COMPONENT NEWS

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High parts count affects reliability

One of the greatest detriments to instrument reliability is a high parts count. Regardless of steps taken to ensure high product reliability, such as conservative stress levels on all components, a high parts count can set an upper bound on reliability that can't be changed significantly by other good design practices.

Moreover, a high parts count directly affects both heat and workmanship problems.

In order to enable designers and evaluators to get a handle on parts population effects early in the design phase of an instrument, a program was written for the CDC computer to make quick and easy reliability predictions. These predictions are made on the "parts population" technique.

The "parts population" technique produces a failure rate for an instrument by multiplying the quantity of each component (example: the number of digital IC's) by an average failure rate for that component, and summing the results to get a failure rate per thousand hours. MTBF (mean-time-between-failure) of the instrument, then, is simply 1000/failure rate.

The component failure rates are "average" rates, assuming a 50% stress level, and approximately 25°C ambient. The feasibility of using varying stress levels (such as MIL-217B pi factors) is being studied.

The MTBF figures obtained by this method should not be considered an exact prediction, but rather a "ballpark" indication. In the past, however, this technique has proven to be a fairly accurate indicator of the reliability (or unreliability!) of an instrument.

Note that an instrument's reliability can be predicted in segments by using this method. In this case,

$$MTBF_{system} = \frac{1}{\frac{1}{MTBF_1} + \frac{1}{MTBF_2} + \ldots} = \frac{1000}{\text{failure rate}_1 + \ldots}$$

This program is simple to use, requiring about five minutes to run. After logging on the CDC system, two commands are required to execute the program:

```
OLD, RELY/UN=ACEØTRC
–RELY
```

After this, the computer provides a description of the program, along with instructions. The program asks questions such as,

```
HOW MANY POWER DIODES
? (and the user responds) 8 (return)
```

Once the quantities of the various components are entered, the program calculates and displays the predicted failure rates and MTBF figures.

At this point, the user can modify the quantities of any components and rerun the calculation, to see how changing quantities affects the predicted MTBF value. Another option of the program is a listing of the component failure rates used in the reliability prediction.

For user suggestions or more information concerning this program, contact Tom Clark, Component Applications, ext. 6511. For more information on reliability predictions, contact Jack Stoll in Reliability Engineering, ext. 5298.

ALSO IN THIS ISSUE

Static-sensitive devices require special handling

The following article discusses the extent of static damage to semiconductors at Tektronix and some recommendations to minimize component static problems. The upcoming issue of ENGINEERING NEWS contains an article on how to static proof your instrument.

Does Tek have static damage problems?

Component Evaluation and Manufacturing Engineering have conducted experiments and collected data to determine the magnitude of static damage to semiconductors in our production areas.

Various active device types were measured parametrically, subjected to "typical" kit prep and production handling, and then retested for parameter degradation. Devices sampled include ECL, MOS, low-power Schottky and linear IC's as well as high-frequency FET's and bipolar transistors.

As confirmed industry-wide, MOS devices definitely demonstrated static damage. Out of a sample of 50 MOS parts, five had degradation in leakage parameters and five were catastrophic failures. Other devices showed inconclusive or no evidence of static damage in these tests.

Interestingly enough, some MOS devices had been given special handling in conductive containers in the warehouse but were not handled any differently than other devices in the kit prep or assembly areas. And, the Calculator, Systems, 7000-series, and Medical product lines, among others, were complaining of a high DOA rate for MOS devices.

Why are MOS devices susceptible to static damage?

By nature of their construction and high impedance, MOS devices are particularly susceptible to static damage. A static discharge can carbonize and/or rupture the thin metal-oxide film between the gate lead and the source.

Thus, MOS failures from static damage are classic ruptures of the silicon-dioxide dielectric under the gate or capacitor metallization, which produces shorts in the affected area. Damage of a non-catastrophic nature is usually indicated by increases in reverse leakage current or subtle parameter degradation.

Internal protection for MOS circuits is often used but has limitations and can encumber the circuitry. Diffused resistors and limiting resistors offer some internal protection but are limited in respect to the amount of voltage they can handle. Zener protection circuits require greater than five nanoseconds to switch, and can therefore turn on after an electrostatic discharge has reached the MOS gate dielectric.

Are other devices susceptible to static damage?

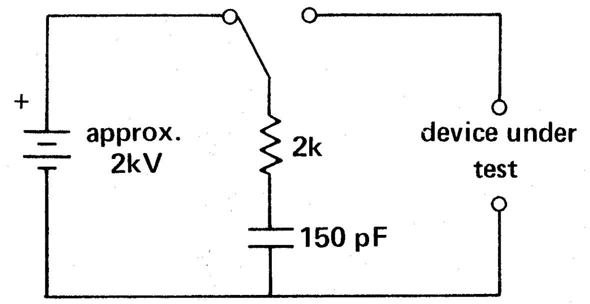
IC Manufacturing has observed some effects of static damage to devices manufactured by their SHF-II process (super-high frequency — shallow base bipolar). The performance of these parts could be degraded by simply placing the parts in a plastic box and shaking it.

Static prevention measures are now in effect for the manufacture and shipment of these and all MOS devices.

Jerry Willard in Component Evaluation recently conducted several tests to determine the static sensitivity of some Tektronix part-numbered discrete diodes and transistors. The test circuit, recommended and used by Martin Marietta Corp., simulated the body discharge into the semiconductor's leads.

The test circuit is shown below. Not all of the possible electrical charge values found in our plant were used. Instead, we used a value of capacitance representative of an average human body and a voltage somewhat lower than average.

