component news

Sept 1, 1978 COMPANY CONFIDENTIAL Issue 262

Bipolar power fights back!

Power transistor technologies have been stable for several years. Now, a veritable flood of new device structures and package formats have appeared, mostly from Japan.

In standard power devices there is a direct trade-off between safe operating area (SOA) and speed. In order to increase SOA, bases are made quite thick. Unfortunately, these parts have an f_T of approximately 800 KHz to 2 MHz , at best. Parts that have an f_T of 15 MHz or more have thin bases and are considerably more fragile, resulting in large SOA derating at anything more than a modest collector-to-emitter voltage.

The new transistors feature high speed with large SOA — a rare combination before found only in expensive military and space type parts, but available now at low prices.

emitter ballasting

The main technique used to achieve these goals is emitter ballasting. Several configurations of this technique are used, each with varying degrees of improvement over standard, non-ballasted devices. In addition, base ballasting is also used, although it is not as effective as emitter ballasting.

Studying the SOA graphs for a variety of power devices (both large and small) shows that the SOA of even a 50 amp transistor is not much different than that of a 1 amp device at higher voltages. Transistors below 1 amp are usually small enough in physical size that their power dissipation is limited to less than what their SOA would allow.

Since conduction pushes to the edge of the emitter area at moderate to high currents, modern transistors are constructed with as much emitter periphery to total emitter area as possible. This leads to the familiar multiple emitter "fingers" (also known as interdigitation) as shown in Figure 1.

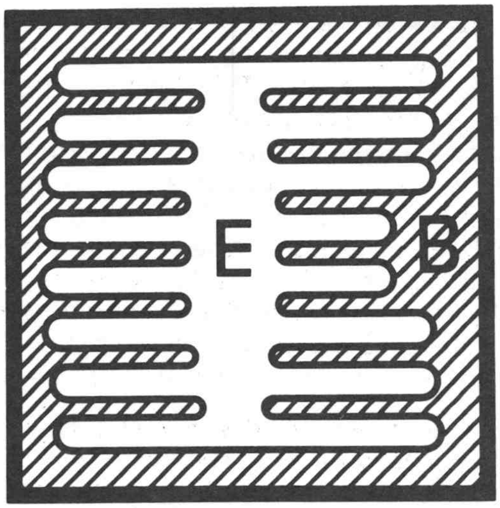

Figure 1 - Modern interdigitated transistor structure

Each of these fingers, along with the base and collector areas underneath, form a unit transistor. If small enough, each of these unit transistors will have SOA characteristics identical to a small discrete transistor. However, because they're all bussed together in parallel, the SOA of the composite part will be that of the smallest unit transistor.

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There are two limits in the amount of interdigitation in a device – a fabrication restriction and an effectiveness limit. If a very large number of emitter and base areas are used, mask alignment becomes more critical, resulting in lower yields and higher cost. Also if the metallization area is made too small, high current densities will lead to electro-migration (i.e., eroding away the emitter metal).

The best techniques to overcome the "weakest link" is to use emitter ballasting where resistors are inserted in series with each emitter finger. Then, any undesired increase in the current through a particular emitter will be limited by the resistor, so that each one will tend to draw approximately the same amount of current.

base ballasting/floating emitter

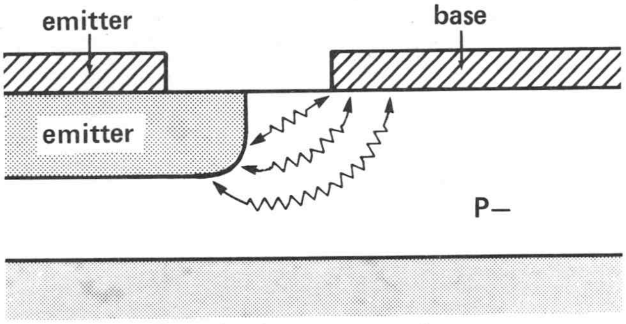
Another way to increase safe operating area is base ballasting. Several Japanese manufacturers have developed this scheme, which they call the "floating emitter."

All transistors have an internal series base resistance (R_{bb}'), caused by the relatively high resistivity base doping. This high resistivity is required to produce useful current gain in the transistor. Through the base of a transistor there are large variations in resistance due to differing path lengths from base to emitter. The conduction from emitter to collector takes place at the point where the base-to-emitter paths are shortest. This is usually at the corner of the emitter diffusion, as shown in Figure 2. Because of this property, only a small portion of the emitter region is actually used.

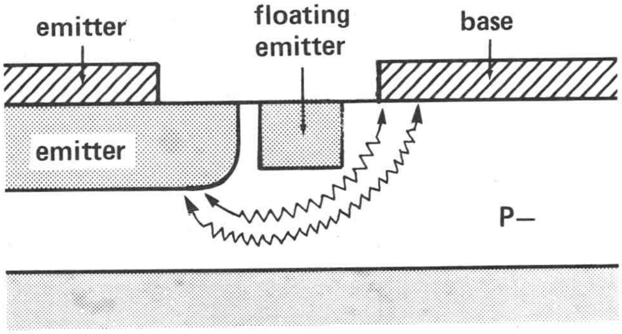
The floating emitter design uses a fixed resistance in series with R_{bb}' resistance that is large relative to the variations in R_{bb}' to swamp them out and to enhance more of the emitter area. The extra resistance comes from a ring around the actual emitter, but not directly connected to it. The ring is made at the same time, from the same material, and the same depth of diffusion as the emitter (see Figure 3). Thus, the term "floating emitter."

Due to bandgap phenomenon, when forward potential is applied to the base-emitter junction, the floating emitter establishes a depletion region which lengthens the path for carriers to travel. This longer path through the high resistivity base is the larger fixed resistance.

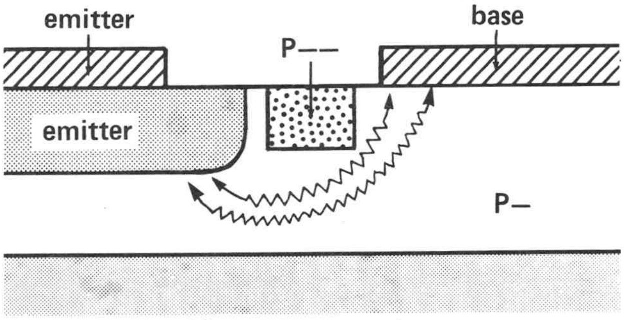
The possible drawbacks are increased $R_{bb}'\ C_{cb}$ time constant which can lower the effective speed of the device, and a slightly higher V_{be} voltage.



Standard power transistor



Floating emitter



Motorola power base

Figure 2 - Comparison of standard and base ballasted structures

Motorola power base

Power base is Motorola's enhanced epibase process that offers SOA equivalent to single-diffused or "hometaxial-base." They have utilized the same theory as the Japanese designers, but their implementation is different.

Instead of forming the resistance ring at the same time and the same doping as the emitter, a separate step is used. The power base ring is not as heavily doped, so the resistance is somewhat less. To make a more exact replacement of single-diffused, the base thickness was increased to reduce f_T to single-diffused levels, also helping SOA.

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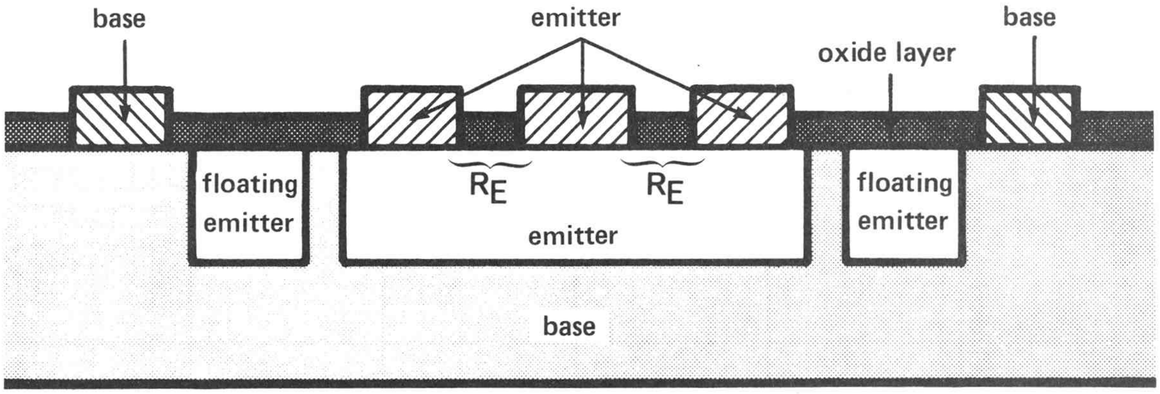

Figure 3A - Cross-sectional view of 2SB706/2SD746 structure

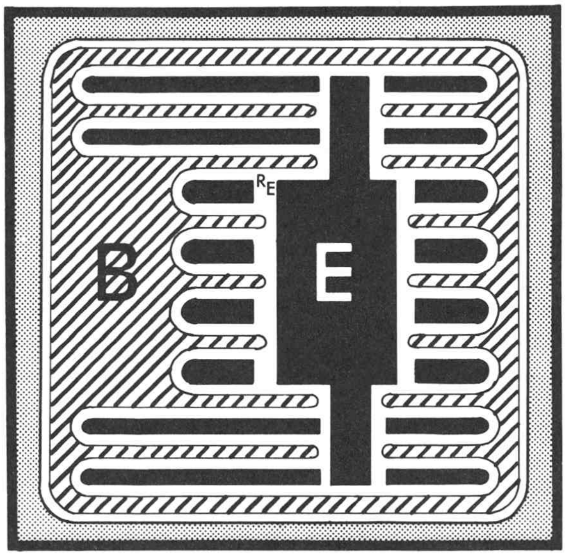

Figure 3B - Top view of 2SD746

new structures

In its latest series of audio output devices (2SB706/2SD746), NEC has used a technique of emitter ballasting that is elegant in its simplicity.

