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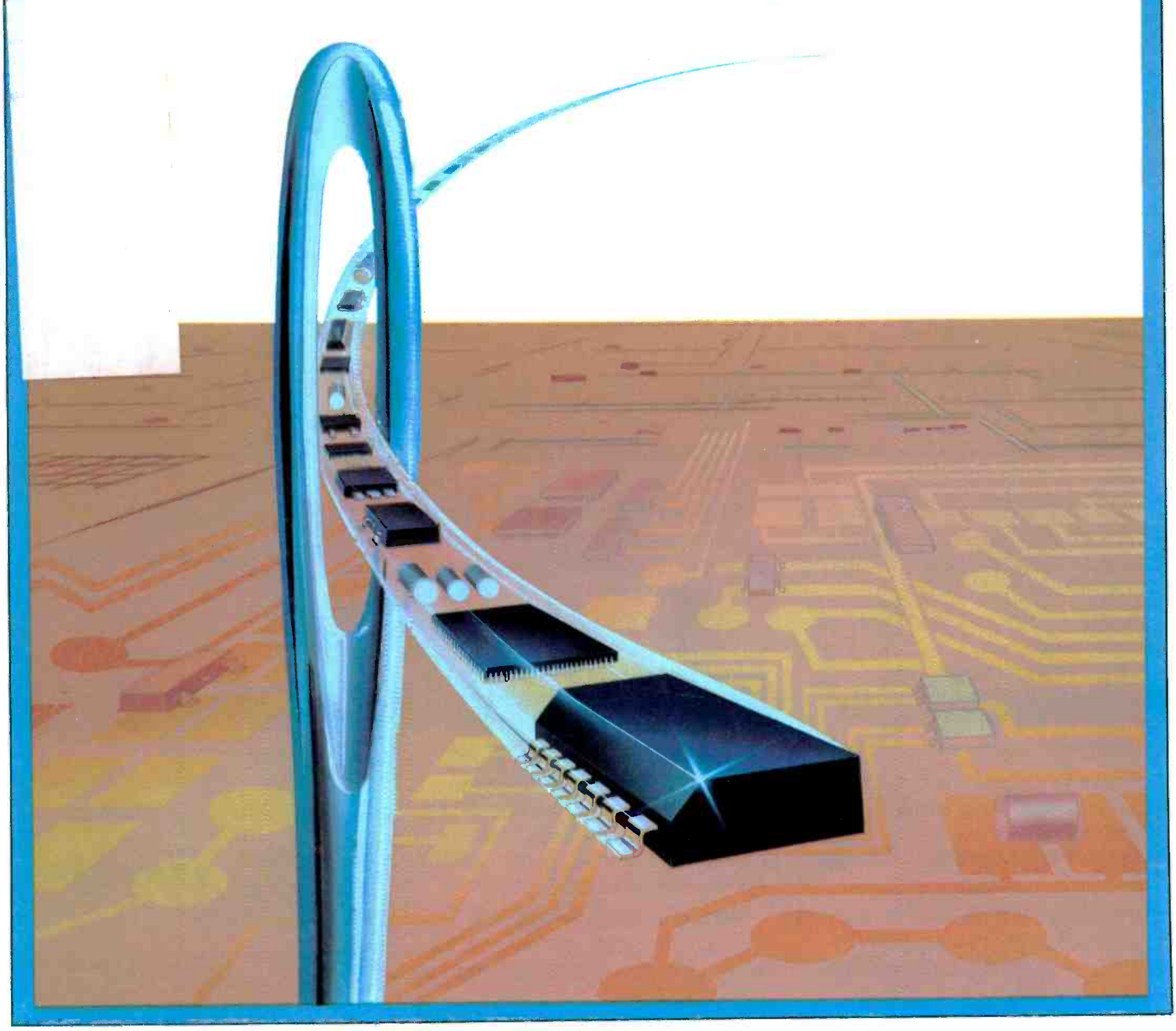
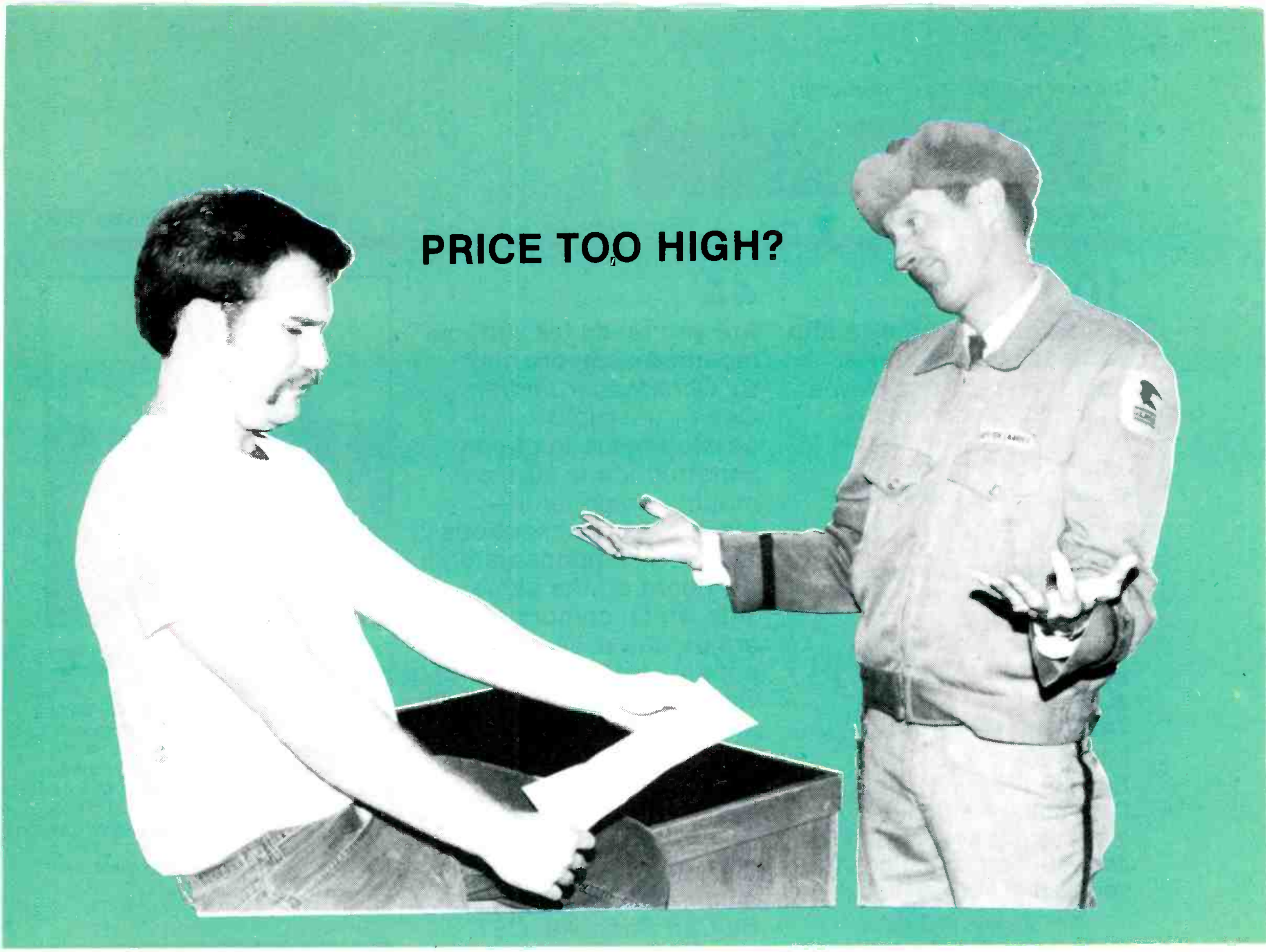
Surface-mount components





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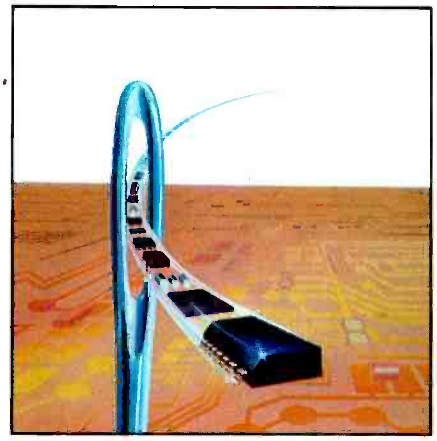

The current crop of tiny lightweight consumer electronic products: Walkman cassettes, Watchman televisions, hand-held TV cameras, pocket-sized color televisions, all owe their existence to manufacturing technology that crams huge numbers of circuit functions into almost no space at all. Key to this extreme miniaturization are surface-mount components and ICs, such as those depicted on the cover. *(Photo courtesy of Motorola Semiconductor Products.)*

Page 8

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Dealing with surface-mount technology

Back in the early days of electronics, it was possible to perform a lot of service on radios and televisions without even knowing what a soldering iron looked like. If a diode or an active device (vacuum tubes) was the cause of the problem, which was most often the case, it was a simple matter of pulling the old tube out of the socket and plugging in a new tube.

Then came transistors, and although some transistors were socketed, many more were soldered directly into the circuit. The arts of soldering and desoldering flowered.

Not too many years ago, integrated circuits were introduced, and soon servicers were scratching their heads and trying to figure out ways to unsolder a 16-pin DIP. New soldering/desoldering equipment and aids hit the market: soldering iron heads capable of heating all IC pins at once, spring-loaded IC extractors, vacuum desoldering tools, desoldering braid. In fact, thanks to the advent of ICs, soldering and desoldering have been elevated to the status of a fine art.

It seems though, that manufacturers are determined to stay several steps ahead of people who are trying to desolder and resolder their circuits. Now that people are beginning to become adept at dealing with dual-in-line packaged (DIP) ICs, the manufacturers are beginning to introduce surface-mount components.

Actually, there are a number of advantages to surface mounting of components: tighter packaging and lower production costs, to name two. But that doesn't alter the fact that it presents yet another learning process for someone who wants to service these products. But then, like it or not, innovation, with its attendant changes in methods and procedures, is the lot of anyone involved in a business as dynamic as electronics.

Make no mistake about it, surface-mounted components and ICs are already here in such small products as video cameras and watchman-type televisions. In the future, a veritable flood of these devices will be introduced into consumer products. Anyone who wants to service the next generation of consumer electronic products will have to know how to handle them.

In this issue, "Are you ready for surface-mount components?" describes in some detail why manufacturers are introducing surface-mount components and how they're connected to printed circuit boards. The information it contains might help you prepare for this new technology.

We'll bring you further information on surface-mount as we learn about it.

Nils Conrad Persson

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ELECTRONIC SERVICING & TECHNOLOGY is the "how-to" magazine of electronics. It is edited for electronic professionals and enthusiasts who are interested in buying, building, installing and repairing home-entertainment electronic equipment (audio, video, microcomputers, electronic games, etc.).

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For technical data circle number (6)

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Restoring versatility to your cable-connected VCR

The Cablemaster cable/VCR programmer bridges the gap between cable TV and VCR programming. The system uses the VCR's full programming capabilities without affecting the quality or quantity of cable received from the CATV converter by turning the CATV converter on/off to the chosen channels at preselected times.

Thousands of new cable subscribers, who also own VCRs, have discovered that their VCRs programmability has suddenly been limited to single-channel recording, and that their cable converter must now be left on for extended periods of time in order to do time-shift program recording. The problem with VCRs is their incompatibility with the converter/descrambler, which prevents the VCR recorder from changing channels. A consumer who has bought a VCR with a 14-day, 8-event, automatic time feature has wasted the investment, because the only channel that can be taped is the one to which the converter/descrambler is tuned. The VCR, of course, must always be set to channel 2 or 3 to match the converter. The problem becomes clear–it's the converter/descrambler tuner which must be given programmability.

The CableMaster from JNEL Corporation, Mansfield, MA, solves this problem. It enables cable subscribers to use their VCRs full programming capabilities without affecting the quality or quantity of cable received from the CATV converter.

The infrared CableMaster cable/VCR programmer system turns the CATV converter on and off to the chosen channels at preselected times that have also been programmed into the VCR. By controlling the cable TV converter, it enables the VCR to record unattended up to eight separate programs on eight different channels, including pay channels over a 2-week period.

Also, the unit's infrared circuitry and personality plug-in modules are designed for compatibility with every make and model of infrared cable TV converter. Should the cable converter model be changed for any reason, the device will require only a different personality module. Personality modules will also be available to control satellite receivers with infrared remote features.

The programmer will control and enhance older VCRs with little or no timing ability. Other features include automatic sequencing of programmed events; no cables or other connections to the VCR or cable TV converter; elimination of the need for cable ready VCRs; an ac power adapter–either 120V, 60Hz or 50Hz. Installation of the unit requires little more than setting the unit on top of your VCR or cable converter and making program selections. Once programmed, it works automatically.

The unit is expected to be available in this month, and it will be provided with one personality module. Replacement personality modules will be available.

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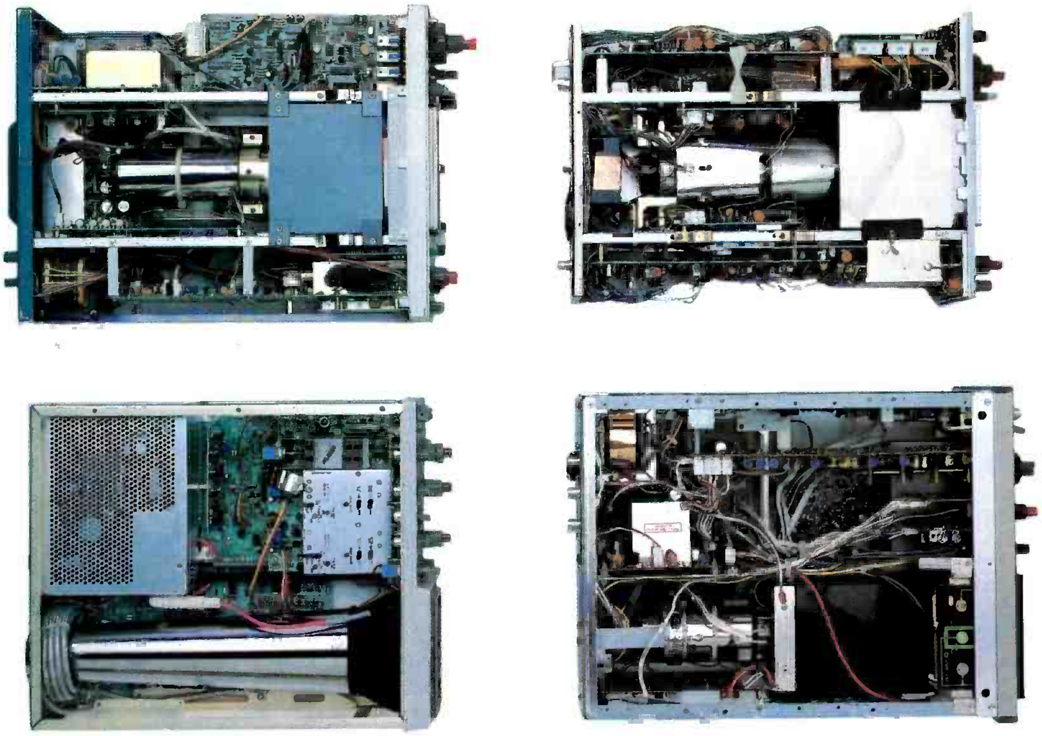

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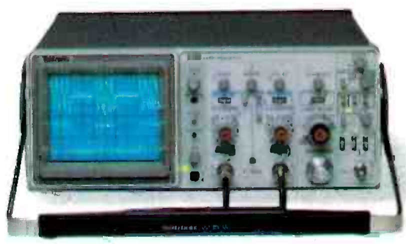

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see what he's saying—

Phone system offers video and audio communications

The first compact color video phone system, considered by many to be the key to widespread use of videoconferencing in business, government and eventually home applications, has been introduced. At $20,000 for a terminal, it's a little steep for home use just yet, but electronic products, from computers to VCRs, have a history of coming down in cost to where they are affordable.

The new motion color system, called the PVS (Personal Videoconferencing Station), by Widcom, Campbell, CA, consists of four components: a desktop console with speaker, color camera and two color monitors, a copy stand for color graphics and a versatile keyboard/drawing pad that controls the sytem.

According to Robert D. Widergren, president of Widcom, "The system will permit videoconferencing to originate from individual offices for the first time, placing the technology where it belongs. During the next few years, we intend to make video telephoning as routine as the traditional voice phone call."

The PVS is engineered to work in a local area network with each PVS in a building connected by coaxial cable. It can co-reside on broadband cable with various data networks.

When used with Widcom's VTC-56 coder/decoder, users may telephone across the country or around the world using one of several common carriers with video transmitted and received at 56 kilobits over digital phone lines or satellite links.

"In addition to its unusually low operating costs, 56 kilobit service does not lock the user into singular point-to-point communication. It's the only service that's as easy to use as regular telephone service and which permits the user to call a variety of sources," Widergren said.

The newly introduced Personal Videoconferencing Station (PVS) designed for business and government applications offers the following features: dual memory still-store system; 6-color electronics blackboard; alphanumeric character generator; copy stand and variable audio system.

The combination of the compact office phone and the Widcom VTC-56 codec, with its dramatically reduced transmission costs, will open major new opportunities in the field of telecommunications. ES&T

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You'll want to try one out, of course, so drop into your nearest electronics distributor and drop one.

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Understanding the audio compact-disc player

The compact digital audio disc player is designed to convert information permanently recorded on a 4¼-inch disc into an analog signal that can be amplified by an audio amplifier and played through speakers to reproduce sounds; ordinarily music. While this disc is being played, it is turned in a circular motion by a motor, while a pickup senses the information recorded on it. In these characteristics, the CD (compact disc) player, resembles a standard turntable.

That is where the similarity ends.

The CD player is an incredibly complex, sophisticated digital instrument. A glance at Figure 1, the block diagram, gives some idea of the circuitry that comes packed into one of these units. For starters, at the very heart of the CD player are two microprocessors: one for controlling the sensors, the other for decoding control. This complexity is a little frightening at first, but familiarization with the circuitry helps clear up what's going on.

The turntable/pickup system

As with a standard turntable, one of the key components in a CD player is the motor that turns the disc. On a standard turntable, the disc turns at a steady 33⅓ rpm (or perhaps 45 or 78 rpm) and the stylus rides the groove from the outside to the center. The variation in tangential velocity, resulting from the decreasing radius between the spindle in the center and the stylus, is compensated for by varying the modulation rate of the audio signal recorded on the disc in the opposite direction. Take a look at the difference in the appearance between the inner and outer grooves of a typical recording.

In the CD player, because the music signal is digitally encoded in pits and flats, as described in the related article, the rate at which the data stream is sensed by the pickup must remain as close to constant as possible. This means the speed of rotation of the disc must be varied throughout the playing of the record in order to keep the data rate constant.

Another complicating factor in the CD is the pickup system. There is no groove to lead the stylus. There is no stylus as such. The pickup is, instead, a laser/-photodiode arrangement. In order to move the laser *stylus* across the disc as it turns, a complete stylus position sensing/drive system must be introduced.

This article, based on the NAP Consumer Electronics Corporation's *Technical Training Manual for the Compact Audio Disc Player,* will give a description of this turntable pickup system. Future articles will cover other portions of the CD design and operation.

Turntable motor amp

Figure 2 shows the turntable motor amp circuitry. The rate the data streams from the disc enters the Error Correction IC is totally independent on the rotational speed of the turntable and the location of the pickup unit. The speed the track is moving with respect to the pickup unit must be kept as constant as possible. If the disc were rotated at constant speed, the data rate near the center of the disc would be lower than that of a track near the outside edge of the disc because the diameter of the outer tracks is much larger, and so the outer tracks can contain much more information in one revolution of the disc.

In the error correction (ERCO) IC, the rate information enters is compared to the output of a voltage controlled oscillator (VCO). If the rate of data coming into the comparator is too high or too low, an error signal is created and applied to the turntable amplifer. This error signal is called *MCES* for motor control error signal and is applied to connector 325 on the servo PC board shown in Figure 2.

The MCES has a 50 percent duty cycle that *jitters*. The rate of jitter determines the amount of drive current supplied to the turntable motor. At initial start-up of the motor, the focus control O line is switched *off* (low) by the servo microprocessor and is applied to pin 3 of IC6209; this allows the turntable motor to run, starting the rate the data stream is received by the ERCO IC. FCO is also applied to pin 6 of IC6205, insuring the MCES signal does not prematurely start the turntable motor by keeping the MCES signal line turned *off* with the output of IC6205 pin 1.

Radial servo

Information about the position of the radial tracking arm is obtained from the amount of light falling on the photodiodes, which converts the light deviations to electrical deviations. The photodiodes are arranged in pairs and the outputs are summed to create two error signals. Radial Error 1 is the sum of the currents of diodes 3 and 4 (i3 + i4) with Radial Error 2 being the sum of diodes 1 and 2 (i1 + i2). The radial error signal is derived by subtracting the sum of one pair from the other pair $RE \times (i3 + i4) - (i1 + i2)$.

