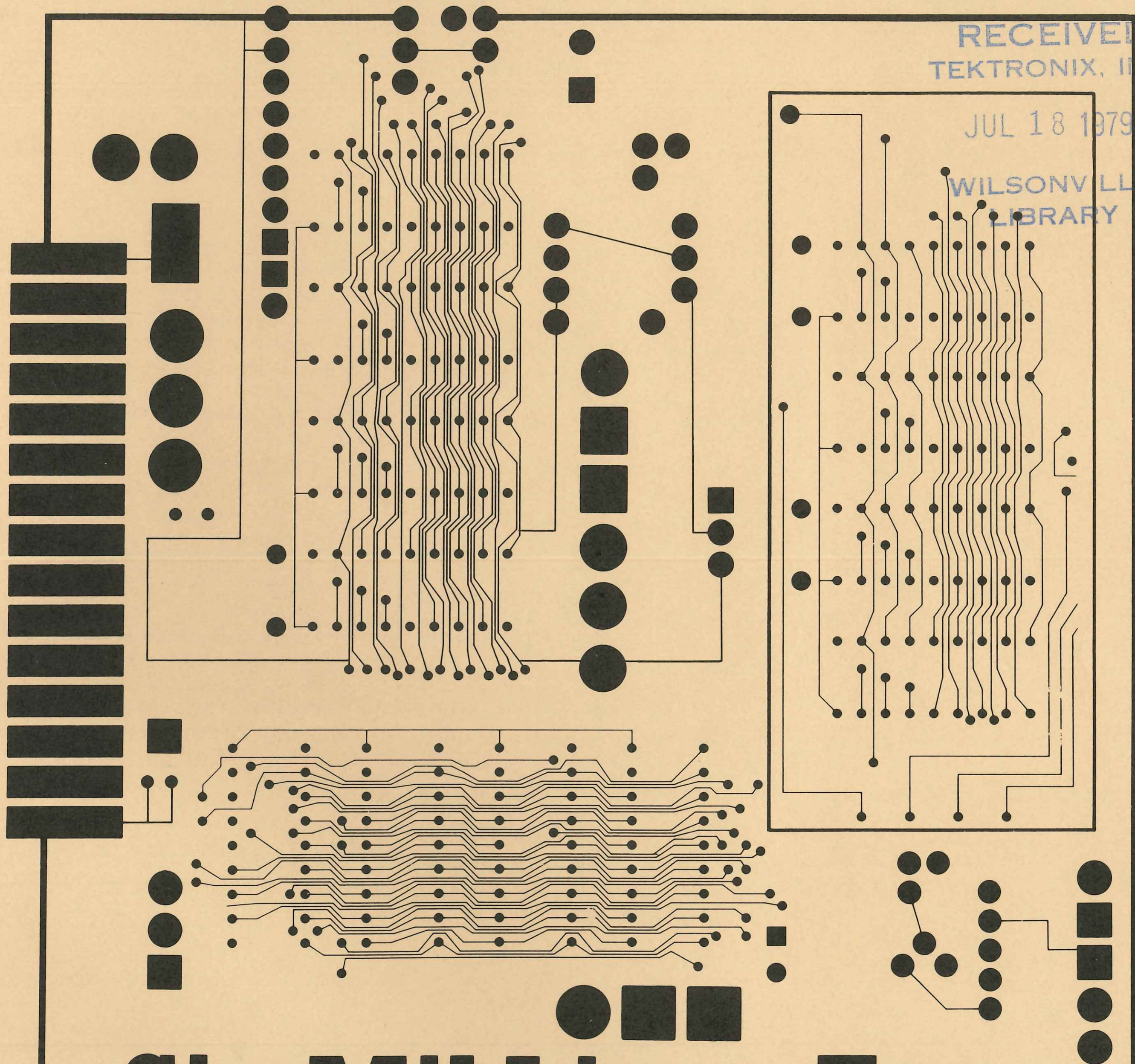
ENGINEERING NEWS

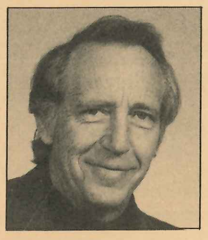
COMPANY CONFIDENTIAL

FEBRUARY, 1979



Six Mil Lines For Tek PC Boards?

Six Mil Lines For Tek PC Boards?



Glenn Schwalbe, Electrochemical Development Engineering, ext. 7830 (Beaverton).

Progress in printed circuit board technology clears the way for progress in other areas of electronic product manufacturing: space savings, increased circuit modularity, and long-range savings in materials costs. Electrochemical Development Engineering's charter is to provide Tektronix with state-of-the-art components and processes using electrochemical technology which includes circuit board technology. This article is the first of several articles on developments in that technology.

Most Tektronix electronic products have circuit boards using runs (circuit lines) as narrow as 12 mils. However, in December 1977, Underwriters' Laboratories certified printed circuit boards with runs as thin as six mils. Competitive pressure leads us to examine the trade-offs of these very narrow runs.

ALTERNATIVES

While our products are increasingly more complex, customers are also demanding smaller and lighter products. Circuit board designers can meet increasing complexity in several ways: use more boards, larger boards, multilayer boards, or put more circuits on the same board space. Using more boards or larger boards is unattractive because raw materials costs are increasing, volume productivity has limits, assembly and interconnection become more complex, and because mechanical designs are more difficult to resolve because of greater circuit density.

Using multilayer boards saves space but is not attractive from a manufacturing point of view: reliability is lower for multilayers than for comparable two-layer boards, and costs are higher. However, despite these drawbacks, many applications do require multilayer boards.

BENEFITS

Having more circuits on each board by using narrower circuit runs offers several benefits. For a given product, narrower runs enable us to use fewer and smaller boards thus allowing the product to be smaller. Fewer boards also means lower costs for laminate and lower handling costs. Processing costs such as deburring and copper etching will be lower because thin-clad laminates require less etch time, chemicals, and waste treatment.

Fortunately, we can use our present processing equipment. In manufacturing six- and eight-mil-line boards, we won't face any capital expenditures. Instead, successful production of six- and eight-mil-line boards depends on process control and attention to operational details.

Another major benefit of six- and eight-mil runs is that their use allows circuit board designers more room for innovative designs such as laying runs between integrated circuit pads and extensive use of feed-throughs (connections from one side of a board to the other through copper-plated holes).

