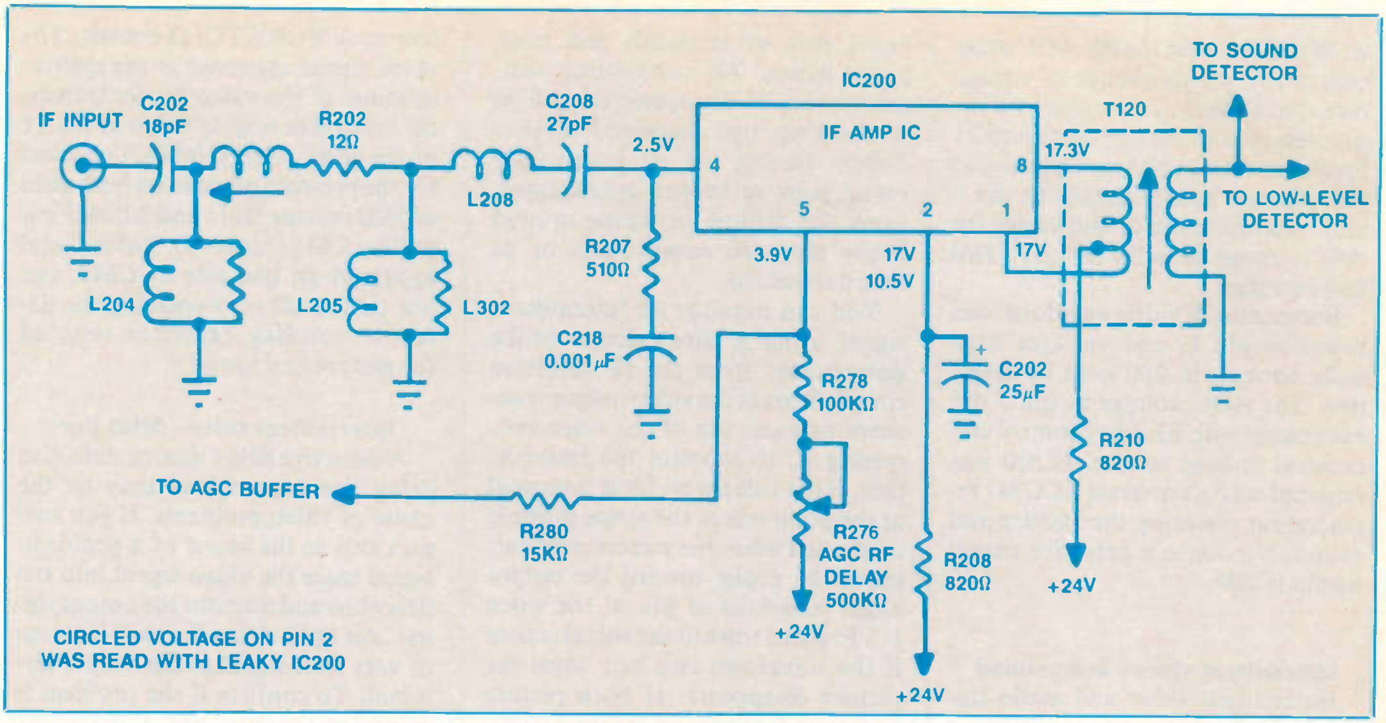


Figure 7. Scope the IF IC stages with the demodulator probe and scope. Determine if signal is going in pin 4 and coming out at pin 8 of IC200.

AGC or IF amp

Problems in the IF section may be the result of insufficient IF AGC voltage causing shut-off of the IF preamp transistor. Measure the IF AGC voltage at the base of IF transistors and RF AGC at the tuner. Rotate the RF AGC control and delay AGC and notice if the voltage changes. Suspect a defective AGC circuit when this voltage does not vary (Figure 6).

When the IF amp, video detection and AGC circuits are found in one IC component, the IF AGC is developed internally. This IF AGC internal voltage controls the gain of the IF stages and is used as comparison against the setting of the AGC delay control to develop the RF AGC voltage.

If AGC voltage is not present, try connecting an external voltage from the bench power supply. Adjust the external voltage until the picture returns. Both the AGC IF and tuner voltage are positive in the solid-state chassis. In the case when RF and IF AGC voltage can be varied normally but there is still no picture, suspect the IF transistors or the IF processing IC.

Troubleshooting the suspected IF processor

In a modern TV set, the IF stages may be included with several other circuits within one large IC or they may be fabricated as a separate IC component. In one Philco E25-7 chassis I was working on, there was no sound or picture, but there was a clear raster. I connected the oscilloscope to input terminal 4 and output terminal 8, but no video signal appeared on the scope face. A tuner subber connected to the IF cable had no effect. Adequate IF video output signal should be present at terminal 8 of IC 200 (Figure 7).

Supply voltage terminal 2, which should have measured 17V, actually measured 10.5V. The voltages at all other pins of the IC were quite close to the values printed on the schemat-

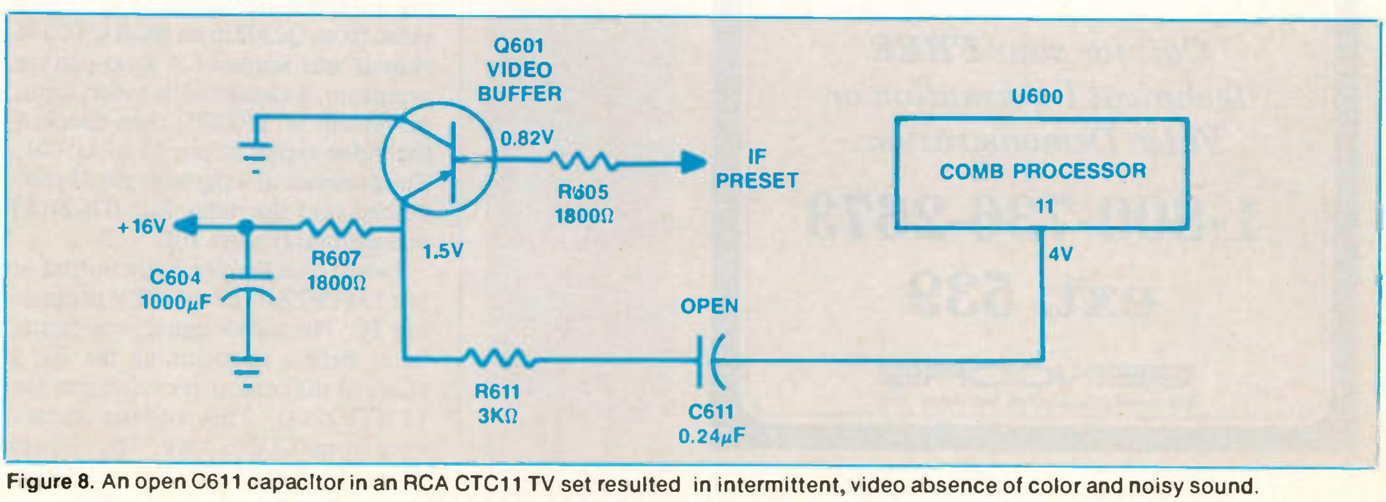


Figure 8. An open C611 capacitor in an RCA CTC11 TV set resulted in intermittent, video absence of color and noisy sound.

ic. When I rotated the RF AGC delay control, very little change of voltage occurred at pin 5. To determine if the problem was in the IC, or caused by improper AGC voltage, I connected the external bench supply to pin 5 and common ground, and varied the AGC voltage from 0V to 7.5V. This had no effect.

Because no IF video waveform was found at pin 8, and voltages were quite normal, IC 200 must be defective. The AGC voltage at pin 5 did not change with RF delay control and external voltage source. IC200 was replaced with a universal ECG747 replacement restoring the picture and sound. No doubt a defective circuit within IC200.

Intermittent video - noisy sound

Intermittent video and audio signals may occur just about any place within the IF - video circuits. Most intermittent video problems are caused by transistors, IC's, poor soldered pins or terminals and poor board wiring. An intermittent component may be discovered by cooling or heating the suspected device. Gently flexing the pc board may reveal poor or broken connections. Look for broken pc wiring around heavy mounted components or pc board standoffs.

You can monitor an intermittent signal using a direct scope probe downstream from the IF detection circuit. Start at the video output transistor or input pin of the video processing IC to monitor the intermittent. If the video waveform is normal at the point where the scope probe is connected when the picture cuts out, move the probe toward the output video transistor or pin of the video IC. Proceed toward the signal source if the waveform cuts out when the picture disappears. If both picture and sound disappear, suspect a defective component ahead of the IF detector circuits. No color - no picture and lots of noise was the symptom in an RCA CTC111 chassis. The video signal appeared at the emitter terminal of the video buffer transistor, but there was no video at pin 11 of the comb filter (U600). I checked for the presence of video on both sides of 3KΩ resistor R611 and 0.024μF capacitor C611 (Figure 8). Video signal appeared on one side of C611, but not on the other. Replacing the defective coupling capacitor restored the picture and sound.

Intermittent video - delay line

A defective delay line, or defective delay line connections may be the cause of video problems. If you suspect this as the cause of a problem, signal trace the video signal into the delay line and monitor the output signal. An open delay line will have no or very little signal at the output terminal. To confirm if the problem is caused by the delay line, short across the delay line. If the picture returns, even if it's distorted or displays some lines, this indicates that the delay line is defective. In a Panasonic GXLHM chassis, the signal was normal up to the delay line, but video was intermittent when monitored at the output terminal (Figure 9). A poor connection was suspected at one of the board terminals.

I resoldered all connections on the pc board, and again monitored the video. The problem remained. Replacing the delay line restored the intermittent picture to normal.

Troubleshooting the video IC processor

In a TV set that has a video processor IC, scoping the signal at the video input terminal and the luma output terminal will determine if the video IC is the culprit that's preventing a normal picture. The incoming video from Q2302 in an RCA CTC156 chassis was scoped for a no-picture symptom. I checked the video input waveform at TP2307, then checked the video signal at pin 53 of U1001. The presence of a signal at pin 53 confirmed that the delay line (DL2701) was normal (Figure 10).

Next I checked the luma output at pin 13 (TP2705) of the CTV processing IC. No video signal was found here. Before condemning the IC, I checked the brightness voltage at pin 15 (TP2713). This voltage should vary from 0.7V to 1.8V. The voltage at pin 14 should vary from 1.6V to

(Continued on page 56)

VCR theory, troubleshooting and adjustment

By Frank Thomas

Many questions arise when repairing or troubleshooting a VCR, for example:

1. What tools will I need?
2. Where do I buy parts?
3. Are there any specialized tools I'm going to use?
4. What items should I work on and which should I leave alone?

It is the purpose of this article to answer these questions, as well as others concerning VCR servicing. Two essential pieces of equipment for servicing the electrical/electronic portions of a VCR are:

- An isolation transformer
- A good oscilloscope with sync separator so that you can sync on the video signal

When a VCR is brought in for service it will almost certainly require cleaning and lubrication. In fact, in some cases cleaning and lubrication may be all that is required.

Figure 1 is a list of cleaning materials and other chemicals required for VCR servicing. These are the items you'll require in order to do a professional job of cleaning and lubricating a VCR.

Other items that you might want to consider in this category are: a small dusting brush, a small hand held vacuum cleaner and a clean rag.

Items needed

1. TF Freon
2. Chamois swabs
3. Rubber revitalizer
4. Vacuum cleaner
5. Clean rags
6. Chamois or foam tipped swabs
7. Molybdenum grease
8. C-ring pliers
9. ISO screwdriver(s)

Figure 1. These items are necessary in order to properly clean and lubricate a VCR.

Tools

The next category is tools. Without these specialized hand tools, trying to do either a repair or alignment job is very difficult. Figure 2 illustrates some of the tools that you should have. Note that these tools are very generic in nature because I work on a lot of different brands of VCRs.

Thomas is a Media Service Electronics Technician at Muskegon Community College in Muskegon, MI.

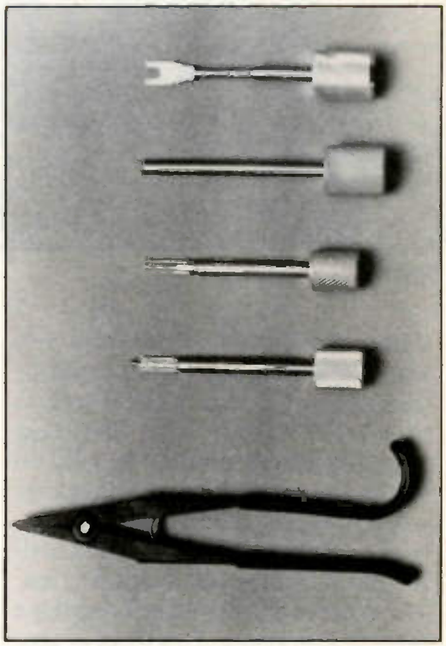


Figure 2. Adjustment of a VCR requires a number of special tools and accessories such as those shown here. See text for a description of each item.

You can purchase them from a manufacturer, a distributor, or one of the many reputable mail-order companies. Let me describe these tools in order from top to bottom. The first one is an A/C head positioning tool which is used on the tapered nut located near the A/C head. You will use this tool when performing the horizontal phase adjustment.

The second item is used for tape guide post adjustment. I call this tool a "castle type" tool. The next two tools are used for performing the back-tension adjustment. Note that they differ in the spacing of the teeth: one is fine while the other one is more coarse. You will need both of them.

The last tool is known as a retaining ring remover. These are used on those retaining rings that will not come off by any other means. They are located on the reel turntables, etc.

I also recommend using a set of ISO (International Standards Organization) Phillips (positive) type screwdrivers. The ISO screwdriver type is nothing more than a metric screw driver. Using these screwdrivers will keep you from chewing up the slots in screws as you would if you used non-metric screwdrivers. Please also note that the Japanese call a Phillips screwdriver a "positive" screwdriver, and the flat-blade type a negative screwdriver.

To recognize a metric screw from others, look for a dimple located at one of the cross points on the top of the screw. To find the correct bit for one of these screws, just remember that the correct bit will hold the screw without support when positioned on the end of the driver tip. In order to properly use them, keep in mind: 80% push and 20% torque, and you should not have trouble removing them.

Other useful items are the following: Small non-metallic dental mirror, a small high-intensity flashlight, and an X-acto knife.

Specialized tools

You will also need some special-

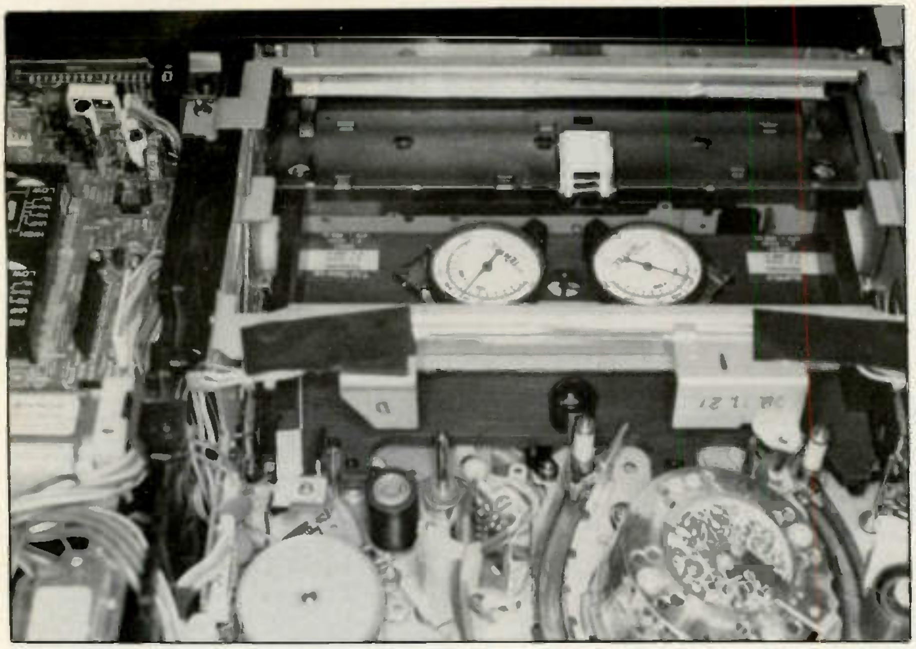


Figure B.

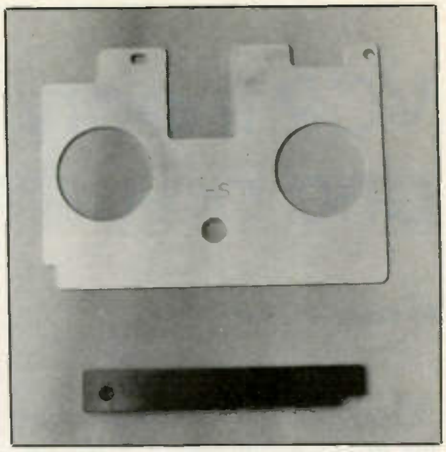


Figure A.

Figure 3. Another adjustment accessory that you will need for VCR adjustment are a master plane jig and reel table height gauge (Figure 3 A). An alternative you might prefer is a spindle height gauge that has six functions in one unit (Figure 3B. Photo courtesy of *Tentel*).

ized tools. Without these tools you won't be able to complete a repair or troubleshoot the mechanical section of a VCR. Keep in mind that these items are generic and can be used on any brand of VCR. A torque gauge will check the condition of belts, brakes and torque very fast and easily, plus it is universal in application. The other tool that will be needed is a tape tension gauge. This piece of gear is also universal and will work on all models of VCR.

You will also need a master plane jig and reel table height gauge (Figure 3A), you could either buy one from the VCR manufacturer/suppliers, or you might prefer a spindle height gauge that has six functions in one unit (Figure 3B).

Disassembling the VCR

Putting the VCR back together after it's been serviced will go more smoothly if you follow certain rules when you're disassembling it. First and most important remember this; *be observant*. Be observant when noticing symptoms, when looking visually inside of the VCR. When you remove a screw, note its length, type and thread type. All this information will be useful when reassembling your unit.

Please be observant of all screw locations. You might even want to draw a diagram of where they came from. The other method of not losing where screws came from is to replace the screws back where they came from after you have gained access to the area you need to get into. Whatever you do, don't leave anything to memory: make notes, drawings or whatever it takes in order not to have any leftover parts when the job is completed.

Second, you should be aware that most VCR screws that have to be removed for disassembly are dyed red in color, or sometimes blue. The color may be vivid or faint, so it's important to look carefully. On PC boards, the disassembly screws may have white arrows pointing to them or have a white circle around them. You may also have to look on the bottom of the unit for arrows that point to screws that need to be removed in order to remove the top cover of the unit.

Also, be observant for screws that are hidden from view that may hinder the removal of a pc board. If you encounter a section of a pc board that doesn't easily come loose after all logical screws have been removed, either look for a hidden screw or reread the disassembly procedures in the service manual. Remember be observant, and don't force anything when disassembling a unit.

Some don'ts and warnings

Please, please leave the V-stops alone. You may look at them, but you're inviting trouble if you try to adjust them. If a unit's V-stops are loose or even have come off, send the unit to the local factory service center for repair. The reason for this caution is simple: the V-stops are set at the factory and ordinarily *never* need to be fiddled with or adjusted. If they do need attention, it takes an expensive test jig to adjust them.

Another potential problem area is the turntable reels. Under those reels are tiny washers that can easily get lost and lodge in some of the moving parts of the VCR.

Here is an example of what not to do. A VCR comes in for service and for some reason or other the reel tables have to come off. So the technician removes either the retaining ring or the plastic retaining washer, removes the reel table, places it next to the unit on the work bench and performs whatever needs to be done. With the job completed he replaces the reels and reassembles the unit. When the technician tries to play a prerecorded tape, there are noise bars going from left to right, looking like a thin line on the receiver.

These bars may be located either at the top or the bottom of the picture. This is a symptom that the tape path needs to be aligned, so the tech performs this adjustment on the unit. The playback mode is rechecked and it looks fine, then the record mode is checked and it too looks fine, but when the technician tries the tape that was recorded on the newly serviced machine in another machine, the noise bars return.

This is what has occurred. When the technician removed the reel tables he/she failed to be observant. The reel height washers under the reel tables stuck to the bottom of the reel table as they often do and went unnoticed. The washers came off the reels in the action of placing the reel tables on the workbench. When the tech replaced the reels, they were installed without the height washer, which caused uneven reel table height and consequently tape path misalignment symptoms. The moral of this story is be observant of the reel height washers and perform the reel table height adjustment/confirmation in the service manual under master plane confirmation adjustments.

The tape path

Take a look at Figure 4. This is an illustration of a generalized VCR tape path with a narrative that locates and defines the function of each component. Please note; the tape is loaded around the video drum and is viewed from the top.