Test circuit:



The devices under test included:

JFET transistors	151-1025-00
	151-1032-00
	151-1042-00
NPN transistors	151-0190-00
PNP transistors	151-0188-00
Schottky diodes	152-0322-00 (small signal)
	152-0581-00 (1 amp)
Zener diodes	152-0227-00 (6.2V, 0.4W)
Signal diodes	152-0323-00 (0.1A, 100V)
Rectifier diodes	152-0400-00 (1A, 400V)
	152-0198-00 (3A, 200V)
	152-0040-00 (2A, 600V)
Fast recovery diodes	152-0224-00 (0.2A, 200V)

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Though Martin Marietta published results, we were surprised to duplicate their findings. We found that all JFET's tested had shorted gates and all the 152-0322-00 Schottky diodes shorted. The 152-0581-00 one amp Schottky parts shorted when stressed to 2500 volts.

In the 151-0190-00 NPN device, low current h_{fe} was greatly reduced when the discharge was applied between the base and emitter (base negative) and between the collector and base (collector positive). This also confirms an IEEE report stating that the voltage breakdown of a semiconductor junction degrades the beta in a transistor.

No damage was observed in the NPN when testing all other possible lead and polarity combinations.

The 151-0188-00 PNP transistor showed no evidence of damage when tested like the NPN. However, one unit stressed to 2500 volts between the collector and base (collector negative) developed a C-B short.

Beta degradation has been observed in some of our instruments and is attributed to a static discharge. For example, in one of our products, we have an over-voltage crowbar in the +5 volt supply. If the wire connecting the +5 volts to the IC's is several feet long, and the discharge voltage is initiated several feet from the crowbar through that wire or ECB runs, the IC's may see short duration pulses 20 volts or a lot higher. Whoops, there goes beta!

No damage was observed in the zener, signal and rectifier diodes tested. We also observed no damage in the fast recovery diode (leakage near breakdown was actually reduced from 50 μA to 1 μA).

The probability that discrete transistors and diodes would be subjected to similar conditions is debatable. However, we do know that once subjected to a static discharge, some transistors and diodes are not entirely immune from damage or failure. These tests established that the failure mechanism certainly exists.

Recommendations for minimizing static damage

Component Evaluation and Manufacturing Engineering do not feel that the expense of setting up complete static control is justifiable at this time. However, we do believe that we can significantly improve MOS and Tek-made SHF-II device performance through awareness of static problems and improved handling techniques.

Here are some general handling rules for static sensitive devices:

1. Keep parts in the original containers.
2. Minimize handling.
3. Use conductive containers such as metal sticks or conductive foam for the storage and transport of static sensitive devices. AVOID using plastic containers, styrofoam or other non-conductive materials.
4. Do not subject static sensitive parts to sliding movement over any surface, especially after the part has been removed from its package.
5. Pick up a static sensitive device by the body. Do NOT handle parts by the leads.
6. Discharge any charge you may have accumulated on yourself before handling static sensitive devices.
7. Use a grounded soldering iron.
8. Be careful when using a multimeter on MOS devices. Certain MOS devices have built-in protective diodes which cannot sustain more than a 10 mA current. A Simpson 260 VOM is capable of producing as high as 300 mA for short periods of time on the x1 ohms scale.

Tek warehouse and kit prep areas are now observing the handling rules given above for all MOS devices. Static sensitive parts are labeled in the warehouse to ensure proper handling. These bright orange tags can be obtained from Don Adams, Purchasing Services, ext. 6695.

CAUTION
STATIC SENSITIVE DEVICE
SPECIAL HANDLING REQUIRED

More extensive static control measures are:

1. Good grounding techniques (keep equipment and your personnel at the same potential).
   a. conductive counter top and floor matting connected to a secondary grounding source.
   b. wrist straps and/or arm sleeves
   c. no synthetic clothing
2. Conductive carriers for storage and shipping of devices
   a. metal tubes for transporting DIP's
   b. conductive polyurethane foam (3M Velostat)
   c. metal handling trays
   d. plastic carriers coated with a conductive spray

Note: Contact Glenn Johnson, ext. 7128, for the purchase of these packaging supplies.

3. Shunting (When the device is shorted, there is no entry path for the static electricity).
   a. pins on IC's shorted with a clip
   b. leads on a transistor clipped together
4. Neutralizing equipment/humidity control equipment

Contact the appropriate engineer in Component Evaluation for assistance with device problems. Jim Lawe, ext. 5807, and Milt Wetherald, ext. 5276 in Manufacturing Engineering have static monitoring equipment and information to help evaluate your area for possible static problems.

PRODUCT SAFETY NEWS

New draft of UL 1244 standard is circulated

Underwriter's Laboratories' proposed standard for electronic measuring and testing equipment, UL 1244, has again been circulated to the industry for comments.

Interest level in the industry has been heightened by the article in **Electronics** (May 29, 1975, p. 75), and now more industry members are on UL's mailing list. The April draft was circulated in June with comment due in early August.

Tek has made extensive comments about this draft, especially regarding the requirement for isolating the signal input terminals from earth ground and other accessible conductive parts. (See article below for details.) A limited number of copies of our responses are available from Product Safety Engineering.

UL is far behind schedule in evaluating industry comments. Evaluation will probably start the week of August 25, continuing for six weeks. Then a letter to industry will be drafted, approved and mailed, taking another two weeks.

Official UL words on UL 1244 should be available towards the end of October. We suspect another joint meeting with industry will be held late this year.

UL 1244, in printed form is 103 pages long. It is both detailed and extensive, especially when compared to Data Processing Equipment (45 pages) and Medical and Dental Equipment (54 pages) standards.

UL appears to have gathered every applicable electronic equipment requirement and put them into this standard. This suggests that testing of submittals under UL 1244 will be lengthy, and thus expensive.

Copies of UL 1244 are available from Product Safety Engineering, ext. 6649, or 7374.

UL 1244 contains significant new requirement

The April, 1975, draft of UL 1244 contains a significant new requirement applicable to all measuring equipment. Simply put, UL 1244 proposes that all measuring terminals be isolated from earth ground and from accessible conductive parts.

