

ENGINEERING NEWS

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Joyce Lekas editor 6601

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Dave K Morton associate editor 6071

HYBRID RESISTORS

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A newly available material enables designers to incorporate resistors into the circuit board material. Called 'Mica Ply Omega,' it consists of an epoxy glass base material, with a thin film resistive layer interposed between the base and the outer copper cladding.

The manufacturing process involves initial photoresistive coating, exposure, and chemical etching. This uncovers a given portion of the thin film resistive material, and superimposes a conductor pattern upon it. The unwanted resistor material is then removed. A final photoresist, exposure, and etch process removes the copper from the desired resistor area and completes the resistor-conductor network. An encapsulation is screened over the resistors and any other areas desired. The parts are then ready for any necessary laser or sand-blast trimming, or immediate use.

We are currently purchasing finished parts produced by this technology for use as a terminating resistor network in the Tektronix calculator. The network consists of 44 120-ohm resistors, 22 on each side of the board.

The resistivities currently available are 100-ohms-per-square material, and 25-ohms-per-square material. In an early feasibility study, the prototype part was a 14 resistor network, with resistor width and spacing set at .020 inch. The standard deviation on 70 prototype resistors was only about 2.8 per cent of the average value. Graphs of the long term drift and temperature shift are shown in figures 3 and 4 respectively.

With a minimum line and space width of .010 inch, the 100-ohms material theoretically produces about 500K-ohms per square inch; the 25-ohms material, about 125K-ohms per square inch. Since distributions tend to get wider as lines get narrower, a trim area must be allotted. This provides enough extra resistor material for trimming to the required tolerances.

Being substantially more expensive than conventional FR-4 board stock, each possible application for this technology should be evaluated in terms of the number of resistors necessary and the area of the board material used.

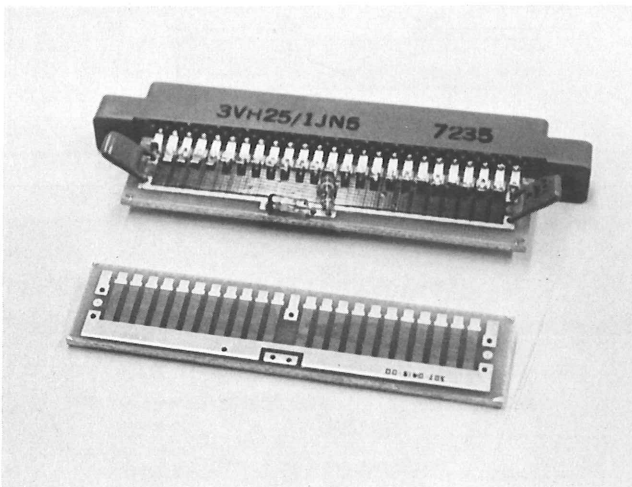
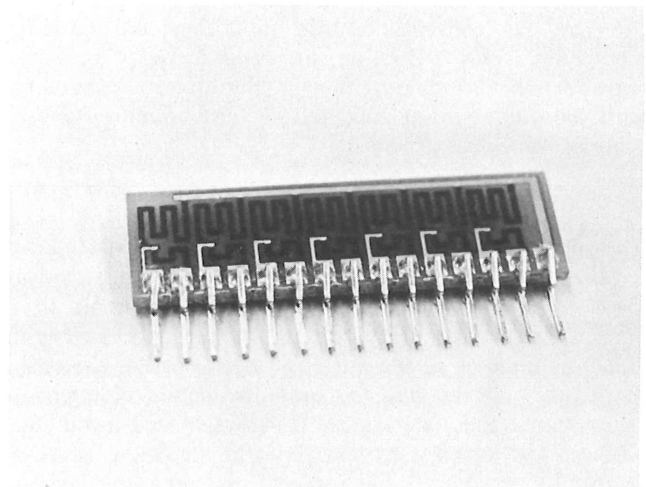


Figure 1 calculator item



prototype

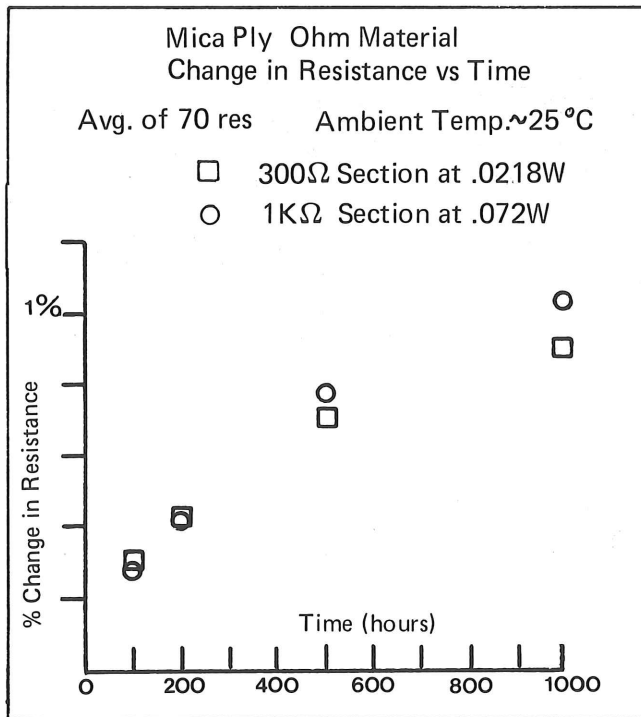


Figure 3 prototype long term drift

For more information on material characteristics, contact Oscar Olson at ext. 6564. Specific questions regarding