Visually inspecting the tape path

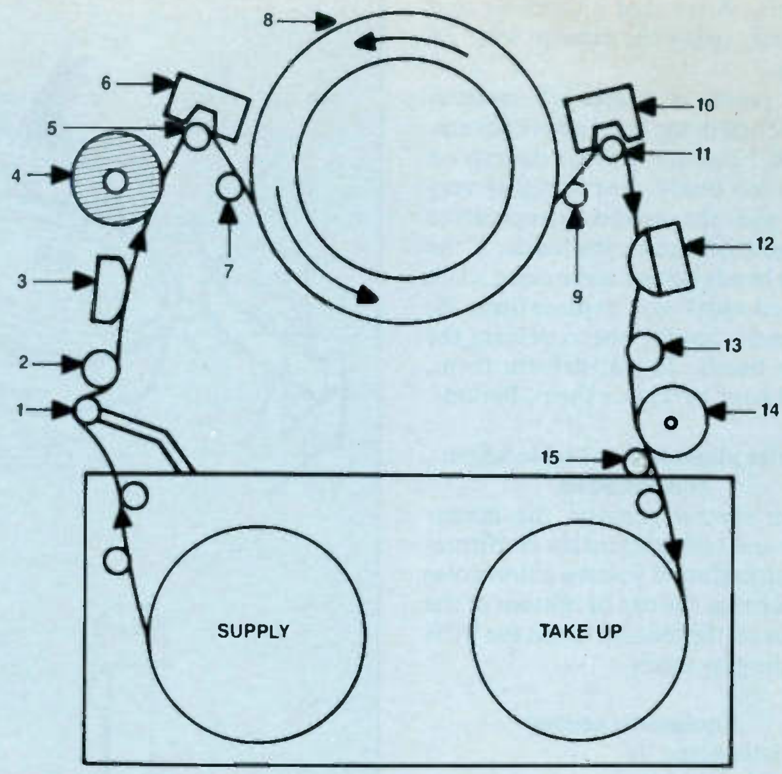
Now that we have a grasp of what's going on in the tape path and its components, lets go into the visual inspection concerning the tape path and its components. Look at Figure 5.

The tools you will need for this inspection are: a non-metallic dental mirror, a small high-intensity flashlight and a VCR cassette (not a test tape).

Cleaning the video heads

The next important item of concern is video head cleaning. See Figure 6 for a general procedure to follow. You should refer to the service literature for specific procedures for whatever VCR you're working on.

You will undoubtedly encounter VCRs with extremely dirty capstans; so soiled that you will rub and rub with the chamois pad and still the capstan will not be clean. In such situations, I apply a little rubber revitalizer with a cotton tipped swab, then wait a bit and swab the now-loosened



1. Supply Tension Post
   a. Provides braking action to supply reel
   b. Regulates tape tension
2. Supply Guide Post (P1)
   a. Provides proper height of tape entering tape path
3. Full Erase Head
   a. Erases information on tape during record mode
4. Impedance Roller (Note: this item and item 3 may be reversed
   a. Reduces tape vibration
5. Entry Guide Roller (P2)
   a. Sets tape height as it enters the video drum
6. V-Stop: Do not touch this item
7. Entry Slant Post
   a. Positions tape around the video drum
8. Head Drum, Cylinder, Upper Cylinder
   a. Contains the video heads
9. Take-up slant post
   a. Sets position of tape leaving the video drum
10. V-Stop: Do not touch this item
11. Exit Guide Roller (P3)
    a. Sets tape height leaving video drum
12. A/C Head
    a. Audio record/playback head
    b. Audio erase head
    c. Record/playback control track head
13. Take-up Guide Post (P4)
    a. Provides height requirements for take-up reel
14. Pinch Roller
    a. Along with capstan shaft, moves tape through tape path
15. Capstan Shaft
    a. Along with the pressure roller, moves tape through tape path

Note: On some models there is a Take-up Tension Arm that is located on the supply side of the VCR. Its function is to determine the amount of braking being applied to the take-up reel via the arm's position.

Figure 4. This is an illustration of a generalized VCR tape path with a narrative that locates and defines the function of each component. Please note; the tape is loaded around the video drum and is viewed from the top.

dirt off. After that I carefully and sparingly spray the capstan with TF Freon.

To repeat a couple of cautions mentioned in the steps above for emphasis. *Never* spray Freon directly on the video heads. The spray is very cold and the sudden temperature change might crack the heads. If the brake bands do not come clean when sprayed with Freon, replace them. Be extremely careful not to deform the brake bands. If you deform them, you'll have to replace them. Period.

Master plane and reel table height confirmation

You should perform the master plane and reel table height confirmation procedure if you see a thin noise bar either at the top or bottom of the picture on the monitor when the VCR is in the play mode.

Equipment needed

1. Master plane jig
2. Reel height gauge
3. A tape previously recorded in SP mode
4. A TV monitor or receiver
5. A dual trace oscilloscope
6. The castle tool

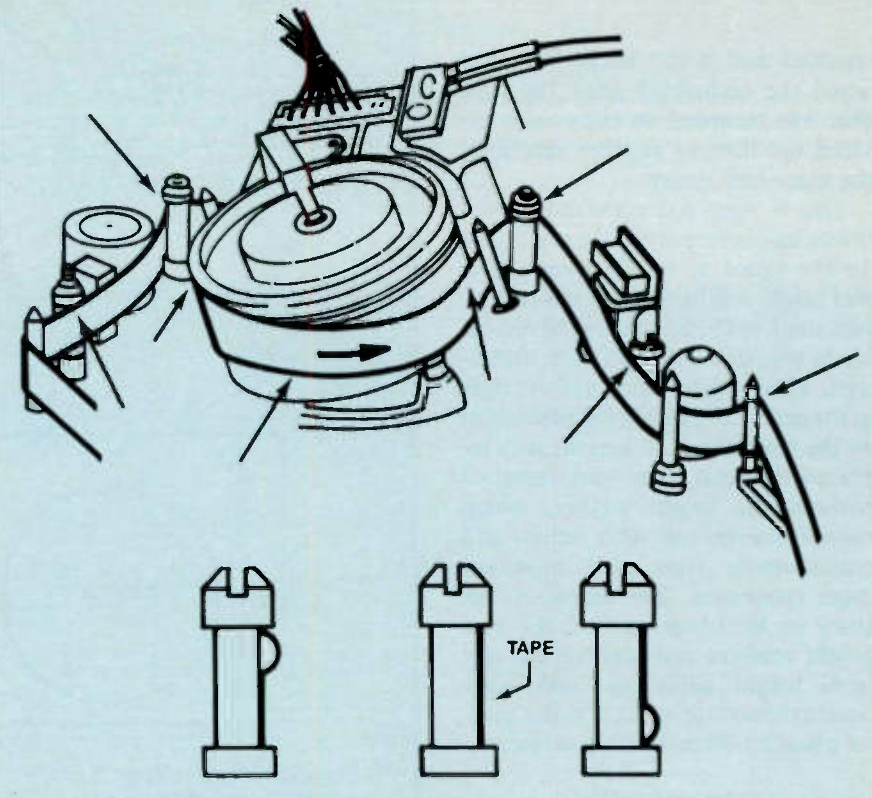
There are two parts to this procedure; a coarse adjustment and a fine adjustment. Here is the procedure for the coarse adjustment.

1. Remove the cassette carriage
2. Install the master plane jig as if it were a cassette
3. Using the reel height gauge, check the perpendicular alignment of P1, P2, P3, and P4 in relation to the master plane jig.

Please note that one end of the reel height gauge is used for the checking of turntable height and the other end is for checking the tape guide posts.

If these posts are not aligned correctly, it will mean that the tape will not be seated correctly, especially on the P2 and P3 guide posts. This will result in the thin noise bars on the monitor.

Concerning the goal of the second method, what we are going for is to make the FM envelope as straight as possible with no rounded edges or peaked edges. Just keep in mind that you are trying to adjust the shape of the FM envelope to be straight. If you have a problem with flicker when viewing both waveforms, use the ver-



Follow these steps in your inspection while the tape is playing:

1. Supply and Take-up Posts
   a. Check for curling or buckling of tape. (Figure 5A.) Correct any problems with Master Plane Alignment.
   b. If after P4 is adjusted there is still tape buckling or curling, adjust the A/C Head inclination screw to correct the problem.
2. Take-up Tension Arm (if there is one)
   a. Check for curling or buckling of the tape; correct any problems with Master Plane Alignment.
3. Entry and Take-up Guide Posts (P2 and P3)
   a. Check for tape curling or buckling. Correct with Guide Post Adjustments.
4. Entry and Exit portions of the Video Drum
   a. The tape should enter and leave the Video Drum smoothly. If it does not, check the guide post or slant posts for a problem.
   b. Insure that the tape rides just above the groove on the lower video drum.
   c. If the tape rides either too high or too low, either perform the Guide Post adjustment or replace the slant posts.
5. Repeat this inspection in the Fast Forward and Reverse Search modes.
   a. Look for tape curling, or buckling at the same inspection points as in the description above.

Here are two checks you should perform while the VCR is in the Stop mode:

a. Check the plastic portion of the Guide Posts. The plastic cylinder should rotate on the post, but the post itself should not rotate.
b. If the Guide Posts are in need of replacement, check the manufacturer's service literature for the proper replacement procedure.

Figure 5. The VCR tape path looks generally like the drawing in Figure 5A. Each point that is indicated by an arrow should be inspected as outlined in the narrative. Note especially the way the tape looks as it passes the entry and exit tape guides. If the tape curls or buckles as shown in Figure 5B, adjust the height of these components as necessary.

Head drum cleaning procedure

1. Unplug VCR and disconnect all cables
2. Remove top cover
3. Remove protective shield, if any. Note location and type of screws.
4. Turn head drum clockwise to locate heads.
5. Spray Freon on chamois swab until saturated. *Never* spray Freon directly on heads. The sudden change in temperature could damage them.
6. Rub the saturated swab with light to medium pressure across the head drum in a horizontal motion (that is, in the same direction followed by the tape across the head drum).
7. Repeat process if necessary.

Cleaning the rest of the tape path

Clean the following components in the tape path in a similar manner:

1. The tension post
2. The supply and take-up posts
3. The impedance roller
4. The Entrance and Exit guide rollers
5. The slant posts
   a. Also clean the slant post slots and lubricate with moly grease
6. The A/C head
7. The capstan shaft
8. The supply and take-up tension arms
9. The supply and take-up reels
   a. Be careful not to lose washers
   b. Clean shaft
   c. Lubricate with moly grease
10. Brake pressure pads
    a. Spray with Freon
    b. Be careful not to deform

Clean with rubber revitalizer

1. The pinch roller
2. The idler wheel
3. The belts (the capstan belt should not stretch)

Check

1. Belts
2. Tension/brake bands: if these don't come clean, replace them.
3. Brake pads: if these don't come clean, replace them.

Figure 6. Follow this procedure to properly clean the head drum and the other components of the tape path.

Master plane checks and adjustments

A. Tools needed
1. Master plane jig
2. Height gauge
3. SP prerecorded tape
4. TV monitor/receiver
5. Dual-trace scope

B. Two types of adjustments

1. Coarse adjustment
   a. Remove cassette housing
   b. Insert master plane jig
   c. Use measuring block to check:
      1) Tape guides: if off, use nut driver to adjust
      2) Reel table height: if off, add/remove washers
2. Fine adjustment (scope w/TV)
   a. Tracking control to detent position
   b. Scope FM envelope from head amp
   c. Trigger scope from head switching signal
   d. Note: if FM signal is too small, A/C head needs horizontal positioning adjustment.

C. Results of scope adjustment
1. P2 is too low
   a. FM signal will have a dip left of center
   b. Monitor: stationary noise bar appears at top of picture
2. P2 is too high
   a. FM signal on left hand side is rounded off
   b. Monitor: Stationary noise bar located three video lines (width of two fingers) on top of picture
3. P3 is too low
   a. FM signal will have a dip on right side of center of envelope
   b. Monitor: noise bar (stationary) at bottom of picture
4. P3 is too high
   a. FM signal on the right hand side will be rounded off
   b. Monitor: stationary noise bar located three video lines on bottom of picture.

D. Adjust the following
1. Reel table height
2. Guide post height
3. Guide height

Figure 7. Proper tape travel depends on proper alignment and adjustment of all of the components in the tape path. This narrative describes some of the symptoms of misalignment in the tape path, and adjustments you should make to correct them.

tical positioning control for the head-switching waveform and remove it off the screen. See Figure 7 for a general procedure to follow in performing this alignment. Please remember that it is broad and generic in form. Refer to the service manual for the particular product for details and particulars. You will usually find the height adjustment referred to in the manual as something like "Height Adjustment of P2, P2, P3, and P4." The fine adjustment is normally labeled "Confirmation/adjustment of envelope output." The reel table height check is called "Reel Table Height Adjustment."

Inspecting for wear

When you have the cassette carriage out, check the idler for wear. A worn idler is the culprit for many problems such as: no fast forward, no rewind, and sometimes, no play mode. I also discovered one time that after I replaced the idler I still had a problem with the idler not operating properly. After inspecting the area, I located the problem to be with the idler driver. This idler driver is usually located on the clutch assembly and is the little drum wheel made either of plastic or rubber that drives the big idler.

This part does get very dirty from contact with the big idler. In some

Troubleshooting belts, idlers and rollers

I. Capstan pressure roller

A. Function

1. Controls the smooth movement of the tape by pressing the tape against the capstan shaft.

B. Defective pressure roller appearance

1. Shiny/glossy
2. Brownish Discoloration

C. Symptoms of defective pressure roller

1. Reduced audio response
   a. Wow, flutter, drag
2. Servo instability
   a. vertical jitter/loss
   b. horizontal tear/loss
3. Tape destruction

II. Capstan Belt

A. Function

1. Transmits speed changes from the capstan motor to the capstan flywheel

B. Defective capstan belt appearance

1. Inside of belt will be shiny
2. Shiny belt also indicates that belt is stretched

C. Results of defective capstan belt

1. Servo Problems
   a. Vertical jitter/loss
   b. Horizontal tear/loss

III. Drive Idler

A. Function

1. Loading tape mode
2. FF mode
3. RR mode

B. Defective drive idler appearance

1. Shiny
2. Cracked around edges

Figure 8. Aging, hardening, cracking and glazing of rubber components in the tape path can cause a variety of problems. Here are some things to look for.

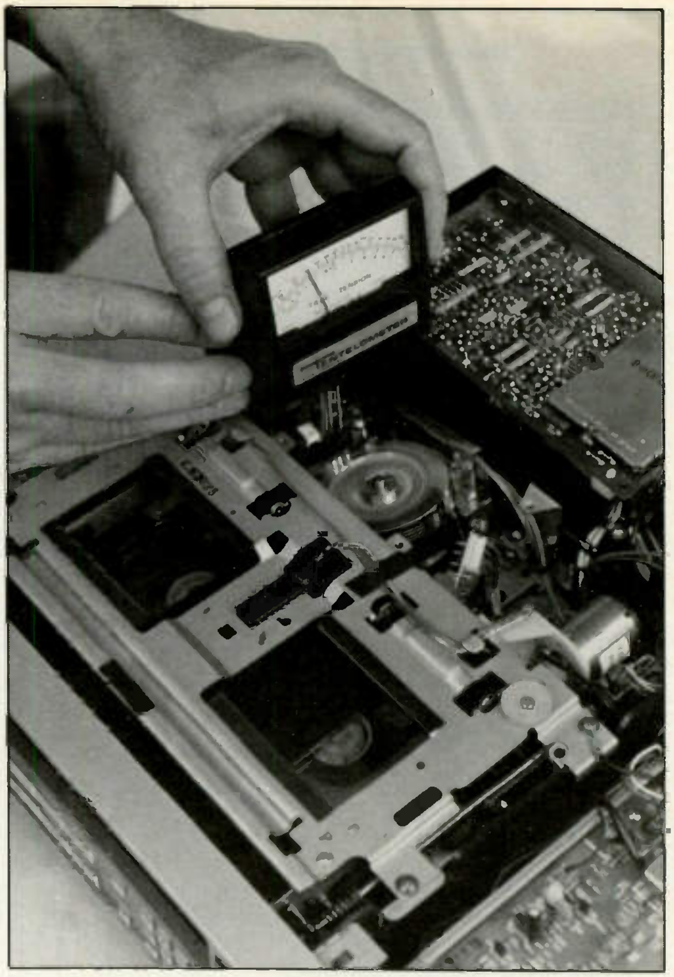


Figure 10. When you need to measure tape tension, there is more than one way to make the measurement. Shown here is a tension meter, a device with fingers that you slip over the tape as the tape moves along the tape path. Because you can use this device to measure the tension at the same place along the tape path in every VCR, it is a universal measuring device. (Photo courtesy of *Tentel*).

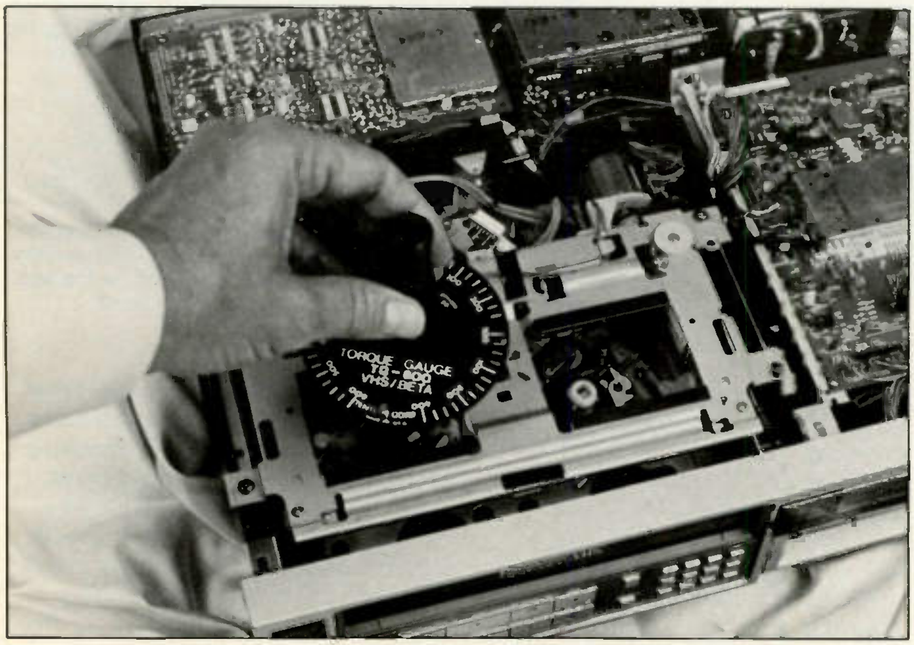


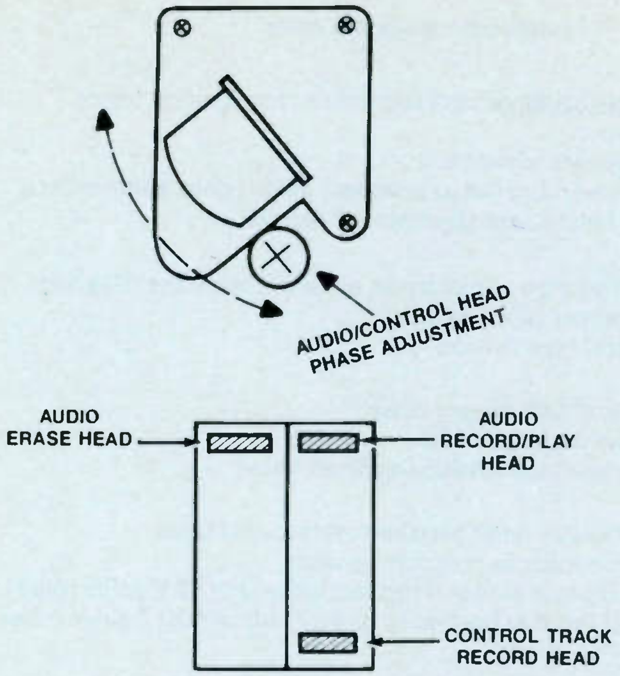
Figure 9. One way to measure torque at various points in the tape path, for example, for checking the condition of brakes, belts, clutches and idlers is to use a dial torque gauge, such as this. (Photo courtesy of *Tentel*).

cases an idler driver can be cleaned with a cleaner and a tooth brush, but there are some that are just worn out. When you encounter one that is worn out, you will simply have to replace the entire clutch assembly because the idler driver is not sold individually. Also check the turntable edges for wear and grease which can cause faulty operation.

One other situation I experienced is when I replaced a retaining ring back on the turntable reel I put it on too tight, causing the reel to bind and the idler could not rotate the reel.

If you have to replace the idler it's time to replace the belts. I go by the rule with newer units, if one belt has to be replaced, they should all be replaced. See Figure 8 for tips on troubleshooting belts and idlers.

There are many types of belts in every machine. Here are the names and functions of some of the most



A/C head adjust (horizontal phase)

A. Special tools: Castle screwdriver and knob with pin screwdriver.
B. Scope connections:
   1. Connect Channel 1 to CTL playback pulse. This connection is normally found on the servo board.
   2. Connect Channel 2 to the Audio Output jack.
   3. Connect the oscilloscope's external sync input to the CTL pulse to sync the display.
C. Remove sealant from the Horizontal Phase adjustment screw, if there is any present.
D. Adjustments:
   1. Adjust the screw labeled "Horizontal Phase" located near the A/C head for maximum amplitude of the CTL pulse.
   2. Check the audio signal so that it does not become so reduced in amplitude that the audio signal becomes lost altogether.
   3. Remember that the CTL pulse amplitude and the Audio amplitude are inversely related. Anything you do to increase the CTL pulse amplitude will decrease the amplitude of the audio signal.

Figure 11. Because the A/C head contains the control track playback head, misadjustment of this component can result in symptoms such as noisy jittery picture, or insufficient range/ineffective tracking range with tracking control on prerecorded tapes. Figure 11A shows the A/C head with its adjustment mechanism. Figure 11B is a plan view of the components found on the A/C head. Figure 11C is a description of how to adjust the A/C head.

common belts you'll encounter. First, there is the main loading belt and (in some cases) a sub-loading belt. The loading belt is normally found closest to the loading motor. These belts are used in every mode of VCR operation. If they slip, FF/RWD may not be possible, or loading to the full play position may not be completed, causing a return to the stop position after apparent full loading.