This means that the vertical input on scopes, the signal inputs on counters, DVM's and spectrum analyzers, and signal outputs on signal generators and pulse generators must all be isolated from the enclosure and from earth ground.

If this requirement becomes a part of the standard, our signal inputs and outputs will have to be isolated almost as well as the patient leads of our physiological monitors.

UL's reasoning for this requirement is to avoid the hazard of a "floating" conductive enclosure. This is where the green-yellow grounding conductor has been opened such that the instrument enclosure can float at the same potential as the signal common terminal.

Tek's DMM's (7D12/M1/M3, 7D13, DM40, DM43, DM501, DM502) already meet this proposed requirement. The 200-series miniscopes come very close to having isolated signal inputs, except that the inputs are not isolated from each other.

Applying this requirement to wideband linear amplifiers or to RF systems poses severe technical problems. The first problem is to find a suitable connector to replace the BNC, since the BNC has an exposed and accessible signal common terminal.

Product Safety Notes No. 24 contains more details on this requirement. A limited number of copies of our response to UL on this issue are available from Richard Nute, ext. 6649.

UL revises printed-wiring board standard

Underwriters' Laboratories, Inc. has extensively revised its Standard for Printed-Wiring Boards, UL 796. Tek's circuit boards comply with UL's revised requirements. Among the new requirements is one which does not allow the intermixing of G-10 and FR-4 materials in multilayer boards. Also, the flame class must be marked on the board in addition to the recognition mark.

Copies of the revised requirements are available from Technical Standards, ext. 7976. Direct any UL related questions to Product Safety Engineering, ext. 6649 or 7374.

PRODUCT SAFETY NEWS (continued)

UL definitions: shock current ≠ leakage current

Numerous UL requirements are common to many UL standards. However, UL has phrases and terminology which can be easily confused by the novice.

Terms such as "leakage current" and "shock current" refer to distinctly different phenomena by UL's definition.

Leakage current is that current which can be measured from any accessible conductive part to earth ground or any other conductive part when the equipment is ready for use. Leakage current is also the current in the equipment grounding conductor.

Crucial to this definition is the condition of "ready for use." This means that all covers are in place. For a plug-in oscilloscope, this means it has either a full complement of plug-ins or the unused compartments filled with blank panels. An accessible part is any part which can be touched by any of the test fingers.

Leakage current is determined by measuring the true RMS voltage across a 1500-ohm resistor which is shunted by a 0.15 microfarad capacitor. (The capacitor compensates for the reduced hazard as a function of frequency.)

Leakage current shall not exceed 0.5 mA.

Shock current is that current which can be measured from any accessible conductive part, exposed during user servicing, to earth ground or any other accessible conductive part with the open-circuit potential more than 42.4 volts peak.

Note the phrase "...accessible...during user servicing...." User servicing is any servicing that might be performed by people other than qualified service personnel and is directed towards maintaining operating equipment in an operating condition without requiring the use of tools. Some examples of user servicing are:

-interchanging plug-ins
-routine replacement of consumable materials such as paper, tape, etc.
-routine cleaning, changing filters, etc.
and, -replacement of wear-out items such as non-rechargable batteries.

Another difference in shock current from the definition for leakage current is that of an open-circuit potential of 42.4 volts peak.

Shock current is determined by measuring the true RMS voltage across a 500-ohm resistor which is shunted by a 0.15 microfarad capacitor. Note that the resistance value is lower for shock current.

Shock current shall not exceed 7.1 mA.

What this says is that an empty plug-in compartment shall not expose any part that exceeds 42.4 volts peak and 7.1 mA with respect to any other exposed part. None of our plug-in scopes meet this criterion today.

For further information, contact Richard Nute or Eddie Richmond, Product Safety Engineering, ext. 6649 or 7374.

COMPONENT EVALUATION announcements

Component Evaluation is now divided into four evaluation groups under the management of Steve Pataki with a manager heading each evaluation team, as follows:

Discrete Semiconductors	Dennis Crop, ext. 7268
Electromechanical Devices	Bruce Goodwin, ext. 5228
R. C. Components	Virg Tomlin, ext. 7709
Microcircuits	Ted Olivarez, ext. 6073

Bruce Goodwin brings to Tektronix an expertise in batteries and electro-chemical couples such as lead-acid, nickel-cadmium, silver-zinc, etc. Bruce previously worked at Nickel Cadmium Battery Co. (now Gould), General Electric Co., Sonotone Battery Co., and at Marathon Battery Co.

Ted Olivarez joins Component Evaluation from IDD Product Evaluation. Ted's background is in analog and digital circuits and he is currently working on a master's in Computer Science through the OSU program at Tek. Usage of the 3260 system for evaluation of active devices, especially LSI and MSI, will largely be the responsibility of the microcircuit group. (See next issue for details.)

Bill Stadelman, from IDD Product Evaluation, also joined Component Evaluation and is assuming the evaluation responsibility for motors. Bill can be reached on ext. 6365. **Alan LaValle**, ext. 5302, replaces Hazel Love (retired) as a technician in the resistor group.

The discrete semiconductor group now has the evaluation responsibility for **transistor and diode arrays** formerly handled by Norm Dodge in the microcircuit group. Tom Jennings, ext. 7711, will evaluate NPN transistor arrays; Louis Mahn, ext. 6389, will handle PNP arrays; and Gary Sargeant, ext. 5345, is responsible for diode arrays.

Pushbuttons now marked with U.V. ink

We have experienced problems in recent months with ink marking chipping, peeling and wearing off small plastic pushbuttons such as 366-1257-xx.

During August, a significant change was made in our marking process which will greatly reduce this problem. Funds were approved to change from epoxy ink to ultra-violet cured ink and new production equipment will be fully operational at the end of September.

Meanwhile, on August 7th, the Plastics Department made the operational change to U.V. ink with some interim equipment borrowed from Dave Shepard, who initially recommended the process change.