In these devices the emitter diffusion area is not totally metallized, and the resistance of the silicon itself is utilized as the ballast resistor. Resistance value measured here at Tektronix is about 2.5Ω per emitter, thus because the device has 16 emitters this calculates to be 0.156Ω for the entire transistor. This method could be used in almost any transistor to increase the safe operating area without a cost penalty.

The only disadvantage is that $V_{CE(SAT)}$ is increased by a factor of $I_E(R_E)$. Because a moderate amount of ballasting is used, the f_T is *only* 15 MHz, with an SOA rating of 100V/1A.

Another approach involves using discrete emitters joined together by the metallization. This is a form of overlay geometry, widely used in RF power devices, as shown in Figure 4. There are 316 ballasted emitters on this die (the 2SC2337/2SA1007, also from NEC). It has a 70/50 MHz f_T and an SOA rating of 100V/0.6A. A small version of this part, with BV_{CEO} of 250V and I_C of 1.5A, is being part-numbered at Tektronix (2SA1006B/2SC2336B). These units have an SOA of 100V/250mA and an f_T of 80/95 MHz.

ring emitter transistors

A different approach is taken by Fujitsu in their "ring emitter transistor," or RET. Instead of a conventional stripe geometry, a series of numerous ring-shaped devices of small geometry, high f_T are integrated on one die. The emitters are then connected through unmetallized silicon, as in the 2SD746.

A whole family of transistors is available, from a 120V/2A unit through a 120V/30A device. A 400V/10A unit will be on the market soon.

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On the 2SA1041/2SC2431 part, 312 RETs are tied together on a 15 amp device. High speed is this transistor's forte, with f_T of 80 MHz and an SOA of 100V/0.4A. These devices would be ideal for switching regulators, because the switching speeds are extremely fast, yet the parts are very rugged.

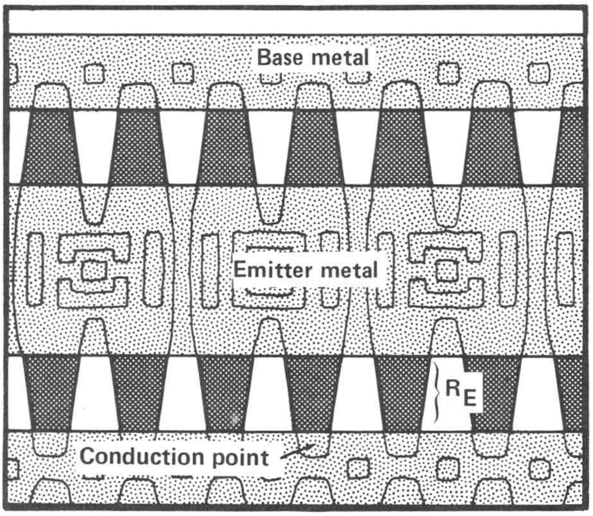


Figure 4 - NEC 2SA1007/2SC2337 overlay geometry

new packages

Traditionally, plastic packaging has been associated with low power, low cost and low reliability. Continual efforts by both domestic and foreign manufacturers have increased plastic package reliability to very near that of metal-cased devices. Plastic has also had more flexibility in mounting, and assembly ease. As an example, in the power field the TO-220 plastic package has very nearly replaced the metal TO-66, not only at Tektronix but industrywide.

TO-3 metal packaging still controls the high power (over 100W) field, but a new series of plastic packages from NEC may change this.

NEC has just introduced their MP-200, MP-100 and MP-50 power transistor packages. The MP-200 (a 200W package) is a unique mounting design. The mounting slots are on the same spacing as TO-3 mounting holes. The bottom plate is a plated, 100-mil-thick copper header to provide a low thermal resistance of 0.750°C/watt. This is less than many metal TO-3 transistors. The collector is connected to the bottom plate.

One of the strong points in this package design is that connections are on the same side as the device's body (see Figure 5). This allows for convenient mounting and wiring, much like the TO-220 package. Another significant factor is that this package is not a "direct replacement" for a metal can device. Historically, this has been the case for plastic packages – TO-220 was a substitute for TO-66 metal, and TI's "plastic TO-3" was to be a TO-3 replacement.

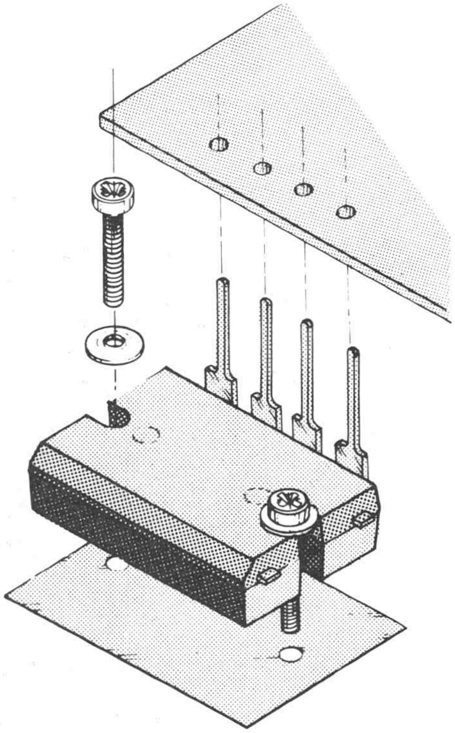


Figure 5 - Same-side mounting on NEC MP-200

The mid-size MP-100 from NEC (see Figure 6) has a Θ_{JC} of 1.25°C/W, yielding a 120W rating. Its mounting holes fit TO-66 spacing and it also has same-side mounting. The MP-50 has the same Θ_{JC} as a good TO-220, but has two mounting tabs and can hold larger transistor die than TO-220 packages.

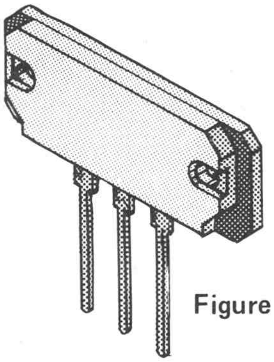
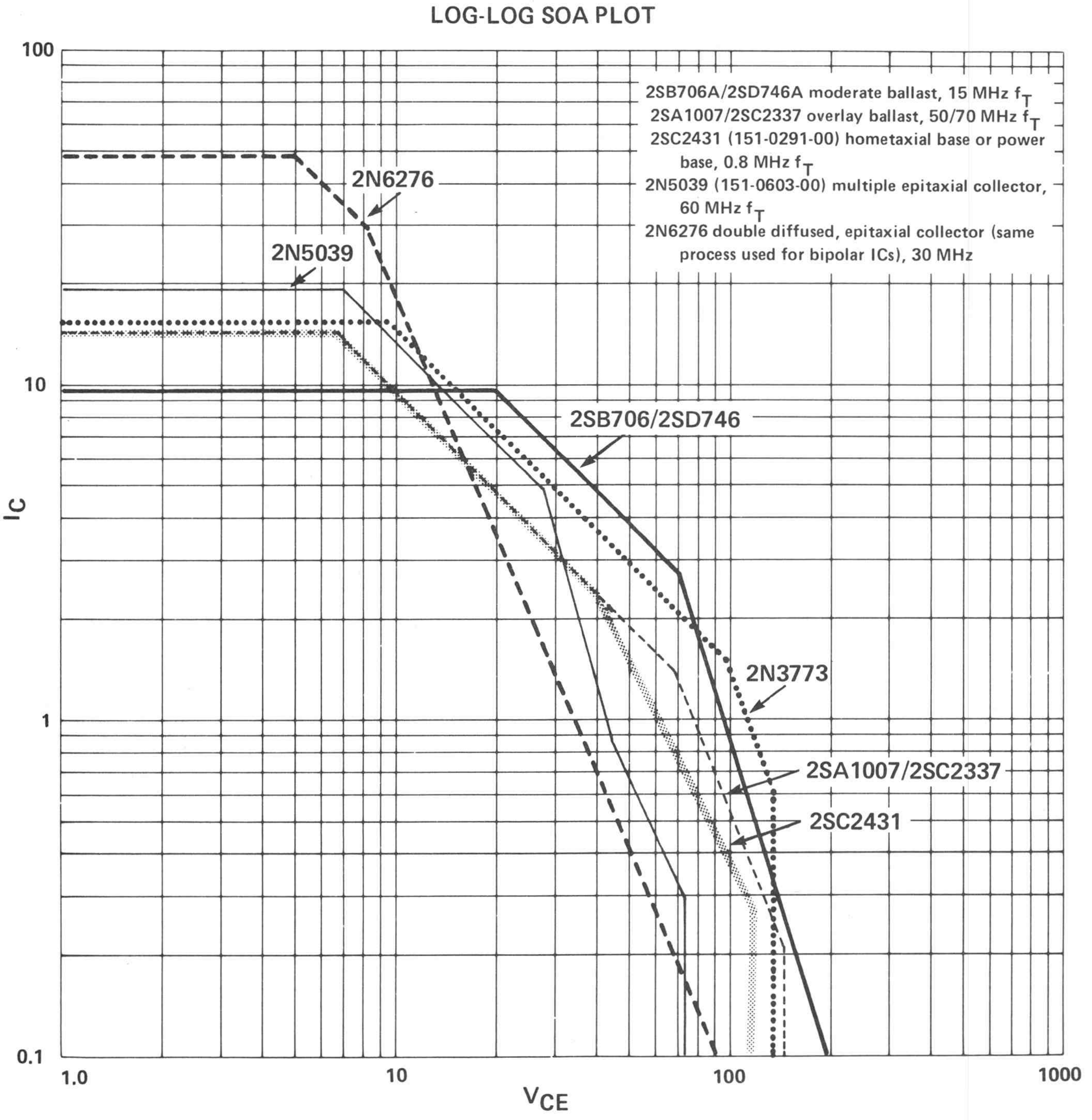