The error sum signals are applied to the radial error amp, Figure 3, at connectors 273 and 274 and are amplified by IC6214A and B. The amplified error signals are applied to pin 1 and 7 of the multiplexer IC6216, which is used to combine additional factors to the system and maintain stability over the radial tracking servo loop. The outputs from IC6216 are applied from pins 12 and 13 to IC6214C pins 9 and 10. The radial error signal on pin 8 of IC6214C

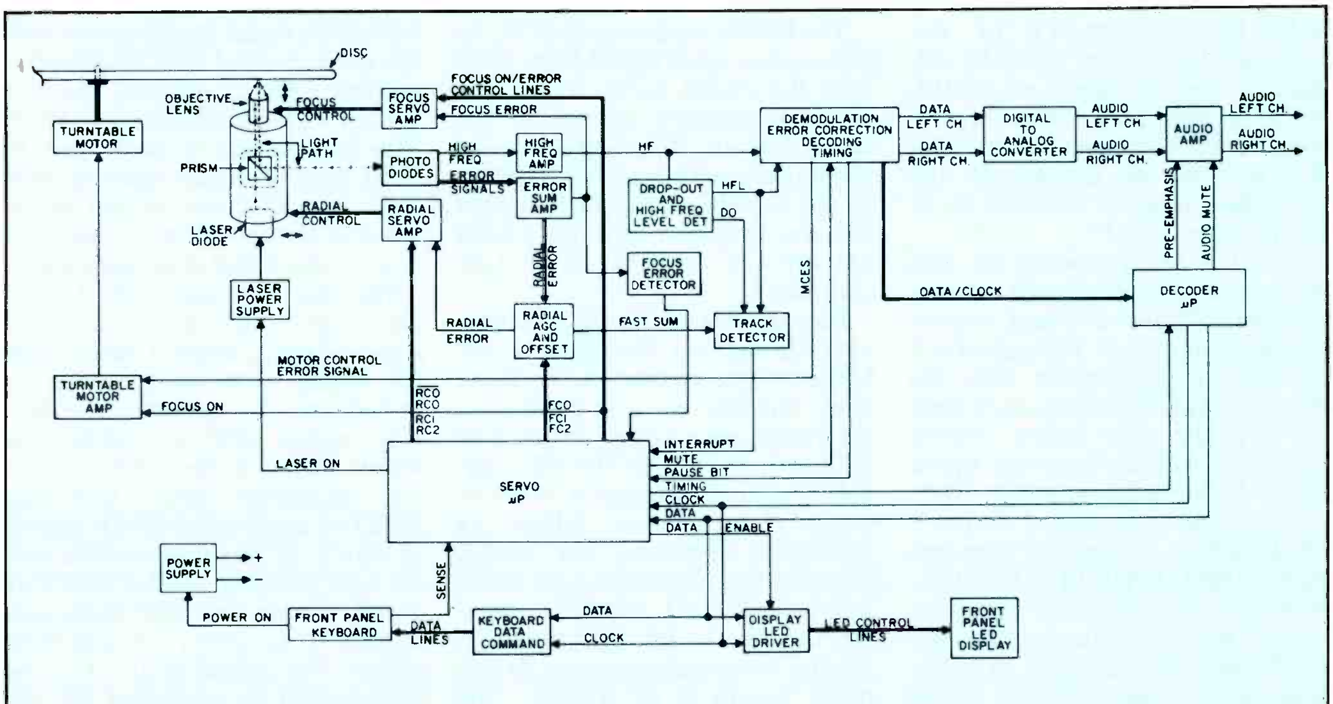

Figure 1 — System block diagram

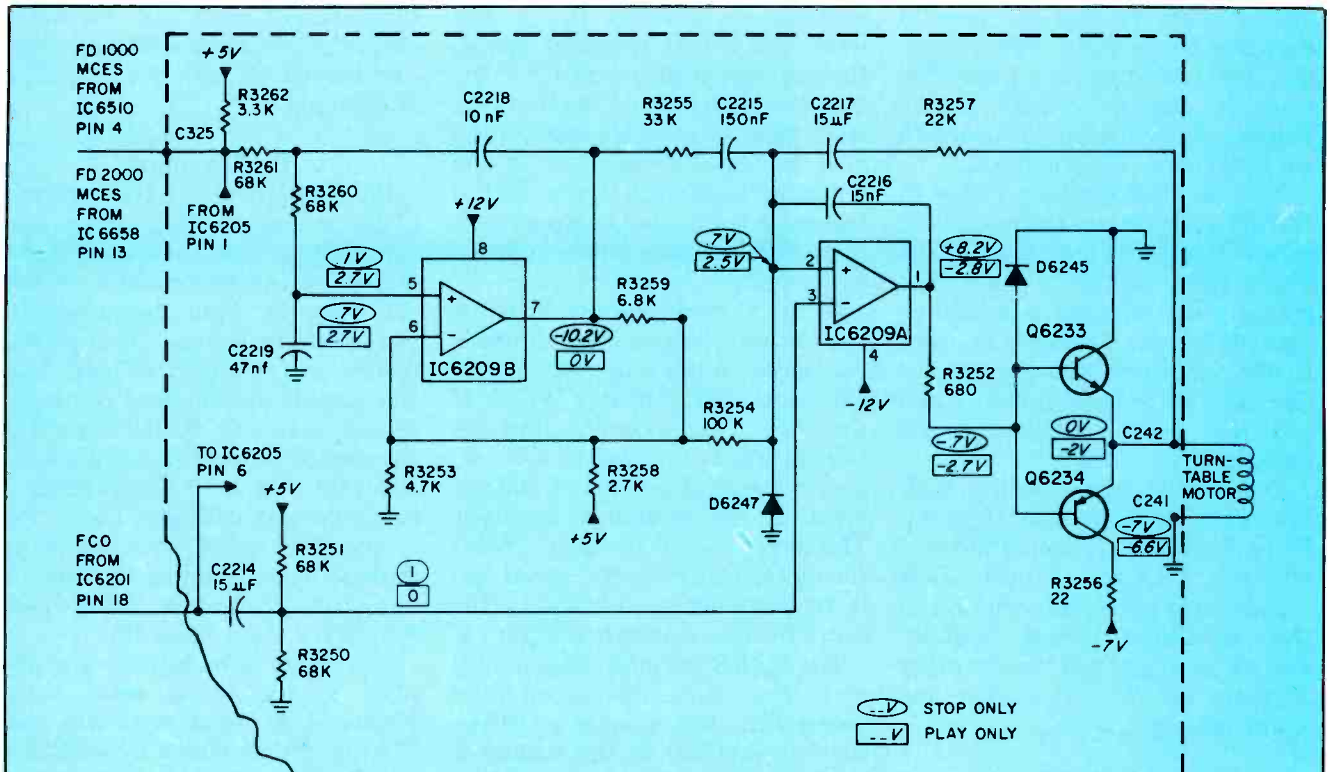

Figure 2 — Turntable motor amp servo PC board

splits into four different paths (RE, RE1, RE2 and IC6212A pin 13) but it is still the radial error signal(RE). The different paths are marked for ease of following through the system.

The offset control, R3315, offsets the asymmetry of the reflected light beam (spot) by offsetting the dc gain of IC216. IC215 is used as a switch to provide dc control over the gain of IC216. This dc control of the multiplier stage is referred to as the *d factor*.

IC6217A pin 3 receives the sum of the radial error signals on connectors 273 and 274 and creates the fast sum signal. This signal will be used in conjunction with the drop-out and high frequency level to provide the servo microprocessor with an interrupt signal (INT) during track jumping.

The radial error signal on pin 8 of IC6214C is applied through R3351 (RE1) to pin 13 of IC6214C, Figure 4. The amplified signal on output pin 14 is coupled through C2259 and R3376 to pin 15 of the loop switch IC6211. Diodes D6256 and D6257 limit the high excursions of the radial error signal. The output of the loop switch is applied to the radial drive IC6218, which provides the drive current to the radial tracking coil. Transistors Q6240 and Q6241 provides stability and increase the dynamic range of the Drive IC.

The 650Hz oscillator, IC6212, injects a sine wave signal from pin 8 into the radial servo loop. This signal is present throughout the servo system. This signal causes the radial tracking arm to oscillate at the 650Hz rate, which swings the arm back and forth for a total amount of travel of 0.1μm ($\pm$0.05).

Because the 650Hz signal is present throughout the system and because the system is a closed loop, the sine wave is present in the radial error signal on pin 8 of IC6214C, Figure 3. The RE2 signal is applied through a low frequency bandpass filter to IC6215D; therefore, the 650Hz signal is only allowed to pass to the input of IC6215D. IC6215D in conjunction with D6252 creates a square wave signal, which is applied to pin 9 of IC6211. The square wave signal opens and closes the loop switch at the 650Hz rate. The input to pin 10 of the loop switch is developed by the servo microprocessor to open the loop switch when radial tracking is lost or track jumping is required by the system. This allows the servo microprocessor to take over control of the radial tracking arm with the radial control 1 (RC1) and radial control 2 (RC2) opening the loop switch with radial control 0 (RC0). The loop switch is held open by RC0 during initial start-up with RC1 and RC2 controlling movement of the arm from its rest position to the initial start position.

The fast sum signal (FS) from pin 1 of IC6217A contains the sums of radial error 1 and 2 plus the 650Hz sine wave signal injected into the system. The fast sum signal (FS) is applied to R3391, which is the input to an active bandpass filter network. IC6215A applies the 650Hz signal to pin 3 of the loop switch and through R3393 to pin 9 of IC6215B which inverts the sine wave and applies it to pin 5 of the loop switch. The output on pin 4 of the loop switch is controlled by the switch control pulse on pin 9 of IC6211, which switches the output

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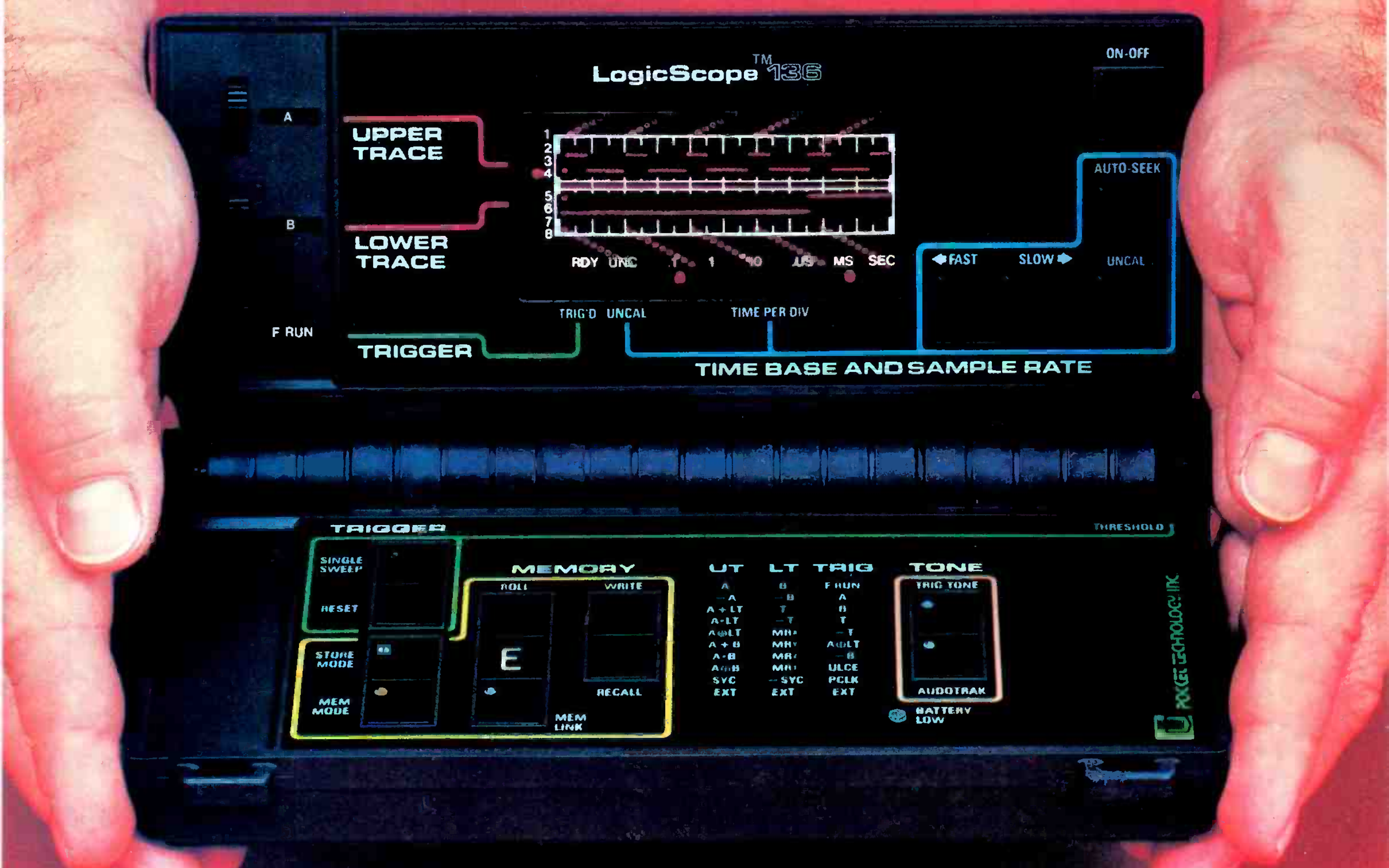

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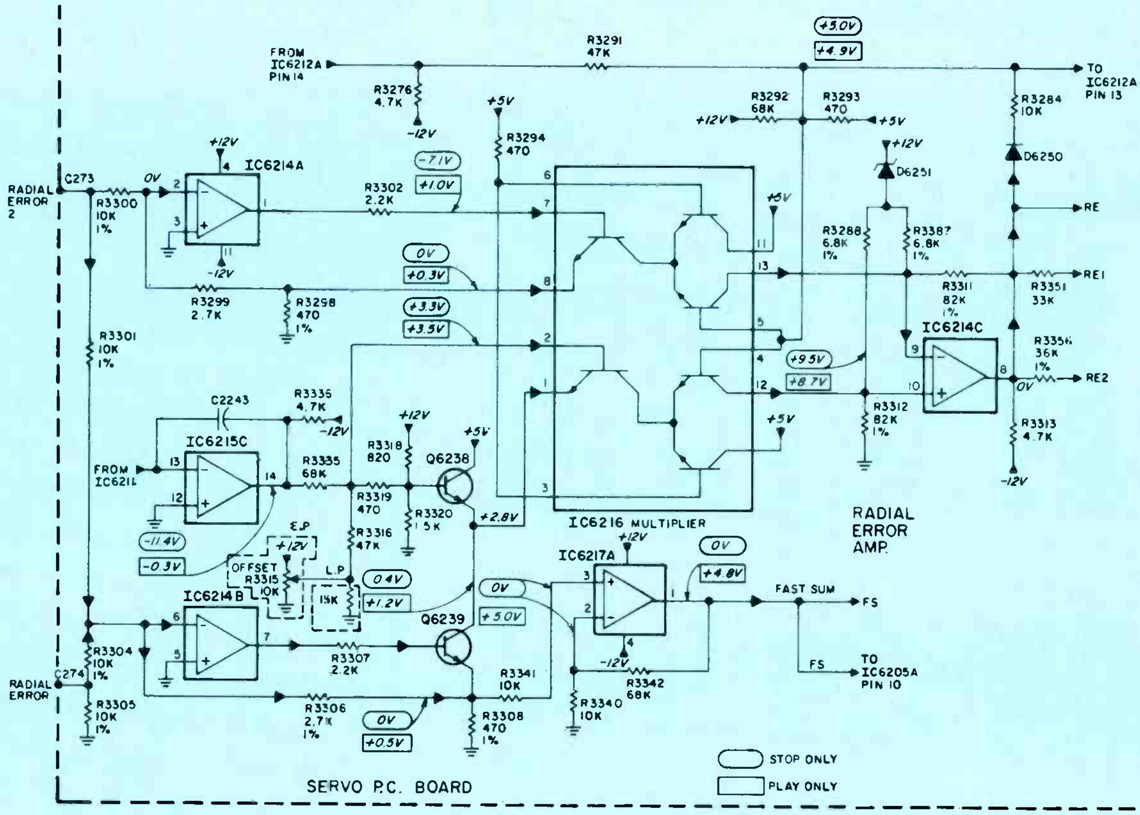


Figure 3 – Radial error amp servo PC board

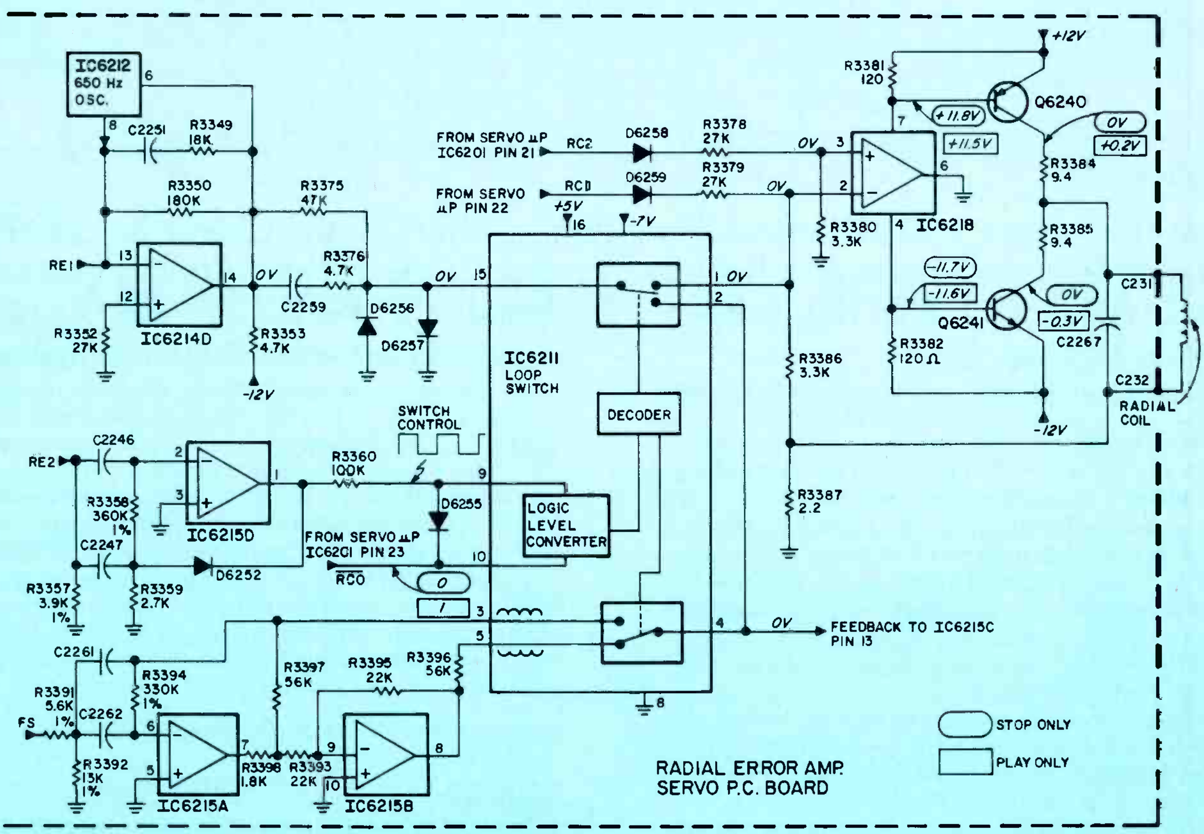
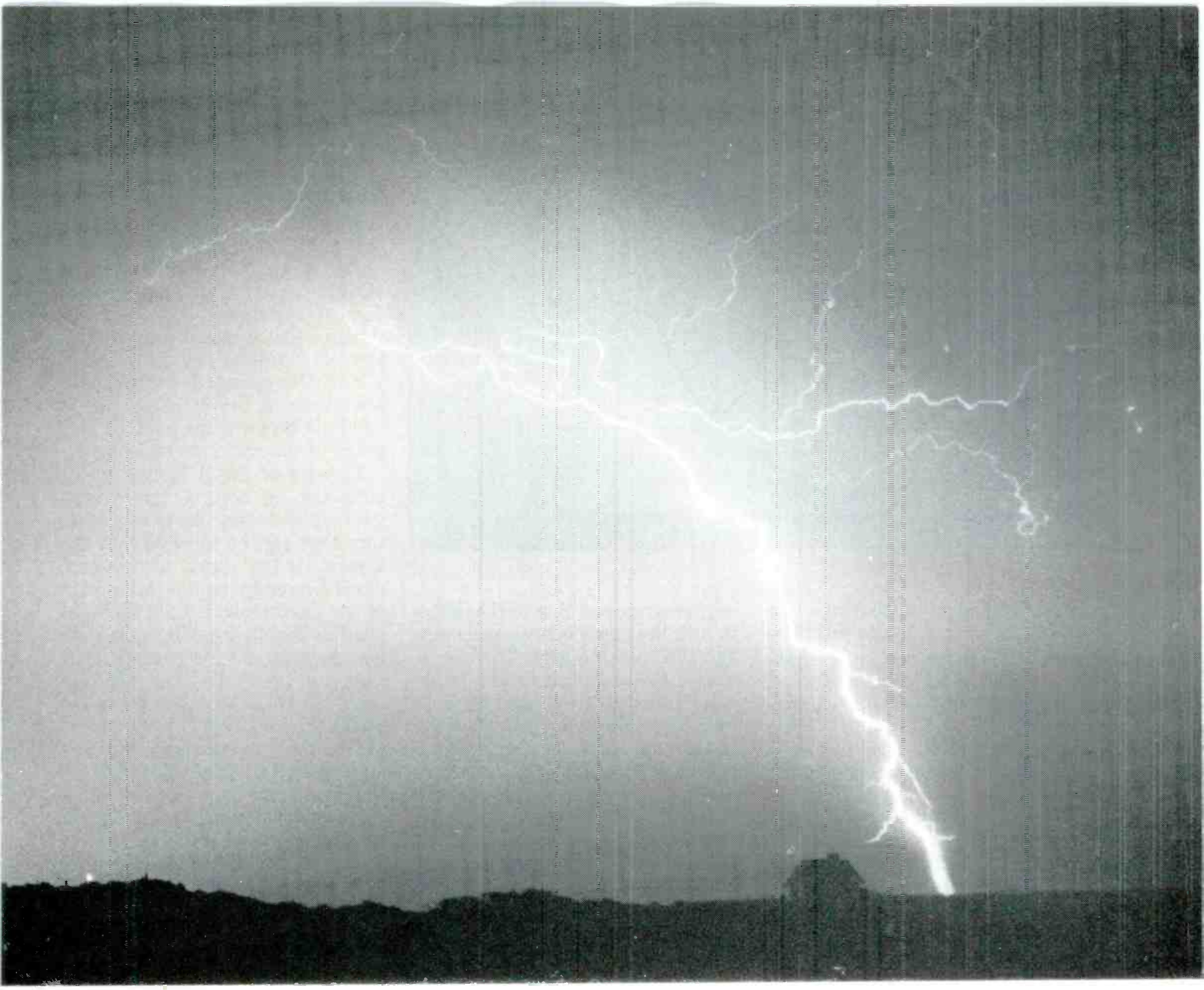


Figure 4 – Radial error amp servo PC board



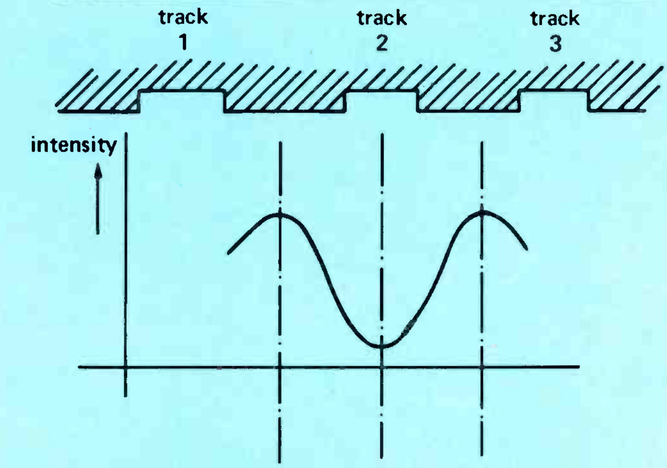


Figure 5 — Curve represents the amount of reflected light

on pin 4 between the two inputs on pins 3 and 5 at a 650Hz rate. The signal developed on pin 4 of the loop switch is the feedback to pin 13 of IC6215C, Figure 3. The output on pin 14 of the IC is the average dc voltage level to control the gain of the stage connected on pin 2 of the multiplier IC6216.

Figure 5 illustrates the curve that represents the amount of reflected light from the disc. The curve shows that maximum light is reflected when the beam is directly between the tracks, and minimum light is reflected when the beam is directly on the center of the track. Then by injecting a 650Hz signal into the radial servo loop, the tracking arm starts to oscillate at that rate.

Figure 6 shows the effects of the oscillation on the reflected light beam. When the light beam hits the center of the track, it results in a positive signal as a result of the injected 650Hz signal. If a shift occurs in the beam to the right of the track, the resulting reflected beam will be in phase with the injected signal, and during a shift to the left of the track, it will result in a reflected beam that is in phase opposition (out of phase) with the injected signal. Then by detecting the reflected signal synchronously, a dc control signal is developed and is referred to as the *d Factor*. The d Factor, in conjunction with the radial error signal, controls the gain of one section of the radial servo loop.

The d Factor corrects for an asymmetric spot, due to the deviation in the angle between the disc and the tracking arm. This deviation in the angle causes the radial error signals (i1 + i2) and (i3 + i4) to become unequal, even when the beam is on center of the track.

Figure 7A shows the resulting waveforms and dc level created from the 650Hz signal when the light beam is directly on the center of the track. The switch-controlled square wave signal applied to pin 9 of IC6211 switches the input signals on pins 3 and 5 of IC6211 at a 650Hz rate. The input on pin 3 is the opposite of the input on pin 5. The output on pin 4 of IC6211 is a sine wave swinging above and below the zero reference. This signal is applied to pin 13 of IC6215C, which results in an average dc level of zero on the output of IC6215C pin 14.