Another type of belt is the cassette loading belt. Its purpose is to load the cassette into the carriage via the cassette loading motor. When this belt decides to go bad, it will emit a very high pitched squeal that will make you think the machine is dying.

The main belt is another kind of belt you will encounter in a VCR. This is the main belt for the capstan and it maintains capstan speed as well as the mechanical response for the servo system. It will also affect the wow/flutter characteristics of the linear audio track.

On some VCRs you'll encounter a Main FF/RWD belt. This belt is attached between the capstan motor and the clutch assembly. This belt provides the drive for the reels in the FF/RWD, Play, search and the unloading modes of operation. If this belt starts to slip, tape will spill or slow starting in fast forward may occur.

Also, please keep in mind that the capstan/main belt must not stretch. If this belt does stretch, don't try to revitalize it and put it back in the VCR. Replace it; period. See Figure 8 for a general guide on belts and idlers to assist you in your troubleshooting.

Torque/tension measurements

There are three methods of checking out torque problems with a VCR. The first method is to use the Komichi tool. This costs about $300.00 and may be difficult to use.

The second method of checking torque is to use a torque measuring cassette. Because of differences in manufacturing, even among VCR models from the same manufacturer, it will be necessary to purchase several different cassettes.

The third method of diagnosing torque problems is to use a dial torque gauge (see Figure 9). This gauge can be used for checking the condition of brakes, belts, clutches and idlers. It will also help to diagnose problems in tape stretching and destruction, ejected cassette problems where the tape is hanging out of the cassette, poor FF/RWD performance, and marginal torque situations as well as tape handling problems. This type of tool may be calibrated in the field, and may be applied universally to all makes and models of VCR.

As with torque measurements, when you need to measure tape tension, there is more than one way to make the measurement, but one method is clearly superior. The first way is to use a tension measuring cassette. The problem with this is that because of manufacturing differences, even among VCR models of the same manufacturer, you will have to buy several cassettes.

The alternative is to use a tension meter (see Figure 10). This is a device with fingers that you slip over the tape as the tape moves along the tape path. Because you can use this device to measure the tension at the same place along the tape path in every VCR, it is a universal measuring device. This unit will check for tape tension problems that can result in tape stretching, intermittent video, audio and control track problems, as well as flagging or hooking problems. It will also take care of high tension problems such as tape edge damage, premature video head tip wear, tape stretching and destruction as well as hooking and flagging situations.

The horizontal phase adjustment

Another important check, is confirmation of the A/C head alignment, also called the "horizontal phase adjustment." If this adjustment is off, you'll observe some of these symptoms: muffled sound, tape speed problems during playback, high-pitched audio, noise bars that run through the picture on the monitor/receiver as well as problems that falsely lead you off into the capstan servo circuits. All of these problems may be caused by the A/C head (horizontal phase) being off.

Figure 11A is an illustration of an A/C head and its positioning movement. Please refer to this illustration as we discuss this topic of horizontal phase positioning, or if you read your service manual about it. The A/C head (Figure 11B) contains the following sections: audio record/playback head, audio erase head, and the control track playback and erase head. Refer to the illustration of this component for location of these sections.

As you can see, this A/C head is the input source for the audio playback/record amps, as well as for the servo processing control track pulses. If the positioning of this head is off, the control track pulses will be recorded and/or read incorrectly and the VCR will not operate properly.

In order to perform adjustment of the A/C head, you'll need a technical manual, A/C head positioning tool, sealant remover, a dual-trace scope and a test tape. I use a non-OEM test tape because it is less expensive (approximately $30.00 Compared to the manufacturer's suggested tape at $300.00), and it does the job.

For an oscilloscope I use a service-oriented oscilloscope with a built-in sync separator that gives me rock solid, fiddle free sync. It's important in performing VCR service to be able to lock up properly and solid.

With the test equipment connected and the tools in place all you have to do is to follow the instructions in your service manual for proper procedures. Just keep in mind the following items: 1). the guide post adjustments affect the FM envelope waveform (shape) and 2). the Hori-

(Continued on page 58)

Symptoms, causes and cures

1.	Symptom:	Tape curling or buckling around tape guides; top or bottom.
	Cause:	Improper adjustment
	Cure:	Check and adjust as necessary guide posts, guide rollers, reel height, and alignment of capstan
2.	Symptom:	Top portion of picture on monitor is bending (flagging)
	Cause:	Improper tape tension
	Cure:	Adjust tape tension
3.	Symptom:	Intermittent picture noise
	Cause:	Tape tension too low
	Cure:	Increase tape tension to correct value
4.	Symptom:	Stationary noise bar(s) on prerecorded tapes
	Cause:	Guide roller improperly adjusted
	Cure:	A) If bar is at top of picture, adjust ENTRY guide roller B) If bar is at bottom of picture, adjust EXIT guide roller
5.	Symptom:	Picture is noisy with jitter on prerecorded tapes
	Cause:	A/C head (horizontal phase) is out of alignment
	Cure:	Realign A/C head
6.	Symptom:	Insufficient range/ineffective tracking range with tracking control on prerecorded tapes
	Cause:	A/C head misadjusted
	Cure:	Readjust A/C head
7.	Symptom:	Extremely noisy picture with a 30Hz flicker
	Cause:	Video head or playback preamp malfunction
	Cure:	Check video heads and playback preamps. Always check for drum flip-flop signal at preamps
8.	Symptom:	Thin horizontal noise line at bottom of picture
	Cause:	Head switching is set too early
	Cure:	Adjust head switching
9.	Symptom:	Vertical jitter, loss of video sync
	Cause:	Head switching is set too late
	Cure:	Adjust head switching
10.	Symptom:	Problems on playback mode w/video and chroma on all tapes
	Cause:	Problem is in VCR video/chroma playback circuitry
	Cure:	Troubleshoot video/chroma circuits
11.	Symptom:	Random black streaking when playing a tape of the NTSC color bars
	Cause:	Head resonance misadjusted, or worn heads
	Cure:	Check and adjust head resonance as necessary, or replace worn heads
12.	Symptom:	Trailing black streaks, or no video
	Cause:	Limiter balance misadjusted
	Cure:	Readjust limiter balance

Figure 12. The VCR is a complex system. When you're faced with a malfunctioning VCR, this list of symptoms, causes and cures will help you isolate the problem to a specific area of the unit.

13. Symptom: Picture when playing tape of NTSC color bars lacks contrast
Cause: Playback level too low
Cure: Increase playback level

14. Symptom: Picture is black and white with weaving lines
Cause: 30Hz head switching square wave is absent from the luminance record/playback process IC
Cure: Trace head switching square wave to see where it disappears.

15. Symptom: VCR loads tape, then ejects it
Cause: One of three windings in cylinder motor defective, or magnet on cylinder cracked
Cure: If head cylinder is defective, replace it

16. Symptom: When eject button is pressed, unit tries to unload, then goes into shutdown
Cause: Cassette door stuck open during ejection mode
Cure: Determine cause of stuck door, and correct

17. Symptom: When unit is in record mode and record pause is selected, unit goes into stop mode
Cause: Defective matrix switch
Cure: Repair or replace matrix switch

18. Symptom: VCR loads, then immediately unloads tape
Cause: System control problem, or servo problem
Cure: Isolate problem to system control or servo system and correct

19. Symptom: VCR plays at only one speed
Cause: Defective speed selection circuit
Cure: Determine nature of defect and correct

20. Symptom: Tapes that have been recorded on the VCR produce a poor picture when played back
Cause: Chroma record bias misadjusted
Cure: Readjust chroma record bias

21. Symptom: VCR will not load tape or go into any mode selected. Drum and cylinder moves only slightly instead of several rotations, then stops
Cause: Tape detector lamp defective
Cure: Check lamp for operation and replace as necessary

22. Symptom: Picture shows snow and lack of color. Appears to be dirty head
Cause: Tracking control not in detent position
Cure: Check operation of tracking control

23. Symptom: VCR will load tape, FF, and RR, but when play mode is activated it goes into shutdown
Cause: VCR timing is incorrect
Cure: Readjust timing

How AGC works

By Lambert C. Huneault, CET

When asked the question "How does AGC work?" one of my former electronics students once answered: "Very well!" While that wasn't exactly the answer I had expected, in a way the student wasn't too far off the mark because AGC does work very well indeed. As a matter of fact, it is so effective and beneficial that it's used—in some form or other—in a wide variety of home entertainment and communications equipment.

The many names of AGC

Automatic gain control (AGC) is a generic name. The feature is commonly found in AM radio receivers, where it's generally referred to as automatic volume control (AVC); in FM radios where it's simply known as AGC; in audio tape recorders where it's often called automatic level control (ALC); in VCRs and television receivers where it's simply called AGC when it controls the gain of the RF and picture IF section, and either ACC (automatic color control) or ASC (automatic saturation control) when it controls the gain of the chroma amplifier section. And to add to this mixed bag, there is also *keyed AGC, delayed AGC* and *amplified AGC*. As a matter of fact, this Absolutely Great Concept (AGC) is applied in so many different ways that this series of articles could readily be subtitled: AGC, AVC, ALC, ACC, ASC and ATJ (All That Jazz)!

We'll examine all of these forms of gain control and explain how the various circuits work. But before tackling specific circuits, let's examine the AGC concept in general.

Huneault, now retired, was an electronics instructor and head of the REE department at St. Claire College of Applied Arts and Technology in Ontario, Canada.

The AGC concept

Automatic gain control involves two circuits: the controlling stage and the controlled stage(s). This is illustrated in Figure 1 where the controlling stage is labelled AGC DETECTOR and the controlled stage is a SIGNAL AMPLIFIER. The principle is simplicity itself: a sample of the amplified signal is rectified by the AGC detector; the resulting dc bias is filtered by the R1-C1 network (to remove signal pulsations) and fed back as a control voltage to the signal amplifier. The purpose of the closed loop circuitry is to automatically adjust the gain of the signal amplifier so as to keep the amplitude of the output signal relatively constant in spite of variations in the average strength of the input signal.

For example, let's assume that the average amplitude of the input signal is *increasing*, for some reason or other. Normally the amplitude of the output signal would tend to increase as well. However, with a stronger signal fed to its input, the AGC detector would produce a higher dc bias voltage at its output; and this increased control voltage applied to the signal amplifier would *decrease* the gain of that controlled stage, thus preventing

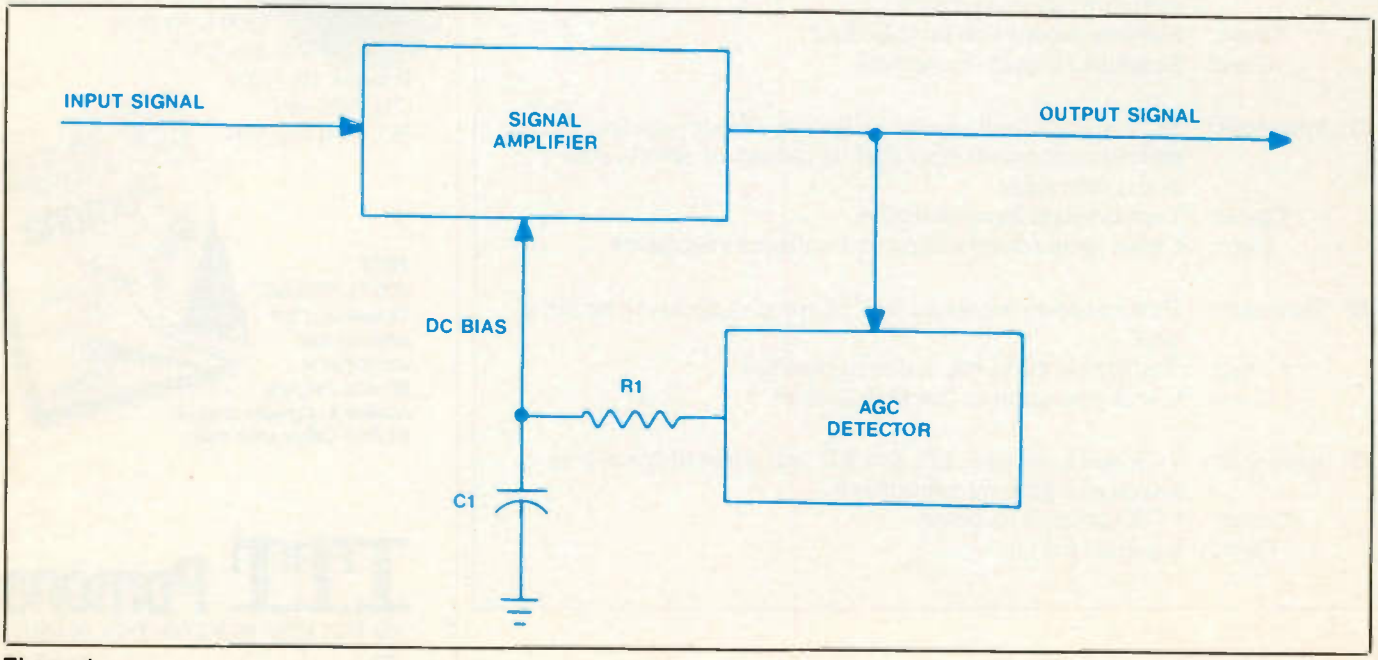


Figure 1.

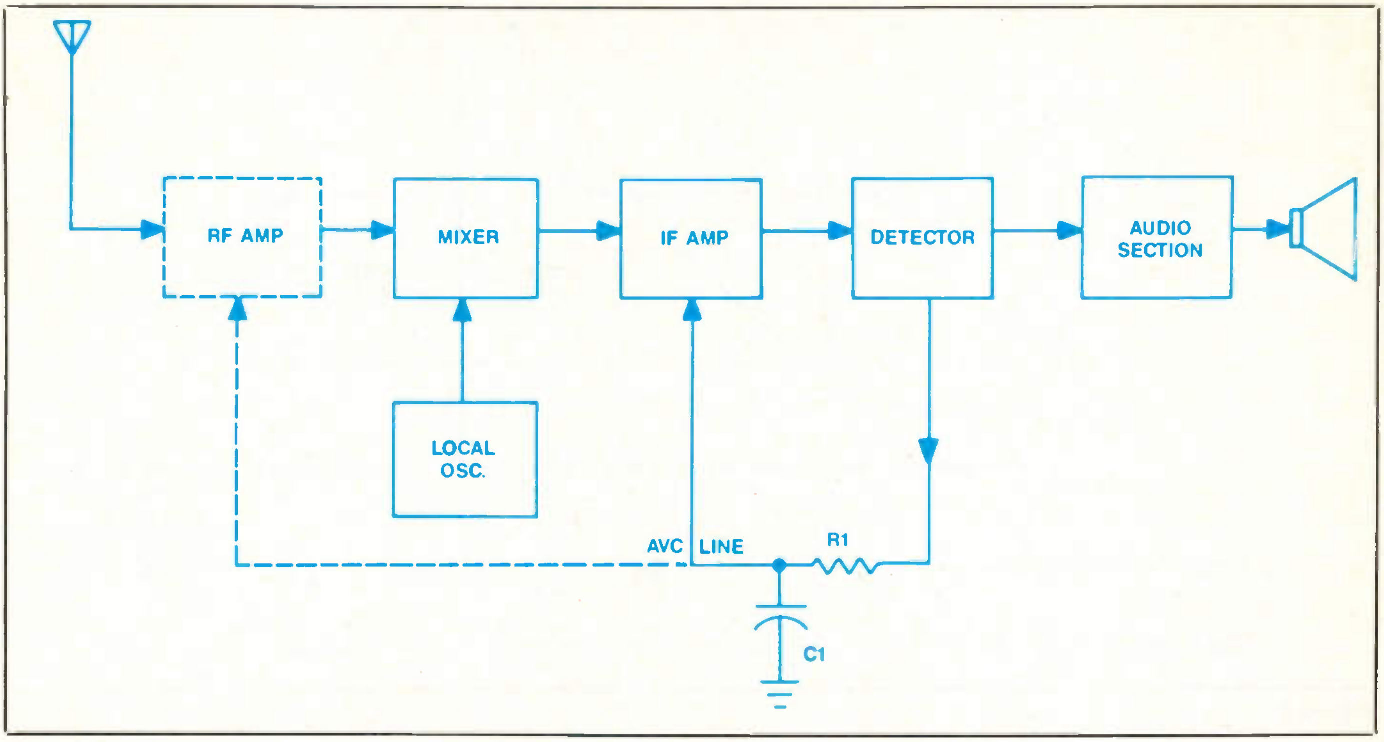


Figure 2.

the output signal level from rising substantially even though the input signal is indeed rising in amplitude.

On the other hand, if the input signal strength were to *decrease*, the output signal would likewise tend to decrease and less AGC bias would be produced by the detector. This would allow the gain of the controlled stage to *increase*, thus preventing the output signal level from dropping substantially. In summary, then, thanks to AGC the average amplitude of the output signal remains virtually constant even when the strength of the input signal is fluctuating.

Just how is this concept applied in consumer electronic equipment? For starters, let's examine the AGC circuit which most of us originally cut our teeth on: automatic volume control in AM radio receivers.

Automatic volume control (AVC)

AVC is featured in virtually all AM radios because, as its name implies, it's able to automatically control the gain of the receiver in such a way as to maintain a constant volume of sound output in spite of wide variations in the strength of antenna input signals encountered while tuning across the broadcast band. Naturally, signals differ in strength because of differences in transmitter power and antenna location; but a second reason they can fluctuate (fade in and out) is because the signal strength varies when received over long distances, via the ionosphere, especially at night. AVC goes a long way towards minimizing this fading. A third and important advantage of AVC is the prevention of receiver overloading in the presence of very strong local signals.

Figure 2 is a block diagram showing how AVC is implemented in an AM receiver (or in the AM section of an AM/FM radio). Although a separate AVC detector is sometimes featured, most receivers get by with the AM detector serving double duty, i.e. recovering the audio and producing the AVC control voltage by rectifying the modulated IF signal. The pulsating dc voltage from the detector is filtered by the R1-C1 network. With a typical time constant of about 0.1 second, this low-pass filter eliminates the audio signal from the rectified output of the detector, and passes only its dc component (average voltage, which depends on signal strength) on to the controlled circuits which usually consist of one or two stages in the IF amplifier section, and the RF amplifier (if the receiver features one).

Oldtimers undoubtedly remember that in vacuum tube radios the AVC voltage was always negative and was invariably applied to the control grids of remote-cutoff tubes; the higher the negative bias voltage, the lower the transconductance and voltage gain of the controlled IF/RF pentodes. In transistor radios, the situation is a little different. The AVC bias may be either positive or negative, depending on whether the controlled stages feature PNP or NPN transistors; and depending also on whether the circuit features forward or reverse AGC.

Transistor characteristics

Naturally, the base-emitter junctions of the RF/IF transistors must be *forward biased* in order for these amplifiers to operate. However, transistors can operate in two different gain-control modes, depending

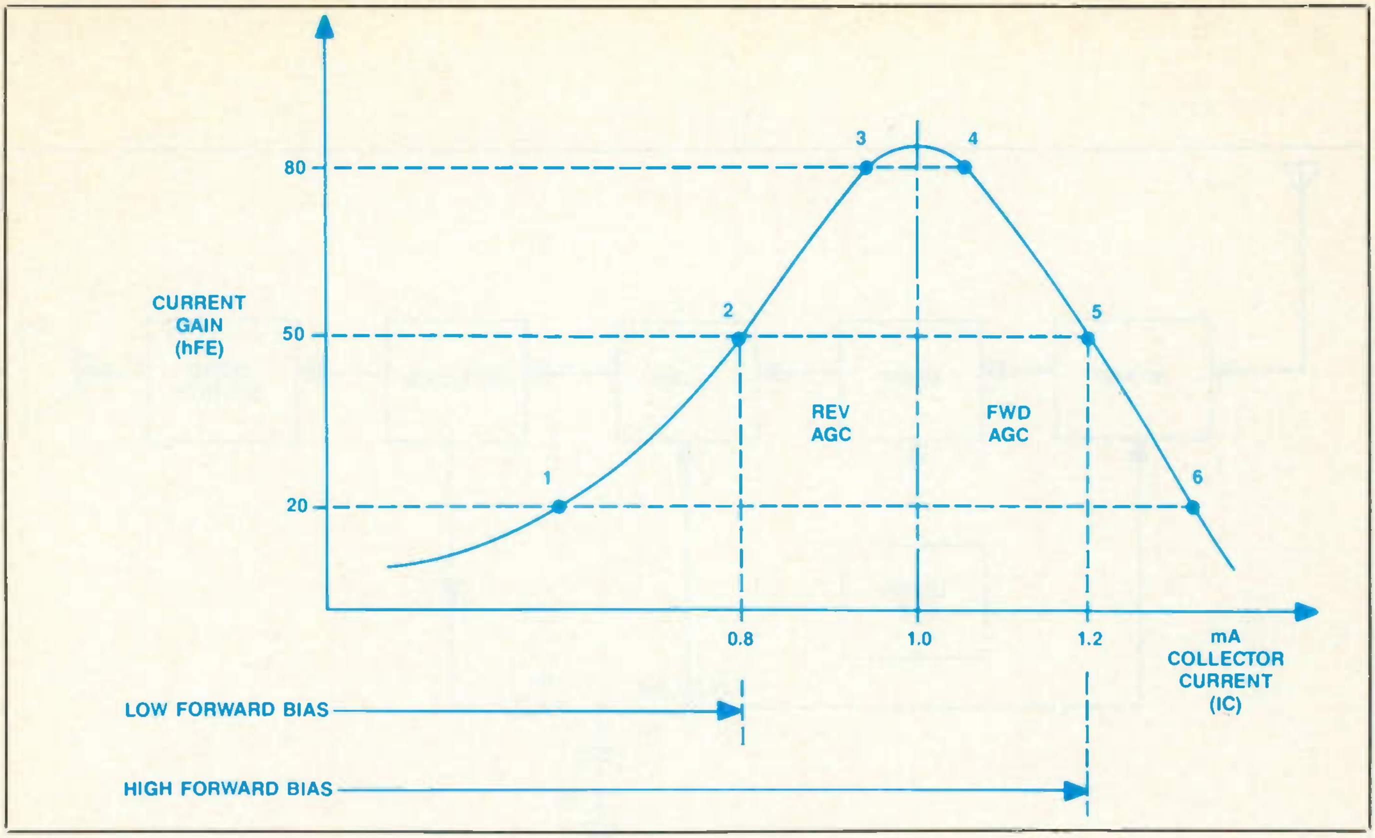


Figure 3.

on whether they are heavily or only lightly forward biased. This is illustrated in Figure 3, a graph of current gain vs collector current for a typical transistor. Note that if the transistor is forward biased only slightly, its operating point falls on the left side of the characteristic curve.