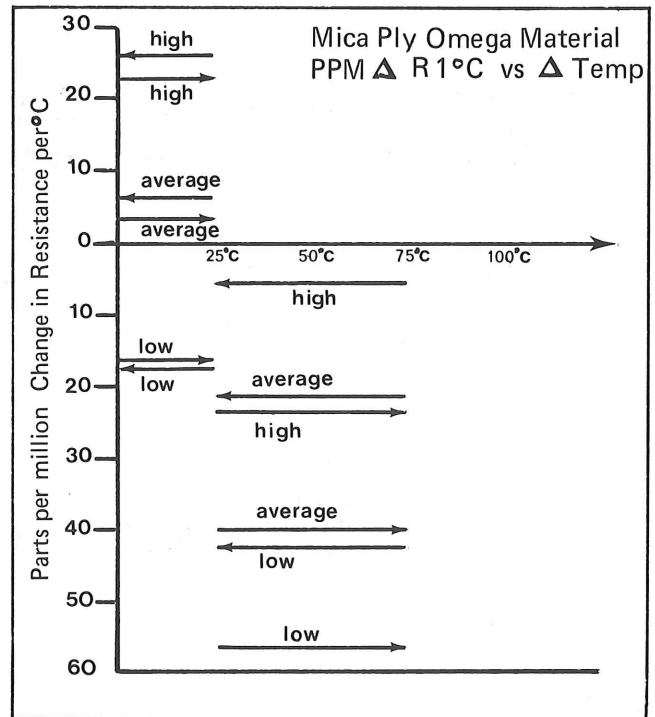


Figure 4 prototype temperature chart

application should be referred to the engineers in the Hybrid Design group.

LEADLESS HYBRID CIRCUITS

by Bob Stanton

The actual assembly process of an integrated circuit plays a major role in determining its overall cost. With material and labor prices increasing, many integrated circuit and hybrid manufacturers are reviewing the advantages of 'flip chip' technology. Flip chip packaging employs a typical integrated circuit or component, with all electrical contacts brought to the top surface of the chip, and solder bumps formed on these areas. The devices are then bonded face-down, with the solder bumps resting on an appropriate interconnection pattern on a given substrate.

Flip chips were designed to improve reliability and reduce the cost of conventional die mounting and bonding techniques. This reduction in assembly cost becomes apparent when comparing the flip chip's one-step bonding with the die mounting and multiple wire bonding steps of more conventional circuits.

The contact bumps used on flip chips have been made from a variety of metal processes. The most widely accepted of these starts by producing the integrated circuit in a conventional manner. The circuit is then passivated with silicon dioxide or silicon nitride glass, and contact holes are etched through the glass to expose the metal bonding pads. Aluminum (and later nickel) is evaporated onto this surface, and patterns etched to form the bump areas. A copper barrier layer is electroplated on, and a final layer of solder is either plated or dipped onto this copper, forming

the individual solder bumps. These bumps are 5 to 6 mils high, 6 mils in diameter, and are spaced 12 to 18 mils apart, center to center.

Substrates are ceramic or glass, with thick film conductor and resistor patterns printed on one side, or on both sides. Glass dams are added to protect the resistors and isolate the

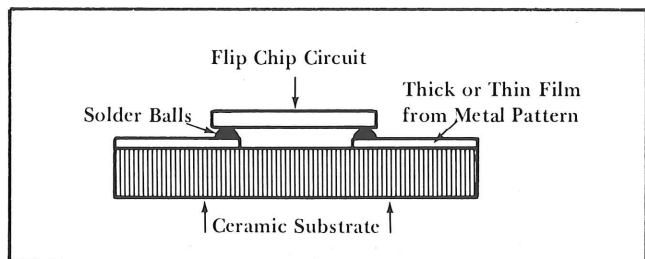
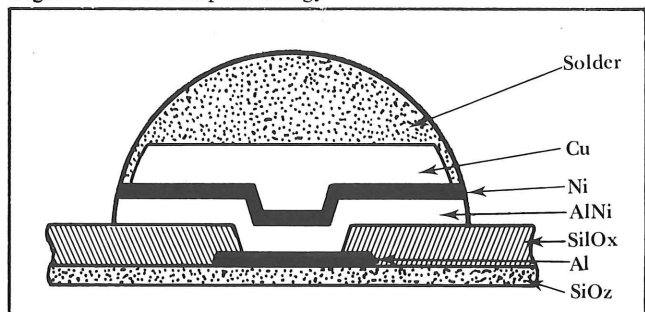