CONSTRAINTS

As in any engineering advance, there are drawbacks as well as benefits in using six- and eight-mil runs.

Electrochem manufacturing must devote even more attention to detail than they now do. For example, in just one area of printed circuit board processing, creating the filmwork, Manufacturing personnel must follow at least the seven guidelines shown in figure 1.

Because of the narrow run widths and the close spacing between runs, Manufacturing will not be able to repair board areas that have cut runs. This means that reducing the number of rejects will require careful process control and handling.

Nor will photo image repair and touch-up of the photoresist prior to plating be possible because of the close spacing. Using microscopes, it is possible to repair damaged runs, but a better way is to strip the photo image and reprocess until the image is perfect.

Another requirement is that circuit board designers *must* use computer-aided design to generate artwork. Computer-aided design provides precisely-controlled runs and spacings and thereby aids quality control.

Six-mil circuit board runs will also require thin copper-clad laminate. Refer to figure 2. Etching runs on thick copper-clad laminate requires a longer etching process. This length of time allows the etching to undercut each run, leaving only two or three mils of the run attached to the laminate. Thinner copper-clad laminate requires less etching time. Consequently, the undercut is much less too. For example, etching thin copper-clad laminate to produce six-mil runs will leave as much as five and a half mils still attached to the laminate. ("Ultra-Thin Copper Clad PC Boards", an article in the June 1,

CONSTRAINTS USING SIX- AND EIGHT-MIL RUNS

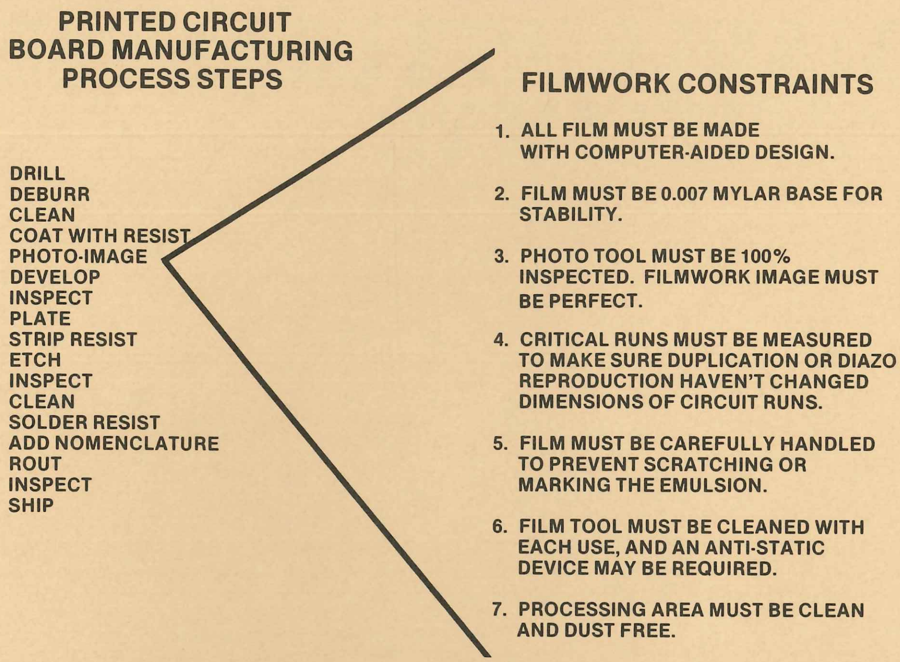


Figure 1. Six- and eight-mil lines on printed circuit boards will bring constraints as well as benefits. One constraint is that Manufacturing must tighten its process controls even more than now. For example, in just *one* process area, creating filmwork, board designers and Manufacturing personnel must follow the seven guidelines shown here.

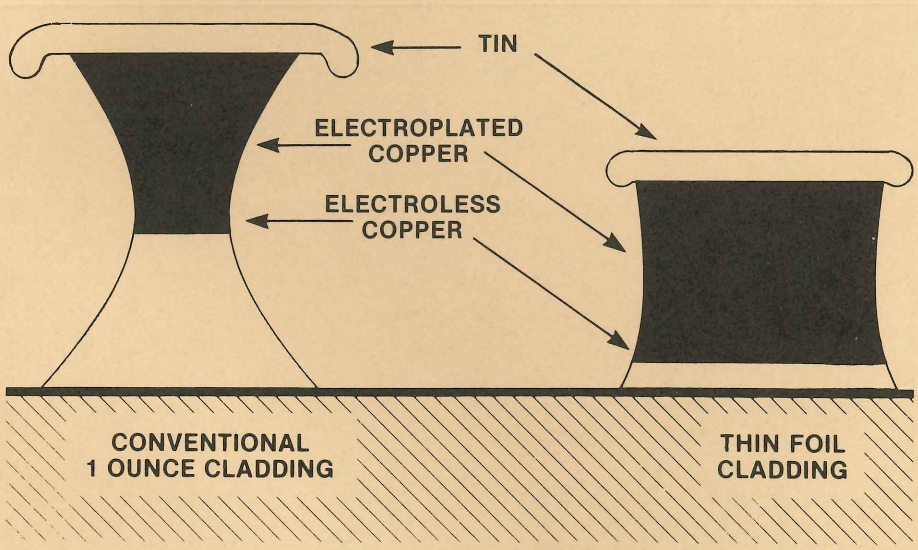


Figure 2. To produce six-mil runs, Manufacturing must use thin copper-clad laminate. Etching runs on "thick" (one-ounce) cladding requires a long etching process. During this lengthy process, the etchant undercuts each run, leaving only two or three mils of the run attached to the laminate. Thinner copper-clad laminate requires less etching time and consequently less undercut. Less undercut means fewer broken runs and therefore more reliable circuit boards.

1977 **Engineering News,** discussed this in detail; for a copy, call T&M Publicity on ext. 6792 or write to 19/313. An extensive report is available by calling Glenn Schwalbe on ext. 7830).