This is the *reverse AGC* region of the graph. For example, let's assume that the base-emitter bias is just sufficient to produce a collector current of only 0.8mA (operating point 2 on the curve); this results in a current gain (beta) of 50 in this example. If, on the other hand, forward bias is increased sufficiently to raise the collector current to 1.2mA (operating point 5), the transistor's current gain is once again 50 but the amplifier is now operating in the *forward AGC* mode (right side of the curve).

This particular graph shows that the maximum value of current gain is achieved when the collector current is 1mA but in a *power* transistor maximum gain might occur with a collector current of a few amps, for example. However, all transistors feature that same general shape of characteristic curve . . . when forward bias is reduced sufficiently, the current gain decreases because the transistor approaches cutoff; and when forward bias is increased sufficiently, current gain again decreases as the transistor approaches saturation. Maximum gain occurs with a moderate amount of forward bias, somewhere between the two extremes.

Reverse AGC mode

Keeping the above principle in mind, let's examine a receiver designed to operate in the reverse AGC mode. See Figure 4. IF amplifier transistors Q2 and Q3 are both AVC-controlled in this receiver; in some radios, only the first IF amp is gain-controlled. The amplified IF signal is coupled through T3 to the detector circuit which includes diode X1, RF bypass capacitor C7 and load resistor R7 (volume control). In addition to being coupled through the wiper of R7 to the audio amplifier section, the pulsating dc audio signal (positive polarity, from the cathode of X1) is filtered by the R5-C5 AVC filter and fed back as a control bias to the bases of Q2 and Q3.

Because the transistors are PNP, a negative dc voltage must be applied to their bases in order to turn them on. That forward bias voltage is obtained from the –9V power supply, and is applied through R2 to the Q2 and Q3 bases. R2, R3, R5 and R7 form a voltage divider which produces just the right amount of forward bias for the Q2 and Q3 bases; resulting in, let's say, operating point 3 in Figure 3 (transistor gain = 80), with no signal received.

With a medium strength signal tuned in, a moderate amount of *positive* dc voltage is produced at the detector's output and fed back via the AVC line to the N-type bases of the PNP transistors, thus *opposing the negative bias* provided by the power supply. That's why this AVC mode is referred to as *reverse AGC*.

Supposing that, as a result, the forward bias is reduced sufficiently to lower the collector current down to 0.8mA (operating point 2 on the curve of Figure 3), we note that the transistor gain is reduced to 50 while that medium strength signal is received. If a stronger signal is tuned in, the output of the detector (AVC voltage) becomes more positive yet, further reducing the IF transistors' negative forward bias voltage.

As a result, the collector current is reduced further and the operating point shifts to, say, point 1 on the curve; thus reducing the transistor

(Continued on page 37)

ES&T Manufacturers' schematics PROFAX

February 1991

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RCA
CTC 107 Color TV.......................................3073

FREQUENCY SYNTHESIS TUNER CONTROL SCHEMATIC

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

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

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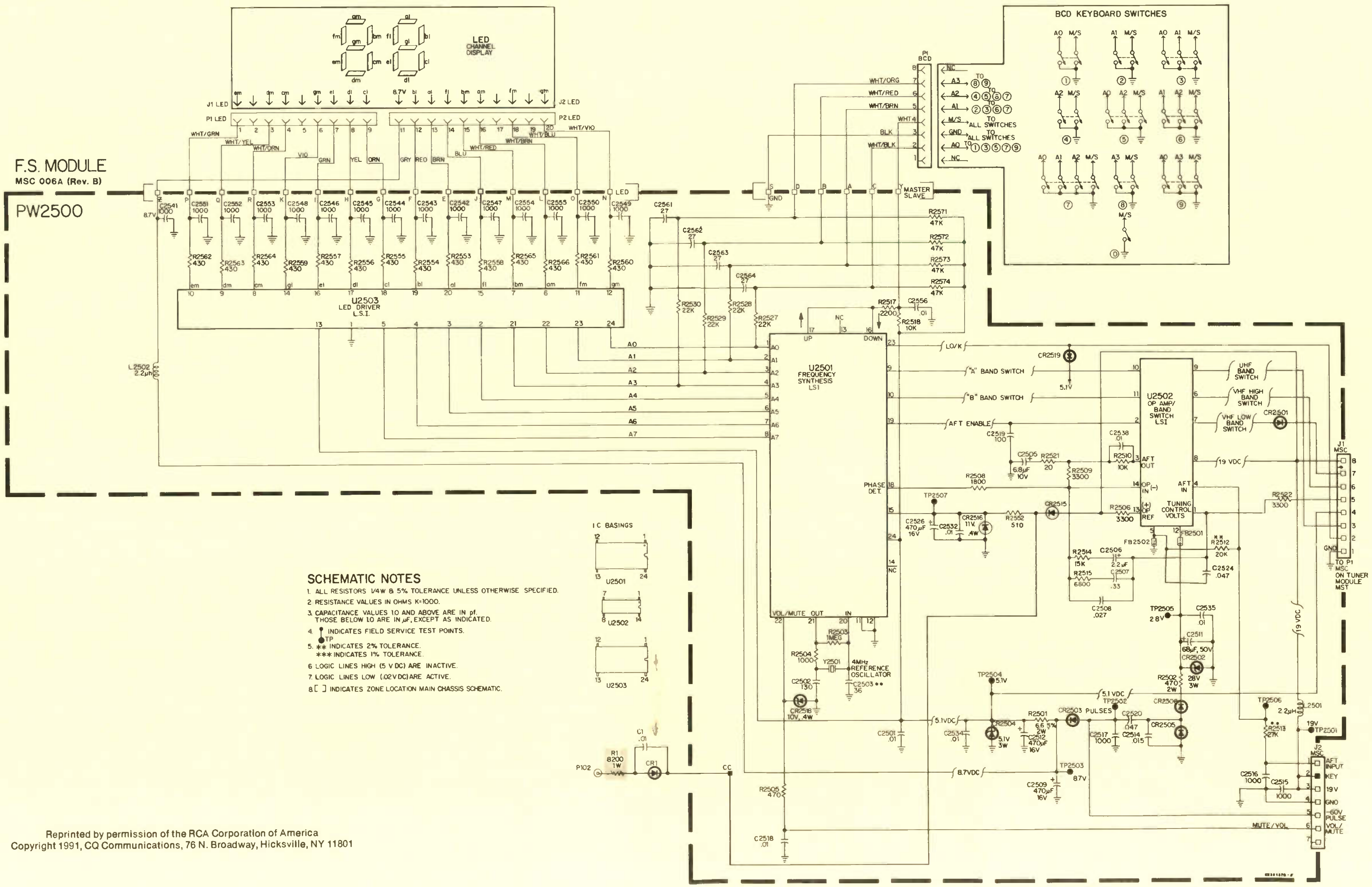

SCHEMATIC NOTES

1. ALL RESISTORS 1/4W & 5% TOLERANCE UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS K=1000.
3. CAPACITANCE VALUES 1.0 AND ABOVE ARE IN pf. THOSE BELOW 1.0 ARE IN μF, EXCEPT AS INDICATED.
4. TP INDICATES FIELD SERVICE TEST POINTS.
5. ** INDICATES 2% TOLERANCE. *** INDICATES 1% TOLERANCE.
6. LOGIC LINES HIGH (5 V DC) ARE INACTIVE.
7. LOGIC LINES LOW (.02VDC)ARE ACTIVE.
8. [ ] INDICATES ZONE LOCATION MAIN CHASSIS SCHEMATIC.

Manufacturers' schematics
FEBRUARY 1991

RCA CTC 107 COLOR TV

CHASSIS SCHEMATIC - SIGNAL CIRCUIT

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CHASSIS SCHEMATIC - SIGNAL CIRCUIT

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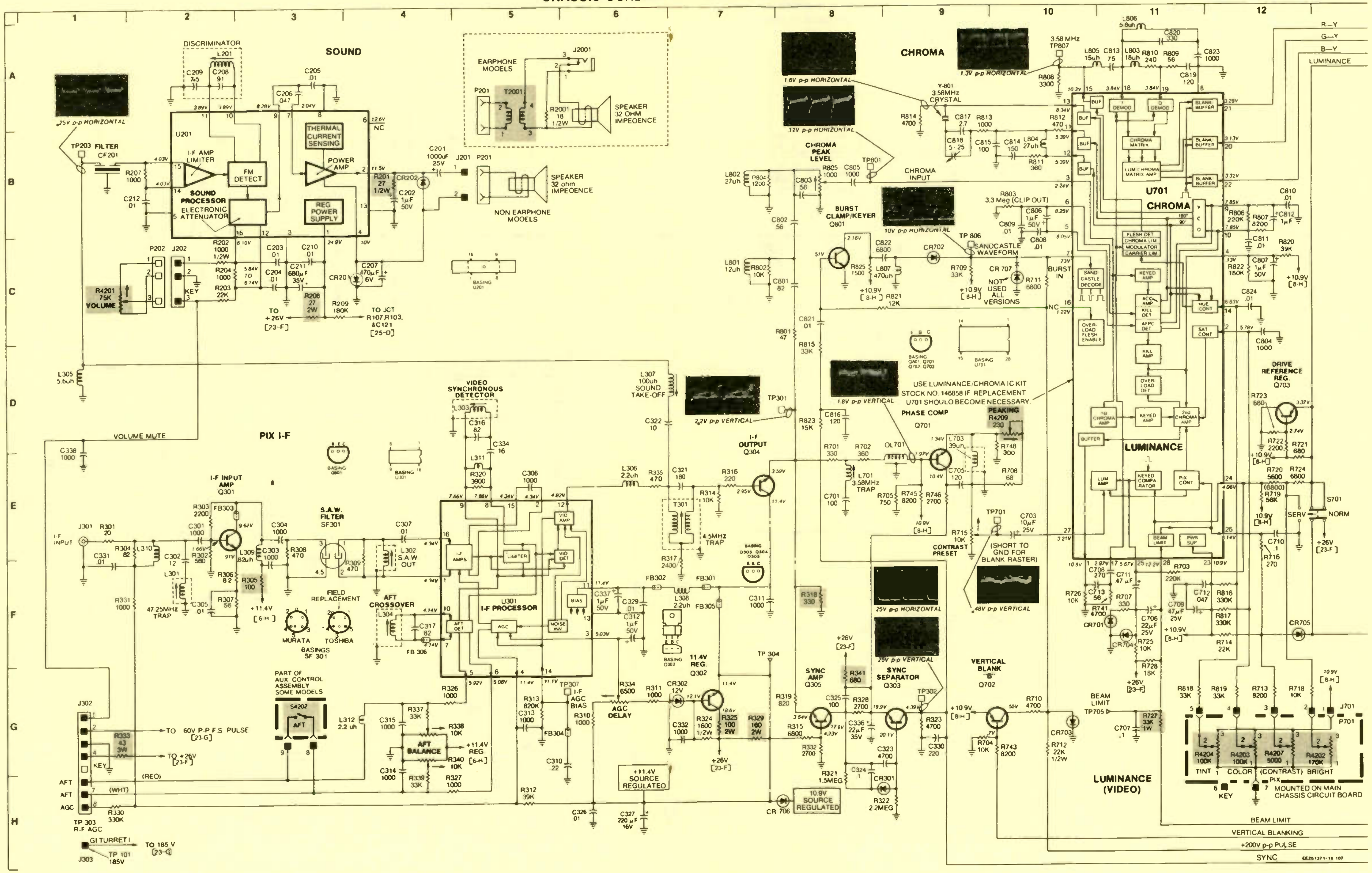
CHASSIS SCHEMATIC — SIGNAL CIRCUIT



CHASSIS SCHEMATIC - DEFLECTION CIRCUIT AND POWER SUPPLY

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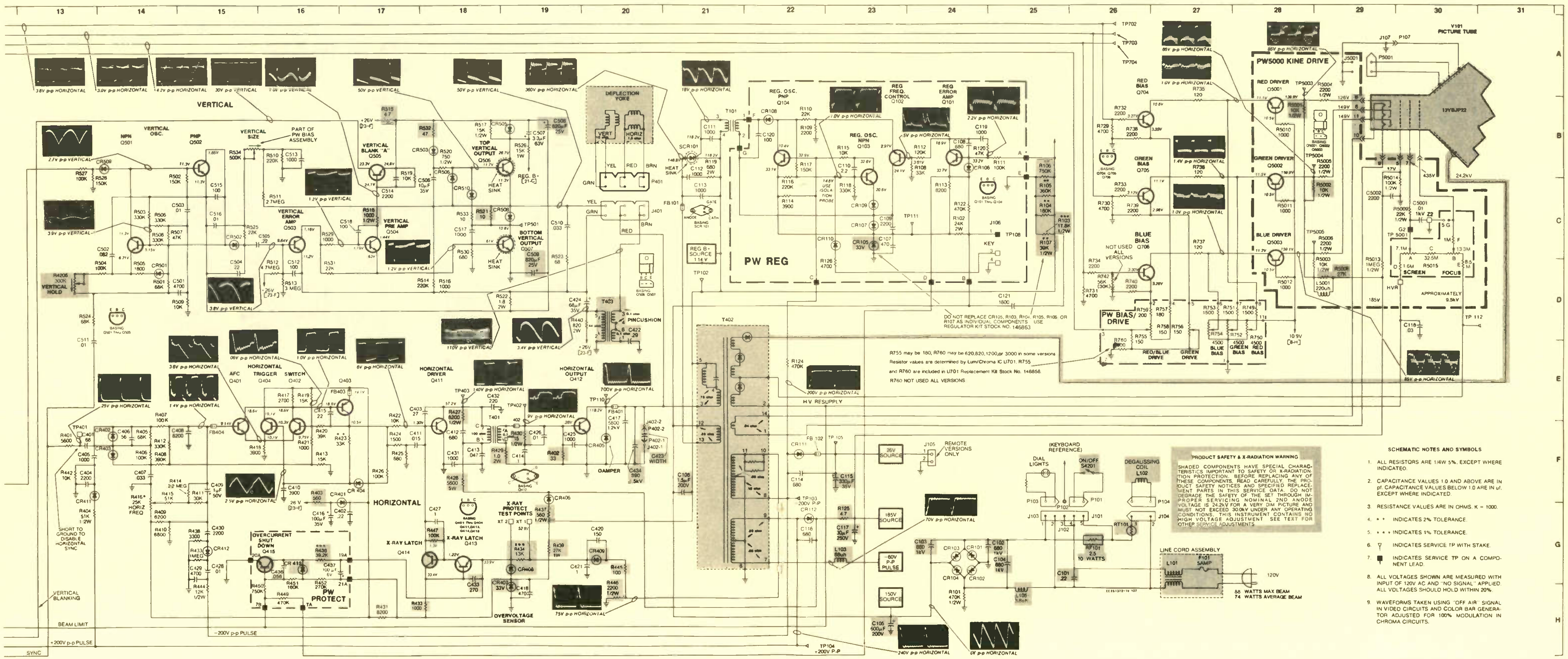

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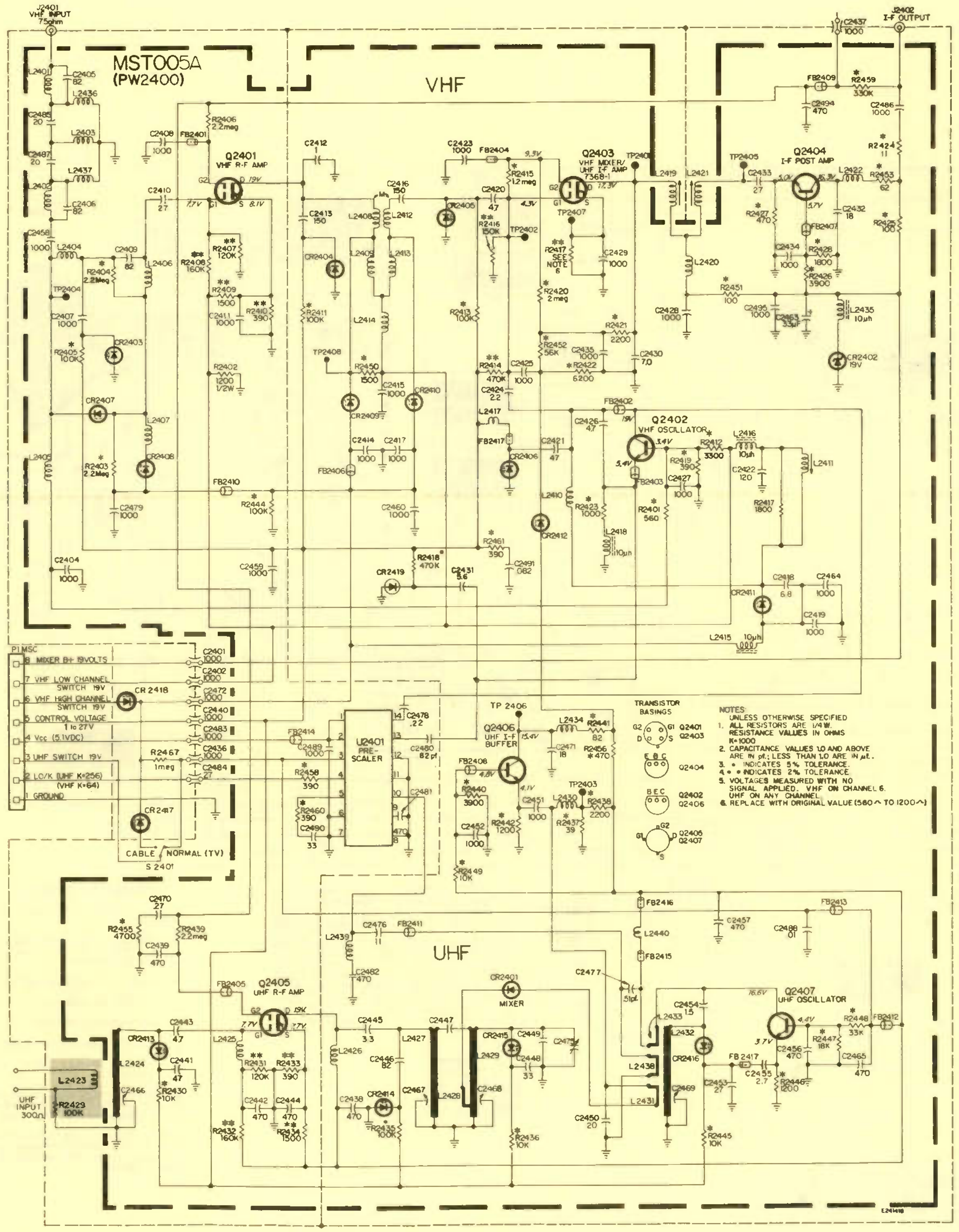

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FREQUENCY SYNTHESIS TUNER MODULE

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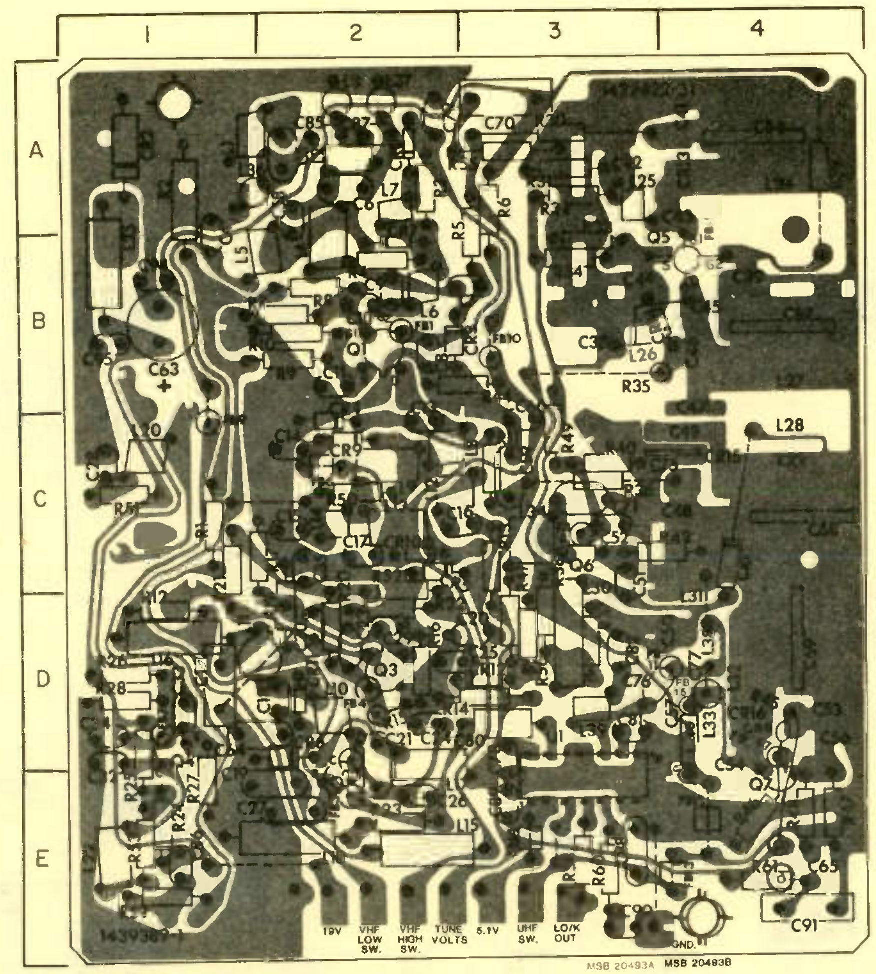