Therefore, as of August 7, pushbuttons are being marked with U.V. curable ink and can be identified by a small dimple on the back edge of the button. This process virtually eliminates ten troublesome variables of the old ink.

The present status of ink marking on plastic pushbuttons is that all tests continue to show that the permanence of the U.V. ink is several magnitudes greater than the epoxy ink.

Additionally, within a day or so of operation with the interim equipment, the operator was already positively impressed with increased production rates and with the consistency of line width on the U.V. ink marked buttons.

The consistency of character appearance (style of print) and ink line width (boldness of printing) between different pushbutton part numbers still needs improvement. The inconsistency is primarily due to a lack of consistency in design. Bill Vaughn has taken on the responsibility for correcting this.

Long-range solutions to the marking of pushbuttons (and plastic in general) are being actively investigated. In particular, a proprietary method and a state-of-the-art technique both look quite promising. Chuck Hamilton is heading this effort.

The significant thing at this point is that with the ultra-violet curable ink now being used, we anticipate the customer/user complaint frequency to taper off dramatically.

For more information, contact Bob Russell in Manufacturing Engineering, ext. 5809.

AQL's tightened at T.I.

The Special Circuits Department at Texas Instruments began a program of tightening the AQL's on all outgoing standard catalog products. This includes all IC product lines, including L, LS, CMOS and crosspoint switches.

As of September 1st, all continuity and functional tests are done at an AQL of 0.15% and the 25°C DC screens at an AQL of 0.65%. Prior to May, these tests were performed at an AQL of 0.25% and 1.0%, respectively.

Editor's note . . .

Due to shutdown and vacation schedules, this issue is long overdue. With renewed vigor, future issues will go back on a biweekly (± a few days) publication schedule.

The emphasis of **Component News** is on component-related technical articles, especially information of an application or reliability nature helpful to a design engineer. Your comments, suggestions and contributions are always welcome. Send them to 39-105 or call ext. 6867.

Signetics seminar Sept. 24

Signetics will present a seminar on MOS microprocessors and field programmable logic arrays (FPLA's) on Wednesday, September 24th from 1 to 5 p.m. in Bldg. 50's Council Room.

Dave Umari and Ron Cline from Signetics will provide engineering and application details. Ron, a senior engineer, recently co-authored an article in **Electronic Design** (Vol. 23 No. 18, Sept. 1, 1975) entitled "Field-PLA's simplify logic design."

Call George Roussos, Purchasing, ext. 7927, for more information on the seminar.

3M adhesives seminar Oct. 3

The Industrial Specialties Division of 3M Co. will present a seminar on adhesives Friday, Oct. 3 at 9 a.m. in Building 50 auditorium. For further information, contact Sharon Webb in Purchasing, ext. 7912.

Will the person who borrowed the data on delay lines from Mel Christensen please return the material as soon as possible to 39-015. Thanks.

....Technical publications on file....

While some of the publications listed or described below are not new, they are pertinent to the interests and needs of Tektronix. For more information, call Technical Standards, ext. 7976.

Cooling of Electronic Equipment by Alan W. Scott Covers conduction, radiation, natural convection, forced air cooling, and various other means of cooling electronic equipment and components. Design examples and formulas for racks, cabinets, and high power tubes are included.

UL 1054 **Special-Use Switches** – This standard covers manually operable and mechanically operable special-use switches for use on direct or alternating current or for alternating current only, and for which load ratings do not exceed 60 amps at 250 volts or a lower potential and 30 amps, or 2 HP at 600 volts or a lower potential. ($2)

UL 62 **Flexible Cord and Fixture Wire** – The requirements of this standard cover fixture wires and flexible cords, except armored cords, for use in accordance with the National Electrical Code. Does not cover assemblies of flexible cords, such as power-supply, which are covered by other standards, nor any use at a potential over 600 volts. ($5)

UL Electrical Construction Materials List – This publication contains the names of companies which have qualified to use UL listing for their products. The listings pertain to electrical equipment which has been evaluated with reference to hazards to life and property and conformity to the National Electrical Code. ($3)

UL Recognized Component Index – This index contains the names of companies which have qualified to use UL recognized markings on or in products which have been found to be in compliance with UL requirements. ($7)

UL 224 **Extruded Thermoplastic Insulating Tubing** The requirements of this standard cover insulating tubing that usually is round in cross section and that consists entirely of extruded thermoplastic. The product may or may not be heat-shrinkable and may or may not be made of a material whose basic constituent is a cross-linked polymer. ($2)

UL 1053 **Ground-Fault Sensing and Relaying Equipment** – This standard covers over-current sensing devices, relaying equipment, or combinations of over-current sensing devices and relaying equipment which will operate to cause a disconnect at predetermined values of ground-fault current not exceeding 1200 amps, in accordance with the National Electrical Code. Equivalent equipment is also covered in this standard. ($2)

UL 1414 **Across-The-Line capacitors, Antenna-Coupling and Line-By-Pass components for Radio and Television Type Appliances** – Requirements cover capacitors and combinations of capacitors and resistors rated 85°C that are employed in nominal 120-volt, 60 Hz circuits where failure of the component may result in casualty, fire, or shock hazard. ($2)

UL 467 **Grounding and Bonding Equipment** – Covers grounding and bonding equipment for interior wiring systems in accordance with the National Electrical Code. Requirements cover ground clamps, bonding devices, grounding and bonding bushings, water-meter shunts, armored grounding wire, ground wires and the like. Intended to comply with the American National Standard National Electrical Code, C1. ($3.50)

ANSI C33.77 **(UL498) Standard for Attachment Plugs and Receptacles** – 1973 print with 1974 update. Requirements of this standard cover attachment plugs and receptacles, cord-connector bodies, appliance plugs, etc. – all for use in accordance with the National Electrical Code. Does not cover devices rated at more than 200 amps or more than 600 volts.