Figure 6 - NEC MP100



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Presently, these packages are available only from NEC, although it is likely some suppliers may copy the Japanese packages. It is possible the MP-200 may become *the* standard for large plastic power transistors. Six pairs of 2SB706A/2SD746A are used as the outputs for the Pioneer SX1980 receiver's amplifier, which boasts 270 continuous watts per channel.

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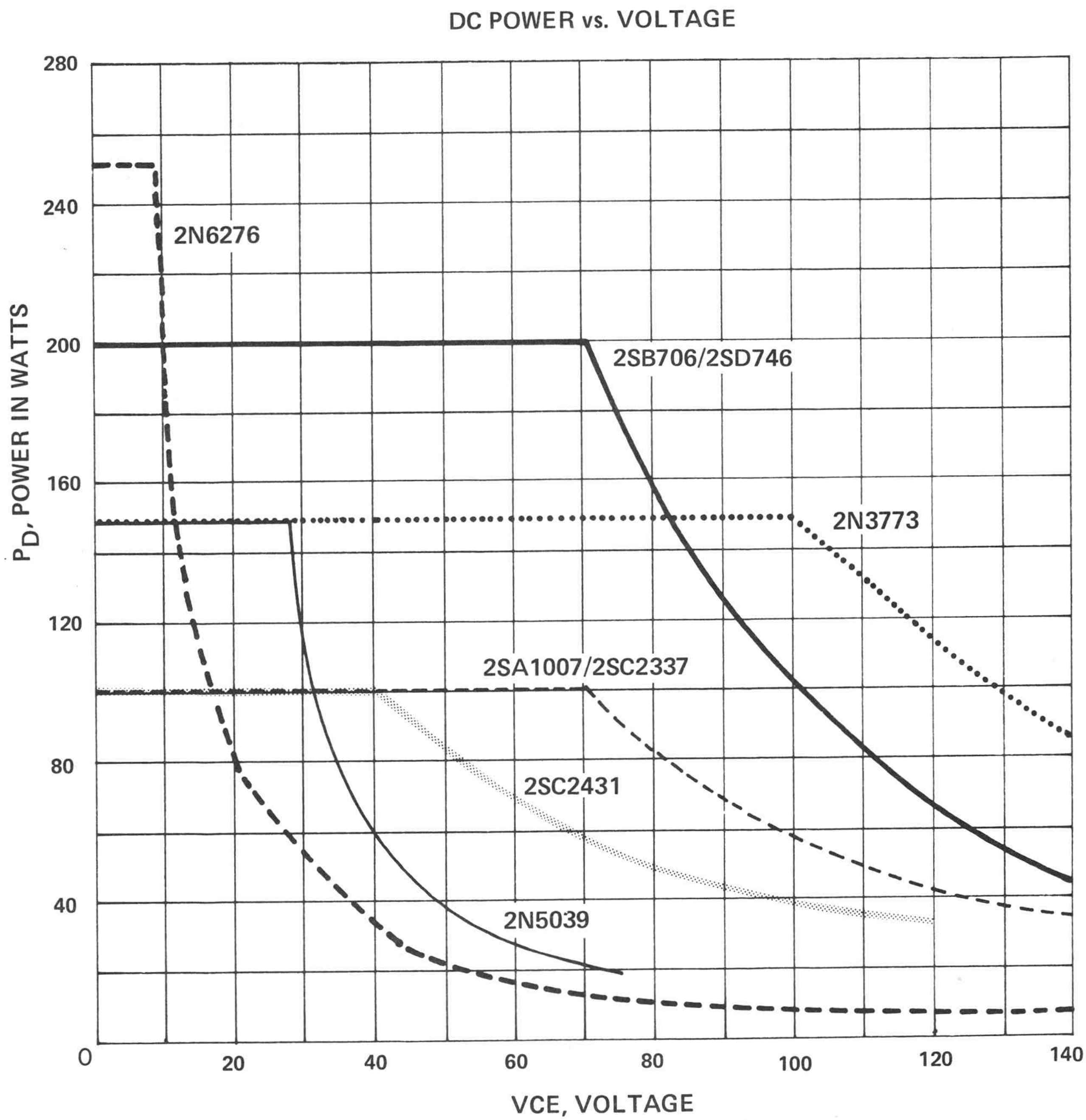
To specify transistor ruggedness, an SOA graph is required. Shown here are DC SOA curves for devices using a variety of processes and structures.

The use of log-log SOA plots is an industry-wide practice. They give readable resolution at extremes of current and voltage. Unfortunately, the apparent range between the strongest and the weakest parts is not readily seen on a log-log plot. However. . .



. . . a DC power-voltage plot (shown above) definitely separates the strong from the weak!

more information

These transistors are seriously being considered by a design group at Tektronix. If you are interested in more details, please contact me at **58/299 (ext. 5345).**

Jim Williamson

Safety-rated fuseholders recommended

Component Engineering recently completed an evaluation on safety-rated fuseholders for our products. These fuseholders have component recognition from UL, and are certified or approved by CSA, VDE, SEMKO and SEV.

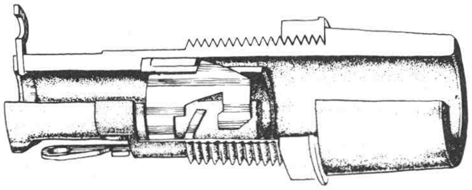
The devices accept either the standard 3AG fuse or the international 5 x 20 mm fuse. Two versions accommodate the need for high or low profile. Both have identical lengths, but the high-profile version requires 1.22″ behind the panel and 0.551″ in front, while the low-profile unit extends back 1.61″ and forward 0.157″. Current rating is 6.3 amps at 250 volts.

All current-carrying contacts in the fuseholders are recessed or protected so they are inaccessible when the fuse carrier is removed. The carrier is also insulated. Access to the fuse requires use of a screwdriver, which deters tampering.

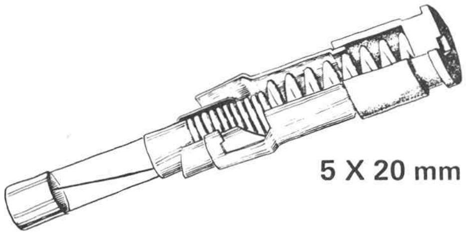
Installation is accomplished using a polycarbonate mounting nut. During our evaluation, we found this nut loosens slightly under heat cycling, and we recommend using an additional lock-washer to mount the device. Torque on the nut/lock-washer should be between 10 and 15 in/lbs.

The following fuseholders have been Tek part-numbered:

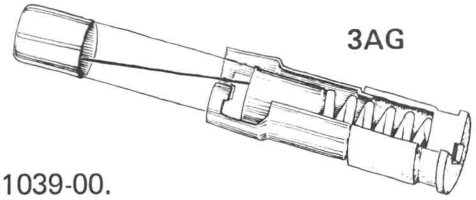
204-0832-00	low-profile body
204-0833-00	high-profile body
200-2264-00	3AG carrier (1¼ x ¼″)
200-2265-00	5 x 20 mm carrier



High-profile fuseholder



5 X 20 mm



3AG

The ½″ lock-washer is available under Tek P/N 210-1039-00.

CE and Product Safety highly recommend this device for primary circuits in new designs. Please contact me at 58-299 (ext. 6365), if you'd like more information.

Joe Joncas

Recycling IC carrier tubes

Many microcircuits purchased by Tek are shipped and stored in plastic tubes. The tubes protect the devices from handling damage, electrostatic discharge and environmental extremes. When empty, these carrier tubes are recycled by production areas to Integrated Circuits Manufacturing (ICM) where they're used for our ICs.