PW 2400—Component Location Guide

C2404 ..... 1B	C2426 ..... 2E	C2451 ..... 3C	C2478 .... 3E	CR2407 ... 2B	FB2411 ..... 3D	L2416 .... 1D	Q2401 ..... 2B	R2415 ..... 2D	R2438 .... 3D
C2405 ..... 2A	C2427 ..... 2E	C2452 ..... 3C	C2479 .... 2A	CR2408 ... 2A	FB2412 ..... 4E	L2417 .... 2E	Q2402 ..... 2E	R2416 ..... 2D	R2439 .... 4A
C2406 ..... 2A	C2428 ..... 1C	C2453 ..... 4D	C2480 .... 3D	CR2409 ... 2C	FB2413 ..... 4E	L2418 .... 2E	Q2403 ..... 2D	R2417 ..... 1C	R2440 .... 3C
C2407 ..... 3B	C2429 ..... 2D	C2454 ..... 4D	C2481 .... 3D	CR2410 ... 2C	FB2414 ..... 3E	L2420 .... 1C	Q2404 ..... 1D	R2419 ..... 2D	R2441 .... 3D
C2408 ..... 2B	C2430 ..... 2D	C2455 ..... 4E	C2482 .... 3D	CR2411 ... 2D	FB2415 ..... 4D	L2422 .... 1E	Q2405 ..... 3B	R2420 ..... 2D	R2442 .... 3C
C2409 ..... 2B	C2432 ..... 1D	C2456 ..... 4D	C2485 .... 2A	CR2412 ... 3D	FB2416 ..... 4E	L2424 .... 4A	Q2406 ..... 3C	R2421 ..... 1C	R2444 .... 3B
C2410 ..... 2B	C2433 ..... 1D	C2457 ..... 4D	C2486 .... 1E	CR2413 ... 4A	FB2417 ..... 4E	L2425 .... 3A	Q2407 ..... 4E	R2422 ..... 2D	R2445 .... 4D
C2411 ..... 2B	C2434 ..... 1D	C2458 ..... 2A	C2487 .... 2A	CR2414 ... 3B	L2401 .... 1A	L2426 .... 3B	R2401 ..... 1C	R2423 ..... 2E	R2446 .... 4E
C2413 ..... 2C	C2435 ..... 2C	C2459 ..... 3C	C2488 .... 3E	CR2415 ... 4C	L2402 .... 2A	L2427 .... 4B	R2402 ..... 1A	R2424 ..... 1E	R2447 .... 4E
C2414 ..... 2C	C2438 ..... 3B	C2460 ..... 3C	C2489 .... 3E	CR2416 ... 4D	L2403 .... 2A	L2428 .... 4C	R2403 ..... 2A	R2425 ..... 1E	R2448 .... 4E
C2415 ..... 2C	C2439 ..... 4B	C2463 ..... 1B	C2490 .... 3E		L2404 .... 2B	L2429 .... 4C	R2404 ..... 2B	R2426 ..... 1D	R2449 .... 3C
C2416 ..... 2C	C2441 ..... 4A	C2464 ..... 1D	C2491 .... 4E	FB2401 ... 2B	L2405 .... 1B	L2430 .... 3D	R2405 ..... 3A	R2427 ..... 1E	R2450 .... 2C
C2417 ..... 2C	C2442 ..... 3A	C2465 ..... 4E	C2494 .... 1B	FB2402 ... 2D	L2406 .... 2B	L2431 .... 4D	R2406 ..... 3A	R2428 ..... 1D	R2451 .... 1C
C2418 ..... 2D	C2443 ..... 3A	C2466 ..... 4A	C2495 .... 1B	FB2403 ... 2E	L2407 .... 2A	L2432 .... 4D	R2407 ..... 2B	R2430 ..... 3A	R2452 .... 2C
C2419 ..... 1E	C2444 ..... 3B	C2467 ..... 4B		FB2404 ... 2D	L2408 .... 2C	L2433 .... 4D	R2408 ..... 2B	R2431 ..... 3A	R2453 .... 1E
C2420 ..... 3D	C2445 ..... 4B	C2468 ..... 4C	CR2401 ... 4C	FB2405 ... 4A	L2409 .... 2C	L2434 .... 3C	R2409 ..... 2B	R2432 ..... 3A	R2455 .... 3A
C2421 ..... 2D	C2446 ..... 4B	C2469 ..... 4D	CR2402 ... 1A	FB2406 ... 2C	L2410 .... 2D	L2435 .... 1B	R2410 ..... 2B	R2433 ..... 3B	R2456 .... 3D
C2422 ..... 1D	C2447 ..... 4B	C2470 ..... 3A	CR2403 ... 2B	FB2407 ... 1D	L2411 .... 1D	L2436 .... 1C	R2411 ..... 3C	R2434 ..... 3B	R2458 .... 3E
C2423 ..... 2D	C2448 ..... 4C	C2471 ..... 3C	CR2404 ... 2C	FB2408 ... 3C	L2412 .... 2C	L2437 .... 2A	R2412 ..... 1D	R2435 ..... 3B	R2459 .... 1E
C2424 ..... 2D	C2449 ..... 4C	C2475 ..... 3C	CR2405 ... 2C	FB2409 ... 1C	L2413 .... 2C	L2438 .... 4D	R2413 ..... 3C	R2436 ..... 3C	R2460 .... 3E
C2425 ..... 2D	C2450 ..... 3D	C2476 ..... 3D	CR2406 ... 2D	FB2410 ... 3B	L2414 .... 2C	L2439 .... 3D	R2414 ..... 3D	R2437 ..... 3D	R2461 .... 4E
		C2477 ..... 4D			L2415 .... 2E	L2440 .... 4E			U2401 .... 3D

NOTE: Add 2400 Series Prefix To Item Numbers

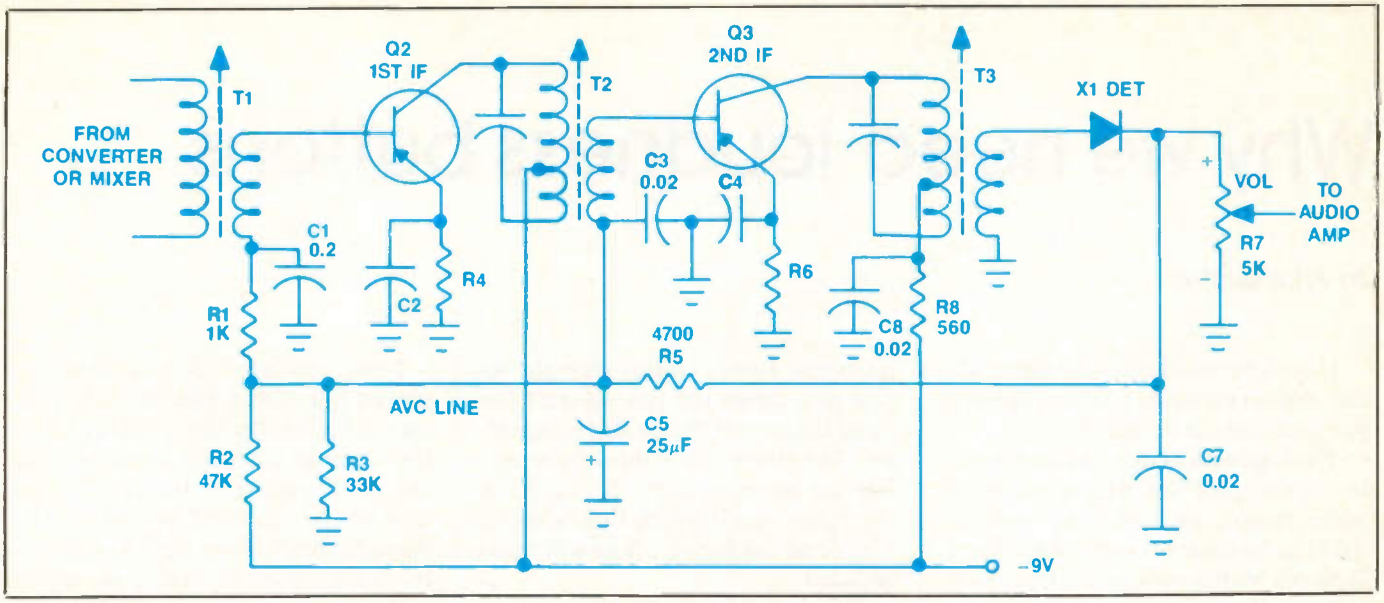

Figure 4.

gain to 20. So we see that the stronger the signal received, the lower the gain of the IF transistors. This not only prevents the volume from increasing appreciably, but also prevents distortion caused by overloading when strong local stations are tuned in.

When a very weak signal is received, the resulting small AVC voltage provides very little opposition to the forward bias, allowing the operating point to shift back up the curve, close to point 3. The transistor gain thus increases toward 80, preventing the volume from dropping substantially on the weak signal.

A few comments about the circuit

Before leaving the circuit of Figure 4, a few comments are in order. R1-C1 and R8-C8 are RF decoupling networks. Also note the fairly large capacitance of AVC filter capacitor C5. With the 4700Ω R5, the 25μF cap results in a time constant of just over 0.1 second. Veterans of vacuum-tube radio battles will undoubtedly recall that the AVC filter used to feature a much smaller capacitor and much higher resistance in those pre-transistor age receivers; 2.2MΩ and 0.05μF were typical values, resulting in the same 0.1 second time constant. Any idea why the difference?

Well, because vacuum tubes were voltage-operated devices, no current flowed along the AVC line; thus a large resistor was featured, reducing the required capacitance (and cost) of the filter capacitor. But transistors are a different kettle of fish . . . they are current-operated (low impedance) devices. Because current does flow along the AVC line, a 2MΩ resistor is out of the question. About 5KΩ is more like it, necessitating a much larger capacitor to produce that one hundred millisecond time constant necessary to filter out the audio. Thus an *electrolytic* capacitor is normally found in that circuit . . . and is often the culprit in AVC related problems such as oscillations.

Another interesting feature of this circuit is that the cathode of the detector diode receives a negative voltage from the power supply, via resistors R2 and R5. This small amount of forward bias applied to the germanium diode is not detrimental; on the contrary, it shifts the operating point of X1 to a more linear portion of its characteristic curve.

More on AGC next month

Next month's installment on AGC will cover forward AGC, the AGC overload diode, AGC in FM radios, automatic level control, and AGC in television. Stay tuned. ■

Why we need loudness buttons

By John Shepler

Have you wondered why the loudness button on stereo receivers doesn't just increase the volume?

The loudness switch had its origins in the complex loudness controls of older radios, especially car radios. Today, the loudness control has been replaced with a volume control. This is generally nothing more than a single or ganged logarithmic taper pot. The loudness control of days ago was considerably more complex. It consisted of a single or dual pot with resistors and capacitors attached to taps.

So what's the difference? Doesn't the volume control in today's radios do the same job?

The volume potentiometer today simply changes the amount of signal that drives the power amplifier and speakers. As you turn down the control knob, the volume drops proportionately. Listen closely though. As you turn down the pot, doesn't the tonal balance of the music change also? The lower the volume, the less full the music sounds. If you listen carefully, you'll notice that both the highs and lows drop off as volume is reduced.

Shepler is an electronics engineering manager and broadcast consultant. He has more than 20 years experience in all phases of electronics.

This loss of fullness in sound at low volumes was investigated many years ago by Fletcher and Munson of Bell Labs. The results of their studies were a set of curves that show how the frequency response of the human ear changes with volume. Figure 1 shows the basics of this effect.

At high volumes, the response of the ear is relatively flat through the audio spectrum from 20Hz to 20kHz. As the sound intensity is lowered, the ear becomes less sensitive to the low and high frequencies. At low volumes, the ear is most sensitive to midrange frequencies, such as voices. Even a very expensive radio will sound like it has a 2 inch speaker if you turn down the volume enough.

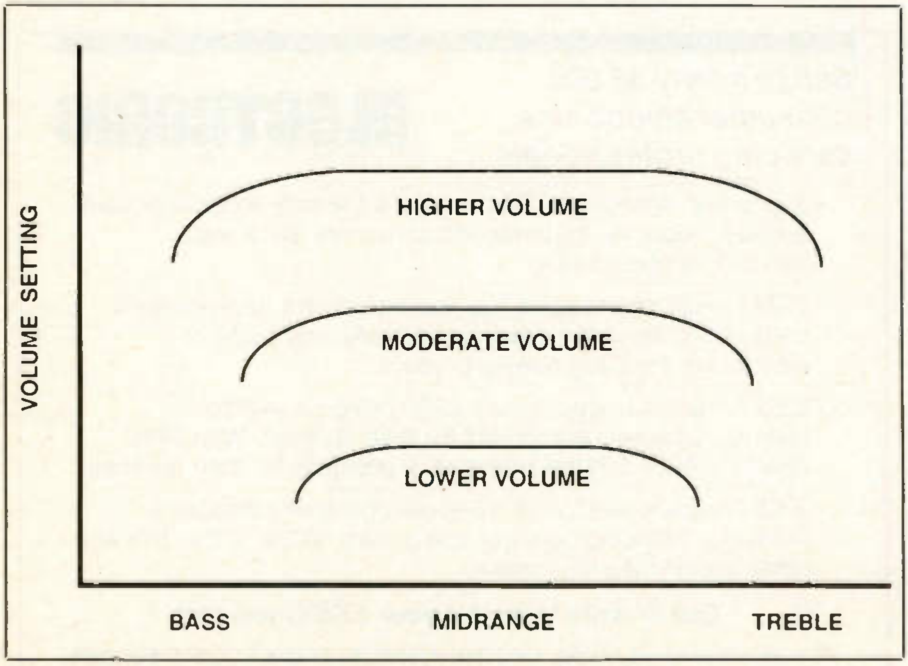

Figure 1. How volume seems to change frequency response.

Now, consider that most music is played fairly loud and recorded that way. The tonal balance that is set at the recording studio assumes that you are listening at "normal" volume levels. Those of us who like to listen at much lower "background" levels are forced to turn up the treble and base tone controls or settle for weak sounding audio. The alternative to fiddling with the tone pots is to push the loudness switch.

The loudness button is less expensive substitute for the ganged and tapped loudness potentiometer. Pushing the loudness button connects a Resistor-Capacitor filter or two at the amplifier input. Most loudness switches boost bass. Some boost both bass and treble. The result is not so much to make the music louder as it is to restore the tonal balance you enjoyed at higher volume levels.

You can put this knowledge to practical use when customers complain that audio systems that sounded great in the showroom, sound weak and thin in their homes. You can explain that in the quiet of their living rooms they have set the volume low. They need to use the loudness switch and/or the tone controls to recalibrate the tonal balance of their system. You'll likely wind up with some favorably impressed customers.

Also, if you own or have access to an older car, try playing with the loudness control. See if the frequency response doesn't remain constant as only the intensity of the sound from the speakers increases and decreases.

Perhaps someday this feature will be revived in consumer audio. New designs might even use digital switched capacitor filters to automatically change equalization per the Fletcher-Munson curves as the volume knob or raise/lower buttons are manipulated. The loudness switch would no longer be required. ■

Computer software for service center management

By Conrad Persson

A year ago, we published an article on the subject of computer software for managing a consumer electronics service center. In addition to the general run of extremely useful software for personal computers, such as spreadsheet, word processing and data base programs, that article described the kinds of service center management software that were readily available at that time. In this rapidly changing world of technology that we live in, a lot can change in a year. In this article, we'll be providing a brief description of the software described in last year's article, and in addition we'll outline some of the other kinds of software recently made available that makes the lives of service center managers still more pleasant and productive.

The computer as manager

As the world has become more complex, technology has developed products to help us handle that complexity. One of the most important tools of today is the personal computer. All kinds of businesses are finding that computers can help with day to day administrative chores. For starters, spread sheets, one of the first classes of programs to really make the computer a useful tool of the small business owner allowed him to easily perform masses of calculations and perform "what if" comparisons.

Since that time, a number of good word processor programs have come along that reduce the chore of preparing correspondence, and in some cases, virtually automating the preparation and mailing of letters and other paperwork.

Persson is editor of **ES&T**.

Another very useful class of general-purpose software is data base management software. This type of software allows the user to maintain masses of data, such as lists of customer names, addresses and phone numbers and business that these customers have represented in the past. A good data base program will allow someone who is well versed in its operation to analyze the data it contains in an almost endless number of ways.

For example, you could ask it to give you list of customers in a particular zip code, along with the amounts spent by customers there, or, conversely, you might ask for a list of customers who have had projection TVs and/or camcorders serviced by zip code or telephone exchange to see where your more affluent customers are concentrated. With a good database program, your ability to access and analyze data are limited only by your imagination and fluency with the program.

Service center management

Unlike these general-purpose computer programs, service center management software provides support for the servicing facility in just about every aspect of the business. With one of these packages, when a product is brought in for service you enter the customer's information and the nature of the complaint. If this is a repeat customer you may just have to type in his phone number, and the rest of the information is brought up automatically from the computer data base.

Here's a rundown of some of the features of a software product that provides a broad range of service center management capability. Because software such as this can vary considerably in its usefulness, depending on the particular needs and management style of the managers, we recommend that before making a commitment to purchase such a system that you compare the features and ease of operation of several packages.

Job tracking/scheduling

As the customer's job information is entered into the system, the computer automatically creates a job ticket and stores the information. Now you can do several things:

- Easily handle customer phone inquiries. Just enter the customer's phone number or name and the job information is on the screen.
- Instantly access a job's current status just by supplying the appropriate code number.
- Get detailed job status information.
- Maintain a complete history of each unit by serial number or by customer number.
- A summary schedule lets you see the whole day's schedule at a glance.
- You can do scheduling by territory.
- Obtain a printout of both technician routing sheets and a management summary sheet.

Inventory management

The inventory program gives you the individual parts movement by the month, cross reference data, prices, quantity and a re-order report. By checking the movement record, you can adjust quantities ordered to make sure you have adequate inventory of parts without being stuck with a large inventory of slow-moving parts. By coupling this information with manufacturer's shipping time, you can order replacement parts early enough to cut down on back orders.

Invoicing

With some programs, you may enter repair descriptions and labor pricing ahead of time. The information is then on record allowing you to automatically invoice by making number selections for repair descriptions and labor prices. In addition, this program segment allows you to print both customer and standard NARDA invoices and to automatically print post cards informing customers of the status of their unit.

Codes and tables

User-defined codes and part pricing tables let you customize your system and speed up data entry. All the technician needs to do is to press a special key to see the list of possible code entries. They include codes for unit types, brands, manufacturers, technicians, status of jobs; e.g., parts on order or estimate, customer approval, return shipping method, sales taxes, vendors.

Forms and reports

A service management software system can save you time and money in several ways by doing much of the paperwork for you. First, a valuable technician will have to take less time away from repair work to do paperwork. Second, you only have to enter the customer data once. After that, the computer will automatically generate the information in the proper format to match your different forms. Finally, the various computer generated reports allow you to see where your money is going and how fast. Some of the forms and reports that are available are: management reports, such as daily work in process report, work completed not picked up, technician unit report, technician productivity report, production detailing report, job tracking/scheduling. Also available are invoicing reports, warranty and service literature information and inventory management.

Yet more computer help

As wonderful as these computer programs are, one thing is absent from their capabilities: input from and communication with the manufacturers. At least two systems now include communication with the manufacturers as part of their features.

For example, one such system, OASIS by KeyPrestige, provides information from subscribing manufacturers to service centers. Once a manufacturer subscribes to this system, a manufacturer's specific data base is created and continually maintained, Service centers can access this data and obtain information on claims, parts availability and pricing, technical bulletins and more, as authorized by the subscribing manufacturer. A service center that wishes to access this system only needs to have a PC and the appropriate communications software.

When the user connects with the central source mainframe, they instantly have access to all authorized information. The screens are all

Service management software companies

Active Software
1208 Apollo Way, Suite 507
Sunnyvale, CA 94086
408-732-1740

America West C&E, Inc.
311 Washburn Drive
Rock Springs, WY 82901
307-382-5663

Applied System Technologies, Inc.
100 Highpoint Drive
Chalfont, PA 18914
215-822-8888

Automated Systems, Inc.
PO Box 6142
4827 Pioneers Blvd., Suite 100
Lincoln, NE 68506
402-489-2717

Advanced Technology Group
205 Regency Executive Park Dr., Ste. 306
Charlotte, NC 28217
704-521-8113

Computer Transaction Systems
58 Lochmere Ave, PO Box 56
North Weymouth, MA 02191
617-331-6968

Core Software, Inc.
26303 Oak Ridge Drive
Spring, TX 77380
713-292-2177

The DATA Group
77 South Bedford Street
Burlington, MA 01803
617-272-4100

IBM Corporation
Wholesale Distr. & Services Industry
P.O. Box 2150
Atlanta, GA 30055
404-238-2126

KeyPrestige, Inc.
11605 Knott Avenue, Suite B
Cypress, CA 90630
714-893-1111

Magic Solutions, Inc.
180 Franklin Tpk.
Mahwah, NJ 07430
201-891-6383

Mini Computer Software Specialists
200 Executive Drive
Brookfield, WI 53005
800-543-2130

Service Control System II
National Electronic Servicing Dealers Association
2708 W. Berry Street
Ft. Worth, TX 76109
817-921-9062

Ogment Group
PO Box 781
Lafayette, CA 94549
415-284-4142

Professional Business Systems Company
490 #F West Arrow Hwy.
San Dimas, CA 91773

Sidon Data Systems
18007 South Mitchell
Irvine, CA 92714
714-553-1131

Soft-Serve
7042 Marco
Pontiac, MI 48054
313-334-8115; 800-458-6909

menu driven and easy to use, and on-line help is available, according to the company.