ANSI C83.93 **(EIA RS-178-B) Solderability Test Standard** – This standard defines a test for solderability of solid lead wires, terminals, and conductive accessories of component parts, using rosin-type flux and solder per QQ-S-571.

EIA RS-325 **Ignitability and Flammability Tests** – Describes tests for determining the tendency of a component or similar part to start or contribute to a fire. Does not identify particular components to be tested.

JEDEC Publication No. 92, **1975 Cathode Ray Tubes, Glossary of Terms and Definitions** – Glossary developed by the Electronic Industries Association in close liason with IEC, IEEE and the Society for Information Displays. It supplements Tek STD A-101.

EIA JEDEC No. 72 **Recommended Practice for Conversion of US to Metric Dimensions for Color and Monochrome Cathode Ray Tubes and their Component Parts.**

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Technical publications (continued)

Drafting Standards for Aluminum Extruded and Tubular Products — Prepared by the Aluminum Association to outline certain basic practices that are necessary with extruded products — a subject not adequately covered by ANSI or other standards making bodies.

Designation System for Aluminum Finishes — Covers mechanical and chemical finishes as formulated by the Aluminum Association.

Welding Aluminum — Published by the American Welding Society. It is a comprehensive coverage of welding processes for welding aluminum alloys.

EIA JEDEC, Pub. No. 77 Recommendations for Letter Symbols, Abbreviations, Terms, and Definitions for Semiconductor Device Data Sheets and Specifications — Contains sections B General Terms and Definitions, section C Diodes and Rectifiers.

IEC Pub. No. 148, and 148A Letter Symbols for Semiconductor Devices and Integrated Microcircuit Expresses as nearly as possible, an international opinion on symbology.

EIA RS-359 (ANSI C83.1) EIA standard: Colors for Color Identification and Coding — Colors are intended to be applied to the markings of electronic components such as resistors, capacitors, and wires. Contains color plates.

ASME SI-2	ASME text booklet SI Units in Strength of Materials
CSA C22.2 No. 96 - 1974	Power Supply Cable for Use with Portable Apparatus
CSA C22.2 No. 125 - 1973	Electro-medical equipment
IEC C.I.S.P.R. Pub. 2	Specification for C.I.S.P.R. Radio Interference Measuring Apparatus for the Frequency Range 25 MHz to 300 MHz
IEC Pub. 27-1 Amend. 1	Letter Symbols to be used in Electrical Technology
IEC Pub. 68-2-21	Basic Environmental Testing Procedures — Part 2: Tests TEST U: Robustness of Terminations and Integral Mounting Devices
IEC Pub. 106	Recommended Methods of Measurement of Radiated and Conducted Interference from Receivers for Amplitude-Modulation, and Frequency-Modulation and Television Broadcast Transmissions
IEC Pub. 148A	First supplement to Publication 148 (1969) — Letter Symbols for Semiconductor Devices and Integrated Microcircuits
IEC Pub. 191-3	Part 3: General Rules for the Preparation of Outline Drawings of IC's
IEC Pub. 278A	First supplement to Publication 278 (1968) — Documentation to be Supplied with Electronic Measuring Apparatus
IEC Pub. 326A	First supplement to Publication 326 (1970) — General Requirements and measuring methods for printed-wiring boards
IEC Pub. 326C	Third supplement to Publication 326 (1970) — General Requirements and Measuring Methods for Printed-wiring boards, Multilayer Printed Boards
ISO 1043	Symbols for Terms Relating to Plastics
MIL-F-28811	Frequency Standard, Cesium Beam Tube
MIL-N-18307E	Nomenclature and Identification for Electronic, Aeronautical and Aeronautical Support Equipment including Ground Support Equipment
NEMA IS 1.1-1975	NEMA Stds Publication for Enclosures for Industrial Controls and Systems
UL 45	Portable Electric Tools
UL 73	Motor-Operated Appliances
UL 115	Asbestos- and Asbestos-Varnished-Cloth-Insulated Wires
UL 122	Photographic Equipment
UL 133	Varnished-Cloth Wires and Cables
UL 187	X-ray Equipment
UL 198.1	Class H Fuses
UL 198.6	Plug Fuses
UL 198.6	Fuses for Supplementary OverCurrent Protection
UL 224	Extruded Thermoplastic Insulating Tubing
UL 467	Grounding and Bonding Equipment
UL 489	Molded-Case Circuit Breakers and Circuit-Breaker Enclosures

ELECTRICAL PARTS LIST

The following
is a cumulative listing of
new common electrical parts
numbered since February 1975

For those who have a
ELECTRICAL Parts Catalog (Vol 1, Yellow)
this also serves as an update
to the sections of that
Catalog.

Note: We will begin preparation for the next issue of the Electrical Parts Catalog soon. Because of its bulk, and for several other reasons, we will be splitting it into two volumes. If you have any comments or suggestions, please call me at ext. 7974.

Fred Schade, Documentation

MICROCIRCUITS (section 1)

DIGITAL

TTL — general

74194	156-0697-00	H+	4-bit shift register	16 DIP
74221	156-0706-00		dual monostable multivibrator with schmitt-trigger input	16 DIP
74265	156-0696-00	G+	quad complementary output (AND-NAND)	16 DIP
8838	156-0653-00	I+	quad unified bus transceiver	16 DIP
8574	156-0737-00		3-state 1-K field programmable ROM	16 DIP

TTL — Schottky

74S02	156-0690-00	F+	quad 2-input NOR	14 DIP
74S32	156-0739-00		quad 2-input OR	14 DIP
74S64	156-0703-00	F+	4-2-3-2 input AND-OR	14 DIP
74S86	156-0707-00		quad 2-input exclusive OR	14 DIP
74S138	156-0694-00	I+	decoders/demultiplexers	16 DIP
74S139	156-0693-00	I+	decoders/demultiplexers	16 DIP
74S174	156-0738-00		quad hex D flip-flop with clear	16 DIP
74S194	156-0744-00		4-bit bidirect universal shift register	16 DIP
74S182	156-0692-00	I+	look ahead carry generator	16 DIP
74S251	156-0701-00		8-input data selector/multiplexer	16 DIP
74S381	156-0691-00	J+	arithmetic logic unit/function generator	16 DIP

