

# From digitizers to charge-coupled devices:

(This no-nonsense, jargon-free overview of Tek products was produced under the direction of Corporate Public Relations Manager Jan Ohman says it came about because "there are many audiences, including editors, government officials and the local community," who really don't understand our complex array of products. She also mentioned—and we agree—that many non-technical Tek employees could use the same information.)

- **Instruments**—general test and measurement tools for research and development (R&D), engineering, manufacturing, and servicing. These tools include oscilloscopes, digitizers, signal processing systems, and associated accessories.

- **Communications**—specialized types of instruments for use in communications systems design, operation, and maintenance. This category includes spectrum analyzers, television products, data communications analyzers, and testers for both fiber optic and metallic cables.

- **Design Automation**—products focused primarily on the design, simulation, verification, and analysis of digital integrated circuits systems and subsystems associated with modern computer technology. These products include computer-aided engineering (CAE) and computer-aided software engineering (CASE) products, microcomputer development products, logic analyzers, and semiconductor test systems.

- **Information Display**—tools for displaying, manipulating, and documenting information, from business pie charts to three-dimensional views of spacecraft designs. Products include display terminals, PC graphics subsystems, workstation products, input and output devices, and software application and development tools to support these.

- **Components**—a wide variety of specialized hardware used in the above products. This category includes integrated circuits (ICs), hybrid circuits, display devices, and printed circuit boards (PCBs).

## Instruments

### Oscilloscopes

**Oscilloscopes** are basic electronic instruments that graphically display changes in voltage that occur within an electrical circuit over a period of time. Considered to be the most general, widely used measurement tool in the electronics industry, the oscilloscope is essential in the design, test and repair of many types of electrical equipment. Oscilloscopes can be used to study anything that can be converted into an electrical waveform: sound, heat, pressure, velocity, biological signals, nuclear phenomena.

A familiar type of oscilloscope (or "scope") is the medical monitor used in hospitals to track a patient's heartbeat. The monitor draws a continuous picture showing the rhythm (frequency), strength (amplitude), and shape of the heartbeat. In technical terms, the heartbeat is converted to an electrical signal and electronically displayed. The graphical representation of the heartbeat is referred to as a waveform.

Scopes vary in bandwidth (how fast a signal they can detect). Input signals are differentiated by their frequency or repetition rate, and are measured in hertz—a scientific unit for once per second. (A megahertz means a million times per second, and a gigahertz a billion times per second.)

As a general purpose testing tool, applications for oscilloscopes are many and varied. An oscilloscope can be used by an auto mechanic to check adjustments during a tune-up, or to measure heat build-up on the axle when brakes are applied. A more sophisticated oscilloscope can be used to measure the build-up of energy in a laser or the separate pulses in a pulse laser (in measurements of sub-billionths of seconds).

Some input signals may be very strong, but not repetitive, lasting just billionths of a second—not long enough to trace a waveform on a conventional oscilloscope display. Such transient (short-lived) waveforms can arise from lightning strikes, explosions, or high-energy laser pulses. A special cathode-ray tube

(CRT) called a direct-view storage tube is designed to retain these transient images for long-term viewing. Other oscilloscopes use digital technology to capture, store, and analyze waveforms.

The performance of some oscilloscopes can be varied, by adding one or more "plug-ins." For example, a plug-in amplifier can expand the sensitivity (amplitude segments) of the display, thus broadening the range of input signals the scope can measure. Plug-ins also include multichannels, multimeters, counters, oscillators, digitizers and various types of analyzers.

### Digital Oscilloscopes & Digitizers

Originally, all oscilloscopes were "analog"—they simply took an electrical event (typically a continuously varying electrical signal) and displayed a literal pictorial image of that event. The resulting display was a smooth, continuous waveform representing electrical "motion."

Although **digital oscilloscopes** are also used to display waveforms, their display is based on a series of closely spaced measurements rather than a continuous monitoring of the input signal. In much the same way that a movie conveys the illusion of motion by projecting a series of snapshots taken at very close intervals, the digital scope reconstructs a waveform from numerous individual measurements taken along the input signal's transition. The resulting waveform display is a "dotted-line" representation of the signal. The viewer, however, sees this image as a continuous line if the intervals between measurements are short enough.