Current menu options

A user can make as many or as few inquiries as desired with each dial-up session. Status can be checked with one or several subscribers on the following items:

Claims - A user can inquire about the status of claims. Included in this screen is all the necessary claims information. A window at the bottom of the screen will display any additional information that is applicable, including any reason for rejection or non-payment.

Parts - This screen will display part numbers, descriptions, availability and applicable prices.

Bulletins - This feature offers users technical information to assist in repairs. Users can order bulletins or print them in-house while on-line.

According to the manufacturer, options that will be added to the software in the future are parts ordering, electronic transmission of warranty claims, special announcements, and more.

Electronics service management system (ESMS)

Another provider of software for consumer-electronics service management is IBM. According to that company, their new product is a new software offering for small- to medium-sized independent consumer electronics service centers. The software is intended to speed and simplify operations by allowing repair shops to communicate directly with various manufacturers from their personal computers in order to process warranty claims, order parts, deliver pricing and technical information. In addition, says the manufacturer, ESMS provides important service center management applications, such as work order processing, parts inventory, cash drawer, customer letters and technician evaluations.

This software, available either separately or in conjunction with an IBM PS/2, can operate on a single PC or in a local area network with several connected personal computers supporting multiple users. Service centers will communicate with manufacturers via the IBM Information Network.

A caveat

A service management system won't make your business run any smoother all by itself, any more than an oscilloscope will diagnose a problem in a product. It's a tool. You have to learn how to use it and teach other people in your business how to use it. And you have to use it consistently and correctly.

One other comment: these systems are probably not for every servicing facility. A low-end system, software only to run on your own PC may cost several hundred to over a thousand dollars. A high end system for a large shop, software or software and hardware, may cost several thousand dollars. On the other hand, if a shop is large enough to use one of these systems, and the people who will use it are dedicated enough to making it work, the benefits may well far outweigh the cost. ■

dB or not dB, that is the question

By Jud Williams, CET

Probably the most important measurement to be made when you're trying to determine if a problem lies in the cable system or the TV is signal strength. Fortunately a very simple system was established for the telephone companies some time ago which applies to cable and MATV: the decibel.

The interesting thing about this measurement system is that it deals in relationships some of the time and absolutes the rest of the time. This leads to some confusion, which certainly needs clarification. We refer, of course to the designation dB versus dBmV.

Let's explore the dBmV first because it deals in absolutes similar to using a regular voltmeter. In fact, when measuring in dBmV (decibel-millivolts) we are measuring voltage. This voltage is different from the usual concept of voltmeter measurements in that it is used only in the case of 75Ω cable.

This contrasts with the normal voltmeter since it doesn't matter what the source of the voltage is, although in order to make a measurement using a standard voltmeter, the impedance (or resistance) of the circuit being measured must be something less than the input impedance of the meter being used. This is necessary so that the meter does not load the circuit under test, thus producing an erroneous reading.

Establishing a reference level

We said earlier that dBmV measurements are used in systems that have a constant impedance of 75Ω. Back in the early days of TV, it was established that the reference level 0dBmV would be a potential of 1mV measured across 75Ω. It was felt that such a signal level would produce a noise-free signal at the input of a standard TV receiver. If the signal were less than 1mV, there would be traces of noise detectable on the TV screen.

Instead of constantly referring to voltage levels in a cable system as so many mV or μV of signal, we use a meter that reads in dBmV instead. The reason this is so convenient is that by making our reading in dBmV we are in effect saying that the signal level is twice as much as our reference, or maybe half as much as our reference, or some other multiple of the reference.

As an example, let's say that we are measuring a signal level of 6dBmV. That is, in fact, twice the voltage of the 0dB reference level referred to earlier. If our meter tells us that a particular signal level is 20dBmV, then it is telling us that it is ten times greater than 0dBmV. See how simple it is to determine how much greater a signal is by using terms such as twice as great, or ten times as great as some other value.

It's similar to the manner in which air speed is measured these days. We hear that something goes as fast as the speed of sound (Mach 1). Then we hear of something that travels at twice the speed of sound (Mach 2). That's similar to saying that the speed of sound is 0dBmph (dB-miles-per-hour) and twice the speed of sound is 6dBmph. If something were to travel at half the speed of sound we would of course say that it was traveling at −6dBmph.

So it is with cable system measurements. We can go either plus or minus, and the concept is still the same. We talk about something being twice as great, or half as great, and we know that we are saying + or −6dBmV.

Some other examples of dBmV equivalents are:

- 6dBmV = twice as great
- 12dBmV = four times as great
- 18dBmV = eight times as great
- 20dBmV = ten times as great
- 40dBmV = 100 times as great
- 46dBmV = 200 times as great.

Note that by adding 6dBmV to 40dBmV, we can see that 46dBmV is twice as great as 40dBmV.

So there you have it. Using dBmV to calculate gain and loss is really simple when you take a moment to reflect on it. By the way, when we use this chart for determining the amount of gain or loss for dBmV, the same applies for dB.

Remember, we have been talking about a concept that has a reference, so that we always were talking about dBmV being derived from the absolute of 1mV measured across 75Ω.

Relative measurements using dB

Now we will go to the ordinary dB, or decibel. When we eliminate the mV from dBmV, we are left with a rather different concept. We are no longer working with an absolute value such as used in measuring potential (voltage).

We are now going to think in terms of gain or loss. We know that when we talk about amplifiers, we are referring to devices that amplify, or have gain. When we talk about a passive device such as a splitter, we are talking about loss. Loss in this case means that the signal on the output of the device is less than on the input. The question is "how much gain or loss does a certain device have?"

Here's where the dB comes into play. Let's say we are confronted with a situation where we have −20dBmV of signal at a certain point. Note that we said dBmV here. And let's say that we need +20dBmV. It is easy to see

Williams is owner of Performance Technological Products, a company that manufactures and services products used by the cable TV industry.

that we need an amplifier that has a gain of 40dB.

From the example, we see that we are talking about the gain as being the amount needed to make up for the loss we have at this particular point. Determining the required gain becomes simple addition. The amount of gain required to go from −20dBmV to +20dBmV is 40dB.

Using dB to determine amplifier gain

Let's look at another example. Often when designing a 75Ω system, we begin at the final destination of the system. By definition, the final TV set to receive a signal needs a 0dBmV level to have a noise-free picture. Here we make our measurement in terms of dBmV to determine the required voltage level at this point. The TV is connected to a tap by a length of cable that presents a loss of so many dB. The tap itself has what is called insertion loss, also measured in dB. The length of trunk cable between the tap and the closest amplifier has losses, designated as dB. The amplifier has a particular gain, also specified as dB. The signal at the amplifier would be measured as so many dBmV.

So now we have two points where it is relevant to know the signal level in absolute terms, so we use dBmV. The difference between these two dBmV level readings indicates the loss that takes place between the amplifier location and the TV. The loss may be determined by subtracting the reading at the TV set from the reading at the amplifier. If the level at the set is less than 0dBmV, then we know that the gain of the amplifier must be adjusted to bring it up to that level.

If, for example, the level at the set is −6dBmV, then we know that the amplifier must be adjusted sc that it will have 6dB more gain. If there is enough excess gain in the amplifier, replacing the existing attenuator pad with one with 6dB less loss should rectify the problem.

But is it really necessary to know that 6dB is twice as great a gain or loss? Maybe not. What is important is that we know that by simple addition and subtraction we can determine what is needed to set levels properly. ■

Dealing with decibels without using logarithms

By Lambert C. Huneault, CET

The equation that defines decibels is dB = 10 log (P1/P2). For some reason or other, this formula although really simple scares a lot of technicians away. And many students too, as 26 years instructing in electronics has taught me. It seems that the logarithms are the dreaded part; therefore, rather than force feeding logs to people who don't want to deal with the mathematics, we're going to try to explain decibels (dB) in a more palatable way: without any gourmet math at all!

So hop aboard as we embark on this journey into the realm of decibels, a field which far too many newcomers and oldtimers find intimidating. The vehicle we'll use is simplicity itself: multiplication by 2 and division by 2. We'll keep everything simple, all the way.

Bels and decibels

Named in honor of Alexander Graham Bell, the inventor of the telephone and other sound devices, the bel is a little too large a unit for many practical purposes, so we normally use its smaller offspring, the decibel. 1 bel = 10 decibels. Decibels are very handy and useful in expressing sound levels and power ratios. For example, if the power of a signal at the output of an amplifier is 50 times greater than the power of the signal at the input, the amplifier is said to have a gain of 17dB. If the sound level (audio power) produced by loudspeaker A is 100 times greater than that produced by speaker B, we say that there's a difference of 20dB between them. And if the power of a signal at the output of a transmission line is 1/4th the power level of the signal at the input, the line is said to produce a 6dB attenuation or loss.

Now how in the world did we arrive at these dB figures? One way would be to figure out the common logs of the power ratios using either a calculator or log tables, and apply the formula stated at the beginning of the article; but that would be cheating, wouldn't it? After all, this article is titled "Decibels Without Logarithms!"

The easy way

So here's how we're going to do it. Let's start with a couple of essential facts of life we need to remember: every time we double the power, we increase the decibels by 3; and if the power is increased by a factor of ten, it so happens that the decibels also go up by 10. These two basic relationships are a direct consequence of logarithms, but who cares? However, because they are important building blocks, these facts need to be displayed and remembered. So we've got them neatly framed for you in Table 1. Easy enough so far.

Next, let's expand that table a little... the easy way. Starting with the premise that doubling the power increases the decibels by 3, how many dB do we end up with if we increase the power by a factor of 4 instead of 2? Well, 4 being twice as big as 2, we simply add another 3dB, so we end up with 6dB as shown in Table 2. That wasn't hard now, was it?

If we once again double the power ratio, making it 8 instead of 4, we add still another 3dB, making it 9 instead of 6. See Table 3.

Now that we're getting the hang of

Huneault, now retired, was an electronics instructor and head of the REE department at St. Claire College of Applied Arts & Technology in Ontario, Canada.

POWER RATIO	dB
10	10
2	3

Table 1

POWER RATIO	dB
10	10
4	6
2	3

Table 2

POWER RATIO	dB
10	10
8	9
4	6
2	3

Table 3

POWER RATIO	dB
64	18
32	15
16	12
10	10
8	9
4	6
2	3

Table 4

POWER RATIO	dB
100	20
64	18
32	15
16	12
10	10
8	9
4	6
2	3

Table 5

it, let's continue doubling the power ratio from 8 to 16, 32 and 64; adding 3dB each time, we get 12, 15 and 18 decibels, respectively. This is shown in Table 4.

This doubling of the power ratio and adding 3dB each time is kid stuff, isn't it? So let's get really brave now and tackle the big stuff! Remember the other essential fact noted above, i.e. increasing the power tenfold results in an increase of 10dB? Well, using that principle, let's multiply the power ratio of 10 by a factor of ten, making it 100. This gives us 10dB more than the 10dB previously shown in Table 1; thus a power ratio of 100 corresponds to 20dB, as shown in Table 5. Note that our table is gradually getting bigger, as we keep adding a few new numbers to the ones already in there.

Likewise, we could keep on multiplying power ratios by 10 indefinitely, adding 10dB each time, and we'd get results such as in Table 6. But let's not get carried away!

Instead, let's get back to Table 5 and turn it around so that the dB column is on the left. This gives us Table 7, a mirror image.

POWER RATIO	dB
1000000	60
100000	50
10000	40
1000	30
100	20
10	10

Table 6

dB	POWER RATIO
20	100
18	64
15	32
12	16
10	10
9	8
6	4
3	2

Table 7

dB	POWER RATIO
20	100
18	64
17	50
15	32
12	16
10	10
9	8
6	4
3	2

Table 8

Stating the obvious

If adding 3dB corresponds to doubling the power, it follows that subtracting 3dB must be equivalent to reducing the power by half. Even math-shy technicians should have no problem with that! O.K. then, let's start at the top of Table 7, where 20dB equals a power ratio of 100. If we subtract 3dB from 20, the resulting 17dB obviously corresponds to a power ratio equal to half of 100, i.e. 50. This is shown in Table 8.

In a similar manner, let's keep subtracting 3dB from 17 on down, each time cutting the corresponding power ratio by half. The resulting 14, 11, 8, 5 and 2dB give us power ratios of 25, 12.5, 6.3, 3.2 and 1.6, respectively. Note that power ratios are rounded off to the nearest single decimal, to keep things simple. The results are shown in Table 9.

The dB column in that table shows that so far we've done a pretty good job of filling in most of the numbers between 1 and 20. But the table isn't quite complete without the few missing numbers, so let's not quit just yet.

Up and down

Starting in the middle of Table 9, where 10dB corresponds to a power ratio of 10, let's move in both directions, increasing decibels in steps of 3 on the way up, i.e. 13, 16 and 19dB; and decreasing decibels in similar steps of 3 on the way down, giving us 7, 4 and 1dB. The corresponding power ratios are thus 20, 40 and 80 on the way up, and 5, 2.5 and 1.3 on the way down, as shown in Table 10. Of course 0dB means no change, i.e. a power ratio of 1:1.

Well what do you know?... we've done it! We've figured out all the corresponding power ratios from 1 to 20 decibels without the help of a slide rule, calculator or log table. I wonder how A.G. Bell would feel about that!

dB	POWER RATIO
20	100
18	64
17	50
15	32
14	25
12	16
11	12.5
10	10
9	8
8	6.3
6	4
5	3.2
3	2
2	1.6

Table 9

Table 10 reveals at a glance that decibels and power ratios do not have a linear relationship; that's because logarithms are not linear to begin with, as any log table or logarithmic graph paper will show you. But that's neither here nor there. The important thing is that, should you ever need it, Table 10 can easily be recalled or reconstructed without any mathematical skills, books or calculators. Now that we've got the table, let's put it to work for us in a few practical applications.

Practical examples

Problem 1: Suppose that the output power needed in a particular application is 80W but the signal available to us has a power of only 2W. Obviously, we need an amplifier. How many decibels of gain should this amplifier feature? Solution: The ratio between output and input powers is $80/2 = 40$. So, we simply look up that ratio in Table 10, and find that 16dB corresponds to it. Therefore we need a 16dB amplifier. If we were to solve this problem accurately, by means of logarithms, we'd get an answer of 16.020599dB. In truth, then, we must confess that Table 10 is not absolutely, perfectly accurate; but who cares about two one-hundredths of a dB anyway?... especially since a change in sound level of less than one dB cannot be detected by the human ear in the first place!

dB	POWER RATIO
20	100
19	80
18	64
17	50
16	40
15	32
14	25
13	20
12	16
11	12.5
10	10
9	8
8	6.3
7	5
6	4
5	3.2
4	2.5
3	2
2	1.6
1	1.3

Table 10

dB	POWER RATIO
40	100
38	80
36	64
34	50
32	40
30	32
28	25
26	20
24	16
22	12.5
20	10
18	8
16	6.3
14	5
12	4
10	3.2
8	2.5
6	2
4	1.6
2	1.3

Table 11

Problem 2: A signal suffers a loss of 25dB as it travels along a long transmission line. If the power level of the input signal is 1.6W, how much power is available at the output of the line?

Solution: Look up 25dB in Table 10. What's that, you say?...The table only goes up to 20dB?... No problem! Simply look up 20dB and 5dB (for a total of 25dB) and multiply their corresponding power ratios (100 and 3.2). 100 X 3.2 = 320. Thus the output signal is 1/320th of the input signal, i.e. 1.6W/320 = 0.005W, or 5mW. Using logarithms and precise calculations, we'd get an answer of 5.0596mW, so once again the difference is no big deal. Incidentally, Tables 10 and 6 can be combined to figure out the relationship between any dB figures and power ratios, big or small.

dBm

Although decibels are commonly used to express power ratios,they are sometimes used to indicate actual power levels. In such cases, the specific power level is compared to an arbitrarily chosen reference power which is given a value of zero dB. A reference power commonly used in the industry is one mW, and decibels used to express power levels relative to this reference are usually called dBm (m for milliwatt). Therefore 0dBm = 1mW. Powers above 1mW are assigned positive dBm values, while powers below 1mW are expressed as negative dBm numbers.

Problem 3: How much power does + 12 dBm represent?

Solution: Look up 12dB in Table 10; the corresponding power ratio is 16. Therefore the actual power is 16 times greater than the 1 mW reference, namely 16mW. Simple, isn't it?

Problem 4: How many dBm correspond to a power level of 250μW?

Solution: Because 250μW (0.25mW) is 1/4 of 1mW, the power ratio is 4. Table 10 shows that the corresponding number of decibels is 6. Therefore 250μW can be expressed as −6dBm, i.e. 6dB below one milliwatt.

Voltage ratios

Decibels can be used to express voltage ratios as well as power ratios. There's only one minor fly in the ointment: for voltage ratios, the formula becomes $dB = 20 \log (V1/V2)$. Note the multiplier 20, instead of the 10 used with power ratios. You can blame that on the well- known relationship between power and voltage: $P = V^2R$. But enough said about math.

The important thing to remember is that dB values are twice as high when used with voltage ratios. For example, doubling the voltage corresponds to a gain of 6dB, not three; ten times the voltage equals 20dB, not ten; and so forth. Table 10 can easily be converted from power ratios to voltage ratios by applying this two-for-one principle, i.e. by doubling all the dB values. It then becomes Table 11. For dB values in between those shown, we can interpolate fairly accurately. For example, 19dB is equivalent to a voltage ratio of 9; 31dB corresponds to a voltage ratio of 36; etc... Since 6dB corresponds to a voltage ratio of 2, a voltage that's down by 6dB on the side of the response curve of a TV receiver's if section, for example, is obviously equal to only half of the reference voltage, say at the top of the curve.

dBmV

Just as dBm values are used to express actual power levels relative to one milliwatt, dBmV values can be used to express actual voltage levels relative to one millivolt. Thus 0dBmV = 1mV. This industry standard is measured across a 75Ω impedance.

Here's an example: If the signal picked up by a TV antenna is 10mV (10,000μV), this voltage can be expressed as 20 dBmV because 20dB corresponds to a voltage ratio of 10:1. In other words, 20dBmV is 10 times greater than the 1mV reference. Now, if the 75Ω cable feeding the antenna signal to an MATV amplifier introduces a voltage loss of 12dB, but the amplifier has a gain of 18dB, we end up with a voltage of 26dBmV at the amplifier's output (20 - 12 × 18 = 56). That's what so great about decibels... they can simply be added or subtracted. But what level of signal voltage does that 26dBmV represent? Well, look up 26dB in Table 11, and you'll find that it corresponds to a voltage ratio of 20:1. Therefore the output voltage is 20 times greater than the 1mV reference, namely 20mV (20,000μV).

A Shakespearean ending

So there you have it... decibels the painless way— without logs! If you remember the extremely simple method of constructing Tables 10 and 11 demonstrated in this article, the next time you are faced with a decibel problem but are caught with your calculator down, you won't have to panic or even hesitate, unlike the technician who, faced with such a problem, allegedly pondered: "dB or not dB, that is the question!" ■

Test your electronics knowledge

By Sam Wilson

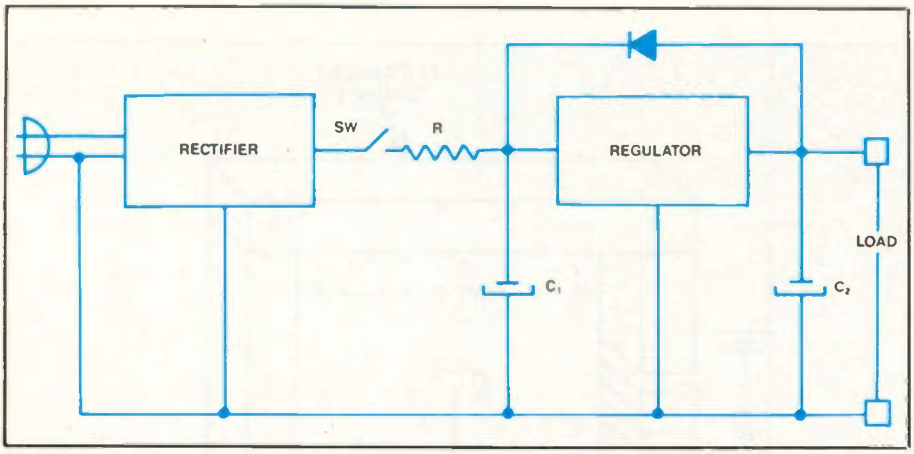

Figure A.