Figure 1 basic flip chip system

Figure 2 solder bump metallurgy



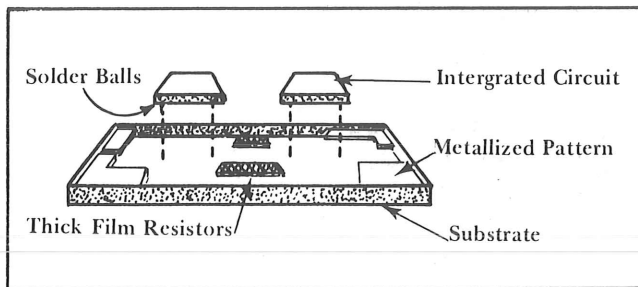


Figure 3 attachment of flip chip

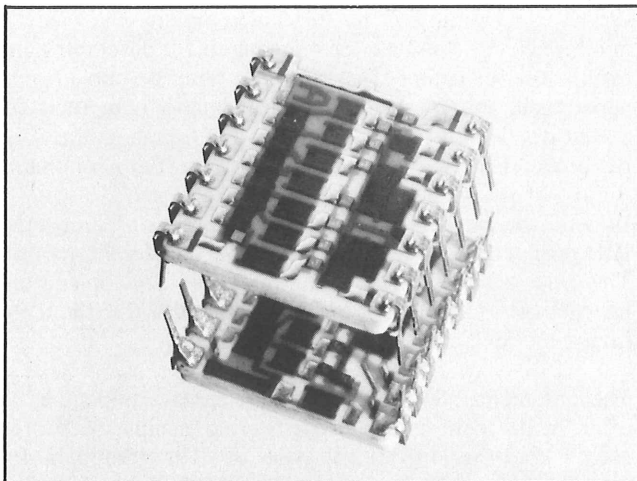


Figure 4 hybrid shaper circuit

solder areas. Thick film gold conductors and resistors interface well, and such connector pads are relatively resistant to solder leaching. Screen printing is limited to larger geometries so, in some cases, thin filming of gold is substituted in place of thick filming. Very small line size and spacing may be achieved with this method, in addition to a high level of circuit "Q".

Reflow soldering has proven to be a highly productive and reliable method of die to substrate bonding. This is accomplished in either a belt furnace or a high temperature vapor reflow system. Initially, substrates receive a pre-tinned exposure to solder. A mild solution of flux is painted onto the bonding areas, and the die is positioned face-down over the bonding pads. These pre-assembled circuits are placed on carriers, which are then passed through the furnace's heat zone. As the solder melts, a wetting action pulls the die into correct alignment. A later rapid cooling process helps control the solder ball collapse (insuring the die remains suspended 2 or 3 mils above the substrate on its solder pedestals), and freezes the die into place.

The H-213 Shaper circuit, used in the 7L5 plug-in and pictured above, has been assembled using this process and purchased die. The device contains 18 diodes, 14 pins which connect to 28 pads, and uses 36 active bonds. All connections on this device are simultaneously soldered in one heat cycle through the furnace. The 9 die located on the underside of the substrate remain in place during soldering due to the surface tension of the flux on the bonding pads. The device's electrical performance and reliability is comparable to that of chip and wire bonding

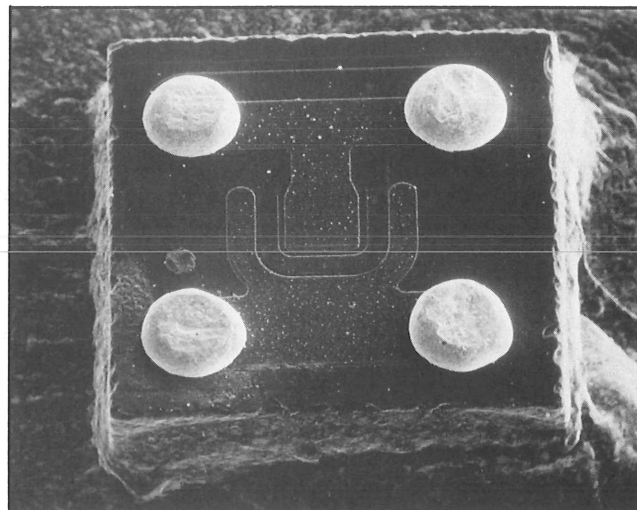


Figure 5 purchased H-213 diode

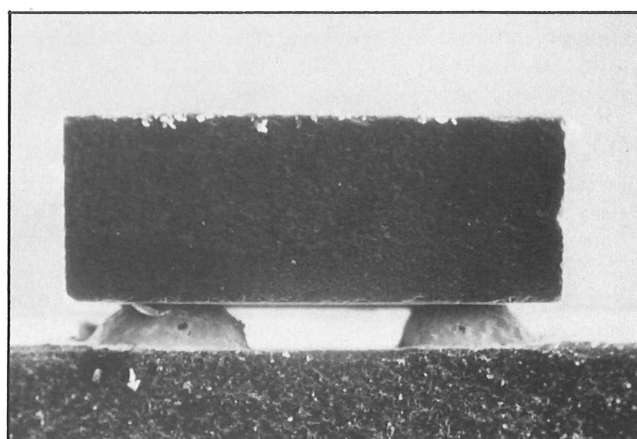


Figure 6 getting close to your flip chip

manufactured models. In addition, assembly costs appear to reflect a 50 per cent reduction over previous methods.

Availability of flip chip devices is still somewhat limited. This is perhaps because there has been no bump size or spacing standardization. However, most large manufacturers have these devices as catalog items, or will build on special order. General Electric Corp. and IBM produce flip chip circuits in their high volume, low cost, automated assembly lines. Motorola Semiconductor and Micro Components Corp. have been successful suppliers and second source vendors of these devices.

Additional work is being done with purchased transistors and a 10 bump operational amplifier. A 150 mil square test die, containing 40 bumps, is also being developed presently at Tektronix. Heat sink techniques are being evaluated to improve the limited power capabilities of flip chips. Future applications include low cost, high volume circuits; and low to medium power circuits with many input and output leads, such as digital logic circuits.