A waveform represented digitally, as a series of numbers, can be stored in a digital memory such as that used by computers. An oscilloscope that captures and stores waveforms in this manner is called a **digital storage oscilloscope (DSO)**. Once digitized and stored in DSO memory, the waveform can later be recalled, displayed, analyzed, compared with other waveforms, or transferred to a computer for data collection and analysis.

**Waveform digitizers** are similar to digital storage scopes except that they have no display screen. They are typically used to capture waveforms and transfer them to a computer. In large research projects, for example, numerous waveforms may be captured from different parts of an experiment by banks of waveform digitizers. This mass of experimental waveform data is then off-loaded to a computer for sorting and analysis.

The premiere distinction of waveform digitizers is that they generally employ the latest digitizing technology. Digitizing is done in "real-time" (as the waveform actually varies), at extremely high speeds, and with a great deal of precision and accuracy. These high-performance, real-time attributes make waveform digitizers particularly useful for capturing one-shot waveforms such as lightning strikes, high voltage discharges, laser pulses, rocket ignition, material failure, and other phenomena common to advanced research and engineering.

### Signal Processing Systems

To process a signal means to change it in some way to make it suitable for a particular use. Radio signals are processed by frequency modulators for use in FM receivers. In the digitizers described above, analog signals are processed by analog-to-digital (A/D) converters.

**Signal processing systems**, however, refer to the type of processing that allows several different instruments to feed data into a computer for compilation and analysis. A typical signal processing system combines digital storage scopes or waveform digitizers with a computer and analysis software. Since most modern instruments, including many models of oscilloscopes, are digitally programmable, such a system often encompasses the power to automatically set up instrumentation, as well as to gather measurement data from the instruments, analyze the data and print final results.

In more common terms, signal processing systems are to the technical community what spreadsheets and financial systems are to Wall Street, what word processing and satellite news links are to Time and Newsweek. Signal processing systems are information gathering and processing tools for scientists and engineers.

## Communications

### Spectrum Analyzers

A **spectrum analyzer** is a special kind of oscilloscope that displays and measures the amplitude of the individual frequency components of a complex signal. It is an essential tool used to check and adjust transmitting and receiving equipment throughout the whole range of communications.

The spectrum analyzer display shows amplitude vs.

frequency rather than amplitude vs. time (the latter being what an oscilloscope displays). The spectrum of individual frequency components can be shown as a bar graph or a continuously varying analog display, or it can be digitized for use in computer-controlled systems of automated spectral measurement and analysis. For example, a spectrum analyzer can be used by an engineer to align and maintain a radar system, or to verify broadcast quality and maintain broadcast signals within FCC regulations.

To gain some insight into frequency components and the frequency domain, think about striking a single key on a piano. You would hear a single, pure tone or frequency. Strike eight keys simultaneously and you hear a more complex sound made up of a collection or "spectrum" of frequencies. Except for fundamental waveforms (pure tones), most waveforms—from the sound of an orchestra to space vehicle telemetry—are made up of a spectrum of frequencies. A spectrum analyzer, then, is an instrument that breaks a waveform into its individual frequency components.

### Television Products

Several specialized types of oscilloscopes have been developed to help broadcasters and service technicians maintain the level of quality that television viewers have come to expect. **Video picture monitors** are used to check overall picture quality, while **video waveform monitors** examine the separate video signals. **Vectorscopes** are used for precise adjustment and monitoring of color signal relationships and quality.

Various types of **signal generators** produce specialized reference waveforms for broadcast transmission test and alignment. **Audio signals** are also monitored, and both **audio and video synchronizers** are used to assure that all signals mesh properly on the television screen.

### Cable Testers

Communications systems use millions of miles of cables ranging from voice-frequency telephone lines to the high-frequency cabling used on satellite dishes. **Cable testers** are used to measure the length of these cables, and to detect the location of breaks or reflections indicating pinches or other irregularities that degrade transmission quality.