TTL — low power

93L16	156-0741-00		synchronous 4-bit binary counter	16 DIP
80L96	156-0702-00	I+	3-state hex inverter-buffer (common input)	16 DIP
80L98	156-0729-00		3-state hex inverter -buffer	16 DIP

TTL — low power Schottky

74LS05	156-0724-00		hex inverter with open-collector outputs	14 DIP
74LS09	156-0728-00		quad 2-input AND with open-collector outputs	14 DIP
74LS12	156-0722-00		triple 3-input AND with open-collector outputs	14 DIP
74LS27	156-0718-00		triple 3-input NOR	14 DIP
74LS33	156-0730-00		quad 2-input NOR buffer with open-collector outputs	14 DIP
74LS42	156-0736-00		BCD-to-DEC decoder	16 DIP
74LS75	156-0735-00		4-bit bistable latch	16 DIP
74LS76	156-0731-00		dual J-K flip-flop with preset and clear	16 DIP
74LS90	156-0656-00	I	decade counter	14 DIP
74LS132	156-0721-00		quad schmitt-trigger NAND with totem-pole output	14 DIP

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TTL – low power Schottky (CONTINUED)

74LS164	156-0651-00	J-	8-bit parallel-output series shift register	14 DIP
74LS170	156-0732-00		4 x 4 register files with open-collector output	16 DIP
74LS196	156-0727-00		30 MHz preset decade or binary counter/latch	14 DIP
74LS221	156-0733-00		dual monostable multivibrator with schmitt-trigger input	16 DIP
74LS266	156-0652-00	H-	quad 2-input exclusive NOR with open-collector output	14 DIP
74LS283	156-0679-00	J-	4-bit binary adder	16 DIP
74LS368	156-0720-00		hex driver, 4-line/2-line enable with 3-state out	16 DIP
74LS295A	156-0734-00		4-bit right-shift/left-shift register with 3-state output	14 DIP

MICROPROCESSORS (MOS)

6800	156-0426-00	O+	microprocessor	40 DIP
6810	156-0716-00		1K static RAM	24 DIP
6820	156-0427-00	M-	PIA (Peripheral Interface Adapter)	40 DIP
6850	156-0658-00		ACIA (Asynchronous Communications Interface Adapter)	24 DIP
8008	156-0454-00		8-bit parallel CPU (Central Processing Unit)	18 DIP
8008-1	156-0643-00		8-bit parallel CPU	18 DIP

CMOS

4006	156-0681-00	J+	18-stage static shift register	14 DIP
4025			triple 3-input NOR	14 DIP
4069	156-0745-00		hex inverter	14 DIP
74C107	156-0680-00	J+	dual J-K flip-flop with clear	14 DIP
74C174	156-0682-00	J	hex D flip-flop	16 DIP
7511	156-0723-00		quad SPST analog inverter switches	16 DIP

MOS – general

Intel C2101	156-0698-00	M+	1K static RAM with separate input/output	22 DIP
Sig 2606B-1	156-0695-00	M+	1K RAM	16 DIP
Intel 2704	156-0689-00	O+	4K static erasable PROM	24 DIP
Intel 2708	156-0708-00		8K static erasable PROM	24 DIP
MC3459	156-0740-00		quad NAND address line driver	14 DIP

ECL

10113	156-0687-00		quad exclusive OR	16 DIP
10135	156-0688-00	J+	dual J-K master-slave flip-flop	16 DIP
10144	156-0657-00	M	256-bit RAM	16 DIP
10158	156-0746-00		quad 2-input non-inverting multiplexer	16 DIP
10186	156-0743-00		hex D master-slave flip-flop with reset	16 DIP
SC62438L	156-0705-00		dual A/D comparator	16 DIP

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LINEAR (MICROCIRCUIT section continued from page 2)

OPERATIONAL AMPLIFIERS

CA3130S	156-0686-00	I-	CMOS 30V/μs slew rate	8 DIP
LM318	156-0742-00		CMOS 50V/μs slew rate	
LM725	156-0685-00	J+	125,000 voltage gain	8 DIP
LM741H	156-0700-00	I+	0.5V/μs slew rate	TO-5

VOLTAGE REGULATORS

LM323	156-0684-00	K+	voltage regulator, 5V, 3A	TO-3
LM723H	156-0699-00		voltage regulator, 2-37 V, 150 mA	TO-100
7905.2	156-0655-00		negative voltage regulator, 5.2 V, 500 mA	3-terminal plastic pkg.

Misc

7520	156-0719-00		10-bit multiplying DAC	TO-5
14046	156-0704-00	I+	phase-locked loop	16 DIP
MC2321-01	156-0717-00		integrating ADC	custom
MC1405			ADC subsystem	16 DIP

TRANSISTORS (section 2)

151-0527-00	controlled rectifier, Si, 2N6241
151-0604-00	NPN, Si, Fairchild S42140
151-0605-00	NPN, Si, die form
151-0606-00	NPN, Si, Darlington, TI TIP142
151-0607-00	PNP, Si, Darlington, TI TIP147
151-0608-00	NPN, Si, microwave, Fairchild FMT4020
151-0609-00	NPN, Si, microwave, Fairchild FMT4225
151-1090-00	Field-effect, dual, National SF93001
151-1090-02	Field-effect, monolithic, dual, National SF93007
151-1093-00	Field-effect, depletion mode, TI AST6450
151-1097-00	Field-effect, P-channel, National SF88010
151-1098-00	Field-effect, DMOS, Signetics CR585DC

SEMICONDUCTOR DEVICE, DIODE (section 3)

