THE MAGAZINE FOR PROFESSIONAL ELECTRONIC AND COMPUTER SERVICERS

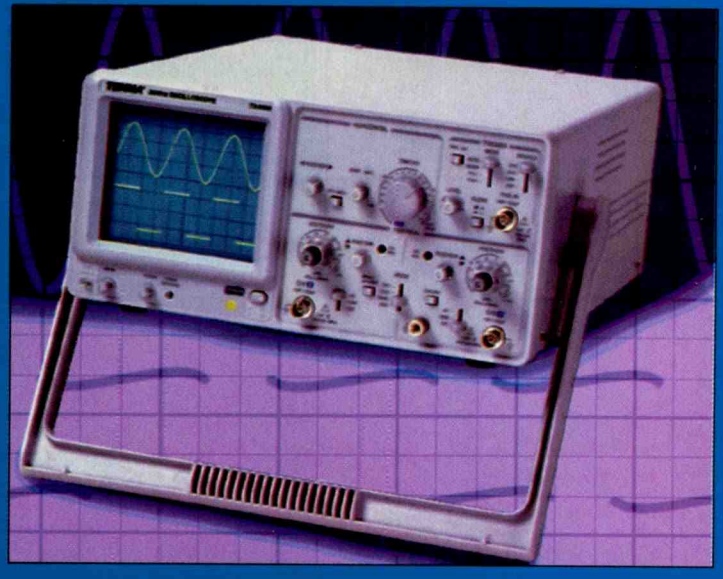
ELECTRONIC™ Servicing & Technology

July 2001

Network Server Technologies

Microwave Ovens

OSCILLOSCOPE UPDATE; Making Differential Measurements



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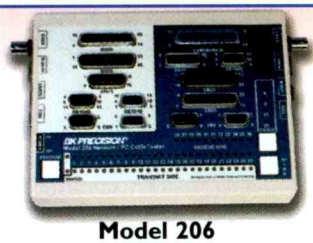

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- Burst operation
- External frequency counter to 30MHz
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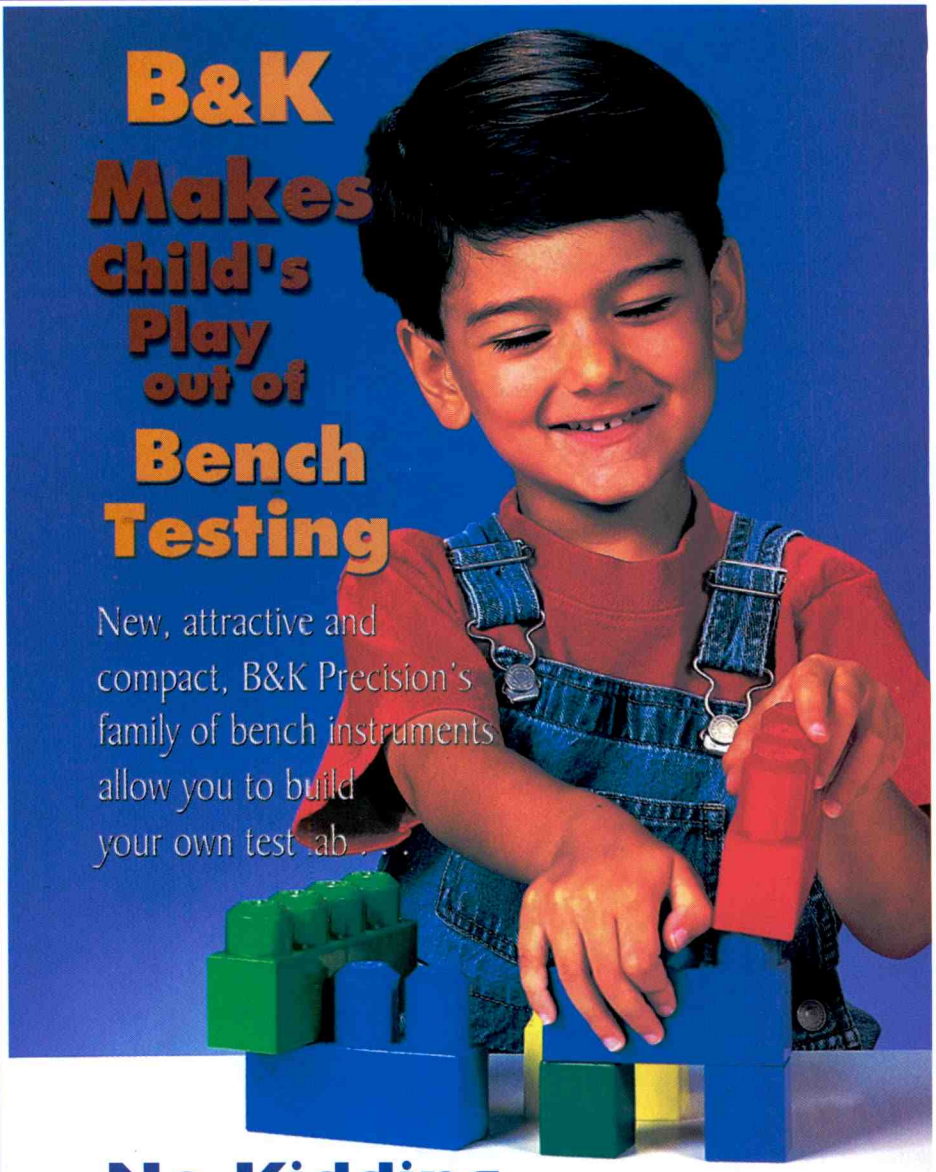

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ELECTRONIC Servicing & Technology

Volume 21, No. 6 July 2001

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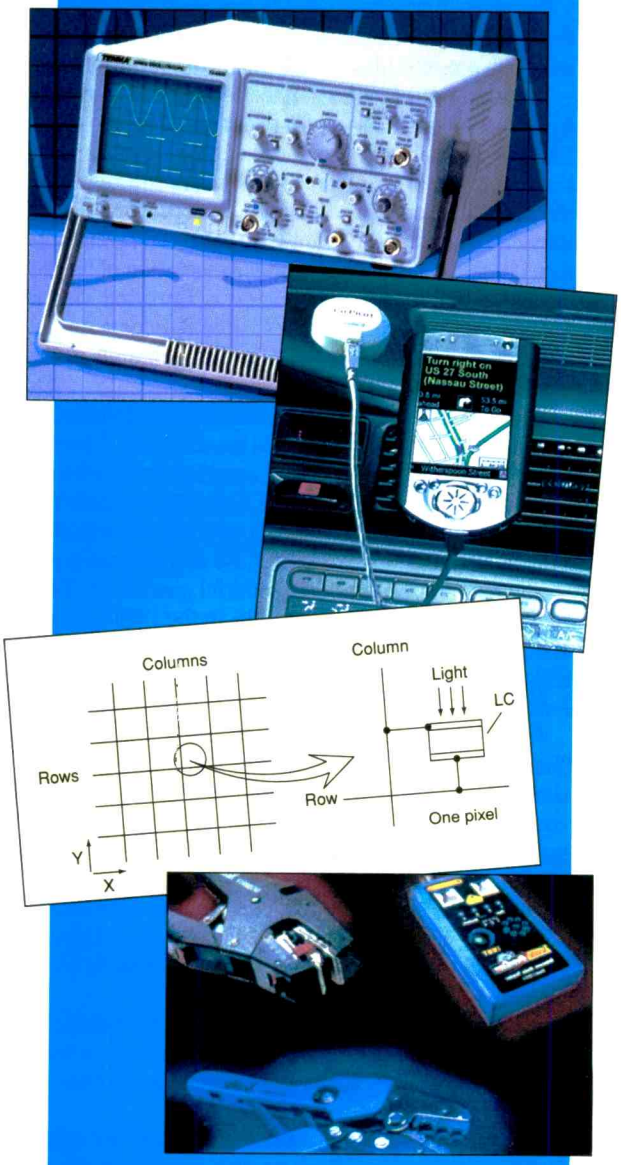

Cover Photos Courtesy of MCM Tenma & B&K Precision

DEPARTMENTS

Editorial

by Nils Conrad Persson

THE BENEFITS OF ASSOCIATION

I've just made my hotel and air travel reservations for the annual National Professional Service Conference (NPSC) taking place in Las Vegas from Sunday July 29 through Saturday August 5.

I suppose it was because I began making these preparations at the time my July Editorial was due that it occurred to me that it might be a useful idea to talk about the value of associations.

Consumer electronics service technicians and managers have a number of associations. To my knowledge, the organizations that most closely suit the needs of technicians and managers are the Electronic Technicians Association, International (ETA-I), the National Appliance Service Association, National Electronic Service Dealers Association (NESDA), the Professional Servicers Association (PSA), the National Association of Service Dealers (NASD), the International Society of Certified Electronics Technicians (ISCET) and the United Servicers Association. Some of these associations have affiliate associations at the state or local level.

While looking for ideas on this editorial, I visited several websites to get a better insight into associations. I found it interesting to find that there are even associations to which executives of associations belong, to wit: the Washington (state) Society of Association Executives (WSAE), and the American Society of Association Executives (ASAE). No doubt there are many more.

The WSAE website had a wonderful quote from "Democracy in America," by Alexis de Tocqueville. In the 1830's, Tocqueville and a companion, both citizens of France, visited the United States, ostensibly to study the penal system in this country, but actually to study how this newfangled concept of "democracy" was working out.

One of the facts about this new world that fascinated Tocqueville was the propensity of its citizens to form associations: "Americans of all ages, all conditions, and all dispositions constantly form associations. They have not only commercial and manufacturing associations, in which all partake, but associations of a thousand other kinds — religious, moral, serious, futile, general, or restricted, enormous or diminutive."

So why do people join associations? I don't think that the WSAE will mind if I borrow some of the reasons they state for participation in associations.

- Meetings, conventions, education and training are a major focus of associations. Education is provided in a number of ways: seminars, conventions, on-line education, documents, public information and education activities.
- Communications and publications are key activities of associations. Most associations publish some kind of newsletter, journal, magazine or bulletin to keep members informed, or, in some cases, to inform the public.
- Associations perform industry research, establish product and service standards. Such standards advance industry practice and safeguard consumers, as well as establish codes of ethics for the industry or profession.
- Through public information, and public information campaigns, as well as by professional and grassroots lobbying, associations advocate for the trade, profession or cause they represent.
- Whether for members or the general public, associations are often the first and best source to call source to call, for general information, regulations, standards, best practices, and referrals to members or other resources. Association websites can also provide a great deal of information.
- Last, but not least, some associations also provide group benefits such as property and casualty or health insurance, group purchasing, travel, scholarships and more.

All of these association activities mentioned above are activities pursued by the associations to which consumer electronics service technicians and service managers belong. For example, NPSC, the NESDA convention, features a full slate of meetings and seminars that teach: technical skills for technicians, management skills for managers and people who wish to become managers, personal enrichment for all attendees, and provide interaction between manufacturers and servicers. The recent convention put on by the combined efforts of ETA-I and PSA provided many of the same benefits.

Both ISCET and ETA-I have pioneered technician certification efforts, publishing CET (Certified Electronics Technician) study guides and offering proctored CET testing.

Moreover, these associations have worked with manufacturers, government agencies, and other organizations to insure that the interests of their members are being considered.

Unfortunately, when you take a look at the consumer electronics service profession it's pretty obvious that there are far more people who are eligible to be members of these associations than there are members. In essence, a few practitioners are doing a great deal of work above and beyond their daily toil at the bench or the manager's desk to attend meetings, work with manufacturers, create standards for education, ethics and a whole lot more. Some of these guys even give of their time, and spend their own money on travel, to help other organization members become more successful at their jobs. A lot of other potential members reap the benefits of some of these efforts without putting in anything of their own.

There are, of course, a few good reasons, and a lot of bad excuses for not joining an association. Some non-members claim that it just takes too much time. There is some truth to that, but many members make the countervailing argument that the education and support they receive from membership far outweighs the time they spend participating in the association.

Some other abstainers claim that they don't want to belong to an association because they possess information, "secrets," that help them be successful and they don't want to share that information with their potential "competition." That is a particularly sad excuse. In the first place, no one is going to force information out of someone. And in my experience, the most generous association members with their time and advice, are some of the most successful servicers, and generally a pleasure to be around. And they're not afraid of competition; they welcome it.

Some nonmembers are afraid that the organizations are already so well established that if they join they will be seen as an outsider. Nothing could be further from the truth. These organizations want as many members they can, and welcome new members with open arms. .

There are a lot of good reasons for being a member of an association, and few good reasons not to. The more participants in the associations that represent a profession, the better the profession can become. If you're not a member of an association, at least think about getting involved.

Conrad Persson

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News

Executive Changes at Hughes Electronics Corporation and DIRECTV, Inc.

EL SEGUNDO, Calif., June 26, 2001 - Hughes Electronics Corporation announced today that Roxanne S. Austin, 40, has been named president and chief operating officer (COO) of DIRECTV, Inc., effective immediately. Austin has been chief financial officer (CFO) of Hughes since June 1997. She joined Hughes in 1993, and has served as treasurer, chief accounting officer and controller. Austin will retain her position as executive vice president of Hughes, and remain a member of the Hughes Executive Committee. She succeeds Odie C. Donald, who has served as DIRECTV president since April 2000 and is leaving DIRECTV to pursue other personal and professional interests. Donald will continue to serve as a consultant to DIRECTV throughout the remainder of 2001 and into 2002.

Eddy W. Hartenstein, 50, currently corporate senior executive vice president of Hughes, and chairman, DIRECTV Global, continues as chairman and chief executive officer (CEO) of DIRECTV, Inc.

Austin is succeeded by Michael J. Gaines, 43, who has been promoted to corporate vice president and CFO. Gaines has also been named to the Hughes Executive and Management Committees. He was previously corporate vice president, finance, and treasurer for Hughes.

"Mike Gaines is a seasoned executive and proven leader," said Jack C. Shaw, Hughes CEO. "He worked closely with Roxanne Austin and the Hughes leadership team as we transformed Hughes from an aerospace and defense contractor to the nation's leader in digital television and broadband entertainment and communications. His rich experience and knowledge of our business, combined with the leadership he has demonstrated in his previous assignments, make him a strong addition to the senior leadership team."

Patrick T. Doyle, 45, has been named treasurer of Hughes, and will retain his existing responsibilities as corporate vice president, controller and chief accounting officer. Yvonne B. Perlberg, 54, has been named a corporate vice president of Hughes, and will retain her existing responsibilities as vice president and general auditor of Hughes, in charge of corporate assurance and advisory services. Perlberg joined Hughes in 1988 as director of government liaison and contract compliance, and has served in her current position since 1993.

Jonathan M. Rubin, 45, has been promoted to vice president, Hughes Investor Relations. He joined Hughes in 1982 and was promoted to director of Investor Relations in 1998. Rubin will retain primary responsibilities to communicate Hughes strategies, financial results and business operations to the investment community.

Hughes Electronics Corporation is a unit of General Motors Corporation.

Indium Announces Solder Price Increase

Clinton, NY - Indium Corporation of America has raised solder paste prices 12-15% across all product lines.

According to Charles Less, VP Marketing, "We have experienced a significant and steady decline in solder paste prices without regard to the material's positive impact on bottom line costs. While some suppliers curtail funding for critical R&D and technical support programs, we continue investing in the ability to offer our customers increased productivity and enhanced performance by leveraging these vital functions."

DTV Manufacturers Announce Broad Support for Digital Interface

In an effort to speed the rollout of digital television (DTV), the Consumer Electronics Association (CEA) has announced that the majority of digital television manufacturers plan to implement the IEEE 1394 digital interface in their digital video products and have endorsed the Digital Transmission Content Protection (DTCP) system for protecting content transmitted across the 1394 interface. DTCP (also known as "5C") is an encryption and authentication technology that can be used to protect content as it is being transferred over a digital connection in a home network, such as from a DVD player or set-top box to a DTV set or from a set-top box to a recorder or other digital devices. "Broad endorsement of DTCP by digital television set manufacturers is an important step to help facilitate and speed the transition to digital television," said CEA President and CEO Gary Shapiro in a letter the association sent today to Federal Communications Commission (FCC) Chairman Michael Powell. "We believe that a commonly accepted copy protection system will be a major factor in facilitating the rollout of digital television via cable and ensuring that content providers make high value content available to the cable industry." DTCP also is gaining momentum in Hollywood. Two major studios, Sony Pictures Entertainment, Inc. and Warner Brothers, already have agreed in principle with the 5C group to support DTCP and discussions with other studios are underway.

To further support the digital transition, DTV manufacturers are developing new terminology and graphic descriptors that will assist consumers in selecting interoperable digital video products. CEA's Video Division Board and its 1394 Interface Strategy Working Group are finalizing terms and logos that will allow a consumer to see a product at retail, note the descriptor and/or graphic, match that descriptor/graphic with another product and be assured that the products are designed to interoperate. The baseline definition is expected to apply to products that utilize DTCP to secure encoded content over an IEEE 1394 serial connection.

"Once finalized, these descriptors and graphics will help consumers take full advantage of the exciting opportunities created by digital television and related products by reducing confusion in the marketplace," said 1394 Working Group Chair and Mitsubishi Digital Electronics Vice President, Marketing Bob Perry.

22% of Consumers Do Not Know Who to Call for Home Network Installation

According to the results of a Consumer Electronics Association (CEA) survey released today, entertainment features of home networks, such as distributed video and Internet audio, have grown nearly as popular with consumers as the safety and efficiency applications that have sustained the industry. Home networks facilitate communication among the appliances, home systems, entertainment products and information devices in a home so they can work cooperatively and share information. The proliferation of digital products and content has created many new applications for home networks.

CEA's online survey of 1,100 adults ages 18 to 65 was conducted during March 2001 to gauge consumers' awareness, attitudes and opinions toward the emerging applications of home networks. The survey found that fifty-three percent (53%) of participants were somewhat to very interested in having the ability to listen to a single source of music from any room in the house. Fifty-eight percent (58%) expressed interest in watching a central video source - such as a DVD player in the living room - on televisions in other parts of the house and thirty-six percent (36%) were interested in video conferencing using televisions or computer monitors within the home. There also was significant interest in applications that linked different types of products and systems in homes. Forty-six percent (46%) indicated they would like the volume of their stereos or televisions to be lowered automatically when the phone rang and forty-nine percent (49%) wanted the caller's name and number to appear on their television screens. A home computer network that provided simultaneous Internet access to multiple computers attracted interest from forty-two percent (42%) of respondents, while forty-one percent (41%) would like to use their stereos to listen to music from the Internet.

While there is significant interest in the entertainment and information features home networks provide, the safety, convenience and energy efficiency functions remain most appealing to consumers, according to the survey. The most popular options were a lighting system with a vacation setting to turn lights on and off, giving the house a "lived-in" appearance while its owners are out of town (61%) and a system that automatically sets back a home's water heater and thermostat to save energy (65%). Sixty-five percent (65%) also wanted separate thermostat controls for each room in the house to make it comfortable everywhere and save energy.

"Consumer demand for the features of home networks is high, especially among Internet users," said Dave Hill, vice president of business development for Panja Inc. and chairman of CEA's Home Networking and Information Technology (HNIT) division. "But making consumers aware that the features they want are already for sale remains a hurdle for the industry."

Approximately one-third (33%) of the survey participants indicated that they had seen or heard something about home networks during the previous 12 months. Out of those, the majority (62%) received their information from television and from newspapers or magazines (43%). Relatively few received their information from a source that was likely to sell home networking products. Thirty-six percent (36%) found information on the Internet and only three percent (3%) had seen anything in a retail store.

Furthermore, twenty-two percent (22%) said they would not know whom to call for installation of a home network.

Distributor M-Tronics Has Relocated

On July 1, 2001 M-Tronics, a distributor of original and generic parts has relocated to 603 Edgemere Avenue, Uniondale, NY 11553. The new local telephone is 516-538-1382, Fax: 516-538-1383. The toll free number remains 888-223-5515, nationwide except for Long Island, NY.

Prelco Moves NJ Facilities

Parts Distributor Prelco Electronics has moved to new facilities at 100 Old Camplain Road, Hillsborough, NJ 08844. Tel: 908-429-9999, Toll Free: 888-773-5268, Fax: 908-429-5577.

DIRECTV Activates 10 Millionth Location

DIRECTV, Inc. of El Segundo, California, announced that it had activated its 10 millionth customer in June, 2001. The company, a unit of Hughes Electronics Corporation claims to be the third largest provider of multichannel television in the United States with service to one of every 10 TV homes.

Sams Photofacts on Big Screen and Projection TVs

Sams Technical Publishing has announced the release of coverage on Big Screen and Projection Sets, called PHOTOFACT® GOLD.

The 1st PHOTOFACT® GOLD is available from participating Sams Distributors as of June 2001 and covers GE model 46GW948YX3. The 2nd PHOTOFACT® GOLD will be available in August 2001 and each month thereafter.

Sams Technical Publishing is seeking input from the service community to help determine which Big Screen and Projection Sets to cover. Make and model numbers should be forwarded to samstech@samswebsite.com to be considered for future PHOTOFACT® GOLD sets.

Sams Technical Publishing, formerly a division of Howard W. Sams, continues to publish PHOTOFACT® service documentation and technical books from PROMPT® Publications. Sams Technical Publishing is located in Indianapolis, IN and can be found on the World Wide Web at www.samswebsite.com.

Online Showcase for Growth and Opportunity of Consumer Electronics Market

Digital America 2001 showcases the growth and opportunity of the consumer electronics market, from handheld computers and personal video recorders (PVRs) to wireless phones and MP3 players. Available free as an online-only publication at www.ce.org/digitalamerica/, Digital America 2001 explains new technology trends that are enhancing consumers' lifestyles and workstyles by bringing information, entertainment and connections almost anywhere. Digital America 2001 offers descriptions and data on sales volume, the market and consumer satisfaction for video, audio, wireless, mobile, integrated home systems, accessories and communication, home networking and information technology. Sales of virtually every product category registered increases last year, many attained new records and the industry's transition to a true digital era accelerated.

Some highlights from Digital America 2001 include:

The digital videodisc (DVD) player continues to be the fastest growing product introduction in consumer electronics history. DVD sales to dealers in 2000 doubled to more than eight million units because consumers appreciate the improved picture and sound quality that the players bring.

Digital television (DTV) continued its impressive introductory phase, reaching $1.4 billion sales in just its third year. Camcorders, spurred by new digital features and models, surged 22 percent to 5.8 million, while one of the newest product categories, the PVR, blossomed to more than one million unit sales. This is a tenfold increase.

Digital Music: In 2000, sales of digital music players exceeded one million units for the first time.

Another growth area, home theater had sales up 10 percent to more than $10 billion.

In the area of digital imaging, sales of digital cameras more than doubled in 2000 to nearly five million units, as the digital revolution inspired new products to view, enhance and store the images.

In the area of information products, while sales of desktop computers have leveled off, the sales of printers, modems, fax machines, scanners, monitors, other peripherals and software grew and totaled about $14 billion.

Handheld devices continued their impressive growth with more than six million units sold.

Web capability and other digital features contributed significantly to a record year for wireless phones, with 18.9 million wireless phones sold to retailers in 2000. That's 21 percent more than in 1999.

Cordless phone sales passed the 40 million mark in 2000, and now represent a growing majority of the more than 70 million telephones Americans bought during the year.