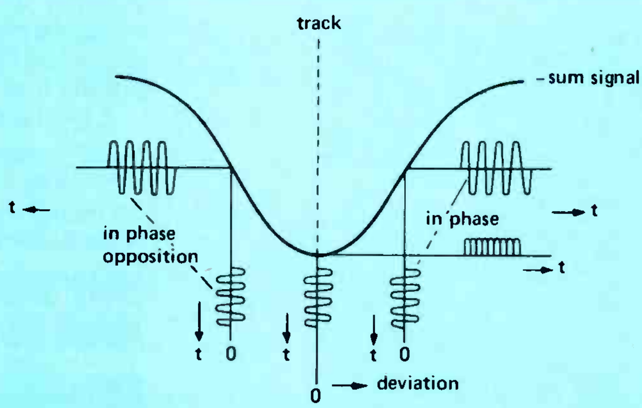


Figure 6 — Effects of 650Hz oscillation

Figure 7B shows the results of the signal when the light beam is to the left of the center of the track. The input signals on pins 3 and 5 are out of phase and appear on pin 4 resulting in the output of IC6215C pin 14 to go negative. Figure 7C shows that only the positive half cycles are applied to pin 4 resulting in pin 14 of IC6215C to go positive. Therefore, the phase of the 650Hz signal is used to control the gain of this stage of the radial servo loop.

The use of the d Factor is not sufficient to control the overall gain of the system due to other factors that can be induced into the system. If the output of the laser diode decreases or the reflectivity of the disc is low, it then becomes possible for the tracking system to become unstable; to prevent this, the gain must be controlled to react to this deviation from the nominal level. This is provided by the *k Factor* to adjust the systems gain when the signals deviate from the normal levels.

The 650Hz signal is once again used by the radial tracking system. The phase of the 650Hz signal is strongly influenced by the gain of the system. If the gain increases or decreases, then the phase shift between the original and the returning signal will also increase or decrease. Then both signals can be compared and the resulting signal can be used to control the gain of the second stage of multiplier IC.

Figure 8 shows the 650Hz oscillator and the dc control generator for the k Factor. The

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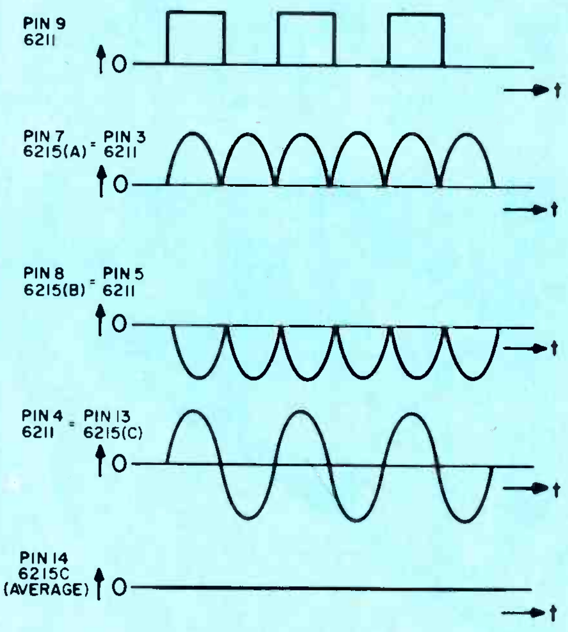

Figure 7A — Light beam centered on track

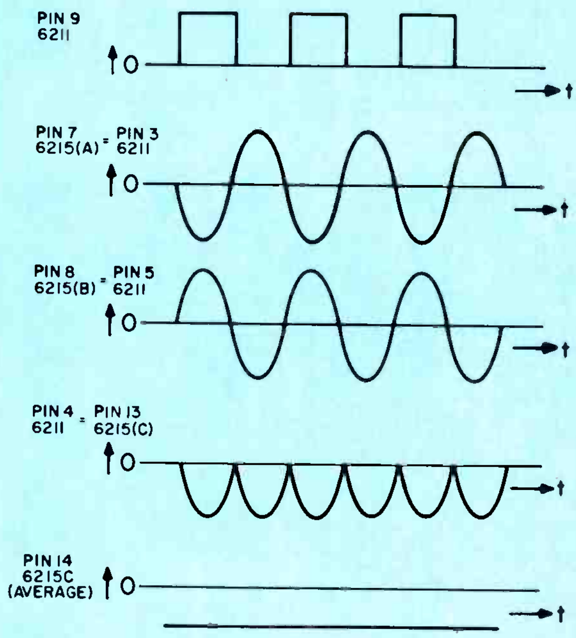

Figure 7B — Light beam left of the track

oscillator, IC6212B, injects the signal into the radial servo loop through R3328 and C2244, a 45 degree phase shifter, to pin 13 of IC6214D, Figure 4. The signal is also extracted from the loop at pin 14 of IC6214 and applied to R3370, Figure 8, which is the input to the bandpass filter of IC6212D and associated circuitry. The 650Hz signal is extracted from the system and applied to pin 6 of the square wave converter IC6213B. The output on pin 4 is applied to a phase detector, IC6213C. The oscillator output on pin 8 of IC6212B is applied to a reference IC, IC6213D pin 8 which converts the oscillator output to a square wave that is in phase with the generated 650Hz sine wave. The output of the reference IC, pin 10, is applied to the phase detector IC pin 1, where the phase of the generated signal is compared to the phase of the extracted 650Hz signal. If the gain increases or decreases, the phase of the returning signal increases or decreases. The two signals, compared by the phase detector, develop a difference signal on the output pin 3, which is applied to pin 12 of the switch IC6213A.

The Radial Control O (RCO) is applied to pin 13 of IC6213A and is used to control the output of IC6213A. If the player is correctly tracking, then RCO is positive and $\overline{RCO}$ is zero, thus allowing the difference signal to appear on pin 13 of IC6212A. If the reflected light is less than nominal, then the phase shift of the 650Hz signal from the servo loop decreases relative to the oscillator signal.

As a result, the duty cycle of the phase detector decreases. The input on pin 13 of IC6212A, an integrator, becomes less positive causing the output voltage on pin 14 to go more positive. The output on pin 14 of IC6212A is feedback to pins 4 and 5 of the multiplier IC6212, which results in transistors connected to the two pins to conduct harder and the amplification factor returns to its nominal level.

When the radial tracking has been switched *off* by the servo microprocessor, the incoming information from the phase detector is also switched *off*. Diode 6250 and R3284 pass the radial error (RE) signal from pin 8 of IC6214C to the integrator IC6212A. If the radial error signal becomes greater than nominal, then the input on pin 13 of the integrator becomes more positive, therefore decreasing the output level on pin 14 and IC6216 will conduct less. Consequently, the radial error signal decreases to its nominal value. This creates the conditions necessary for AGC, which keeps the gain and system bandwidth constant by the use of the 650Hz signal.

Figure 9 shows the left and right motion detector circuit. The radial error (RE) signal from IC6214C pin 8, Figure 3, is applied to pin 13 of the servo microprocessor. The microprocessor measures the time between two consecutive positive going signals, which is approximately 0.5ms. If the speed of the arm's motion across the tracks is constant, the time between the two consecutive pulses will also be constant. If the speed is too slow, the time between the positive going edges of the square wave will be longer than nominal. If the speed is too high, the time will then be shorter than nominal.

When track jumping is being performed, the servo microprocessor takes over the control of the radial tracking arm. The microprocessor monitors the input on pin 13 to determine the rate of the track jumping. If it is too fast or too slow, the microprocessor applies a positive voltage to either RC1 or RC2 until the width of the input signal on pin 13 returns to

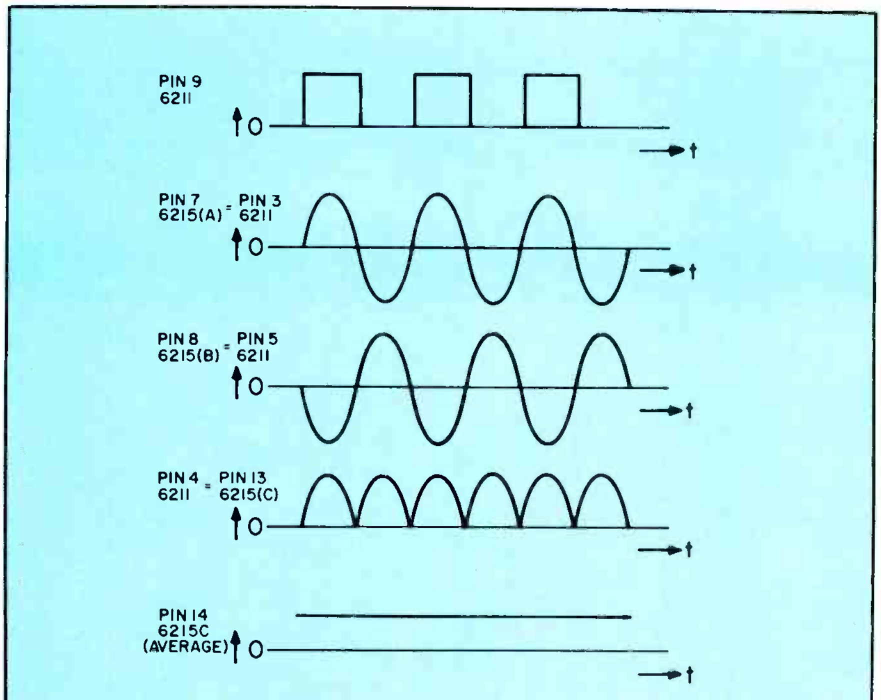

Figure 7C – Light beam right of the track

nominal. If the speed is too slow, RC2 will be made positive by the microprocessor, and if the speed is too high, then RC1 is made positive, thus holding the track jumping at a constant rate of speed.

If a shock occurs to either the left or right side of the player, this will also cause the width of the signal on pin 13 to increase or decrease. The microprocessor acts accordingly, either switching RC2 or RC1 on to correctly brake the movement of the tracking arm. If the shock comes from the top and side at the same time, then loss of focus and radial error is possible if the shock is too drastic. The loss of these two signals will cause the servo microprocessor to shut the system down and return to the normal start position.

The focus control O (FCO) output on pin 18 of the servo microprocessor is used to hold the motor control error signal (MCES) line at 0V before start-up, thus preventing the turntable motor from rotating until the servo microprocessor receives the *play* command from the front panel. The high frequency (HF) signal from the HF amplifier is applied to connector 531 on the decoder PC board, Figure 10. The HF signal is coupled through C2516 to the differential amplifier, consisting of Q6530, Q6531 and their associated circuitry. The two outputs are coupled through C2520 and C2521, inverted relative to each other, and applied to two fullwave rectifiers consisting of diodes D6550, D6551, D6548 and D6549. Diodes D6544, D6545 and D6546 along

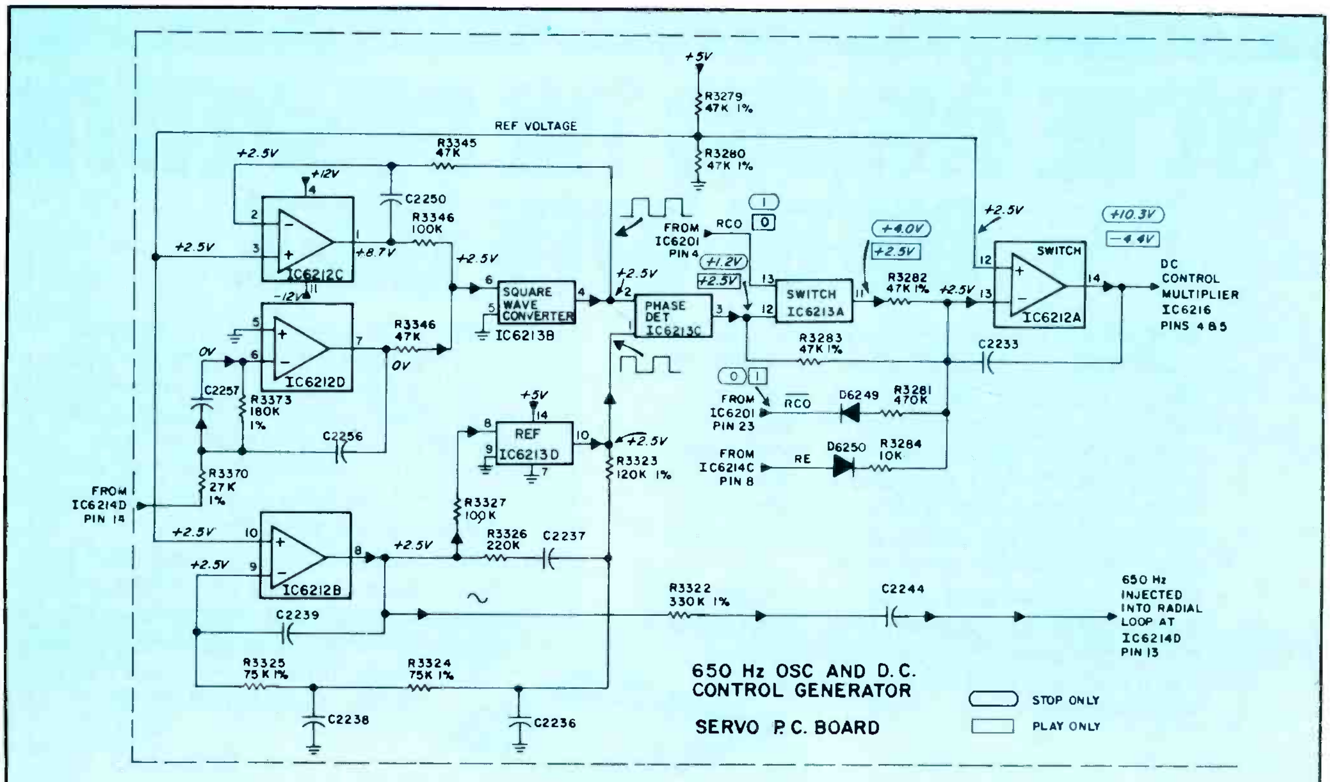

Figure 8 – 650Hz oscillator and PC control generator

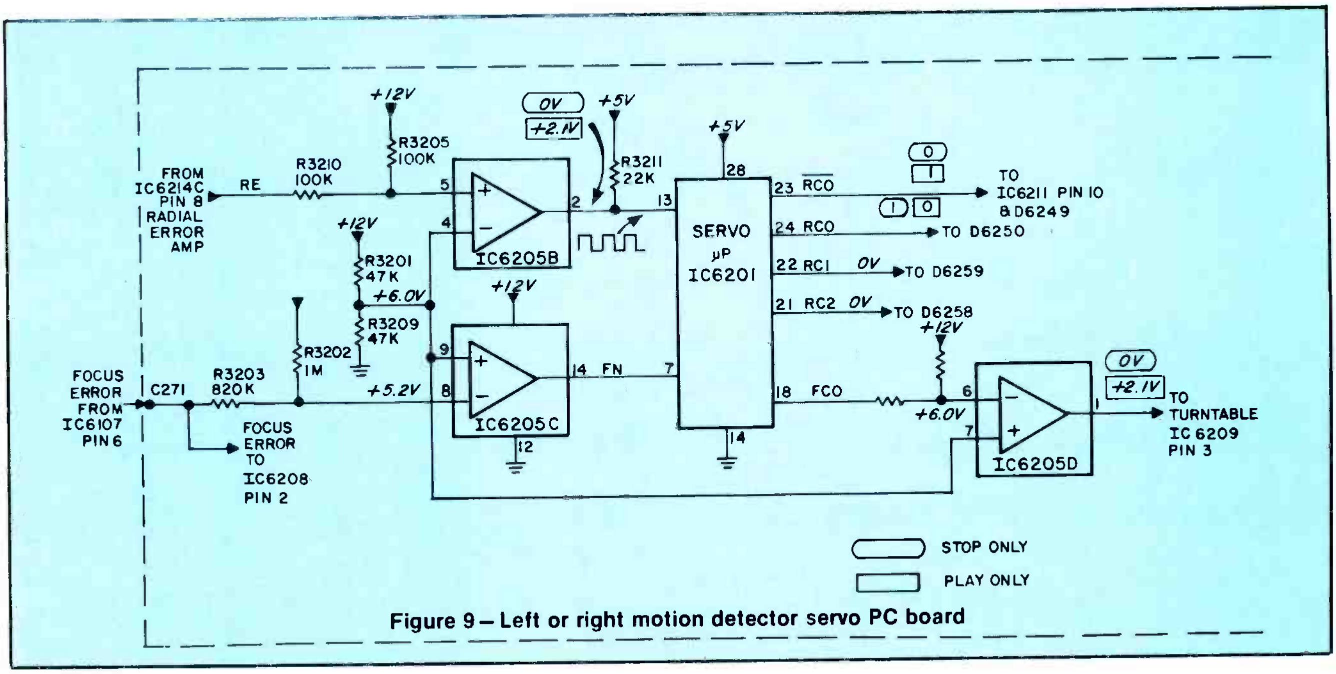

Figure 9 – Left or right motion detector servo PC board

with R3552 form a clamping circuit to clamp the output level of the differential amplifiers.

The output from the fullwave rectifier D6550 and D6551 is applied through R3536 to pin 2 of IC6508A, the HF Level Detector, and through R3537 to pin 6 of IC6508B, the drop-out detector. The output of the second, fullwave rectifier diodes D6548 and D6549 is applied to pins 3 and 5. The input on pins 3 and 5 will not vary as much as the input on pins 2 and 6, due to the smoothing capacitors C2525 and C2527. These two capacitors have different values and are discharged through different resistor values.

If the level of the HF signal is nominal (1 Vp-p) and no drop-outs are in the signal, then pin 3 will be positive relative to pin 2, and the output on pin 1 will be positive. The voltage on pin 3 is also applied to pin 5 and is more positive than the voltage on pin 6, therefore causing pin 7 of the output to become positive also.

If the signal level drops to approximately 65 percent of its nominal value, then pin 3 will go negative, causing the output on pin 1 to go to 0V, therefore indicating a loss of HF signal. The voltage now on pin 5 goes negative, but the voltage on pin 6 is more negative than the voltage on pin 5, which causes no change in the output on pin 7.

When a drop-out (DO) in the HF signal occurs, the level will drop to 10 percent of its nominal value. Then, the voltage on pin 5 will become more negative than the voltage on pin 6 and the output on pin 7 will become 0V, indicating a drop-out has occurred in the HF signal. The output voltages on pins 1 and 7 of IC6508 are prevented from changing very quickly by Q6533. The high frequency level HFL and DO levels can change very rapidly when the light beam encounters fingerprints on the disc, which causes the levels to switch back and forth very quickly. This can cause the system to become unstable due to fast variations in the two levels.

The drop-out and high frequency level is applied to connectors 321 and 322 of the track detector on the servo PC board, Figure 11. When the radial tracking arm moves quickly across the disc, the radial error (RE) which controls the arm, must be switched *off* by the servo microprocessor. Control of the radial servo system is obtained by using the DO and HFL signals in conjunction with the fast sum (FS) signal from the radial servo system.

When there is no DO in the HF signal, then DO equals zero and goes positive and the HFL is positive when the HF signal is nominal (1Vp-p). The two levels are the reverse of each other when DO and HFL does occur. The FS signal from the radial servo system apears on the collector of Q6242, which acts as a switch and is operated by the HFL applied to IC6217B. Q6242 conducts when the level of HFL is correct. When the transistor conducts, the FS signal appears on pin 11 of IC6205A.

The output signal on pin 13 will become positive if the slow sum (SS) on pin 11 is more positive than the signal on pin 10, and pin 13 will be 0V if pin 11 is more negative than pin 10. When a loss of HF signal occurs, pins 3 and 5 of IC6207B will then become zero and pin 4 the drop-out input stays at zero. Then pin 6, which is tied to pins 1, 2 and 8 of IC6207A, will go to zero causing the output on pin 9 to go to zero.

The interrupt (INT) signal to the servo microprocessor pin 12 is active when its level is zero. When pin 12 of the servo microprocessor is low, it takes over the control of the radial tracking arm by activating the four outputs to the radio servo system. These outputs are used to move the arm from inside to outside and back to the inside during track jumping and to hold the arm in its last known position due to a large loss of information. This can be caused by dirt, fingerprints, and scratches blocking the passage of the light beam to a portion of the track of pits on

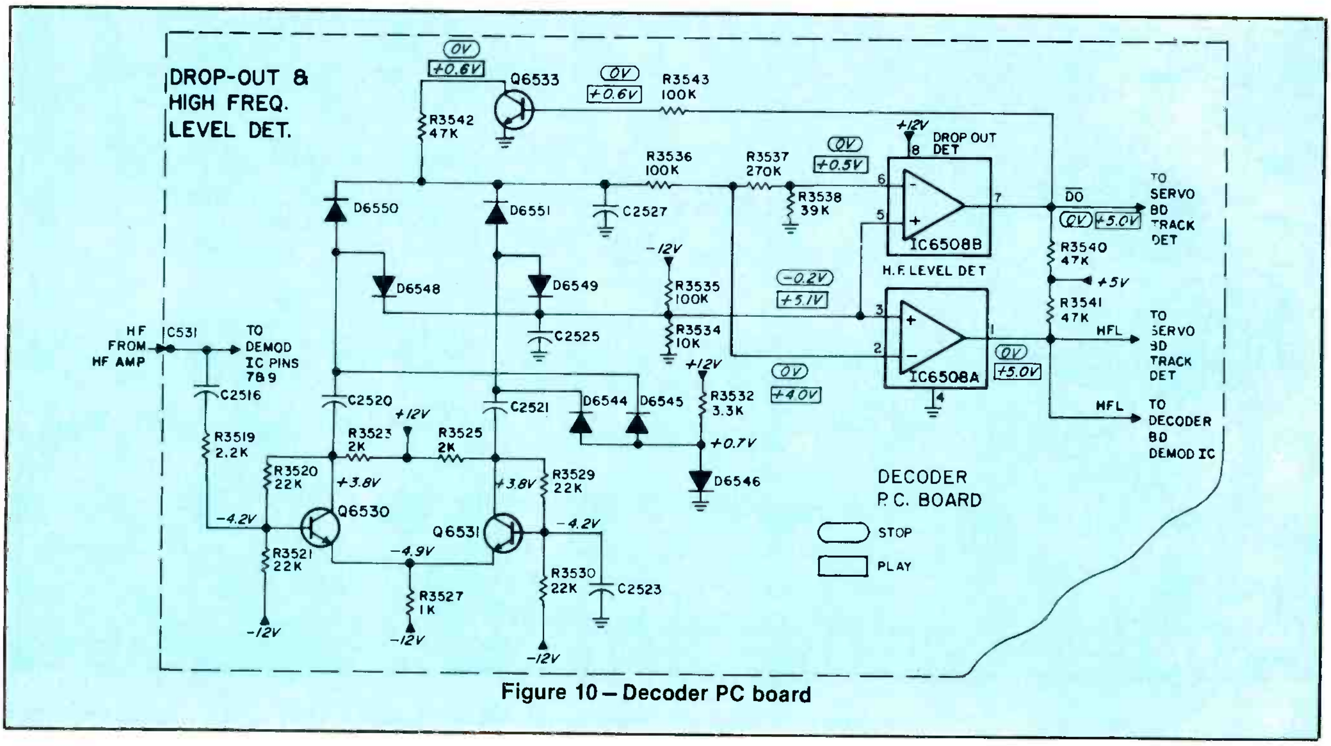

Figure 10 – Decoder PC board

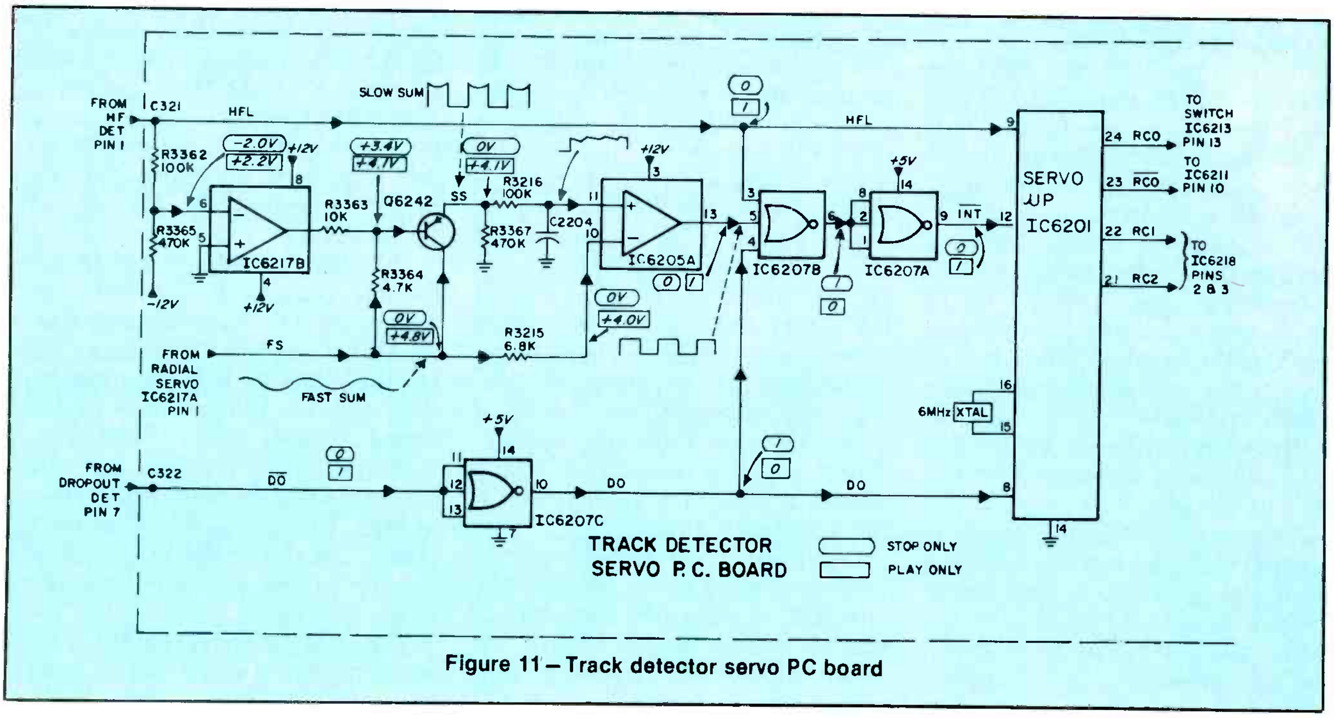

Figure 11 – Track detector servo PC board

the disc. This prevents the system from becoming unstable and start to skip or jump tracks each time the loss occurs.