1. The diode in the circuit of Figure A
   A. Protects the rectifiers
   B. Protects the regulator when the switch is first closed
   C. Protects the regulator when the switch is first opened
   D. (None of these choices is correct)

2. The resistor (R) in the circuit of Figure A
   A. Protects the rectifiers
   B. Protects the regulator when the switch is first closed
   C. Protects the regulator when the switch is first opened
   D. (None of these choices is correct)

Wilson is the electronics theory consultant for ES&T.

3. What is the Shakespeare quote represented by the circuit in Figure B (Hint: determine the output of the circuit)

4. You would expect to find a cascode circuit in
   A. A low-frequency circuit
   B. A high-frequency circuit

5. Draw a test setup for measuring the voltage across a dry cell that does not draw current from the cell. Do not use an electrostatic voltmeter.

6. Draw a test setup for measuring the internal resistance of a dry cell without using the short-circuit current. Do not use an electrostatic voltmeter.

7. Two quick checks of an audio amplifier use square waves and triangular waves. One advantage of using triangular waves is that they are made of all harmonic frequencies. The square wave is made only of odd harmonic frequencies. What is another advantage of using a triangular waveform for the test?

8. When the switch in the circuit of Figure C is closed, the lamp will be
   A. ON, and OFF when the switch is open
   B. OFF, and, ON when the switch is open
   C. (Neither choice is correct. The transistor is useless.)

9. All radios have at least four sections. They are
   A. Some type of antenna system
   B. A method of selecting one signal and rejecting all others
   C. A method of reproducing the intelligence
   D. And ____________.

10. Here is an easy one. Who was the first person to send a radio message in the United States?
   A. Hertz
   B. Marconi
   C. Bell
   D. Edison

(Answers on page 58)

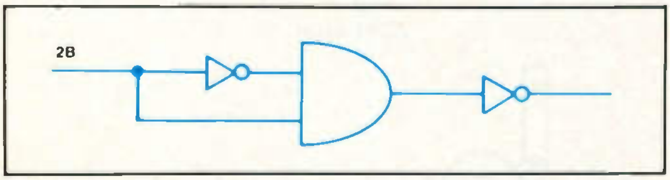

Figure B.

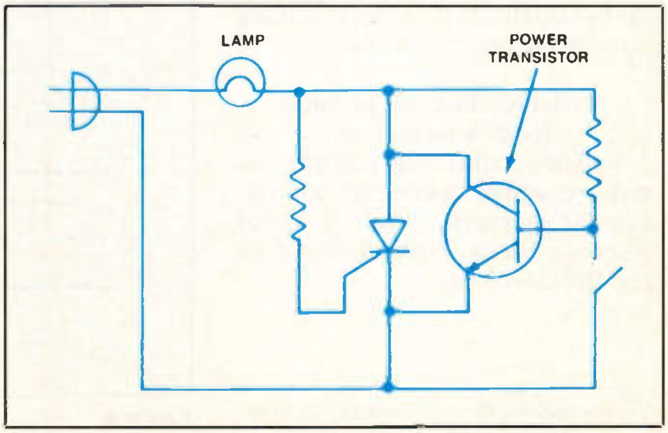

Figure C.

More about magnetic flux

By Sam Wilson

The practice of describing magnetic flux in terms of lines may have started from a simple experiment that is often performed in grade school science classes. A sheet of white paper is placed over a magnet. Iron filings are sprinkled over the paper. The filings arrange themselves in lines connecting the north and south poles of the magnet.

These lines—called flux lines are actually lines of equal magnetic intensity. If you placed a unit north pole at the north pole of a magnet it would move along one of the flux lines.

Well, that is what the theory says. No one has ever been able to produce a unit north pole. It is an invention of the scientists for measuring and explaining magnetism.

I will now discuss some examples of electromagnetic devices that cannot be easily explained by flux lines cutting conductors. This does not alter the theory of devices already discussed.

You need to know that the idea of flux lines cutting through conductors to induce voltage is actually a model used to describe various aspects of magnetism. It is a convenient way of describing induced voltages and other magnetic and, (electromagnetic) effects. Be that as it may, it is used extensively in advanced theory discussions. In the following discussion a different model is used. It describes the process of inducing a voltage by visualizing flux lines threading through the center of a coil.

Variable reluctance pickups for disk recordings

Variable reluctance pickups for disk recordings operate by controlling the magnetic flux in a closed magnetic circuit. Figure 1 shows the principle involved.

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

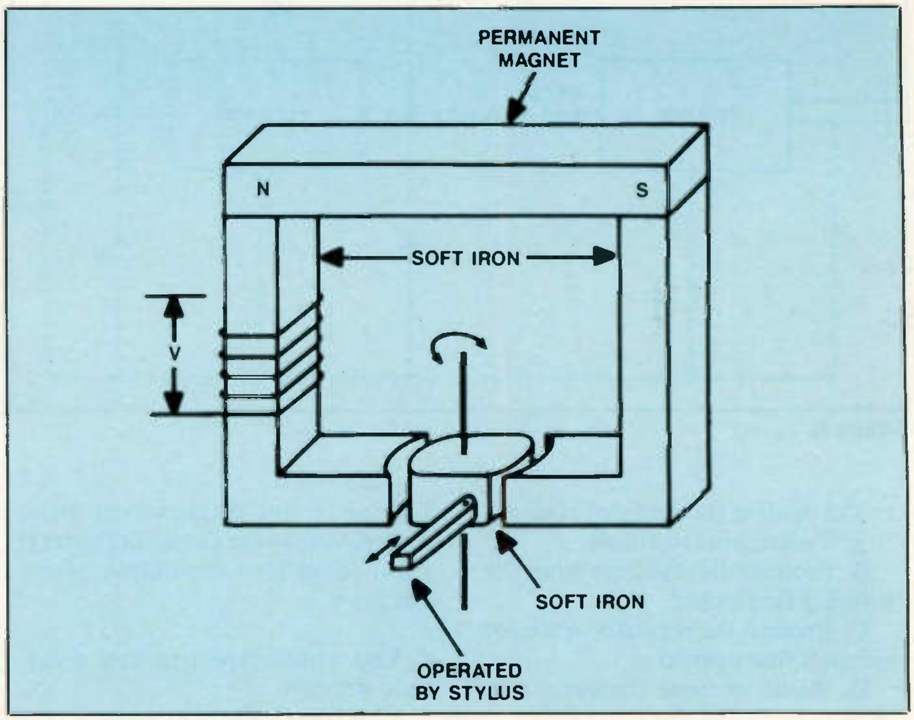

Figure 1.

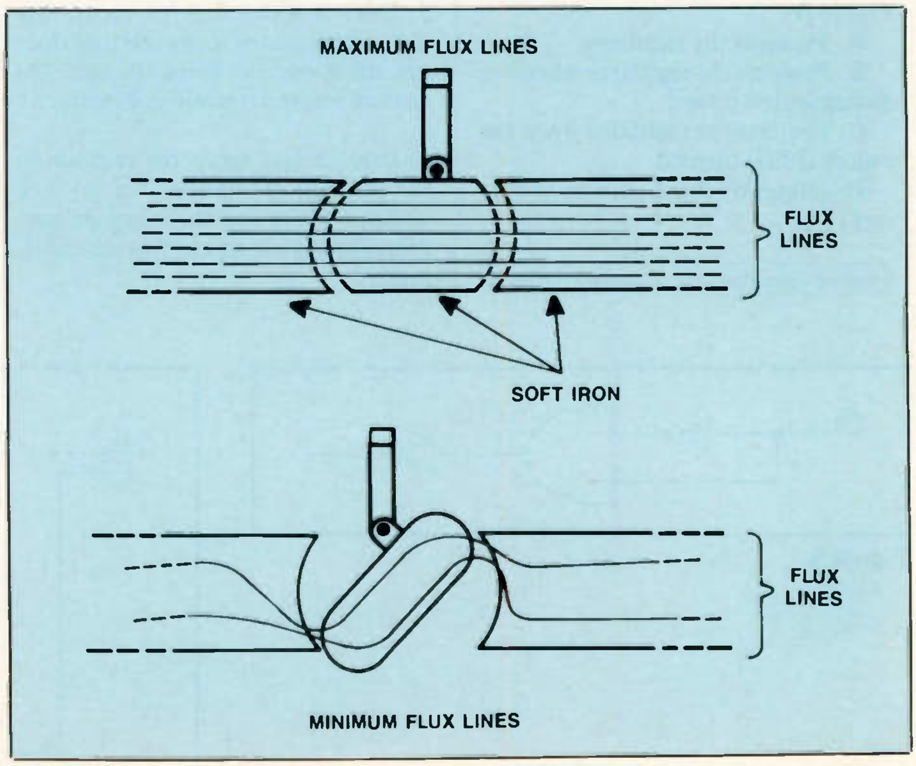

Figure 2.

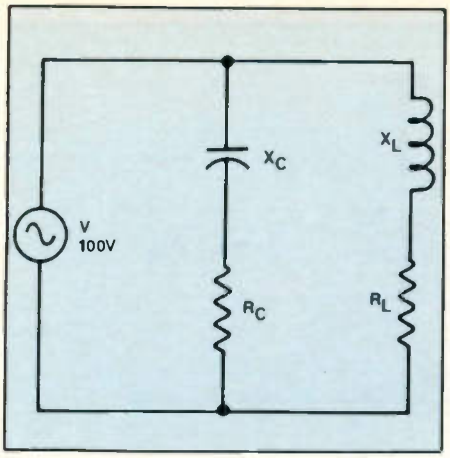

Figure 3.

The permanent magnet supplies the flux for operating the device. The soft iron magnetic circuit is made of soft iron bars and a movable soft-iron insert in the gap of the magnetic circuit. The movable insert can be positioned as shown in the bottom view of Figure 2.

The coil in Figure 1 produces an output voltage that varies with the flux. The soft iron slug is moved by a stylus following a record groove.

Changing the reluctance of the circuit controls the amount of flux through the coil. It is presumed that all of the flux lines are in the magnetic circuit. In other words, there is no flux leakage.

Using the concept of flux "threading through the center of the coil," the voltage is induced by changing the amount of flux in the coil center.

Note, however, that the flux actually circles the coil. Increasing the flux can be presumed to have occurred by the flux having moved outward—from the center—through the turns of the coil.

You should know about Carpal Tunnel Syndrome

This article is not about the effects of CRT low-frequency electromagnetic radiation (meaning the cathode-ray tube used for computer and word processor display). I have been studying that subject for some time, but I am not yet ready to go into a full-blown discussion.

This is about another health problem associated with the use of computers and word processors. It is called Carpal Tunnel Syndrome (CTS). It is a problem for all types of display including CRT, liquid crystal, and any other kind that may be used. The symptom is a very painful inflammation of tendons, blood vessels and ligaments in the forearm and hand. It is caused by the repetitive misuse of the arms and hands when you sit for hours at the computer or word processor.

This syndrome was called to my attention by my good friend Dr. Ron Weinstein. Dr. Weinstein is a great help to me when I am looking for scientific backup of articles for this column. His doctorate is in mathematics, and he is very knowledgeable on all science subjects.

We were discussing the possibility of danger to computer users caused by electromagnetic radiation. He called my attention to the fact that there is another problem—CTS—associated with people who sit for long hours at a computer or word processor.

CTS is a very serious problem. It causes terrible pain and it requires a long period of recovery. The best "cure" is to know about it and avoid it.

Here are some suggestions by the experts.

- Get your CRT directly in front of you so that you don't have to sit for long periods with your head at an angle. You should be looking straight ahead at the CRT.
- Your keyboard should be positioned so that your forearm is parallel with the floor. Your fingertips should be in line with your forearms.
- Don't hunch your shoulders over the keyboard. Be in a relaxed upright position.

CTS is classified as a soft-tissue disorder. Today, such disorders account for almost 40% of worker compensation claims.

Additional explanation of parallel resonance

Recently I received an informative letter from Mr. Cliff Watkins of Depoe Bay, Oregon. He calls my attention to the fact that in my discussion of admittance I apparently jumped over an important aspect of admittance. I will now clarify that point. The circuit of interest is shown in Figure 3.

Admittance is the reciprocal of impedance [$Y = 1/Z$]. Usually the Y and Z are written with a dot over each letter, or, they are written in some way that says they are complex numbers. Another way of writing the equation is:

$$Y = 1/[R \pm jX]$$

If you multiply the numerator and denominator of the right side of that equation by the conjugate of the denominator you get the correct meaning of admittance. The conjugate is the same impedance written with the opposite sign for the j term.

Using the case of a resistor in series with a capacitor, the equation is handled like this:

$$Y = 1/Z = 1/(Rc\text{-}jXc)$$
$$= [1/(Rc\text{-}jXc)]x[(Rc + jXC)/(Rc + jXc)]$$
$$= (Rc + jXc)/(Rc^2 + Xc^2)$$
$$= [Rc/(Rc^2 + Xc^2)] + j[Xc/(Rc^2 + Xc^2)]$$

The important thing about this equation is that Y is in two parts. The "real" part is called the *conductance* [G] of the circuit.

$$G = Rc/[Rc^2 + Xc^2]$$

That part of the admittance has nothing to do with resonance, so, I disregarded it in my previous article. The second part of the equation is called *susceptance* and is usually given the symbol B_C. Since I disregarded conductance (because it has nothing to do with resonance) I wrote Y_C and Y_L with only the "imaginary" parts of the equations.

It has been pointed out to me that the discussion would have been easier to understand if I had stated the requirements for resonance in terms of the susceptances—not admittances. Resonance occurs in a parallel circuit when the susceptance are equal:

$$B_C = B_L.$$

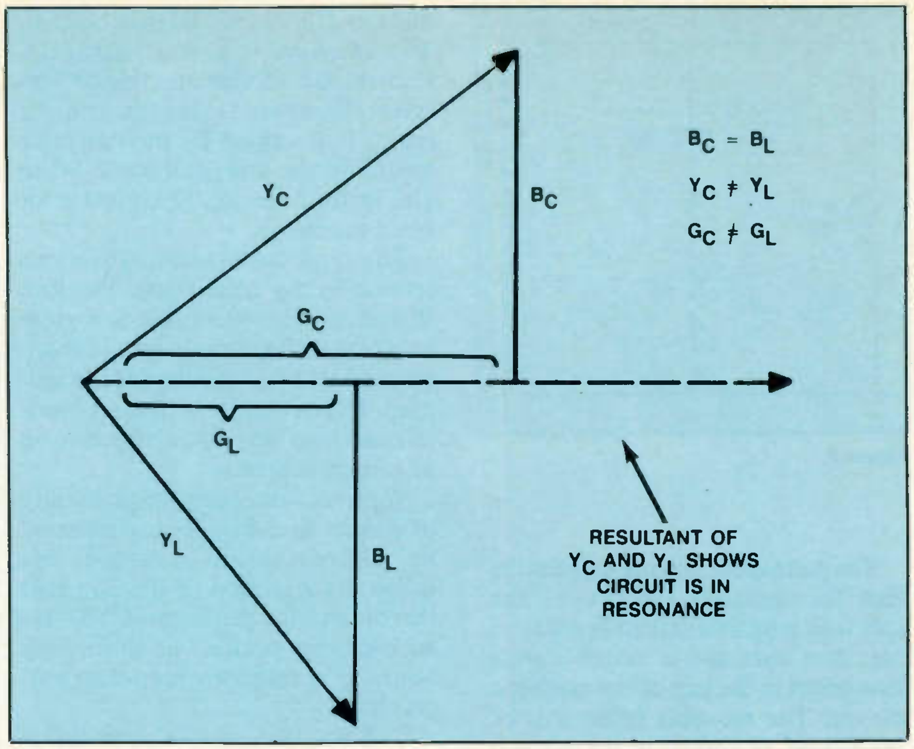

Figure 4

Actually, the parallel circuit of Figure 3 can be resonant even though the admittances are not equal, but, the susceptances must be equal. I have included a typical phasor diagram in Figure 4. Note that the conductances, susceptances, and, admittances are marked on the two admittance triangles. The admittances and conductances are not equal, but, the susceptances are equal. The resultant drawn for Y_C and Y_L shows that the circuit is in resonance.

What does all this mean about parallel resonance?

The circuit of Figure 3 can be in resonance *even though the currents in the branches are not equal!* The circuit can be resonant even though X_C does not equal X_L. The circuit can be resonant even though R_C does not equal R_L. The susceptance *must* be equal in order for the circuit to be resonant.

That point was not clearly stated in the September article. Thanks again to Mr. Watkins and others who reminded me that I skipped over that fact. The equations given in that article are correct. ■

Books

Electrostatic Discharge Protection for Electronics - By Neil Sclater; Tab Books; 240 pp; $29.95.

Modern circuit design technology continues to improve the power, speed, and compactness of virtually all electronic devices. The downside of these efforts to make products smaller and faster, however, is that today's electronic components are becoming more vunerable to overstress from electrostatic discharge (ESD). Popular high-tech devices such as CMOS and gallium arsenide ICs are much more sensitive to static buildup in manufacturing, testing, storage, shipping, and even on the job - where their failure is becoming increasingly costly both in property damage and in the health of employees. The book is a source of information for anyone involved in the production, packaging, distribution, or repair of electronic components and assemblies - as well as for providers of static-control products and equipment. Here, readers will learn about the origins and effects of ESD and what can be done to prevent dangerous static levels in the workplace. The author presents an in-depth survey of those devices, techniques, and shielding methods being used by many companies to combat this destructive phenomenon. Contents include static electricity, principles of electronics, electrostatic discharge damage mechanisms, semiconductor device, board and system protection, test equipment, personal protection against ESD and the complete ESD control program with appendices, references and glossary.

Tab Books, Blue Ridge Summit, PA 17294-0850.

Encyclopedia of Electronics Circuits-Volume 3 By Rudolf F. Graf, TAB Books; 832 pp; $29.95 paper, $60.00 hard.

The Third volume of the Encyclopedia of Electronic Circuits offers readers hundreds of all-new schematics for the latest electronic circuits from Motorola, Teledyne Instruments, and many other industry leaders. This collection of original circuits includes a meticulous index and cross-references. Readers will find more than 100 separate chapters, including complete descriptions of the latest alarm and security circuits, smoke, moisture, and metal detectors, capacitance, current, voltage and frequency meters, amplifiers, receivers and transmitters.

TAB Books, Blue Ridge Summit, PA 17294-0850.

Easy Electronic Projects for the 556 Dual Timer, By Delton T. Horn; TAB Books; 556 pp; $15.95 paper; $23.95 hard.

Almost all modern electronic devices include timer and timing circuits. In 49 Easy Electronic Projects for the 556 Dual Timer, the focus is on the theory and operation of the 556 dual timer, one of the most popular hobby-oriented circuits ever produced. Electronics expert Delton Horn provides hobbyists with a collection of interesting easy-to-build and useful projects divided into three categories: timing projects, signal-generator projects, and LED display projects. Readers will find detailed coverage of: multivibrator circuits, tone and wave generators, frequency dividers, relay drivers, LED flashers and extended range timers. Horn also includes a few "just for fun" projects, such as toy laser, electronic dice, and roulette wheel. All of the projects are inexpensive, and can be built in one evening. With this book, it's easy to understand why the 556 dual timer is the integrated circuit most electronics hobbyists prefer.

TAB Books, Blue Ridge Summit, PA 17294-0850.

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PANASONIC

2789-1 . . CLT-204R-1, CLT-2052-1, CLT-2053-1, (CH. ADP187)
2792-1 .... CTL-2061S (CH. AEDP177/GL7H2
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ZENITH

2790-2 .... SE2593W, SE2593Y, SE2799Y
2793-2 ...... SE2721H, SE27725R, SE2727H

Is the all-digital simulcast HDTV system the television of the future?

By the ES&T staff

The television set of tomorrow will be vastly different from today's thanks to HDTV. Unfortunately that will mean still more study for servicing technicians who want to keep up. Here's a description of one broadcast system that might be the basis of tomorrow's TV.

The color TV picture available with current technology is good. For those who remember the early days of monochrome TV, it's an almost unbelievable improvement. On the other hand, for those who've seen any form of high-definition (HDTV) system, the NTSC picture is relatively crude. Over the past several years a number of companies and agencies have been working on the development of an HDTV system. Here's a progress report on one such system.

Transmission system

The FCC plans to choose a "simulcast" system when it selects the U.S. Standard for HDTV broadcasts in 1993. That means that today's NTSC television stations will continue to broadcast as they do now. HDTV will be broadcast simultaneously on currently unusable channels, the "taboo" channels left vacant in today's TV system to avoid interference between channels.

Zenith pioneered the simulcast approach with its original digital-analog "Spectrum Compatible" (SC-HDTV) system. Recognizing the benefits of an all-digital approach, researchers at Zenith and AT&T went to work 18 months ago to enhance the SC-HDTV system by incorporating new digital techniques. Like the original SC-HDTV system, the new all-digital transmission system uses a low-power transmitter and signal processing steps to avoid interference into NTSC channels.

Low-power transmission eliminates HDTV interference into NTSC signals. With digital technology, eliminating interference from the strong NTSC signal into the weak HDTV signal posed a significant technical challenge.

Zenith's solution — digital filtering of HDTV and NTSC signals— makes it possible to reap the benefits of a full-digital HDTV system without compromises.

The new technology centers on a unique digital filter at the HDTV transmitter and a complementary filter in the HDTV receiver.

The digital filtering technique allows error-free reception of HDTV signals because interference from the standard television signal is virtually eliminated. Bothersome ghost images, common in some broadcast areas, also will be greatly reduced (if not eliminated).

As a result, a consumer with a high-definition television set will receive HDTV signals without interference from standard television broadcasts. Conversely, a neighbor using a conventional set will receive standard television signals without interference from HDTV. This interference-free reception will be achievable even

This article is based on information provided by Zenith Electronics Corporation.

in locations between two transmitters that are operating on the same channel and located in nearby metropolitan areas.

