A key element of our ongoing initiative to deliver product solutions consistent with premier-level customer service is our new world-class product manufacturing operation. Located at our corporate headquarters in Anaheim, CA, this high capacity manufacturing facility features a combination of advanced technology machinery and instrumentation, a highly trained staff of engineers and technicians, and rigorous, comprehensive quality control protocols.

In March 2003, we significantly expanded our manufacturing capabilities with the addition of our printed circuit board assembly (PCBA) plant, joining our existing facilities for product assembly, testing, inspection, packaging, and order fulfillment. As a result, we are now able to completely control our manufacturing, from the raw circuit board materials to the final assembled products.

Despite the global trend of overseas manufacturing, the vast majority of Extron products are still manufactured in California. We believe that with a continuous, tightly regulated system of quality control and manufacturing protocols throughout the production life cycle, we can ensure that what you receive is of high quality and reliability, at competitive prices, and quickly delivered to you. Although some of our higher volume products may fit the model of volume production overseas, most Extron products require a manufacturing approach with special dedication, precision, and workmanship that we can closely monitor and easily refine whenever necessary.
In June 2004, Extron manufacturing operations received ISO 9001:2000 certification. The ISO certification indicates that Extron has met global quality process control standards devised by the International Organization for Standardization.

Extron world-class manufacturing is part of our Total Quality Management System of design, manufacturing, and testing — from research & development through production, and all the way to customer service. With the addition of our new PCBA facility, we’ve enhanced our capability to serve you by reinforcing stringent quality standards, improving cost efficiencies, and expediting the development of new, high performance, and effective product solutions for your evolving requirements.

Printed Circuit Board Assembly Facility

The PCBA plant is a state-of-the-art, high capacity manufacturing center, situated in the building that formerly housed Inline, Inc. This facility is dedicated to the assembly of circuit boards for Extron products. We no longer rely solely on outside vendors to assemble the printed circuit boards for our products.

Three identical circuit board production lines enable the product yields required to quickly turn around orders. At the same time, multiple circuit boards are simultaneously accommodated, minimizing production downtimes for equipment changeovers. Each production line has separate automated assembly and soldering equipment, inspection and testing operations, and technician workstations.

PCB Assembly

In the initial phase of printed circuit board assembly, the boards undergo high speed
automatic component insertion. Vision assisted surface mount machines populate the circuit boards with components at speeds of up to 11 components per second. These machines are fully automated and extremely precise, contributing greatly to the cost savings in the board assembly process.

IC chips, resistors, capacitors, and other components required for a particular circuit board are loaded onto the surface mount machines using shuttle carts. To minimize production downtime, shuttle carts can be preconfigured for different circuit boards, enabling quick exchange when a new batch of circuit boards is to be produced. Once the components have been placed (and adhered), the circuit boards undergo a high temperature heating process to solder the components to the boards.

Extron also employs real-time x-ray examination of the circuit boards. The x-rays provide detailed, three-dimensional views of solder joints that are otherwise concealed from view by the surface-mounted components. Software inspection algorithms are used to identify solder joints that are irregular and considered beyond acceptable tolerance conditions.

Next, a team of dedicated technicians manually insert through-hole components on the circuit boards. All electrical assembly technicians are trained in High Reliability Interconnection Technology, and are experienced in hand soldering, wire termination, mechanical assembly, and detail wire routing.

The boards are then loaded onto special fixtures and passed through the wave solder machine, which automatically sellsers only through-hole components. By passing over a pool of 500 degree molten solder, dozens of circuit board components can be soldered in a single pass. This cost-effective process takes only 3 to 4 minutes per board, compared to several hours it could take a technician to perform manually. By using fixtures of standardized sizes, the machine continuously accommodates multiple circuit boards while minimizing production downtimes for changeovers.

Following the wave soldering, final visual inspections and electronic tests are performed. As the final step of printed circuit board assembly, the stuffed circuit boards are comprehensively tested for electronic integrity. The Scorpion Flying Probe Testers test individual circuit on every board. Six independently moving probes systematically test hundreds of components in a matter of minutes. By testing static measurements and inducing voltages and currents, the Scorpion measures the actual electronic values of each installed component, quickly assuring that each board meets all engineering specifications. The circuit boards are then ready for final product assembly.

Upon completion of the Surface Mount Technology process, every circuit board is subjected to Automated Optical Inspection (AOI), where the components are quickly inspected using 13 cameras and various modes of illumination for close-up views of the circuit board from multiple perspectives. The surface of the circuit board is automatically scrutinized for solder defects and components that may be missing, extraneously present, damaged, or improperly mounted.
The technicians perform their tasks at work stations with the aid of a paperless, online work instruction system through computers networked throughout the production floor. Each technician views detailed diagrams and information on an LCD monitor, such as the mapping of components onto a circuit board. The electronic documents also facilitate verification of hand work performed by a previous technician. Further, key benefits of the paperless work instruction system include the ability to quickly implement running changes in production, and controlled costs through minimized distribution of paper documents.

Benefiting Our Customers
The modern and highly efficient production methods throughout our world-class manufacturing help keep volume high, while ensuring the maximum level of quality. Extron can therefore produce truly superior products for the world market — products that are competitively priced, reliable, and in stock when you need them.

The addition of the PCBA plant was a substantial yet worthy investment for Extron, a manifestation of our refusal to accept any compromises. Extron’s capability to maintain complete control of our product manufacturing is an integral aspect of our ongoing dedication to exceed your expectations. Delivering products of superior performance, dependability, and value is part of our longstanding commitment to provide premium service, support, and solutions, collectively known as Extron’s S3 philosophy.
World Trade Institute Rebuilds Using Extron Products

Until September 11, 2001, the World Trade Institute of Pace University (WTI/Pace) operated out of their headquarters on the 55th floor of the World Trade Center’s north tower. After the disaster, WTI/Pace’s executive team vowed to rebuild, and it wasn’t long before they were back in operation in make-shift facilities using borrowed equipment. Planning began immediately for a more long-term solution; one that would include classroom technology to meet the needs of students, teachers, and seminar attendees for years to come.

WTI/Pace’s New Home

Early last year, WTI/Pace moved into the new facility at 163 William Street, only a few blocks away from the World Trade Center site. The new facility includes 20 classrooms, break-out rooms, a multipurpose room and administrative offices on 10 floors. When planning the new facility, WTI/Pace retained the services of Lilker Associates Technology Solutions Group (TSG), a consulting engineering firm, to design the audio/video, network cabling, and security systems.

WTI/Pace had very specific requirements for their AV systems. Each room would feature a ceiling mounted LCD projector, motorized screen, VCR, DVD player, and multiple laptop interface points. WTI/Pace requested a centralized control panel in each room that would enable instructors to turn equipment on and off, select between sources, and control program audio. The final AV system design represents the new standard for Pace University and will eventually be deployed in over 100 classrooms campus-wide.

“At WTI/Pace, instructors are often asked to move from room to room, and many are non-tech-savvy outside contractors, so the controls had to be easy to learn and identical in every room,” explains Morais Miranda, Director of Lilker Associates TSG (www.lilker.com). “There are a lot of rooms, so we needed something cost effective, and something that could be installed and configured very quickly.”

Overcoming the Challenges

The building on William Street was built in 1931 and, therefore, presented several construction challenges including plaster walls, low ceilings, and few straight lines. Many of the rooms required creative plans for wall surface wiring and projector mounting. The project schedule would be challenging, all construction occurred in phases and much of the work had to be completed during semester breaks.