Electronics on the road also experienced significant growth: Mobile electronics for the car include new radio data system (RDS) receivers, global positioning system (GPS) navigation devices, video displays with multiple sources and vehicle security systems.

Accessories sales also experienced growth: Accessory items make CE products easier to use or simpler to take on the road. Accessories continue to grow in popularity, with sales growing by 10 percent in 2000, to $1.5 billion.

Consumer electronics products provide information, entertainment and education at an affordable cost to consumers across the country, and CEA tells that story in Digital America 2001. The online publication also includes a historical account of the industry's development, a timeline of significant technology achievements and a directory of industry sources.

Companies Announce New Low-Cost IEEE-1394 Reference Design for Consumer Applications

Xilinx, Inc. and Digital Harmony today announced DHIVATM-X (Digital Harmony Interface for Video and Audio), a complete low-cost reference design based on a Xilinx SpartanTM-II FPGA (field programmable gate array). The reference design provides OEM manufacturers the ability to immediately integrate IEEE-1394 and HAVi (Home Audio Video interoperability) functionality to consumer products such as CD players, set-top boxes, audio video receivers, DVD Players, VCRs, surround sound decoders, residential gateways, and home and professional studio equipment. DHIVA-X is immediately available. For additional information visit the Xilinx eSP website at www.xilinx.com/esp.

DHIVA-X, a cost-reduced version of the popular DHIVA, provides support for S100, S200 and S400 data rates with IEEE-1394a enhancements and is capable of transmitting or receiving eight channels of digital audio, one digital video stream, or one MPEG-2 transport stream in full duplex. DHIVA-X uses IEC-61883 for isochronous transmission of audio and video over IEEE-1394, and supports the industry-standard AV/C command set for control of devices. Options are available for DTCP (Digital Transmission Content Protection) allowing transmission of copy-protected material and embedded HAVi support.

"Leveraging the low-priced Spartan-II FPGAs serves as the catalyst for the broad deployment of Digital Harmony's 1394 technologies for a wide-range of AV and consumer applications," said Greg Bartlett, president of Digital Harmony.

"We are very excited to be working with the leader in IEEE-1394 solutions," said Robert Bielby, director of strategic applications for Xilinx Inc. "By taking advantage of the integrated features of the Spartan-II family we have created the lowest total-cost solution while maintaining flexibility and performance addressing a wide-range of applications."

Xilinx eSP is the industry's first web portal dedicated to accelerating the design and development of consumer products based upon emerging standards and protocols. The eSP website is a comprehensive resource delivering a powerful array of solutions and information in a single location. Solutions found on the site range from reference designs to IP cores and result from collaboration with a wide range of industry leaders.

Oscilloscope Update: Making Differential Measurements

by Dr. Arnold Banks

The oscilloscope depends on a signal voltage and/or current signal from the test circuit in order to create a waveform of meaningful data for the user. In contrast to the digital multimeter (DMM), today's oscilloscopes are unsurpassed in their measuring capabilities. When an oscilloscope uses a differential probe it transforms the oscilloscope into a super instrument for displaying the more subtle measurements that would just fly over the knobs of most digital multimeters. This describes many techniques used for making differential measurements. It also explores the different types of measurements you can make with a differential probe, and how to use a conventional oscilloscope when measuring differential voltages.

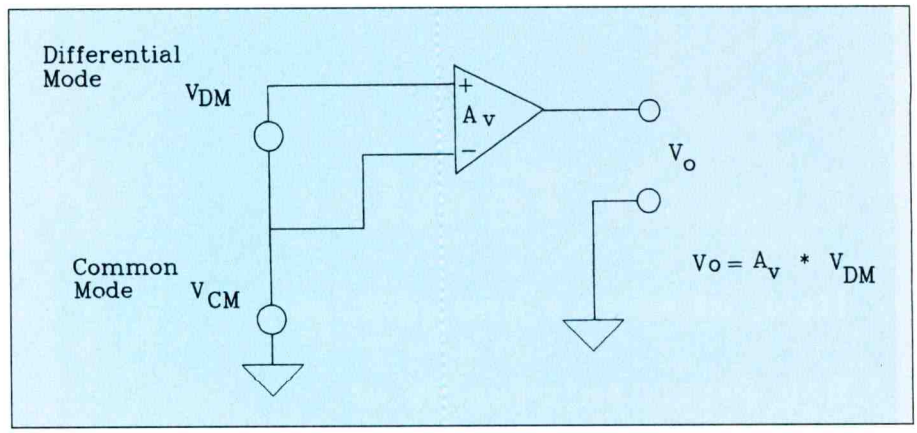

Figure 1. Diagram of differential amplifier with input signals.

Differential vs. Single-Ended Techniques

When an oscilloscope is equipped with a differential amplifier; or uses a differential probe for making measurements, the oscilloscope becomes a test tool for troubleshooting problems that are impossible to detect with conventional single-ended measurements.

Single-ended measurements often hide high power distribution problems because the oscilloscope's ground lead provides an alternate ground path from which the signal is measured. In addition to the measurements changing, single-ended measurements often alter the circuit's operation.

When using a differential probe it is possible to track down problems not normally seen via conventional measurements. For example, placing the inputs of a differential probe right on an IC's power supply lead gives a true picture of the device's power condition. Even if the power supply looks clean, both the ground and power pins may be moving with respect to each other's grounds in the system. By using the differential probe, it is possible to view ground gradients between an individual device ground and other grounds in the system. Digital bounce is a good example of a ground gradient. Placing a differential probe on the inputs and ground pins of a device gives a true picture of what signals that device actually sees at its inputs and ground.

A differential amplifier amplifies the difference of two signals when applied to the amplifier inputs, and rejects any voltage which is common to both inputs. See Figure 1. The transfer equation is:

$$V_0=Ap(V_{+in} - V_{-in})$$

where: V_0 is referenced to earth ground.

The voltage of interest, or difference signal, is referred to as the differential or differential mode signal and is expressed as V_{DM} (V_{DM} is the V_{+in} - V_{-in} term in the transfer equation above). Figure 2 is a diagram of a differential amplifier making a floating measurement.

The voltage that is common to both inputs is referred to as the *Common-Mode Voltage* expressed as V_{CM}. The characteristic of a differential amplifier to ignore the V_{CM} is referred to as *Common-Mode Rejection* (CMR). The ideal differential amplifier rejects all of the common-mode component, regardless of its amplitude and frequency

In Figure 3, a differential amplifier is used to measure the collector/emitter voltage at TP1 and TP2 in the step-down switchmg power supply. As the control element switches from ON to OFF the

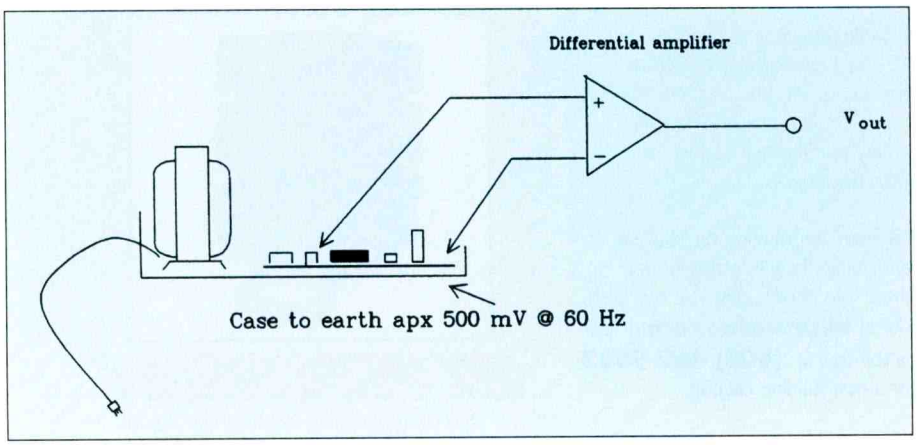

Figure 2. Differential amplifier measuring on a floating ground.

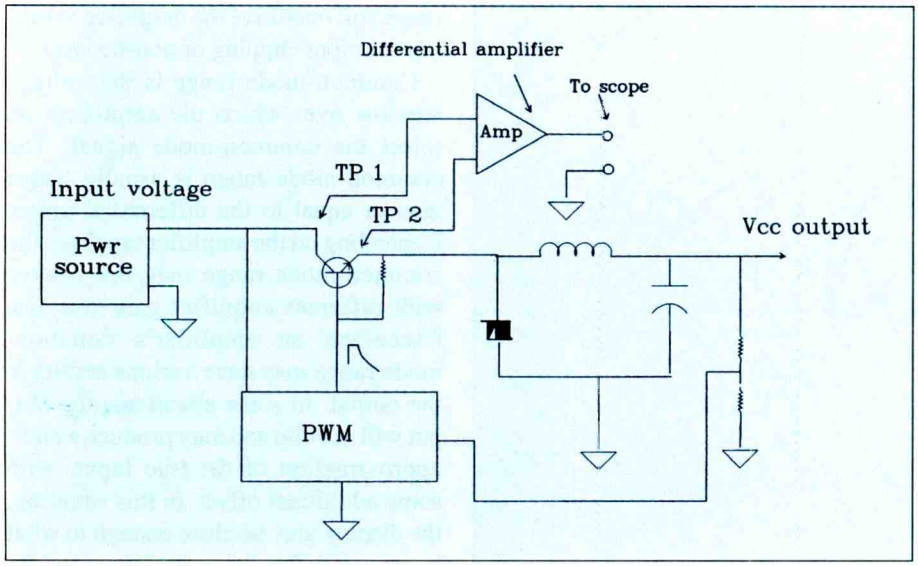

Figure 3. Switching supply connected to a differential amplifier.

emitter voltage swings positive, then negative. The collector swings to 0V and then to a positive voltage which is output to the catch diode. The differential amplifier allows the oscilloscope to measure the true VCE signal at a sufficient resolution such as 2V/division while rejecting most of the unregulated output voltage source and ground.

Differential Amplifiers

Common-Mode Rejection Ratio (CMRR) is the ability of differential amplifiers to eliminate the undesirable common-mode signal. All differential amplifiers have a small amount of common-mode voltage which appears as an error signal in the output, making it indistinguishable from the desired differential signal. There are two mathematical formulas used to describe CMRR. The first is "square root of the signal to noise ratio of the output divided by the signal to noise ratio of the input." The second, and most common, is defined as "differential-mode gain divided by common-mode gain referred to the input."

$$CMRR = \sqrt{SNR_{output}/SNR_{input}}$$

$$CMRR = A_{DM}/A_{CM}$$

For evaluation purposes, we can assess CMRR performance with no input signal. The CMRR then becomes the apparent V_{DM} seen at the output resulting from common-mode input. It is expressed either as a voltage ratio or in dB:

$$DB = 20\log (A_{DM}/A_{CM})$$

To get a better idea of the differential amplifier's CMRR, let's examine the following example. Suppose we need to measure the voltage in the output damping resistor of an audio power amplifier as shown in Figure 4. In this example a CMRR of 100,000:1 would be equivalent to 100dB. At full load, the voltage across the damper (V_{DM}) should reach 35mV, with an output swing (V_{CM}) of 80 V_{P-P}.

The differential amplifier we use has a CMRR specification of 100,000 at 1kHz (with the amplifier driven to full power with a 1kHz sine wave, one hundred thousandth or 100 dBs at 1 kHz). With the amplifier driven to full power with a 1 kHz sine wave, one hundred thousandth of the common-mode signal will erroneously appear as VDM at the output of the differential amplifier, which would be 80V/100,000 or 800µ V. The 800µ V represents up to a 2.3% error in the true 35mV signal.

The measured output voltage could be as high as 35.6mV with a 2.3% error. The CMRR specification is an absolute value, and does not specify polarity (or degrees of phase shift) of the error. Therefore, the user cannot simply subtract the error from the displayed waveform. CMRR is generally the highest (best) at dc and degrades with increasing frequency of the V_{CM}. Some differential amplifiers plot the CMRR specification as a function of frequency.

If we were to try to measure the CMRR error in Figure 4, we would quickly run into problems. The common-mode switching signal is a square wave and the CMRR specification assumes a sinusoidal (sine wave) component. Because the square wave contains energy at fre-

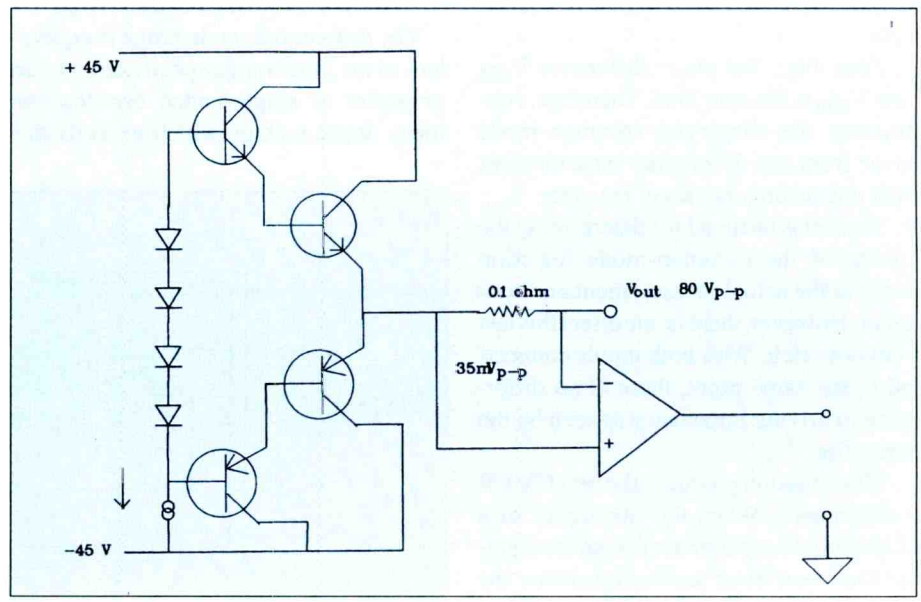

Figure 4. Common-mode error from a differential amp with 100,000 CMRR.

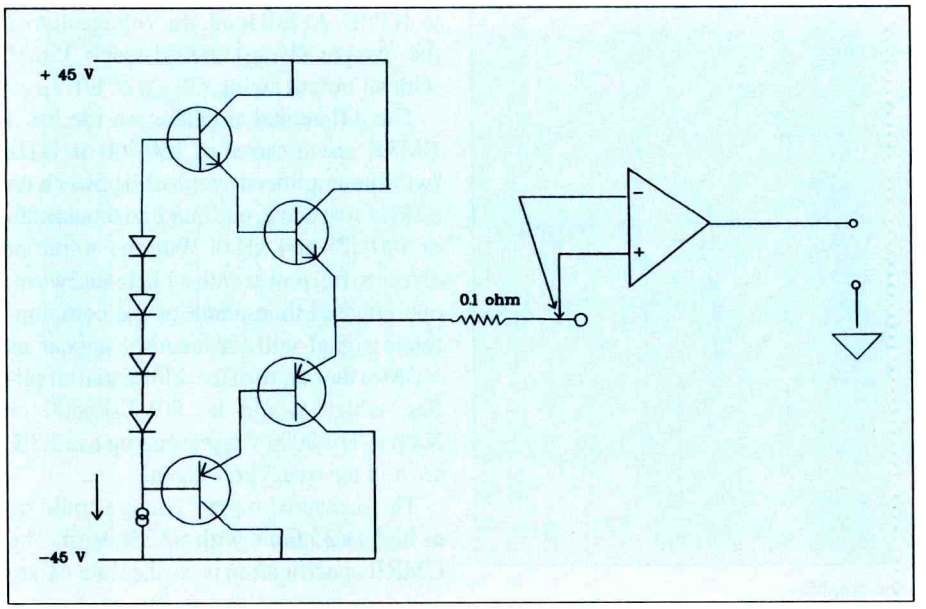

Figure 5. Empirical test for adequate common-mode rejection.

quencies considerably higher than 30kHz, the CMRR will probably be worse than specified at the 30kHz point.

Test and Measurement

Because the common-mode component expects a sine wave, a simple test exists that can quickly determine the extent of the CMRR error (Figure 5). Temporarily connect both input leads to the signal source (in our example, the emitter/resistor (Figure 5). The oscilloscope is displaying only the common-mode error. You can now determine if the magnitude of the error signal is significant.

Remember, the phase difference V_{CM} and V_{DM} is not specified. Therefore, subtracting the displayed common-mode error from the differential measurement will not accurately cancel the error.

The test is outlined for determining the extent of the common-mode rejection error in the actual measurement environment. However, there is one effect this test will not catch. With both inputs connected to the same point, there is no difference in driving impedance as seen by the amplifier.

This situation produces the best CMRR performance. When the two inputs of a differential amplifier are driven from significantly different source impedance, the CMRR will be degraded.

Differential and Isolator Parameters

In order to take full advantage of the many uses and applications of differential amplifiers and probes, the user must become acquainted with some of the more general specifications and parameters of theses devices. An understanding of differential amplifiers and differential probes will help you choose the best measuring technique for your application. Of these specifications the following two outlined here are of special impoftance.

The Differential Mode Range

The differential mode range is equivalent to the input range specification of an amplifier or single-ended oscilloscope input. Input voltage which exceeds this range will overdrive the amplifier, resulting in output clipping or non-linearly

Common-mode range is the voltage window over which the amplifier can reject the common-mode signal. The common-mode range is usually larger than or equal to the differential range. Depending on the amplifier topology the common-mode range may not change with different amplifier gain settings. Exceeding an amplifier's common-mode range may have various results in the output. In some situations, the output will not clip and may produce a close approximation of the true input, with some additional offset. In this situation, the display may be close enough to what is expected that it is not questioned by the user. It is always a good practice to verify that the common-mode signal is within the acceptable common-mode range before making any differential measurements.

Maximum Common-Mode Slew Rate

Maximum common-mode slew rate is specified for some differential amplifiers and most isolators. This specification is often confusing but very important. Part of the confusion results from a lack of standard definitions between instrument manufacturers. Also, differential amplifiers and isolators behave differently when their maximum common-mode slew rate is exceeded. Essentially, maximum CM slew rate is a supplemental specification to CMRR. The specification is usually given in units of kV/ms.

Some types of differential amplifiers,

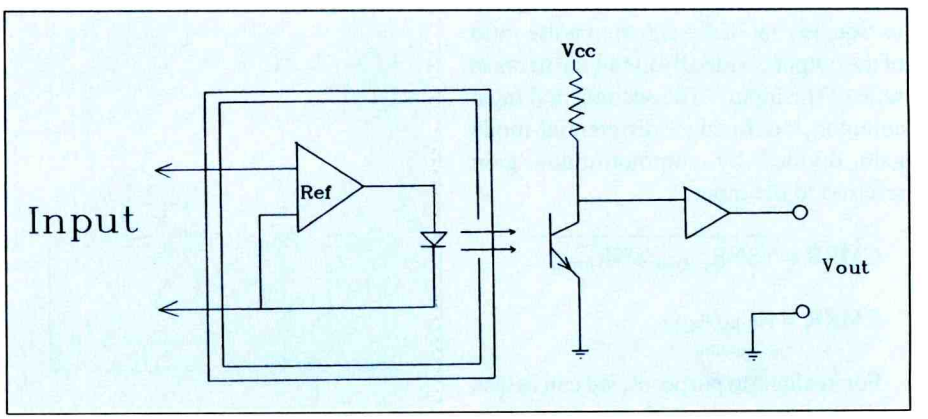

Figure 6. Diagram of isolation probe.

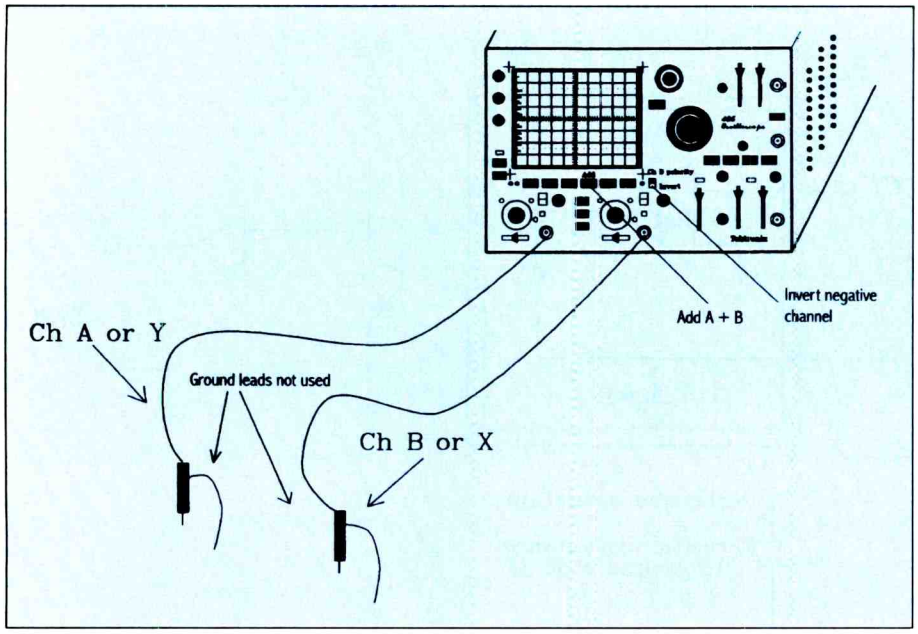

Figure 7. Quasi-differential mode and setup.

like other amplifiers, reach a large signal slew limitation before the small-signal bandwidth specification is exceeded. When one or both sides of a differential amplifier are driven to slew-rate limiting, the common-mode rejection is degraded very rapidly Unlike CMRR, maximum slew rate does not imply an increasing amount of common-mode feed-through in the output. Once the maximum common-mode slew rate is exceeded, all bets are off; the output is likely to clamp at one of the power supply rails.

Isolator Parameters and Limitations

In isolators, however, the effect is more gradual - like CMR in a differential amplifier. As the common-mode slew rate increases (as opposed to frequency), more of the common-mode component "feeds through" to the output. Intuitively, the specification would imply a maximum slew rate at which a known amount of feed-through appears in the output. It is important to note that with some isolators, the CV slew rate specification is actually a maximum nondestructive limit. The ability to make meaningful measurements is lost at slew rates much lower than the maximum specification. When using an isolator it is best to test the common-mode feed-through before making critical measurements. This is easily done by driving both the probe tips and the reference lead with the same common-mode signal and observing the output. Figure 6 shows a diagram of an isolation probe.

Quasi-Differential Techniques

Conventional single-ended oscilloscopes cannot make differential measurements without using special probes or isolators to protect the circuit and instrument from damage. Attempting to do so without any of these devices will only cause a small fireworks display. However most single-ended oscilloscopes do have the ability to make simple differential measurements. This mode of oscilloscope use is called quasi-differential.

While limited in performance, this technique may be adequate for some measurements. To make a differential measurement, two vertical channels are used, one for the positive input and the other channel for the negative input (Figure 7). The channel used for the negative must be set to invert mode and the display mode set to the "ADD channel A + channel B."

For proper operation, both inputs must be set to the same scale factor, and both input probes must be identical models. The display now shows the difference in voltage between the two inputs.

To maximize the CMRR, the gain in both channels should be matched. This can easily be done by connecting both probes to a square wave source with an amplitude within the dynamic range of the Volts/Div setting (about +6 divisions). Set one of the channels to "uncalibrated-variable" gain and adjust the variable gain control until the displayed waveform becomes a flat trace (Figure 8).