Two basic kinds of cable are used: wire or metallic for electrical transmission of information, or fiber-optic for lightwave transmission. The fundamental concept of both types of cable testers is the same: precise measurement of electrical echoes. The cable tester applies a fast pulse of voltage (for metallic cables) or light (for fiber-optic cables) to one end of the cable, and displays timed reflection (echo) waveforms caused by irregularities along its length and by the break at the end. This process of reflection measurement and analysis is called time-domain reflectometry, or simply TDR, and cable testers are often referred to as TDR's.

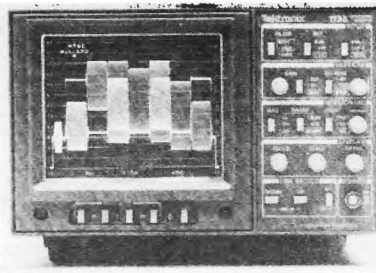
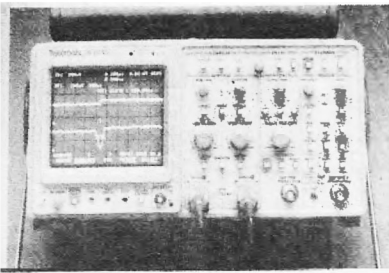
### Data Communications Analyzers

Digital data communication links are used for networking computers and workstations together, for linking personal computers through telephone modems to central computers, and for compressing multiple voice channels into single digital telecommunications channels for long-distance connections. **Data communications analyzers** are special instruments that detect data content errors and assist in analyzing and isolating error sources. They can be used to check newly installed communications links to verify that they are data-grade links, or to troubleshoot existing data links when problems occur.

### Television Production Equipment

A wholly owned Tektronix subsidiary, The Grass Valley Group, manufactures a range of television production equipment. **Switchers** are used to assemble visual elements into the complete program seen by the viewer, e.g. to "cut" (switch) from one camera to the next, "dissolve" (fade-out, fade-in) from one scene to another or to add text to a television picture. Switchers are used "live" in the case of news and sports programs, and "off-line" in editing suites, where the picture elements have been pre-recorded on videotape.

Switchers can create some special effects, but more complex effects are achieved with **digital special effects equipment**. These are high speed digital computers capable of expanding, compressing, and rotating television images in almost any conceivable manner. A fully featured digital special effects system can create the same variety of effects seen in films, but with a difference: the effects are achieved in seconds or minutes as opposed to the days or weeks required with film techniques.



# A non-technical overview of Tek products

Editors are special-purpose computers used in editing suites. They are used to start and stop videotape recorders and control the operation of switchers and digital effects systems. Editors perform to an "electronic script" prepared by the operator and stored in the computer. Editors are much faster to use than motion picture splicing machines. Although many prime-time television programs are shot on film, editing is done with TV editors.

## Line and Terminal Equipment

In addition to television production equipment, Grass Valley Group manufactures a wide variety of line and terminal products that are used for distributing, synchronizing, processing and routing television signals throughout television studios.

## Telecommunications Equipment

Grass Valley Group also produces a range of video products for use by telephone companies and other common carriers. The core product group is a family of fiber optic transmission systems which are used to deliver television images over long distances.

## Graphics Equipment

Grass Valley Group's wholly owned subsidiary, Dubner Computer Systems, produces a variety of equipment that generates synthetic television images. Examples include: **Character (font) generators** for use in captioning scenes, **painting systems** enabling artists to electronically "draw" and modify television images and **animation systems** to create moving, animated sequences.

## Design Automation

### Logic Analyzers

**Logic analyzers** are the oscilloscopes of digital design. Where standard oscilloscopes represent signals in the time domain, and spectrum analyzers in the frequency domain, logic analyzers work in the digital data domain. They are used by design engineers to analyze and debug design circuitry at a component, board or system level.