To meet WTI/Pace’s stated needs, Lilker Associates TSG developed a design for each classroom that includes an Extron computer-video interface along with a MediaLink™ switcher and controller. The choice to use Extron products for interfacing and controls was an easy one, according to Nick Asadourian, Lead AV Designer for Lilker Associates TSG. “I’ve been including Extron products in my designs for over 20 years,” explained Mr. Asadourian. When asked to explain why, he answered succinctly, “Quality, dependability, and delivery.”

Those same three words could also explain why Lilker Associates TSG brought in AV systems integrator, Verrex Corporation (www.verrex.com), to handle all of the project’s cabling and installation tasks. Verrex has been in business for 56 years and is still family owned and operated. With years of experience installing Extron products and a wide range of in-house system integration expertise, Verrex was Lilker Associates TSG’s first choice to handle the job. Their
previous experience working with Verrex instilled confidence that they could work together to achieve the project’s goals.

“We were retrofitting an old building and, as usual, the schedule and budget were tight,” says Tom Berry Jr., President of Verrex. “So I was happy to hear that Extron MediaLink™ switchers and controllers were part of the design. Extron has proven technology backed up by awesome technical support. That gave me great deal of confidence from the beginning.”

Extron at the Heart of the System

The Extron RGB 464xi, a universal, analog computer-video interface is used in each room allowing students and teachers to make presentations using a laptop PC. The RGB 464xi with Extron Advanced Digital Sync Processing (ADSP™) provides all-digital processing of sync signals. This avoids the tearing and other image distortions encountered when using poor sync processing methods with digital display devices (DLP, LCD, D-ILA™/LCoS, plasma, etc.).

For routing and switching signals from the various sources, the design called for a rack-mounted Extron MLS 306 switcher teamed up with a third-party amplifier for program audio. During the project, the MLS 306 was retired by Extron and replaced with the Extron MLS 406MA, a six input, multi-format active switcher. This change was actually a boon to the project, because the MLS 406MA features a 20 watt (rms) integrated mono amplifier, eliminating the need for a separate amplifier, which saved money and rack space.

Audio has become an integral part of many of Extron’s products and nothing has been held back when it comes to the audio capabilities found on the MLS 406MA. For example, the switcher includes loudness control, which compensates for the normal decreased hearing ability of the human ear at low volume levels by automatically boosting the low and high frequencies as the system volume decreases. This powerful, yet flexible feature makes the MLS 406MA a perfect fit for all of the small classrooms as well as the larger multi-purpose room.

Along with the computer signals from the RGB 464xi interfaces, each classroom’s A/V system has to handle signals from a ceiling mounted LCD projector, a DVD player, and a VCR. With six inputs, the MLS 406MA is an ideal choice to be the heart of these systems. Three inputs are configurable for composite video or S-video on either BNC or 4-pin mini DIN connectors (stereo audio for these are on...
RCA connectors) and three can be configured for computer-video on 15-pin HD connectors (stereo audio is either on captive screw connectors or 3.5 mm stereo mini jacks). Inputs four, five, and six are also configurable via RS-232 for computer-video, as well as composite video and S-video.

Centralized Control

To control the system, designers combined the Extron MLC 206 AAP MediaLink Controller with the Extron IRCM-DVD+ IR Control Module Architectural Adapter Plate (AAP). Together they offer universal projector and DVD player control, including the projector’s power on/off, input switching, and volume in addition to all the functions of the DVD player. The wall-mounted MLC 206 AAP/IRCM-DVD+ combo is also able to control all of the functions of the MLS 406MA including power on/off, input source selection, and volume and loudness control. The Verrex installation team configured the room control features of the MLC 206 AAP to control screen settings and room lights in every classroom.

“The combination of the Extron MediaLink switcher, controller, and the IRCM-DVD+ allowed us to provide the same aesthetically pleasing, easy-to-use control interface in every room,” says Dan Worth, Project Engineer at Verrex. “Installation and configuration went smoothly — thanks to dependable hardware and software support from Extron — and we didn’t need to hire any high-priced programmers.”

According to Donna Sharp, Executive Director of the World Trade Institute, the system has exceeded their expectations. “The new facility is great,” says Sharp. “The built-in technology is easy to use and flexible enough to meet a variety of teaching and learning needs. The facility caters to both the corporate seminar attendee and traditional university students; a mixed audience of age, background, and purpose. Having the flexibility to use laptops, video, videoconferencing equipment, and even music allows the instruction to stay up-to-date and reach a broader audience. We continue to receive positive feedback from many who are enjoying the use of the facility.”

Looking to the Future

For 30 years, WTI/Pace has provided professional seminars and degree programs for individuals and organizations that operate in the global marketplace. WTI/Pace is a major institute for international trade education, offering courses in logistics, finance, trade documentation, hazardous materials, insurance, Customs law, government regulations, security, importing and exporting, Internet technology, and marketing. WTI/Pace’s Language Center offers one of the country’s most exhaustive foreign language training programs. According to WTI/Pace, the new 45,000 square foot space is intended to be temporary, since they hope to move back to their original site when the World Trade Center is rebuilt.

The new facility has allowed WTI/Pace to significantly expand the scope of their international trade and logistics educational programs. With a larger space and reliable A/V technology in every classroom, WTI/Pace representatives feel they have an improved learning and working environment for their talented students, instructors, and staff.

To learn more about the World Trade Institute of Pace University and their broad curriculum of international trade, logistics, and language courses and seminars, visit them on the Web at http://www.wti.pace.edu.
New Cables, Adapters & Termination Tools
Simplify System Installations

At the heart of any A/V system are the cables, adapters, and connectors that tie the components together. Extron offers high quality cables specifically engineered for every signal type, precision machined problem-solving adapters, and ergonomic, time-saving termination tools. With 24-hour customer support and overnight delivery in most cases, Extron offers integrators a complete cable package.

Extron Universal BNC Crimp Tool

In addition to the current lineup of 58 bulk cable models, more than 6,000 cable assemblies, and scores of connectors and adapters, Extron announces several new products specifically designed with you, the A/V professional, in mind.

Extron Universal BNC Crimp Tool
Terminating Extron cables no longer requires multiple tools or dies. The rugged lightweight stamped steel frame is built to survive the most rigorous work environments, and the die has been specially engineered by Extron to exert maximum crimp force for reliable and consistent terminations. Each crimp area on the tool is color-coded: orange for Mini HR, purple for Mini 59, red for RG59/HR, and green for RG6/SHR BNC connectors.

Three New Cables

The three newest cables from Extron are designed, engineered, and manufactured to achieve the same level of quality and performance you’ve come to expect from each Extron cable in the existing line. Each cable is UL approved and NEC rated, and comes in plenum and non-plenum varieties.

The Extron BNC-5 Mini HR + STP 22 Dual Cable, part of the Mini High Resolution family of bulk cables, features five miniature high resolution coax cables and two shielded twisted pair cables conveniently combined into one integration-friendly jacket. Bringing together two widely used types of conductors into one cable is a simple innovation that can save time and streamline installation. BNC-5 Mini HR + STP 22 Dual Cable is ideal for applications requiring RGBHV signals and two-channel stereo audio or mono audio plus control signals.

The BNC-5 Mini HR + STP 22 Dual Cable carries red, green, blue, and separate horizontal and vertical sync on five 26 AWG, 75 ohm, coaxial, color-coded conductors. These conductors are combined into a single jacket with two color-coded 22 AWG shielded twisted pair cables. The BNC-5 Mini HR + STP 22 Dual Cable is smaller in diameter, easier to
pull, and less time consuming to install than multiple, single coaxial cables and audio/control cables.