The primary limitation of using this technique is a rather small common-mode range, which results from the oscillo-

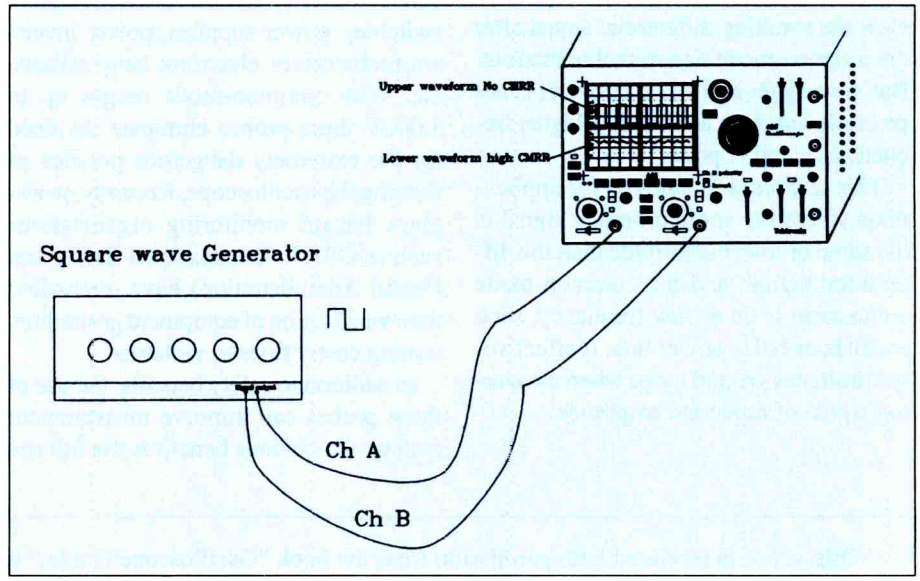

Figure 8. Oscilloscope inputs to square wave generator maximizes CMRR in both input channels for quasi-differential mode.

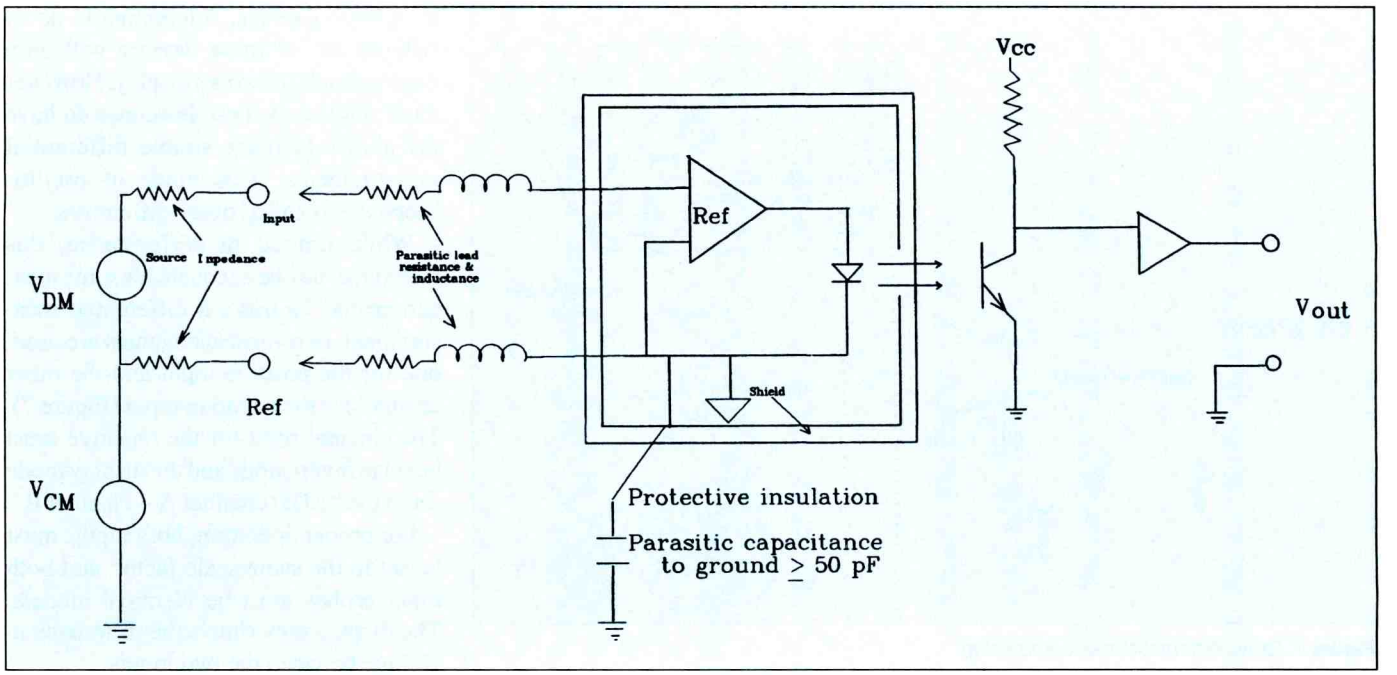

Figure 9. Isolation amp with unequal input cepacitance.

scope's vertical channel dynamic range. Generally, this is less than ten times the Volts/Div setting from ground. Whenever VCM >VDM, this mode of obtaining a differential result can be thought of as extracting the small difference from the two voltages.

Most digital storage oscilloscopes perform waveform math in the digital domain, after the analog signal has been digitized. The limited resolution of the analog-to-digital converter is often not adequate to view the resulting differential signal after the common-mode signal is subtracted out. But the ac gain in the two channels is not precisely matched, as CMRR at higher frequencies is rather poor.

This technique is suitable for applications where the common-mode signal is the same or lower amplitude than the differential signal, and the common-mode component is dc or low frequency, such as 50Hz or 60Hz power line. It effectively eliminates ground loops when measuring signal of moderate amplitude.

High Voltage Differential Probes

A new probe has appeared on the market: a high-voltage active differential probe. Its new topology; which boasts of new fixed attenuation with switchable differential gain, allows these probes to keep their full common-mode range in gain settings. The single attenuator greatly reduces complexity resulting in lower cost to the user.

These types of probes provide an affordable, safe method ofmeasuring line-connected circuits commonly found in switching power supplies, power inverters, motor drives, electronic lamp ballasts, etc. With common-mode ranges up to 1,000V these probes eliminate the need for the extremely dangerous practice of floating the oscilloscope. Recently, workplace hazard monitoring organizations such as OSHA (Occupational Safety and Health Administration) have intensified their verification of equipment grounding, issuing costly fines to violators.

In addition to safety benefits, the use of these probes can improve measurement quality. An obvious benefit is the full use of the oscilloscope's multiple channels with the simultaneous viewing of multiple signals referenced to different voltages.

Because the probes are true differential, both of the inputs are high-impedance, high-resistance, and low capacitance. Floating oscilloscopes and isolators do not have balanced inputs. The reference side (the ground clip on the probe) has a significant capacitance to ground. Any source impedance the reference is connected to will be loaded during fast common-mode transitions, attenuating the signal.

Worse yet, the high capacitance can damage some circuits (Figure 9). Connecting the scope common to the upper gate in an inverter may slow the gate-drive signal, preventing the device from turning off and destroying the input bridge. This failure is usually accompanied with a bright spark and some smoke at your test bench, something many technicians can attest to.

With the balanced low input capacitance of high-voltage differential probes, any point in the circuit can be safely probed with either lead. ■

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Network Server Technologies

by John Ross

A server can operate as either a dedicated or a shared device. Moreover, a server can facilitate the sharing of resources and can distribute files, provide access to software, or distribute messages to a variety of system users who may use different variations of equipment. In addition, the server and network rely on some type of network operating system.

This article considers servers from a generic point-of-view, but it also introduces other types of servers with a look at CD and DVD servers, web servers, and proxy servers. From there, this article considers server technologies from both the purchase perspective and from the maintenance perspective. While the article takes a close look at the parts that make up a server, it also gives you an overview of fault tolerance and load balancing issues.

CD-ROM and DVD Servers

A CD-ROM or DVD server makes a number of CD-ROMs or DVDs available to network users. The use of a CD-ROM or DVD server can ease the workload of system administrators through the capability to install software over the network from the server. CD-ROM or DVD servers provide shared access to databases, documentation, and other software. With optical disk servers becoming part of the network domain or NDS tree, a system administrator can grant and revoke permissions to the servers.

Most optical disk servers can interoperate with a number of network operating systems and protocols. Along with the capability to share data to network clients, most optical disk servers can share data as NFS mountable volumes. In addition, system administrators can configure the servers over the web.

Despite the advantages offered by optical disk servers, several disadvantages also exist. Even though standards exist, some manufacturers may not allow the sharing of optical-based information under some configurations. In addition, the use of multimedia software on CD-ROMs and DVDs also offers special problems for network users because no method exists for sharing the audio portion of the software over a network. Although compact disk technologies offer good data transfer rates, the drives have very slow random access speeds.

To lessen the problems with speed, most optical disk servers cache as much as 160Mb of data to the controller memory. Some manufacturers provide a hard disk as a caching solution. In addition, many CD-ROM and DVD servers allow system administrators to create an image of the disks onto the internal hard disk of the server.

Web Servers

A web server delivers hypertext documents through the HyperText Transfer Protocol, or HTTP, standard. Among the different varieties of available web servers, features include:

- user authentication
- directory indexing
- search capabilities
- directory level security
- virtual hosting
- customized responses to errors, and
- user directories

In addition, web server tools may also provide the capability to create content and manage site functionality. Many web servers support Java and JavaScript for establishing server-side and client-side content and Application Programming Interfaces for establishing program interaction. Active Server Pages, or ASP, allow scripted pages residing on the server to generate dynamic content when requested by a client browser. Tools such as the Microsoft ActiveX Data Objects, or ADO, allow a connection from the web server to a database.

Accessing textual, video, or audio content through the World-Wide Web involves communication between a Web-browser client and a Web server that utilizes the HyperText Transfer Protocol. With this, all communication occurs through the Internet. The communication begins with the typing of a URL (universal resource locator, also known as a "website") into the web browser. Then, the client computer locates the IP (Internet provider) address associated with the domain name given for the primary DNS (domain name system) server.

Once the client computer and the browser begin to request and receive files from the same URL, the constant need for a DNS look-up does not exist. When the client computer accesses a different URL and begins to retrieve a different web site, the DNS lookup initiates. Web servers may exist in any facility that has Internet connectivity.

Web Server Farms

Web server farms offer the advantage of replicated disk content. However, the use of replicated disks can result in higher expenditures. The reliance on replicated content requires content synchronization, or the duplication of any change to content data on all nodes.

Proxy Servers

A proxy server provides filtering and caching for a local-area or enterprise network. With those two functions, proxy servers improve the performance and security at the point where a local-area network interconnects with a wide-area network or the Internet. Filtering provides a pre-defined collection of sites that users can visit. Caching allows frequently-access web documents or web sites to store on the proxy server. Rather than going on to the Internet to download a page, a user accesses a proxy server cache for the site and gains faster response times.

Most proxy servers consist of dedicated Pentium-based computer systems that run only the proxy server software and have approximately 10Mbytes of RAM per user. System administrators usually

place proxy servers at the point of possible bottlenecks. Proxy servers can typically handle ten-to-fifty simultaneous users. The use of multiple proxy servers often requires the application of a load balancing mechanism

Server Types

Network servers may be based on any of several types of computers, depending on the volume of information to be stored on the server and the number of users that will be connected to the server. Following is a list of some of the computers that are used as servers.

Mainframes

A mainframe computer functioning as a file server can manage large amounts of data generated by network users and network management software. In addition, a mainframe can store data in a data warehouse, distribute processing tasks to connected workstations, collect results, and consolidate files. However, the use of a mainframe as a server shifts a portion of the processing responsibilities back to the individual workstations.

Superservers

Originally developed during 1989, a superserver takes advantage of multiprocessor designs. Multiple processors may operate with a single bus for the entire system or use multiple buses that eliminate contention. Computers configured for use with multiprocessor technologies usually include fast-wide or ultra-wide SCSI RAID (small computer system interface redundant array of independent disks) controllers, large amounts of processor cache memory, large amounts of error correcting RAM, fast Ethernet cards, and reporting systems. Along with supporting large data transfers, superservers also support the implementation of all network operating systems and protocols.

In addition, superservers include an input/output structure similar to that seen with mainframe computers but have a higher packet throughput. Because the I/O processors implement control logic and concentrate data, the central system processor does not contend with single-byte data accesses, LAN (local area network) protocols, or the location of data on the disk drive. Moreover, the configuration of the superserver hardware allows system administrators to centralize and compartmentalize LAN administration on one server.

Single-Processor Servers

In most scenarios, a standard single-processor microcomputer can perform server functions. Much of the performance has become possible because of improvements in processors, bus designs, and disk technologies. Microcomputer-based servers also benefit from the low-cost availability of higher-speed processors. Although microcomputer-based servers lack the capabilities of mainframes or superservers, microcomputers offer the flexibility to accommodate any specialized need such as imaging, gateway connection, and facsimile.

Purchasing a Server

When preparing to purchase a server, consider the number of processors, the bus architecture, the main memory, the amount of memory cache, the type of storage devices, the amount of storage provided through the devices, the number of bays, and the number of I/O ports. Sub-sections following this section provide additional information about processors typically used in servers. While the bus architecture includes the Industry Standard Architecture, (ISA), Peripheral Component Interconnect (PCI) or Extended Industry Standard Architecture (EISA), the main memory refers to the amount of random access memory contained within the computer and memory cache refers to the amount of required wait time for program initialization.

Servers may include a variety of storage devices such as disk drives, tape drives, and optical disk drives. Extra bays in the server allow the installation of additional disk drives or other peripherals. Most servers offer input/output expansion slots that accommodate the attachment of devices such as printers and scanners.

Processors

Microprocessors differ in the number of instructions executed; the number of bits processed within a single instruction; and the number of instructions that the processor can execute per second. Microprocessors employ either the complex instruction set computing (CISC) architecture or the reduced instruction set computing (RISC) architecture. Intel x86 and Pentium processors are prime examples of CISC technology. The limited command set and simpler architecture of RISC processors allows those devices to execute instructions three or more times faster than a CISC processor at any given clock speed.

CISC-Based Microprocessors

Although RISC-based microprocessors have a traditional place in the embedded systems market, manufacturers of CISC-based processors have begun to reshape their products for the embedded market. According to industry marketing managers, CISC-based processors provide a stable, known architecture for embedded development; and the capability to allow developers to bring products to market quicker. Single board, PC-compatible computers can implement market-attractive features while accelerating software development. Designers can shorten time-to-market by taking advantage of software resources currently available for the mainstream processors.

In addition, the CISC-based processors such as the Intel Pentium family offer greater performance and higher processing speeds. As an example, Intel has enlisted a group of third-party developers in cooperative support activities such as tools, operating systems, and BIOS. CISC-based processors such as the 80C186, the Intel386, the Intel486, and the Pentium family of microprocessors have been used in embedded applications such as Internet appliances. During late 1997, Intel announced the formation of embedded applications support for existing 200MHz Pentium MMX processors. The new embedded application Pentiums feature double 32 kilobytes of on-chip cache, enhanced

branch prediction and pipeline, and deeper write buffers.

RISC-Based Microprocessors

Because new applications continue to evolve, the demand for high-speed RISC microprocessors has grown substantially. The performance gains seen within embedded microprocessor technologies--where the number of instructions per second has grown from several million to over 2000 million instructions per second--have occurred because of the capability to place millions of transistors on a single chip. In turn, this has led to superscalar architectures with multiple-integer and floating-point execution units, and high levels of pipelining.

Superscalar architectures that have multiple execution units provide the capability to execute two or more instructions simultaneously. Superior pipelining schemes add pipeline stages to the processor and allow the placement of multiple instructions in the CPU execution queue. As a result, new instructions in the pipeline begin with each clock cycle.

Each of these architectural improvements has led to the addition of more complex instruction sets to superscalar processors. Because of the increase to 128-bit wide buses in microprocessors such as the Alpha, CPU word lengths have grown from 16 to 64 bits. Therefore, 64-bit data words can be divided into 2, 4, and 8 subwords. As a result, a processor involved with digital signal processing, image processing, or multimedia applications can perform as many as eight parallel computations on the data words.

The improved computational power also results from minimum clock speeds of 200MHz to maximum clock speeds of 600MHz and higher along with exceptional integer and floating point performance. At the high end, data throughput may reach 2 billion instructions per second. Each of the improvements in computational power and throughput also requires the addition of large caches; the use of dynamic execution control; the implementation of multiple execution units; and advances in register logic and branch prediction.

Storage Device Standards

The abbreviation "ATA" signifies "AT Attachment" while "ATAPI" represents ATA Packet Interface (the "AT" refers to the original IBM AT computer). Originally developed during 1989 by a division of Control Data Corporation called Imprimus, the Western Digital Corporation, and Compaq Computer, ATA/ATAPI served as an interface for only Compaq computers. Because the ATA/ATAPI standard uses a command execution protocol that allows the operation of compact disc and DVD drives and players on the same interface cable as hard disk drives, the ATA/ATAPI standard has become the most popular storage device interface.

Although most manufacturers designate EIDE (enhanced integrated drive electronics) as the current standard for the inexpensive, high performance hard disk drives used in personal computers, EIDE and ATA/ATAPI represent the same standard. Registered as a trademark of the Western Digital Corporation, the Enhanced IDE, or EIDE host controller can accomodate four attached logical drives. Because the controller connects directly to the PCI bus, it allows personal computer systems to incorporate large capacity disk drives and higher data transfer rates.

The SCSI Standard

Pronounced as "scuzzy," the term SCSI represents the "Small Computer System Interface" and allows the connection of a variety of devices to a personal computer. With the connection made through a SCSI card installed within the computer, the SCSI standard offers the fastest available I/O connection, supports high-speed mass storage devices, and transfers data at rates ranging from 10Mbytes per second to 160Mbytes per second.

Using a unique identification number for each device connected to the SCSI chain, a SCSI controller card offers connectivity for internal and external peripherals and can connect up to 7 to 15 devices per channel. As a result, SCSI-connected devices can multitask and accept simultaneous read/write operations. The first and last devices on a SCSI bus terminate and stop the data signal. Table 13.1 provides a listing of SCSI interface types and specifications.

Fault Tolerance in Servers

Network servers include features that guard against the loss of data. Fault tolerance in terms of hardware becomes defined as maintaining 100 percent availability, safeguarding critical data, and maintaining user productivity during the failure of any network component. Network administrators rely on hardware and software fault tolerance solutions.

Hardware Fault Tolerance

The hot standby solution to fault tolerance involves the duplication of the CPU, ports, network interfaces, memory expansion cards, disks, and input/output channels. As a result, an alternate hardware component can assume responsibility if a network failure occurs. The secondary system monitors the tasks of the primary system and duplicates the tasks.

In contrast to the hot standby system, the use of a load-balancing mechanism allows all hardware components to function simultaneously. The load-balancing

TABLE 13.1 — SCSI TYPES, SPEEDS, CONNECTORS, AND APPLICATIONS

TYPE	SPEED	BUS WIDTH	CONNECTOR	MAXIMUM # OF DEVICES	APPLICATION
SCSI-1	5 MB/s	8-bit Narrow	50-pin Centronics	8	Scanners and tape drives.
SCSI-1	5 MB/s	8-bit Narrow	DB-25	8	Zip Drives
SCSI-2	10 MB/s	8-bit Narrow	50-pin High Density (mini 50, micro 50)	16	CD-R, DVD, and Jaz Drives
Ultra SCSI	20 MB/s	16-bit Wide	50-pin High Density (mini 50, micro 50)	8	CD-R, DVD, and Jaz Drives
Wide SCSI	20 MB/s	16-bit Wide	68-pin High Density	4	Hard Disk Drive Connections
Ultra Wide SCSI	40 MB/s	16-bit Wide	68-pin High Density	16	Hard Disk Drive Connections
Ultra2 SCSI	80 MB/s	16-bit Wide	68-pin High Density	8	Hard Disk Drive Connections
Ultra160 SCSI	160 MB/s	16-bit Wide	68-pin High Density	16	Hard Disk Drive Connections
Ultra2 LVD (Low Voltage Differential)	160 MB/s		68-pin High Density, 12' Length	16	Peripheral and Hard Disk Drive Connections
Single-ended SCSI	40 MB/s	16-bit Wide	68-pin High Density, 3 Meter Length	16	Peripheral and Hard Disk Drive Connections
Ultra2 HVD (High Voltage Differential)	40 MB/s		68-pin High Density, 25 Meter Length	16	Peripheral and Hard Disk Drive Connections

mechanism reallocates processing tasks to other components if a failure occurs. However, the load-balancing system depends on a more sophisticated operating system that can continually monitor the system for errors. When a component failure occurs, the operating system adapts to the problem by dynamically reconfiguring the system.

Software Fault Tolerance

Fault tolerant software works in conjunction with server hardware to ensure the availability of data and to maintain server operation during a failure. During operation, the fault tolerant software switches processing tasks from primary to secondary hardware components. With the hot standby solution, the software shifts complete control to the standby system after detecting an error. The switch occurs regardless of the type of component failure. With the load balancing system, only the component experiencing the failure becomes replaced by the secondary component.

Near Fault Tolerance

A near fault-tolerant system features servers that monitor one another through a standard RS-232 connection or a network link. Each system maintains a log of error messages generated by the operating system utilized by the other unit. Moreover, both servers share the same disk drives. When a catastrophic error occurs on one server, the other server assumes control and accesses the applications and files held on the primary server.

Load Balancing

Load balancing for a cluster of servers equally distributes the load across the nodes. Several hardware and software load-balancer solutions can distribute an incoming stream of requests among a group of servers. Using web servers as an example, hardware load balancers operate between the Internet and Web server farm by connecting to the Internet router and the internal LAN using two separate network segments. The load balancer acts as a fast regulating valve between the Internet and the pool of servers.

During operation of the web servers, the load balancer uses a virtual IP address to communicate with the router and masks the IP addresses of the individual servers. Because only the virtual address becomes apparent to the Internet community, the load balancer acts as a safety net. The other network segment connects to a hub or switch with a pool of multiple physical servers attached.

Software load balancing on a cluster utilizes the Domain Name System server. Round-Robin DNS--built in to the newest version of DNS--distributes the access among the nodes in the cluster. For name resolution, Round-Robin DNS returns the IP address list of nodes in a cluster and places the different address first in the list for each successive hardware switch.

Another load balancing method statically partitions and assigns customers to the servers. As an example, load balancing would partition 100 customers as 10 customers per server within a configuration consisting of 10 web servers. However, static partitioning does not account for changing traffic patterns or changes in the content of the sites. The designated partitions cannot adjust to accommodate any changes in traffic or site dynamics. ■

Global Positioning Systems

By the ES&T Staff

When you're driving, it's nice to have a competent navigator. You're driving through town, for example, and as you cruise down the street your navigator consults the city map, and sings out "take a left at the next intersection." You carefully make the left turn, and a little way down the road, your navigator tells you to turn right. You make that turn, then drive for several minutes and after giving you a series of turns, your navigator tells you you have arrived at your destination.

The above is an unremarkable occurrence, except for the fact that your navigator is not a human being clutching a paper map, but a computerized navigation system, complete with computerized maps (and a real voice that talks to you, audibly), that resides on your laptop computer or personal digital assistant (PDA), and that is receiving input from a global positioning system (GPS).