COSTS

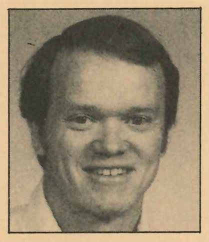
In the short range, using six-mil runs seems more expensive. Though processing and quality control will probably be more expensive than with 12-mil run boards, improved processing control will restrain increasing manufacturing costs. Nevertheless, the electronic industry can no longer afford to think of printed circuit boards as unimportant and cheap components. We don't hesitate to put twenty $35 integrated circuits on a $10 circuit board, but we do hesitate to use a $50 board in spite of the benefits it may bring. We must realize that advanced technology printed circuit boards are a vehicle for progress in other areas of electronic product manufacturing. □

ANSWER SYSTEM TAPE AVAILABLE

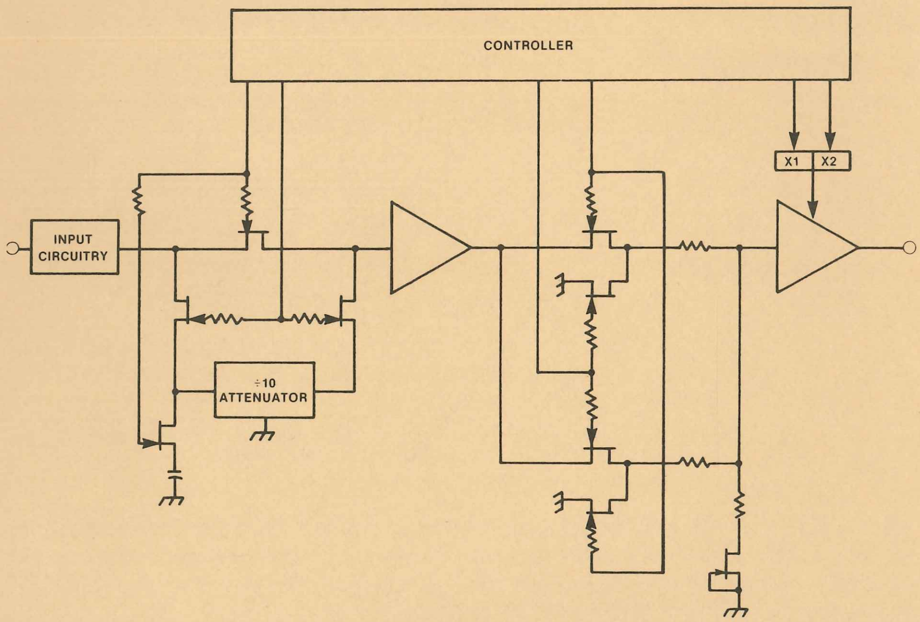
Cassette recordings of Programmable Instrument Seminar No. 8, "The ANSWER System," are available from Ann Baynton (Digital Product Coordination group). To borrow the cassettes, call Ann on ext. 7095. □

PATENTS RECEIVED

PROGRAMMABLE ATTENUATOR WITH FET SWITCHING



Des Murphy,
High-Frequency Component Development, ext. 7033 (Beaverton).



High-impedance programmable attenuators have used rotary or turret construction and electromechanical devices. Compared to newer alternatives, such attenuators are expensive, unreliable and perform poorly.

Recently, hybrid passive attenuators appeared on the market. In these devices, manufacturers mount hybrid passive attenuator elements on a circuit board. Cam-actuated circuit-board-mounted contacts provide switching. These attenuators perform better and are more reliable than turret and rotary attenuators, but they have drawbacks: they are not programmable, and the contacts suffer from mechanical wear and tear. Mechanical deterioration adversely affects high-frequency performance.

In the invention shown here, a high-impedance step attenuator uses programmable FET switches. The FET switches don't have the maintenance problems that plague electromechanical switches. This invention includes both high-impedance and low-impedance attenuator sections mounted on a circuit board. In the high-impedance attenuator section, additional active FET switches and passive networks compensate for parasitic capacitances inherent in the FET's. Thus, this programmable attenuator has an extremely wide frequency response. The 7A16P Programmable Vertical Amplifier uses this circuit. □

ENGINEERING NEWS PAPER POLICY

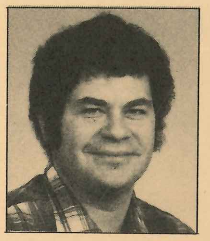
Recent issues of **Engineering News**, **Software News** and **Forum Reports** were printed on Exact Matte paper. We selected Exact Matte for its exceptional qualities and its low cost (15% less than the Howard Offset paper formerly used).

Sized (made water-resistant) with a particle coating, the paper surface allows photographs to be printed as clearly as those printed on more expensive, coated (slick) stock. Additional advantages are uniform texture and opacity, necessary qualities for printing charts, drawings and technical equations.

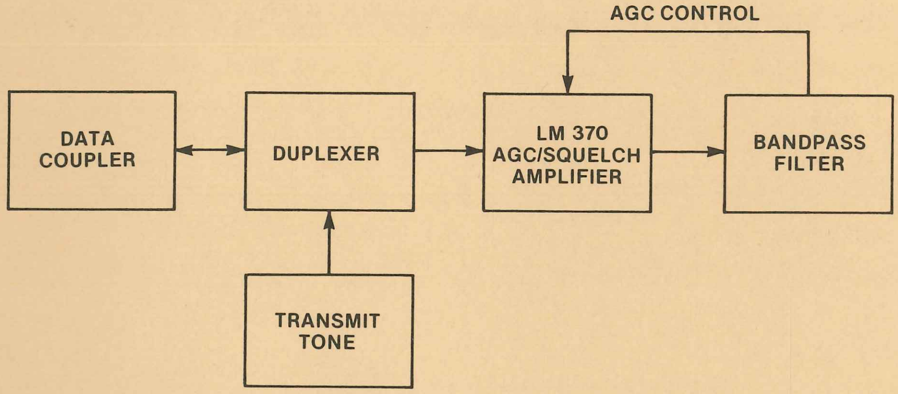
Exact Matte paper is not recycled paper (recycled paper is too expensive) and is not WOWable, but it *can* be recycled. Send extra **Engineering News** and other non-WOWable paper, in quantity, to Material Evaluation at D.S. 71-474. Non-WOWable paper should be marked "SALVAGE".

For more information call Joan Metcalf (graphics designer for **Engineering News, Software News,** and **Forum Reports**) on ext. 6792. □

MODEM MOD FOR BAD TELEPHONE LINES



Walt Catino, Service Instruments Division Applications Engineering, ext. 206 (Town Center).