The age of digital control is here

This discussion should make clear that the application of digital technology to music playback has made what was once relatively straightforward and simple to comprehend, extremely complex. That's what happens every time digital technology is applied to anything.

But digital technology is applied to systems in spite of the massive increase in complexity because the benefits of digital technology are great. Table 1 compares the performance of a standard disc player with that of a compact disc. In every way, the digital system beats the analog system. Also, the introduction of microcomputer control makes it possible to program the player to play the disc as chosen by the operator. It's possible to skip sections or to repeat selections or to perform other operations not available on standard analog turntables.

This article is a first step by **ES&T** to describe the technology of digital disc players. Other articles will follow.

Here's how music is encoded on a compact digital audio disc

The digital information contained on the compact audio disc record is retrieved from the record by the means of a laser beam, which generates an infrared light beam that detects the track of pits and flats on the disc. The beam is generated by a semiconductor diode mounted in a light pen assembly shown in Figure S1. Figure S2 shows the laser unit separated from the upper section. The upper section contains the photodiodes and collimator lens. The laser unit contains the laser diode and a single photodiode and the prism.

The laser generates two light beams as shown in Figure S2. The main beam emerges from one end of the laser diode and is used to retrieve the information on the disc. The secondary beam emerges from the other end and is used to control the intensity of the light beam being emitted by the laser.

An important factor for good operation of the player is that the amount of light landing on the disc is held constant as possible. The intensity is, however, dependent on the current fed through the laser and on the temperature of the diode. Therefore, the intensity of the light beam can be kept constant by controlling the current supplied to the laser diode. There is a fixed relationship between the intensity of the main beam and the secondary beam. The light of the secondary beam is used as a measurement of the main beam, and is accomplished by installing a photodiode directly below the laser diode as shown in Figure S3.

This photodiode is called the monitor diode and the signal from this diode is applied to the laser power supply and controls the amount of current supplied to the laser diode. If the intensity of the light beam is too low, the signal from the monitor diode is too small and the current is increased, and conversely if the signal is too high.

The light leaving the laser diode passes through a semi-reflective prism, which allows the light coming from the laser to pass through. The reflected light returned from the disc is deflected onto the photodiodes. The prism is a wedge shaped optical glass that splits the return beam into two beams as shown in Figure S4. The photodiodes convert the reflected light into electrical signal. A total of four diodes have been mounted slightly apart in groups of two. The prism splits the beam and one-half lands on one pair of diodes and the other half on the second pair.

The purpose of the collimator lens is to converge the light beam into a parallel beam; that is, light tends to spread out in all directions as the distance from the source increases. The lens converges the light beam into a parallel path to fill the aperture of the objective lens.

The objective lens is mounted on the radial tracking arm. Figure S5 shows a cut-away drawing of the optical device used to track the up and down movement of the disc. The objective lens is mounted on a ring of magnetic material and connected to the housing by two leaf springs, which are used to provide tension and keep the barrel of the objective lens straight in its cylinder throughout its range of travel. The housing contains a coil which produces a magnetic field when an electrical current is applied, and exerts a magnetic force on the magnetic material that the objective lens is mounted on. This force moves the lens up or down, depending on the polarity and magnitude of the coil current.

Figure S6 shows a drawing of the optical pick up unit and the location of each of the optical devices and the path of the light beam from the laser to the disc and return to the photodiodes. The objective lens focuses the light beam onto the disc and the reflected beam is returned to the semi-reflective prism, where the beam is split. The two beams from the prism fall on the two pairs

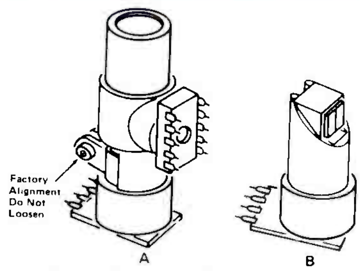

Figure S1 – Light pen assembly

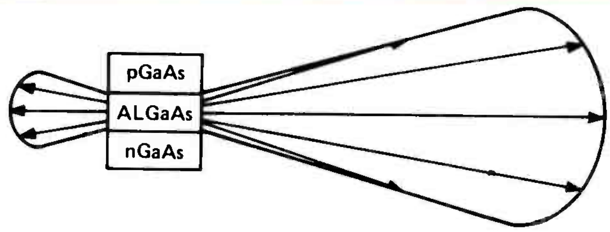

Figure S2 – Laser beams

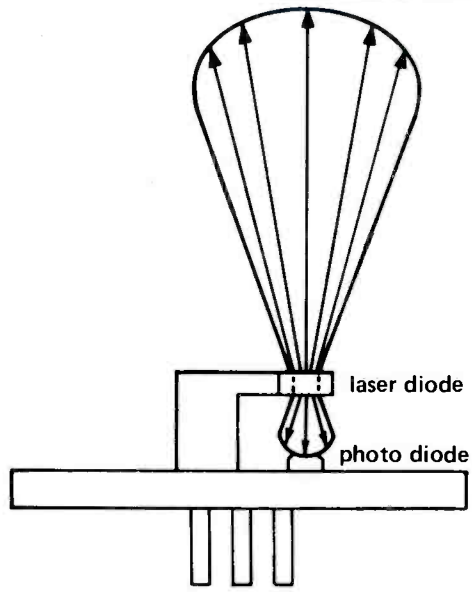

Figure S3 – Monitoring photodiode

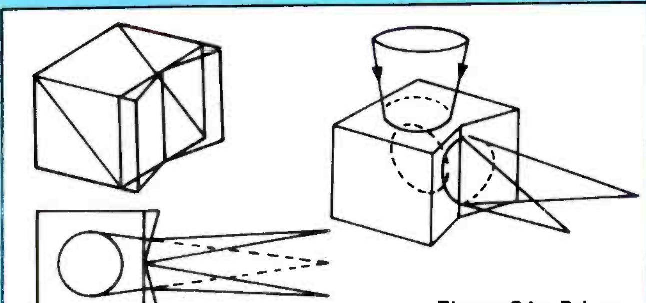

Figure S4 – Prism

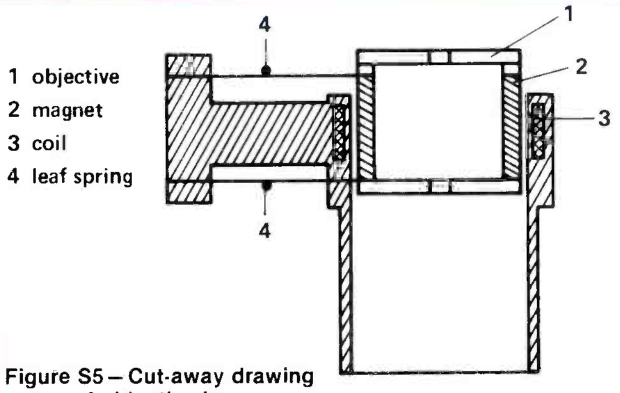

Figure S5 – Cut-away drawing of objective lens

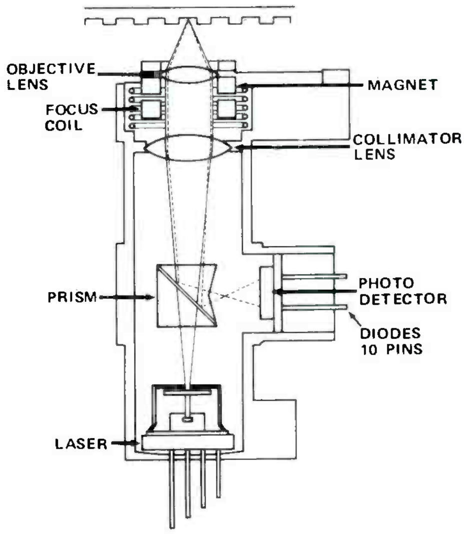

Figure S6 – Optical pickup unit

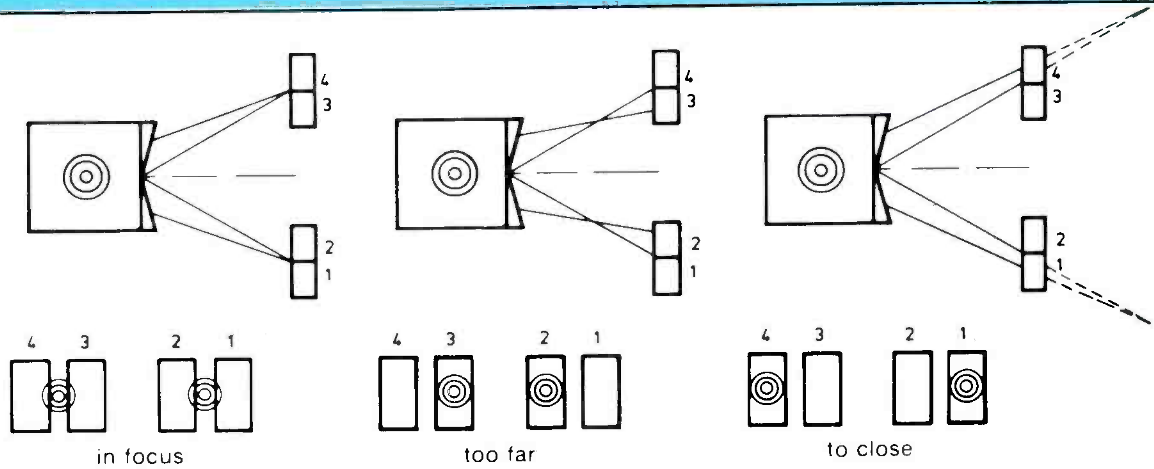

Figure S7 – Three conditions of the objective lens

of diodes, which are used to create error signals to control the movement of the objective lens and maintain correct focus.

Figure S7 shows the light beam deflected by the prism in three conditions. The first condition is when the objective lens is focused perfectly on the disc. Both beams are landing directly on the center of the two pairs of diodes. The second condition is when the objective lens is too far from the disc and the two beams are landing on the inside diode of each pair. The third condition is when the objective lens is too close to the disc and the two beams are landing on the outside diode of each pair. In the focused condition, a zero error exists from the photodiodes and the objective lens remains at its nominal position.

In the too far condition, an error signal is created to return the objective lens to its nominal position by applying the error signal to the focus servo control circuitry. In the too close condition, the opposite error signal is created and applied to the focus servo control circuitry to move the objective back to its nominal position and zero error is once again obtained.

Figure S7A shows an illustration of the physical layout and dimensions of the photodiodes. The four photodiodes are located on a single chip and the large area around the four photodiodes is used as a guard diode. The function of the fifth diode (guard diode) is to conduct any current created by stray light landing on the diode to ground. The stray light landing on the fifth diode causes electron-hole pairs in the silicon chip which would be recombined before they reached the four photodiodes. To avoid interference or damage to the photodiodes the electron-hole pairs are discharged to ground by the guard diode. □

The music on a CD is read out using a laser beam

This is how it's done...

Compact disc record

Figure D1 shows a magnified view of a disc, composed of thousands of circular *tracks* made in a continuous spiral from the inside to the outside of the disc. These tracks are analogous to *grooves* in an ordinary audio record. However, the tracks of a compact disc are not grooves. The tracks consist of microscopic *pits:* minute indentations in the disc material. The width of the pits is only 0.4μm, with a depth of 0.1μm. The distance between the spiral tracks is held constant at 1.6μm and is called the track *pitch*. The combination of the *pits* and *flats* (area between the pits) is used to reproduce the digital recorded information.

The pits and flats that represent the digital information are actually 1.1mm below the transparent surface of the disc (see Figure D3). The light beam passes through the transparent base material to retrieve the information. The light reflected by the pits is not as bright as the light reflected by the flat area. The rotation of the disc combined with the pits and flats passing over the light beam create a series of *on* and *off* flashes of light being reflected back into the system, thus modulating the light beam.

The length of the pits and flats determines the information contained on the track. Figure D3 shows a track of pits and flats. The pits and flats can vary in length from 1 to 3μm. The analog waveform below the pits and flats represents the decoded signal after digital to analog conversion. The pits reflect less light than the flat area, and the length of the two vary to recreate the original analog signal.

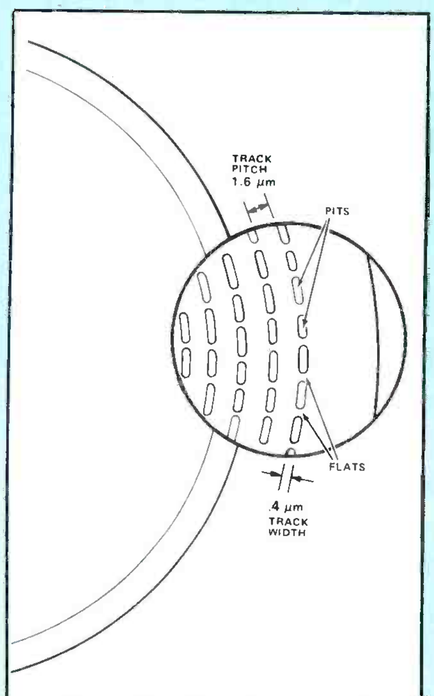

Figure D1 – Magnified view of compact disc tracks

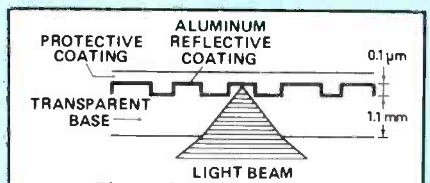

Figure D2 – Cross section of compact disc

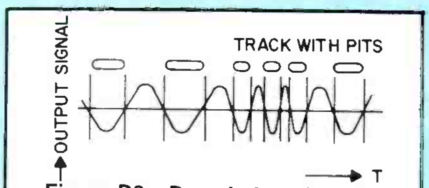

Figure D3 – Decoded audio output waveform generated from the pits

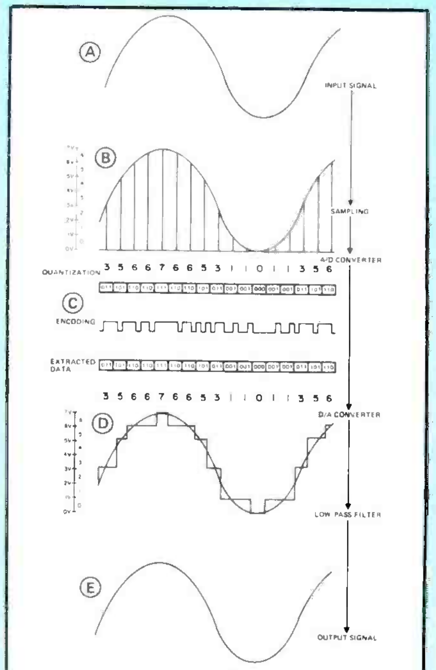

Figure D4 – Conversion from analog-to-digital and from digital-to-analog

Digital sound reproduction

Figure D4 shows the conversion from analog-to-digital and from digital-to-analog. The analog waveform in Figure D4A is sampled and measured at short intervals as shown in Figure D4B. In the analog-to-digital converter, the measured values are converted into binary numbers and encoded into a pulse train as shown in Figure D4. The pulse train is then placed on a transmission system, detected, and converted into its original form by reverse process.

The transmission system, in this case, is the compact disc. The encoded information is contained in the pits and flats of the disc. The infrared beam is modulated by the pits and flats to create the pulse train of digital information. The detected pulse train is applied to the digital-to-analog converter as shown in Figure D4. The detected information is converted back to its original waveform by the digital-to-analog converter as shown in Figure D5. The audio waveform is sampled at a high rate of speed, and the value of each sample is measured and converted to a binary number. The string of successive binary numbers is the digital equivalent of the audio waveform and as long as the binary numbers maintain their true values, the waveform is expressed with an accuracy that depends only on the sampling speed of the binary number. The advantage of the binary code in this respect is that it has two conditions, 0 and 1, which can be easily represented by electrical circuits being switched *on* and *off* As long as the digital circuits can detect the difference between these two conditions, the string of numbers will be perfectly preserved.

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Circle (15) on Reply Card

Test your electronic knowledge

By Sam Wilson

1. A SAW filter gets its name from:
A.) the fact that its response curve looks like teeth on a wood saw.
B.) the first letters of Surface Acoustic Wave.
C.) The first letters of Severly Attenuated Width.
D.) the fact that its cutoff is so sharp that it looks like it was sawed off.

2. Capacitor C_1 in Figure 1 is used for tuning an oscillator. Capacitor C_2 is used for making small changes in the range of frequencies set by C_1. Capacitor C_2 is called a ______________.

3. Capacitor C_2 will have the greatest effect on oscillator frequency at the:
A.) highest frequency.
B.) lowest frequency.

4. Rodney Lanyard decided to switch from the original manufacturer's circuit to the one he designed. (His version is shown in Figure 2.) However, he can't calculate the size of the fuse that should be used. Assuming the *rating* of the fuse is twice the actual current, what advice would you give to Rodney?

5. The voltage induced in a coil is given by the equation:

$$v = -L\,di/dt$$

where:
v is the self-induced voltage
L is the coil inductance
di/dt is the rate of change of current through the coil
Maximum induced voltage occurs when the sine wave current in the coil is:
A.) maximum.
B.) minimum.

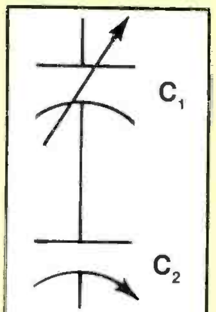


Figure 1

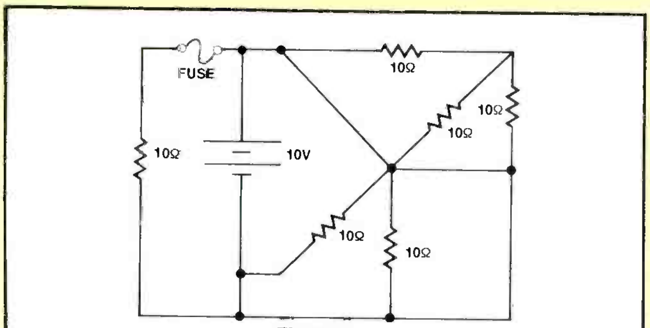


Figure 2

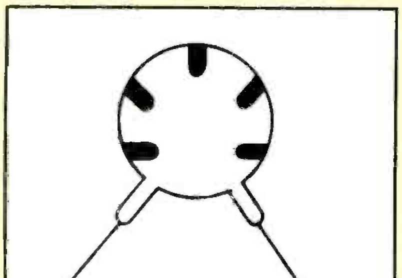


Figure 3

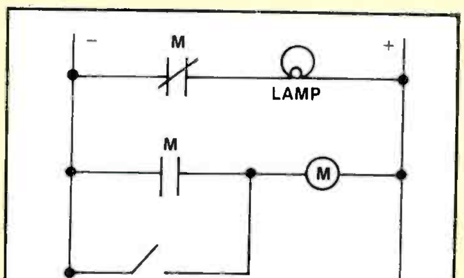


Figure 4

6. It is useful to review the history of electronics to help us get into lockstep with the new technology. The first electronic TV device was developed in:
A.) Mexico.
B.) The United States.
C.) England.
D.) Russia.

7. The best way to be sure you can read the color code for all different types of capacitors is to have a good wall chart. Which of the following is *not* given in the color code of the disc ceramic capacitor shown in Figure 3?
A.) capacity
B.) tolerance
C.) voltage rating
D.) temperature coefficient

8. Some color TV receivers can be adjusted by a signal from the transmitter called:
A.) VITS
B.) VIRS
C.) SCA

9. Can you read relay ladder diagrams? For the one in Figure 4:
A.) the lamp will turn *on* when SW is closed, and, it will go *off* when SW is opened.
B.) the lamp will turn *off* when SW closed, and, it will turn *on* when SW is opened again.
C.) the lamp will turn *off* when SW is closed, and, it will stay *off* when SW is opened again.
D.) none of these choices is correct.

10. You have a typical full-wave rectifier circuit that has an output voltage of +15V. Can you change that to a power supply with an output of −15V by simply reversing the diodes?

Answers on page 37

Continued from page 28

Answers to quiz

1. B. The name comes from the fact that waves travel through the filter on the surface of a piezoelectric material. Those waves are similar to the waves on the surface of a pond after you throw a stone in the water.

2. padder (not trimmer)

3. A. The tuning capacitor will have its minimum capacity at the high end of the oscillator frequency range. So, the padder will make up a greater part of the total capacity when the oscillator is at its highest frequency.

4. Advise Rodney to go back to the manufacturer's original circuit. He has designed a short circuit across the battery.

5. B. Actually, the maximum rate of change of current occurs when the current is zero.

6. D. The inventor had the unlikely name of Boris Lvovich.

7. C

8. B

9. C. After the switch is closed, the normally-open contact closes and stays closed after the switch is opened. This is a latching circuit.

10. No! The electrolytic capacitors must also be reversed.

Part one

Don't let power line disturbances damage your electronic equipment

By Jerry Whitaker, Editor, *Broadcast Engineering*

The ac power coming into a home is a potential source of electronic equipment malfunctions and component failures; it carries not only the 60Hz power needed to run the facility, but also a variety of voltage *sags, surges* and *transients*. These abnormalities cause different problems for different types of equipment.

An ac voltage sag is generally defined as a decrease of 10-35 percent below the normal line voltage for a period of 16ms to 30 seconds. A surge, on the other hand, is a voltage increase of 10 to 35 percent above normal, lasting 16ms to 30 seconds. (See Figure 1.) Sags and surges rarely cause problems for home electronic equipment. Transients, however, are another story.

The scope of the problem

Sensitive, solid-state equipment used today can be disrupted, or even destroyed by random short-duration spikes riding on the ac waveform. If not attenuated, these brief pulses (sometimes lasting only a few microseconds) can destroy semiconductors, disturb logic operations or latch-up microcomputer routines.