Is this some science fiction story that will one day come true when the technology has arrived and will cost thousands of dollars? Nope, remarkably, this technology is available now, this minute. And even more remarkable, is that the whole shebang, including the PDA could cost less than $1000.00 (more, of course if you're using a laptop) and is far more accurate and faster than a human with map could ever be. The GPS unit and the associated software costs a mere $399.00.

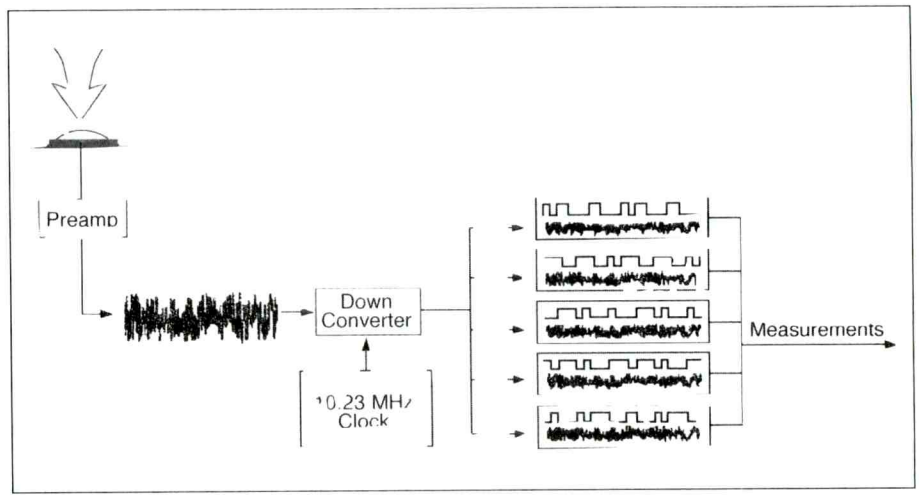


Figure 1.

So, What is GPS, Anyway?

The following description of the GPS is adapted from the description of the system found on the U.S. Navy's website that's devoted to GPS matters. The GPS is a DoD (Department of Defense) developed, worldwide, satellite-based radionavigation system that will be the DoD's primary radionavigation system well into the next century. The constellation consists of 24 operational satellites. The U.S. Air Force Space Command (AFSC) formally declared the GPS satellite constellation as having met the requirement for Full Operational Capability (FOC) as of April 27, 1995. Requirements include 24 operational satellites (Block II/IIA) functioning in their assigned orbits and successful testing completed for operational military functionality.

Prior to FOC an Initial Operational Capability (IOC) was declared on December 8, 1993 when 24 GPS satellites (Block I and Block II/IIA) were operating in their assigned orbits, available for navigation use and providing the Standard Positioning Service (SPS) levels specified below.

You may read that GPS provides two levels of service, Standard Positioning Service and the Precise Positioning Service. That was the case until spring of 2000. Today, everyone can make use of the precise positioning service. Because you may still find documents that refer to the two levels of service, we'll reproduce that information here.

The Standard Positioning Service (SPS) is a positioning and timing service which will be available to all GPS users on a continuous, worldwide basis with no direct charge. SPS will be provided on the GPS L1 frequency which contains a coarse acquisition (C/A) code and a navigation data message. SPS provides a predictable positioning accuracy of 100 meters (95 percent) horizontally and 156 meters (95 percent) vertically and time transfer accuracy to UTC within 340 nanoseconds (95 percent).

The Precise Positioning Service (PPS) is a highly accurate military positioning, velocity and timing service which will be available on a continuous, worldwide basis to users authorized by the U.S. P(Y) code capable military user equipment provides a predictable positioning accuracy of at least 22 meters (95 percent) horizontally and 27.7 meters vertically and time transfer accuracy to UTC within 200 nanoseconds (95 percent). PPS will be the data transmitted on the GPS L1 and L2 frequencies. PPS was designed primarily for U.S. military use. It will be denied to unauthorized users by the use of cryptography. PPS will be made available to U.S. and military and U.S. Federal Government users. Limited, non-Federal Government, civil use of PPS, both domestic and foreign, will be considered upon request and authorized on a case-by-case basis, provided: It is in the U.S. national interest to do so. Specific GPS security requirements can be met by the applicant.

Again, the above is out of date information. For some time now, the deliberate degradation of the GPS performance

has been discontinued, and the precise positioning is now available to all users.

GPS Signal Characteristics

The satellites transmit on two L-band frequencies: L1 = 1575.42 MHz and L2 = 1227.6 MHz. Three pseudo-random noise (PRN) ranging codes are in use. The coarse/acquisition (C/A) code has a 1.023 MHz chip rate, a period of 1 millisecond (ms) and is used primarily to acquire the P-code. The precision (P) code has a 10.23 MHz rate, a period of 7 days and is the principal navigation ranging code.

The Y-code is used in place of the P-code whenever the anti-spoofing (A-S) mode of operation is activated. The C/A code is available on the L1 frequency and the P-code is available on both L1 and L2. The various satellites all transmit on the same frequencies, L1 and L2, but with individual code assignments.

Due to the spread spectrum characteristic of the signals, the system provides a large margin of resistance to interference. Each satellite transmits a navigation message containing its orbital elements, clock behavior, system time and status messages. In addition, an almanac is also provided which gives the approximate data for each active satellite. This allows the user set to find all satellites once the first has been acquired.

GPS System Segments

The GPS consists of three major segments: space, control and user. The space segment consists of 24 operational satellites in six orbital planes (four satellites in each plane). The satellites operate in circular 20,200 km (10,900 nm) orbits at an inclination angle of 55 degrees and with a 12-hour period. The position is therefore the same at the same sidereal time each day, i.e. the satellites appear 4 minutes earlier each day.

The control segment consists of five Monitor Stations (Hawaii, Kwajalein, Ascension Island, Diego Garcia, Colorado Springs), three Ground Antennas, (Ascension Island, Diego Garcia, Kwajalein), and a Master Control Station (MCS) located at Schriever AFB in Colorado. The monitor stations passively track all satellites in view, accumulating ranging data. This information is processed at the MCS to determine satellite orbits and to update each satellite's navigation message. Updated information is transmitted to each satellite via the Ground Antennas.

The user segment consists of antennas and receiver-processors that provide

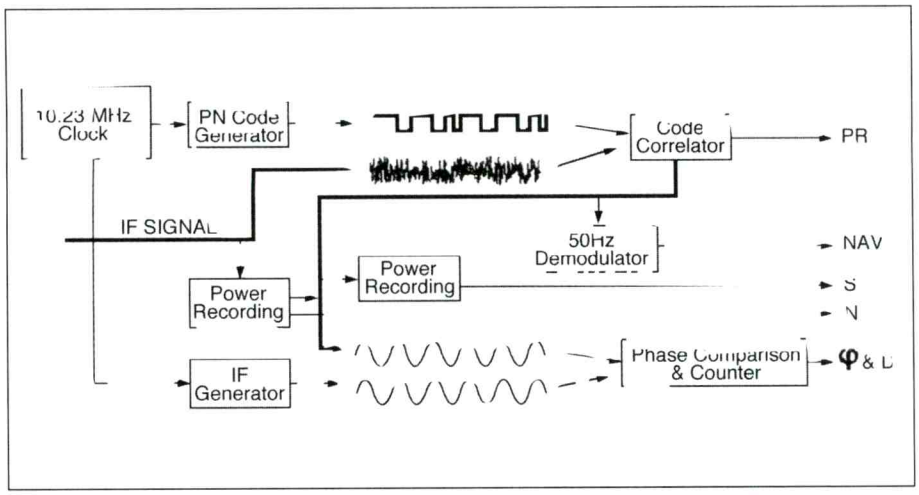


Figure 3.

positioning, velocity, and precise timing to the user.

GPS System Time

GPS system time is given by its Composite Clock (CC). The CC or "paper" clock consists of all operational Monitor Station and satellite frequency standards. GPS system time, in turn, is referenced to the Master Clock (MC) at the United States Naval Observatory (USNO) and steered to UTC(USNO) from which system time will not deviate by more than one microsecond. The exact difference is contained in the navigation message in the form of two constants, A0 and A1, giving the time difference and rate of system time against UTC(USNO,MC). UTC(USNO) itself is kept very close to the international benchmark UTC(BIPM), and the exact difference, USNO vs. BIPM is available in near real time.

The latest individual satellite measures are updated twice daily. The best current measure of the difference, UTC(USNO MC) - GPS is based on filtered and smoothed data over the past two days.

USNO Series 4 provides 10 days of past time comparisons of USNO Master Clock minus individual GPS satellites.

GPS Time Transfer

GPS is at the present time the most competent system for time transfer , the distribution of Precise Time and Time Interval (PTTI). The system uses time of arrival (TOA) measurements for the determination of user position. A precisely timed clock is not essential for the user because time is obtained in addition to position by the measurement of TOA of four satellites simultaneously in view. If altitude is known (i.e. for a surface user), then three satellites are sufficient. If time is being kept by a stable clock (say, since the last complete coverage), then two satellites in view are sufficient for a fix at known altitude. If the user is, in addition, stationary or has a known speed then, in principle, the position can be obtained by the observation of a complete pass of a single satellite. This could be called the "transit" mode, because the old transit system uses this method. In the case of GPS, however, the apparent motion of the satellite is much slower, requiring much more stability of the user clock.

The Receiver

A GPS receiver has to detect and convert the signals transmitted from all of the satellites into useful measurements. The signals from the satellites have been provided with the characteristics of spread spectrum and correlation properties. See Figure 1 for a block diagram that shows what happens to the signal at the receiver.

The antenna is usually omnidirectional with a gain of 3dB. This gain factor causes signals coming from below the horizon (the antenna ground plane) to be ignored. A coaxial cable runs from the antenna to the receiver. The cable serves as a conductor for a voltage from the receiver that appears at the antenna, and provides power for a preamp for the GPS signal. The GPS signal thus amplified is conducted via the coax to the receiver.

The GPS signal is routed through a high-pass filter. This filter rejects any signal frequency components that are outside the bandwidth of the L1 signal. A local oscillator generates a sinusoidal signal that is used to modulate the received RF signal. This modulation process generates a signal with two separate frequency components.

The local oscillator frequency is chosen so that one of the frequency components of the modulation process is approximately 40kHz. This component is separated from the other frequency component of the signal by passing the signal through a low-pass filter. Another result of this filtering is the removal of some noise.

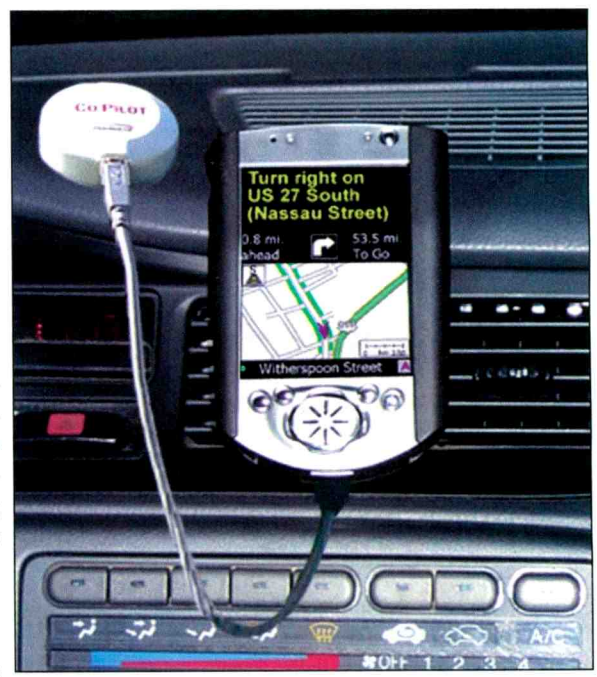


Figure 3.

Performing Measurements on the Signal

The de-spreading operation is performed by mixing the IF signal down to zero and sending copies of the signal into separate channels (Figure 2). Each of these channels extracts the code and carrier information for a particular satellite. A replica of the code is generated by the numerically controlled oscillator (NCO). This code is then correlated with the noisy if signal. The process of correlation also de-spreads the signal, moving it to above the noise floor.

The pseudorange is measured as the time shift required to align the internally generated signal with the if signal, scaled by the speed of light.

Types of GPS Receivers

There are two main types of receivers: those that can track a number of satellites simultaneously, and those that track satellites one at a time.

The receivers that track satellites one at a time (sequencing receivers) use a single channel to measure the C/A code and move it from satellite to satellite to gather the data. They generally have fewer components and are less expensive, but they have drawbacks. For example, the sequencing can interrupt signal measurement and timing resolution of the satellite signal detection, and they may be less accurate.

Parallel, or continuous, receivers can receive signals from several satellites at once. This provides them with several advantages, such as being able to continuously measure a position. Their obvious disadvantage is that they would generally be more expensive than sequencing receivers.

GPS vs GPS-Based Navigation

A GPS unit does one thing. It uses information from the constellation of satellites put in place for the purpose to determine the location of the unit on or above the earth. That can be very valuable information, indeed, especially if you're somewhere in a wilderness where you otherwise have no idea where you are. A GPS navigation system, on the other hand, uses position information from the GPS system, along with mapping data, to keep track of your position, and, if you have programmed in where you want to go, to tell you how to get there.

One GPS-based navigation system, the one we described at the outset of this article (Figure 3) is called "Copilot," and is offered by a company called TravRoute, 1000 Herrontown Road, Princeton, NJ, www.travroute.com.

The TravRoute database is a complete digital representation of the United States highway and street network. It provides the comprehensive depth and coverage needed for accurate, door-to-door routing and navigation. The database includes: 100 million addresses, 6 million+ miles of streets, 1 million+ miles of highways, 250,000+ cities and towns, 15,000+ highway exits with service information, One-way streets for 100+ metro areas, Nearly 3 million points of interest including hotels, restaurants and golf courses.

How Useful is a GPS-Based Navigation System?

For anyone who does a lot of driving that includes lot of stops at unfamiliar locations, having a co-pilot can be a useful thing. In the following paragraphs, a home inspector who does a lot of driving describes how GPS based navigation helps him. We should warn readers that the narrative presented here was gleaned from the company's press releases, so it might tend to be a little biased.

Home Inspector

Open the phone book in almost any town looking for a caterer, a tax preparation service, or even a pet sitting service and you'll see that operating a small business can be very competitive. More people than ever before are taking the plunge and going into business for themselves. In fact, the U.S. Bureau of Labor Statistics reports that self-employment more than doubled in the past decade. To prosper in today's business environment, entrepreneurs and independent business owners need an edge - something to set them apart from the competition. Home inspector Jim Oler found the key to creating a positive impression from the moment he pulls into customer driveways - the voice-activated CoPilot GPS route guidance system from TravRoute.

Jim lives in Utah and travels to jobs over a large area. "I drive up to a house in a town where I've never been before and I just smile," he says. "Customers are amazed I found their properties without asking for directions. Actually, I did get directions - just not from them. The GPS-based navigation system guided me right to their front doors." Using this system to find any address, Jim recently expanded his territory into the lucrative California real estate market, but even when traveling in familiar areas, the product helps Jim drive straight to an address without backtracking or making a wrong turn. "Sometimes I know where a town is, but not what exit to take or which way I should I turn on local roads." "With all the extra work I completed, the navigation system more than paid for itself the first month I had it!"

"I save about two hours a day with CoPilot and those two hours give me time for additional inspections." Jim also uses the device to plan his route and schedule appointments. "With this system, I don't ever have to retrace my steps or spend time buying and then poring over maps to plan my itinerary. I enter a set of addresses and the system shows me the best possible order of visits and the travel time to each place. I'm able to set appointments closer together because I don't have to allow contingency time in case I get lost. CoPilot allows me to plan an achievable schedule every work day." Another important benefit is that it gets Jim where he's going on time, no matter what. "People are really busy these days and I need to respect that by being on time. If I encounter a traffic jam, and with the road construction in and around Salt Lake City it happens a lot these days, I never sit and wait. I just get off the roadway any place I can and the device finds me a new route quickly and automatically. It says, 'Determining new route,' and talks me around any traffic problem." Aside from helping Jim provide great customer service, CoPilot makes Jim's life on the road a lot less stressful. "I recently completed 15 hours of driving in two days, traveling on roads I'd never covered before," he reports. "With CoPilot on board, I just sat back and listened to an audio book or thought about upcoming business opportunities. I never had to worry about when to make the next turn. The unit would wake me out of my reverie with a polite reminder such as 'one mile ahead, turn right on Utah highway 89,' and I'd make the turn with no problems."

"I recently had an appointment with someone who was going to walk through an inspection with me. The house was on an obscure cul-de-sac, but I arrived early (with a little help from my navigation system) and got started. He arrived 20 minutes late, completely stressed out, saying he couldn't find the place. I didn't waste the opportunity to tell him about my CoPilot." Every marketing study shows that word of mouth is the best form of customer referral. Will people remember Jim Oler when a friend asks them to recommend a home inspector? "They'll remember me," says Jim. I'm the guy who arrived on time and never even called for directions."

Implications for Service

Something like a GPS based navigation system might be of use for consumer electronic service centers that make a lot of on-site calls. It might be instructive to have a look at how much time is wasted getting to the right address, how much goodwill is lost because the technician shows up late, and do some calculation to see if a navigation system would actually help save any of that time or egg on the face.

Are these products candidates for service by consumer electronics service centers. At the moment, we don't know, but we're looking into it, and the next time we treat this subject, we'll report what we've found out. If any readers are servicing GPS and related products, we'd appreciate being told about it. Please let us know. ■

A History of Electronic Display Technology (Part 3)

Light Valve Technology From Pixelated Light Valves to Piezoelectric Mirror Light Valves

Adapted with the permission of Texas Instruments, from an article by Dr. Larry J. Hornbeck, which originally appeared in the Texas Instruments Technical Journal of July-September 1998. Dr. Hornbeck was the inventor of the Digital Micromirror Device™ optical switch, which is at the heart of Digital Light Processing™ technology.

In the January issue and the April issue, we published the first two parts in a four-part series of articles that would describe the history of electronic projection display technology. The series is based on the article cited above. This segment will cover light valve technology from pixelated light valves to piezoelectric mirror light valves. Please note: figure numbers are continued from the previous segments in order to preserve continuity.

Pixelated Light Valves

The oil-film and the photoactivated liquid-crystal light valves are examples of non-pixelated structures. Their addressable resolution is determined by the number of e-beam lines. On the other hand, there are light valves for which the addressable resolution is fixed by dividing the display area into pixels and addressing with an x-y matrix of row and column electrodes.

There are several advantages to a pixelated light-valve approach. In a color projection system, three light valves are generally used, one for each primary color (R,G,B). In a non-pixelated light-valve projector, the electron beams from three electron guns are aligned to converge the primary color images at the projection screen. This can require initial adjustment and maintenance of the registration. On the other hand, in a pixelated light-valve projector, convergence is set at the factory and no further adjustments are normally required. Another advantage of pixelated structures is that they can be addressed with an active matrix of transistors. This provides for a more compact and lower weight projection display system compared to e-beam or CRT-addressed systems requiring glass vacuum bottles.

Passive-Matrix Addressing

The earliest and simplest approach to addressing a matrix of liquid-crystal pixels is called passive matrix addressing. It consists of an x-y matrix of row and column electrodes, as shown in Figure 25. The intersection of each row and column electrode defines one pixel. The bottom address electrode is connected to a row electrode, the top to a column electrode. The object of the passive-matrix addressing scheme is to generate a set of voltage waveforms on the row and column electrodes so that any set of intersections can be activated without turning on unselected intersections.

There are two properties of the liquid crystal that make this scheme work, provided the matrix is not too large. First, there is a threshold voltage below which the liquid-crystal cell is not turned on. Second, the liquid crystal responds to the square of the applied voltage, averaged over a time shorter than the turn-on time for molecular reorientation.The sharper the threshold for turning on the liquid crystal, the larger the number of rows and columns that can be successfully addressed with the passive-matrix technique. Over the years, research has led to display architectures called "supertwisted nematic," or STN, which have provided sharper thresholds and the ability to address more lines.

Active-Matrix Addressing

As the number of resolution lines increases, passive-matrix addressing

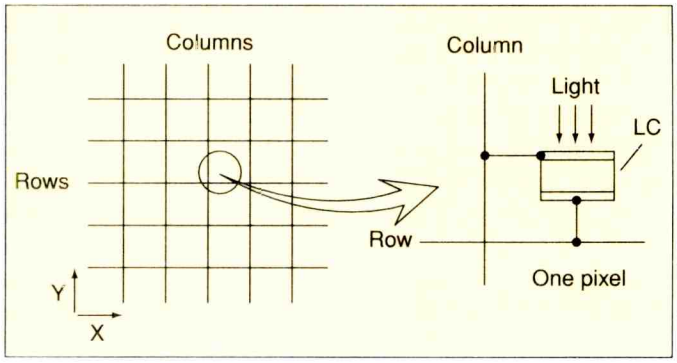


Figure 25. Passive-matrix address method.

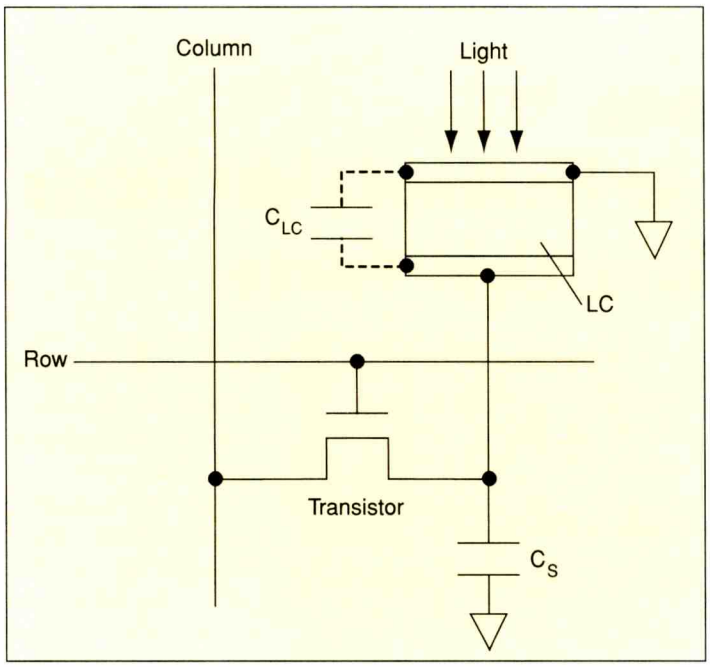


Figure 26. Active-matrix circuit for LCD.

begins to fail. Pixels that are supposed to be off turn on, and the contrast ratio is degraded. Active-matrix addressing solves this problem. As shown in Figure 26, at the intersection of each row and column electrode, a single transistor acts as an analog switch. One side of the transistor is connected to the column electrode and the other side to both a "storage" capacitor (CS) and to a liquid-crystal capacitor (CLC). The liquid-crystal capacitor is formed by the sandwich structure consisting of the address electrode, the liquid-crystal material and a grounded counterelectrode. The addressing circuit works in the following way. First, the column electrodes are charged to the desired analog voltage levels for a given line. Then the transistor switches for that line are turned on by the row electrode and the capacitors are charged to the analog voltage levels set on the column electrodes. After the switches in that row are turned off, those voltages remain stored until the next video frame, when the capacitors are recharged or refreshed to new analog voltage levels. Light leakage from the projection lamp can produce photogenerated leakage currents in the transistors. Leakage currents are also produced by the finite off impedance of the transistor. The storage capacitor CS adds capacitance to reduce the discharge effect on the stored voltage.