Within Tektronix, many engineers use modems for communicating between "board buckets" and the Scientific Computer Center's Cyber systems. The most commonly used modems are the SCC E-5131-XB and the Crt Engineering E-5767-X. Both modems seem designed for the low-noise telephone lines used at the Beaverton campus.

When SID Applications Engineering moved to Town Center in Aloha, we found our modems' RECEIVE sensitivity too low for the telephone lines between the Cyber and Town Center.

The two Tektronix modems, like most modems, are designed to receive signals at a -8 dB level. At Town Center, the level varies between -15 dB and -25 dB. The transmit tone interfered with the low-level signals and produced an intolerable number of errors. (Occasionally the telephone lines did provide good signal levels but we couldn't rely on them.) Apparently the varying line levels required an automatic gain control. A control device that would provide a gain of up to 10 dB would solve the problem.

National Semiconductor makes an LM370 AGC/squelch amplifier ideally suited for this application.

In either the SCC or CRT Engineering modem, you can insert the LM370 between the duplexer and the bandpass filter (this placement avoids disturbing the filter's characteristics). The LM370 taps AGC feedback from the second filter stage, thus varying the gain only of the frequency ranges we're interested in (2025Hz-2225Hz in the RECEIVE mode, 1070-1270Hz in the TRANSMIT mode).

The LM370 does amplify the transmit tone somewhat, but the filter makes the increase insignificant. Ordinarily the LM370 requires dual power supplies, but in this application they aren't needed because, even at full gain, the LM370's output voltage swing isn't great enough. Also, the LM370's maximum supply voltage is 24 volts, which means that the dual supplies (+ and -12v) would operate the LM370 too close to its maximum voltage rating.

At the Town Center, we've used these modified modems for 3 months and are no longer plagued by receive errors.

FOR MORE INFORMATION

For a schematic of the modified E-5131-X13, call T&M Publicity on ext. 6792 or write to 19/313. Ask for Special Design File No. 27. □

POROUS ZINC ELECTRODE STUDY

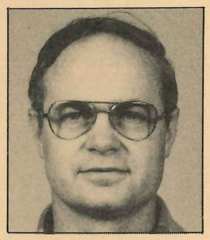
At the October, 1978 Electrochemical Society meeting in Pittsburgh, Drannan C. Hamby, Nancy Jo Hoover and Kent Piepgrass presented "Concentration Changes in Porous Zn Electrodes During Cycling." Hamby, Hoover and Piepgrass are Linfield College (McMinnville, Oregon) students studying materials at the Linfield Research Institute.

A Tektronix Foundation grant enabled the researchers to buy an atomic absorption spectrophotometer for their study.

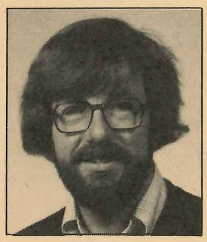
For a copy of the study, call T&M Publicity on ext. 6792 or write to 19/313.□

PATENTS RECEIVED

EXTRACTING SYNC INFORMATION FROM A COMPOSITE WAVEFORM



Stephen A. Roth, TV Products Engineering, ext. 7457 (Beaverton).



Kenneth G. Schlotzhauer, Monolithic Circuits Engineering, ext. 6362 (Beaverton).

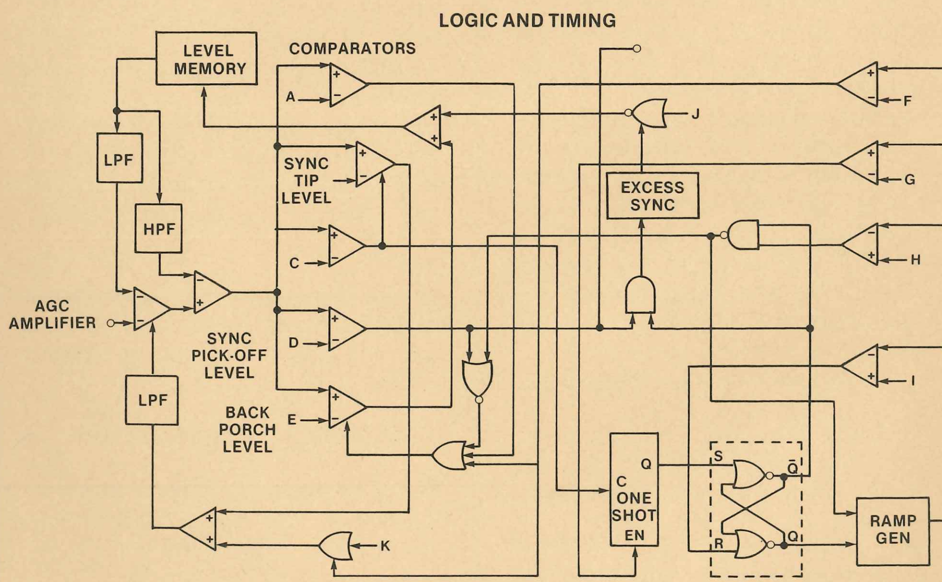
Nearly all Tektronix TV products require a sync stripper circuit to extract sync information from a composite video signal. The products use the sync information to synchronize their circuits with video signals.

For some products, the extraction must be very precise. For example, products which regenerate and replace the sync require very high precision extraction. However, there are problems that the extraction circuits must overcome: the sync signals may contain unwanted information such as 60Hz hum, white noise, or impulse noise; transmission errors (such as loss of low frequencies or "tilt") may degrade sync signals; and sync signals may contain unwanted information in the sync pulse itself (an example is "sound in sync"). Also, the sync signal's amplitude may vary over a 100/1 range (8 volts to 80 millivolts), and sometimes even the dc level may suddenly change.

The patented circuit shown here optimally solves these sync extraction problems. Most Tektronix TV products use this circuit in one of two forms: assembled with discrete components or as an integrated circuit.

In the sync-extraction process, an AGC amplifier amplifies a replica of an input composite video signal and shifts its level until the sync tip and blanking level arrive at the upper and lower voltage levels respectively. There is a middle level between the upper and lower lines. The patented circuit shown here determines the sync information from the time at which the sync pulse crosses the middle level.