(See May 1974 Component News for more background.)

IDD'S ENGINEERING COMPUTERS

Since the early days of IDD, computers have played a significant part in the development of terminals and peripherals. The 4002A, 4023, and the 4010 terminals are designed to interface directly into the expanding computer environments. So are a number of supporting peripherals (floppy discs, joysticks, graphic tablets, etc.). This interface is functional in both the direct connect, and timesharing modes. In order to design and verify the performance of Tektronix terminals and peripherals, it is necessary that design engineers have an intimate knowledge of the various computer architectures and software characteristics.

The specific uses of computers in IDD Engineering include computer and modem interface design; terminal and peripheral performance verification; computer environment simulation; and software development.

Since money and schedules are tight, engineers will usually turn to already existing facilities for assistance in getting their jobs done. The desired ratio of computers to engineers in a utopian environment would be 1 to 1. However, since space and expenses must always be taken into consideration, a ratio of 4 or 5 engineers to 1 computer is more realistic. This is for hardware engineers, using medium-sized mini's for software development and simulation work.

Presently, there are a number of PDP 11/05's used by our engineers. They assist in designing computer interfaces for

the IDD product line, and check the performance of various instruments in pseudo-host/remote terminal applications. Coupling the power of the small, desk level mini with that of a built-in microprocessor (i.e., the CDC Synchronous Interface), makes a powerful system for checking the various IDD products. In this environment, the medium mini's (PDP 11/45's) can be timeshared for developing and maintaining programs. Programs can later be copied onto paper tape, and then read into the smaller computers for execution. This type of hardware development operation has proven beneficial, while keeping the cost at a minimum.

Uses of the medium mini's for development of supportive IDD product line software is handled in a different manner. The programmer (software developer) can develop and test his package in a shared computer environment, without the luxury of a dedicated system.

The statement, "Software makes the hardware happen," is often heard from software engineering groups. Software's actual contribution to the sale of IDD terminals and peripherals is estimated at between 50 and 70 per cent (i.e., sales are made easier because adequate supportive software exists). Although the actual revenue generated from the sale of software is relatively small when compared to total IDD sales, its contribution cannot be ignored. Presently, there are more than 20 different software packages available from IDD. These range from support of our 4002A terminal and the Nova computer, to the large Advanced Graphing-II software package for major timesharing systems. Since the terminals manufactured by Tektronix are used in conjunction with computers of other manufacturers, the necessary software must be developed on the more popular external timesharing systems. The PDP-10 and GE networks are used for this development and check-out, as well as the in-house TSO 370 and Cyber 70 systems. Software is also developed in support of the medium-sized mini computers, and the engineering PDP 11/45's and Interdata 7/16's are utilized for these functions.



Figure 1 7 terminal computer



Figure 2 telephone computer

What They Have

The reputation of IDD Engineers as innovators applies not only to their ability to get the hardware job done, but also extends to their uses of computers. They are presently using two medium-sized PDP 11/45's as shared machines, each computer having its own unique features. One of the machines (a 28K version with three discs, two tape units, a paper tape I/O, and a 250 line per minute printer) has seven Tektronix terminals attached to it. They operate at 1,800 baud or faster. Five of the terminals are located approximately 500 feet from the computer, with two in the immediate vicinity. One line is multiplexed between two terminals, with a mechanical switch in the line to determine which terminal is active. The line switching capability is being extended to two more lines, so control can be switched to the areas where need dictates. This computer is frequently operated 24 hours a day, at least six days a week, with a total logged terminal time in excess of 250 hours per week. Although the demand fluctuates from period to period, it is expected that total terminal use hours will at least double within the next year.

To accommodate the various engineers, and still maintain vendor supplied software, the standard vendor software is

provided with a timesharing front end. This approach has allowed computer sharing to occur over a greater scope than could be handled by a single one on one operation. The cooperation among IDD engineers has been the major reason for successful multiple terminal usage.

Although little is heard about IDD Engineering's computer facilities, their use is quite extensive. The fast moving data communications industry requires that an engineer stay abreast of state-of-the-art developments. To design terminals and peripherals without immediate local access to a computer would be extremely difficult. As data communication devices become more sophisticated, and processing capabilities gradually move from the central computer to remote devices, the use of computers in designing intelligent terminals is an absolute necessity. IDD Engineering's need for greater and more sophisticated computer power will increase as the division grows.

So what do you want to know about computer facilities in the Sunset plant? There must be something on your mind after all of this. If so, contact Del Williams, ext. 287 Sunset.

PCB MATERIAL IMPROVEMENTS

Which material is optimum for your printed circuit board needs, considering the following factors.....electrical properties; physical strength; solderability; conductor thickness; thermal conductivity; flexibility; cost? There are many different materials available, each displaying its own characteristics and limitations.

Most applications are satisfied by using 1/16 inch thick epoxy fiberglass, clad on both sides with 1-oz. copper. This material is inexpensive, very strong, and fire resistant. However, its dielectric constant and hook are too high for some applications, so another material called PPO was sometimes used.