Early LCD panels were transmissive and fabricated on large glass substrates. The transistors developed for use on the glass substrates are called thin-film transistors or TFTs. They differ from bulk silicon transistors in that the active channel of the transistor is fabricated from a thin-film deposition, whereas bulk silicon transistors (memories, microprocessors, etc.) are formed from single-crystal silicon. The TFT concept using cadmium selenide (CdSe) as the active material was demonstrated and reported in 1962 by P.K. Weimer of RCA.

T.P. Brody and others working at Westinghouse Research Laboratories reported the first use of active-matrix addressing for an LCD display in 1973. At first they focused on tellurium and later they switched to CdSe as the semiconducting material. In 1979 P.G. Le Comber reported the operation of TFTs formed from amorphous silicon. This material was compatible with glass substrates because it had a low deposition temperature (~300 ° C) and the technology for depositing amorphous silicon over large areas could be borrowed from solar cell technology. Le Comber's report led to a surge in the development of active-matrix addressing for LCDs.

A cross section of an amorphous silicon TFT is shown in Figure 27. The architecture has an inverted gate structure in which the gate of the transistor is under the semiconducting material, as opposed to the usual arrangement of gate on top for single-crystal silicon transistors.

The ideal TFT switch combines a low on resistance with a high off resistance. Amorphous silicon is much inferior to its single-crystal counterpart in these respects, and oversized TFT transistors are required to compensate for these deficiencies. In a transmissive LCD light valve, larger transistors mean less clear aperture for the light to pass through, because the transistors require an opaque light shield placed over them. Light leakage into the transistor produces photogenerated charge that will discharge the capacitor.

Following the commercialization of amorphous silicon LCD panels, there has been a large effort to produce TFT materials having more ideal transistor properties. This effort has been driven by the need to maximize the clear aperture, increase the display resolution, reduce the size of the LCD panel and its associated optics and to integrate row and column drivers on the same glass substrate. The result has been the polysilicon transistor that in recent years has become the main approach for LCD light valves. Panel sizes for projection display applications have been reduced from 6 inches on a side

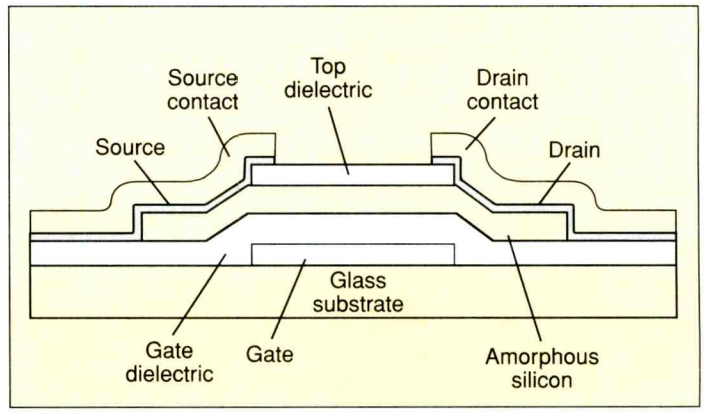


Figure 27. Inverted gate, amorphous silicon TFT.

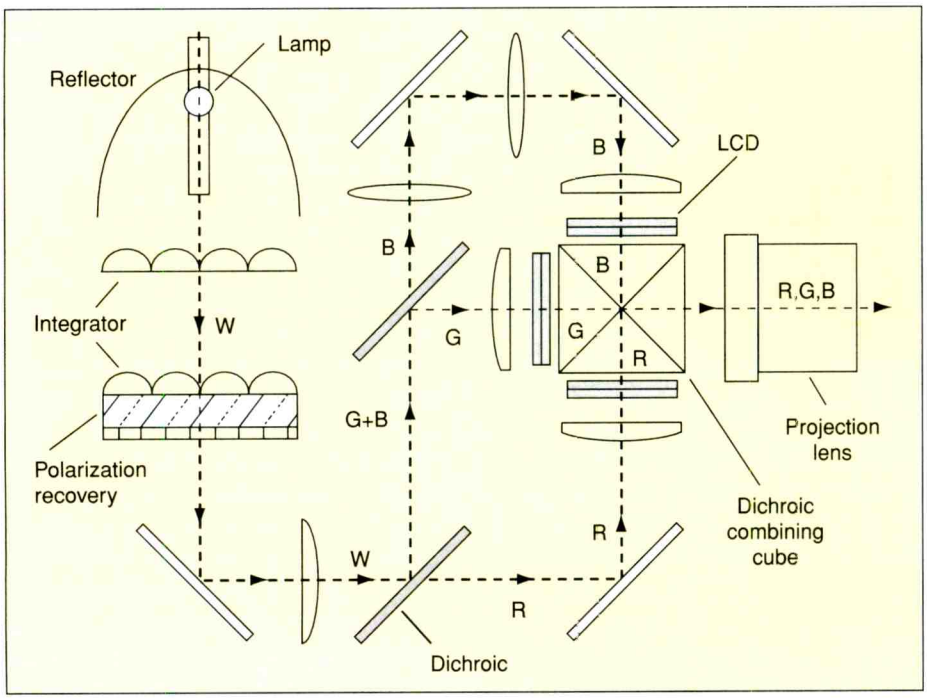


Figure 28. Transmissive LCD projector.

to diagonals of 1.3 inches or less while maintaining high aperture ratios.

However, the quartz substrates used in the preparation of polysilicon transistors are expensive. Recently, a lower temperature polysilicon (low-temp poly) approach has been developed in which glass can be used instead of quartz for the substrate. In this process amorphous silicon is deposited onto glass substrates and recrystallized by locally heating the amorphous silicon with an excimer laser.

LCD Projectors, A Decade of Rapid Progress

The first LCD color video projector was introduced to the market in 1989 by the Sharp Corporation. Although of limited resolution, its introduction signaled a decade of rapid developments leading to video and graphic projectors with higher resolution, greater light efficiency and brightness, improved colors and reduced

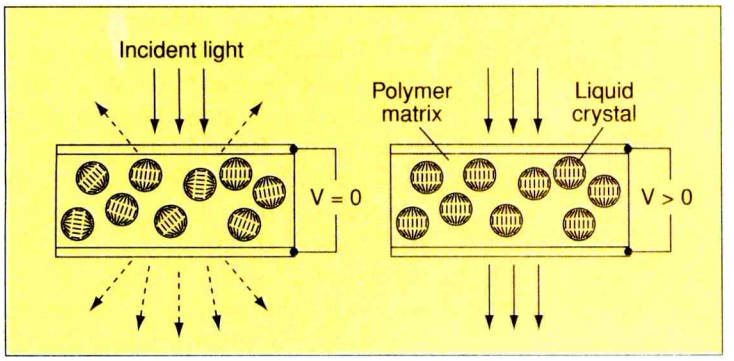


Figure 29. Polymer-dispersed liquid crystal.

weight and volume.

Early LCD projectors employed transmissive cells based on amorphous silicon TFTs or diode switches. The weight and volume of these projectors were reduced by continuing efforts to shrink the size of the pixels and the resultant size of the LCD panel and associated optics. To maintain a high aperture ratio for efficient light transmission, the large amorphous silicon transistors of the earlier panels were replaced with more compact polysilicon transistors. Today, compact projectors typically employ polysilicon-addressed LCD panels, ranging in size from 0.9 inches to 1.3 inches on the diagonal and based on the 90-degree twisted nematic alignment mode.

Figure 28 shows an example of a compact transmissive LCD projector. This particular design addresses the classic problem of polarization losses that amount to more than 50% of the available light from the lamp. It employs a polarization recovery system to deliver exceptional luminous efficiency.

Light from the arc lamp passes through a microlens integrator that homogenizes the light beam for improved uniformity. The polarization recovery plate polarizes the light and then acts on the rejected polarization component by rotating its polarization direction and reinserting it into the optical path. The white light (W) is then separated into its primary colors, red, green and blue (R,G and B) by a series of dichroic filters and directed to three LCD panels, one for each color. After the light is modulated, a color-combining dichroic "x-cube" combines the red, green and blue images into a single color image that is projected to the screen.

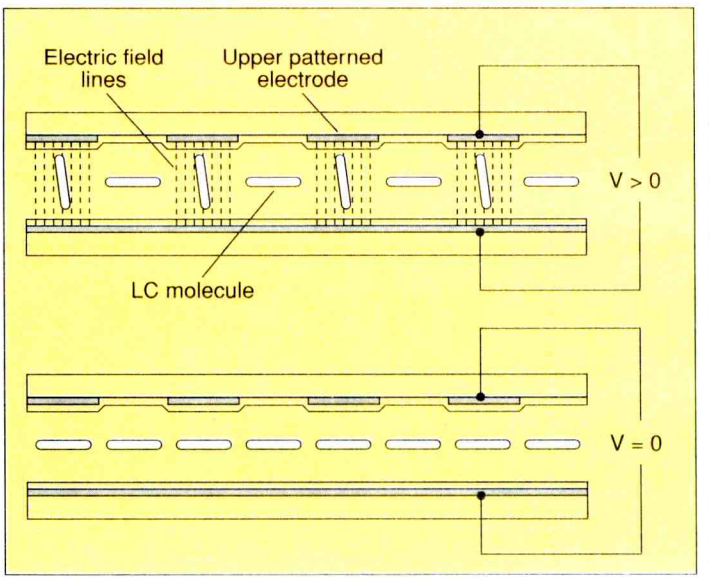


Figure 30. Diffraction grating LCD (one pixel).

In addition to polarization recovery, another technique can be used for increasing the luminous efficiency. A microlens array focuses light from the condenser lens into the clear aperture of each pixel, thus increasing the apparent aperture ratio. Taken together, these two enhancements to the luminous efficiency have overcome the classic problem of low luminous efficiency in polarization-dependent, transmissive LCD projectors.

Driven by the need for higher resolution projectors that are both compact, lightweight, and efficient, a new class of projector products has been announced in 1998. These products use reflective LCD light valves on single-crystal silicon address circuits (so-called silicon backplanes). They employ even smaller pixels, because the address circuitry can be hidden under the reflective aluminum address electrode of the pixel (similar to the DMD architecture described later). Both homeotropic and 45-degree twisted nematic liquid-crystal alignment modes are employed.

The optical layout of the reflective LCD projector is similar to the transmissive projector, except polarizing beam splitters are used to reflect the light into each LCD chip. The polarizing beam splitter was introduced earlier and illustrated in Figure 22 (see ES&T April 2001, page 35).

Other LCD Projection Technologies

There are a number of other LCD technologies that have potential application for projection display applications. One of these is the ferroelectric liquid crystal (FLC) display, a bistable light valve that can be used in the reflective mode over a single-crystal silicon address circuit. The FLC material consists of LC molecules that have a permanent electric

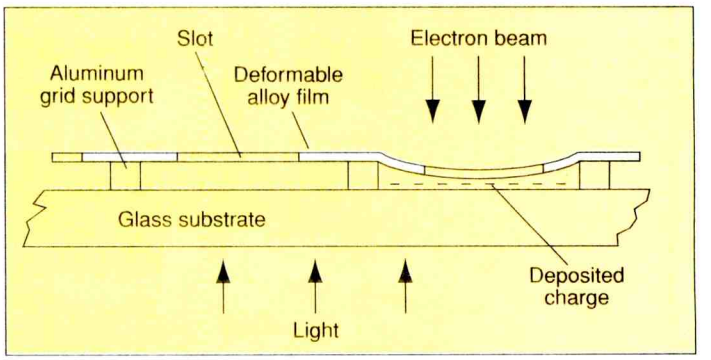


Figure 31. Metal membrane target.

dipole moment.

Application of a voltage pulse with polarity in one direction or the other causes the FLC to switch between two stable molecular orientational states. As the FLC is switched from one state to the other, polarized light is modulated between bright and dark states. Because light can only be turned on or off, gray scale is achieved by a pulsewidth modulation technique.

The switching speed of the FLC with 5V address is short compared to normal nematics (~100 µs vs. ~10 ms). The shorter switching speed results from the strong forces exerted on the molecules by the electric field because of their permanent electric dipole moment. In a time-multiplexed color applica-tion using a single FLC device and a rotating color disc, this switching speed will support 64 gray levels per primary color.

Two other LCD technologies are of note because they do not require polarized light and thus do not have the light losses associated with polarizers. The first is often called polymer-dispersed liquid crystal (PDLC), although it has a variety of other names. The transmissive version is shown in Figure 29.

The PDLC material consists of droplets of a nematic LC dispersed in a solid polymer matrix. With no applied electric field, each droplet of LC is randomly oriented, producing a random change in index of refraction. Light passing through the cell is scattered, leading to a dark off state. When a field is applied, the LC molecules within each droplet align with the field, producing a near uniform index of refraction. Light is no longer scattered, resulting in a bright cell.

A second LC technology that does not require a polarizer relies on light diffraction, working on the same principle as the oil film, acousto-optic, elastomer and micromechanical grating light valves. Figure 30 illustrates one technique for producing a diffraction grating LCD. Within each pixel a set of fine transparent electrodes is patterned as shown. With zero applied electric field, all LC molecules are oriented in the same direction. With an applied field, the molecules rotate under each electrode and a diffraction grating is produced by the periodic variations in index of refraction.

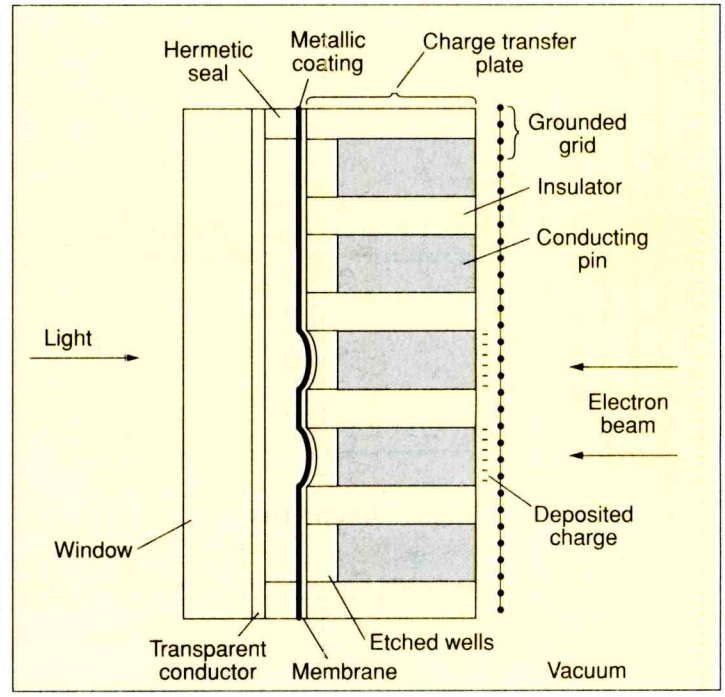


Figure 32. Membrane light modulator.

Projectors based on PDLC or diffraction-grating LC technology have lower image contrast than projectors based on polarization modulation. The recent introduction of practical polarization recovery optics and microlens illuminator arrays has mitigated the luminous efficiency advantage of these technologies and made them less attractive for projection applications.

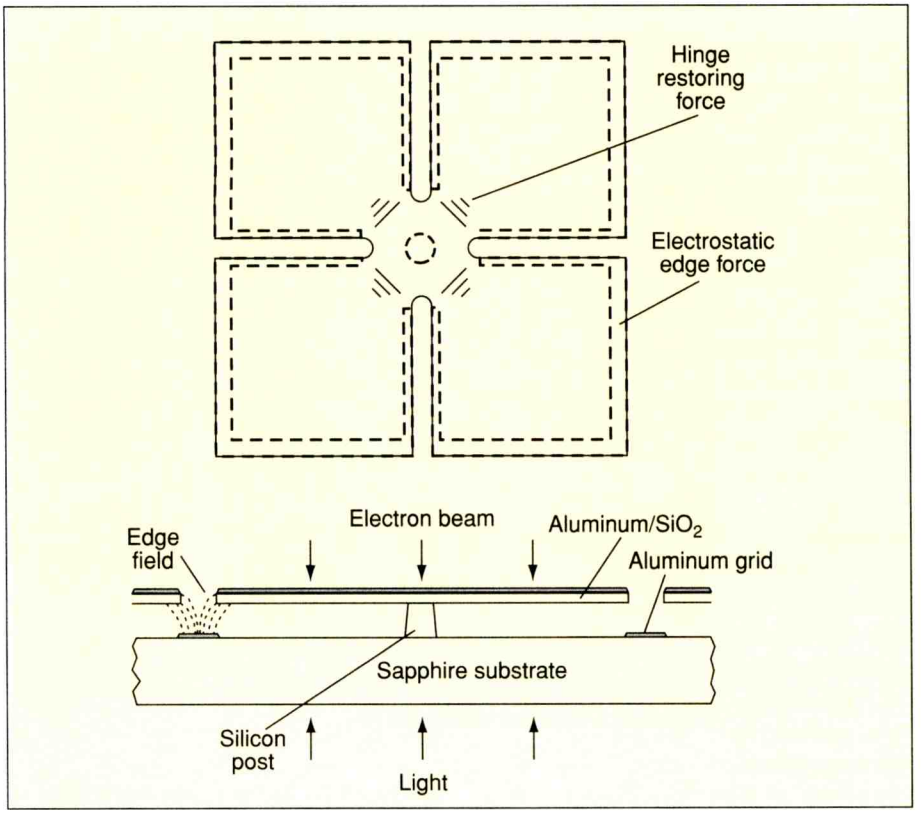


Figure 33. Target of Mirror Matrix Tube (one pixel).

LCD Performance Issues

There has been a continuing effort over the years to improve the performance characteristics of the LCD, including molecular response times (image lag), contrast ratio (black levels), and image stability (changes in color balance and gray scale with changes in temperature and with long-term exposure to light).

The turn-on and turn-off times for molecular reorientation of the liquid crystal must be made much shorter than the video frame time of 16 ms if image "lag" or smearing is to be prevented. High address voltages, low fluid viscosities and small cell gaps favor short response times. Small cell gaps, however, can lead to brightness nonuniformities and loss of light modulation or brightness. Typical analog LCD projection displays have response times that are just under the video frame time of 16 ms. Therefore, these displays will show image lag, manifested as a blurring of the fine details in a moving image, or in a stationary image when the camera is panning rapidly.

As the display resolution increases, fixed panel or chip sizes result in smaller pixels, and fringing electric fields between neighboring pixels become a serious problem. The fringing fields lead to anomalous orientations (or disinclinations) of the liquid-crystal molecules at the pixel boundaries, resulting in degradation of contrast ratio. Video black levels become noticeably gray and images can even begin to look "soft." Fringing field effects are even more difficult to control for the new reflective LCD "chip" technologies in which pixel sizes continue to shrink as resolution increases.

Ease of setup and stable projection display performance are crucial to customer satisfaction, particularly in the demanding home theater and audio/visual rental and staging markets. Two effects lead to instabilities in LCD projectors; photodegradation products and changes in voltage threshold with changes in temperature. These can result in gray scale and color balance that are unstable over time. Both effects are exacerbated in high-brightness applications because the higher light intensities in the liquid crystal promote more rapid photodegradation and create higher liquid temperatures because of light energy absorption. Reflective LCDs fabricated on single-crystal silicon can be effectively cooled through the chip substrate, thereby providing more margin to thermal effects but not to photodegradation.

Large investments are being made each year in the development of new liquid-crystal materials having more ideal properties for a broad spectrum of digital and analog LCD projection display applications. As in the case of the CRT, steady performance and reliability improvements are anticipated each year.

Membrane, Cantilever-Beam and Piezoelectric-Mirror Light Valves

Over the years, a number of light-valve technologies have been developed that rely on the micromechanical movement of mirror surfaces to defocus incident light or to "beam steer" the light around a Schlieren stop.

Membrane Light Valves

These devices have either relied on metal-coated polymer or thin metal mem-branes as the deformable material. In 1970, J.A. van Raalte at RCA Laboratories reported on a metal membrane light valve that did not contain organic materials and therefore could be sealed in a vacuum tube and e-beam addressed. A cross section of the e-beam "target" is shown in Figure 31 for two pixels. The modulated e-beam deposits charge through thin openings or slots in the metal membrane onto a glass substrate. The charge deposited on the substrate electrostatically attracts the membrane, deforming it into a concave shape. The deformation acts to defocus incident light around a Schlieren stop and the light is projected to the screen. Limited performance was achieved because of the low contrast ratio, probably caused

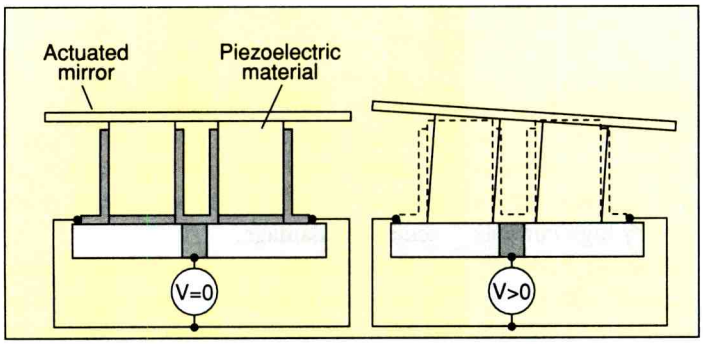


Figure 34. Actuated Mirror Array concept (bulk approach).

by diffracted light from the openings in the membrane.

Another membrane light-valve approach was originally developed by K.P. Preston of Perkin-Elmer Corp. in 1969 for use in optical computing. Called the membrane light modulator (MLM), the membrane was formed out of nitrocellulose and metallized with antimony for reflectivity. It was addressed by metal electrodes underlying the membrane air gap.

In 1990, an e-beam-addressed derivative of this technology (e-MLM) was reported. Shown in Figure 32, the membrane is fabricated and metallized, then placed onto a charge transfer plate (pin-grid matrix). A modulated and rasterized e-beam deposits charge on pins of the charge transfer plate. A voltage drop is produced across the air gap between the pin and the metallized membrane, and the membrane deforms accordingly. Refinements to this technology were reported in 1992. The e-MLM was demonstrated as both a visible display and a dynamic infrared scene projector.

Cantilever-Beam Light Valves

This technology does not have the susceptibility to optical blemishes inherent in the nitrocellulose membrane light valve. Particulate contamination trapped between the membrane and supporting substrate creates "tents" in the membrane that greatly magnify the apparent size of the particles. Texas Instruments 1981 membrane-based analog DMD technology was susceptible to such blemishes and they are evident in the projected image. This tenting effect is avoided in the cantilever approach because the mirror surfaces can be formed monolithically over the substrate.

In 1973 Nathanson and Guldberg of the Westinghouse Corporation filed for patent applications on a technology that later became known as the Mirror Matrix Tube, an e-beam-addressed light valve. In 1975 an 800 x 600 resolution projection display was demonstrated based on this technology. A top view and cross section of one pixel are shown in Figure 33. The mirror is made of aluminized silicon dioxide (SiO2) shaped in a cloverleaf pattern and supported by a silicon post over a sapphire substrate. The air gap is formed by selectively wet etch-ing the silicon from under the SiO 2 prior to the depo-sition of a thin layer of aluminum. When the aluminum is deposited, it not only forms a mirror-like surface on the SiO 2 , but also an electrical grid on the substrate. The sapphire substrate becomes the face-plate of the e-beam tube, with the cloverleaves on the vacuum side. The sapphire serves to transmit light from the projection lamp onto the mirrors.