The new Low Capacitance Serial Control/Digital Audio STP 24 and Low Capacitance Serial Control/Digital Audio STP 24 Dual Cable offer twice the performance of the Extron Serial Control/Audio cables. They are a high performance solution for transmission and distribution of serial digital audio and serial control signals, such as RS-232, in a variety of AV applications from home automation to internet based control and monitoring systems for universities, government facilities, and commercial venues.

Extron Low Capacitance Serial Control/Digital Audio STP 24 Dual Cable are ideal for serial control and AES/EBU (Audio Engineering Society/European Broadcasting Union) commercial digital audio applications. These shielded twisted pair cables provide controlled impedances that meet AES/EBU standards, maintaining the integrity of the signal. Engineered as a dual purpose cable, it fulfills industry AES / EBU standards for digital audio distribution and is exceptional for long distance transmission of RS-232, RS-422, and RS-485 signals.

These new cables solve many common issues. For more specialized installations, you may need cable assemblies, a special application cable or even a custom cable above and beyond the bulk cables to complete the run.

11 New Video and Audio Adapters and an Indispensable A/V Adapter Kit

Having the right adapter on hand can go a long way to streamline the integration process, save time and circumvent problems in rental/staging and permanent installations as deadlines loom or when unanticipated connectivity complication comes into play.

In addition to the wide variety of specialty and commonly use connectors already available, our 11 new adapters allow for more installation flexibility and are conveniently offered in packs of 10, 50 an 100. For even greater savings, the new Extron A/V Adapter Kit features an assortment problem-solving barrel, right angle, T-type and panel mount adapters, and is an indispensable addition to every installer’s tool kit.

Extron adapters are of the highest quality materials, manufactured within strict tolerances using fully machined parts (not stamped, die cut, or pressed). With our extremely competitive pricing, we can be your single source for these everyday accessories. These commonly used items are easy to order, and mix and match. Stock some now so you will have them close at hand when you need them the most.

Extron offers an extensive line of adapters and connectors proven to meet common and unexpected integration needs.
Expanding Options Through Timely Delivery

To enhance our support and commitment to East Coast dealers, last Fall Extron opened a 12,400 square foot bulk cable distribution warehouse. Located in Raleigh, North Carolina, the new facility serves customers in the Midwest, Southeast, Northeast, and Mid-Atlantic United States, providing faster ground-rate delivery of cable orders at a lower cost.

Bulk cable shipments for the Western United States and Canada, as well as sales order processing for all regions continue to be handled by Extron’s dedicated Customer Support Representatives from our Anaheim, California, headquarters. All orders received by 1:00 pm Pacific Standard Time are shipped the same day without the need for costly second-day or next-day services in most cases. With distribution centers in the U.S., Asia and Europe, we are able to provide bulk cable shipments from our extensive inventory quickly and affordably.

From rugged and reliable termination tools to timely delivery, Extron offers a complete cable package — the service, support and solutions — you can rely on for all of your professional A/V cabling needs. For more information, call your Extron Customer Support Representative.

Cable Assemblies, Special Application and Custom Cables

Complementing our bulk cables, Extron offers hundreds of high quality cable assemblies for video, audio, A/V UTP (Unshielded Twisted Pair), digital, and control signal distribution applications. Most are available in convenient pre-cut lengths from 3’ (0.91 m) to 300’ (91.44 m) depending on the model. Extron cable assemblies are manufactured from our bulk cable stock and terminated with high quality 75 ohm BNC, 15-pin molded/backshell, 15-pin HD, 4-pin mini DIN, captive screw or RJ-45 connectors. Besides standard male and female connectors, Extron also offers 90 degree up or down BNC and VGA connectors on select cables, further expanding your installation options. Each cable assembly is carefully tested for quality workmanship and pin-to-pin continuity before it is approved for shipment to the customer.

We also provide any number of special application and dedicated cables. These include: RS-232 control, DVI, slave, skew-compensation, 9 DB Female-2.5 mm TRS configuration, Mac/Quadra 15-pin HD, and 13W3 cables.

When a custom cable is required, simply use the convenient Custom Cable Request Form found at the back of the Cable Product Guide, current Product Catalog, or online at www.extron.com. Select the length, quantity, type, pin assignments, and connectors you require. You may be surprised how easy and affordable it can be. As always, your Extron customer Support Representative is available by phone to answer any questions.

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Five Advantages to the Extron One Source Solution

Save time and effort with the Extron One Source Solution for all of your cable needs.

1. **One point of contact:**
   From products to purchase orders and accounting, there is no need to juggle multiple manufacturers to source products for an entire job.

2. **24-hour customer support:**
   Knowledgeable, reliable Customer Support Representatives and Application Engineers provide system support from source to display regardless of manufacturer.

3. **Customer focused convenience:**
   One vendor with a comprehensive portfolio of superior products designed to maximize installation options and focused on your needs.

4. **Smart designs, efficient installations:**
   Ongoing customer education and design assistance produce cost-effective, efficient designs.

5. **Just-in-time delivery:**
   Increase productivity and lower overhead with greater control over product sourcing and delivery schedules.
What Does Extron’s ISO 9001 Certification Mean To You?

Your customers expect quality. They expect products and services to be delivered on time and to meet their requirements. To ensure that Extron is a strong link in your quality chain, we’ve been fundamentally committed to strict quality management since our inception. In June 2004, Extron’s manufacturing operations received ISO 9001:2000 certification, confirming that Extron’s processes and procedures conform to the strictest of quality standards, and giving you more reasons than ever to feel confident about choosing Extron products.

What Is ISO Certification?

The International Organization for Standardization (ISO), headquartered in Geneva, Switzerland, is a network of national standards institutes from 148 countries working in partnership with international organizations, governments, industry, business, and consumer representatives. The ISO family of standards is important for companies that do business internationally because it represents an international consensus on quality management processes.

When an organization has a management system certified to an ISO 9000 standard, it means that an independent auditor has checked that the processes influencing quality conform to the relevant standards requirements. The objective is to give an organization’s management and customers complete confidence that the organization is in control of the way it does things.

While no organization must be ISO certified, it is fast becoming the standard for conducting business in the international arena. In fact, ISO 9000 is the only quality system accepted internationally.

Quality Management That Brings Peace of Mind

The ISO 9001:2000 standards govern a company’s quality management and quality assurance processes, with a particular emphasis on customer satisfaction. These standards are not specific to any particular product or service. ISO 9001 covers design, manufacturing, installation and service. The year 2000 revision of the standard includes procedures for managing quality objectives, continual improvement, and monitoring of customer satisfaction.

Certified companies are required to create formal, documented procedures, ensure all team members follow those procedures, and undergo regular check-ups by internal and external auditors. When you choose Extron products, you can be confident that you will benefit from:

- Services designed to meet your needs and ensure your satisfaction;
- Products manufactured with quality planned and documented into every step in the process;
- A team of trained employees performing consistently and with the goal of improving all operations; and
- Our commitment to you to do what we say we will do.

Extron’s compliance with the rigorous ISO 9001:2000 standard ensures that we have a well-documented quality management system, and provides you with increased assurance that your needs and expectations — and those of your customers — will be met.
Clutching a cup of that vending machine coffee in the student lounge and listening intently to Don’s experience building a 400 watt transmitter using five 6AG7’s mounted to the underside of a large coffee can lid which submerged those tubes upside down into a reservoir of water, was a riveting discussion for anyone in engineering school. What’s a 6AG7? It’s a medium-sized, pentode, metal-can radio receiving tube with an octal (8 pins) base. Originally used as a video output amplifier in ‘50s era TV receivers, this tube is capable of only 10 watts plate dissipation. Don’s ability to communicate with other hams was complicated by the need to replenish his coolant in real time using a small watering can kept nearby. Immersed to within one half inch of their base, these five tubes generated a constant column of steam.