Experience in the computer industry has shown most unexplained problems resulting in disallowed states of operation are actually caused by transient overvoltages on the utility feed. With the increased use of microcomputers in home electronic products, (VCRs, compact digital audio disc players, personal computers, etc.) some form of transient protection for these devices is frequently advisable.

The subject of transient overvoltages has been extensively studied in the computer industry. A pioneering effort by the IBM Systems Development division in 1974 (conducted by George Allen and Donald Segall), showed voltage spikes lasting between 10 and 100μs in a frequency range of 10-100kHz occur on an average of more than 50 times per month in a typical *commercial* environment.

Other more recent studies have shown power line transients caused by utility company switching, distribution system faults, large loads going on- and off-line and lightning, can occur as often as 900 times per month. These spikes can reach 2kV (or more) and last up to 30ms.

Transient overvoltages come in a wide variety of forms, from a wide variety of sources. They can, however, be broken down into two basic categories: those generated through natural occurrences and those generated through the use of equipment, either in the home or elsewhere.

Natural occurrences

Natural phenomena causing power line transients consist mainly of lightning and wind storms, including tornados. The *lightning effect* can be compared to that of a capacitor. (See Figure 2.) A charged cloud above the Earth will create an oppositely charged area below it of about the same size and shape. When the voltage difference is sufficient to break down the dielectric (air), the two *plates* of the *capacitor* will arc over and neutralize their respective charges. If the dielectric spacing is reduced, as in the case of a conductive steel structure (such as an antenna), the arc-over will occur at a lower than normal potential and travel through the conductive structure.

A typical lightning strike consists of a stepped *leader* progressing toward the ground at a velocity that may exceed 50m/μs. When sufficient potential difference between the cloud and the ground exists, arcs move from the ground to the leader column, completing the ionized column from cloud to ground. A fast and bright return stroke then moves upward along the leader column at about one-third the speed of light. Peak currents from such a lightning strike can exceed 100,000A with a total charge as high as 100 coulombs.* The radiated field frequency ranges from 10Hz to 40kHz. Higher frequency components are also present, but of much less intensity.

The lightning effect can also occur between charged clouds, with current movement between clouds creating a corresponding *earth current*. This earth current may induce significant voltages in conductors buried in line with the charge movement. The *wind storm effect* can induce voltages in conductors either above or below ground due to the rapid changes in the electrical potential of the atmosphere present during such occurrences. In other words, atmospheric charge energy doesn't have to actually strike a conductor, such as an antenna or utility company pole. In many cases, significant voltage transients can be generated solely by induction.

Cloud-to-cloud charge movements will generate horizontally polarized radiation, and cloud-to-ground discharges will generate vertically polarized radiation. Field strengths exceeding 70V/m can be induced in conductors a mile or so from a large strike.

Lightning and other natural occurrences don't have to strike your home, or even nearby, to be a problem. They can strike part of the utility company system and be brought into the home via the power lines.

The utility power distribution system can couple transient overvoltages into a customer's load through induction or direct charge injection. As stated earlier, a lightning strike a mile away from a 12kV line can create an electromagnetic field with a strength of as much as 70V/m. Given a sufficiently long line, substantial voltages can be coupled to the primary power system without a direct hit.

Given the layout of many parts of the utility company power system – long exposed lines over mountain tops and the like – a direct lightning strike to one or more legs of the system is a distinct possibility. Lightning is a point charge-injection process, with pulses moving away from the point of injection. The amount of total energy (voltage and current) and the rise and decay times of that energy seen at the load as a result of a lightning strike is a function of the distance between the strike and the load, and the physical characteristics of the power distribution system (wire size, number and sharpness of bends, types of transformers, types of insulators, lightning suppressors, etc). Suffice to say any direct hit on a 12kV feeder line will

Editor's note:
*A coulomb is the unit of electric charge that is transferred each second by an electric current of 1A. It is approximately equal to 6.24×10^{18} electrons.

generate a very damaging spike to any unprotected load.

Equipment-caused occurrences

Transients in the utility power system are the result of the basic nature of alternating current. A sudden change in an electrical circuit will cause a transient voltage to be generated due to the stored energy contained in the circuit inductances (L) and capacitances (C). The size and duration of the transient depends on the values of L and C and the waveform applied.

A large step-down transformer, the building block of a power system, makes an effective transient waveform generator when energized, or de-energized. Figure 3 illustrates the stray capacitances and inductances of the secondary which can generate a brief oscillating transient of up to twice the peak secondary voltage when the transformer is energized. The length of this oscillation is determined by the values of L and C in the circuit.

The second problem encountered when energizing a step-down transformer is the load is looking into a capacitive divider into the primary. If the interwinding capacitance is high and the load capacitance is low, a spike of as much as the full primary voltage can be induced onto the secondary, and thus the load. This spike does not carry much energy, because of its short duration, but sensitive equipment on the load side could be damaged upon reapplication of power to a utility company pole transformer, for example, as would occur after a power outage.

De-energizing a large power transformer can also cause high-voltage spikes to be generated. Unless switched off at or near the zero crossing, interrupting the current to the primary windings of a transformer will cause the collapsing magnetic lines of flux in the core to couple a high voltage transient into the secondary circuit. If a low impedance discharge path is not present, this spike will be impressed upon the load.

Transients exceeding 10 times the normal secondary voltage have been observed when this type of switching occurs. Such spikes can have damaging results to equip-

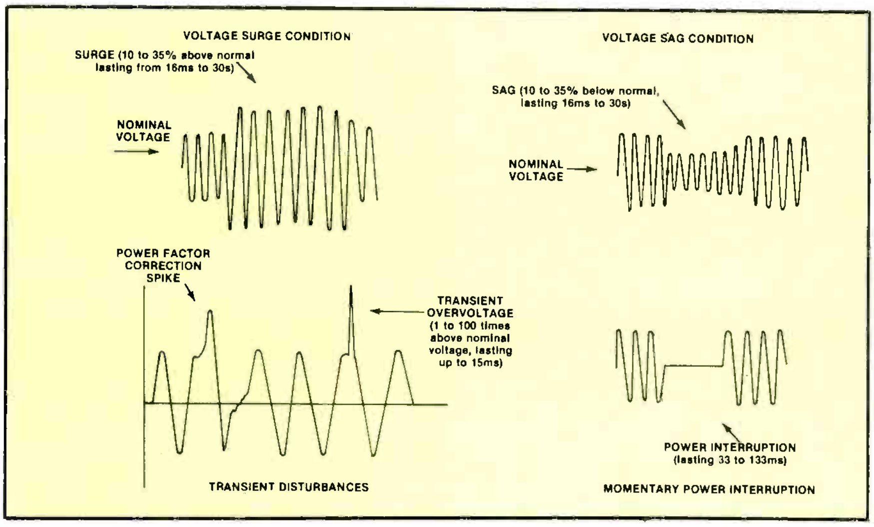


Figure 1. Voltage sags and surges can garble data and stress hardware components. Momentary power interruptions can cause a complete loss of volatile memory and severely stress hardware components. Transient disturbances can cause a wide variety of operational problems, from logic errors to complete system failure.

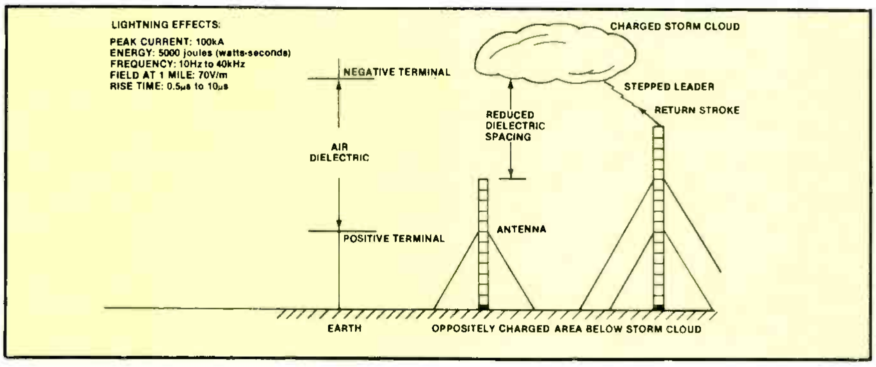
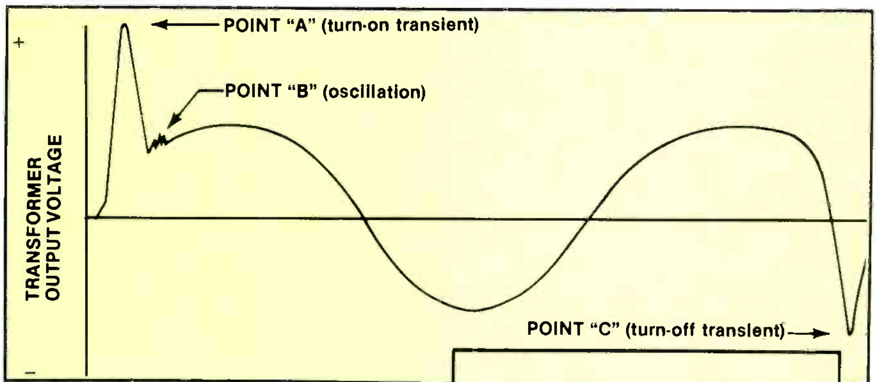


Figure 2. The lightning effect can be compared to the capacitor principle. Shown also are the parameters of a typical lightning strike.



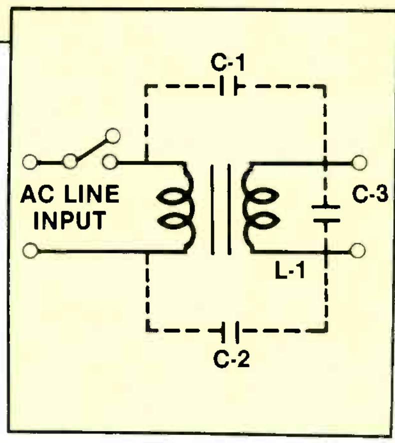


Figure 3. Inductor turn-on and turn-off spikes. C-1, C-2 and C-3 are stray capacitances which form a divider network between the primary and the secondary, causing the turn-on spike shown at point "A." The oscillation shown at point "B" is caused by the interaction of the inductance of the secondary (L-1) and C-3. The spike shown at point "C" is the result of power interruption to the transformer primary, which causes the collapsing lines of flux to couple high voltage transient into the secondary circuit. (Waveforms are exaggerated to emphasize the transient effects.)

ment. For example, the transient produced by interrupting the magnetizing current to a 150kVA transformer can measure 9 joules (watt-seconds). Whether or not these turn-on, turn-off transients would cause any damage depends on the size of the transformer involved and the sensitivity of the equipment connected to the transformer output.

Various utility fault conditions can also result in the generation of potentially damaging overvoltage transients. For example, a fault occurring somewhere in the utility company 12kV distribution system will cause a substantial increase in current in the 60-to-12kV step-down transformer at the local area distribution substation. When a fuse located near the fault opens the circuit, the excess stored energy in the magnetic lines of flux of the transformer will inject a large oscillating spike into the system. Routine load switching by the utility will have a similar effect. These transient voltages can be quite frequent, and in some instances very damaging to equipment rectifiers, capacitors and transformers.

Several other commonly experienced disturbances, such as switch arcing and relay transients, are based on these principles.

Spikes generated by contact bounce occur not only because of physical bouncing upon closing or opening, but also because of arcing between contacts resulting from transients generated by de-energizing an inductive load (see Figure 4). When current is interrupted to an inductor, the magnetic lines of flux will try to maintain themselves by charging stray capacitances. The current will oscillate in the inductance and capacitance at a high frequency; and if sufficiently high voltages are generated, an arc will jump the contacts after they have opened, clearing the oscillating current.

As the contacts separate further, the process is repeated until the voltage generated by the collapsing lines of flux is no longer sufficient to jump the widening gap of the contacts. This voltage may then look for another discharge path, such as inter-winding arcing (unlikely) or other components in parallel with the inductor.

Contact arcing can also occur when an inductor is switched on, if the contacts bounce open after first closing.

Damage caused by transients

Transient protection for home electronic equipment may be necessary because many modern products contain logic systems, sensitive analog integrated circuits and low voltage discrete semiconductors. These devices require a clean supply of power to perform correctly. The first line of defense in the protection of equipment from damaging transient overvoltages is the ac-to-dc power supply.

The power supply components most vulnerable to damage from an ac line spike are generally the rectifier diodes and filter capacitors. Diodes will occasionally fail from one large transient, but many more fail because of smaller, more frequent spikes that bit-by-bit punch through the device's

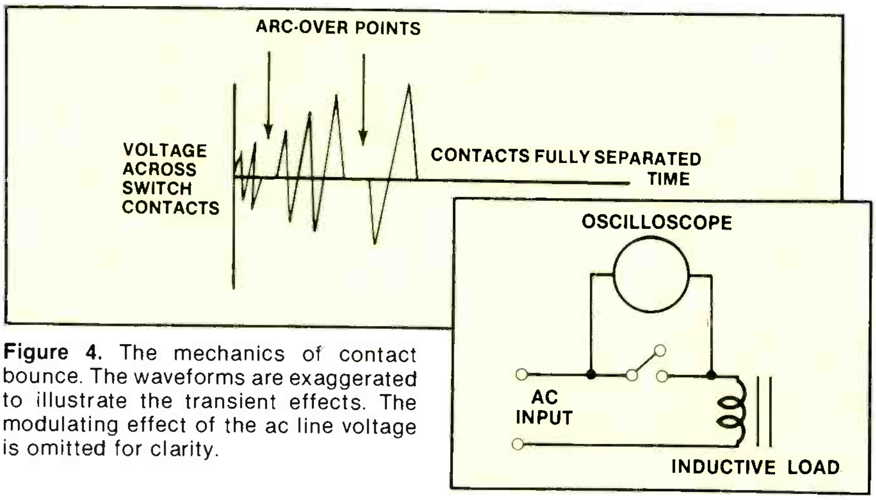


Figure 4. The mechanics of contact bounce. The waveforms are exaggerated to illustrate the transient effects. The modulating effect of the ac line voltage is omitted for clarity.

junction. Such occurrences explain why otherwise reliable systems fail "without apparent reason."

Capacitors are vulnerable to damage due to transients because the device's working voltage may be exceeded during the occurrence, punching a hole in the dielectric and leaving the capacitor useless at its normal operating value. The most damaging conditions result from the *right* timing of an operational change with the *right* amount of residual magnetism in the power supply transformer or dc reactor, or energy in the filter capacitor(s). These situations may well be rare in normal operation, however, the possibility of such *worst case* conditions cannot be disregarded.

Semiconductor failure

Transistors and other semiconductor devices can be destroyed or damaged by transient disturbances in one of several ways. A high reverse voltage applied to a non-conducting PN junction can cause avalanche currents to flow, heating the junction irregularly and consequently releasing more carriers, which conduct added current in the heated junction area. If enough heat is generated in this process, the junction can be damaged or destroyed. A damaged junction will result in higher than normal leakage currents, increasing the steady-state heat generation of the device, which may ultimately destroy the semiconductor junction.

If such a process occurs between the base and emitter junctions of a transistor, the effect may be either minor or catastrophic. In the minor failure mode, the transistor's gain can be reduced due to the creation of *trapping centers* which restrict the free flow of carriers. These *trapping centers* are created by avalanche-damaged emitter-base junctions. In the catastrophic failure mode, the transistor ceases to function altogether.

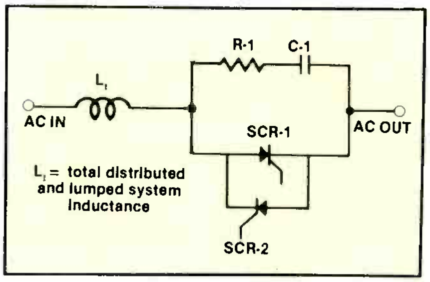


Figure 5. The basic R-C snubber network commonly used to protect thyristors from fast rise-time transients.

Another transient-caused failure mode possible in a semiconductor device is thermal runaway. It is triggered by a sudden increase in gain, resulting from the heating effect of a transient on a transistor. This increased gain caused by the transient disturbance can bring a transistor (operating in the active region) out of its Safe Operating Area (SOA).

The oscillating and decaying tail of many transient disturbances can also subject semiconductor devices to severe voltage polarity reversals, forcing the components into or out of a conducting state. This action can damage the semiconductor junction or result in catastrophic failure of the component. The position of the transient on the ac wave can have a significant effect on the damaging potential of a disturbance. This explains, in part, why identical spikes do not always cause identical component damage.

Thyristors (SCRs), like diodes, are subject to damage from transient overvoltages because of the possibility that the device's peak inverse voltage or instantaneous forward voltage (or current) ratings may be exceeded. Thyristors face an added problem because of transient occurrences due to the possibility of device misfiring.

A thyristor can break over into a conduction state regardless of gate drive if either (1) too-high a positive voltage is applied between the anode and cathode, or (2) a positive anode-to-cathode voltage is applied too quickly (dv/dt rating). If the leading edge is sufficiently steep, even a small voltage pulse can turn a thyristor on. This represents a threat to the device and to the load it controls.

Any application of a thyristor must take into account the device's dv/dt rating and the electrical environment where the unit will operate. A thyristor controlling an appreciable amount of energy should have protection against fast rise-time transients that may cause the device to break-over into a conduction state. The most basic method of softening the applied anode-to-cathode waveform is the resistor-capacitor snubber network shown in Figure 5. This standard technique of limiting the applied dv/dt relies on the integrating ability of the capacitor. In Figure 5, C-1 *absorbs* the excess transient energy, while R-1 defines the applied dv/dt in conjunction with the external system inductance, L_t.

An applied transient waveform (assuming an infinitely sharp transient wavefront) will be impressed across the entire protection network of C-1, R-1 and L_t. The total distributed and lumped system inductance, L_t, plays a significant role in determining the ability to C-1 and R-1 to effectively snub a transient waveform. *Stiff* power sources (having little series inductance or resistance) will present special problems to design engineers seeking to protect thyristors from steep transient waveforms.

Problems can be caused by transient overvoltages, not only

Continued on page 63

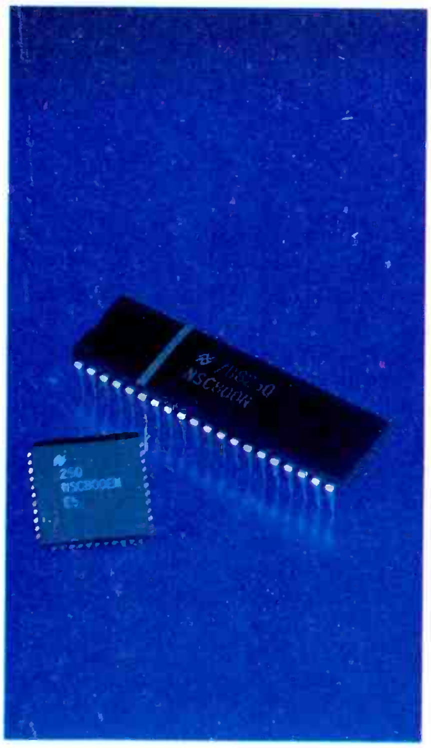
Are you ready for surface mounted components?

By Christopher H. Fenton, Consultant: Western Reserve Tool and Machine Company

Increasing circuit complexity, which drives a need to pack circuit components ever more densely, coupled with the eternal quest of manufacturers to reduce fabrication costs, is fueling development of a new method of circuit construction. In this system, called *surface mounting,* the interconnection between components on a printed circuit board are made on the same side that the components are mounted. There are no holes for leads to protrude, eliminating the idea of component-side/foil-side.

It probably won't be long before consumer electronics products manufacturers will be adopting this technology on a large scale. Not long after that, servicers will be facing the problem of learning how to most effectively remove and replace surface-mounted components when they fail.

This article describes surface-mount technology from the manufacturing point of view: why and how it's being done. **ES&T** will continue to keep in touch with what is going on in the area of surface mount, and plans for the future include publishing information on how to deal with surface-mounted components during servicing, as soon as we are able to obtain or develop such articles. —Editor



A radically new method of mounting electronic components to printed circuit boards has the potential of having long lasting effects on product design, manufacturing and servicing. The surface mounting could render most standard leaded components obsolete within the next several years. Surface-mount component packages have either short *winged* leads or no through-hole leads at all. A typical resistor, capacitor or IC component package contains wire leads that are pushed through plated holes in a circuit board assembly and then soldered to copper foils on the opposite side. These types of devices are predicted to go the way of the vacuum tube with the current rise of surface-mount technology.

Surface-mount packages can house the same chips or components as do the leaded packages, but in much smaller spaces. Surface-mount devices are soldered to foils on printed circuit boards in a way much different from the standard construction techniques used in conventional board assemblies. The circuit boards do not need to have holes drilled in them for a component's leads. As a direct result, surface-mount packages can be spaced much more closely together and the circuit board need not go through a hole drilling operation.

In some of the early applications of surface-mount techniques, they were used in areas where cost considerations were secondary to reliability and size considerations. Discrete surface-mount components were initially attached to ceramic substrates as part of mixed-composition devices. This same concept was later used on less expensive board materials, such as glass/epoxy. As size reduction became more of a factor in many non-military applications, such as computers, automobile electronics and consumer electronics, the demand for surface-mounted parts has risen considerably. As a result, surface-mount parts for these industries are being produced in larger quantities, making them more cost competitive with standard leaded components.

Initially developed during the late 1960s, the surface-mount concept remained in the background as conventional circuit board construction methods were considered adequate through the 1970s. Also, the concept was not considered cost-effective enough to be put into widespread use. With the rise of the microchip, however, size became a more important factor. A size reduction of ½ to ⅔ of conventional used board space is possible with surface-mount devices.

The United States and Japan currently are leaders in surface-mount technology. Japan uses the greatest number of surface-mount devices, primarily in the field of consumer electronics. The U.S. manufacturers are second in number of devices used, but they have been the driving force behind the development of new surface-mount packages, primarily those with higher pin counts. Increased needs within the computer and automobile industries, where the United States is considered the front-runner, is the reason for this. Japanese companies have also developed surface-mount devices, in the form of a 4-sided flatpack. These are not widely applied in the United States, however.

Surface mounting could render most standard leaded components obsolete within the next several years.

Benefits of surface mount

Several major reasons are given for employing surface-mount components in designs using existing technology. Most importantly, with the reductions in circuit size that this process allows, several functions may be combined into single-chip packages. The overall board size may remain the same, but the board will contain more features. Another factor is that designs using surface-mount components are physically smaller that those of an equivalent circuit board built with conventional methods. Finally, surface mounting the components reduces parasitic capacitance and lead resistance. High speed digital and communications equipment are two areas where surface-mount components and construction techniques will improve electrical characteristics.

Surface-mount components are currently available in many different styles of packages. At present, the most common are the chip configurations for passive devices, small-outline packages for semiconductors and ICs, and plastic chip carriers for ICs with high pin counts.

Most discrete components are available in surface-mount packages. The chip packages, for the most part, house resistors, capacitors and inductors. Small-outline (SO) packages generally house transistors and other discrete semiconductors. The SO packages have electrically conductive, tinned surfaces at either end of the component for solder attachment.

Analog circuits and logic families such as TTL and CMOS are produced in small-outline integrated circuit packages (SOIC). The SOIC packages are generally available with eight to 24 pins. Computer memories, microprocessors and other devices with 40 to 68 pins are provided in plastic chip carriers (PCCs). A PCC, also known as *quad-pack*, is square and contains leads on all four sides. The pins of the quad-pack are j-shaped and curl under the package.

Surface-mount component leads are spaced much closer than those of conventional components. As a result, board layout is more critical. Typical insertion-mount boards have 10-mil foils widths and spacing, with component leads and annular connectors spaced at 100-mil intervals. The majority of surface-mount devices have 50-mil lead spacing and some require 25 mils or less. Foils spacing requires six to 10 mils. As density requirement increases, foils width and spacing will decrease to about three to five mils. This change is expected to occur by the end of the decade.