In operation, a rastered and modulated e-beam charges each cloverleaf, causing the four cantilevers to be electrostatically attracted by the edge forces toward the aluminized grid and to bend a maximum of approximately 4 degrees. Light is beam steered around a cross-shaped Schlieren stop according to the cantilever deflection angle. Because the cantilevers of each cloverleaf bend by 45 degrees relative to their edges, diffracted light is rejected by the cross-shaped Schlieren stop and the beam-steered light is passed. The result of this "45-degree discrimination" architecture is higher contrast ratio. This technique is employed in current DMD architectures.

Nevertheless, disappointing contrast ratios of 15:1 were demonstrated. Perhaps this was due to the fact that the electrostatic edge forces produced not only a bending at the hinge, but also produced some curvature to the cantilevers so they no longer acted as planar mirrors.

Piezoelectric-Mirror Light Valves

This class of light valves depends for its operation on piezoelectric materials that expand or contract depending on the polarity of the applied voltage to produce rotation of a mirrored surface. Such a light-valve technology was developed by Aura Systems Inc. in the early 1990s and is called the Actuated Mirror Array (AMA). An early version is described in a patent that was awarded to Aura Systems in 1993. Later, AMA technology was licensed and further developed by Daewoo Electronics Company Limited. One such "bulk" implementation of the AMA is shown in Figure 34.

Two piezoelectric posts are addressed with opposite polarity voltages so that when a voltage is applied, one post expands vertically, while the other contracts. The action of the posts causes an overlying mirrored surface to tilt or rotate. The reported mirror tilt angle is ±0.25 degrees at 30V. Gray scale is achieved by analog operation of the tilting mirrors in a Schlieren optical configuration. Limitations of the bulk AMA approach include a difficult hybrid fabrication process and limited tilt angle. A thin-film approach was proposed in 1997 that would integrate the piezoelectric material onto a silicon address circuit and produce much larger tilt angles.

Cantilever beams acting as mirrors would be driven by thin-film piezoelectric drivers. It is not known whether this concept has been demonstrated in a working display system.

More to Come

The fourth and final segment of this article, detailing the development of the digital mirror device, the technology on which TI's Digital Light Processing systems are based, will be published in the October issue. ■

Microwave Ovens

By Samuel Goldwasser

Microwave ovens represent a different kind of product for both the consumer and the servicer. It's the only piece of completely electronic equipment in the home that is not designed for either entertainment, communications, security or information processing. It's designed to cook food. And it's a relatively simple device. Moreover, because it can deliver both high voltage and high current, it's a dangerous, potentially lethal, piece of equipment to service. We recommend that you read and follow all safety precautions in this article, and that provided by the manufacturer before even thinking about servicing a microwave oven.

Common Problems in Microwave Ovens

The most common problems occur in the microwave generating portion of the system, though the controller can be blown by a lightning strike or other power surge. Bad interlock switches probably account for the majority of microwave oven problems. Also, since the touchpad is exposed, there is a chance that it can get wet or damaged. If wet, a week or so of non-use may cure keys that don't work. If damaged, it will probably need to be replaced - this is straightforward if the part can be obtained, usually direct from the manufacturer. Unfortunately, it is an expensive part ($20-50 typical).

The interlock switches, being electromechanical can fail to complete the primary circuit on an oven which appears to operate normally with no blown fuses but no heat as well. Faulty interlocks or a misaligned door may result in the fuse blowing as described above due to the incorrect sequencing of the door interlock switches. Failed interlocks are considered to be the most common problems with microwave ovens, perhaps as high as 75% of all failures.

No adjustments should ever be required for a microwave oven and there are no screws to turn so don't look for any!

Microwave Oven Safety

Microwave ovens are probably the most dangerous of consumer appliances to service. Very high voltages (up to 5000V) at potentially very high currents are present when operating: a deadly combination. These dangers do not go away even when the oven is unplugged as the high voltage capacitor can retain a dangerous charge for a long time

Careless troubleshooting of a microwave oven can not only can fry you from high voltages at relatively high currents but can microwave irradiate you as well. When you remove the metal cover of the microwave oven you expose yourself to dangerous, potentially lethal, electrical connections. You may also be exposed to potentially harmful levels of microwave emissions if you run the oven with the cover off and there is damage or misalignment to the waveguide to the oven chamber.

There is a high voltage capacitor in the microwave generator. Always ensure that the oven is unplugged and that this capacitor is totally discharged before even thinking about touching or probing anything in the high voltage power circuits. See the troubleshooting sections later in this document.

To prevent the possibility of extremely dangerous electric shock, do not operate the oven with the cover off if at all possible. If you must probe live, remove the connections to the magnetron to prevent the inadvertent generation of microwaves except when this is absolutely needed during troubleshooting. Discharge the high voltage capacitor and then use clip leads to make any connections before you apply power to the oven.

The microwave oven circuitry is especially hazardous because the return for the high voltage is the chassis: it is not isolated. In addition, the HV may exceed 5000V peak with a continuous current rating of over 0.25A at 50/60 Hz. The continuous power rating of the HV transformer may exceed 1500W with short term availability of much greater power. Always observe high voltage protocol.

Safety Guidelines

These guidelines are to protect you from potentially deadly electrical shock hazards as well as the equipment from accidental damage.

Note that the danger to you is not only in your body providing a conducting path, particularly through your heart. Any involuntary muscle contractions caused by a shock, while perhaps harmless in themselves, may cause collateral damage - there are many sharp edges inside this type of equipment as well as other electrically live parts you may contact accidentally.

The purpose of this set of guidelines is not to frighten you but rather to make you aware of the appropriate precautions. Repair of TVs, monitors, microwave ovens, and other consumer and industrial equipment can be both rewarding and economical. Just be sure that it is also safe.

- Don't work alone: in the event of an emergency another person's presence may be essential.
- Always keep one hand in your pocket when anywhere around a powered line-connected or high voltage system.
- Wear rubber bottom shoes or sneakers.
- Don't wear any jewelry or other articles that could accidentally contact circuitry and conduct current, or get caught in moving parts.
- Set up your work area away from possible grounds that you may accidentally contact.
- Know your equipment: TVs and monitors may use parts of the metal chassis as ground return yet the chassis may be electrically live with respect to the earth ground of the ac line. Microwave ovens use the chassis as ground return for the high voltage. In addition, do not assume that the chassis is a suitable ground for your test equipment.
- If circuit boards need to be removed from their mountings, put insulating material between the boards and anything they may short to. Hold them in place with string or electrical tape. Prop them up with insulation sticks: plastic or wood.

- If you need to probe, solder, or otherwise touch circuits with power off, discharge (across) large power supply filter capacitors with a 25W or greater resistor that has a resistance of 5ohms to 50ohms per working volt of the capacitor approximate value.

For the microwave oven in particular, use a 25Kohm to 100Kohm 25W resistor with a secure clip lead to the chassis. Mount the resistor on the end of a well insulated stick. Touch each of the capacitor terminals to the non-grounded end of the resistor for several seconds. Then, to be doubly sure that the capacitor is fully discharged, short across its terminals with the blade of a well insulated screwdriver. I also recommend leaving a clip lead shorting across the capacitor terminals while working as added insurance. At most, you will blow a fuse if you should forget to remove it when powering up the microwave. But don't forget.

- Connect/disconnect any test leads with the equipment unpowered and unplugged. Use clip leads or solder temporary wires to reach cramped locations or difficult to access locations.
- If you must probe live, put electrical tape over all but the last 1/16 of an inch of the test probes to avoid the possibility of an accidental short which could cause damage to various components. Or, better yet, use a probe that is designed so that only the very tip is exposed. Clip the reference end of the meter or scope to the appropriate ground return so that you need to only probe with one hand.
- Perform as many tests as possible with power off and the equipment unplugged. For example, the semiconductors in the power supply section of a TV or monitor can be tested for short circuits with an ohmmeter.
- Use an isolation transformer if there is any chance of contacting line connected circuits. A Variac™ is not an isolation transformer. The use of a GFCI (Ground Fault Circuit Interrupter) protected outlet is a good idea but will not protect you from shock from many points in a line connected TV or monitor, or the high voltage side of a microwave oven, for example. A circuit breaker is too slow and insensitive to provide any protection for you or in many cases, your equipment. A GFCI may, however prevent your scope probe ground from smoking should you accidentally connect an earth grounded scope to a live chassis.
- Don't attempt repair work when you are tired. Not only will you be more careless, but your primary diagnostic tool, deductive reasoning, will not be operating at full capacity.
- Finally, never assume anything without checking it out for yourself.

Don't take shortcuts!

As noted, a GFCI (Ground Fault Circuit Interrupter) will NOT protect you from the high voltage since the secondary of the HV transformer is providing this current and any current drawn off of the secondary to ground will not be detected by the GFCI. However, use of a GFCI is desirable to minimize the risk of a shock from the line portions of the circuitry if you don't have an isolation transformer.

An isolation transformer is even limited value as well since

the chassis IS the HV return and is a large very tempting place to touch, lean on, or brush up against. And, of course, none of these devices will protect fools from themselves!

Take extreme care whenever working with the cover off of a microwave oven.

General System Problems

The following problems are likely power or controller related and not in the microwave generator unless due to a blown fuse or bad/intermittent connections:

- Totally dead oven.
- No response to any buttons on touchpad
- Oven runs when door is still open.
- Oven starts on its own as soon as door is closed.
- Oven works but display is blank.
- Whacked out controller or incorrect operation.
- Erratic behavior.
- Some keys on the touchpad do not function or perform the wrong action.
- Microwave oven does not respond to START button.

First, try unplugging the microwave oven for a couple of minutes, then plug it back in. In some cases this is all that is needed to solve the problem. Sometimes, the microcontroller will get into an anomalous mode for some unknown reason - perhaps a power surge - and simply needs to be reset. The problem may never reoccur.

Note: when working on controller related problems, unplug the connection to the microwave generator (HV transformer primary) from the power relay or triac - it is often a separate connector. This will prevent any possible accidental generation of microwave energy as well as eliminating the high voltage (but not the ac line) shock hazard during servicing.

If this does not help, there is likely a problem with the controller circuitry or its power and you will have to get inside the oven.

Uninvited Guests

Some cockroaches (or other lower life forms) may have taken up residence on the controller circuit board. It is warm, cozy, safe, and from their point of view makes an ideal habitat. If the microwave oven was purchased from a flea market, garage sale, the curb, a relative, or friend, or if the home is in a part of the country where cockroaches are a problem, such visitors are quite possible. Creatures with six or more legs (well, some two legged varieties as well) are not known for their skills in the areas of housekeeping and personal hygiene.

If you find evidence of this type of infestation, clean the circuit board and connectors thoroughly with water and then isopropyl alcohol. Dry completely. Inspect the circuit traces for corrosion or other damage. If there are any actual breaks, these will have be be jumpered with fine wire and then soldered. With any luck, no electronic components were affected though there is always a slight possibility of other problems.

Totally Dead Oven

If the oven is totally dead, first, check power to the outlet using a tester, or a lamp or radio you know works. The fuse or circuit breaker at the service panel may have blown/tripped due to an overload or fault in the microwave oven or some other appliance. There may be too many appliances plugged into this circuit. Microwave ovens are high current appliances and should be on a dedicated circuit if possible. If you attempt to run a heating appliance like a toaster or fryer at the same time, you will blow the fuse or trip the circuit breaker. A refrigerator should never be plugged into the same circuit for this reason as well.

If you find the fuse blown or circuit breaker tripped, unplug everything from the circuit to which the microwave is connected (keep in mind that other outlets may be fed from the same circuit). Replace the fuse or reset the circuit breaker. If the same thing happens again, you have a problem with the outlet or other wiring on the same branch circuit. If plugging in the microwave causes the fuse to blow or circuit breaker to trip immediately, there is a short circuit in the power cord or elsewhere.

Next, try to set the clock. With some ovens the screen will be totally blank following a power outage - there may be nothing wrong with it. Furthermore, some ovens will not allow you perform any cooking related actions until the clock is set to a valid time.

Assuming these are not your problems, a fuse has probably blown although a dead controller is a possibility.

If the main fuse is upstream of the controller, then any short circuit in the microwave generator will also disable the controller and display. If this is the case, a new fuse will enable the touchpad/display to function, but may blow again as soon as a cook cycle is initiated if there is an actual fault in the microwave circuits.

Therefore, try a new fuse. If this blows immediately, there may be a short very near the line cord, in the controller, or a defective triac (if your oven uses a triac). If it does not blow, initiate a cook cycle (with a cup of water inside). If the oven now works, the fuse may simply have been tired of living. This is common.

If the fuse still blows immediately, confirm that the controller is operational by unplugging the microwave generator, power relay, and/or triac from the controller. If a new fuse does not now blow when a cook cycle is initiated - and it appears to operate normally - then one of the components in the microwave generator is defective (shorted).

Some models have a thermal fuse as well and this may have failed for no reason or a cooling fan may not be working and the oven .

Other possible causes: bad controller power supply or bad controller chip. The most common way that the controller circuitry can be harmed is by a power surge such as from a lightning strike. Hopefully, only components on the primary side of the power transformer will be affected. In some cases, circuit board traces may have been vaporized (but repair may still be possible by simply jumpering across the crater). Assuming that the main fuse checks out, then check the power supply for the controller next. Also check for bad solder connections.

No Response to any Buttons on Touchpad

There can be many causes for this behavior (or lack of behavior):

- Door is not closed: on many ovens,

there will be no response to any buttons, even setting the clock, unless the door is securely closed.

- You waited too long: some models (like Sharp) have a timeout. If you close the door but don't proceed to activate any functions with a couple of minutes, they will require you to open and close the door to reset.
- Controller is confused: a power surge or random non-reproducible action of the universe may have resulted in the controller's program ending up in an infinite loop. Pull the plug for a minute or two to reset it.
- Defective interlock switches: this can result in the controller thinking the door is open and ignoring you.
- Faulty controller or its power supply: a power surge may have damaged the electronics. Other than checking for bad connections and obviously bad power supply components, diagnosing this will be tough without a schematic (and possibly much more).
- Touchpad or controller board contaminated by overenthusiastic cleaning: if the owner recently power washed the oven (or even only used some spray cleaner), some may have gotten inside and shorted out the touchpad or controller.
- Defective or damage touchpad: physical abuse is not a recommended technique for getting a microwave oven to cooperate. If there is any visible damage to the touchpad (the outer film is broken) it will probably need to be replaced.

Oven Runs When Door is Still Open

WARNING: Needless to say, DO NOT operate the oven with the door open! While extremely unlikely, the microwave generator could be running!

For microwaves to actually be generated with the door still open would require the failure of all 3 interlock switches. The only way this could really happen would be for the 'fingers' from the door that engage the interlocks to break off inside the oven keeping the interlocks engaged. In this case, the controller would think the door was always closed.

Where no such damage is evident, a failure of this type is extremely unlikely since power to the microwave generator passes through 2 of the 3 interlock switches. If both of these failed in the closed position, the third switch would have blown the fuse the last time the door was opened.

Another more benign possibility is that one or more fans are running as a result of either a defective sensor or normal operation to maintain air flow until all parts have cooled off.

Oven Starts on Its Own as Soon as Door is Closed

If the oven starts up as soon as the door is closed, regardless of whether a cook cycle has been selected, the cause could be a shorted triac or relay or a problem with the controller or touchpad.

First, unplug the oven for a couple of minutes to try to reset the controller.

If this doesn't help, put a cup of water into the oven and let it run for a minute to check for heating. (You could also note the normal sound change or slight dimming of lights that accompanies operation of the magnetron). Much more must be enabled to actually power the magnetron so this might point more to the controller as being faulty but not always.

Oven Works But Totally Dead Display

If all functions work normally including heating but the display is blank (assuming you can issue them without being able to see the display), the problem is almost certainly in the controller or its power supply.

Try pulling the plug for a minute or two, for some reason the display portion of the controller may have been sent out to lunch by a power surge or alpha particle. It woudn't be the first time.

Check for bad connections between the display panel and the power supply and solder joints on the controller board.

With everything else operational, a bad microcontroller chip is not that likely but is still a possibility. If the oven was physically abused, the display panel may have fractured though it would take quite a bit of violence. In this case, more serious damage to the door seals may have resulted as well which would be a definite hazard.

Whacked Out Controller or Incorrect Operation

The following are some of the possible symptoms of a defective controller:

- All the display digits may have come on, EEEE or FFFF, or be displaying in some incomprehensible fashion.
- The end-of-cooking cycle or keypress tone may be wailing away continuously. By 'tone' I mean from the controller (not a low buzzing or humming when attempting to cook which would indicate a microwave generator power problem like a shorted magnetron).
- Pressing a button on the touchpad may result in a totally incorrect action such as entering the time resulting in the oven starting to cook.
- The oven may start cooking (or at least appear to) as soon as the door is closed. Pressing buttons on the touchpad may or may not have any effect. (This could also be a shorted triac or power relay).

First, try unplugging the oven for a couple of minutes; perhaps the controller is just confused due to a power surge, lightning strike or the EMP from a nearby nuclear detonation because it wanted attention.

If you recently cleaned the oven, some liquid may have accidentally gotten inside the touchpad or even the controller circuitry (though this is less likely.

If the oven seems to have a mind of its own, for example, running a cycle you didn't think you programmed, are you sure a previous cook cycle was not interrupted and forgotten? Try to recreate the problem using a cup of water as a load.

Assuming this does not apply, it sounds like a controller problem, possibly just a power supply but could also be the controller chip. My guess is that unless you were to find some simple bad connections or an obvious problem with the controller's power supply, the cost to repair would be very high as the custom parts are likely only available from the manufacturer.

The controller's program may be corrupted (unlikely) but we have no real way of diagnosing this except by exclusion of all other possibilities. Depending on the model, some or all operations, even setting the clock, may be conditional on the door interlocks being closed, so these should be checked.

Some ovens will not allow any actions to be performed if the door has been closed for more than a few minutes. Open and close the door to reset.

A controller failure does little to predict the reliability of the rest of the oven. The microwave generator circuits could last a long time or fail tomorrow. The output of the magnetron tube may decrease slightly with use but there is no particular reason to expect it to fail any time soon. This and the other parts are easily replaceable.

Erratic Behavior

Erratic behavior may be caused by the following situations:

- Whenever the oven performs unexpectedly both during setup and the cook cycle, suspect the controller power supply or bad connections.
- Where problems only occur when entering or during the cook cycle, suspect a power relay or mechanical timer (if used) with dirty or worn contacts, or (less likely) the power surge from energizing the microwave generator or microwave (RF) leakage into the electronics bay affecting the controller.

The filter capacitor(s) in the controller's power supply may be dried up or faulty. Check with a capacitor meter or substitute known good ones. Prod the logic board to see if the problem comes and goes. Reseat the flex cable connector to the touchpad.

For mechanical timers, the timing motor could be defective or require lubrication. The contacts could be dirty or worn. There may be bad connections or loose lugs.The primary relay may have dirty or burnt contacts resulting in erratic operation. If the oven uses a HV relay for power control, this may be defective.

If the times and power levels appear on the display reliably but then become scrambled when entering the cook cycle or the oven behaves strangely in some other way when entering the cook cycle, there are several possibilies:

- The power surge caused by the cook cycle starting is resulting in changes to the settings or else the microcontroller is not interpreting them properly. This may be due to a faulty part or bad connections in the controller or elsewhere. As with intermittent problems, a thorough search for loose ground and other connections and bad solder joints may locate the source of the difficulty.
- Microwave (RF) leakage into the electronics bay due to a faulty joint between the magnetron and the waveguide or structure failure of the magnetron may be interfering with the operation of the microcontroller. Unless the oven was dropped or 'repaired' by an butcher, this sort of failure is unlikely. If you suspect either of these, inspect the integrety of the magnetron-waveguide joint and make sure the RF gasket is in place. Unfortunately, this is sometimes difficult to pinpoint because unless there is obvious mechanical damage, the 'problem' may disappear once the cover is removed for testing.
- On rare occasions, the main fuse may become intermittent rather than failing completely. The surge or vibration of starting can jiggle the element open or closed. It is easy to try replacing it.

Some of the Keys on the Touchpad Do Not Function, or Perform the Wrong Action

Touchpads are normally quite reliable in the grand scheme of things but can fail as a result of physical damage, liquid contamination (from overzealous cleaning, for example), or for no reason at all.

Look carefully for any visible signs of damage or spills. The touchpads often use pressure sensitive resistive elements which are supposed to be sealed. However, any damage or just old age may permit spilled liquid to enter and short the sensors. A week or so of drying may cure these problems. If there is actual visible damage, it may be necessary to replace the touchpad unit, usually only available from the original manufacturer. Also, check the snap type connector where the touchpad flex-cable plugs into the controller board. Reseating this cable may cure a some keys dead problem.

Some people have reported at least temporary improvement by simple peeling the touch pad off of the front panel and flexing it back and forth a few times. Presumably, this dislodges some bit of contamination. I am skeptical as this could just be a side effect of a bad connection elsewhere.

With a little bit of effort (or perhaps a lot of effort), the internal circuitry of the touchpad can be determined. This may require peeling it off of the front panel). Then, use resistors to jumper the proper contacts on the flex cable connector to simulate key presses. This should permit the functions to be verified before a new touchpad is ordered.

Caution: unplug the microwave generator from the controller when doing this sort of experiment.

If the problem was the result of a spill into the touchpad, replacement will probably be needed.

However, if you have nothing to lose, and would dump it otherwise, remove the touchpad entirely and wash it in clean water in an effort to clear out any contamination, then do the same using high pure alcohol to drive out the water, and then dry it out thoroughly. This is a long shot but might work.

Microwave Oven Does Not Respond to START Button

While all other functions operate normally including clock, cook time, and power setting, pressing START does nothing, including no relay action and the timer digits do not count down. It is as though the START button is being totally ignored.

If there is an alternate way of activating the cook cycle, try it. For example, Sharp Carousel IIs have a "Minute Plus" button which will cook for one minute on HIGH. Use this to confirm the basic controller logic and interlock circuitry. If it works, then the problem may indeed be a faulty START button. If it is also ignored, then there may be a bad interlock or some other problem with the controller.

Check for bad interlocks or interlocks that are not being properly activated.

Next confirm if possible that the START touch pad button is not itself faulty.

If you can locate the matrix connections for this button, the resistance should go down dramatically (similar to the other buttons). Assuming it is not the touch pad,

it sounds like the controller is either not sensing the start command or refusing to cooperate for some reason; perhaps it thinks an interlock is open. Otherwise, the timer would start counting. Testing the relay or triac control signal will likely show that it is not there. Check that there are no missing power supply voltages for the controller and bad connection.

Microwave Generator Problems

Failures in the microwave generator can cause various symptoms including:

- No heat but otherwise normal operations.
- Fuse blows when closing or opening door.
- Loud hum and/or burning smell when attempting to cook.
- Arcing in or above oven chamber.
- Fuse blows when initiating cook cycle.
- Fuse blows when microwave shuts off (during or at end of cook cycle).
- Oven heats on high setting regardless of power setting.
- Oven immediately starts to cook when door is closed.
- Oven heats but power seems low or erratic.
- Oven heats but shuts off randomly.

Most of these are easy to diagnose and the required parts are readily available at reasonable prices.

No Heat But Otherwise Normal Operation

If the main power fuse is located in the primary of the high voltage transformer rather then at the line input, the clock and touchpad will work but the fuse will blow upon initiating a cook cycle. Or, if the fuse has already blown there will simply be no heating action once the cook cycle is started. There are other variations depending on whether the cooling fan, oven light, and so forth are located down stream of the fuse.