Today's television signals are plagued by "noise" and electrical interference from appliances and automobile engines. The Zenith/AT&T digital transmission is said to suppress such noise interference and offer a clear picture over the required geographic area for each station. Home VCRs will be able to record and play clear, noise-free videotape recordings.

Digital compression and algorithms

Another major breakthrough at the heart of the new all-digital HDTV system is a video compression algorithm developed by AT&T Bell Laboratories.

HDTV simulcast systems require "compression" of the high-definition signal so it will fit into a 6-MHz TV channel. HDTV systems using all-digital signals require significantly more video compression than their analog counterparts.

AT&T, which has had an active research program in digital video compression for many years, has devised a solution by designing an algorithm that builds on this research. AT&T's breakthrough has several unique features, including:

- Motion compensation—a sophisticated analysis of each television frame at the transmitter to prepare it for transmission, transferring much of the complexity to the encoder to simplify and allow a low-cost decoder in the HDTV receiver
- Adaptive quantization—based on a thorough understanding of the properties of the human visual system and the idiosyncrasies of the "taboo" channel.

The goal is HDTV picture quality so high that the compressed signal is as sharp as a studio original.

The AT&T algorithm, which has been combined with Zenith's compression technology, effectively handles frequent motion and scene changes typical of entertainment applications, such as full-motion, 60-frame-per-second live sports programming. Extensive simulations have confirmed the robustness to noisy pictures (e.g., old films) and to noise in the channel.

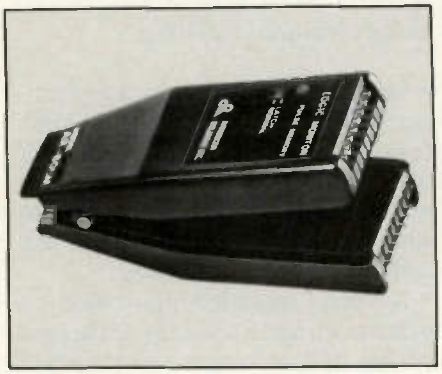
Digital signal processing

HDTV systems require a number of high-speed digital signal pocessors (DSPs) to perform specialized functions such as digital filtering, data decoding and formatting. For example, one of the DSPs developed by AT&T Microelectronics for prototype Zenith HDTV receivers performs about 4 billion operations per second, which is 1,000 times the speed of a typical desktop computer.

These performance levels can be achieved because the DSPs developed from HDTV are highly optimized to perform predetermined functions as opposed to the general purpose programmable devices used in computers and workstations. ■

High speed logic probes

American Reliance has released a pair of new, high-speed, logic probes. The 80LM is a 20MHz model while the 85 HLM is a 40MHz version. Each is a functional equivalent to 16 probes in a single unit. The probes in-

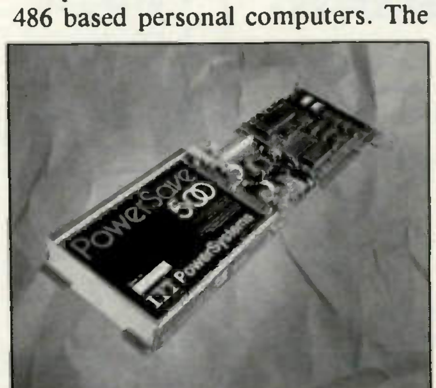


dications of high, low and pulsing inputs for digital ICs of up to 16 pins, and they automatically detect power and ground, and TTL and CMOS logic levels. A handy latch function detects and displays short-duration pulses and holds the indication until manually reset.

Circle (48) on Reply Card

Uninterruptible power supply unit for personal computers

ITT PowerSystems introduces the VIP PowerSave 500, an alternative to traditional uninterruptible power supply units for users of IBM and compatible XT/AT, 286, 386, and 486 based personal computers. The



unit installs entirely within the PC. In the event of a power interruption, PowerSave 500 instantaneously provides backup power, automatically saves a complete image of the PC state to disk, and safely shuts down the entire system. Once the ac power resumes, the device automatically restores the computer's state.

Circle (49) on Reply Card

Equipment cleaning wipes in reclosable pouch pack

New from *Staticide* is equipment cleaning wipes. They are ideal for use

on desks, office equipment, file cabinets, computer covers, telephones, work stations, lab equipment, whiteboards, parts, and tools. The ACL equipment cleaning wipe features a pop-up pouch pack with a reclosable label top. Each pouch contains 40 pre-moistened lint-free wipes.

Circle (50) on Reply Card

Portable inventory system

Percon now offers a unique hand-held portable inventory system-providing simple-to-use, off-line data entry. The system includes four customized inventory control programs

running on a Telxon hand-held computer. Combined this software and hardware system provides simple, reliable, off-line data entry. Users just take the unit out of the box, turn it on, and start scanning.

Circle (51) on Reply Card

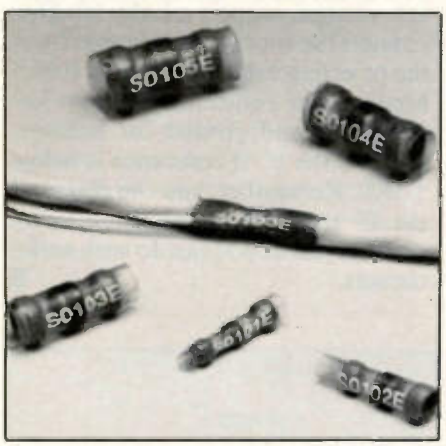
Universal cable tester

Nu Data a manufacturer of data communications and test equipment has announced the CableVision Model 9510 Universal Cable Tester. Housed in a rugged case and operating from internal rechargeable batteries or from the ac adapter, it can be used in the field or on the test bench. The 20 character by 16 row LCD screen shows the capable pin-outs just as they would be drawn, with connector and gender information in plain English. The serial port provides communications with a PC, a terminal or another CableVision tester. This allows backup and restore of cable configuration files as well as swapping files between CableVision testers.

Circle (52) on Reply Card

Heat shrink shield terminators

3M introduces a new one step cable shield terminator which provides an insulated, environmentally-protected strain-relieved solder termination that meets MIL-S-83519 specifications. 3M brand heat shrinkable shield terminators are available in five diameters, with or without preinstalled ground leads, per MIL-S-83519. The shield terminators produce secure solder connections in a



quick three part process: the outer sleeve shrinks, the solder preform melts and flows, completing the connection, the thermoplastic insert melts to provide a seal. A red thermochromic indicator is included in the solder flux. When sufficient heat has been provided for complete melting, it becomes colorless, thus helping the technician know the soldered joint is complete. The completed assembly provides thermal and electrical insulation, identification strain relief, moisture sealing and chemical protection.

Circle (53) on Reply Card

Digital clamp-on volt amp ohmmeter

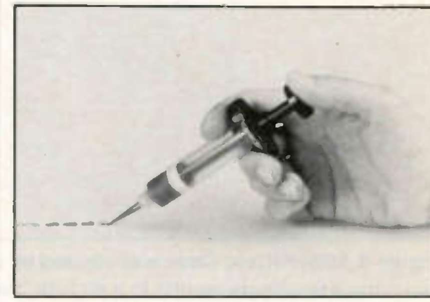
New from *Amprobe Instrument* is the model ACD-10 digital clamp on volt amp ohmmeter. The ACD-10 will directly measure ac current, voltage and resistance. It is only 6 3/4 in-

ches long, drop proof, has a large easy to read 1/2 inch display, autoranging and circuit protection up to 550 volts. It also includes a wrist strap and removable belt clip, maximum jaw opening 28mm/500mcm low battery indication and comes with battery, safety test leads and carrying case.

Circle (54) on Reply Card

New no-drip dispenser replaces hypodermic syringes

Specialty Products announces a new no-drip dispenser which replaces hypodermic syringes. The HP dispenser eliminates drip problems plus requires less push effort to dispense.



The HP uses specially molded zero draft barrels with a unique low friction insert piston. After filling the barrel, the molded piston can be easily inserted by just pushing it into the barrel. Because of the precise interface fit, no air is trapped. Unlike hypodermic syringes which are discarded after use, the HP dispenser is reusable, so only the inexpensive barrel and piston are discarded.

Circle (55) on Reply Card

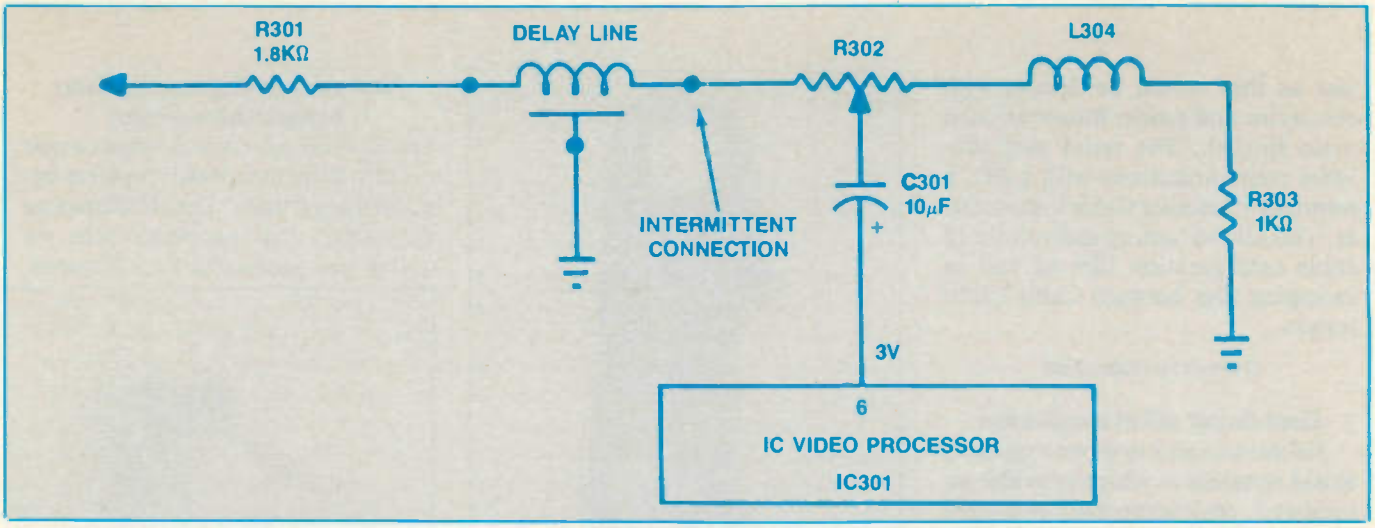


Figure 9. Intermittent video was caused by a defective delay line in a Panasonic GXLHM chassis. If shorting across the delay line input and output terminals results in a picture, even if it's distorted and has lines in it, the delay line is open or intermittent.

2.6V. In this case, very little voltage change was noticed.

Next, I checked the supply voltage at pin 16 (0.9V). If this voltage is low a leaky IC is the likely problem. The voltage was fairly normal (8.7V) in this case. The next step was to check the contrast circuits with a voltage measurement at pin 8 or TP2707. The contrast control should vary the voltage from 3.5V to 6.5V. Very little change was noticed. If the contrast voltage is extremely low, a likely cause would be a leaky CR2701 diode, or leaky beam current transistor Q2703.

In this case, because the video input was normal and there was no output luma signal even though the supply voltage was normal, U1001 was suspected. After replacing U1001, the video stage and brightness was restored.

Conclusion

When you suspect that the problem in a TV set is in the IF or video circuits, scope the IF and video stages with the broadcast or dot-bar generator signal. Take measurements of critical voltages and resistances to locate a defective transistor or IC. If the supply source pin has extremely low voltage, suspect a leaky IC. Disconnect the supply pin terminal from the pc wiring using desoldering braid. Measure the resistance between terminal pin and ground for leakage. Replace the IC if resistance is below 1.5KΩ. Remember, you can diagnose the IF and video stage using signal tracing, just as you can do with audio circuits. ■

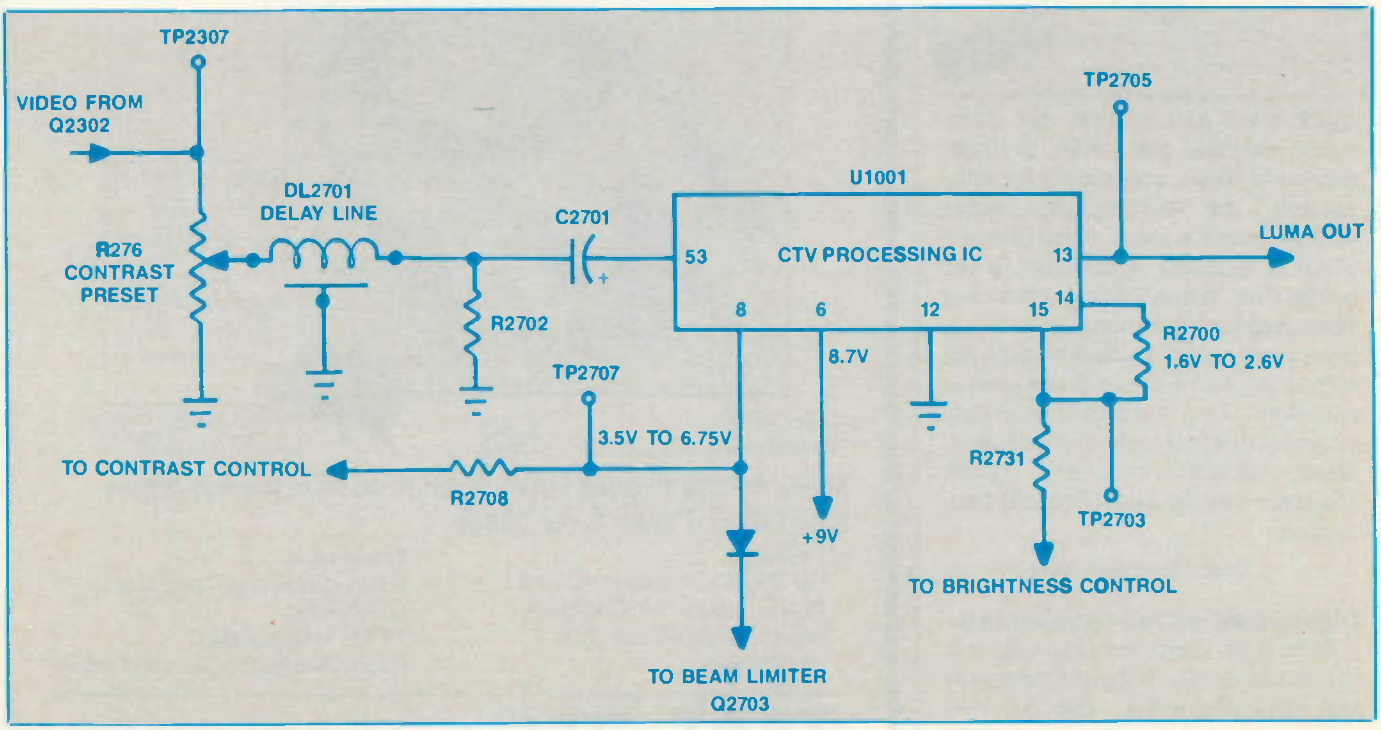


Figure 10. In an RCA CTC156 chassis a video signal was found at pin 53, but there was no luma at pin 13 or TP 2705. The problem was determined to be a defective CTV processing IC (U1001).

Special slots in the PC

By Glenn R. Patsch

You may not be aware that some personal computers have special bus slots. The later model IBM PC/XT with 8 slots and the IBM PC/AT both have a special bus slot. Slot number 8, also referred to as J8, is the special slot. This slot is the one closest to the power supply. Slot 8 should only be used with expansion cards specifically designed for it. Normally an IBM asynchronous communication adapter (a serial port card) is installed in slot 8 and is included with the PC. Some expansion cards have a special jumper that can be set to allow the card to be used in slot 8. The AST I/O Mini II card has a special jumper referred to as E7 that allows it to be used in slot 8. If you put a card in slot 8 that was not intended for it you will get a conflict. You should avoid using slot 8 unless all the other slots are filled. If you are having a problem with a PC with a card in slot 8, try moving it to another slot.

The IBM PS/2 computers have a special auxiliary video connector slot on the system board. The slot can be used as a normal expansion slot, but also allows for a video card to be used. The special slot is easy to spot since it is longer than the other slots. The PS/2 computers have video control circuitry included on the system board. The special slot allows a video card to bypass the system board video and use the video on the inserted card. The video from the inserted card is passed to the 15-pin output connector on the system board.

When inserting cards in a PS/2 system leave the special slot open unless all the other slots are full. Then if a video card is inserted at some time in the future, the other cards will not have to be moved.

Compaq used a special slot for their 386 computers for memory expansion. Most laptop computers have special slots for memory and modem expansion cards. A few laptop computers will accept a standard PC/XT/AT expansion card.

Be aware of special slots used in personal computers. A Zenith PC/AT with a new initial 2400 baud modem card with a fax send capability was placed in slot 8. The modem refused to work properly and appeared to be defective. Moving the card to another slot quickly fixed the problem. Knowing that J8 was a special slot quickly solved a servicing problem. ■

Patsch is a consultant specializing in the selection, evaluation and installation of IBM personal computer and compatible hardware and software.

VCR theory *(from page 21)*

zontal Phase (A/C head positioning) adjustment affects the amplitude of the FM waveform and 3). there is a tradeoff between the maximum sound output and the FM envelope amplitude.

If you have to readjust the A/C head, be sure to remove the sealant from the taper nut for the horizontal phase adjustment or you will either bend the tongs on the alignment tool or strip out the tapered nut. Keep in mind that any time you suspect a servo problem, before you start troubleshooting the servos, make sure that you perform the tape path confirmation check first, as well as confirmation of the A/C head horizontal phase. Failure to do so could well result in a lot of grief and frustration. Figure 11C is a basic guide to this procedure.

VCR servicing symptoms and cures

Servicing a VCR becomes considerably easier if you have an idea of where to begin when you observe a problem symptom. Figure 12 is a list of symptoms commonly observed when a VCR malfunctions, likely causes of the problems and action to take to correct the problem. ■

Test your electronics knowledge

Answers to the quiz *(from page 47)*

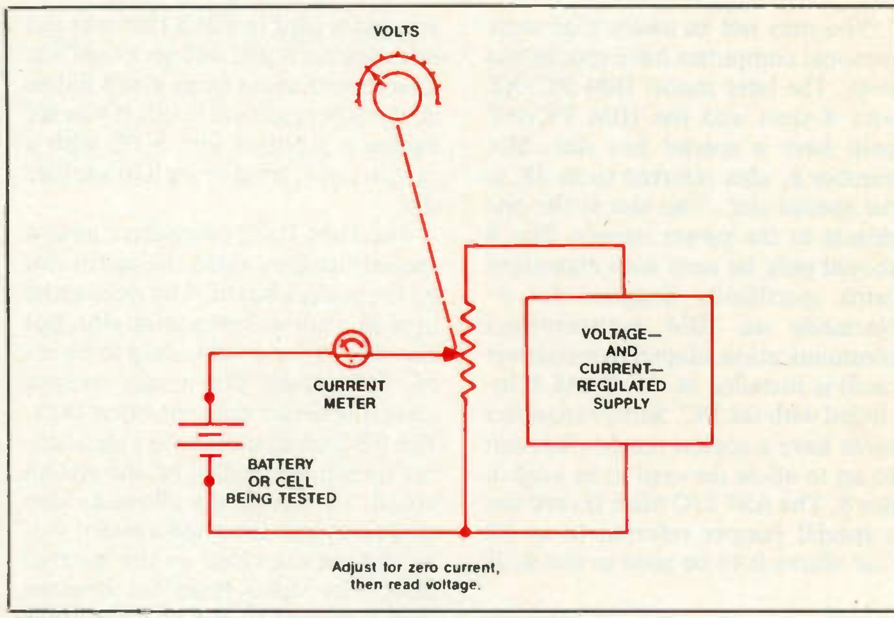


Figure D.

1. **D** - None of these choices is correct.

2. **A** - The surge limiting resistor protects the rectifier diodes from the high charging current of the electrolytic capacitors.

3. To be or not to be . . .

4. Originally the term cascode meant cascaded triode, but, it is used today to mean the equivalent transistor circuit. At high frequencies the input and output signals are isolated from each other. That results in a higher gain because there is no degenerative capacitive feedback.

5. See Figure D. The variable resistor is calibrated to indicate voltage. The resistor indicates the battery voltage when the battery current (I) is zero.

6. The circuit is shown in Figure E.
Make two different measurements for current:
When Ra = ___________, Ia = ___________.
When Rb = ___________, Ib = ___________.
Then substitute the values into the equation in Figure E.

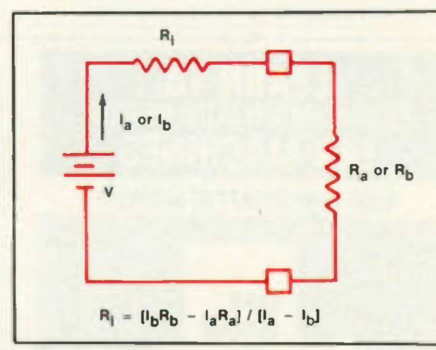


Figure E.

7. Another advantage is that a triangular wave test will show clipping, which may be missed in a square wave test.

8. **C** - If the transistor can pass enough current to light the lamp, there will be no difference between the SWITCH OPEN and SWITCH CLOSED conditions. That makes the transistor useless because the same thing could be accomplished by removing the transistor circuit.

9. A detection circuit. A power supply is not required to make a radio receiver. For example, a crystal has no power supply.

10. D

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