Recently, however, assembly areas have been returning some of the tubes with a few devices still inside. This leads to problems for the people in ICM, because there is no way to identify the status of the parts (reject, failed, misplaced, etc.). Over 500 devices of unknown status have been discovered.

Therefore, ICM is asking all using areas to *carefully* check the carrier tubes before returning them to 48-222. This will help everyone involved and hopefully alleviate the problem.

For more details, contact **Wes Allen (48-162), ext. 6165.**

Adapter developed for data comm tester

SID Applications Engineering has developed an adapter with breakout pins and line switches for the 832 Data Comm Tester. The adapter fits any standard RS232 connector.

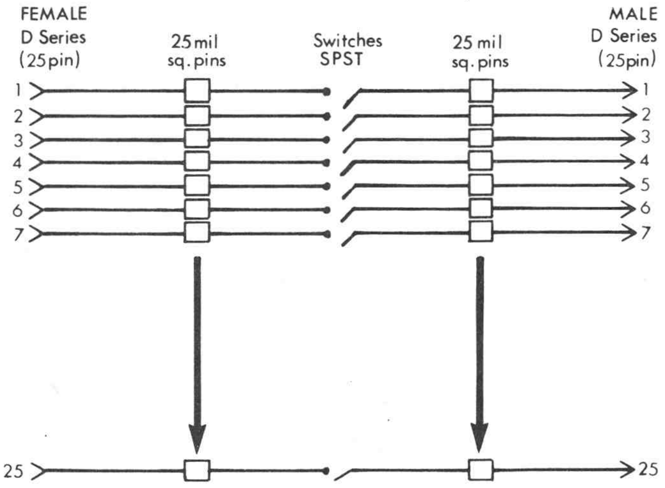
We found in visits to customers that although the RS232 connector on modems is specified to be female, the RS232 connector on terminals is also female in many cases. We also found that we needed extra access to the RS232 lines in addition to the breakout box on the 832, which permits access to the DTE side of the lines.

The adapter fits onto the DCE input connector at the back of the 832. It gives access to the DCE side of the lines, and it can be used as a sex adapter when necessary with the addition of a sex-adapter card.

The adapter has pins for all 25 lines; it has switches for lines 2 through 25. Line 1, the ground, cannot be switched. The version of the adapter we use most often has a male and a female connector. A second version of the connector has two male connectors.

The adapter and sex-adapter card may eventually become standard Tektronix accessories. Meanwhile, you can build your own adapter using the drawing provided.

RS-232 Breakout Box



Female connector	131-0812-00
Male connector	131-2199-00
Switch (3 ea.)	260-1721-00
Square pin	131-1634-00
Prototype number (EC board)	G-0936-XA

For more information, contact **Jim Blethen (41-091), ext. 201.**

Zilog specification and manual changes

Zilog has provided us with the following changes to the Z80-CTC specification and the Z80 Assembly Language Programming Manual:

Specification Change — Z80-CTC

The AC characteristics of the Z80-CTC (2.5 MHz) have been modified as follows:

change	from	to
TS(CK)	210 nS	300 nS
TDH(ZC)	190 nS	260 nS

These changes should not affect most designs. The only problem foreseen is in applications where counter channels are "cascaded;" that is, where the output of one channel is connected to the input of another, a technique used to expand the resolution in "counter mode." Few applications use this technique because of the resolution provided by the pre-scaler in "timer mode." If "cascading" is required, use Z80A-CTC (4 MHz).

Errata — Assembly Language Programming Manual

on pages 93 and 97, change as follows:

from For BC = 0 and A = (HL)
to For BC ≠ 0 and A ≠ (HL)

on pages 85 and 89, change as follows:

from For BC = 0
M cycles: 5
to For BC ≠ 0
M cycles: 5

on pages 258, 262, 269 & 273, change as follows:

from If B = 0
M cycles: 5
to If B ≠ 0
M cycles: 5

For more details on these changes, contact **Bill Pfeifer (ext. 6303) or Wilton Hart (ext. 7607).**

IC reliability

To solder, Or to socket

A high volume of ICs are being used in the production of Tektronix instruments. The ICs are either installed in sockets or soldered directly onto the printed circuit boards. This article documents an evaluation of the two practices, namely whether to "socket" or to solder an IC. Many opinions were solicited and used in this evaluation.

From the servicing standpoint, the cost comparison between the two methods was presented in **Component News # 246**, pages 4 and 5. There are many objections to using soldered ICs because of anticipated longer servicing time. While it is easier to repair socketed ICs by direct replacement, it encourages "shot-gun" repair. This results in a high percentage of "retested-good" field failures.

Most service people agree that soldered ICs demand more troubleshooting skill, but they also feel that troubleshooting soldered ICs will eventually force better technician skills.

From the production point of view, the major concern is cost – material, labor and time. Lynn Holt, STS Manufacturing, has completed a labor cost study on these practices (see Figure 1) and, as expected, the socketed ICs cost more to use.

Some concerns are directed to customer preference. The general feeling is that different customers of different instrument types (e.g., oscilloscopes, TV products, computer terminals, etc.) do not react the same to socketed or soldered ICs. Among customers with more technical background, socketed ICs are preferred because they like to perform their own maintenance. Computer terminal customers who do minimal maintenance on their own tend to favor soldered-in ICs. According to a recent survey, some oscilloscope customers were adamantly *against* the use of soldered ICs.

Reliability is another major concern in this comparison. In **Component News # 246** we reported that up to 50% of the field failures were retested good. The figure in a recent TTL failure analysis of over 100 field returns showed between 30 & 40% good devices. Most of the retested-good parts (about 70%) were socketed parts. The possible reasons for it were: 1) bad socket contacts, 2) false removal, or 3) specification inadequacy.

Socket failures will and do affect the reliability of Tek instruments. Another factor which impacts reliability is the thermal conductivity. Printed circuit boards with tracks soldered to the IC terminals provide better thermal conductivity than those with socketed components. Thus, soldered-in parts will operate at lower junction temperatures, resulting in lower failure rates.

The following recommendations are based on the information gathered.

Use sockets:

1) when the ICs do not have a known, satisfactory reliability level;
2) with complex ICs (e.g., CPU chips) which cannot be exhaustively tested electrically before installation;
3) when the parts need to be hand selected;
4) in multi-layer boards where soldering is kept to a minimum;
5) in board areas where the parts are difficult to access;
6) where strategic test points are located;
7) where customers are not discouraged from doing their own maintenance;
8) if in-plant instrument configurability is mandatory (i.e., putting more or less memory into an instrument for a customer, or to allow expandability).

Use soldered ICs:

1) when the parts have demonstrated, satisfactory reliability levels;
2) to reduce costs;
3) to improve thermal conductivity without adding heat sinks;
4) when there is a good board exchange program;
5) to obtain higher reliability (eliminate socket failures);
6) when compactness is an important factor.

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Figure 1 — Labor cost comparison for IC insertion

This comparison was based on MTM standards wherever possible. Estimates are noted. (1 TMU = .00001 hr.)

A. Hand insert and hand prep ICs and sockets (present method)

Operation	TMU per part
1. Install socket in board	134
2. Prep IC	251 (est)
3. Install IC in socket	340
Total	725 = 7.25¢ per part

B. Hand prep and install IC, trim back of board

1. Prep the IC	251 (est)
2. Install the IC in the board	134
3. Trim the back side	246
Total	631 = 6.31¢ per part

C. Machine prep and trim ICs, install by hand

1. Machine prep and trim ICs	12 (est)
2. Install IC in board	134
Total	146 = 1.46¢ per part

D. Machine insert ICs, trim back of board

1. Machine insert IC	120 (est)
2. Trim back side	246
Total	366 = 3.66¢ per part

(@ $10.00 per hr. labor and burden)

The figure below gives recommendations on selection by part technology.

Parts OK to solder in, if 100% tested:

CMOS DTL TTL	LSTTL STTL ECL Linear

Parts OK to solder in, if 100% tested & burned-in:

MOS RAMs
MOS ROMs

Parts which should be socketed:

CPU/Microprocessors
Complex Interface Devices

Component Reliability Engineering recommends that the ICs should at least be 100% tested before use. The burn-in or pre-stressed ICs are desirable if higher reliability warrants the cost.

The practice of socketing and soldering ICs has been evaluated from the standpoints of service, production, customer preference and reliability. Because of the diversified interests of each instrument line at Tek, there is no blanket policy concerning the use of sockets over soldered, or vice versa.

Steve Hui, ext. 6511

RELY now on CYBER

RELY is now a CYBER system command. This means that after logging on, to execute the parts count reliability program you simply type:

```
RELY
```

There is also a short description of the RELY program on the HELP files. Type:

```
HELP, RELY
```

You must still get MTBF and DERATE from user number ACA0LAM before execution.

For more information, contact **Larry Meneghin, ext. 7268.**

Burned-in TTL and ECL devices

The following list represents the TTL, STTL, LSTTL and ECL devices which have part numbers describing burned-in, screened parts. These parts are supplied in screened form by part vendors. The testing sequence for these devices is described in Tektronix Standard 062-3919-00.