Settling on a standard

Currently, some speculation exists about which package will become the industry standard for applications using 20 to 40 pins. SOIC packages are significantly more difficult to handle, because their leads protrude away from the package body. On the other hand, this makes for easy automatic testing. The PCC package resists damage during production because the leads do not protrude from the package body. Unfortunately, automatic testing is impossible on PCC packages because the automatic tester cannot reach points where the leads are attached. Traces cannot be placed beneath the PCC because it contains closely spaced leads on all four sides. Foil layout is therefore more critical, because board space is boxed in.

Observers forecast that the adoption of SOIC packages as a standard for devices containing up to 40 pins will occur by the end of the decade. However, widespread use of SOICs by the Japanese has reduced cost and increased availability of these devices in packages with lower pin counts.

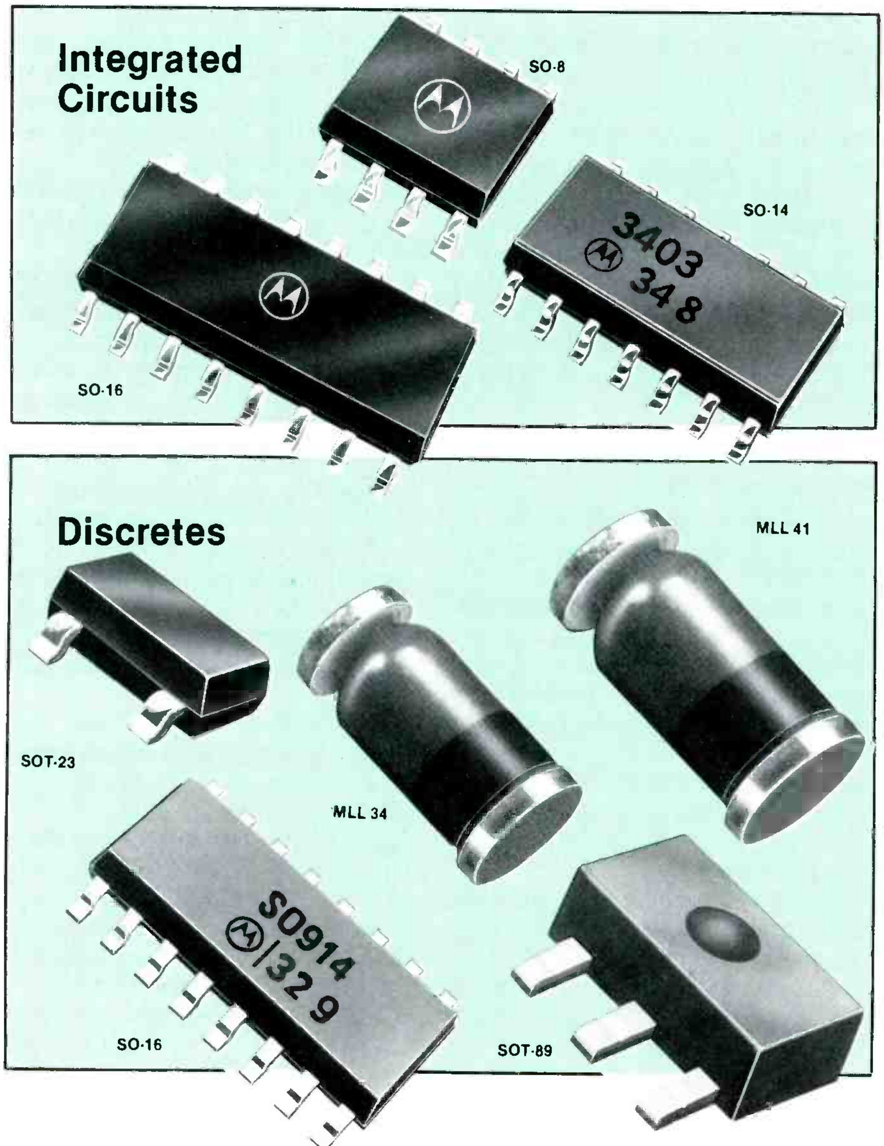
PCCs will also continue to be used appreciably and will still control a large proportion of the market, especially devices with high pin-counts and specialty devices.

High-pin-count devices also come in other types of packages, such as pin grid arrays (PGAs), leadless ceramic chip carriers (LCCCs) and tape automated bonding (TAB) configurations. The LCCC configurations are used primarily in high reliability applications. The PGA and TAB configurations are intended for use in devices having 84 pins or more. The LCCC, PGA and TAB packages require special handling or the use of special materials to realize their full cost-effective potential.

Several functions may be combined into single-chip packages.

The surface-mount manufacturing process

Most manufacturing techniques for building circuit boards with surface-mount components have evolved from standard insertion mount methods. A fundamental difference exists between the two processes, however. The lead-forming stage is not present in the surface-mount process. Pick-up and place machines replace the automatic-insertion equipment in the surface-mount process. A



These electronic device packages are representative of the appearance of surface-mount packages. SO indicates small outline, and MLL stands for Motorola leadless. The largest of these packages, the SO-16, is approximately ½-inch long by ¼-inch wide (including leads). (Courtesy Motorola).

typical pick-up and place machine is computer controlled and positions parts with servo-driven heads. Parts are dispensed from 8mm tape, magazines or from bins.

Surface-mount component leads are spaced much closer than those of conventional components.

Although surface-mount components are soldered to printed circuit board, the attachment and soldering procedures differ from those used in conventional through-hole construction of circuit boards. Conventional boards are automatically *stuffed* with components on one side of the board. Excess wire lengths are trimmed and then the boards are wave soldered.

Surface-mount boards, on the other hand, are first screened with solder paste at all component soldering points. Placement machines then position the surface-mount devices in the solder paste. Manual placement is impractical because of the small size of the parts and their tight placement together in relation to the other components on the board. The cured solder paste holds the components in place until soldering can take place. Larger surface-mount devices may also require adhesive mounting.

Wave soldering can be used with surface-mount devices. Wave soldering equipment may require some modification, however, if previously used with leaded parts. Solder temperature, wave size, number of waves, and the feed/speed parameters may also need to be adjusted. Wave soldering is difficult to control because it causes solder bridging on devices with high pin counts. The plastic chip carriers are particularly difficult to wave solder because they have closely spaced leads on all four sides.

Other solutions to this problem use alternative solder techniques to avoid the solder bridges. One solution called *solder reflow* seems to have the greatest potential for resolving the problem of solder bridging. With solder reflow, a solder paste is screened onto the circuit board before component placement. The paste holds the parts to the board and the assembly is then heated to 210° C. The solder paste melts or reflows, to form solder joints. Surface tension of the solder holds the components in place.

Reflow soldering is done by infrared heating or by a technique called *vapor phase reflow*. Vapor phase reflow heats the solder paste using an inert vapor that boils at 210° C. Surface-mount boards are fed through the vapor phase equipment as in wave soldering. Instead of passing over a wave of solder, the boards pass through the boiling inert vapor. Unlike wave soldering, the vapor phase reflow process is not easily viewed because the process is well controlled to minimize the loss of expensive inert material. The boiling inert fluid is at a constant temperature and conductive heating of all solder joints occurs at the same time.

The heat absorption characteristics are another consideration when infrared light is used instead of the inert vapor to reflow solder. A typical surface-mounted transistor is in a dark package while solder joints are silver colored.

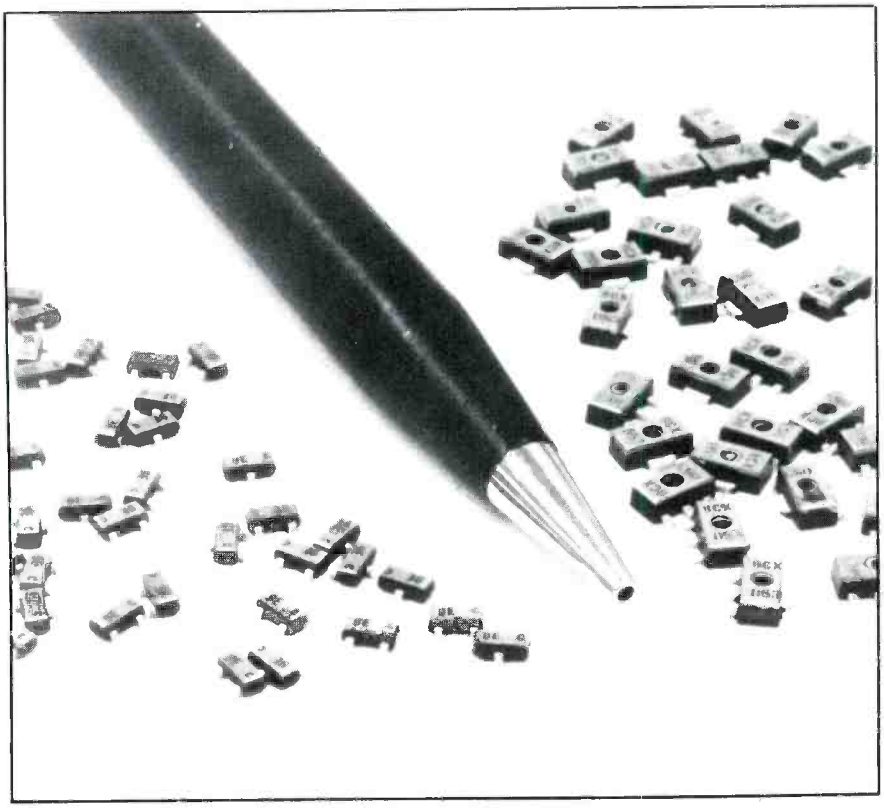
Consequently, the infrared process is not well controlled, and the point is moot on the vapor phase reflow process. The infrared technique is used in less demanding applications, such as those using only passive chip devices.

Some surface-mount attachment techniques use electrically conductive epoxy instead of solder.

Epoxy instead of solder

Some surface-mount attachment techniques use electrically conductive epoxy instead of solder. This method has been used for years to produce hybrid circuits on ceramic substrates. Proposed surface-mount applications will use standard glass/epoxy boards. Epoxy attachment may cost less than soldering in some surface mount applications.

The process begins with the



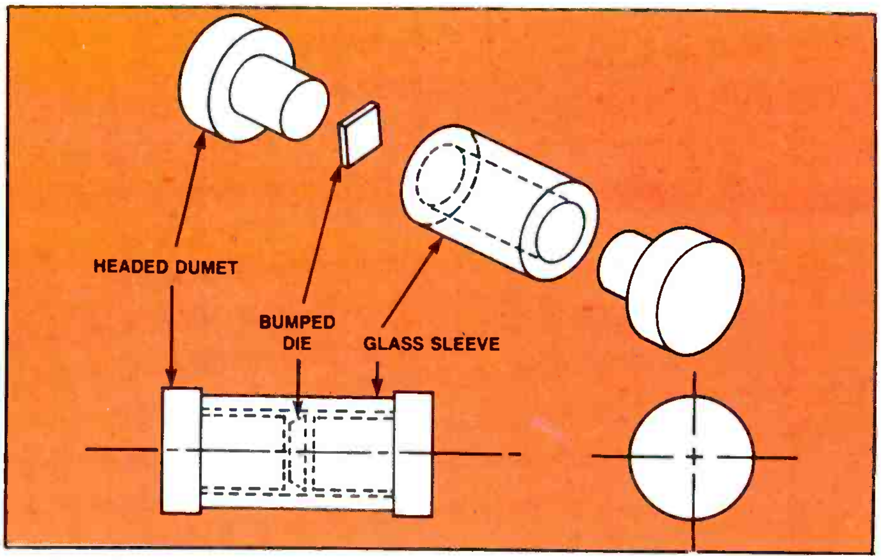
SOT-23 and SOT-89 packages are shown here with a mechanical pencil to give an impression of size. (Courtesy Motorola).

screening of electrically conductive epoxy at all component placement points. Drops of nonconductive epoxy hold larger components in place until they can be cured. Placement machines then position the components on the board. Convection, infrared or vapor-phase heating can then be used to cure the epoxy. Epoxy curing time can occur in minutes and is temperature dependent.

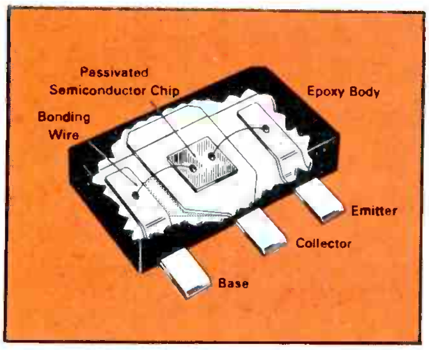
The epoxy process has two key advantages. First, fewer manufacturing steps are involved than in the soldering process. Circuit board annular connectors need not be pre-tinned and there is no need for the soldering flux removal/cleaning operation. Second, conductive epoxies can be formulated to minimize the effects of thermal expansion coefficient mismatch between the component and board materials.

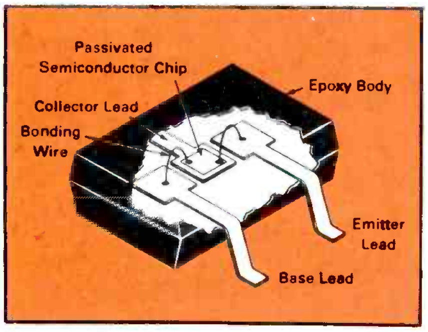
Use of conductive epoxy has some drawbacks. The material costs three times more than solder, and epoxy bridges, unlike their solder counterparts, do not clear themselves when heated. Mixed assemblies are not practical because epoxy must be applied manually to all through-hole connections.

In some cases, conductive epoxies may replace copper circuit board foils. Epoxy *foils* are simply screened onto the copperless board, eliminating the plating and etching step. Though the process reduces manufacturing costs, the long term reliability of epoxy foils has yet to be determined.



Leadless diode construction. (Courtesy Motorola)



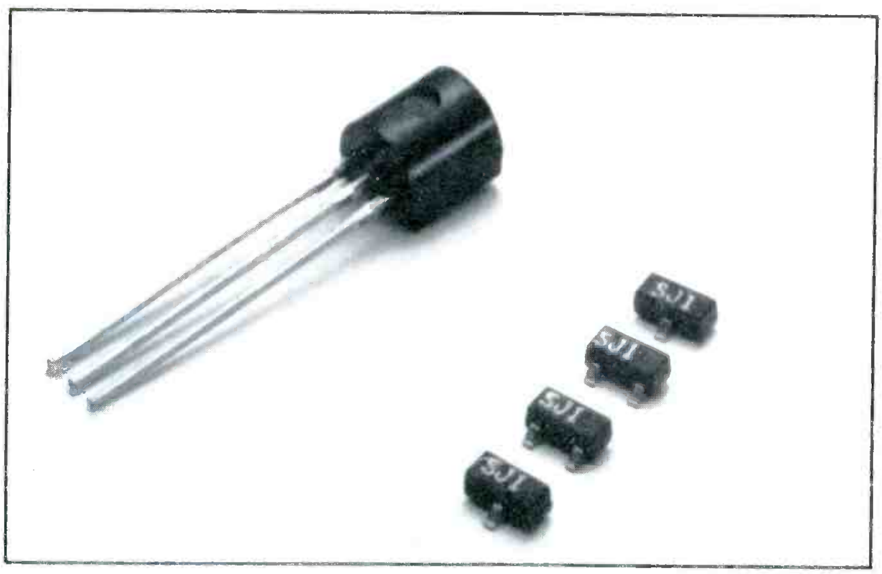


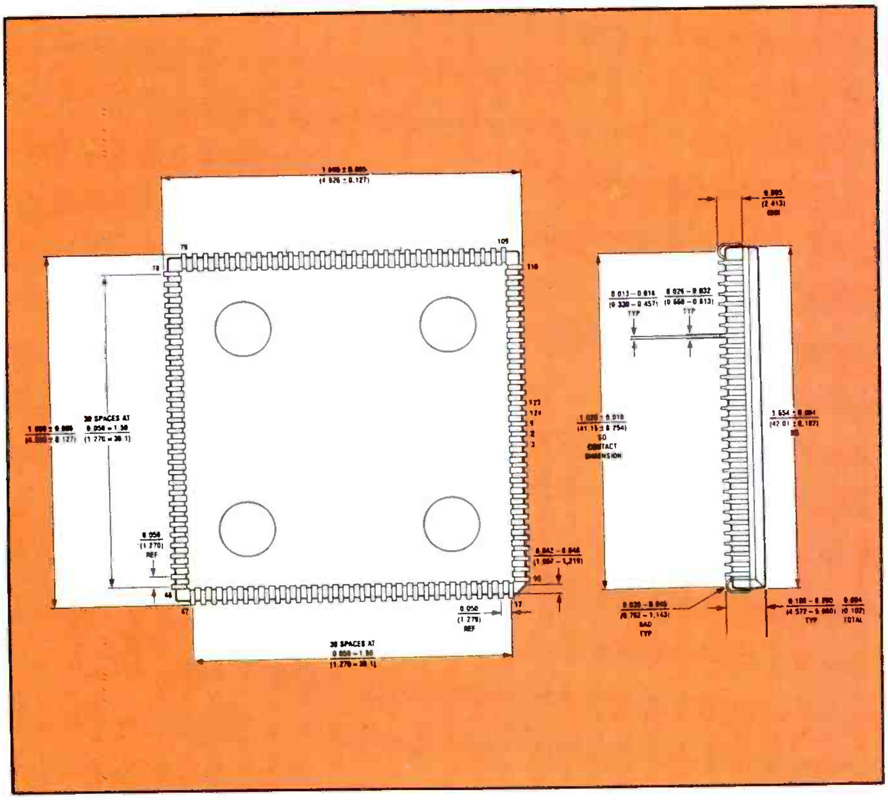
These cutaway drawings show internal construction of two of these devices. (Courtesy Motorola).

The cost considerations

Currently, tooling costs are two to five times higher for surface-mount boards than for conventional packages. Price parity has already occurred with some discrete components.

Even with the current cost penalties, the use of surface-mount technology can reduce overall costs. Reduction in board size as a result of using surface-mount devices can lead to lower material costs, and smaller assemblies mean less packaging and shipping costs. Surface-mount manufacturing areas require less plant space and manpower than do insertion-mount facilities of equal capacity.


Field-effect transistors in SOT-23 packages make a standard TO-92 package look huge. (Courtesy Siliconix).



Outline drawings give an idea of the appearance and complexity of a 124-pin plastic chip carrier. (Courtesy National Semiconductor).

The production equipment is physically smaller and there is no need for a machine that forms and trims compact leads. Decreased packaging, manpower and capital equipment costs may offset increased tooling and component costs.

Even with the current cost penalties, the use of surface-mount technology can reduce overall costs.

Some observers feel that surface-mounting will be the dominant force in board assembly methods by the end of the decade. Faster and more flexible pick-up and place machines are needed for placing components on circuit boards. The key reason tooling costs are so high is in part because of the lack of a standard component package, primarily in the 20 to 40 pin range. Surface-mount component prices are expected to drop to conventional parts price levels during 1986. ES&T

Part I

Analysis of Sylvania Superset Two

Model RXS198WA

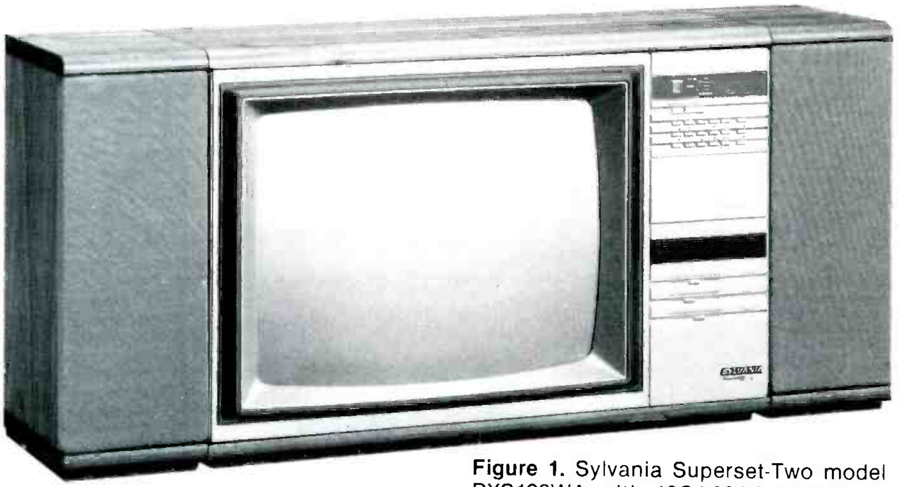


Figure 1. Sylvania Superset-Two model RXS198WA with 19C4-03AA chassis is the top of the 19-inch color-TV receiver line. The two speakers are not attached to the cabinet, and can be placed wherever the customer desires. An internal decoder board produces stereo TV sound, when the program is broadcast in stereo. VCRs and other video/audio devices can connected to three RF inputs or to the receiver's video and audio circuits directly via a jack panel on the rear.

By Carl Babcoke, CET

With stereo broadcast capabilities available today, along with cable, VCR and video game hook-ups, many televisions are being built with a stereo receiver, speakers and accessory modifications included. Recently, NAP Consumer Electronics Corporation loaned to **Electronic Servicing and Technology**, a Sylvania Superset Two, model RXS198WA for our review. This first article, which gives you an overview of its features, will kick off our series concerning the Sylvania Superset Two. Later articles will analyze the circuitry involved in this particular model.

Two features found in many new color TV receivers are stereo TV sound and video/audio direct connections for VCRs and video games. Model RXS198WA (Figure 1) with its E-5000 top-of-the-line chassis has these and many more features such as: 125-channel random-access digital tuning with up-down scanning and on-screen display plus a full-featured remote control; scan-velocity modulation (SVM) for increased picture sharpness; a comb filter for better separation of luminance and chrominance signals; a Dark-Lite picture tube with conical-field focusing, and a 7W-per-channel stereo amplifier with balance and tone controls.

In **ES&T**, the emphasis always is on the circuitry, how it operates and how it can be repaired when necessary. This series of articles will cover all those subjects in detail, but the first part will familiarize you with the customer controls, the general layout of various boards and many of the unusual functions.

Some of this information does not come automatically, even to experienced technicians. For example, my servicing experiences included the first black-and-white TV receivers, the first color receivers, the first transistor radios, and all developments since then. But I made several mistakes by trying to set the on-screen time readout and tune in the TV channels before reading the customer-instruction booklet! Therefore, I would advise you to read the instruction manual before trying to adjust and operate a complicated receiver like this one.

Figure 2. Push-buttons and other controls are arranged in four areas of the Sylvania front panel: the remote sensor and indicator lights at the top; push-buttons for many functions are below; TV controls and other switches are under a hinged door near the center; and balance, bass and treble controls are near the bottom.

Front-panel controls

The customer-operated controls of the Sylvania Superset Two are grouped into four general areas on the front panel (Figure 2). At the extreme top are six indicator lights and the remote-control sensor. Below them are 20 push-buttons for channel selection and other functions. Below the buttons, and hidden behind a hinged door, are the seldom-used picture controls and audio/video switches. Finally, balance, bass and treble audio controls are located about 5 inches from the panel's bottom.

Figure 3 pictures the first two groups. Behind a grill in the black trim at the top is the infrared sensor for the remote control. At the right are six indicator lights that show which of the three accessory

RF inputs and which of three audio/video conditions have been selected, or now are in use.

Push-button functions – Below those are 20 push-buttons for many functions. One button is labeled *power*. It is firmly pushed to turn on the ac power, or later pressed again firmly to turn off the power. None of the 20 buttons latches mechanically at the inward position; thus they cannot indicate the condition by the position.

Next is a wide button labeled *ACC* for accessories. Any of the three RF inputs mentioned and its corresponding indicator light (mentioned before) can be selected by pressing the *ACC* button firmly for about a half second to advance the indicator light (and RF input on the receiver's rear panel) as desired. Each button push advances one step of the ACC-1, ACC-2, ACC-3, ACC-1, ACC-2, sequence. Stop when the desired accessory RF is obtained.