Refer to the circuit diagram. Three main circuit blocks perform sync extraction: an automatic gain control amplifier, a bank of comparators, and a logic/timing circuit. The AGC amplifier normalizes, into a standardized input signal, any composite video signal within its dynamic range. The parallel bank of comparators examines the sync portion of the normalized output for several features. With the logic and timing network, the feedback adapts the AGC amplifier's gain and level to achieve the desired normalization. In fact, a sampled data feedback loop forces the output of the AGC amplifier to place the sync tip at one level and blanking at another. Another comparator, located half way between these two levels, obtains the sync information. □



TECHNICAL STANDARDS AVAILABLE

Technical Standards (part of T&M Operations' Engineering Services) has revised many old standards and produced many new standards in the last year. The table below lists all part-numbered Tektronix technical standards. Unless otherwise specified in the list, call Reprographics on ext. 5577 for a copy of any of the listed standards. Direct questions about Tektronix standards to Technical Standards, ext. 7976.

062-1699-00	Introduction, Directory (in Directory, call Technical Standards, ext. 7976), 26 June 1978.
062-1700-00	Subject Index, Directory (in Directory, call Technical Standards), 12 August 1977.
062-1701-00	Trademarks, Copyrights, and Related Proprietary Matters, 12 June 1978.
062-1702-00	Fabrication, Welding, Soldering, and Brazing, 15 March 1977.
062-1703-00	Finishes, Glossary, 2 September 1977.
062-1704-00	Drafting, Decimal/Inch Dimensioning, 22 June 1978.
062-1705-00	Metric, Drawings*, 5 August 1977.
062-1706-00	Converting Fractions to Decimals, 18 November 1974.
062-1707-00	Rounding off Decimal Numbers, 18 November 1974.
062-1708-00	Drafting, Drawing Format, 1 June 1978.
062-1710-00	Test Method, Test Procedures for Panels and Tags, 8 November 1978.
062-1714-00	Tooling, Wiedeman Dies and Punches, 25 July 1978.
062-1716-00	Drafting, Symbols for Tolerances of Position and Form, 29 November 1977.
062-1718-00	Finishes, Cosmetic, 8 November 1977.
062-1720-00	Finishes, Mold Surface Finishes for Plastics, 12 January 1977.
062-1721-00	Circuit Board, Drafting, 10 November 1978.
062-1723-00	Circuit Board, Manufacturing, One and Two Layers, 2 June 1978.
062-1725-00	Circuit Board, "EC 200B," 4 February 1977.
062-1727-00	Circuit Board, Multi-Layer, Manufacturing, 12 September 1978.
062-1731-00	Hardware, Weld Studs and Posts, 12 January 1977.
062-1732-00	Component Mounting, 10 July 1978.
062-1732-01	Component Mounting, A Series Details, 14 April 1978.
062-1732-02	Component Mounting, B Series Details, 14 April 1978.
062-1732-03	Component Mounting, C Series Details, 14 April 1978.
062-1732-04	Component Mounting, D Series Details, 14 April 1978.
062-1732-05	Component Mounting, E Series Details, 12 October 1976
062-1732-06	Component Mounting, F Series Details, 8 September 1977.
062-1732-07	Component Mounting, H Series Details, 12 October 1976.
062-1732-08	Component Mounting, M Series Details, 12 October 1976.
062-1733-00	Rackmount, 1 February 1977.
062-1736-00	Communications, Technical Terms, 7 January 1977.
062-1737-00	Communications, Abbreviations, Acronyms, and Symbols, 20 July 1978.
062-1738-00	Available Part-Numbered Standards (in Directory, call Technical Standards), 26 June 1978.
062-1778-00	Circuit Board, UL Recognition and Flammability Classification, 24 January 1977.
062-1780-00	Interface Language, High Level Format (replaced by 062-1780-01).
062-1780-01	Interface, General Purpose Interface Bus (GPIB) Codes and Formats, 6 July 1978.
062-1860-00	Product Safety for X-Radiation, 19 May 1975.
062-1874-00	Drafting, Line Conventions and Lettering, 15 May 1978.
062-1875-00	Drafting, Projections, Views and Sections/Details, 13 June 1977.
062-1879-00	Cable, Product Wiring, Internal, 17 March 1978.
062-1880-00	Cable, External Interconnecting and Power Cables, Drafting*, 4 April 1977.
062-2318-00	Circuit Board, Marking Adherence and Solder Flux Cleaning, 1 April 1976.
062-2319-00	Cylindrical Cam Switch, 30 June 1976.
062-2463-00	Index, Letter Series, (Directory, call Technical Standards), 26 June 1978.
062-2476-00	Drafting, Symbols, Schematic Diagrams, Electronic Circuits, 31 July 1978.
062-2801-00	Occupational Safety, Distribution Procedures (call Corporate Safety & Health, ext. 6413), 25 June 1976.
062-2801-01	Occupational Safety, Warning Alarms, 28 June 1977.
062-2801-02	Occupational Safety, Exhaust Hood Classification, 20 September 1976.
062-2801-03	Occupational Safety, Handling Flammable Liquids Under Pressure, 22 February 1977.
062-2801-04	Occupational Safety, Forming and Shaping of Asbestos Materials, 16 September 1976.
062-2801-05	Occupational Safety, Open Tank Classification, 8 August 1977.
062-2843-00	Drafting, Drawing Scale, 5 October 1976.
062-2846-00	Drafting, Glossary, Dimensioning and Tolerancing, 14 October 1976.
062-2847-00	Product Design, Environmental Test, Atmospheric, 15 June 1977.
062-2848-00	Fabrication, Bend Allowance and Deduction, 10 November 1977.
062-2851-00	Cable, Glossary, 2 November 1976.
062-2853-00	Product Design, Environmental Test, Product Classification, 13 June 1977.
062-2858-00	Product Design, Environmental Test, Dynamics; Vibration, Shock & Transit, 17 June 1977.
062-2862-00	Product Design, Environmental Test, Electrostatic Discharge, 20 October 1977.
062-2866-00	Product Design, Environmental Test, Electromagnetic Compatibility, 31 March 1977.
062-2868-00	Finish, Etch, Chromate, and Lacquer on Aluminum, 4 December 1978
062-2877-00	Cable, Wire and Cable Color Coding System, 21 October 1976.
062-3083-00	Documentation, Assignment of Item Name, 8 March 1977.
062-3099-00	Drafting, Engineering Change Order (ECO), 27 April 1978
062-3108-00	Circuit Board, Electrodeposited Gold Plate, Contact Areas, 20 October 1977.
062-3109-00	Documentation, Technical Standards, Procedures and Format, 4 January 1978.
062-3134-00	Color, Color Description, Selection, and Testing, 2 November 1977
062-3159-00	Drafting, Marking, Heat and Roll Stamps, Die Cast and Molded Lettering, 7 June 1977.
062-3500-00	Test Method, Time Delay of 50µ RF Coaxial Cable and Cable Assembly, 16 September 1977
062-3539-00	Test Method, Cables, Spark Test, 4 November 1977.
062-3546-00	Drafting, Draft Considerations, Molded Plastic Parts, 21 August 1978.
062-3716-00	Component I.D. Marking, Transistors and Diodes, 10 March 1978.
062-3744-00	Occupational Safety, Illumination, Minimum (withdrawn).
062-3748-00	Microfiche Requirements for Documents, 2 June 1978.
062-3751-00	Reel Packaging of Components With Axial Leads, 20 December 1978
062-3752-00	Communication, Product Marking, Abbreviations, 6 September 1978.
062-3797-00	Software, BASIC Language, 7 August 1978.
062-3901-00	Drafting, Temporary I.D. of Engineering Drawings Prior to Part Number Assignment, 16 August 1978.
062-3923-00	Test Method, Cables, Jacket Removal, 8 November 1978.