Once readily available and physically similar to epoxy fiberglass, PPO is almost 8 times the cost. For operation at microwave frequencies, several applications require the use of copper-clad teflon or cross-linked polystyrene. Available in flat sheets of various thicknesses, their cost is 10 to 15 times that of epoxy fiberglass (\$20-\$30 per square foot!). So for a price, we've been able to fulfill our circuit board requirements in the past.

During the last 2 years, a variety of materials has begun to appear at the low-cost end of the price spectrum. These materials include polyester glass (with the limitation of no through-hole plating); a low glass content epoxy (with better electrical properties than epoxy fiberglass); and an epoxy polyimide blend. Several manufacturers have also shown interest in making a "super epoxy glass" material, with better than average electrical properties and guaranteed values.

A high level of heat dissipation is provided by using sheet metal circuit boards. These are punched with the desired feed-through holes, coated with plastic, and finally plated with copper to form the circuitry pattern.

When considering materials with a lower dielectric constant than epoxy fiberglass, there are some readily available and relatively inexpensive plastics, many with excellent electrical and structural properties. One fine example is polysulfone. It is widely used as sheet and tubing material for a variety of electrical, surgical, and food-dispensing equipment applications. Costing about the same as copper-clad epoxy glass, it provides a suitable replacement for PPO at approximately 15 per cent of the price. Currently,

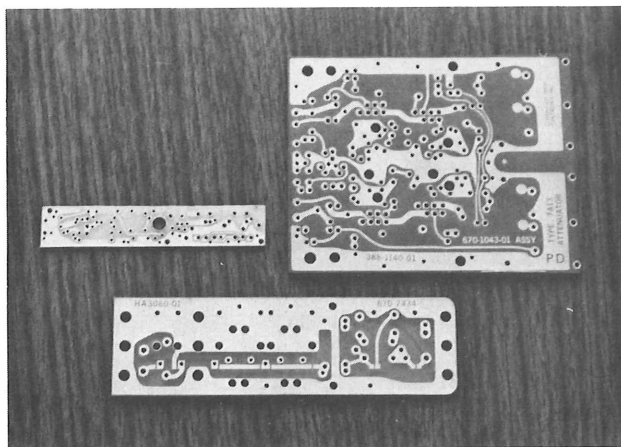


Figure 1 polysulfone boards

polysulfone replacement of PPO usage is proceeding within the company. This will eventually include such high volume users as the 465 oscilloscope. It's possible to thermally mold polysulfone into various shapes, even after the electrical circuitry is added if necessary. This fact was basically discovered by accident. Now we are attempting to take advantage of this unique feature of polysulfone.

A single 90-degree bend circuit board (instead of two separate circuit boards joined together with a connector) is theoretically possible using polysulfone construction.

TPX is another inexpensive material that eventually could show promise. In the same price range as epoxy glass, TPX exhibits the superior qualities of teflon. Originally a strong replacement contender for PPO, it was initially rejected because it also burns very well.

The electrochem group is always working on board material improvements. In the light of the characteristics and limitations mentioned above, we would like to discuss your



Figure 2 polysulfone meets heat

particular PCB needs with you. For more information, contact Jerry Jacky at ext. 7830, or Wally Doeling at ext. 6581.

MAKING CONTACT

Looking In from the Outside

Tektronix is in the complete instrument design, manufacturing, and marketing business. We choose to build individual components only when absolutely necessary, based on performance; availability; quality; cost; etc. Occasionally the uniqueness of a component may substantially contribute to the overall design of an instrument. Switch Engineering exists for this reason.

An instrument designer should first look at what is available from outside markets before he/she proposes a new switch design. If such a new design is really necessary, it is helpful to understand the structure of the Switch Engineering department. In other words, who does what.

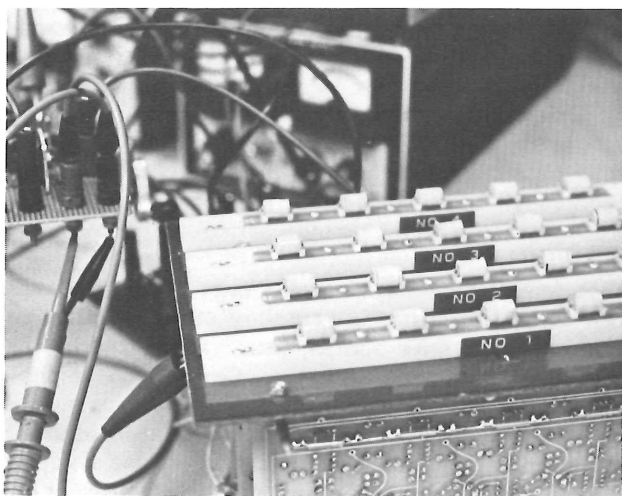


Figure 1 accelerated life testing

Dick Devlin's Electromechanical Component Design department is organized into four groups: Switch Application - Irv Sherbeck; Cam Switch Design and Relays - Bob Aguirre; Slide switches, Pushbutton switches and Pancake switches ("other switches") - Scott Long; and Switch Development - Elmar Wefers. Each group's priorities are separate and individual.

Switch Application

The Switch Application group deals with both Tek-made and purchased customized switch applications. Their engineers will advise on the use and cost of specific switches, and will supply prototypes when necessary. Their efforts are supported by a group which fabricates (cam cutting, shaft making, etc.), and assembles the new switches. This carries the design through its A and B phase (and through the pilot phase in some rare cases). An evaluation group performs tests and cycling of the switches, and designs supportive fixtures and equipment.