The language of the data domain consists of signals representing "1s" and "0s" and binary combinations of those signals. A logic analyzer captures, pictures, and examines these coded "bits" of data streaming over many channels at once. By allowing engineers to examine digital signals in various combinations, the logic analyzer helps design, test, and troubleshoot computers and related devices and systems, from mainframes to microprocessors.

A pattern generator may be used to stimulate circuits to produce varied formats so the logic analyzer can scrutinize the resulting data streams. Tek's most sophisticated logic analyzer combines pattern generation with logic analysis. It is typically used for hardware and software integration, microprocessor design support, verification of prototype integrated circuits, and circuit board testing.

### Semiconductor Test Systems

Much of today's technology depends on complex electronics compressed onto small chips of silicon, a semiconductor material. This technology-on-a-chip is referred to as an integrated circuit, or IC.

**Semiconductor test systems** are designed specifically to meet the total test requirements for mass-produced IC's accurately, reliably, quickly and economically. Tests often include thousands of input signal combinations on as many as 200 or more pins, with verification of the resulting output pin patterns. Pattern requirements may be on the order of hundreds of thousands per device. Reliability goals are often "zero defects" for all operational conditions.

### Computer-Aided Engineering

Computer-aided engineering (CAE) deals with software representation of electronic components, how they are connected together, and how they function together—the meaning, grammar, and syntax of electronic circuit design. CAE tools allow engineers to create and modify complex designs on graphic terminal screens, and to simulate them functionally before building them.

Tektronix CAE systems also facilitate transfer of design data from schematic capture and design verification through layout, fabrication, and final test. This total follow-through provides fully-integrated CAE systems—from concept to finished product—for printed circuit board and application-specific IC (ASIC) design.

## Computer-Aided Software Engineering

Computer-aided software engineering (CASE) applies the principles of CAE to the design of software. CASE tools give software designers a tightly integrated set of structured methods tools that automate the development of software from analysis to design to code verification. These tool sets are graphically oriented and automate the process of conceptualizing and implementing software designs.

## Microcomputer Development

Microcomputer development products help design engineers develop software and firmware (the installed software that controls an instrument) for embedded microprocessor applications (where the microprocessor controls the instrument). These tools include cross assemblers; C, Pascal and Ada™ language development systems; and emulation systems for software/hardware integration and verification.

Tektronix language development systems provide designers with high-level language cross compilers that are optimized for microprocessor applications. Cross assemblers and cross compilers generate programs that can be used on other computers (as opposed to those generated for the specific computer they operate on). Additional software tools, such as editors, assemblers and high-level debuggers, help automate the development and verification phases of product development.

## Information Display

### Graphics Terminals

**Graphics terminals** create, analyze, and display graphic information generated by a host computer for mechanical and electronic design, scientific and medical research, and business and manufacturing applications. Terminal users choose from various features, such as display resolution, screen size, color range and quality, support for local graphics processing, depending on their individual needs. Graphics terminals have a wide variety of applications, from low cost terminals for departmental computing and technical data analysis, to PC graphic systems for design and analysis, to high-performance terminals for three-dimensional solids modeling and stereoscopic viewing.

### Graphics Workstations

**Graphics workstations** combine a graphics display, a computer, a local area network connection, and mass storage in a standalone product. Local processing power enables workstations to offer superior graphics performance and display capabilities and offer the user all the features of a dedicated computer and the productivity advantage needed for complex tasks. Multiple workstations can be linked through networks to allow file sharing, electronic mail and other types of information transfer.

### Graphics Software

**Graphics software products** include both application software and software development tools. Application software is designed to perform particular tasks, ranging from business graphics to two-dimensional computer-aided drafting, to the design and analysis of complex three-dimensional scientific or engineering models. Software development tools are the building blocks that application developers use to write graphics software programs. Both the application software and development tools extensively use the graphics functions provided in terminals, workstations, and color image printer products.

### Graphics Input and Output Devices

Information can be entered into graphics terminals and workstations in ways other than through keyboard. For example, **graphics tablets** can convert drawings to computer graphics by tracking a stylus' movement on a drawing and converting that information to a computer format, and a **graphics input workstation** can scan architectural drawings on paper and convert them to computer formats for quick and economical maintenance.