152-0645-00	Rectifier, fast recovery, 50 V, 3.0 A
152-0647-00	Zener, 6.8 V + 5%, 400 mW, 1N957B
152-0648-00	Switching, 100 V, die form
152-0650-00	Voltage-variable capacitance, 11.5 pF at -3.0 V
152-0651-00	Zener, 28 V + 5 %, DO-7
152-0652-00	Voltage multiplier, 4 kV in, 8 kV out
152-0655-00	Rectifier, 100 V, 5 A, GE A115A

RESISTOR, FIXED (section 5)

CARBON COMPOSITION

301-0515-00	C+	5.1 M ohm ± 5%	0.5 watt
303-0133-00	D+	13k ohm ± 5%	1 watt
303-0134-00	D+	130k ohm ± 5%	1 watt
303-0331-00	D+	330 ohm ± 5%	1 watt

CHIP

307-0497-00	1k ohm ± 5%	0.125 watt

THICK-FILM POWER

307-1033-00	1.2k ohm ± 1%	3 watt

METAL FILM 0.125 watt

321-0130-03	F-	221 ohm	± 0.25%
321-0223-07	G	2.05k ohm	± 0.1%
321-0227-09	F	2.26k ohm	± 1.0%
321-1663-03	F-	23.85 ohm	± 0.25%
321-1664-03	F-	68.8 ohm	± 0.25%
321-1665-03	F-	995 ohm	± 0.25%
321-1666-03	F-	153.8 ohm	± 0.25%
321-1667-03	F-	116.1 ohm	± 0.25%
321-1668-03	F-	52.6 ohm	± 0.25%
321-1669-03	F-	5.31k ohm	± 0.25%
321-1670-03	F-	52.84k ohm	± 0.25%
321-1674-03	F-	79.26 ohm	± 0.25%
321-1675-03	F-	103.2 ohm	± 0.25%
321-1676-03	F-	230.7 ohm	± 0.25%
321-1677-03	F-	331.5 ohm	± 0.25%
321-1678-03	F-	174.2 ohm	± 0.25%
321-1679-03	F-	78.86 ohm	± 0.25%
321-1680-03	F-	35.78 ohm	± 0.25%
321-1681-03	F	1.492k ohm	± 0.25%

METAL FILM 0.25 watt

322-1600-03	F-	52.6 ohm	± 0.25%
322-1601-03	F-	517.1k ohm	± 0.25%
322-1602-00	D+	2.075 M ohm	± 1.0 %
322-1605-03	F-	78.86 ohm	± 0.25%

METAL FILM 0.5 watt

323-0812-07	G	55 ohm	± 0.1%

METAL FILM misc.

325-0197-01	100 M ohm	± 1%	0.5 watt	T-2
325-0198-01	10 G ohm	± 1%	0.5 watt	T-2

RESISTOR, VARIABLE (section 5)

311-1727-00	I	panel	20k ohm ± 10%	2.0 watt
311-1808-00	J	panel	200 ohm ± 20%	0.5 watt
311-1811-00	I	panel	1k ohm ± 20%	0.5 watt
311-1813-00	F	trimmer	200k ohm ± 30%	0.25 watt
311-1814-00	G	trimmer	2k ohm ± 20%	0.5 watt
311-1815-00	J-	panel	50k ohm ± 20%	0.5 watt
311-1817-00	J+	panel	20k ohm ±5%	0.5 watt
311-1827-00	L-	panel	100k ohm ± 20%	1.0 watt
311-1828-00	K-	panel	10k ohm ± 10%	0.25 watt
311-1830-00	K	panel	10k x 10k ohm ± 10%	0.5 watt
311-1831-00	K	panel	2.5k x 1k ohm ± 10%	0.5 watt
311-1832-00	I+	panel	5k ohm ± 10%	0.5 watt
311-1833-00	I+	panel	50k ohm ±10%	0.5 watt
311-1834-00	I+	panel	50k ohm ±10%	0.5 watt
311-1835-00	J-	panel	100 ohm ± 20%	1.0 watt
311-1837-00	I+	panel	500k ohm ± 10%	0.5 watt
311-1838-00	K+	panel	10k ohm ± 10%	0.5 watt
311-1839-00	K	panel	5k ohm ± 20%	1.0 watt
311-1840-00	I+	panel	10k ohm ± 10%	0.5 watt
311-1841-00	J+	panel	1k ohm ± 10%	1.0 watt
311-1842-00	J	panel	100k ohm ± 20%	0.25 watt
311-1843-00	K+	panel	1k x 1k ohm ± 20%	0.5 watt
311-1845-00	J	panel	5k ohm ± 20%	0.5 watt
311-1846-00	J-	panel	100k ohm ± 20%	0.5 watt
311-1847-00	K	panel	250k ohm ± 20%	0.5 watt
311-1848-00	L-	panel	5k x 50k ohm ± 20%	0.5 watt
311-1850-00	J	panel	5k ohm ± 20%	0.5 watt
311-1851-00	K	panel	15k ohm ± 10%	0.5 watt
311-1852-00	K	panel	25k ohm ± 20%	0.5 watt
311-1853-00	J	panel	2.5k ohm ± 10%	0.5 watt
311-1854-00	J+	panel	1k ohm ± 10%	0.5 watt

CAPACITOR, FIXED (section 6)

CERAMIC

TUBULAR

C	volts	tolerance	temperature char/coeff	dia (in)	length (in)	lead space	part number	cost code
9.3 pF	500	±0.1 pF	NPO	0.125	0.320	0.250	281-0795-00	G+
12.1 pF	500	±1.0%	NPO	0.140	0.320	0.250	281-0794-00	G+

MACHINE INSERTABLE

C	volts	tolerance	temperature char/coeff	dia (in)	length (in)	part number	cost code
15 pF	100	±10%	NPO	0.100	0.260	281-0797-00	G-
51 pF	100	±1%	NPO	0.100	0.260	281-0798-00	G-
62 pF	100	±1%	NPO	0.100	0.260	281-0799-00	G-