Because additional vendor burned-in parts are being part-numbered continually, an updated list will be available from the CYBER system by entering:

```
GET, HIREL/UN= ACA0LAM
HIREL
```

Vendor Burned-in Parts

156-0041-05
-0113-03
-0118-02
-0145-02
-0172-02
-0180-04
-0303-01
-0304-02
-0316-04
-0320-03
-0321-02
-0323-02
-0325-02
-0368-03
-0374-02
-0381-02
-0382-02
-0383-02
-0384-02
-0385-02
-0386-02
-0387-02
-0388-03

156-0391-02
-0392-03
-0404-01
-0412-02
-0413-02
-0422-02
-0459-02
-0464-02
-0465-02
-0469-02
-0470-02
-0471-02
-0472-03
-0479-02
-0480-02
-0481-02
-0529-02
-0530-02
-0541-02
-0569-01
-0599-01
-0645-02
-0646-02

156-0651-02
-0652-02
-0656-02
-0679-01
-0690-03
-0718-03
-0720-02
-0724-02
-0728-02
-0733-02
-0735-02
-0736-02
-0738-04
-0784-02
-0798-02
-0852-02
-0865-02
-0874-02
-0875-02
-0910-02
-0913-02
-0914-02
-0916-02

156-0948-02
-0953-02
-0955-02
-0956-03
-0957-01
-0966-01
-0975-02
-0982-03
-0994-02
-1026-02
-1045-01
-1046-02
-1054-01
-1064-02
-1111-02
-1149-01
-1172-01
-1176-01
-1177-01
-1235-00
-1246-01
-1251-00
-1252-00

Interest in use of 100% burned-in TTL parts has been quite high; the following new instrument projects have chosen to use 100% burned-in parts:

S3700
7854
5223
5B25N
1900
1980
492

Ron Schwartz, ext. 6511
Component Reliability Engineering

Personnel announcements

I am pleased to announce that Harriet Krauss has been named manager of the Component Information Systems Group. Her technical and managerial experience with computer systems includes extended periods with IBM, General Electric Company and the Smithsonian Institution. Harriet will be reporting to me. All present members of the CIS group will report to Harriet.

Harley Perkins
Engineering Services

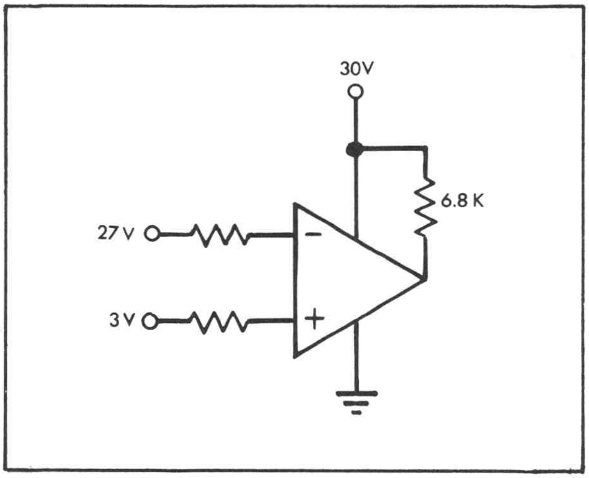
Effective immediately, Dorothy Peterson has been named Manager of the Component Documentation Group. All present members of this group will report to Dorothy. She will report to me.

Harriet Krauss
Component Information Systems Group

New op amp undergoes reliability tests

Reliability tests on Texas Instruments' new plastic package quad op amp (TL064) have been completed.

During initial testing, six failures and four marginal failures were found out of 101 parts. The burn-in circuit is shown below.



Life tests were performed on 70 parts, with burn-in at 125°C for 336 hours. The testing was done on the S3260 with the following results:

number of failures at	
16 hours	2
36 hours	1
96 hours	0
336 hours	0

note: all three failures were I_{OS}

Failure rate calculations for these devices (at 70°C junction temperature) are:

raw parts	0.4% per 1000 hrs
electrically tested parts (no burn-in)	0.17% per 1000 hrs
burn-in and electrically tested parts	0.025% per 1000 hrs

Based on these test results, Component Reliability Engineering recommends:

1. 100% electrical testing on the TL064 op amp;
2. for best reliability, a 100% burn-in at 125°C for 160 hours. This can be obtained by specifying the "PEP 3" option ("PEP" is an extra cost test option available from Texas Instruments).

For more details on these reliability tests, contact **Steve Hui, ext. 6511.**

µP-based keyboard

I have one of Microswitch's new microprocessor-based keyboards for demonstration and evaluation. The keyboard uses an 8748 processor and Hall effect keyswitches. This board has a neat appearance, and crisp mechanical action.

For a demonstration, contact me at 58-299 (ext. 7711).

Jim Deer

New manager in CE

Bob Aguirre is the new manager of Electromechanical Component Engineering, and will coordinate the activities of component engineers, support technicians, writers and aides in that group. He was formerly a project engineer in high frequency component development in Building 39. Prior to coming to Tek five years ago, Bob worked in the aerospace industry in California.

Effects of moisture on resistors

Moisture Resistance Testing

The moisture-resistance test evaluates the resistance of components to deterioration from high humidity and heat in an accelerated manner. Most degradation results from absorption of moisture vapor by insulating materials, or from surface wetting of metals and insulation. Many types of deterioration can then occur — corrosion of metals, distortion and decomposition of organic materials, leaching-out of constituent materials, and changes in electrical properties.

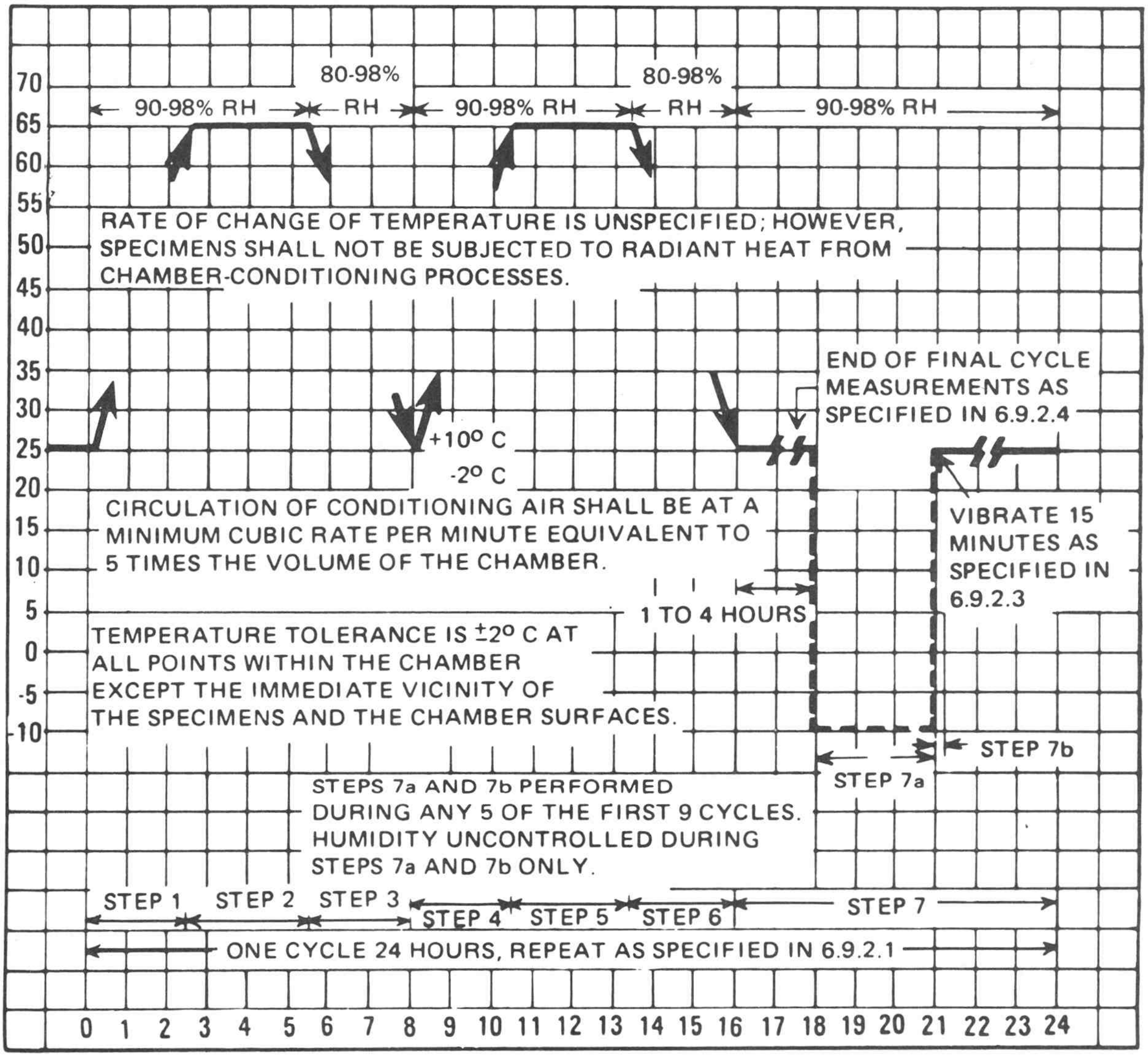
This test is used at Tek and employs temperature cycling — providing alternate periods of condensation and drying and producing a "breathing" action of moisture into partially sealed containers. As a result, deterioration can be detected by measuring electrical characteristics (dielectric withstand voltage and insulation resistance) or by testing the sealing.