Some models may have a separate high voltage fuse. If this is blown, there will be no heating but no other symptoms. However, high voltage fuses are somewhat rare on domestic ovens.

A number of failures can result in the fuse not blowing but still no heat:

- Bad connections: these may be almost anywhere in the microwave generator or the primary circuit of the HV transformer. A common location is at the crimp connections to the magnetron filament as they are high current and can overheat and result in no or intermittent contact.
- Open thermal protector - usually located on magnetron case. Test for continuity. It should read as a dead short - near zero ohms.
- Open thermal fuse - some ovens have one of these in the primary circuit. It may be in either connection to the HV transformer or elsewhere. Test for continuity. It should read as a dead short - near zero ohms.
- Open HV capacitor: test the high voltage capacitor.
- A shorted HV capacitor would likely immediately blow the fuse.
- Open HV diode: test the high voltage diode.
- Open magnetron filament - This failure may also be due to loose, burnt, or deteriorated press (Fast-on) lugs for the filament connections and not an actual magnetron problem.
- Open winding in HV transformer. Testing the high voltage transformer.
- Defective HV relay. A few models use a relay in the actual high voltage circuitry (rather than the primary) to regulate cooking power. This may have dirty or burnt contacts, a defective coil, or bad connections
- Shorted HV diode: test the high voltage diode.
- Short or other fault in the magnetron.
- Short in certain portions of the HV wiring.

A shorted HV diode, magnetron, or certain parts of the HV wiring would probably result in a loud hum from the HV transformer but will likely not blow the main fuse. (However, the HV fuse - not present on most domestic ovens - might blow.)

Depending on design, a number of other component failures could result in no heat as well including a defective relay or triac, interlock switch(s), and controller.

Fuse Blows When Closing or Opening Door

This means that the main fuse in the microwave (or less commonly, the fuse or circuit breaker for the power outlet) pops when the microwave oven door is closed or opened. This may be erratic, occurring only 1 out of 10 times, for example.

The cause is almost certainly related to either the door interlock switches or the door itself. Marginal door alignment, broken 'fingers' which operate the switches, dislocated parts in the interlock mechanism, or a defective interlock switch may result in either consistent or erratic behavior of this type.

On some ovens, this can happen at any time regardless of the control panel settings or whether the oven is in the cook cycle or not. On others, it can only happen when interrupting the cook cycle by opening the door or when initiating the cook cycle from the front panel (if the switches are in the wrong state).

The rationale for this basic design, some form of which is used in virtually all microwave ovens, is that a defect in the interlock switches or door alignment, which might result in dangerous microwave radiation leakage, will produce a hard permanent failure. This will prevent the oven from being used until it is inspected and repaired. As noted, one of the interlock switches is actually across the power line.

- If the switches are activated in the wrong sequence due to a misaligned door, that switch will not turn off before the other switches turn on shorting the power line. Similarly, if its contacts are welded closed, the power line will be shorted when the other switches close.
- Inspect the door, its mounting, and the plastic 'fingers' which operate the interlock switches as well. Again, if the sequence is not correct, the power line will be shorted blowing the fuse. If the oven was dropped, then such damage is quite likely. Look for broken or dislocated parts, warpage, and other indications of problems with the door and interlock mechanism Of course, if the oven was dropped, there could be much more extensive internal damage as well.

Loud Hum and/or Burning Smell When Attempting to Cook

A loud abnormal hum is an indication of a short somewhere. The sound may originate from the HV transformer vibrating and/or from within the magnetron depending on cause. There may be a burnt odor associated with this behavior:

- Shorted HV diode.
- Shorted magnetron (filament to anode) or other internal fault in the magnetron. Arcing within the Magnetron case (visible through ventilation holes in the bottom section) is usually an indication of a bad magnetron.
- Other short resulting from frayed insulation or wires touching in the microwave generator.
- Shorted HV transformer.
- Short resulting from burnt on food (usually) in or around the waveguide.

On-Line Microwave Oven Repair Database

There seems to be information about almost every subject you can think of on line these days. Microwave oven servicing is no exception. A company called Microtech maintains a web site with a large amount of information on microwave oven repair including an on-line Tech Tips Database with hundreds of solutions to common problem for many models of microwave ovens. There are also an extensive list of microwave oven related links to other interesting sites. The comprehensive Safety Info is a must read as well. Microtech also offers instructional videos and books on microwave oven and VCR repair.

It is quite possible your problem is already covered at the Microtech site. In that case, you can greatly simplify your troubleshooting or at least confirm a diagnosis before ordering parts. My only reservation with respect to tech tips databases in general - this has nothing to do with Microtech in particular - is that symptoms can sometimes be deceiving and a solution that works in one instance may not apply to your specific problem. Therefore, an understanding of the hows and whys of the equipment along with some good old fashioned testing is highly desirable to minimize the risk of replacing parts that turn out not to be bad.

Expert System for Microwave Oven Fault Diagnosis

The MIDES (Microwave Oven Diagnosis Expert System) site represents an interesting and possibly useful approach for isolating the cause of many common failures. It will take you through a customized step-by-step procedure based on your symptoms (and specific microwave oven model in some cases) and the results of its suggested tests. For the novice, this may be an effective way of obtaining a solution quickly as long as you follow the extremely important safety information provided by MIDES (or this article). You will not be forced to acknowledge that you have read, understood, and followed their safety precautions and warnings before performing each test. ■

Photofact Index

New Products

Datacom Tools and Testers

Xcelite, a Cooper Tools brand, has introduced a DataCom line of tools and testers. The line includes individual cut-

ters, strippers, and crimp tools, and a newly designed and proprietary line of testers for telecom/cable installers and service personnel, and for data network technicians. The line also includes 13 kits, each tailored for specific use.

CooperTools
Circle (16) on Reply Card

Bench Top Triple Output Digital Power Supply

BK Precision Corporation, announces the addition of The Model 1652 Digital Triple Output Power Supply to its expanding product line. Utilizing a standard 115Vac outlet as the power source, the new bench top units provide variable voltage outputs of 0Vac to 24Vdc, and up to 0.5A at continuous operation. The new dc power supply is suitable for a variety of benchtop applications.

The supply provides 0.5A of output continuously without thermal drifting, says the company.

The unit features a large, easy-to-read front-panel-mounted precision Digital meter that displays voltage or current readings. Other front panel indicators and controls include an OFF/ON power switch, a Power LED, Overload Indicator light, Voltage Adjustment Knob, and built-in soldering iron temperature control.

The Model 1652 provides variable output voltage of 0VDC to 24VDC, 0A to 0.5A output current, +/-5% of full scale meter accuracy and utilizes a standard 115V/60Hz power source.

The compact bench top unit (5.5" H x 6.5" W x 10.5" D) (140mm x 165mm x 267mm) only weighs 12 lb. (5.5Kg) and features output isolation leakage less than 0.1mA (25°C, 50%RH).

Available for immediate delivery, the Model 1652 is priced at $450.00, and comes with a user manual and BK's one-year warranty.

B&K Precision Corporation
Circle (17) on Reply Card

Solder Extractor Hand-Piece

The SX-80 Sodr-X-Tractor hand-piece from PACE features a patented disposable solder collection chamber that reduces hand-piece cleaning to a 10 second operation. The disposable Flux/Soldr Trap provides an environmentally friendly means of capturing removed solder for easy reclamation and also protects operators from contacting solder.

Additionally, the unit utilizes a modular plug-in heater that almost eliminates downtime and is compatible with all "Sensa Temp" power supplies.

Pace
Circle (18) on Reply Card

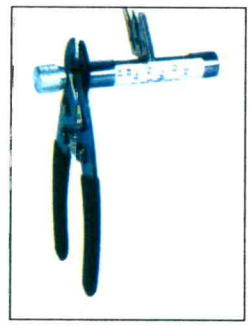
SMA Connectors

RF Connectors has released new additions to its SMA connector and adapter line designed for use with 0.085 and 0.141 semi-rigid coaxial cables. These 50Ω connectors are useful for applications with frequencies up to 18GHz. The RSA-3510-1-085 is a right-angle SMA male and the RSA-3560-141 is a SMA female bulkhead connector. Both styles are available in nickel or gold plated finishes. All of the company's SMA connectors and adapters feature Teflon insulation with gold plated contacts and all bodies are of machined brass or stainless steel construction. Most styles are offered in gold and nickel plated versions. All semi-rigid connectors are designed for use with standard semi-rigid cable and formable, or semi-flex, semi-rigid cables.

RF Connectors
Circle (19) on Reply Card

Wire Cut and Strip Tool

JDV Products has introduced two models, each with a triple stripper (three wire gaps) in one tool. Each tool is equipped with an easy to use dial mechanism, which will move the blade along post to vary shiner (strip-off) length.



The WS201 will cut and strip 22, 24 and 26 AWG wire with no blade change required.

The WS202 will cut and strip 26, 28 and 30 AWG wire with no blade change required.

JDV Products Inc.
Circle (20) on Reply Card

Multi-Function Rework Station

PACE introduces the MBT 250 SDTP multi-function rework station. The MBT 250, features Sensa Temp heat delivery technology which assures accurate temperatures and eliminates the need for calibration when hand pieces or heaters are changed-out. This system is useful for rework and repair applications as it provides

New Products

a platform for Soldering, Desoldering, and SMD Removals. The unit comes standard with the company's most advanced hand-pieces: The PS-80 Soldering Iron, the SX-80 Desoldering Hand-piece featuring a patented disposable solder collection chamber, the TT-65 Thermo Tweez handpiece and the TP-65 ThermoPik. The TT-65 is for removing small, two or four sided SMD packages and for installing discrete components. The TP-65 is for large SMD removals and has an integrated vacuum cup for component lift-off.

Pace
Circle (21) on Reply Card

RF Connectors Introduces a New Sub-Miniature Adapter

RF Connectors announces the release of the RSA-3407-1 adapter as part of their Sub-Miniature line SMA, SMB, MB, MCX, 3.5mm, 1.0/2.3 and MMCX Plug and Receptacle connectors and adapters.

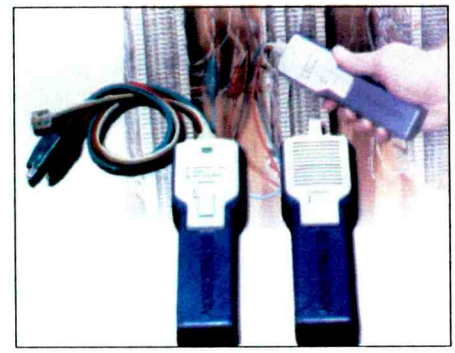
SMA connectors are used in high frequency and microwave applications where small size and performance are required of components. One end of the right-angled adapter is an SMA female and the other is a special male interface for testing and external antenna use on popular Nokia cellular phones. With a body made of machined brass, this adapter features Teflon insulation, gold-plated contacts, gold-plated body and a black Delrin housing on the Nokia plug.

RF Connectors
Circle (22) on Reply Card

Hand-Held Tone Generator/Cable Tracer Identifies Wires Without Piercing Insulation

B&K Precision Corporation announces the addition of a lightweight, hand-held, battery-powered Model 262 Tone Generator and Cable Tracer Kit. The Kit features include portability, flexibility, and low cost.

The Model 262 Kit consists of two components: the Model 260 Tone Generator, and the Model 261 Cable Tracer. The Model 260 Tone generator is a hand-held, battery-powered instrument designed to quickly perform a variety of test on un-energized telephone lines or LAN cables. Alligator clips and a standard RJ11 plug (supplied with the kit) allow the tone generator to be connected to stripped wires, terminal panels, wall plates or modular single line jacks. Features include the ability to check line polarity and provide talk current on dead line. The unit generates Warbled Tones with selectable test frequencies, and front panel LEDs indicate polarity when in the POLARITY mode and continuity when in the CONTINUITY mode. The Model 260 Tone generator can be adjusted to generate up to four distinctive tones.



The Model 261 Cable Tracer is hand-held inductive tracer that will help to identify wires without piercing the insulation. It features a Hi-gain, Hi-impedance amplifier and is capable of identifying tones from a distance of up to 12 inches. It can trace Tone Generator signals through dry wall, wood and many other non-metal surfaces (under ideal conditions) and features a rugged, moisture resistant Mylar cone speaker.

The small size and light weight of the Kit's two components, (7"H x 1.87"W x 1.12"D 5.8 oz, for the Tone generator, and 7.37"H x 1.87"W x 1.12"D, 4.9 oz for the cable Tracer) and the Kit's low price of $59 makes it an ideal addition to any tool box. The Kit is available for immediate delivery.

B&K Precision
Circle (23) on Reply Card

Books

Exploring Lans for the Small Business & Home Office

Author: Louis Columbus
ISBN: 0790612291 • SAMS#: 61229
Pages: 304 • Category: Computer Technology
Case qty: TBD • Binding: Paperback
Price: $39.95 US/$63.95CAN

About the book: Part of Sams Connectivity Series, Exploring LANs for the Small Business and Home Office covers everything from the fundamentals of small business and home-based LANs to choosing appropriate cabling systems. Columbus puts his knowledge of computer systems to work, helping entrepreneurs set up a system to fit their needs.

PROMPT Pointers: Includes small business and home-office Local Area Network examples. Covers cabling issues. Discusses options for specific situations. Includes TCP/IP (Transmission Control Protocol/Internet Protocol) coverage. Coverage of protocols and layering.

Author Information: Louis Columbus has over 15 years of experience working for computer-related companies. He has published 10 books related to computers and has published numerous articles in magazines such as Desktop Engineering, Selling NT Solutions, and Windows NT Solutions. Louis resides in Orange, CA.

Sams Technical Publishing
Circle (33) Reply Card

RCA/GE/Proscan TV Miscellaneous Service Adjustments

Author: Sams Technical Publishing
ISBN: 0790612429 • SAMS#: 61242
Pages: 336 • Category: Troubleshooting & Repair
Case qty: TBD • Binding: Paperback
Price: $34.95 US/$55.95CAN

About the book: Sams Technical Publishing's Engineering Staff has scoured their databases and come up with a good reference book for the shop and useful for traveling service technician! RCA/GE TV Miscellaneous Service Adjustments is a compilation of Miscellaneous Service Adjustments including Factory on Screen Menu settings on the newer sets found in PHOTOFACTS covering RCA/GE televisions from 1994 to 2001. Covering over 530 models, this gathering of facts, figures, adjustments and other information will be a tool that every service technician wants to have in his or her toolbox!

Prompt Pointers: Allows a service technician to carry important information grouped by manufacturer. An excellent tool for technicians of any level. An essential tool for in home repairs.

Sams Technical Publishing
Circle (34) Reply Card

Applied Security Devices & Circuits

Author: Paul Benton
ISBN: 079061247X • SAMS#: 61247
Pages: 280 • Category: Projects
Case qty: TBD • Binding: Paperback
Price: $34.95 US/$55.95CAN

About the book: The safety and security of ourselves, our loved-ones and our property are uppermost in our minds in today's changing society. As security components have become user friendly and affordable, more and more people are installing security systems. Paul Benton covers this topic in a "secure" way, applying proven electronics techniques to do-it-yourself security devices.

Prompt Pointers: Include automobile security systems, basic alarm principles, and high-voltage protection. Outlines over 100 applied security applications. Contains over 200 illustrations.

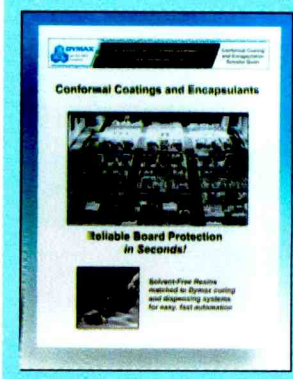
Author information: Paul Benton has been involved in electronics since leaving school originally as a TV and radio technician, before becoming involved in electronic security devices and techniques in the 1980s'. Under the name of Paul Brookes, his mothers' maiden name, Benton has written a number of electronics related books and articles. As a teacher and lecturer at the university level, Benton remains current with today's technologies and currently works for an international electronic company in England.

Sams Technical Publishing
Circle (35) Reply Card

Literature

Conformal Coatings and Encapsulants Brochure

A new selector guide describes a new line of solvent free, light curing conformal coatings and encapsulants. The



brochure features processing information as well as a selector guide listing five (5) conformal coatings and four (4) encapsulants. Also listed are a variety of features, benefits and agency approvals which differentiate the new line from traditional slower curing conformal coatings.

The coatings and encapsulants described cure faster than ever, and incorporate a number of features never before available in light curing coatings. Listed characteristics include viscosity, durometer, Elongation at break, Modulus of elasticity, dielectric strength, volume resistivity surface resistivity, and the unique features and benefits of each. The faster curing capability of these coatings and encapsulants translates to lower processing cost.

New Coatings and encapsulants listed in the brochure include:

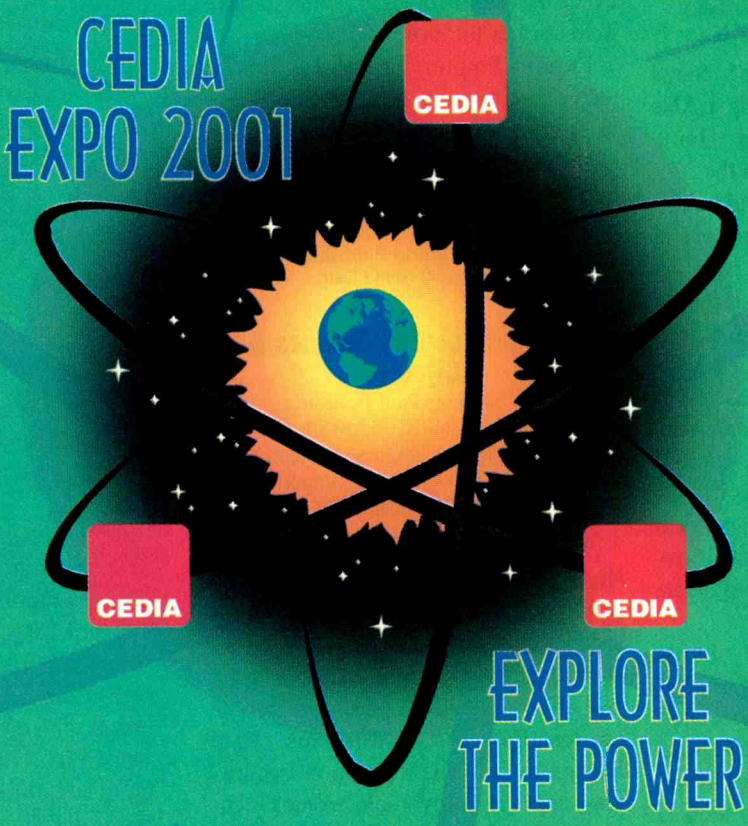
- 984-LVUF - a faster curing grade of UL and Mil Spec approved 984-LVF conformal coating
- 9-20557 - a tough and flexible coating with tenacious adhesion to difficult solder masks
- 9-20558 - a coating for flex circuits; encapsulant for sharp solder points
- 9-984B - a black, opaque coating for concealing sensitive components and circuitry.
- 9-20558 - a new encapsulant that adheres very well to Kapton Flex Circuits.

Systems for dispensing and curing the coatings and encapsulants are pictured and described along with the cure parameters.

DYMAX Corporation
Circle (25) Reply Card

EXPLORE THE POWER

THAT CEDIA EXPO BRINGS TO YOUR BUSINESS



What makes your business a powerful force in the custom electronic design and installation industry?

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Circle (31) on Reply Card

Association News: NPSC 2001 WRAP-UP

Diversification Committee Moves NPSC into Smart Home/Home Theater Arena

While large screen televisions, digital electronics, etc, have been included in past NPSC programs, the NESDA/NPSC Diversification Committee, headed by Fred Paradis, brought these new products and opportunities to the forefront at the Annual NESDA/ISCET sponsored National Professional Service Convention in Las Vegas.

New classes that were offered this year included RF Modulation, Home Theater, ISF training, Structured Wiring, Labor Savings Devices, Plasma Servicing, DLP servicing and a basic two hour Home Theater Boot Camp conducted by Fred Paradis and incoming NESDA VP, Brian Gibson.

Attendance was heavy at each and generated a great deal of conversation in the halls.

The 2002 NPSC Convention will be held in Orlando Florida, Rosen Centre, July 30 to August 3, 2002.

Herrin, Wood Receive Top Awards at NPSC-Las Vegas

M. L. Finneburgh Award of Excellence-Walt Herrin, Hitachi

This award is named after the late M. L. Finneburgh Sr. EHF, a former industrialist who, with his wife, "Babe," inspired association members with speeches of patriotism, good business sense, and the need to affiliate. The award is to honor a rare inspirational individual who performs outstanding and exceptional service to NESDA.

NESDA Person of the Year-Fay Wood, Satisfusion

This award is for an individual who has made significant contributions to advance the best interests of the product service industry and/or the goals of NESDA. It may also be for the accomplishment of a significant deed, or series of deeds, which have or can be expected to improve the service industry and/or NESDA. The recipient does not have to be a NESDA member.

Additional Awards During NPSC

Outstanding NESDA Officer
John Eubanks CET

Outstanding Committee Chairperson
Wayne Markman

Leo Shumavon Award
Dave Wreski

Outstanding Associate President
Marge Bluze

National Friend of Service
PTS Corporation

Regional Friend of Service
Clarence Bell

PARTners in Excellence Award
Tritronics

NESDA President's Awards
Charlie Jost, Thomson
Brian Hanson-Panasonic
George Weiss CSM

Certificates of Appreciation for NESDAnet Activities
Dan Mundy CET/CSM
Chuck Biddinger
Bill Warren CET/CSM
Tech-Line (Indy) (Thomson)
Alvie Rodgers CET (Hitachi)

ISCET Awards at NPSC — 2001

These awards are based on nominations that provide specifics on the individual's technical ability, productivity, efficiency, association work, public image, and community involvement. The selection committee considers these criteria and rates nominees on a point-based system.

ISCET Chairman's Award
The San Diego Community College District

ISCET Governor's Award
Ing. Estelio R. Baltazar Cadena, Dir. General de Centros de Capacitacion Para el Trabajo

Industrial ISCET Technician of the Year
Oscar Romero CET, Hitachi

Preliminary Results to CEA Survey

Karen Krzmarzick, Manager, Technical Education and Services, Consumer Electronics Association, has initiated a survey on the status of today's Professional Electronics Servicer. Here are the first preliminary results derived from NPSC.

Question

The service and support function for consumer electronics products is going through a period of severe transition. Please rank the impact each of these industry challenges has had on your business: (1-greatest impact, 6-least impact)

- lack of qualified technicians
- disappearing authorized service centers
- products that must be repaired in the home
- disposable products
- changing consumer expectations (repair time, repair cost)
- nonserviceable products

Answer - To Date

#1 - Lack of Qualified Technicians
#2 - Disposable Products
#3 - Nonserviceable Products
#4 - Products Repaired in the Home
#5 - Changing Consumer Expectations
#6 - Disappearing ASCs

You can add your input by contacting Daren at 703-907-7045 voice, 703-907-7950 fax, or E-mail: kkrzmarzick@ce.org, CEA Website: www.ce.org.

Mike Webber Reviews History in Outgoing Remarks

Some of the things I am going to say tonight may not sit well with some of you. I did not take the job of President because I wanted to be liked; I took the job because I wanted to make a difference.