Cam Switch Design and Relays involves the study of a multitude of switch designs, and improvements of our basic cam switch manufacturing capability. They are also concerned with increasing the reliability and lowering the cost of Tek-made relays.

"Other Switches"

The "other switches" group is primarily responsible for the design of Tek-made pushbutton switches, various types of slide switches, and lever and pancake switches.

Switch Development

Unlike the individual design groups (which essentially work on new applications of existing switch concepts), the Switch Development group is concerned with exploring entirely new concepts in switching. For example, they are presently working on various forms of programmable switches. Included are motor driven cam switches; solenoid operated cam switch contacts; opto-electrical switches; and a new concept in latching reed switches.

Looking Out from the Inside

An instrument designer usually prefers to use components which have already been fully tested and evaluated. He is generally also on a rather tight design schedule.

Switch Engineering identifies the many groups within the company which do or do not require major design or development assistance with switches and relays. (IDD is a good example of a group requiring very little support. For key switches and keyboards, a highly competitive and innovative manufacturing industry already exists.) Their main switch customers are the various oscilloscope design groups, the TM 500 group, and Spectrum Analyzers.

If possible, Switch Engineering prefers to design switches intended for general use in more than one instrument. This means the switch should be versatile. An example is a particular lever switch designed by the "other switches" group. Rather than trying to meet only one specific switch need for one specific instrument, the lever switch was designed to accommodate four different contact arrangements or combinations. By changing a simple insert in the molding die, the number of switch positions and angle of throw can be changed also. With this feature, Tektronix can manufacture a wide variety of lever switches, each costing approximately 65 per cent less than any purchased lever switch.

The time necessary to proceed from an initial design to a fully tested part is also pointed out by Switch Engineering. Under present conditions, future switch needs have to be defined very early. Tooling time now exceeds 20 weeks. Also, the time necessary for testing and evaluating a new switch through the various stages of its development should not be overlooked. Ideally, all of this should occur prior to the DC of an instrument. A designer should count on 12 to 18 months to develop a new switch concept into a finished component. Designing and packaging a switch from an already existing concept takes 6 to 10 months, depending on its complexity. Also, these lead times actually reflect the best possible case. In view of this, it's obvious that a designer should discuss his/her needs with the Switch Engineering group as early as possible for the best results.

Moving.....?

Please remember to notify ENGINEERING NEWS of your address change. Send to 50-462 or call ext. 6071.

Call for papers

The 21st Annual Conference on Magnetism and Magnetic Materials will be held at the Benjamin Franklin Hotel, Philadelphia, Pennsylvania, on December 9-12, 1975.

SPONSOR: The American Institute of Physics will jointly sponsor this conference with the Magnetics Society of IEEE (in cooperation with the American Physical Society, the Office of Naval Research, the Metallurgical Society of the AIME, and the American Society for Testing and Materials).

TOPICS: Original papers are invited in the fields of:

Experimental and theoretical research in magnetism
Properties and synthesis of new magnetic materials
Advances in magnetic technology

ABSTRACT: Abstracts are due by August 15, 1975. A program booklet of all selected abstracts will be distributed prior to the conference.

OTHER: Details concerning the preparation and submission of abstracts, as well as other conference information, may be obtained by contacting:

R.L. White, Conference Chairman
124 McCullough Building
Stanford University
Stanford, California 94305

or:

B. Stein
Univac Division of Sperry Rand
P.O. Box 500
Blue Bell, Pennsylvania 19422

U.S. National Meeting of International Union of Radio Science (URSI) will be held October 20-23, 1975, at the University of Colorado, Boulder, Colorado.

SPONSOR: The meeting will be sponsored by various societies of IEEE, and the U.S. National Committee of URSI. Local hosts are the University of Colorado, the National Bureau of Standards, the Office of Telecommunications, and the National Oceanic and Atmospheric Administration.

TOPICS: Original papers are invited on the following subjects: Radio measurement methods and standards
Radio and non-ionized media
On the ionosphere
On the magnetosphere
Radio and radar astronomy
Radio waves and transmission of information
Radio electronics
On radio noise of terrestrial origin

papers ...

ABSTRACT: A 200 to 245 word abstract is due by July 14, 1975.

OTHER: Send the original abstract and 2 copies to:

Prof. James R. Wait
Chairman, USNC/URSI Technical Program
Room 242, RB 1, CIRES
University of Colorado
Boulder, Colorado 80302

The National Telecommunications Conference - NTC '75, will be held December 1-3, 1975 at the Fairmont Hotel, New Orleans, Louisiana. The theme is 'Communications - Nucleus of a Nation.'

SPONSOR: IEEE's New Orleans section of the Communications Society Conference Board will sponsor the affair.

TOPICS: Original papers are invited on the following topics:

Communication switching
Space communications
Communications theory
Spectrum utilization
Wire transmission systems
Vehicular communications

Fiber optic communications
Guided wave communications
Data and computer communications
Digital voice, and video technology
Social implications of technology
Energy and environmental impacts on communications
Communications role in national growth
Industrial and power systems communications
Control systems (digital or analog)
Satellite communications
Signal processing
Communications systems
Radio communications

ABSTRACT: All authors of accepted papers should be prepared to make a 20 minute formal presentation at the conference. Prospective authors are requested to submit 5 copies (in English, would you believe) of both the paper and a 1-page summary to:

I.N. Howell, Jr.
South Central Bell Telephone Co.
P.O. Box 771
Birmingham, Alabama 35201

These must be received by no later than May 1, 1975. The completed manuscript (5-page maximum length, camera-ready copy) must be submitted for publication by August 1, 1975.