Monochrome and color output devices produce hard copies of images displayed on graphics terminals and workstations. With varying speed and grayscale capabilities, monochrome hard copy devices can yield photographic-quality images in black and white. Color ink jet and thermal wax printers produce sharp, vividly colored images on paper or plastic transparencies.

## Components

### Integrated Circuits

**Integrated circuits (IC's)** are an assembly of electronic elements in a single structure. Created by various chemical deposition and diffusion processes, IC's contain combinations of active devices (transistors and diodes) and passive components (resistors, capacitors, and inductors) on a substrate such as silicon or gallium arsenide.

IC's using gallium arsenide as a base material offer significant speed and power conservation advantages over silicon IC's. A Tektronix subsidiary, TriQuint Semiconductor, specializes in **gallium arsenide IC's** for digital, analog, and microwave applications.

**Semi-custom IC's** are built by designing interconnect schemes for basic prefabricated structures containing unconnected components. Tek offers various design tools which allow customers to design their own application-specific IC's (ASIC's).

**Charge-coupled devices** are special IC's that convert one form of electric charge to another for additional processing. They are used in waveform digitizers to convert analog signals to digital, or vice versa. CCD imagers, which convert light photons to electrons for amplification, are of particular interest for low-light photography.

### Hybrid Circuits

The combination of several diverse technologies within a single device is known as a **hybrid circuit**. There are two types of hybrid circuits, thick film and thin film. **Thick-film circuits** have passive components (eg. resistors, capacitors) and conductors screen-printed onto a slice of ceramic called a substrate. **Thin-film circuits** have a coating deposited over the substrate surface. Areas are then etched off and the metal is deposited to fill the etched areas forming passive components or conductors. Thin-film circuits, while generally more expensive, allow for either miniaturization or the ability to pack more components in the same area. Active devices (eg. transistors, IC's), which alter the passage of electrons in some way, are then wired or bonded directly to the passive elements on both types of hybrid circuits. This direct bonding method is referred to as **surface-mounting**.

A **multilayer ceramic (MLC) hybrid** is a sandwich of co-fired, stacked and layered substrates isolated from each other which can be interconnected by vertical conductors called **vias**. The top layer of the MLC is a conventional hybrid with active components bonded to the passive layer. Lower co-fired substrates may contain power, ground planes, or sensitive signal circuitry. MLC's are also used as a packaging device for high-density IC's.

A **laser diode module** is a specialized hybrid circuit that creates information electronically but transmits the information over optical fibers. A laser diode module of this type provides high-speed (to a billion digital bits per second) lightwave transmission in fiber-optic communication.

### Circuit Boards

**Printed circuit boards (PCB's)** are the building blocks of electronic equipment. Conductors are etched on a substrate to provide interconnection of devices. For simple applications, conductors are etched on two sides of a substrate. For more complex, higher-density circuit boards, conductors are sandwiched between layers of the substrate. Tektronix typically builds PCB's with two to ten layers.

Devices are interconnected on PCB's by soldering various electronic components (resistors, capacitors, inductors, transistors, etc.) to the board or by mounting unpackaged parts such as transistor chips, hybrid circuit substrates, or even IC chips directly on the board surface (using surface mount technology).

### Display Devices

Much of the **cathode ray tube (CRT)** technology originally developed for Tektronix oscilloscopes is available to outside customers in various types of display devices, including a broad line of standard, modified and full custom CRT's, as well as ultra-high-resolution monochrome monitors. Extremely high resolution makes these monitors useful for sophisticated applications which require grayscale imaging or fine detailing, such as medical, document retrieval, and publishing. In addition, the Tek Touch™ touch panel input device allows interactive communication between an operator and an electronic system by simply touching the screen.

A related product line is avionics color displays which are used in military aircraft instrumentation panels. These color cathode ray tubes are designed to be sunlight readable and are ruggedized to meet military standards. □