Think about it. Would it be possible to leverage 400 watts or more from those five tubes? That’s 800% of their collective power rating. Sure it is. The BIG question is: For how long? Theoretically, that much power could be delivered all day long if the heat can be efficiently transferred away from the crucial elements of the tubes. Efficiently (successfully?) moving potentially destructive heat away from systems doing work is called thermal management.

Getting Into Management

Thermal management is all around us in destructive and non-destructive forms. All objects or systems will, via fundamental physical laws of our environment, attempt to equalize their operating temperature conditions with their surroundings. Warmer objects are said to give up, or transfer, heat to the colder objects. Over time, without additional work applied, all objects within a system will ideally approach the same temperature; thus, attaining a state of thermal equilibrium.

Whether the internal heat rise of an object is self-destructive depends on the rate at which excess heat is transferred away to its surroundings. Remember from Thermo 101: Energy flows from warmer bodies to colder bodies. The transfer of molecular energy to a colder body is the process of equilibrium attainment. In electronic design terms, we call it a heat sink since heat is absorbed, or “sinks into” the colder body. Eventually, both bodies in close relative contact will attain the same temperature as long as no additional energy is input to the system.

Paying Twice

Heat rise in electronic equipment directly affects product reliability. All electronic components contain a “system” of heat production and transfer. Passing electrons rapidly through circuitry to do work causes many particle collisions. Heat rise is inevitable. Within each component are features that draw or transfer the heat rise to ancillary structures. The efficiency of heat transfer internally is limited by physical features and materials.

You might say that we potentially “pay twice” for any system. We pay at the front end in the form of dollars for the power to run the system. We pay again at the back end when temperature effects...
compromise the potential operational life span. Temperature rise has the highest impact on component life.

In our world of electronic product design, we live by this rule of thumb: For every 10 degrees Centigrade rise in temperature, the average reliability is decreased by 50 percent. Or, from the quality assurance department’s point of view, if we can lower the temperature by 10 degrees, we’ll double the reliability. In other words, we will double the expected life within any predictable failure rate. Another way to look at this, for those interested in buying products with good MTBF (mean time between failures) ratings, is that MTBF will, on average, double if the operating temperature is lowered 10 degrees.

Cold is Relative

The concept of cold is relative. Anything feels cold if its temperature is lower than the contacting body. If the contacting body is transferring more energy than the cold body can sink away, the cold body will attain equilibrium with the warmer body and no longer be perceived as colder. In the opposite condition, the colder body will continue to feel cold. Cold bodies of sufficient mass can sink all available heat from a warmer body. Equilibrium will cause the warmer body to become the same temperature as the colder.

The rate at which heat transfer occurs between two bodies depends on the medium of contact in their environment. Solids, liquids, and gases have different rates of transfer, or thermal resistance. Thermal resistance may be thought of similarly to electrical resistance in a circuit. Resistors in a circuit have a corresponding voltage drop associated with a specific current flowing at a given time. Thermal resistance is a measure of how many degrees of temperature rise “drop” across the contact barrier between two bodies’ contact surfaces. This measure of thermal resistance is commonly given in degrees Centigrade per watt. (A direct comparison is not altogether straightforward. If you desire further insight, look up Reference 1 on the Internet.) There is a corresponding thermal resistance between the active heat source and each subsequent contacting body along the path to the external environment. Knowing the thermal resistance at each point of contact in a cooling system allows us to calculate how hot the active component, a silicon chip for example, will become in an application environment. See Figure 1 for a simplistic example of this “shell” concept. Figure 1 will be used in more detail in Part 2 of this article.

At the molecular level, the surface of most bodies is not very smooth. Points of intimate contact exist along with points separated by surrounding air, or other gas. Gases are good insulators and, therefore, have higher thermal resistance or lower thermal conductivity than most solids. Pressure and contact intimacy play a large role in the efficiency of heat transfer. This explains why thermal grease and mechanical fasteners have been the traditional assembly method for power semiconductors and heatsink materials.

Note the relative differences in thermal conductivity of materials in Table 1. It’s no surprise that we use lots of aluminum for component heatsinking. Aluminum’s conductivity is four orders of magnitude higher than air. Conversely, this accounts, in part, for the large surface areas needed with heatsinks (i.e. fins) since the number of gaseous molecules in contact with the aluminum heatsink at any moment is far less than the number of hot aluminum molecules ready to give up energy. Thermal conductivity tracks with the overall resistivity of materials.

The relationships of aluminum, copper, silver, and gold parrot their relative properties as electrical conductors as well as heat conductors. With aluminum being easy to work and lower in cost than copper, it’s the most practical choice.

We must move lots of air molecules to account for the relative inefficiency of air as a heat conductor. Looking diametrically at this attribute, we conclude that air, glass, concrete, and wood are good insulators.

Thermal Management at Extron

So, why am I talking about electronic components when your concerns are likely to be the installation of equipment in racks, furniture, or enclosed spaces? It’s because all the same rules apply at any level of system design. These physical rules rapidly develop into rules-of-thumb for first-order thermal management of a design as our individual experiences grow. By “first-order”, I mean the first point of initial concern and investigation.

Table 1: Thermal Conductivity of Common Materials (at 25°C)

<table>
<thead>
<tr>
<th>Material</th>
<th>Conductivity (Watts/meter-°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic</td>
<td>0.200</td>
</tr>
<tr>
<td>Air</td>
<td>0.024</td>
</tr>
<tr>
<td>Aluminum</td>
<td>250.000</td>
</tr>
<tr>
<td>Copper</td>
<td>401.000</td>
</tr>
<tr>
<td>Carbon Steel</td>
<td>54.000</td>
</tr>
<tr>
<td>Concrete</td>
<td>1.050</td>
</tr>
<tr>
<td>Glass</td>
<td>1.050</td>
</tr>
<tr>
<td>Gold</td>
<td>310.000</td>
</tr>
<tr>
<td>Nickel</td>
<td>91.000</td>
</tr>
<tr>
<td>Paper</td>
<td>0.050</td>
</tr>
<tr>
<td>PTFE (Teflon®)</td>
<td>0.250</td>
</tr>
<tr>
<td>PVC</td>
<td>0.190</td>
</tr>
<tr>
<td>Silver</td>
<td>429.000</td>
</tr>
<tr>
<td>Steel</td>
<td>46.000</td>
</tr>
<tr>
<td>Water</td>
<td>0.580</td>
</tr>
<tr>
<td>Wood</td>
<td>0.130</td>
</tr>
</tbody>
</table>

Table 1: Thermal conductivity of common materials

continued on page...
If I can just stand to indefinitely maintain finger touch on a component during its normal operation at room temperature, it is typically no hotter than about 45°C (113°F) and likely to be reliable. I have given products the finger test for years and it has served me well. Occasionally, I’ll walk by an engineer’s bench and, if we discuss temperature rise issues of a project, I first feel around the operating circuit using my index finger beginning with all the active components, then resistors, then capacitors, etc. For more “resolution”, I use my little finger since it’s less calloused and more sensitive. When I can maintain touch on all components, the circuit design is less likely to develop general temperature-related failures. Of course, cooler temperature sensation is better.

This rule of thumb is for components operating in free air. What happens after the enclosure is applied? This leads to decisions on product environmental operating temperatures. In the future, look carefully at the manufacturer’s specified maximum operating temperature environment. This specification dictates the maximum recommended air temperature that the product should experience when it has reached system equilibrium. Curiously, most products are specified for no higher than a range of about 40°C to 50°C (104°F to 122°F).