OTHER: Authors of accepted papers will receive author's kits upon notification of acceptance.

Finally A Choice

Automation can be the answer to your problems, or simply another source of them. This often depends on choosing the proper system to meet your needs. For years, the mini-computer was the strongest means of automatic data processing available on a small scale. Now this isn't always the case. Today's new hero is often the calculator. Because neither the mini or the calculator is the sole answer to all problems, the advantages and disadvantages of each must be carefully weighed.

Such features as program entry methods; languages; instruction sets; execution speed; memory capacity; and cost are a few of the areas that need consideration when making a choice between a mini or a calculator. An excellent article entitled, "When to use a programmable calculator or a mini-computer to automate a system," is found in the May 16, 1974 issue of 'Electronics' magazine.

The Calculator Products group of IDD is quite aware of the changing role the calculator now plays, and will play in the future of automated systems. Since their conception, the Tektronix 21 and 31 programmable calculator systems have continued to evolve, meeting the needs of a wide range of users. Some very strong and flexible instruments have grown around these two products, allowing a system to be configured to meet a specific need.

Two Tektronix instruments that are directly related to data acquisition and manipulation are the 31/53 Instrument Interface system and the 152 General Purpose BCD Interface. Because of the different plug-ins available with the system, the 31/53 Interface is very versatile. No complex interconnecting wiring is required, only BNC and banana jack connectors are necessary. If speeds greater than its standard 20 samples per second rate are required, an A to D module plug-in can be utilized.

The 152 General Purpose BCD Interface adds even greater flexibility to calculator-based instrumentation. The key feature of the 152 is its ability to interface with any unit using BCD inputs and outputs with the Tektronix 31 calculator. The 152 utilizes inputs of TTL, BCD parallel information (up to 10 characters wide), and provides 56 programmable outputs. There are also 6 programmable +/- triggers available. With 2 separate modes of operation, speed is another big feature of the 152. One mode has a rate of 20 samples per second. The other is a 15K sample per second rate, made possible by a direct memory access capability. Other interface boards can be installed in the basic unit, insuring later expansion as desired. (The 2 accompanying system diagrams give a hint of the depth and