*Revision pending.

1978 ENGINEERING NEWS INDEX

For a copy of an issue or article, call 6792 or write to D.S. 19/313.

JANUARY

Recent Advances in Direct-View Storage Tubes.
The Tektronix Patent Process.

FEBRUARY

Oxygen-Doped Polysilicon Films.
Designing for Safety.
I^2 Process Circuits Now Available In-House.
"Lost" Instruments Mean Lost Profit Sharing.
Plot 10 Easy Graphing.

MARCH

Aluminum for Transformer Shielding.
Error-Correcting Codes and Their Control Features.
Steering Meetings.
Alphanumerics and Graphics Integrated by Virtual Bit-Mapping.
Simulating Flat Panel Displays.
Improvement Through Involvement.

APRIL

From Paper to Circuit Board: Bypassing.
Improved Phosphor Life in DVST's.
Writing Technical Articles.

MAY

Glass-Seal/Solder-Seal Microelectronic Packages.
Human Factors.
GPIB Interface for the DM501.
Circuit Boards from Polysulfone.
Stimulating, Measuring, and Rewarding Innovation.
NASA Industrial Applications Centers.

SUMMER

Shock Model for the 492 Crt.
Finding Ripple Valley Voltage with an HP-25.
Engineering Notebook Responsibilities.
Mechanics of Writing Technical Articles.
GPIB Evaluations Made for Non-Tek Instruments.
New Lead Sets for P6451 Probes.
Trade Magazines Looking for Design Ideas.

SEPTEMBER

The 7912AD Programmable Digitizer.
GPIB Product Information.
Modular Packaging System.
The Human Factor in the Man-Machine Interface.

OCTOBER/NOVEMBER

Real Power Supplies.
Learning to Use Tek Instruments.
MP Error Display Using the 851 Digital Tester.
Designing for Service.

DECEMBER

Designed-in Diagnostic Features for Processor-Based Instruments.
NBS Traceable Transition Time Measurements at Tek.
Display Distortion in Mono-accelerator CRT's.
25-Inch 4016 Computer Display Terminal.

FITTING TEST PATTERNS INTO LSI TESTERS

Trent Cave (Semiconductor Test Systems Engineering) wrote "Compressing Test Patterns to Fit into LSI Testers," an article in the 12 October 1978 issue of **Electronics**.

* * * * *

All papers and articles to be published outside Tektronix *must* pass through the Publicity department for confidentiality review. T&M Publicity helps Tektronix employees write, edit, and present technical papers and articles. Further, the department interfaces with Patents and Licensing to make sure patent applications have been filed for all patentable designs discussed in the paper or article.

For more information or for assistance, call T&M Publicity on ext. 6792 or drop by 19/313. Authors working in the Information Display Group should first contact the IDG Publicity department for assistance (ext. 2343, Wilsonville). □

DEC PROCESS-CONTROL SYSTEM SEMINAR

On 21 February 1979 (Wednesday), representatives from Digital Equipment Corporation will present their new MINC system. MINC is a modular, minicomputer data-acquisition system having an IEEE-488 interface. The seminar will focus on MINC's components and its capabilities for laboratory and process-monitoring applications. Research scientists and process engineers should find the seminar especially interesting.

For more information about this seminar, Programmable Instrument Seminar No. 9, call John David (Digital Product Coordination group) on ext. 7095. □

Designed-in diagnostic features......
STRATEGIES FOR INSTRUMENT CIRCUITRY

Chuck Haymond, LID Production Test Engineering, ext. 5638 (Beaverton).

Dave Levadie, LID Production Test Engineering, ext. 5638 (Beaverton).

This is the second part of a three-part article. The first part described kernel diagnostics for processor-based products. For a copy, call T&M Publicity on ext. 6792 or write to 19/313.

INFORMATION FEEDBACK

Every diagnostic routine and procedure depends on information feedback. Diagnostic tests set up instrument conditions and expect one of two kinds of feedback. The first is designed-in **readback** (circuitry that enables a diagnostic routine to read the condition of the hardware). The routine then either displays information, branches to another routine, or prompts the servicer to perform some action.

With the second kind of feedback, the diagnostic procedure requires the servicer to make measurements. The procedure thus relies on the servicer for feedback and sometimes for analysis of the measurements.

In most processor-based products, instrument circuits are peripherals on the processor bus. The processor sends addresses and data to the instrument circuits and reads data from them. Diagnostic routines for such configurations usually send data to addresses on the bus and either check for a valid response from the circuitry or wait for an interrupt or an operator response.

Servicing an instrument usually requires reading more information from the circuitry than normal instrument operation requires. For example, during normal operation, a processor doesn't need to read data in ROM's that do not provide memory for the processor (for example, ROM's used for signal generation).

Obviously, a verification routine must be able to read the data in such ROM's. Similarly, a troubleshooting routine may need to read output latch conditions that are normally write-only during functional operation.

Readback circuits do require more board space and edge connector pins. One way to reduce these extra requirements is to multiplex signals from several test points into a single signal which the diagnostic routine can read from an I/O port. This reduces the number of signal paths required.