Common wisdom in electronic product design dictates that active components will have higher operating temperatures than their respective environment (unless, of course, you are building refrigerators). When this is not true, the system will fail due to over-temperature conditions. This thermal difference works to draw heat from the active components. In system design this concept is working at all levels from components on circuit boards to equipment components mounted in racks.

The specified maximum environmental operating temperature is intended to reflect the considerations for thermal stratification from environment to enclosure to component to package to chip to operating junction. And here we come to the all-important point – the junction temperature.

The junction in a component is that boundary where the concentration of electron activity is highest, thus creating the most heat generation at the molecular level while doing useful work. Every contact layer between the junction and the outside world adds cumulative thermal resistance, or temperature drop. From the outside looking in, higher environmental temperatures mean less heat per unit area per unit time conducts away from the junction. Beyond the maximum junction temperature, molecular interactions occur at such a rate to become self-destructive. Actual “melt-down” of the junction usually occurs.

Good practice involves deciding on useful design guidelines for successful management within the maximum junction temperature specification. For semiconductors, a common guideline is to remain within 80% of the maximum while operating the product within the maximum environmental temperature. Junction temperatures range typically from about 100°C to 150°C. The enclosure plus all other “junctions” encountered between the outside environment and the semiconductor’s junction temperature present a complex design responsibility. Should the systems integrator not follow recommended product temperature guidelines, the remaining 20% temperature rise headroom may determine the difference between system success and failure.

As systems designers, you are most often confronted with a collection of products each of which has an energy requirement rated in watts of electricity. How do we determine how much heat will be produced within the immediate environment for that system of equipment? Let’s start with an understanding of the relationship between the basic units used to quantify heat, power, and cooling.

### BTU Content of Common Energy Sources

<table>
<thead>
<tr>
<th>Source</th>
<th>Unit</th>
<th>BTU Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude Oil</td>
<td>Barrel (42 gallons)</td>
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<tr>
<td>Gasoline</td>
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<tr>
<td>Heating Oil</td>
<td>1 Gallon</td>
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<tr>
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<td>Natural Gas</td>
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<tr>
<td>Propane</td>
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<td>Coal</td>
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<tr>
<td>Electricity</td>
<td>1 Kilowatt-Hour</td>
<td>3,412</td>
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</tbody>
</table>

Table 2: BTU content of common energy sources
BTUs, Watts, and Tons of Air

Determining heat loads, temperature rise, and cooling solutions fall within a realm of related, but different, units. Electronic equipment essentially takes all supplied power and converts it to heat. Power consumption (read: heat generation) in electronic equipment is normally stated in watts. Heat rise is typically stated in British Thermal Units per hour (BTUH). Cooling systems, such as air conditioners, may be rated in “tons” of cooling capacity, or in BTUH. Calculations for management of heat load situations can become complex. Within most industries, rules of thumb and typical value models for heat contribution are used to lighten the task of computation. Let’s take a look at these important relationships.

Watts

One watt is equal to one ampere of electric current operating through one volt potential difference. One thousand watts used over one hour’s time is one kilowatt-hour. Some good numbers to remember for use in conversion are:

- One watt-hour of electricity produces 3.412 BTUH.
- One ampere of electricity operating at 115 VAC generates nearly 400 BTUH.
- At 230 VAC, one ampere is generating twice that amount.

Usually we assume that our equipment is a pure resistive load and we use the stated wattage rating verbatim. Heavy equipment loads with inductive or capacitive components can cause a phase shift between voltage and current usage resulting in a lower power factor. The power factor, when less than 1, raises the apparent power requirements and must be factored into our total power calculation.

British Thermal Unit

The BTU equates to the amount of energy (about 252 calories, 0.293 watt-hours, or 1,055 joules) required to raise one pound of water from 58.5 to 59.5 degrees Fahrenheit at standard pressure (30 inches of mercury). An item using one kilowatt-hour of electricity will generate 3412 BTU. You may find it interesting to look at Table 2, which lists the BTU content of many common energy sources.

Tons of Air

I’ve often times thought the units of air conditioning capacity to be a peculiar concept. It happens to be one of those units derived from more primitive beginnings, that being melting ice. One ton of cooling capacity equals the amount of cooling provided by melting one ton (2,000 lbs.) of ice. Therefore, a 2-ton air conditioner does the same work as two tons of melting ice per hour. Air conditioner capacity may also be stated in BTU per hour, BTUH. One ton of cooling equals 12,000 BTUH. That typical two-ton system is equivalent to 24,000 BTUH.

We’ve looked at some definitions and imparted some of our rules of thumb for thermal management, which I hope you may find useful in the future. You may find that you have developed some of your own rules of thumb; or in the adverse case, maybe you’ve developed burnt thumbs. This article lays the foundation for additional discussion on the practical application side of thermal management that I will cover in Part 2… namely, considerations for installing equipment in small spaces and equipment racks. If I could conjecture about some rules of thumb my friend Don might have used for his two-ton system are:

1. Be sure the water can flow. Usually we assume that our equipment is a pure resistive load and we use the stated wattage rating verbatim. Heavy equipment loads with inductive or capacitive components can cause a phase shift between voltage and current usage resulting in a lower power factor. The power factor, when less than 1, raises the apparent power requirements and must be factored into our total power calculation as it pertains to heat production.

Thermo 101

When it comes to the study of heat, energy, and thermal issues, the fundamental laws governing heat transfer always come into play. I’m talking about the laws of thermodynamics, which characterize the study of energy. We know that energy exists in many forms and is used to bring about change or to perform useful work. Energy exists as heat, light, electrical energy, and chemical energy. Our understanding of energy transfer within our universe revolves around the concept of the “closed system”.

The first law of thermodynamics states that energy may be transferred or changed, but cannot be created or destroyed. This is often referred to as the conservation of energy and implies that the total amount of energy in the universe is constant and merely changes from one form to another.

The second law pertains to heat transfer. With the closed system concept in mind, for any spontaneous process there will be an increase in entropy. Entropy is a measure of the amount of disorder in a system. Other equivalent ways to consider the second law are: a) heat flows only from a warm body to a colder body; b) not all heat may be converted to useful work; c) all isolated systems become disordered in time. The second law most notably applies in our understanding of heat engines and the direction of heat transfer.

The third law describes the relationship of thermal motion and temperature as we measure it. When all thermal motion of molecules stops, a condition of absolute zero is attained. Absolute zero represents 0°Kelvin, or -273.15°C. The estimated temperature of empty space in the universe is about 2.7 Kelvin.

Near the beginning of this article the concept of equilibrium is discussed. As it turns out, the concept of equilibrium implies a MOST fundamental law preceding the first law of thermodynamics. The concept is: If, at the same time, two systems are in thermal equilibrium with a third system then all three systems are in thermal equilibrium with each other. Being so fundamental, this concept has been coined as the “zeroth law of thermodynamics”.

References
4. Laws of Thermodynamics at http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/thereq.html
5. Laws of Thermodynamics at http://www.emc.maricopa.edu/Faculty/farabee/BIOL806/BioBookEner1.html
The Extron DA AV EQ Series is a family of 10 high performance video and audio distribution amplifiers models designed to split and extend composite video, S-video, and stereo audio signals. Most models feature gain and EQ adjustments for compensation of signal level and high frequency loss that occurs over long cable runs.

Housed in durable and compact half-rack metal enclosures, the DA AV EQ Series is designed for easy integration into both new and existing A/V systems including boardrooms, training facilities, home theater, command and control centers, and rental and staging environments.