Test Procedure

1. Initial measurements — prior to step 1 of the first cycle, the specified initial measurements should be made at room ambient conditions.
2. Number of cycles — specimens should be subjected to 10 continuous cycles, each as shown in Figure 1.
3. Measurements — initial resistance should be measured before the test. After step 6 in the final cycle, the resistors should be exposed to a temperature of 25° + 2°C and a relative humidity of 90 to 98 percent, for 1½ to 3½ hours.

continued on page 14

Figure 1



RATE OF CHANGE OF TEMPERATURE IS UNSPECIFIED; HOWEVER, SPECIMENS SHALL NOT BE SUBJECTED TO RADIANT HEAT FROM CHAMBER-CONDITIONING PROCESSES.

END OF FINAL CYCLE MEASUREMENTS AS SPECIFIED IN 6.9.2.4

CIRCULATION OF CONDITIONING AIR SHALL BE AT A MINIMUM CUBIC RATE PER MINUTE EQUIVALENT TO 5 TIMES THE VOLUME OF THE CHAMBER.

VIBRATE 15 MINUTES AS SPECIFIED IN 6.9.2.3

TEMPERATURE TOLERANCE IS ±2° C AT ALL POINTS WITHIN THE CHAMBER EXCEPT THE IMMEDIATE VICINITY OF THE SPECIMENS AND THE CHAMBER SURFACES.

STEPS 7a AND 7b PERFORMED DURING ANY 5 OF THE FIRST 9 CYCLES. HUMIDITY UNCONTROLLED DURING STEPS 7a AND 7b ONLY.

ONE CYCLE 24 HOURS, REPEAT AS SPECIFIED IN 6.9.2.1

After removal from the test chamber, resistors should be permitted to dry for a maximum of four hours at 25° + 2°C at no less than 50 percent relative humidity. Such drying atmosphere should not be forced, circulating air. At the end of the drying period, final resistance is measured.

Humidity characteristic (steady state)

Results from the moisture resistance tests sometimes vary because of the equipment required, and because the results obtained are largely a function of the apparatus used; size of chamber, etc. The following steady state humidity test is recommended by Allen-Bradley in place of the moisture resistance test for obtaining better isolation of the effects of moisture.

Initial resistance values should be measured. Excessive handling and surface contamination should be avoided. Resistors are then placed in a chamber at a relative humidity of 90 to 95 percent at an ambient temperature of 40° + 2°C for a period of 240 hours. After removal from the chamber, the resistors should dry at room ambient temperature for four hours to remove surface moisture. Following this, final resistance measurements are made.

Conditioning

(recommended by Allen-Bradley)

All resistors, except those hermetically sealed with enclosures of metal, glass or ceramic materials and appropriate seals, are susceptible to moisture absorption. This moisture can affect resistance values to a varying degree, depending on materials, construction, dimensions and the duration of exposure to atmospheres with high relative humidity.

To eliminate this variable from test results, moisture removal by conditioning with warm *dry* air is mandatory for comparing results. Use of a ventilated room in an air conditioned space is recommended.

Resistors should be conditioned in *dry* 100°C (+5°C, – 0°C) air for the approximate time listed in Figure 2. This is normally sufficient to remove absorbed moisture. Longer drying may be required where resistors have been stored for long periods of time under unusually high relative humidity. Conditioning should be done before any other type of testing is performed.

Resistor Type	Maximum Continuous Power Rating at 70°C Ambient (Watts)	Recommended Conditioning Time at $100^{\circ}\mathrm{C}^{+5}_{-0}\,^{\circ}\mathrm{C}$ (Hours)
BB	1/8	25
CB	1/4	50
EB	1/2	75
GB	1	120
HB	2	130

Figure 2

Conductance

Electron conductance is the desired method for achieving stable resistors. In solids this phenomenon is determined by the number of free electrons and their mobility. Random-moving electrons are accelerated by an applied electric field. The electrons are rescattered by collisions with parent atoms of the crystal lattice or by impurities. This occurs in approximately 10^{-14} seconds. They are continually being scattered and redirected, producing a net drift velocity. A temperature increase causes more random activity, hence higher resistance (a plus temperature coefficient for metals).

Hydrolysis

Hydrolysis is the restructuring of the resistor material and location, by the presence of moisture. The material becomes mobile, causing permanent damage or destruction to the resistor. Distilled water has a conductance of 0.5×10^{6} ohms per centimeter cubed. A film, 1/100 millimeter thick one centimeter square, has a resistance of 500 megohms. Surface moisture on a clean resistor has about 1% resistance reduction on a 50 megohm value.

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Resistor specifications:

(moisture effect expressed as △R)

Resistor/rating	Typical* (+ %)	Manufac-turer (%)	Mil spec (%)
Carbon composition			
1/8 watt	9.0	0 + 15	0 + 15
1/4 watt	6.0	0 + 12	0 + 12
1/2 watt	7.0	0 + 14	0 + 14
1 watt	5.0	0 + 8	0 + 8
2 watt	4.0	0 + 7	0 + 7
Carbon film			
1/4 watt	2.0	5	–
Metal film			
standard	0.05	0.1	0.5
special	0.01	0.04	0.4
Wire wound			
single layer	0.1	0.2	0.2
multi-layer	0.02	0.1	0.05
single layer molded			
1 watt	1.0	2.0	–
2 watt	3.0	5.0	–
Thick film	0.1	0.5	0.5
Thin film	0.1	0.4	–
Varistors		not specified	
Thermistors		not specified	
Steady State Humidity			
Carbon composition			
1 KΩ value	9.0	–	–
1/8 watt	9.0	–	–
1/4 watt	6.0	–	–
1/2 watt	6.0	–	–
1 watt	4.0	–	–
2 watt	4.0	–	–
Carbon film			
1/4 watt	2.0	–	–

**Typical* most often indicates a level where 95% of the resistors are equal or better

Moisture Effects:

Carbon composition

The carbon composition resistors are responsive to ambient humidity. Water vapor is readily admitted through the porous, molded-phenolic covering. The vapor invades the resistance material and separates the contact between particles. This causes a net increase in resistance. The effects are reversible, except after heat pulses. The water vapor will expand when the resistor is power surged or soldered. This action causes a permanent positive resistance shift.

Carbon Films

The construction is similar and moisture effects are the same as metal films.

Metal Films

(metal films, evaporated metals or alloys, or sputtered films)

Water vapor can enter the resistor material and spread or disturb the crystal lattice. This would cause a resistance decrease when reacting with water vapor.

External surface contamination would cause a reduction in resistance by shunt current leakage. Physical or chemical hydrolysis in the external covering could cause a force upon the resistive material. This change could result in either an increase or a decrease in resistance, depending on the direction of the force.

Metal Oxides

Moisture addition causes metal hydroxides to form. These are usually more conductive than the oxides, and reduce resistance. External covering changes would produce the same results as metal films.

Wirewounds

The resistance wire is almost unaffected by moisture. Wire less than 0.001 inches in diameter will be affected by residual chlorides or hydroxides. Hydrolysis causes a decrease in resistance unless turns of wire are shorted. Most moisture effects on wirewound resistors are caused by coating reactions.

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Even hermetically sealed resistors respond to a moisture test. Internal chemical and physical changes continue and are accelerated by heat and temperature cycling.

Other Devices

Varistors are moisture protected. The resistance varies from 10^{12} ohms at low voltage to as low as 1 ohm above the turn-on voltage. The rated voltage is ± 5% or ± 10% at one milliamp. Small changes in resistance are difficult to measure.

Thermistors of the plus 0.7%/°C type are gold-doped silicon and are packaged like diodes. Small resistance changes are difficult to measure. The plus T/C switching types are barium-titanate doped. Coatings are used for identification or electrical insulation. The ceramic character of the material allows most commercial applications to be bare.

The negative T/C thermistors are complex metal-oxides processed to a ceramic state. Small resistance changes are hard to measure, also. Long-term stability is not affected by moisture.

The following general statements from Allen-Bradley apply to moisture effects on carbon composition resistors:

1. Low-value resistors exhibit less change due to humidity, temperature and voltage than high-value resistors.
2. Resistance changes due to increase in moisture content are always positive.
3. Resistance changes due to humidity are temporary, and are sometimes reversible.
4. Change of resistance which has occurred due to humidity can be essentially eliminated by conditioning the resistor at 100°C or by dry storage.
5. The effects of humidity may be minimized by operating the resistor with as little as 1/10 rated wattage load.

More Information

If you'd like more information about moisture and its effect on resistors, please contact me at 58-299, ext. 6520.

Ray Powell

Suggestions to improve parts availability

problem

Many, if not most, components listed in the *Common Design Parts Catalogs* can be found in stock on a day to day basis. However, some listed parts are not immediately available from stock and therefore must be procured. This delays availability.