Digits from zero to nine are for random-access selection of TV channels, or for setting the on-screen digital time. Two valid digits must be entered for each channel before the system will change to the new channel. Channels 2 through 9 must have a zero entered before the channel number, or the tuning will not exchange (the selection was not valid).

If an invalid channel number (such as 5, 01, 99 or 85) is entered, the number will appear in the lower-right corner of the screen for about six seconds while the previous channel also remains on the screen. After the six seconds, the number disappears – the circuit has forgotten it! This is a good system because an invalid number caused no disturbance (the system ignores it), and the channel number received by the tuner circuit is displayed so the viewer can check it for accuracy (and correct it if necessary).

Figure 3. Some details can be seen of the sensor/indicator-light area above and the 20 push-buttons below.

There are two ways of obtaining an invalid number even when the correct buttons are pushed in the correct sequence. The receiving sensor's pick-up pattern is only about 60 degrees wide, and that of the remote-control unit while the buttons are being pushed can cause a severe reduction of infrared strength at the receiver; and the elimination of one or both channel numbers makes the entry invalid.

Another possible hazard is the slight time delay after a channel-selecting button is pressed before the circuit acts on it. Therefore, *if the numbers are pushed too rapidly, one or more might not activate the circuit.* **Remember:** Push each button firmly to the bottom of its travel. Try to keep the button depressed for a quarter to a half second. If the buttons are pressed firmly with authority, there should be no ciphers or invalid numbers.

At the lower left corner of the group of push-buttons are the channel-up and channel-down buttons, with arrowheads to show the direction. A short firm push moves the tuner up or down one channel. But if a button is pushed and held, the channels are scanned slowly at perhaps two or three per second.

If the receiver is to be used where only a few channels will be viewed, the non-favorite channels can be deleted (temporarily; they can be restored) by the *add*-and *delete* push-buttons under the door (described later). If only four channels are left active, it is quicker to scan those four than to select each by the direct-access method.

The same zero through nine buttons also are used to set the on-screen clock. After the television has been unplugged from ac power and then is plugged in and turned on, these conditions will be found: (1) channel 3 will be tuned in; (2) the sound will have minimum volume; and (3) the time digits in lower-left corner of the screen will be replaced by the letters PF, for power failure. Tune in a channel and increase the sound volume to normal. Next, set the on-screen time readout.

From another clock, notice the correct time. Press the *set time* push-button, and three zeros will appear in the time area, replacing the PF. *Do not attempt to tune in a channel now; the system is ready for time adjustment only.* Push the buttons for the correct time. If it is 11:04, push one, one, zero and four. If it is 3:50, push three, five and zero. Those numbers should appear on the screen (replacing the three zeros), but without the colon between hours and minutes. Finally, press the *set time* button again. The colon should appear between the hours and minutes digits and alternately flash on and off (Figure 4). That's all. It is safe now to use the same push-buttons to tune in TV channels.

Incidentally, I was caught by the requirement to press the *set time* button a second time to complete the time setting and restore the channel functions. The Sylvania had just been unpacked and I was in a hurry to try it out. I pressed the *set time* button and entered the time but didn't know then about pressing the second time, so I attempted to tune in stations with the push-buttons. Neither the program on the screen nor the channel readout changed, but some strange time digits appeared before I read the instruction book and corrected the mistake.

Another button (Figure 3) is marked *Q/view* for quick-view. Assume that a viewer has been watching channel 10, and later channel 3 is selected. If channel 10 is wanted again, it is necessary only to press Q/view once firmly. Then a second push of Q/view tunes in channel 3 again. In fact, if other channels are not selected between them, pushing Q/view will change from 3 to 10, from 10 to 3, from 3 to 10 etc.

The *mute* button (upper right corner of the button area) eliminates all sound from the receiver's speakers. It does not eliminate the audio that is available from the jack panel at the rear.

The *recall* button brings the channel-number (in upper-right corner), the accessory-RF-number (in lower-right corner) and the digital-time (in lower-left corner)

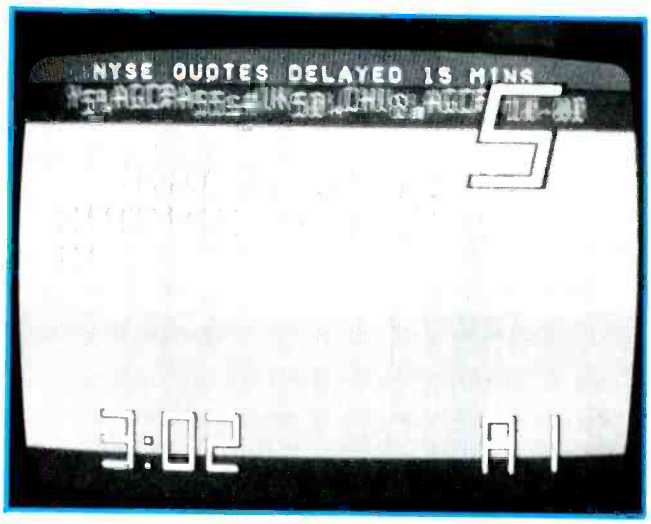


Figure 4. Pushing the recall button adds these three readouts to the picture. The time is in the lower-left corner, the channel number is in the upper-right corner, and the accessory RF input number is shown in the lower-right corner. This photograph was made from the Sylvania receiver.

Figure 5. The seldom-used TV controls and some very important switches are located under the hinged door (seen at the bottom, a bit out of focus). If the AV switch is pushed in to the *on* position, the screen will show a blank raster and there will be no sound unless external audio and video are connected to the jack panel. If the *mono-stereo* switch is moved accidentally to the SAP position during normal TV reception, the sound will be eliminated. Details are given in the text.

displays to the screen. The letters and numbers are white with a black border, so they are easily seen in the picture. Any time the recall button is pushed firmly, all three displays are made visible, with very large channel numbers at first. After about two seconds, the channel numbers begin to shrink in size and move to the left. Finally, after a total of about five seconds, all displays are blanked out. This assumes the recall button is pushed and then released. If the button is held down steadily, all three readouts will be seen on the screen (Figure 4) until the button is released, and then the previous sequence (with shrinking channel number and eventual blanking) is followed.

Finally, the VOL-with-upward-arrowhead and VOL-with-downward-arrowhead buttons are located at the lower-right corner of the push-button area. Sound volume changes are very slow and smooth when these buttons are used. For example, about 10 seconds are required for a change from minimum to maximum, or from maximum to minimum. Just push the proper button and keep steady pressure until the desired volume is reached before you remove your finger from the button. If you overshoot the mark and the sound is too loud or too soft, try again in the opposite direction.

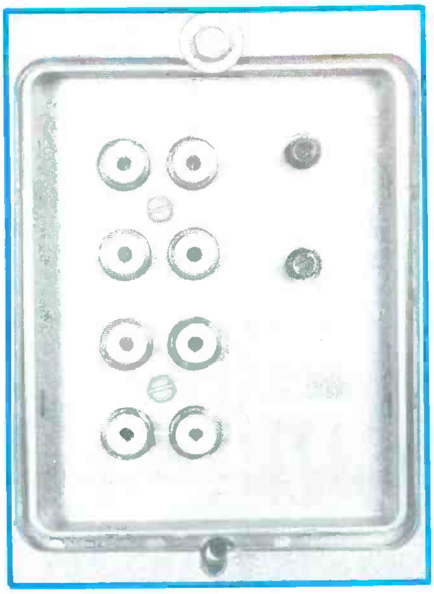


Figure 6. Phono jacks on the rear panel have a video input and output, stereo audio input and output, and right and left external speaker jacks. The video and audio inputs have gain controls marked IN ADJ. Models with internal speakers will have a selector switch beside the speaker jacks. (Note: The panel should have been dark gray, almost black. But the lettering on it was pastel, and the company that makes our photographic prints made the panel lighter so the lettering would be more distinct.) These jacks are soldered directly to the audio/video input/output board which is behind the jack panel.

Seldom-used controls—A hinged door below the push-buttons can be opened to allow access to the sharpness, brightness, picture-contrast, tint and color-saturation controls for the television (Figure 5).

To the left of the sharpness control is a 3-position switch labeled *MONO, STEREO* and *SAP.* The switch is for selection of TV sound. Moving the switch to mono connects both audio channels together for monaural audio. Changing to stereo position when the TV audio is broadcast in monaural still provides monaural sound. However, *it is necessary to move the switch to the stereo position to hear the audio in stereo* when it is broadcast on

Symcures Wanted

Electronic Servicing and Technology needs a broader variety of television Symcures. Especially needed are reports of Quasar, General Electric, Sylvania (or Philco), Sony Sears and Magnavox.

Symcures are, by definition, solutions to problems that have been encountered during the repair of *more than one* television set of the same make and model, and that may reasonably be expected to be a source of *recurrent* failure.

Please give the brand, model number, Photofact number, a brief description of the symptoms, a rough hand-drawn schematic of the area containing the defect, and a short description of the cure (including whether the defective component was open, leaky, shorted or intermittent).

ES&T editors will adapt the material to the Symcure format and have Photofact-style schematics prepared.

Send seven Symcures each time. Only six will be published, but the extra gives the editor a spare for one already printed in the past (or otherwise not suitable to the format). $30 will be paid for each page of six actually published (remember to include full name and address).

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television in stereo. A stereo-audio TV program will illuminate the stereo light that is located at the top of the front panel to the right of the ACC-3 indicator light. If TV stereo-audio broadcasts are expected, just keep the switch in the stereo position and notice the change of sound when the stereo indicator lights.

A third position of the switch is labeled SAP for Separate Audio Program, perhaps in a foreign language. Sound will be obtained at this position *only* when the program is in stereo and when the special SAP FM carrier is added to the stereo audio. If the switch is moved to the SAP position under any other conditions (such as normal TV reception), *there will be no sound.*

The *add* and *delete* push-buttons are used with the up and down scanning of TV channels. Any unused channels can be removed easily from the up/down scanning, although they are still available via direct-address selection. Just tune in the channel that's to be deleted and then push the delete button. The accessory display will be displaced by CHC, meaning channel clear. But next time up or down scanning is used, it will jump over that channel. Any number of channels can be deleted.

In a similar method, any formerly deleted channel can be added to the up or down scanning mode. Because scanning cannot stop on that channel, you must use direct-access method with the channel push-buttons to select the channel. Then when the deleted channel is seen on the screen, press the add button. That's all.

The *normal/cable* switch needs an explanation, also, because incorrect operation can cause many useless service calls to customer's homes. There are two differences between normal and cable operation. One concerns the choice of signal sources. For normal operation, the VHF tuner is supplied from a VHF antenna or CATV cable connected to ACC-1 RF input, while the UHF tuner is supplied from a separate UHF antenna (or UHF signal from a band splitter). But when the switch is moved to *cable* position, the tuners are supplied solely from whatever is connected to the ACC-1 RF input, assumed to be CATV cable.

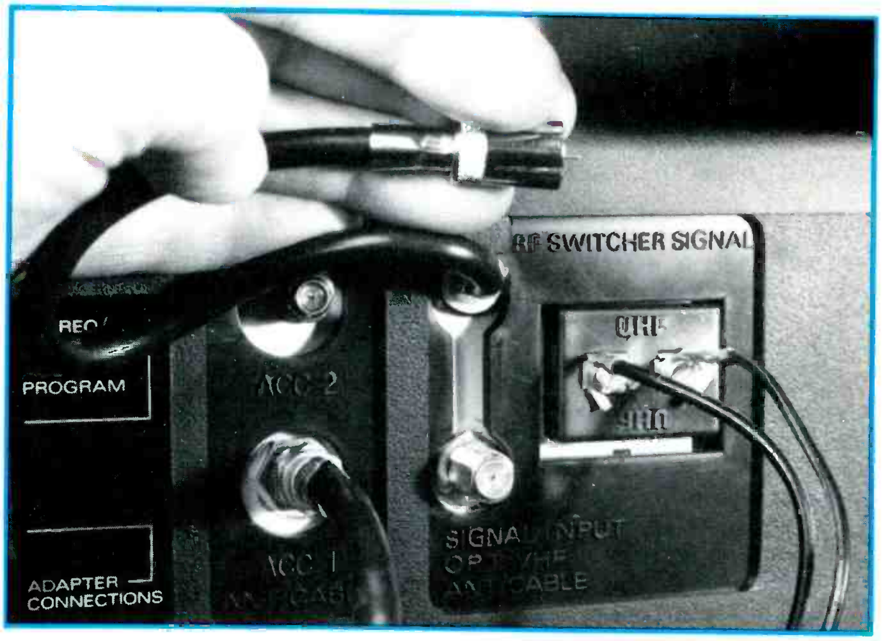

Figure 7. These accessory and signal-input coax jacks can be connected in several different ways according to need. When VHF and UHF antennas alone are used, the RF switcher-signal cable (shown held by fingers) is removed from the signal-input jack (just below it) and the VHF coupling transformer and coax are connected to the signal-input jack. The UHF downleads are connected to the two UHF binding posts. That is all. Notice that the RF switcher is not used.

The second difference is the on-screen readout in the lower-right corner. This readout normally shows A1 for ACC-1 RF input, but when the switch is pushed to *cable* position, the readout changes to CA1 meaning cable signal at ACC-1 input.

No problems should be encountered with this system so long as the customer does not misadjust the normal/cable switch. Or unless someone (such as myself) wants to operate with cable for all available cable channels plus being able to tune in UHF channels directly, without cable.

Perhaps you wonder why anyone would want cable and direct UHF. There are two principal reasons. Some cable systems convert a local UHF channel to VHF of another channel number. Problems can arise when a powerful over-the-air local VHF station is on the same channel. Under some cable disrepair or weather conditions, the UHF station on cable can have severe cross-modulation from the over-the-air station whose picture will be seen moving across the cable/UHF picture. And sometimes the UHF-on-cable sound has excessive noise from the interference.

Another reason for reception independent of the cable is to have *some* TV stations to watch during those frequent times when the cable goes dead.

Because of the internal signal switching, some peculiar results can be obtained from the normal/cable switch when cable and UHF antenna are used. For example, if UHF channel 41 is tuned-in with the switch at the normal position, the operation is normal and the readout in the lower-right corner of the screen shows A1. But tune in any other channel, change the switch to the cable position and push 41 again. This time there is no station, only snow, and the lower-right readout says CA1 (the time and channel number are correct). Changing the switch to normal does not change the symptoms, unless normal is selected and the station channel number pushed again, which tunes in the station correctly.

Automatic time and channel—Another useful feature (not described in the Sylvania literature) is the on-screen automatic readouts of time and channel number that occur on the hour and half-hour. The time is in its usual place, but the channel number is moved to the lower-right corner. After a few seconds, the readouts are blanked until the next half-hour.

Audio/video switching—Above the color-saturation knob is a push-button labeled A/V OFF and A/V ON. When the switch is in the out position (A/V OFF), conventional color TV reception with sound is obtained. Unless external sources of audio and video are connected (as shown later), *pushing the switch in to the A/V-ON position eliminates the TV sound and shows only a blank raster* (with adjustable brightness) on the screen. *This simulates a dead television.*

The in or A/V-ON position switches the receiver's video and audio circuits to receive the external video and audio signals that enter via the jack panel on the cabinet's rear (Figure 6). All eight jacks are the RCA phonograph female type. At the bottom are jacks for right and left speakers, such as the two that are supplied with the instrument. Audio from these jacks comes from a 7W-per-channel stereo amplifier, and the sound is affected by the volume, balance and tone controls that are located on the front panel.

When the A/V-OFF and A/V-ON switch is at the out (or off) position that allows normal TV operation, video for VCR recording comes from the upper-left jack marked *video out*. Simultaneously, line-level audio (monaural or stereo, according to the program) comes from the two jacks marked *audio out*.

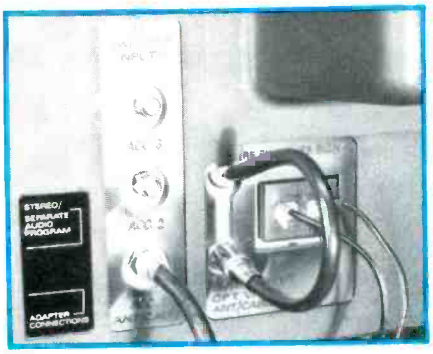

Figure 8. When the RF switcher is to be used, the cable marked RF *switcher signal* is pushed onto the signal-input optional VHF-input jack (as shown). The CATV cable is connected to the ACC-1 antenna/cable RF input (it can be selected from the front panel). Other audio/video devices with RF output can be connected to ACC-2 and ACC-3 and selected from the front panel. (Lighting used to bring out the almost invisible indented lettering made some areas of the picture too light.)

Incidentally, the audio-output signals are not affected by the front-panel volume, balance or tone controls. Nor is the audio muted during station selection.

When the direct video and audio from a VCR or a videodisc is to be brought into the receiver acting as a monitor, the video is connected to the jack marked video in, while the audio (either mono or stereo) is connected to the jacks labeled *audio in*. Gain controls are provided for the video and the audio signals.

Antenna/cable connections

Many different combinations of antennas, cable and several RF signals from VCRs and video games can be connected to this Sylvania receiver. For use only with antennas, as shown in Figure 7, the UHF down-lead wires are attached to the two UHF binding posts. After the shielded switcher-output cable is removed, the coax connector of an impedance-matching transformer can be pushed onto the signal-input coax connector (on the chassis), and then the VHF

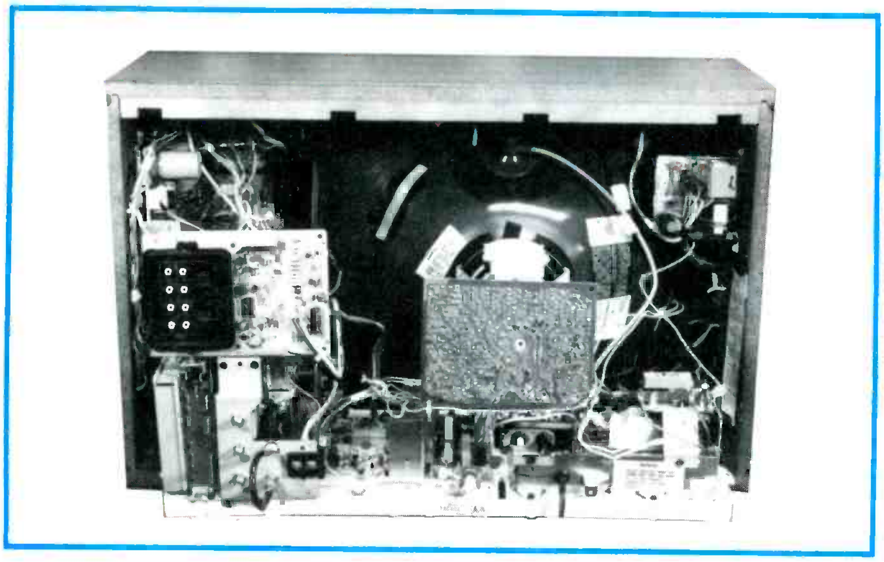

Figure 9. Three large circuit boards and up to nine smaller plug-in boards fill the Sylvania 19C4-03AA almost to overflowing.

down-lead wires connected to the 300Ω side of the matching transformer. The rabbit-ear and UHF bow-tie antennas that come with the receiver can be wired that way. Or the down-leads of UHF and VHF outdoor antennas can be connected as described.

When VCRs, video games and other accessories with RF outputs are to be added, the internal RF-switcher must be used as shown in Figure 8. Connect the RF-switcher output coax cable to the signal-input coax connector. All VHF and MATV cable signals must be connected to ACC-1 (sometimes this is done through a VCR and its switching) at the bottom. Then a videodisc player or a digital audio-disc player is connected to ACC-2 (the center input). Finally, a video game or other accessory with RF output is connected to ACC-3 (top of the three inputs).

After the wiring is completed, several pushes on the ACC button (located with the front-panel controls) increments the diode-operated RF switcher through the three inputs in turn until the desired one is reached. This is similar to operating a stepper switch with a simple switch, and must be done each time a new accessory is to be operated through the television as a monitor.

Before we leave the photograph in Figure 8, notice the unused words at the left of the RF-switcher inputs. Obviously, they are superfluous here. Previous versions of the 19C4 chassis did not have the multichannel (stereo) sound-decoder board inside (as this one does). Instead, it was to be added later, sitting on top of the receiver where it was connected to the receiver circuitry by two multi-conductor cables and plugs. The unwanted words in Figure 8 are remnants of the previous version, and should be ignored. The present 19C4-03AA Sylvania chassis has the stereo-decoder board inside where no extra connecting cables are needed.

Comments

Circuitry of the Sylvania 19C4-03AA chassis is contained on three main circuit boards (including one with the CRT socket which is larger than most) and up to nine plug-in boards. As shown by the Figure 9 photograph taken after the back was removed, the density of boards and components is very high. This might cause some complications during troubleshooting (or during our detailed analysis of the circuits in future issues). However, the boards plug in with connectors, so removal of most boards should not be difficult.

The complexity has been reduced by electronic switching of audio and video circuits on the audio/video boards and the accessory inputs (Figure 10). Electronic switching eliminates bulky multisection rotary switches and many cables.

Color-picture quality—A few instrument tests and many viewing and listening tests have been made. Of special interest were the effects of the comb filter, the scan-velocity modulation (SVM) and the automatic sharpness circuits that contribute to a better picture.

Several preliminary scope tests and observations proved the SVM circuit does increase the sharpness. Although the contrast also appeared to be higher, a closer examination showed the improvement was to the narrow black and white vertical lines in the picture. These were sharper and seemed blacker or whiter respectively on the Sylvania than on an older conventional color receiver used as a standard.

Colored sections of pictures were relatively sharp, apparently from good bandwidth, and the fit was excellent with the luminance signals. Evidently the comb filter is doing an adequate job of removing the luminance from the chrominance, because only one case showed weak colored rainbows moving on a striped necktie.

When the sharpness control was advanced for better sharpness, all of the snow, grain, cross-modulation and minor ghosts that are visible on most cable TV pictures began to be objectionable. I am anxious to see the improvements when a videodisc or a good-quality

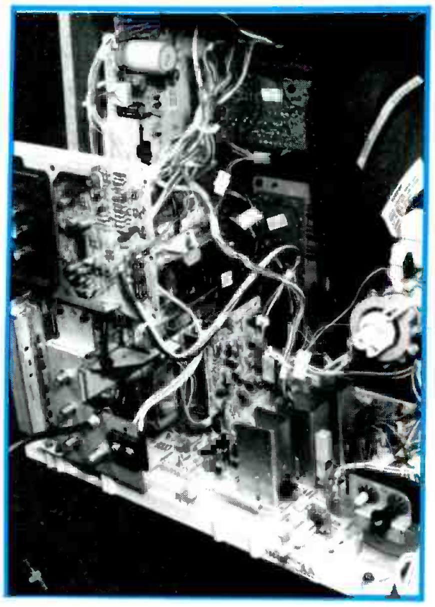

Figure 10. An oblique view shows the crowded tuning and signal side of the Sylvania receiver. The large board behind the jack panel is the audio/video input/output board, and the other board to the right above is the audio board. Other boards will be identified later in the series.

VCR tape is viewed on the Sylvania screen.

Stereo sound—When an audio-cassette tape deck was connected to the two audio-input jacks, the sound quality was more than adequate. Music through the internal stereo amplifiers and the two external speakers supplied with the machine should satisfy almost all customers. Only in direct comparison with my larger component system did it fall short. The tone controls have moderate range, and the straight-line, sideways-moving knobs show the settings at a glance.

TV-program audio from the jack panel was tape recorded several times and found to have good frequency response without problems of horizontal frequency causing beats in the audio recording.

Over the years, I have obtained audio from television's low-level stages and sent the sounds to a hi-fi system, or recorded it on tape. Usually the results are inferior. Many of the older televisions had noticeable video buzz in the sound, the high-frequency response was non-existent, often the 15.734kHz horizontal-sweep would ride piggy-back on the connecting cable (even when shielded), and most such attempts at obtaining TV audio were unsatisfactory. When viewed against this background, the operation of the Sylvania TV audio is excellent when brought out to other equipment.