MGP 462
Dual Window Multi-Graphic Processor

The Extron MGP 462 and MGP 462D are powerful, high resolution graphic processors which enable dual image display for applications requiring critical quality graphics and video presentations. They combine high performance RGB and video scaling with picture-in-picture display that is fully customizable.

The MGP 462 features our exclusive integrated Graphic Still Store, which captures on-screen content, and then stores the image for background display, or even archiving to a PC. Images can also be uploaded to the MGP 462, ideal for themed multimedia presentations. The MGP 462 includes four fully configurable inputs that accept video, HDTV, or computer-video. SDI input is optional (standard with the MGP 462D). In addition to full front panel controls, the MGP 462 can be remotely controlled through RS-232, and features IP Link for remote management and monitoring.

Cable Cubby® 200
Surface-Mountable Enclosure for Cables and One AC Power Outlet

Extron has added the Cable Cubby 200 to its popular line of surface-mountable enclosures. Like all Cable Cubby models, the economic Cable Cubby 200 mounts discretely into virtually any tabletop and fits nearly flush with the surface when closed, remaining unobtrusive even when in use.

The Cable Cubby 200 provides inconspicuous access to one AC power outlet and up to three data, audio, or video cables. Cables can be pulled through the openings in the panels—which accommodate varying cable diameters and connector types—and pushed back through for out-of-sight storage until needed. The Cable Cubby 200 is available in a black powder finish, and is UL/CUL and CE compliant.
**NEW**

**HSA 822M**

Motorized, Double-Sided, Vertically Lifting Hideaway™ Surface Access Enclosure

The new **HSA 822M**, motorized Hideaway Surface Access enclosure is a double sided enclosure that rises smoothly out of the table to reveal power, data, and other popular AV interface connections. When closed, the lid of the HSA 822M fits flush with the tabletop, storing connectors out of sight.

The new enclosure is ideal for high profile executive boardrooms and conference rooms. Its quiet, motorized operation lends itself to environments in which elegant and automated systems are important factors. The HSA 822M can be raised and lowered via contact closure or by pressing on the top surface.

**Model** | **Part#** | **List Price***
--- | --- | ---
USA AC Outlet | HSA 822M US ...............60-719-0A .... | $3,295.00
United Kingdom AC Outlet | HSA 822M UK ...............60-719-08 .... | $3,295.00
Israel AC Outlet | HSA 822M ISRAEL ............60-719-0C .... | $3,295.00
Central Europe AC Outlet | HSA 822M EU ...............60-719-0D .... | $3,295.00
France AC Outlet | HSA 822M FRANCE ............60-719-0E .... | $3,295.00
Australia AC Outlet | HSA 822M AUS ...............60-719-0F .... | $3,295.00
India AC Outlet | HSA 822M INDIA .............60-719-0G .... | $3,295.00
Swiss AC Outlet | HSA 822M SWISS .............60-719-0H .... | $3,295.00

Models listed are black finish. These products are also available in brushed aluminum finish.

URL: www.extron.com/hsa822m

Shipping December 2004

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**AC OUTLET OPTIONS FOR HSA AND CABLE CUBBY ENCLOSURES**

![AC Outlet Options]

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**NEW**

**HSA 822MS**

Motorized, Table Surface Matching, Double-Sided, Vertically Lifting Hideaway™ Surface Access Enclosure

The Extron **HSA 822MS** is a motorized, surface matching, vertically lifting enclosure for computer-video interfacing and connector access. The HSA 822MS blends into the tabletop surface when closed, making it almost invisible to the eye, and is elegantly designed to store connectors out of sight until the next presentation. It can be raised and lowered by contact closure, or by pressing the top surface.

In addition, the HSA 822MS includes a modular faceplate on two sides with two RJ-45 connectors and opening for four single space Architectural Adapter Plates (AAPs). Two unswitched AC power outlets are provided on the adjacent faceplates.

**Model** | **Part#** | **List Price***
--- | --- | ---
USA AC Outlet | HSA 822MS ..................60-721-0A .... | $3,295.00
United Kingdom AC Outlet | HSA 822MS UK ...............60-721-0B .... | $3,295.00
Israel AC Outlet | HSA 822MS ISRAEL ............60-721-0C .... | $3,295.00
Central Europe AC Outlet | HSA 822MS EU ...............60-721-0D .... | $3,295.00
France AC Outlet | HSA 822MS FRANCE ............60-721-0E .... | $3,295.00
Australia AC Outlet | HSA 822MS AUS ...............60-721-0F .... | $3,295.00
India AC Outlet | HSA 822MS INDIA .............60-721-0G .... | $3,295.00
Swiss AC Outlet | HSA 822MS SWISS .............60-721-0H .... | $3,295.00

Models listed are black finish. These products are also available in brushed aluminum finish.

URL: www.extron.com/hsa822ms

Shipping January 2005

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*Prices listed in US Dollars, valid for US sales only.

www.extron.com

continued on page 18
The Extron MLC 226 IP MediaLink Controller with IP Link™ provides an enhanced user interface for centralized room control. Loaded with all the attributes of the MLC 104 IP, the MLC 226 IP controller adds features such as additional source selection buttons, room control buttons, six configurable relays, and IR learning.

The MLC 226 IP is compatible with Extron’s Control Module AAPs to provide remote control of VCRs, DVD players, and room functions such as lighting and screen operation. To provide an additional point of control in the room, the optional SCP 226 can be paired with the MLC 226 IP as well as the IR 402 wireless remote control.

Model | Part# | List Price*
--- | --- | ---
MLC 226 IP with three-gang faceplate | MLC 266 IP ..........................60-600-02 ....... $1,195.00
MLC 226 IP with AAP openings | MLC 266 IP AAP ..........................60-600-12 ....... $1,200.00
MLC 226 IP with low profile lectern faceplate | MLC 266 IP L ..........................60-600-32 ....... $1,195.00
MLC 226 IP without faceplate | MLC 266 IP (controller only) .... 60-600-00 ....... $1,145.00

Models listed are black finish. These products are also available in white and RAL9010 white.
URL: www.extron.com/mlc
Shipping December 2004

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The Extron MLC 104 IP MediaLink Controller with IP Link™ provides a simplified user interface for centralized room control. Building on the features found in the MLC 104, the MLC 104 IP controller adds Extron’s innovative IP Link Ethernet control technology.

IP Link enables remote diagnostics, asset management, and support using GlobalViewer™, a free Web-based asset management and remote control software application. The optional SCP 104 Secondary Control panel is available for the MLC 104 and MLC 104 IP to provide a second access point to control the A/V system.

Model | Part# | List Price*
--- | --- | ---
MLC 104 IP with two-gang faceplate | MLC 104 IP ..........................60-573-02 ....... $845.00
MLC 104 IP with AAP openings | MLC 104 IP AAP ..........................60-573-12 ....... $850.00
MLC 104 IP with low profile lectern faceplate | MLC 104 IP L ..........................60-573-32 ....... $845.00
MLC 104 IP without faceplate | MLC 104 IP (controller only) .... 60-573-00 ....... $795.00

Models listed are black finish. These products are also available in white and RAL9010 white.
URL: www.extron.com/mlc
Shipping December 2004

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The Extron MLC 104 MediaLink Controller provides a simplified user interface for centralized room control. The MLC 104 provides universal projector control, backlit buttons, and volume control. As part of the MediaLink System, the flexible MLC 104 is an intuitive remote control panel engineered to standardize operations and control of audio, video, and computer sources into an easy-to-use A/V system. Standardization also makes setup and maintenance easier to support.

The MLC 104 is available in several different form factors: with AAP openings, a lectern faceplate, or as a standalone, customizable controller without a faceplate.