This problem is the result of such things as shortages, brand new part, instrument cancelled, delays in processing initial order, not Current Status or the part being changed. Sometimes the present stock is dedicated to and needed for current production. In such cases, initial Engineering parts may have to be ordered on a special requisition.

solution

Don't assume the part is available. Check early to assure timely availability. Rush orders are disruptive, incurring special handling costs and creating much needless frustration.

Handle every part basically as if it were a new part. Let the appropriate areas know about your upcoming requirements. This is important even if parts are available today. Planned stock levels may be too low for your demands unless you make an input. Also, someone may change the characteristics of the part without your knowledge unless your need is made known.

Check the specification, a sample part, and/or the engineering buyer to be sure it is really the part you want, that it hasn't changed and to determine when parts will be available.

where to locate

<u>Specification document:</u>
Reprographics (58-038), or call ext. 5577
<u>Status:</u>
Screening report, or call ext. 5923
<u>Buyer:</u>
See back of parts catalog, or call ext. 7911.

Fred Schade

Preliminary wire standards developed

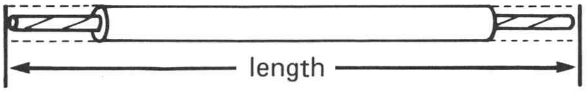
We have investigated wire lengths, strip lengths and the tolerances of each in Wire Prep, with the idea of standardization.

Having established, published standards would mean fewer set-ups, less waste from errors, improved productivity and a general reduction in inventory. In addition, using areas would find it easier to order parts, set-up, maintain inventory control, etc.

Field and plant failure repairs could be facilitated if lengths are specified on the plus side. Also, the military suggests the capability to repair a part three times (using a 3/16" strip length would mean ordering the length 9/16" longer than normal).

We have developed a preliminary standard, and invite your comments concerning this proposal. Please address your feedback within the next two weeks to **Larry Berry, NPI Engineer (19-182), ext. 6887.**

This standard specifies:
(1) Minimum wire length
(2) Increments of lengths
(3) Strip lengths and tolerances



All dimensions in inches or fractions

lengths	tolerances	increments	strip length	tolerances
1½ - 6	+1/4 –1/8	½	3/16	+1/16 –1/32
6 –24	+1/2 –1/4	1	3/16	+1/16 –1/32
24 - 48	+1 –1/2	2	3/16	+1/16 –1/32
48 - 96	+1 1/2 –3/4	3	3/16	+1/16 –1/32
96 & over	+2 –1	4	3/16	+1/16 –1/32

Strip lengths above are for open barrel crimp terminals such as the Berg Mini and Maxi P.V.

The standard strip for flexible coax will be 3/4" ± 1/16".

Closed barrel terminals such as the Hollingsworth terminals require a 3/8" ± 1/16" strip.

CE responsibility changes

Because of numerous recent changes in component engineer responsibilities, we are including a revised Component/Engineer listing in this issue (see page21).Briefly, the changes are as follows:

Betty Anderson, 6389	Visible LEDs
Peter Butler, 5417	Bulbs; spark gaps
Rod Christiansen, 5953	Cables; metal tubing
Jim Deer, 7711	Electromechanical printers; joysticks
Jim Howe, 6303	Microprocessor peripherals, interfaces
Paul Johnson, 6365	SCRs, SCSs; transistors: triacs, unijunctions
Joe Joncas, 6365	Power cords, receptacles, plugs
Louis Mahn, 6389	IR emitter, laser diode
Bill Stadelman, 7711	Crystal and SAW filters; generators; magnetic tapes and heads; power transformers
Byron Witt, 5417	Air filters; insulating sleeves

TECHNICAL STANDARDS

The function of Technical Standards is to identify, describe, and document standard processes, procedures, and practices within the Tektronix complex, and to insure these standards are consistent with established national and international standards. Technical Standards also provides a central repository for standards and specifications required at Tektronix. *Chuck Sullivan, manager (58-187)*

new and revised standards available from Technical Standards

MIL-C-23216C (Apr. 1978) Contacts, Electric, Connector — Cancelled. Use MIL-C-39029.
MIL-R-39035B Amendment 1 (Mar. 1978) Resistors, Variable, Non-wirewound (Adjustment type), Established Reliability.
ANSI/UL 187 Review copy of X-Ray Equipment
ANSI C92.1-1971 Voltage Values for Preferred Transient Insulation Levels (TIL) ($3)
UL 62 (May 1978) Revision pages for Standard for Flexible Cord and Fixture Wire
IEEE 683-1976 Block Transfers in CAMAC Systems, Recommended Practice for ($4)
EIA RS-449 (1977) General Purpose 37-Position and 9-Position Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange ($9.50)
ANSI/NFPA No. 70-1978 National Electrical Code. Revised and supersedes ANSI C1-1975; NFPA No. 70-1975 ($6.25)
IEEE 194-1977 Standard Pulse Terms and Definitions ($7)
UL May 1978 Hazardous Location Equipment Directory ($1.75)
UL May 1978 Electrical Construction Materials Directory ($4.75)
UL May 1978 Electrical Appliance and Utilization Equipment Directory ($6.50)
JIS C 6361 Japanese Industrial Standard — The Interface between Modem and Data Terminal Equipment

in stock and available on request

MIL-HDBK-63038-1(TM) Technical Writing Handbook (May 1977)
MIL-HDBK-63038-2(TM) Technical Writing Style Guide (May 1977)
Metric Laws and Practices in International Trade, a Handbook for U. S. Exporters, put out by the Bureau of International Economic Policy and Research, U. S. Dept. of Commerce, Sept. 1976.
Word of the Computer - Newsweek 1974
NBS Technical Note 910-2 (Feb. 1978) Self-Study Manual on Optical Radiation Measurements
BSI 3534: 1962 Specification for Safety Isolating Transformers for Industrial and Domestic Purposes (British Standards Institution)
AS2075-1978 Terms and Notations for Gears (Standards Association of Australia)
ANSI 221.66-1977 Electrically Operated Automatic Vent Damper Devices for Use with Gas-Fired Appliances
Words of the Computer Age 1974 Edition - An abridged glossary of terms used in Electronic Data Processing. Published by ANSI.

available from our lending library

NBS Monograph 160 Geometrical Considerations and Nomenclature for Reflectance, (Oct. 1977) National Bureau of Standards

new and revised 062 part number standards available from Reprographics

062-1708-00 Drafting Standards - Drawing Format. This standard has been updated.
062-1723-00 Circuit Board Standards - Manufacturing, One and Two Layers. This is a major revision.
062-1701-00 Documentation Standards - Trademarks, Copyrights and Related Proprietary Matters. This new standard sets forth the proper use of trademarks, trade names, copyright notices, disclaimers and proprietary content statements.
062-3478-00 Component Mounting Standards - Mounting Hole Standard. Reformatted and revised from Volume I.
062-1780-00 Interface Standards - General Purpose Interface Bus. GPIB Codes and Format. Completely revised, twenty additional pages added to this standard.
062-3923-00 Test Method Standards - Cables, Jacket Removal. This standard has been updated.

for information on the above publications, please call Carol Whitmore, Technical Standards, ext. 7976.

Component News New Components

This column is designed to provide timely information regarding new components, vendors, availability and price. "New Components" can also be used as an informal update to the Common Design Parts Catalogs. Samples may or may not be available in Engineering Stock.