In general, if the processor can read back more information, then the diagnostic procedure can depend less on the servicer's skill and expensive external measurement devices.

STRATEGIES

For component-level troubleshooting, every diagnostic strategy will require the servicer to make some measurements. For example, kernel-debugging routines require the servicer to use some measurement device to verify signals. Diagnostic routines for the rest of a product also require measurements. The number of measurements depends on the amount of readback circuitry in the product and on the nature of the product's circuitry.

Some designers tailor their diagnostic strategy to one test instrument such as a signature analyzer or transition counter. With this **single-test-instrument approach,** diagnostic routines simply generate test signals. This strategy is memory efficient because the software needs only to set up repetitive signal patterns without performing much error analysis. However, test instruments such as the signature analyzer produce only go/no-go measurements. Therefore, this strategy requires detailed documentation of valid measurements as part of the service procedure. Also, this strategy requires some administrative overhead to update the software and documentation to reflect product modifications.

If the product is intelligent enough, the software can tell the servicer which measurements to make and what the valid signal conditions are. Otherwise, the service manual's troubleshooting procedure can provide that information.

Test instruments or systems that have both signal generation and measurement capability often use a **self-measurement strategy.** The Tektronix S-3260 Automated IC Test System, for example, has a test fixture that enables a servicer to patch "outputs" into "inputs" using one to verify the other. As another example, the 832 Data Communications Tester designers designated some already-present signals as test signals and provided jumpers enabling the servicer to inject these signals into other circuits.

Continued on page 10

Continued from page 9

As a general rule, if an instrument's signal-measurement circuits work, the servicer can use them to troubleshoot other circuits (thereby reducing need for test equipment).

Systems as large as automatic testers often include a computer, a terminal, and mass storage. With such systems, the designer can use the **guided-probe diagnostic strategy.** With this strategy, the designer builds a programmable signal measurement and data acquisition probe into the system. This strategy requires sophisticated software and mass storage for signature tables, device-type-to-IC-number cross-reference tables, and interconnect maps. Guided-probe software prompts the servicer to move the probe from one point to another on a suspected board. The software reads the probe's measurement and tells the servicer where to place the probe next.

DIAGNOSTIC ROUTINES

Even though a diagnostic routine's structure depends on the nature of the product it's designed for, some generalizations are possible.

Designers should structure the diagnostic package to allow the servicer to run routines either as a batch stream or individually. With this capability, the servicer can run the whole diagnostic package for an overview of an instrument's condition and then run individual diagnostic routines to troubleshoot suspected circuits.

All diagnostic routines in a package should have the same format for selection, operation and error indication. Diagnostic routines should also be able to enter a loop when they find a fault, thus enabling the servicer to take action. If a line printer is available, the routines should provide optional printing. The diagnostic system software can set up a RAM table to store operator-selected options. Then each routine can read the option switches and act appropriately.

INTEGRATED PACKAGE

There are several types of diagnostic routines: power-up, verification, and component-, board- or module-level fault isolation routines. To maximize programming efficiency and minimize diagnostic procedure complexity, a product's diagnostic routines should form an integrated diagnostic package. Thus, if a verification routine fails, either the routine itself or the service manual should tell the servicer to run an appropriate troubleshooting routine. The troubleshooting routine can then give the servicer a choice: find and replace the defective module or set up loops that allow the servicer to check signals and look for component failures.

Unfortunately, calibration software cannot always be easily integrated into a diagnostic package. Calibration software helps the servicer perform adjustments and tolerance checks rather than perform go/no-go testing. Diagnostic routines and procedures should help the servicer determine if a product needs recalibration or if a fault condition may be due to a calibration problem. The diagnostic routine or documentation should indicate the appropriate calibration routine.

DIAGNOSTIC SOPHISTICATION

Several factors affect diagnostic routine design. For instance, the sophistication required of diagnostic software is inversely proportional to service and manufacturing personnel's technical sophistication. Other factors are the mean time to repair acceptable to the customer and other useability criteria specified in the product's Electronic Instrument Specification. Service and manufacturing test strategies also affect diagnostic routine design. (See "The Trade-Off Between Designed-In Serviceability and Development Costs" in the January **Engineering News.**)

DEBUGGERS

Servicers familiar with a product's circuitry, bus structure, and programming characteristics can use a diagnostic debugger that allows reading and writing addresses and data on the bus.

The debugger may be either a hardware test fixture having switches and displays, software that communicates with a terminal, or a combination of the two. The most useful software debuggers allow the servicer to load and run routines and set break points. To help them develop new products, designers often invent debuggers that can also help servicers locate faults.

However, having diagnostic strategy rely on debuggers has drawbacks: (1) the servicer must usually be very familiar with instrument circuitry and programming; (2) debuggers are inefficient troubleshooting tools if complex programming is required to set up circuit conditions for testing; and (3) debuggers themselves require documentation and support, especially where hardware is involved.

Despite their disadvantages, debuggers can be useful as simple but effective "bit-bangers", and as such can be considered for inclusion in the diagnostic package. They can be useful for on-the-spot trouble-shooting when diagnostic routines can not isolate a fault. Unfortunately, when diagnostic routines aren't available, debuggers, by default, are the only troubleshooting tool.

CHICKEN-AND-EGG PROBLEM

A designer can't write diagnostic routines without some idea of what faults will have to be diagnosed, but that information usually isn't available until an instrument is in pilot production. Fortunately, if the hardware has been designed with self-diagnosis in mind, the designer can usually solve these chicken-and-egg problems by changing diagnostic software rather than having to change the hardware.

MEMORY TESTING

Memory chips are one of the most failure-prone components of processor-based products. In the field, some memory failures are "dynamic" (they occur only under certain operating conditions).

MORE ON TESTING THE PROCESSOR

In the previous article, we mentioned setting up a "forced instruction mode" for the microprocessor. With the microprocessor in this condition, most catastrophic processor failures can be detected.

More subtle failures are more difficult to diagnose. Digital Equipment Corporation is now including some clever power-up self-tests in their PDP/11-series processors. These tests exercise the processor's internal circuits; the processor will not operate if the test fails.

Unless a processor incorporates this type of self-test, the only way to thoroughly test the processor is by trying to exercise its instruction set. Since such tests can be very complex, designers often either (1) use a simplified test that checks only such circuits as the processor's registers, arithmetic logic unit, and interrupt circuitry, or (2) assume that the verification tests of the rest of the instrument necessarily also check processor operation (the verification routines won't run unless the processor works).