Model | Part# | List Price*
--- | --- | ---
MLC 104 with two-gang faceplate | MLC 104 .................................60-665-02 ....... $695.00
MLC 104 with AAP openings | MLC 104 AAP .................................60-665-12 ....... $700.00
MLC 104 with low profile lectern faceplate | MLC 104 L .................................60-665-32 ....... $695.00
MLC 104 without faceplate | MLC 104 (controller only) .... 60-665-00 ....... $795.00

Models listed are black finish. These products are also available in white and RAL9010 white.
URL: www.extron.com/mlc
Shipping December 2004

*Prices listed in US Dollars, valid for US sales only.
The Extron **MPX 423 A** is a unique media presentation matrix switcher that merges four independent matrix switchers into a single, compact enclosure: a 4x2 VGA switcher, a 4x2 S-video switcher, a 4x2 composite video switcher, and a 12x2 stereo audio switcher.

Cost-effective and integrator-friendly, the MPX 423 A expands projector input capabilities, while providing an additional output for a second display used in a presentation. It is also useful for preview monitoring. With two switcher modes and IP Link™ Ethernet monitoring and management, the MPX 423 A is ideal for a variety of small-scale applications including classrooms, training and conference facilities, and home theaters.

<table>
<thead>
<tr>
<th>Model</th>
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<tr>
<td>MPX 423 A</td>
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<td>$1,995.00</td>
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URL: [www.extron.com/mpx423a](http://www.extron.com/mpx423a)

**Now Shipping**

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The new Extron **MTP T 15HD RS** and **MTP R 15HD RS** Mini Twisted Pair Transmitter and Receiver work together to send high resolution RGBHV and bi-directional RS-232 signals up to 600 feet (185 meters) over a single CAT 5/5e/6 cable. They are compatible with RGBHV, RGBS, RGsB, S-Video, composite video, and component video; as well as HDTV component video signals with bi-level or tri-level sync.

These new products are compact, so they’ll fit just about anywhere and are ideal for applications such as large training facilities, museums, airports, movie theaters, and hotels.

Employing our newest twisted pair technology, the MTP T 15HD RS and MTP R 15HD RS offer superior image quality and set a new price/performance standard for twisted pair products.

<table>
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<th>Model</th>
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URL: [www.extron.com/mtpt15hdrs](http://www.extron.com/mtpt15hdrs)

**Now Shipping**

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The **MPA 122** is a compact, economical, stereo power amplifier for small integration solutions, such as a basic classroom system with audio from a video projector. Using improved Class D amplification technology for high efficiency, the MPA 122 delivers 22 watts (rms) total into 4 ohms and 14 watts (rms) total into 8 ohms. The MPA 122 accepts balanced and unbalanced stereo signals, and features remote volume adjustment and muting controls.

<table>
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URL: [www.extron.com/mpa122](http://www.extron.com/mpa122)

**Now Shipping**

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*Prices listed in US Dollars, valid for US sales only.*

www.extron.com
VTG 300R
Handheld Rechargeable Battery Powered Video and Audio Test Generator

The VTG 300R broadcast quality video and audio test generator includes an integrated rechargeable battery and charger, and operates continuously for about five hours. This rugged, portable reference tool provides accurate video signal reproduction as RGB, component video, S-video, and composite video.

The VTG 300R features 34 video scan rates, including three new rates previously not available with the VTG 300 (1080p/24sF at 48 Hz for HDTV, 1280 x 768 at 60 Hz, and 1366 x 768 at 60 Hz for 16:9 aspect ratio displays). The 13 video test patterns include new ramp, 80% window, and 20% window patterns. The audio tone generator offers six audio test signals.

Model | Part# | List Price*
------|------|------------
VTG 300R | 60-543-02 | $1,125.00

URL: www.extron.com/vtg300r
Now Shipping

MVX Series
VGA and Stereo Audio Matrix Switchers

The Extron MVX Series of VGA and stereo audio matrix switchers are economical solutions for applications that route computer-video with stereo audio. Available in 4x4, 4x8, 8x4, and 8x8 I/O sizes, the MVX Series comes standard with RS-232 control capability, as well as Extron’s QuickSwitch Front Panel Controller (QS-FPC™). Other control options for the MVX Series include the Extron MCP 1000 control panel, MKP 1000 control keypad, and IR 501 remote control. With a space-saving 1U high, full rack enclosure and convenient 15-pin HD connectors, the MVX matrix switchers are ideal for applications such as boardrooms, classrooms, and video conference rooms.

Model (I/O Size) | Part# | List Price*
----------------|------|------------
MVX 44 VGA A (4x4) | 60-635-21 | $995.00
MVX 48 VGA A (4x8) | 60-636-21 | $1,695.00
MVX 84 VGA A (8x4) | 60-637-21 | $1,695.00
MVX 88 VGA A (8x8) | 60-638-21 | $2,495.00

URL: www.extron.com/mvx
Now Shipping

SW MTP T 15HD A Series
VGA Stereo Audio Switchers with Integrated Twisted Pair Transmitter

The Extron SW MTP T 15HD Series is a versatile family of switchers for selecting and transmitting high resolution computer-video and audio signals to presentation displays over a single unshielded twisted pair cable (UTP cable).

The SW2 MTP T 15HD A, SW4 MTP T 15HD A, and SW6 MTP T 15HD A are two, four and six input, one output switchers that transmit RGBHV, RGBS, RGsB, HDTV, and other high resolution video and audio signals to a compatible MTP receiver. Each switcher can be controlled using the front panel or remotely via contact closure or RS-232 signals.

Model (Inputs) | Part# | List Price*
---------------|------|------------
SW2 MTP T 15HD A (2) | 60-648-01 | $990.00
SW4 MTP T 15HD A (4) | 60-649-01 | $1,190.00
SW6 MTP T 15HD A (6) | 60-650-01 | $1,390.00

URL: www.extron.com/sw2mtpt15hda
Shipping December 2004

*Prices listed in US Dollars, valid for US sales only.
Overcoming Skew
Improving Image Quality in Twisted Pair Transmission

As the demand for high resolution digital video systems grows, A/V professionals now have more options than ever. Coaxial cable is no longer the necessary choice. Advancements in the development of twisted pair cable and connecting hardware are enabling integrators to build complex systems for a broad range of applications. While using twisted pair cable has numerous advantages over coaxial cable, high resolution twisted pair systems are commonly plagued by something called “skew.” In this Tech Corner, we’ll discuss the nature and origin of skew, how to avoid it completely when you can, and how to compensate for it when you can’t.

What is Skew?
In twisted pair video systems, skew is a distortion in the image caused by the late arrival of one or more of the color signals. The delayed color signal is shifted to the right of the other colors in the image, resulting in very poor image quality that can cause viewer fatigue.

Interestingly, the source of skew is the cable itself. Data grade twisted pair cable (Cat 5, Cat 5e, and Cat 6) was developed for computer networks where the main concern is not skew, but crosstalk. Ethernet networks consist of two signals, transmit and receive, running long distances in close proximity. To minimize the crosstalk between individual twisted pairs, the rate of twist is varied among the pairs of wire. This has a side effect of making the twisted pairs vary in length. The pairs with more twist per inch will have a longer length and signals sent down each pair will arrive at the receiver at different times. Computers have little trouble resolving this time differential, but high resolution video systems are less forgiving.

Skew is not a problem when twisted pair cable is used for composite video or S-video signals, because the signals are sent on a single pair of wires. High resolution video signals, on the other hand, are subject to skew, particularly at long distances, because the transmitter processes the signal and sends each color down a separate pair.