The cost of everything we use in our business has increased many times. Salaries are up. Truck expense is up to an all time high. Supplies, advertising, and rent are more costly than ever before. Efficiency is at an all time low. A great many shop owners have spent so much time acquiring the knowledge of how to service a piece of today's complicated electronic equipment, they have had to neglect their responsibility of management knowledge. Where have all of our good, well-trained technicians gone? That is simple. They have gone to firms who can pay what is necessary. Where they can make more money than we have been paying, with overtime beginning after 40 hours per week, pensions, insurance, and other fringe benefits not available from us. They are lost to our field. Even the shop owner does not receive proper remuneration for his skills, to say nothing of his Capital Investment. How then can he pay an employee enough to hold him? If ever there was a time for pooling our resources of knowledge and wisdom, it is now. The problems that face us are far larger than any one man can hope to cope with by himself. There is a crying need for unified action to stem the tide that will eventually engulf Independent Service.

These words are not mine. Mr. W. J. Inman, President of the Texas Electronics Association, wrote them in November 1957. I was nine years old. My first reaction was I couldn't believe that we have been complaining about the same things for 44 years. But then I realized that I have been coming to NESDA conventions for 30 years, and we are still complaining about the same things today as we were at my first convention. If we don't change, my grandson will be hearing the same thing at his first NESDA convention in 18 more years if NESDA is still alive. I say it's time to stop complaining. I say if this industry is ever going to change, it's up to us!

In 1971, I was an automobile mechanic while going to college. C. J. Rucker, who was my father in-law, asked me if I would like to get in the electronics business. I was tired of the heat, cold and dirty hands. Electronic technicians made more than automobile mechanics. At that time, a 25" color TV was about the price of a good used car. In 2001 a 25" color TV won't make a down payment on a used car and the average automobile mechanic makes more than I do today. If you think about it, it seems to me that our industry has gone backwards for us. We have allowed this to happen.

"Our work is not done. The power of "we" is up to you and I. There is no one else out there."

Our good friend Walt Herrin said "you can't join hands if you're pointing fingers". We need to stop pointing fingers ladies and gentlemen. We have to start asking what we can do, rather than saying it can't be done. We have to stop saying it won't work because we have tried that before. If we've tried it before, it doesn't mean it won't work now. Things are different today than they were five years ago. Things are different than they were last year. We have to be open to all ideas, because if we don't, when some new person comes along, we will suck the life right out of them when we chant, it won't work because we've done that before. Some animal species eat their young. NESDA has been one of these species for far too long.

Last year, I passed out buttons that said "who you gonna call". There are a few less people to call this year than last, and we need to ask ourselves why. Are we going to be one of them next year? Are we going to keep pointing fingers, or are we going to join hands? Are we going to tell everyone that we can't do something, or are we going to join together to get things done? I feel it is better to join together than to say it can't be done. We need the new blood in this industry before the prevalent cancer has destroyed them. Let's not tell them it can't be done! They don't know that, and we might just be surprised by their results.

This year the button reads "first class, coach, or standby". This is a dangerous statement, because you better be ready to deliver what you promise. If there is a manufacturer that is willing to pay a first class price, you need to deliver first class service. Two weeks ago Donna and I spent nine hours getting from Chicago to Dallas flying standby. Did we have the right to complain we, were flying standby? Where would we have gotten if we had complained? If we had paid coach fare, we would have gotten somewhere had we complained. Just think what would have happened if we had paid first class fare! If you keep giving first class service at standby fare, you will be one of the ones that we won't be able to call. If you deliver your service at the proper price, no one has the right to complain whether it is first class, coach or standby. Ladies and gentlemen, this is business. Make your decisions in a business like manner. Gone are the days when a manufacturer can set up your competitor down the street to be an authorized service center. Chances are he is no longer there. Who are they going to call? For us survivors, the opportunities haven't been this good in a very long time. I believe that there are some manufacturers that are starting to listen to what we have been saying these last two Conventions. There are still some that are not hearing us. Our work is not done. The power of "we" is up to you and I. There is no one else out there.

NESDA has a new leadership team this year in President John Eubanks and Vice President Brian Gibson. John is the most dedicated and hardest working person in this association. Brian is the new kid on

(Continued on page 52)

President Eubanks' Awards Banquet Remarks

How many of you noticed that a couple of dedicated individuals aren't with us this year? Last December 1st we suffered the loss Robert Harrell from Tennessee and on January 8th we lost William Murphy from Ohio. Bob Harrell was NESDA President from 1986-87 and Bill Murphy was Region 5 Director from August 1997 until January of 2001. We cherish all their service to our association with the recollection of the warm friendship they offered for so long. Lets dedicate a moment of silence to these beloved members and all our other members and friends who have passed away since NPSC 2000.

Many of you know that I am one of strong faith and although humanly incapable of escaping my many faults sincerely want to do the right thing. Often I turn to scripture to seek answers for tasks I am given with encouraging results. I want to thank Gerry McCann for giving me the pleasure and opportunity to make my first official assignment after being elected to ask a blessing on Wednesday evening at the Sony sponsored dinner. Of all assignments, public speaking is most likely my weakest asset as unfortunately you are about to discover. My wife tells me to lighten up and not be so stiff, easy for her to say she is sitting out there with you and I'm up here stumbling along. I am a student of the Bible and although my intent isn't to preach to anyone, I thought I might share a few observations from my studies with you. Some of you know that numbers have specific meanings in scripture other than their numerical quantity. We use these interpretations daily in many subtle ways that you may or may not notice. In scripture the number 5 represents "Grace" and of course the definition of Grace is unmerited favor. Ever hear the term "Grace Period"? Now where would you think that term could have originated? Ever notice on a billing you receive by snail mail, the number of days granted after the due date that is considered reasonable or the non-penalty grace period? Many times that number is 5.

Another small observation is the way we document time. First by the day, just as it was in scripture, only today most observe the change of the day to occur at midnight rather than six hours earlier. We assign a suffix in a twelve-hour system so that we know the specific hour intended whereas the military and others use a 24- hour clock to avoid confusing the hours of a clock within the12 hours. The time between midnight and noon is AM, afore-meridian and from noon to midnight is PM, post-meridian. There are still only seven days in our week just as there were seven days of creation in scripture. Months are calculated from the cycle of the moon and represent an actual period of 28 days, however this is not a correct number when multiplied by 12 to fill the entire year so we have applied days from month to month to compensate because the year is determined by the sun. To further identify a specific year, initially it was done in scripture by tying the number of years to a specific king's reign, which produced more confusion than it resolved. Then an individual was born who commanded such significance that all the time prior to his birth was referred to as BC and the time since is referred to as AD. In our association another man from Florida, George Bluze CET/CSM/EHF was at our NESDA helm when our association was in our "BC time period" if you consider that to mean "Before Clyde". I have said all that to say this. It is certainly morning in NESDA because it is now Afore Mack and another President from Florida is in office. Rest your concerns I do not anticipate counting any ballots.

The task at hand for our association can be compared to commencing a voyage by sea, sailing into uncertain conditions. The first step is to prepare for the voyage and then to cast off or weigh anchor. Our association is faced with a similar situation with the winds of change causing us to depart from the safety of old harbors sailing into the future upon a sea of constant change. A future that will be difficult at best due to approaching industry storms created by so many changing technologies continually requiring course corrections to reach every new harbor of opportunity. Sailing away from the safety of no wake zones and on to the sea of unpredictability caused by our partners introducing new products at an unprecedented rate disturbing an otherwise calm industry. Changing pilots or captains after embarking upon this voyage is certain to demand even more attention throughout our passage. Our association must become the life preserver for every member embarked with us on this voyage, ready and prepared to throw a lifeline to any adrift along the way. We don't have time to discuss who is responsible for the leak in the bottom of our boat, we must understand that pointing fingers and fixing blame will not replace the need to bale water or provide time to repair our leak. It doesn't matter who is at fault when you are all in the water eight miles from the closest land and that is straight down, better known as "bottom".

So let me thank Clyde for his all his past service and all that he will be called upon to provide as we prepare to cast off and sail into uncharted waters. I look forward to working with Mack Blakely and serving our association as helmsman. I wish to close by pledging to always do the right thing. God speed Clyde Nabors!

John Eubanks CET

CET Test Results at NPSC

Congratulations to:
Daniel Champion
passed Associate
Don Cressin, CET
passed Journeyman

Newly Accredited CSMs:
Walter Seymour
Raymond Smith
Andrew Doyle
John Wilkins
Kent Newsom

Incoming President John Eubanks NPSC Issues Report and Committee Assignments

It is my pleasure to inform you that the NESDA membership and Board elected myself, John N. Eubanks CET President and Brian Gibson CET Vice President, then selected Mack Blakely to become our next Executive Director. Region one elected Fredrick Paradis CSM Region1 Director and Don Cressin was elected to be the Region 3 Director in addition I nominated him and the Board approved him to become our next NESDA Treasurer. Clancy Harms was elected to be the Region 7 Director.

The membership approved all our recommended Bylaws changes submitted by the Bylaws Committee, providing many new areas of membership categories allowing some at reduced rates. The Bylaws were temporarily suspended by a 75% vote from those in attendance to allow a vote on the recommended new Advisory Board Member positions, which passed unanimously, installing Walt Herrin, Kim Wagener, and Fay Wood as Exofficio Board Members.

A great deal of work was accomplished and many things are shaping up to make this coming year a very dynamic year to be a NESDA/ISCET member. Many issues that previously delayed the Certified Service Center Certification program endorsed by CEA have been resolved and the NESDA Board approved continuing to go forward in this area. I can tell you, we are much closer to this becoming reality.

The Committee Chairs have been selected but there are still many opportunities to serve in all areas. Contact the Chairman of the committee that you would like to serve upon and offer your assistance. I feel sure it will be welcomed and appreciated.

I want to ad a special thanks to Kim Wagner because her expertise in legal matters made it possible for our Board to achieve far more than would have normally been expected. We signed the new ED's contract with unanimous Board approval and resolved the CSC bylaws issues because of her willingness to help.

Listed below are the new NESDA Officers, Board members and Committee Assignments.

I. ***New Board Advisory Members:*** Walt Herrin, Kim Wagner, Fay Wood

II. ***Treasurer: Don Cressin CET/Assisting*** Kim Wagner

III. ***Secretary:*** Mike McCray CSM

IV. ***NESDA Representative to the ISCET Board:*** John Eubanks CET

V. ***NESDA Standing Committee Assignments:***
   a. **By-laws:** Billy F. Williams EHF
   b. **Membership Development:** Brian Gibson CET, Co-Chair Fay Wood/All Board Members
   c. **Industry Relations:** Wayne Markman
   d. ***State/Local Representatives:*** Pat Viscardi
   e. ***Past Presidents:*** Mike Webber CSM
      1. Nominating
      2. Ways & Means
      3. Awards
   f. ***Information & Technology (Computer):*** Jim Panopoulos
   g. ***Legislative:*** Don Cressin CET/George Brownyard CET
   h. ***Endorsements:*** Richard Mildenberger CET
   i. ***Professional Service Management:*** Randy Whitehead CSM
   j. ***Convention Committee Executive Director +Co-Chairs:*** George Weiss CSM & Billy F. Williams EHF

VI. ***Special Committee Assignments:***
   a. ***Diversification:*** Fred Paradis
   b. ***Certified Service Center:*** John Eubanks CET/George Brownyard CET/ Kim Wagner
   c. ***First Time Attendee:*** Pat Viscardi
   d. ***Marketing:*** Fay Wood
   e. ***NWSN:*** Gerry McCann CET/CSM
   f. ***Special Projects:*** Dave Melwid
   g. ***Electronics Hall of Fame:*** Larry Steckler EHF/Billy Williams EHF/George Bluze EHF
   h. ***Electronic Hazardous Waste Disposal Committee:*** Marge Bluze

Mike Webber Reviews History in Outgoing Remarks *(Continued from page 5)*

the block full of fresh ideas. When they have an idea, let's not tell them it can't be done. Let's ask them what we can do to help. Let's join them in this new beginning, along with Frederick Paradis, Don Cressin and Clancy Harms our new region directors. Let's not stand in their way. For us old timers, let's let them have their new beginning without our past. Their new ideas just might prevent NESDA from becoming a geriatric social club. My sincere hope is that NESDA won't once again become that species that eats it's young.

We also have a new beginning with our new Executive Director Mack Blakely. Mack does an incredible job with the Texas Electronics Association. I have all the confidence in him to effectively get the job done. TEA was dying on the vine when Mack took the job as Executive Director. Through his guidance the membership has not declined like our industry. The finances of TEA are in good order, and the overall attitude of this organization is a positive one, thanks to Mack.

I want everyone to give Clyde and Opal Nabors a round of applause. Without them, NESDA would not be here today. Back in the darkest hour of our history, I can remember when they worked on settling our insurance problems at home on their own time. This dedication to NESDA will never be matched again. Your NESDA family would never feel right without saying good bye, and giving you something in appreciation for the years that you have given to us. We have a small token of our gratitude for the many years we have shared together. Clyde and Opal, you are a class act.

In closing, I would like to thank all of you for allowing me to serve as your President this past year. I have never had a greater honor in my life. I would like to thank my leadership team for all of NESDA's accomplishments this past year. My opening statement was that I took the job as President because I wanted to make a difference. The excitement and energy you can feel from this new leadership team is the continuation of that difference I wanted to make. My ultimate goal is to never let this excitement and energy fade. To me this is more valuable than any plaque I can hang on the wall or any kind words anyone can say. I will never go away, this is family, ladies and gentlemen.

Most of all, I would like to thank my best friend, my closest advisor, the smartest person I know, my wife Donna.

Thank you from the bottom of my heart.

Mike Webber, CSM

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Sencore VA62A Universal Video Analyzer, with all manuals & probes. Excellent working condition $800.000 plus shipping. Electronic Servicing & Technology magazines years 1976-2000, most sets are complete. Popular & Radio Electronic magazines 1989-2000. Most sets are complete. Call or write for lists & prices on above magazines. RCA field service manuals years 1971-1985. $10.00 each or all 7 for $50.00 plus shipping, Contact John Brouzakis, 247 Valley Circle, Charleroi, PA 15022, phone 724-483-3072.

2 tube caddies with over 1,000 tubes (most boxed) $400, Sencore CR-70 picture tube tester & rejuvenator $325, Sencore SC-61 Waveform analyzer $400, Sencore VA-48 Video Analyzer $100, Sencore LC-75 Z meter $150, Sencore PR-57 Isolator transformer $100, Static mat $15, Weller solder station $50, Microfiche reader $50, magnifying lamp $25, or all for $1500. (303) 733-1161 or (303) 691-9739.

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Simpson 467 Digital Meter with Accessories $50.00, Vell Man Hand Held-O-Scope $150.00, BK-O-Scope Dual Trace 2125 $250.00, Protect-O-Scope Dual Trace 3502C $200.00, Gold Star 4 Digital Bench Meter $150.00. Asa A Davis Jr, 210 West Fifth Street, Lexington, KY 40508 Tel: 859-253-9796.

Sencore VA62, NT64, VC63 with HV probes $500.00, HP 1740A Dual Trace 100mHz oscilloscope $450.00, B&K 467 picture tube restorer $150.00. ES magazines 1975 to present $150.00. Frank Wolff (207) 872-2504.

Must sell because of stroke and retirement. Electronic equipment: Sencore VA62 $495, VC63. $100, SC61 $495; TenTelometer model T2-H7-UM $225; Torque Gauge model TQ-600 $165; Microfiche reader with Dual Carriage screen size 13" x 20" $100; Bell & Howell Model ABR-1060. If you buy all I will include all my microfiche and other technical data mostly Panasonic. VCR & TV a large amount. Donald K. Schlueter 816-330-3341.

VA-62 TV/Video Analyzer with VC-63 VCR Test Accessory, SC-61 60MHz Oscilloscope, LC-76 "Porta-Z" LC Tester, CR-70 "Beam Builder" CRT Tester, "Handy 53" RC Subber, TF-26 "Cricket" Transistor/FET Tester, 40kilovolt HV Probe with meter, Variac, RCA Isolation Transformer, DC Power Supply. Will accept best offer(s) for all or part. Ask for Bruce at 1-208-983-1310 (Pacific time zone, daytime).

Atari 800, 1050 disc drive, Heath HVA 122A monitor, all for $75-pick up preferred with all manuals. Heath H8 computer with manuals $50, Stancor isolation xformer (500w) $40, Sola constant voltage xformer (250w) $30. Leonard Duschenchuk 1519A NW Amherst Drive, Pt. St. Lucie, Fl 34986-2445.

A Fluke model 77 multimeter, made in the USA, complete with holster, leads and owner's manual in like new condition, $100 plus freight. Has been used approx. 5 times. T. Walton, 4400 N. Holiday Hill Rd. #506, Midland, Texas 79707, phone (915) 520-6553.

WANTED

Service manual for Sansui model G-6000 AM-FM stereo amp. Corrado Electronic Repairs, 603-774-7864. Will pay fair price.

Want to buy original or copy of complete repair manual (paper), for Pioneer model CT-F9191 tape deck. Have microfiche, too hard to read, and no repair instructions. Send price to McCombs Electronics, 703 Old Cedar Rock Road, Easley, S.C., 29640.

Sylvania Polymeter model 221Z, output transformer for Crosley radio model 124, power Transformer for Atwater Kent radio model 40. Paul M. Williams 2364 Beaver Valley Pike, New Providence, PA 17560-9622, Tel: 717-786-3803.

Doing camera work - need technical training manuals Panansonic, Sony, JVC and Sharp. Contact ABC Electronics-1252 Crescent Drive, Glendale, CA 91205.

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Anything associated with the RCA Selectavision CED Videodisc Player. The Needle pickup Video System RCA developed and marketed in the Early 80's. PLAYERS, PARTS, REMOTES, SERVICE MANUALS, ADVERTISING MEMORABILIA, etc. Will pay TOP DOLLAR, email me at dj3928@aol.com, or write to: Darrell Johnson, 11247 Hardinsburg Road, Cecilia, KY 42724.

RCA 27" TV model F27171CP - need front mask P/N MK1011. Contact George, 570-467-0562

Schematic or operation manuel for Raycon Model 901LF, 900 MHZ, wireless, transmit and receive units, PN10105-100-01 and 10105-101-01. Schematic for Hitachi SR2004 stereo receiver, Contact C. Ellis, J&K Repair, 9419 Waller Rd.E., Tacoma, WA 98446; (253) 531-8142(H) (253) 475-7711(W) E-mail: cellis@robinson-noble.com

AKAI VCR Model VS-525U-needed bad or good, Head Motor PN 8BM-M3223A020B, Part # on part 357699B 7B M3223C5011 SM-230 service manual needed will copy & return, JVC model RX-517V & JVC model KD-A5J. GE camcorder model CG-9805 needed for parts, Harmon Kardon stereo cassette deck Model hk 300XM need a cassette deck ASSY for parts. Video & VCR Repairs, 21 Lombardy Drive, Baltimore, MD 21222.

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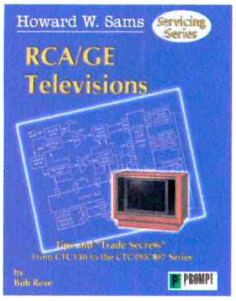

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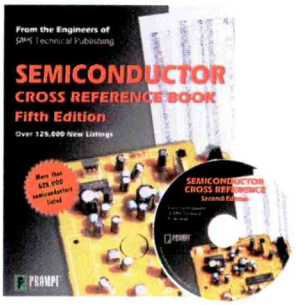

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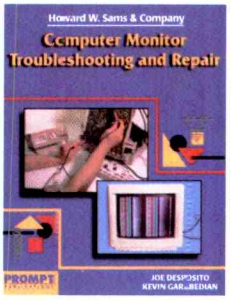

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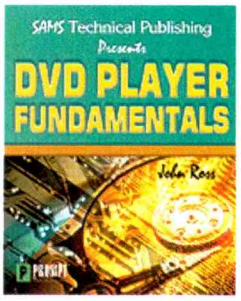

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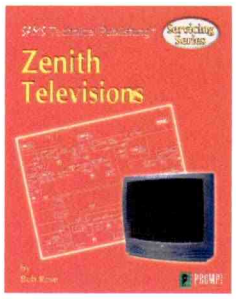

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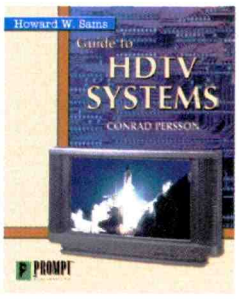

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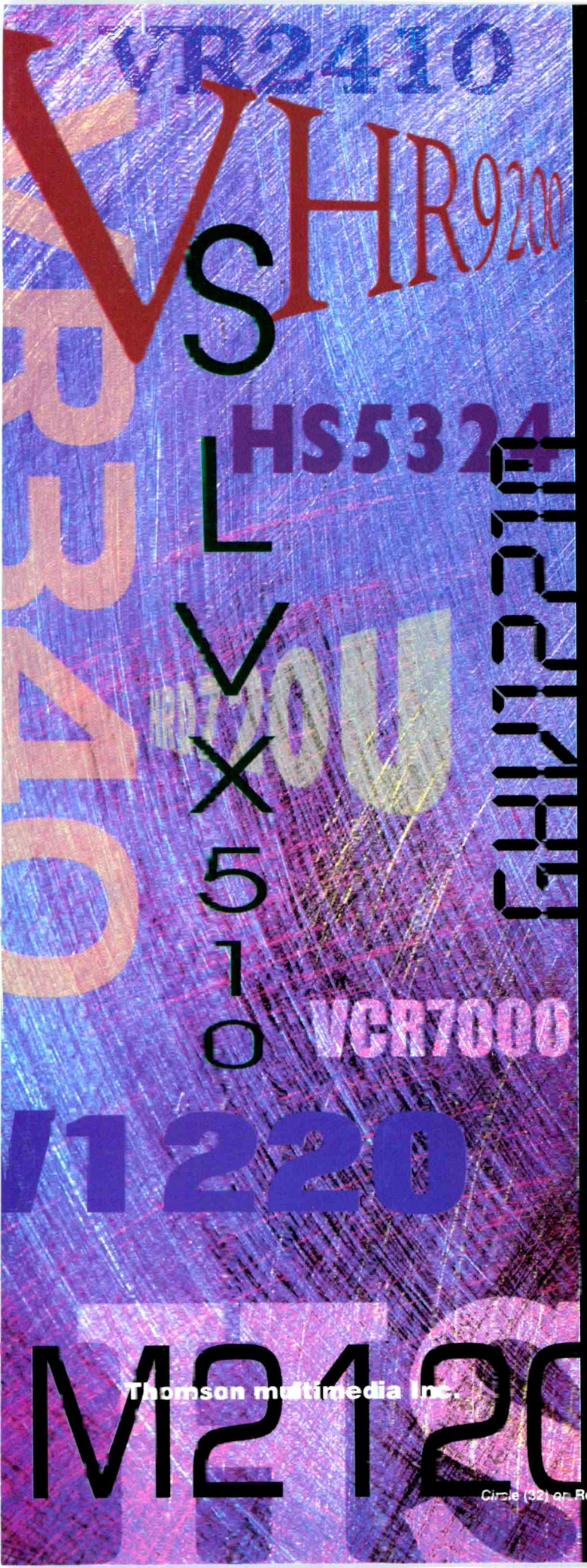

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