However, it is frustrating to have available a receiver with the proper stereo-decoder and stereo-audio circuits and not be able to hear TV stereo sound. None of the stations in this area (or any so far found on cable) can broadcast TV stereo audio. The wider bandwidth required makes necessary expensive extensive alterations (or aural transmitter replacement) before even network TV stereo sound can be broadcast here locally. Until that happens (or a manufacturer brings out a test generator) that feature must go untested.

In summary, I have been pleased with the performance of the Sylvania Superset Two model RX-S198WA and am enthusiastic about analyzing all the major circuits. One feature not described is the infrared remote control. It has 19 push-buttons, just one less than the receiver panel, and it can perform all the same functions, except *time set* which can be done only at the panel. This receiver could be called a *color-receiver/monitor* because it has provisions for connecting VCRs and other accessories either by RF via cables or by connecting video and audio sources directly. Of course, the versatility carries the threat that customers might operate some of the many switches wrong and thus ask for warranty service where there is no defect. These calls are not under the factory warranty. Therefore, technicians should learn all these potential problems and be prepared to solve them easily.

Next article

Circuits of the low-voltage power supplies, start-up, shutdown and the SCR-type regulator will be explained with waveforms, voltages and troubleshooting suggestions. ES&T

What do you know about components?

More about resistors and diodes

By Sam Wilson

Since this series started, I have received a number of letters from friends and many suggested that I discuss additional material on the subjects already covered. In this article, I'll include some of the ideas on resistors that came in the mail.

Update on resistors

Although still more carbon composition resistors are in existence, they have been replaced in new designs by carbon film resistors. The higher noise of the carbon composition type is given as one of the reasons.

The use of carbon film resistors presents some special problems. Unlike with carbon composition types, the film type does not have a specific size for a given power rating. Also, because the shape of the film types may vary from one manufacturer to another, you have to be more alert when making a substitution.

Not all carbon film resistors are classified as being non-flammable! You have to be careful not to replace a non-flammable resistor with one that isn't. Also, remember it is a bad idea to replace film types with carbon composition types. You might introduce additional (and unwanted) noise into the system.

If someone asked you to give the color codes for the following resistor tolerances, how many would you know?

± 20 percent	________
± 10 percent	________
± 5 percent	________
± 2 percent	________
± 1 percent	________

If you knew red is the color code for ± 2 percent, and brown is the color code for ± 1 percent, then you can give yourself a gold star. We don't even have to talk about the other three.

I'll continue to update the articles as the letters come. I sincerely appreciate your comments.

More about diodes

In the last issue, I talked about some special-purpose diodes. Because there are so many kinds, it wouldn't be possible to cover all of them in the next 40 issues.

One of the first types was made from *galena*. That's another name for lead sulfide. Early *crystal* sets used this component for a detector. Figure 1 shows its construction. To use it, you have to move the cat whisker to different points on the surface until you (eventually) locate a spot where rectification (and detection) takes place. I know of at least one case where the patience of the operator wore out before the magic spot was located.

Today, *point contact* diodes are made with the cat whisker permanently attached to the crystal. They don't use galena to make them, but they are still made with the metal-to-semi-conductor junction. Because of the very small rectifying region, they have very little capacitance, and a very low forward voltage drop. They're used mostly for detectors.

I saw the prisoners in the movie "Stalag 17" make a radio out of things they had stolen out of the kitchen. So, I decided that would be a good project for my students. In my mind, it would be impossible. As often happens with students, they can do the impossible experiments. It is the ones with Ohm's law they can't handle.

They made the diode by melting some solder. While the solder was cooling, they sprinkled sulfur onto the surface. Then, the used a very fine wire for a cat whisker. They made the rest of the parts with the same clever ingenuity. The headphones, though, were obviously from a parts supply house. "Very good, but, how did you get those headphones?" I asked. (I wanted them to know they couldn't put anything over on *me*.)

"We stole them – like in the movie."

A diode can also be made by pushing the sharp edge of a razor blade against a copper wire. I'm sure you have also heard about bedsprings and dental work that get into some kind of wierd combination to make a detector and, in fact, a complete radio.

The point is, diodes range in complexity from types that can be made at home to very complex structures like the magnetron.

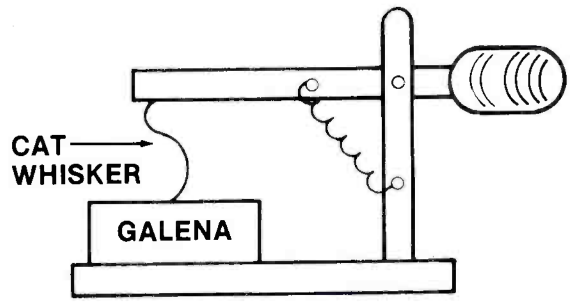

Figure 1

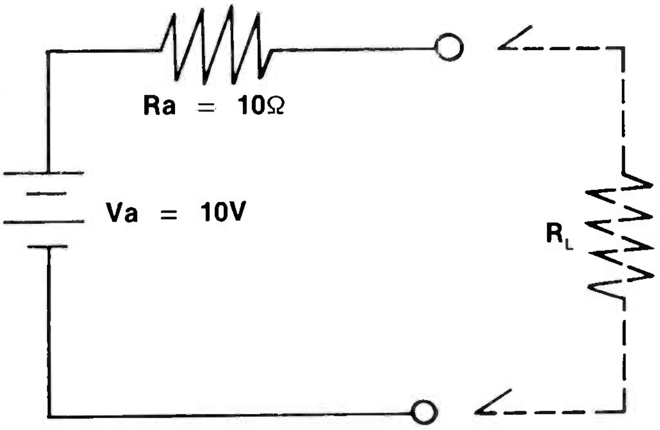

Figure 2

Load lines

All of the diodes have at least one characteristic in common: they are all nonlinear devices. Another way of saying that is: *You can't calculate the current through a diode by using Ohm's law.*

It is an easy matter to find the current graphically. The procedure involves plotting a *load line.* It will be reviewed here – not because you have to do it as part of your everyday job, but, because it will help to give some insight into the diode's character.

Consider the simple circuit of Figure 2. If you plotted every possible value of voltage across resistor R_L, and the corresponding value of current through that load resistor, you would get the load line shown in Figure 3.

Actually, only two of the points are needed to plot that line:

when V = O, I = Va/Ra
and, when I = O, V = Va

The resistance of a diode is nonlinear, but whatever its value it *must* lie somewhere on the load line of the circuit in which it's connected. Figure 4 shows a diode characteristic curve. If you connect the diode which has that curve across the simple circuit of Figure 2, the amount of current will depend upon the diode's resistance for that particular set of circumstances. Drawing the load line on the characteristic curve, as shown in Figure 5, will provide the information on the current through the diode and the voltage across the diode.

That's all very well for the circuit of Figure 2. But, suppose you want to connect the diode across a more complicated circuit with three or four resistors, and more than one battery?

A basic theorem in electrical theory says: *no matter how many resistors and batteries a circuit has, you can* ***always*** *simplify it to the one shown in Figure 2.* If you simplify the circuit, then a resistor across the simplified version of Figure 2 will draw the exact same current, and it will have exactly the same amount of voltage across it as it would in the original complicated circuit.

The name of that handy mathematical trick is *Thevenin's Theorem.*

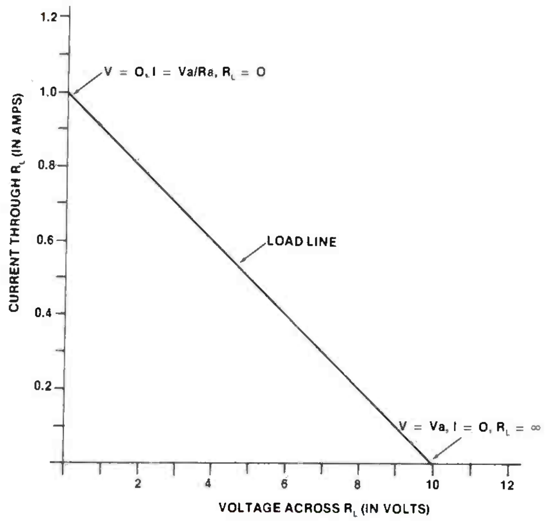

Figure 3

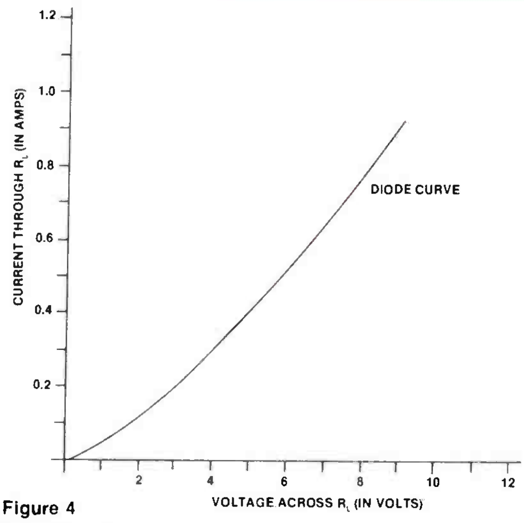

Figure 4

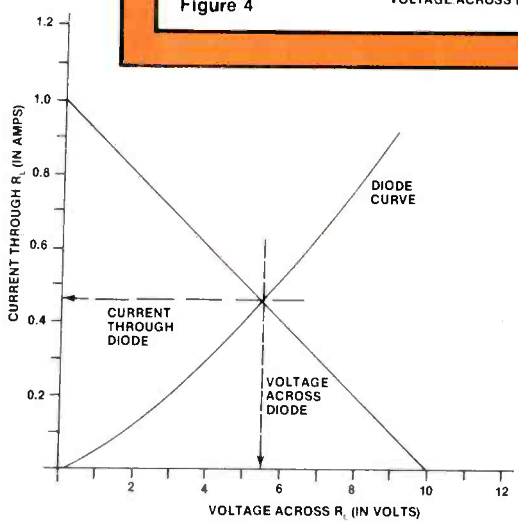

Figure 5

If you put a diode in an ac circuit, the theory is the same but the resistance becomes impedance; and, the battery becomes an ac generator.

From the procedure just described, it should be obvious that putting a different diode in the circuit will give a different solution because the characteristic curve of the diode will not be the same. So, even though two diodes look the same, and do the same kind of work, they will not perform the same in a given circuit.

Some thoughts on replacing diodes

As in the case of resistors, your best bet is to get an exact replacement. Remember some guy at the factory went to a lot of trouble working out all of the required math to get it just right, so his choice (an exact replacement) will work best.

If you try to replace a point contact diode with a junction type, most likely it won't work: the forward voltage drop across the diode will be too high. Also, the added capacitance will very likely cause a problem.

If you try to replace a hot carrier type with a junction type, it probably won't work because the reverse recovery time will be too long. Also, there will likely be small spikes of reverse voltage that can't be tolerated in the circuit where the hot carrier diode was used.

Zener diodes are rated by voltage and power. If you put the wrong one in a circuit for replacement, it can make the circuit worthless. Worse yet, it may work just long enough to get the repaired unit back into its cabinet, then burn out because it has the wrong power rating.

We'll spend some more time with diodes in the next issue. ES&T

Products

Videotape explains satellite TV

"The Remarkable Dish," a professionally produced videotape designed for Winegard TVRO dealers is now available from the *Winegard Company,* Burlington, IA. The 7-minute videotape explains to consumers, in easily understood terms, how satellite TV works, featuring Winegard products and installations. The tape includes a blend of NASA space clips, colorful graphics and live-action footage.

Circle (84) on Reply Card

Satellite reception electronics package

Lowrance Electronics, Tulsa, OK, announces the introduction of a state-of-the-art electronics package for satellite reception. The XP Performance Package features an LNA with a 60-80 degree low noise temperature with a gain of 47-49dB. It also incorporates a ferrite polarized feed system with less the 0.15dB loss and completely linear operation. The receiver, System 70, is recognized for its video and audio performance. The XP Performance Package includes all the equipment and cables for a complete electronics hookup. The package comes with either the System 70X mono or System 70S stereo receiver.

Circle (85) on Reply Card

Logic comparator

Jensen Tools, Phoenix, AZ, introduces the Bugtrap model 2074A logic comparator, offering logic comparison with a substantial increase in testing capability. The 2074 accurately tests the full line of 14, 16, 18 and 20 pin TTL ICs, including tri-state, bi-directional and open collector ICs, even 5V TTL RAMS and bipolar ROMS.

The Bugtrap 1074A tests dynamically, in circuit, at system speed under actual operating conditions and requires no interpretation of digital activity. A malfunctioning IC will cause one or more LEDs to light and latch, exposing the fault line.

Circle (86) on Reply Card

PC circuit repair/ modification kit

Bishop Graphics, Westlake Village, CA, introduces the E-Z Circuit printed circuit repair and modification kit. Using conductive copper tape, donut pads and copper sheets, this kit provides a quick, reliable and cost-effective method of repairing or modifying burnt, broken and lifted PCB circuitry. Each repair kit contains an assortment of adhesive-backed current conducting copper products, including tape, donut pads, a 5" x 6" copper sheet, a roll of polyester insulating tape and step-by-step application instructions.

Circle (87) on Reply Card

Telephone loop tester

Model 4 (Type 2) telephone tester, introduced by *Triplett Corporation,* Bluffton, OH, offers revised and optional programmable frequencies, plus improved frequency accuracy. The tester includes a tone generator, transmission test set, volt-ohmmeter and 8455-type capabilities to measure power influence, circuit noise, circuit loss or line milliamp checks and loop-around on telephone company or privately installed systems.

Circle (88) on Reply Card

Wriststraps

Desco Industries, Walnut, CA, offers a new line of wriststraps, grounding cords and testers for ESD (electrostatic discharge) protection devices. These wrist strap products are manufactured using the latest ESD technology. Wristbands are designed to provide maximum wearer comfort and safe reliable discharge paths for static charges. Ground cords are rugged reinforced retractile coil or straight wire cords designed to provide long life with safety.

Circle (89) on Reply Card

ES&T

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For Sale: B&K model 801 capacitor checker, $75. Conar tube checker, $50. *Stan Hayman 19707 Turnberry Way, N. Miami Beach, FL 33180; 305-944-5674.*

Wanted: S-meter for a Hallicrafter model SX-28 in good condition. *Paul Capito, 637 W. 21st St., Erie, PA 16502.*

Needed: Supremes manuals TV 16 & 19 and instruction/service manual for Shintron 366 amp. *C.T. Huth, 130 Hunter St., Tiffin. OH 44883.*

Needed: Output transformer #P-42004 for NEQ-360 Nippon equalizer booster, serial No. 30209479, schematic/service manual. *Jean Ketel Mathieu, 218-20 112th Ave., Queens Village, NY 11429.*

For Sale: Conar UK231 tuned signal tracer with probes and owners manual; EICO 324 RF generator with shielded RF cable and owners manual; Radio Shack untuned signal tracer. All for $100 or best offer, plus U.P.S./C.O.D. charge. *Mark Dawson, 233 16th St., Apt. 109, Jersey City, NJ 07302; 201-798-2084.*

Needed: Any condition recorder for Playmate size tapes as was used in defensive instrument's alarm dialer. Also schematic dealer #AT-555. *Harold Klotzle, 410 Cleveland Road, Ravenna, OH 44266; 216-297-1491.*

Needed: Pin-cushion transformer for Philco-Ford color, part No. 32-10182-1. Used in chassis 3CS90-91 or 3CY90-91. Part no longer available from manufacturer. New or from junk chassis acceptable. Anybody know if any other part would substitute. Appreciate help or information. *Gene Cheatham TV, 1938 Michigan Road, Madison, IN 47250; 812-273-2083.*

For Sale: RCA yoke fly 504, new, half-price; VTVM R/D instruments model No. 1600 B, best offer under $50; excellent condition VCR/VHS Quasar VR1000, with two tapes, best offer under $150. *Joe LaGuardia, 30064 SW 158 Court, Homestead, FL 33033; 305-245-1012.*

For Sale: Tektronix 2215 oscilloscope, dc to 60MHz, dual trace, dual time base, included with scope are two P6120 probes, front cover and full documentation, total run time 21 hours, $1100. *Leon Small, Barre Road, Hardwick, MA 01037; 413-477-6083.*

For Sale: Simson multimeter model 464D; Sencore TC28 tube and transtester; B&K H.V. 44 probe; Vis-WP26A isotap; plus hundreds of tubes and parts. Make offer on any or all. *Paul Kozlowski, 124 Fairview Ave., High Bridge, NJ 08829; 201-638-8025.*

Needed: Schematic and parts list for a stereo recording reinforcement mixer made by Technical Audio Products (Tapco), model 6200A. Will pay for the copy and postage. *Arthur R. Vickery, P.O. Box 742, Torrington, CT 06790.*

Needed: Jackson model X-100 color bar generator; Jackson color bar generator, model 700 or 712; Hickok 661 color generator; Hickok 209C VTVM with probes; Hickok 295X generator; Hickok 209A VTVM. *J.G. Shoemaker. 600 First St., Leechburg, PA 15656; 412-842-8321.*

For Sale: Sencore VA48, $825; B&K model 467 CRT rejuvenator, $300; B&K model 1248 color bar generator, $135. *Advanced TV & Video Service. 19217 Watkins Mill Road. Gaithersburg, MD 20879; 301-977-6787.*

For Sale: Sencore VA48, excellent condition, all leads and manuals, $750. *Howard Mason, 317 Dorchester Drive, Route-1, Linwood, NJ 08221; 609-927-0119.*

Needed: Schematic and parts list for Jerrold Division CATV cable converter, model No. JRX-3DIC-105. Also need schematic and parts list for EICO model No. 955 in-circuit capacitor tester. Will pay for copies and postage. *Joe LaGuardia, P.O. Box 1151, Homestead, FL 33030*

For Sale: Leader LBO-520 30MHz dual trace scope, $350; Sencore VA48, $725. Both in good condition with manuals and leads. *J & S Enterprises. 3015 Clarksville St., Paris. TX 75460; 214-785-3641*

Needed: Schematics for two old radios: Grunow, model 5L and an Atwater-Kent, model 206. I will pay for copies or any information. *Abie D. Clark. Clark Radio and TV. 3205 Tait Terrace, Norfolk, VA 23509; 804-853-3715*

For Sale: Heathkit IO-4101 vectorscope, has pattern generator, 1-year old, make offer. *Christopher Papin. 1510 C Mews Drive, Kansas City, MO 64131; 816-941-0173*

Wanted: A schematic for a Precision-Paco oscilloscope model ES-550B. Will pay supplier for any copying and shipping expenses. *Wesley J. Knox. 4822 Mt. Casas Drive, San Diego, CA 92117*

Wanted: Radio and color TV course with or without the experiments. Must be reasonable. Send information to: *Daniel Seidler, 5827 S. Campbell Ave., Chicago, IL 60629*

For Sale: Used flys, tuners, yokes from miscellaneous Admiral, Coronado, GE, Magnavox, Motorola; same parts for solid state Admiral, Quasar, RCA Sears, Zenith. Also: two manuals by Wallace's Telaides, a 1946-1954 RCA TV schematic diagrams and 1954 models Crosley, Emerson, Philco, Raytheon, Setchell Carlson, Zenith. *D.J. Aijala. 50 Fir Circle, Babbit, MN 55706*

Needed: Schematic, tubes, layout and any other available service information on the Hallicrafter radio receiver model SX42, serial No. HA76511. Will buy or pay for reproduction cost. *Jean K. Mathieu. 218-31 105th Ave., Queens Village, NY 11429*

Needed: Instruction manual for TEAC model A3340S reel-to-reel tape recorder. Willing to pay for copy and shipping charges. *Dan Maldonado, 1360 63rd St., Brooklyn, NY 11219; 212-256-6466*

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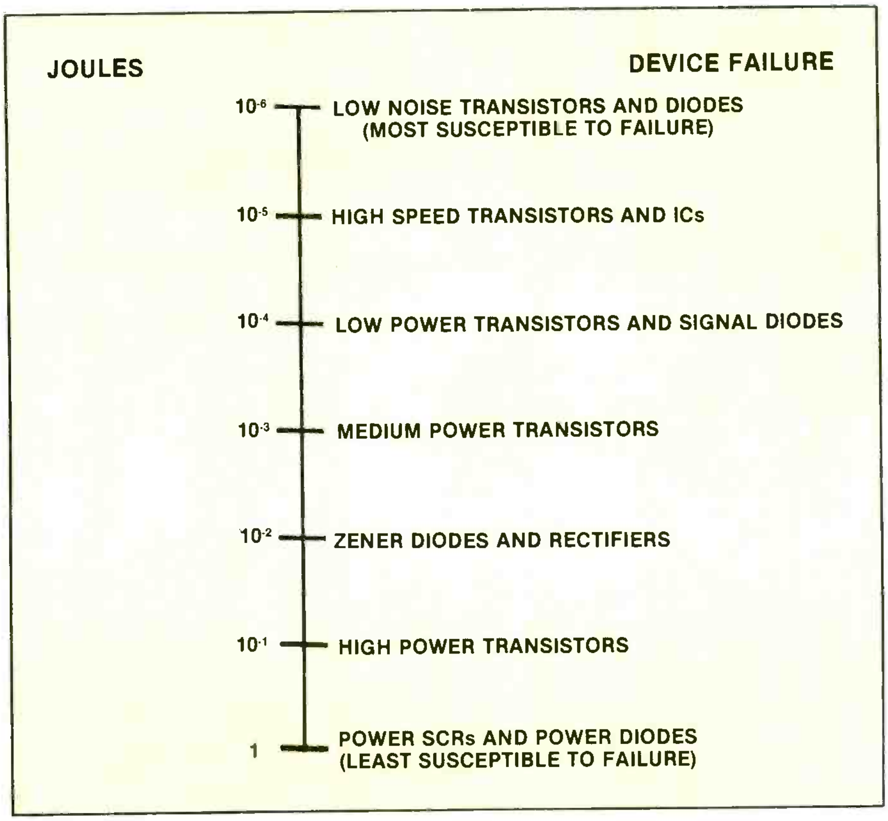

Figure 6. An estimate of the susceptibility of semiconductor devices to failure due to transient energy. A transient duration of several microseconds is assumed.

through device failure, but also due to logic state upsets. Studies have shown an upset in the logic of typical digital circuitry can occur with very low transient energy levels. Such logic state upsets can result in microcomputer latch-up, lost or incorrect data, program errors and control system shutdown.

In addition to the single-occurrence logic upset, exposure of semiconductors to a high transient environment can cause a progressive degradation of the device, which can eventually result in total failure. Figure 6 shows the energy-vs.-survival scale for several types of semiconductors. This chart clearly shows the importance of effective transient suppression.

Keeping these demons out

Manufacturers now offer a wide variety of transient suppression devices to protect sensitive home electronics equipment. The concluding article in this series, describing the design and function of some of these devices, will be published in the next issue of ES&T.

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PICTURE TUBE REBUILDING EQUIPMENT, working or not, write or call: Chicago Television, 633 North Semoran Blvd., Orlando, Florida 32807. Ph. 275-9543. 11-84-9t

WANTED: Old tubes and parts for tube type radios, including capacitors, coils, knobs, vibrators, Rider Manuals, etc. Antique Electronic Supply, 1725 W. University, Tempe, AZ 85281. 2-85-2t

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Cut your video service time in half

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

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

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

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

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

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

TOLL-FREE 1-800-843-3338
In Canada Toll-Free 1-800-665-4871
South Dakota, Alaska, and Hawaii call collect at 605-339-0100.

Please send complete VA62 details:

Name ____________________
Address ____________________
City ____________________
State ____________ Zip ________
Phone ____________________

(Mail to Sencore, 3200 Sencore Drive, Sioux Falls, SD 57107)

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For Demonstration Circle (3) on Reply Card