So, how much of a time delay is too much? The Cat 5e standard specifies a maximum delay skew limit of 45 nanoseconds (ns) over the entire length of the cable used. This is not acceptable for analog RGB signals. For high resolution video transmission, skew delay must be as close to zero as possible. Measurements taken here at Extron of a typical 1024 x 768 signal with a refresh rate of 60 Hz (pixel clock of 65 MHz) showed the pixel duration to be approximately 15 ns. For an image running at 1280 x 1024 pixels, with a refresh rate of 60 Hz (pixel clock of 135 MHz), the pixel duration was approximately 8 ns. Depending on the resolution, the delay skew resulting from a length difference of three feet will most likely need compensation.

For example, imagine you’re working with a brand of Cat 5e cable with a documented delay skew of 1.451 ns per foot. On a moderate cable run it wouldn’t be unusual to find a difference of five feet between the shortest and longest wire pairs, resulting in a cumulative delay skew of 7.255 ns (5 feet x 1.451 ns). This would be very close to one pixel width off at the 1280 x 1024 rate and half a pixel width off at the 1024 x 768 rate.

Avoiding Skew: Skew-Free™ Cable
The best way to handle skew is to keep it out of the system altogether. And the best way to do that is install a twisted pair cable specifically designed for video transmission, like Extron Enhanced Skew-Free™ A/V UTP Cable.
With our Enhanced Skew-Free cable, the length of each twisted pair is uniform so the red, green, and blue signals arrive at the receiver simultaneously. This cable is comprised of four, color-coded twisted pairs of 23 AWG wires and can be terminated with RJ-45 connectors.

The plenum version of the Extron Enhanced Skew-Free™ A/V UTP Cable has a plenum-rated jacket constructed with special fire protectant agents for use in applications where National Electric Code (CL2P) cable is required. Plenum cable can be run through open air spaces, eliminating the need for conduit and reducing installation costs.

Of course, it’s not always possible to use Skew-Free cable. Twisted pair video systems are often installed using existing data grade cable. If such systems require high-resolution video to be transmitted long distances, skew is bound to be a problem.

**Compensating for Skew: Two Methods**

**Skew Compensation Cables:** Since the cause of the problem is the varying distance between the individual wires, one solution is to add a length of cable (a skew equalization cable, or patch cable) to the wire that is shorter, to equalize the distances. Coaxial cable is preferred as an equalization cable since it maintains proper impedance.

The good news is that twisted pair cable test equipment measures and reports wire pair length, and the test results on the various pair lengths can be used in selecting the right length of skew compensation cable. Extron skew compensation cables are made in 10 different sizes, from two to 20 feet long.

**Skew Equalizers:** Extron manufactures two devices that use a time delay circuit on each color input that can be independently adjusted from 0 to 39 nanoseconds. The only difference between the two is the type of output connectors used. The **SEQ 100 BNC** and **SEQ 15HD Skew Equalizers** each feature three rotary switches on the front panel for adjusting the time delay. These independent rotary switches allow each color signal to be delayed to compensate for the different lengths of each pair of wires.

You can connect an Extron SEQ 100 Skew Equalizer between the twisted pair transmitter and the video source or between the twisted pair receiver and the display device, whichever is more convenient. The SEQ 100s can be mounted in a rack or under furniture and are equipped with external international power supplies.

As with skew compensation cables, twisted pair cable test equipment can be used to measure the lengths of the twisted pairs and determine the appropriate settings on the skew equalizer. If cable testing isn’t feasible, some trial and error is required to get the settings just right. Set up the system with a test pattern displayed on the screen. Examine the test pattern for loss of horizontal registration and make adjustments to the skew equalizers until the image is optimized.

Clearly there are numerous potential pitfalls when designing a twisted pair system for high resolution video. The advantages are also numerous, and Extron has a wide range of options for overcoming any technical challenges you may encounter.
Toshiba is offering the TLP-X4500U, an LCD projector ideal for use in large venue environments. This projector features three LCD panels at native XGA (1024 x 768) resolution. Brightness is rated at 4,500 ANSI lumens, and contrast ratio is specified at 750:1. The TLP-X4500U features a picture-in-picture mode for simultaneously displaying multiple connected video sources, top panel access to the lamp for convenient replacement, and a “whisper” mode which reduces fan noise. The TLP-X4500U has a suggested USD list price of $6,499.

Digital Projection recently introduced the iVision HD-7, targeted toward home theater and other applications. The iVision HD-7 features the high performance DLP™ HD2+ chipset, which includes a single DLP imaging device at 1280p (1280 x 720) native resolution, and a seven-segment color wheel. Brightness and contrast ratio are specified at 1,000 ANSI lumens and 3,000:1, respectively. Optionally available are a fixed, wide-angle lens, and a long-throw zoom lens. The iVision HD-7 has a suggested USD list price of $11,995.

Pioneer has introduced the PDP-504CMX, a 50-inch plasma display that features two Expansion Solutions™ card slots for accommodating various communications and video solutions from Pioneer and third-party manufacturers. For all Pioneer plasmas that support the ES format, Extron recently introduced the IPL M PDP-ES IP Link™ Ethernet interface module, which features an integrated Web server and pre-loaded control pages. The PDP-504CMX offers a native resolution of 1280 x 768 (WXGA) and PureDrive® video processing. A series of customizable display modes are included to help prevent image burn-in. The PDP-504CMX has a suggested USD list price of $12,500.

Panasonic recently unveiled the PT-DW7000U, a three-chip DLP projector for large venue applications. The PT-DW7000U utilizes three DLP devices at WXGA (1366 x 768) resolution, and delivers more than 5,000 ANSI lumens brightness and a contrast ratio of 3,000:1. Included are the Dynamic Iris for adaptive aperture adjustment, the BriteOptic™ dual-lamp system which provides for operational redundancy, and optional Ethernet connectivity for remote control and monitoring. The PT-DW7000U has a suggested USD list price of $27,000.

The ES70-116CMW from Hitachi is one of the newest VisionCube rear projector displays. Imaging is generated by three LCOS panels at SXGA+ (1400 x 1050) native resolution, and then projected onto a 70-inch lenticular screen with black striping to minimize ambient light interference. This projection system also features Optical Beam Control to uniformly distribute light throughout the screen and allow for wide-angle viewing. The ES70-116CMW has a suggested USD list price of $28,500.

ExtroNews publishes information about new products that are relative to the Extron product line in the New News section. If you would like a new product to be reviewed for New News, please send a press release, literature, contact name, and a color slide or photo to: New News c/o Lee Dodson, Extron Electronics, 1230 South Lewis Street, Anaheim, CA 92805, phone: (714) 491-1500, ext. 6394, or send e-mail to extronews@extron.com.
Tweeker Clock

Tweeker Use #70

With more than 50 Extron tweakers on hand, what’s an integrator to do? Put them to good use, of course. Tony Locke, of AV Frontiers in Redmond, Washington, built this clock out of pieces from a craft store. Twelve tweakers are fixed in place — each one is graced with a Roman numeral and a wood accent piece — forming the face of the clock. The clock is on display in the lobby of AV Frontiers, where customers comment on its nautical appearance and uniqueness. Tony says he has ideas for the remaining dozens of tweakers, but, he says, "They will require more thinking and planning."

Send us a photograph and brief explanation of how you use the Tweaker. If we publish it in a future issue of ExtroNews, we'll give you a free VTG 300.

Please send entries along with contact information to: Extro Tweaker Contest, 1230 South Lewis St., Anaheim, CA 92805.

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| Feb 24–25 | Philadelphia, PA |
| Mar 14–15 | The Netherlands |
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