Vendor	No.	Description	When available	Tek P/N	Approx. Cost	Engineer to contact
analog devices						
Motorola, Sprague	MC1413P ULN2003	High current transistor array, 7 darlington drivers	now	156-1245-00	$ 1.00	Matt Porter
NEC	NE57835	6 GHz high frequency transistor in SOE package	now	151-0689-00	3.00	Matt Porter
Motorola, RCA	MC1391P	TV horizontal processor (8 pin DIP)	now	156-1147-00	1.00	Matt Porter
Analog Devices	AD581J	Voltage reference 10V ± 0.3%	now	156-1249-00	2.85	Gary Sargeant
T.I.	TIR102A	Dual 6A rectifiers in TO-220	now	152-0718-00	.37	Gary Sargeant
Motorola	1N5456B	100 pf Tuning Diode, 30 PIV	now	152-0719-00	2.35	Gary Sargeant
Amperex	BYW29-100	7A Fast rec. rectifier, TO-220	now	152-0720-00	.90	Gary Sargeant
Amperex	BYW30-100	12A Fast rec. rectifier, DO-4	now	152-0721-00	1.87	Gary Sargeant
Motorola	MC3423u	Programmable over-voltage protection IC	now	in process	.80	Jim Williamson
Motorola, T.I.	TL494,	Switching regulator control IC	4th Q.	no P/N	3.50	Jim Williamson
Plessey	SP9685	3 nS ECL comparator, compatible with AM685	now (samples)	no P/N	6.00	John Hereford
digital devices						
Intel		8291 GPIB talker/listener	now	no P/N	30.00	Jim Howe
Intel		8292 GPIB controller	now	no P/N	30.00	Jim Howe
AMD		9517 Multimode DMAC	now	no P/N	——	Jim Howe
Synertek		6545 enhanced CRTC	Sept.-Nov.	no P/N	——	Jim Howe
Western Digital		1791 dbl. density FDC	now	no P/N	60.00	Jim Howe
Motorola	68B00	8 bit 2 MHz microprocessor	now	156-0426-xx	15.00	Carl Teale
resistor, capacitor, optoelectronic devices						
Dialight	550-0305	Yellow LED indicator, 0.25" cube pkg., radial leads	now	150-1063-00	.43	Betty Anderson
Monsanto	MV5352	High intensity (45 mcd) yellow LED	soon	150-1065-00	.40	Betty Anderson
Beckman	SP-332-01	7 seg., 2 digit 0.33" char., 5 sec. initial ionization gas display	Nov.	150-1015-00	3.40	Betty Anderson
Beckman	SP-331-02	7 seg.,1½ digit, 5 sec. initial ionization gas display	Nov.	150-1039-00	3.40	Betty Anderson
Dale	LDP1601-331G	16 DIP 8-330Ω ± 2% network	now	307-0636-00	.36	Ray Powell
Dale	MSP06A01-202G	6 SIP 5 - 2KΩ ± 2% network	now	307-0637-00	.24	Ray Powell
G.E.	V18ZA1	18V DC 0.5 watt-sec MOV	now	307-0638-00	.57	Ray Powell
Western Thermistor		15 KΩ @ 25°C, 500Ω ± 5% @ 125°C thermistor	Dec.	307-0639-00	.64	Ray Powell
Bourns	4310R-101-500	10 SIP 9 - 50Ω ± 5% network	Sept.	307-0640-00	.29	Ray Powell
Dale	FP3236021	36 KΩ ± 5% 3 watt film resistor	Sept.	307-0641-00	.09	Ray Powell

COMPONENT CHECKLIST

The "Component Checklist" is intended to draw attention to problems or changes that affect circuit design. This listing includes: catalog and spec changes or discrepancies; availability and price changes; production problems; design recommendations; and notification of when and how problems were solved. For those problems of a continuing nature, periodic reminders with additional details will be included as needed.

Tek P/N	Vendor	Description of Part	Who to Contact
no Tek P/N	Motorola	General Purpose Interface Adapter	Jim Howe, 6303

There is a problem in the 68488 GPIA which will, unless corrected, almost certainly preclude its use at Tek. Motorola has stated that the chip is now being redesigned to fix this problem.

If the 68488 is an active talker, and is serial polled by the bus controller, there is a high probability that one output data character will be lost. This particular problem will not reveal itself using most of today's GPIB controllers (such as the 4051) which wait for a data stream to be terminated by the 'END' message before taking control to conduct a serial poll. Future bus controllers may be expected, however, to simply take control synchronously in the middle of an ongoing data stream to rapidly respond to Service Request.

In this case, *the 68488 cannot be guaranteed to correctly inform the instrument microprocessor that is has aborted the character.*

The only indication given by the 68488 that it may have aborted a character is the SPAS interrupt status bit. As we have noted in **Component News** on several occasions, the SPAS bit is not preserved by the 68488. Therefore, there is no guarantee that the instrument microprocessor will realize that the 68488 has undergone a serial poll.

In addition, there is a possibility that the 68488 will be readdressed to talk by the GPIB controller before the instrument microprocessor can respond to a SPAS interrupt. In this case the microprocessor will read the Interrupt Status register, and will find the Byte Out ('BO') Interrupt Status bit set. This is because 'BO' is set on completion of output handshake or on entering Talker Active State with the transmit register empty. On finding 'BO' set, the microprocessor will have to assume that the character was correctly transmitted, while in fact it was aborted.

Redesigned parts are expected from Motorola in November. It is true that their present design is in accordance with IEEE-488 as it is now written, in that the output character is aborted following Serial Poll. The problem lies in the way the 68488 cannot guarantee that the sequence of events can be detected by the instrument microprocessor.

Component/Engineer listing

Call the appropriate engineer listed below or stop by 58-299 for information on purchased components. (**Note:** The Digital Group is now located at 58-125.)

ATTENUATORS	Byron Witt 5417
BATTERIES	Byron Witt 5417
BULBS	Peter Butler 5417
CABLES	Rod Christiansen 5953
CAPACITORS	
ceramic, high-voltage, mica	Harry Ford 6520
electrolytic, film	Don Anderson 5415
variable	Alan LaValle 5415
COILS	Harry Ford 6520
CONNECTORS	Peter Butler 5417
CORES, ferrite	Byron Witt 5417
CRYSTALS	Byron Witt 5417
DELAY LINES	Byron Witt 5417
DIODES	
visible LEDs	Betty Anderson 6389
IR emitter, laser diode	Louis Mahn 6389
all others	Gary Sargeant 5345
DISPLAYS	Betty Anderson 6389
ELECTROMECHANICAL PRINTERS	Jim Deer 7711
FANS	Bill Stadelman 7711
FETs	Jerry Willard 7461
FIBER OPTICS	
cables, emitters, decoders	Louis Mahn 6389
FILTERS	
air	Byron Witt 5417
crystal and SAW	Bill Stadelman 7711
light	Jim Deer 7711
line	Joe Joncas 6365/Herb Zajac 7887
FUSES, FUSEHOLDERS	Joe Joncas 6365
GASKETS	Rod Christiansen 5953
GENERATORS	Bill Stadelman 7711
HARDWARE	Rod Christiansen 5953
HEAT SINKS	Jim Williamson 5345
INDUCTORS	Byron Witt 5417
INTEGRATED CIRCUITS	see microcircuits
JOYSTICKS	Jim Deer 7711
KEYBOARDS	Jim Deer 7711
KNOBS	Rod Christiansen 5953
LAMPS, LAMP SOCKETS	Peter Butler 5417
LIGHT-EMITTING DIODES	Betty Anderson 6389
MAGNETIC TAPES and HEADS	Bill Stadelman 7711
METERS	
digital panels	Chris Martinez 7709
general	Joe Joncas 6365
MICROCIRCUITS	
A/D converters	Chris Martinez 7709
bubble memory devices	Eric Peterson 6302
CCD-analog	John Hereford 6700
CCD-digital	Eric Peterson 6302
CMOS devices	Wilton Hart 7607
communications	Matt Porter 7461
comparitors	John Hereford 6700
D/A converters	Don Gladden 6700
digital semiconductor storage	Eric Peterson 6302
EAPROMs, EPROMs, PROMs	Bob Goetz 6302
ECL devices	Don VanBeek 6301
FPLAs, PALs	Ted Olivarez 7607
MICROCIRCUITS, continued	
high speed logic	Don VanBeek 6301
hybrids	Jerry Willard 7461
linear devices	Don Gladden 6700
low-power Schottky TTL	Wilton Hart 7607
MOS(general)	Bill Pfeifer 6303
operational amplifiers	John Hereford 6700
regulators	
linear	Chris Martinez 7709
switching	Jim Williamson 5345
RAMs	Eric Peterson 6302
ROMs	Bob Goetz 6302
Schottky TTL	Don VanBeek 6301
TTL devices	Ted Olivarez 7607
MICROPROCESSORS	Carl Teale 7148
bit-slice microprocessors	Ted Olivarez 7607
peripherals and interfaces	Jim Howe/Bill Pfeifer 6303
Z80, 8080, 8085	Wilton Hart 7607
MICROWAVE components	Byron Witt 5417
MONITORS	Harry Ford 6520
MOTORS	Bill Stadelman 7711
MULTIPLIERS, high-voltage	Gary Sargeant 5345
OSCILLATORS	Byron Witt 5417
PHOTOCOUPLERS	Louis Mahn 6389
POTENTIOMETERS	Gene Single 5302
POWER CORDS/receptacles/plugs	Joe Joncas 6365
RAW MATERIALS, metals, plastics	Rod Christiansen 5953
READOUT DEVICES	Louis Mahn 6389
RELAYS, mechanical & solid state	Paul Johnson 6365
RESISTORS	
fixed	Ray Powell 6520
variable	Gene Single 5302
SCRs, SCSs	Paul Johnson 6365
SHIELDS	Harry Ford 6520
SPARK GAPS	Peter Butler 5417
SLEEVES, insulating	Byron Witt 5417
SPEECH, input & output	Jim Deer 7711
SOCKETS	
crystal	Byron Witt 5417
all others	Peter Butler 5417
SWITCHES	
general, solid state	Joe Joncas 6365
reed	Paul Johnson 6365
TERMINAL PINS	Peter Butler 5417
TERMINATIONS	Byron Witt 5417
THERMISTORS	Ray Powell 6520
TRANSDUCERS	Byron Witt 5417
TRANSFORMERS	Byron Witt 5417
power	Bill Stadelman 7711
TRANSISTORS	
field-effect	Jerry Willard 7461
phototransistors	Louis Mahn 6389
power	Jim Williamson 5345
small signal, arrays	Matt Porter 7461
triacs, unijunctions	Paul Johnson 6365
TUBING, metal	Rod Christiansen 5953
WIRE	Peter Butler 5417

component news

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