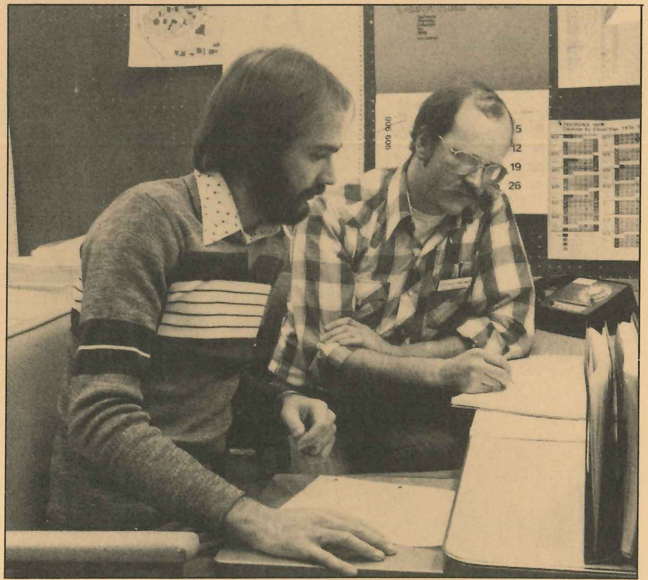
If untraceable errors occur, a diagnostic procedure should prompt the servicer to replace the processor. This is particularly relevant during kernel troubleshooting, and should have been mentioned in our first article.

Fortunately, memory test patterns are available that reveal many such failures. (For information and sources of information about test patterns for various memory devices, contact the authors.)

If a dynamic memory's refresh circuits can be disabled, either by hardware or software, the servicer or diagnostic routine can test the memory for data retention. This is useful in finding intermittent dynamic RAMs problems.

An exhaustive treatment of memory and processor testing is beyond the scope of this article. We are collecting information on the subject, particularly on ROM check character generation routines and microprocessor testing. We would appreciate your contributions. Please call us on ext. 5638 or write to 39/240. □

PROFILE MICROPROCESSOR SUPPORT



The Microprocessor Support group manager is Charlie Montgomery (right). Les Matheson (left) is hardware support project leader.

The Microprocessor Support group, part of the Scientific Computer Center, provides hardware and software development tools for Tektronix engineers in the Beaverton, Wilsonville, and Grass Valley areas.

For software development, Microprocessor Support provides development packages that include compilers, assemblers, linkers and downloaders. Available in uniform user formats, these packages help engineers develop software for various microprocessors. To access the packages on the Scientific Computer Center's Control Data Corporation Cyber computer, type HELP, MICROP. (MICROP is available only on the A machine.)

For hardware development, Microprocessor Support provides unassembled "bit buckets" (microcomputers and their operating systems), active system debuggers, and logic device programmers (such as PROM and FPLA).

For services or consultation, call Charlie Montgomery (Microprocessr Support group manager) on 5865 or drop by D.S. 58/126. □

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PATENTS RECEIVED
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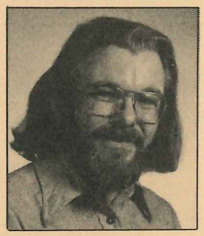
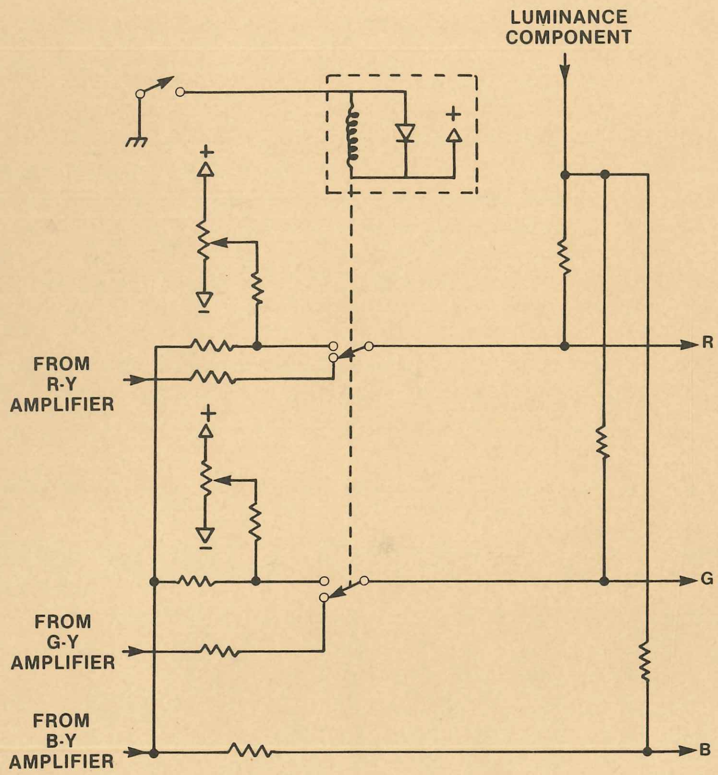


Philip S. Crosby, T.V. Products Engineering, ext. 7079 (Beaverton).

Charles W. Rhodes, T.V. Products Engineering, ext. 7068 (Beaverton).

The demodulated blue component of a decoded National Television System Committee signal is more susceptible to noise and chrominance aberrations than the red and green components. Formerly, a TV monitor operator wanting to see only the blue component had to look at a blue picture to see aberrations. This invention makes the displayed picture white to make viewing easier. □



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Why EN?

Engineering News serves two purposes. Long-range, it promotes the flow of technical information among the diverse segments of the Tektronix engineering and scientific community. Short-range, it publicizes current events (new services available and notice of achievements by members of the technical community).

Contributing to EN

Do you have an article or paper to contribute or an announcement to make? Contact the editor on ext. 6792 or write to 19-313.

How long does it take to see an article appear in print? That is a function of many things (the completeness of the input, the review cycle and the timeliness of the content). But the *minimum* is six weeks for simple announcements and about ten weeks for major articles.

The most important step for the contributor is to put his message on paper so that the editor will have something with which to work. Don't worry about organization, spelling and grammar. The editor will take care of those when he puts the article into shape for you.

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