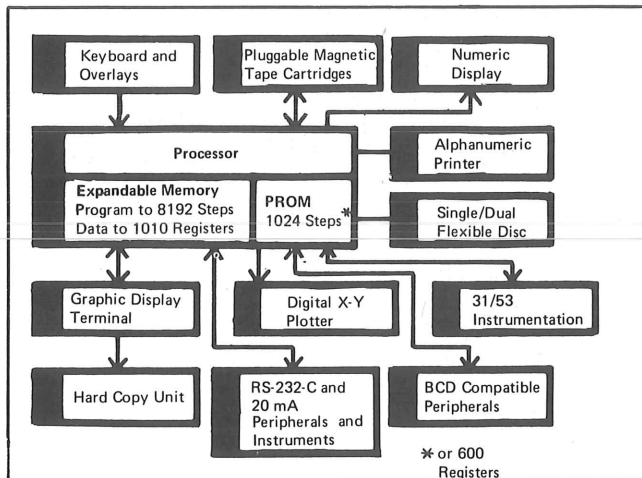


Figure 1 Tektronix 31 system chart

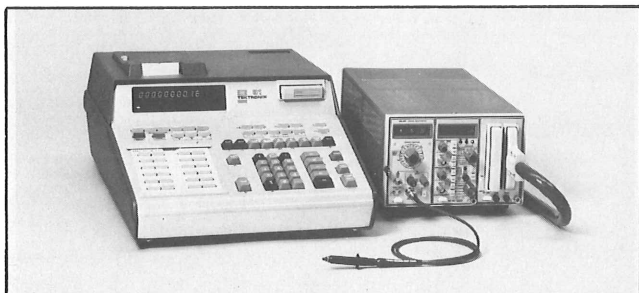


Figure 2 the package deal

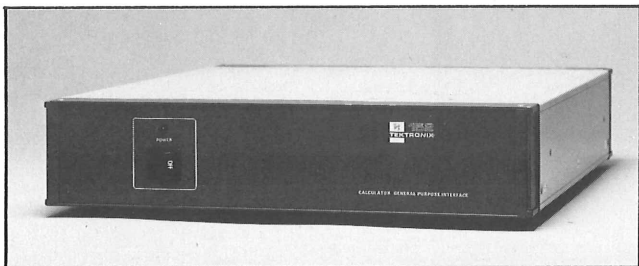


Figure 3 Tektronix 152 General Purpose BCD Interface

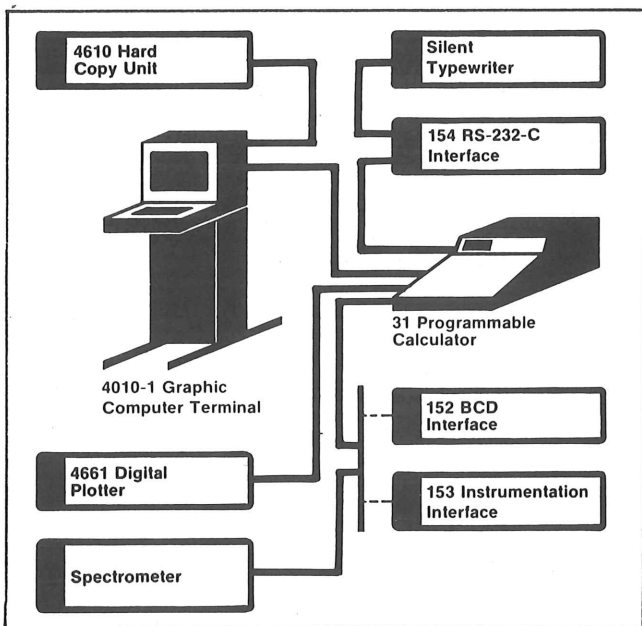


Figure 4 one way to do it

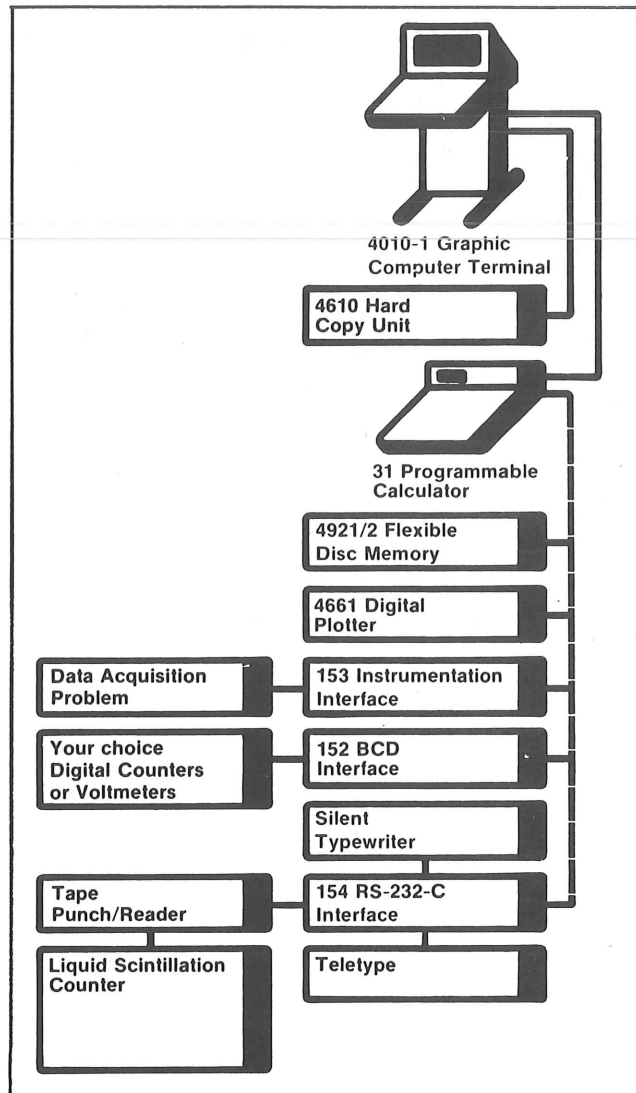


Figure 5 another way to do it

flexibility made possible by using the proper components in system assembly.)

With the computational power and supportive instrumentation of today's calculators, there is definitely an alternative available for the mini. Also, the new IEC Interface Bus will make the marriage of various system components with the calculator even easier.

For questions regarding calculator-based instrumentation, please contact me, Steven Joy, at ext. 235 Sunset.

IEEE Meets

A panel from Tektronix will address IEEE's Portland Electronics Group at 7:30 p.m., April 16, in the auditorium of Building 50. A program on the current status of various display devices and their potential applications and limitations will be presented.

For more information, contact Aris Silzars, ext. 6911.

Scientific Computer Center

microprocessor software status

Software	Current Status	Program Source
INTEL 4040 Assembler	Operational	INTEL
INTEL 4040 Simulator	Operational	TEK (Norm Kerth)
INTEL 8080 Assembler	Operational	INTEL
INTEL 8080 Simulator	Operational	INTEL
INTEL 8008 Assembler	Operational	TEK (Wendell Damm)
INTEL PL/M	Est. Operational 4/21	INTEL
INTEL 3000 Assembler	Operational	INTEL
INTEL 3000 ROM Mapper	Operational	INTEL
MOTOROLA M6800 Assembler	Est. Operational 4/21	MOTOROLA
MOTOROLA M6800 Simulator	Program not received yet from	MOTOROLA

To get the latest status, type HELP, MICROP. For the answers to toughies, call Bill Lowery, ext. 5865.

TEK CYBER 73 Operating Hours

TEK Runtime	M,T,F	7am - 9pm	TEK Runtime (free)	Sat	9am - 5pm
TEK Runtime	W,TH	8am - 9pm	Systems Time is only if necessary, otherwise Time Sharing is valid until midnight. Any questions? If so, please call Tom Bohan at ext. 7446, or Bob Mainero at ext. 5104.		
Maintenance hours	W,TH	4am - 8am			
Systems Time	M thru F	9pm - 12am			

Effective immediately, Technical Education Director Harley Perkins will reside at 39-015. His phone extension will remain 6186.

389-94

MAUREEN KEY