FEEDTHRU

C	volts	tolerance	temperature char/coeff	remarks	part number	cost code
5000 pF	100	+100% -0%	X5W	8-32 thread	281-0796-00	I-

DISC and PLATE

C	volts	tolerance	temperature char/coeff	dia (in)	lead space (in)	remarks	part number	cost code
4700 pF	7,500	+80 -20%	Y5S	1.625 x 1.031	—	opposed radial leads	283-0367-00	H
1000 pF	12,000	±20%	Z5U	.800	.620	radial	283-0368-00	G+
5.6 pF	500	±0.25 pF	NPO	.150 sq.	.100	radial	283-0369-00	G-
.027 µF	100	± 5%	W5R	.300 sq.	.200	radial	283-0370-00	G

CAPACITOR, FIXED (CONT)

CHIP

MONOLITHIC

C	volts	tolerance	temperature char/coeff	nominal size	part number	cost code
0.5 pF	75	±0.05 pF	+35 PPM ± 15 PPM/°C	.020 x .020 x .006	283-0366-00	G-
0.82 µF	100	± 30%	Z5U	.180 x .230 x .070	283-0355-00	I+

CAPACITOR, FIXED (CONT) (section 6)

PLASTIC

C	volts	tolerance	dia (in)	length (in)	lead length	remarks	part number	cost
20 µF	200	+10%	1.230	1.950	1.500	metallized mylar	285-1120-00	K+
0.47 µF	200	+5%	0.700	1.344	1.500	polypropylene & foil	285-1121-00	H-
0.25 µF	120	+10%	0.437	0.875	1.500	metallized polypropylene	285-1122-00	I+
1.0 µF	200	+20%	0.460	1.000	1.500	metallized mylar	285-1123-00	H-
.022 µF	400	+20%	0.340	0.721	1.500	polypropylene film & foil	285-1124-00	F-
0.2 µF	100	+5%	0.297	0.625	2.500	metallized mypro	285-1129-00	I-
0.22 µF	100	+1%	0.297	0.625	2.500	metallized mypro	285-1130-00	I-
0.05 µF	100	+5%	0.250	0.500	2.500	metallized mypro	285-1131-00	G+
0.33 µF	100	+1%	0.343	0.750	2.500	metallized mypro	285-1133-00	I-
0.1 µF	100	+5%	0.234	0.625	2.500	metallized mypro	285-1134-00	H-
.0047 µF	8000	+10%	0.480	1.940	1.625	metallized mylar	285-1137-00	H+
.010 µF	8000	+10%	0.660	1.940	1.625	metallized mylar	285-1138-00	I-

ELECTROLYTIC ALUMINUM

C	volts	tolerance	dia (in)	length (in)	lead length	remarks	part number	cost
1.0 µF	250	+75 -10%	0.335	0.740	1.375	tubular, axial leads, insul. slv.	290-0763-00	F+
5.0 µF	100	+50 -10%	0.401	1.140	1.500	tubular, axial leads, non-polar	290-0764-00	G
20.0 µF	450	+50 -10%	0.760	1.749	1.250	tubular, axial leads, insul. slv.	290-0765-00	H-
2.2 µF	160	+50 -10%	0.335	0.582	0.218	single-ended with par. leads	290-0766-00	I+
4.7 µF	160	+50 -10%	0.414	0.681	0.218	"	290-0767-00	F+
10.0 µF	100	+50 -10%	0.414	0.886	1.375	tubular, axial leads, insul. slv.	290-0769-00	F+
100.0 µF	25	+50 -10%	0.414	0.681	0.218	single-ended with par. leads	290-0770-00	F-
220 µF	10	+50 -10%	0.414	0.681	0.218	"	290-0771-00	F-
330 µF	25	+50 -10%	0.512	1.339	1.375	tubular, axial leads, insul. slv.	290-0772-00	G+
1000 µF	10	+50 -10%	0.512	1.339	1.375	"	290-0773-00	G+
22 µF	10	+50 -10%	0.217	0.512	0.218	single-ended with par. leads	290-0776-00	F-
1.0 µF	50	+50 -10%	0.217	0.512	0.218	"	290-0778-00	F-
10.0 µF	50	+50 -10%	0.335	0.512	0.218	"	290-0779-00	F-

SWITCH, TOGGLE (section 9)

Switch logic	volts	amps	actuator type	Fig.	Length	Mounting type	Mounting detail no	UL listed	part number	cost code
DPST on-none-off	125 VAC	15	metal bat	1	1.312	.469-32 bushing	A25	yes	260-1805-00	K-
SPDT on-off-on	20 V	0.4	metal bat	2	0.360	.250-40 bushing	A10	no	260-1809-00	J-

CONNECTORS (section 12)

131-1744-00	D-subminiature receptacle; 15 male contacts	L-
131-1746-00	Side-entry receptacle for two 0.025 square pins; 0.100 centers, circuit board mount	J+
131-1749-00	Side-entry receptacle for 10 0.045-dia. pins; 0.156 centers; circuit board mount	I-
131-1750-00	Ten 0.045-dia. pins on nylon carrier strip; 0.156 centers; circuit board mount	I-
131-1756-00	Edge-board connector; 6/12 contacts; 0.156 centers; flow-solder tails	J+
131-1766-00	Male twist-lock power plug; 125 V, 15 A	J
131-1771-00	Side-entry receptacle for six 0.025 sq. pins; 0.100 centers, circuit board mount	J+
131-1780-00	Right-angle header receptacle; 2 x 25 0.025-dia pins; 0.100 x 0.100 grid; mates with 2 x 25 "Quickie" plug on 50-conductor ribbon cable	K+
131-1781-00	"Quickie" plug; 2 x 25 female contacts on 0.100 x 0.100 grid; terminates 50-conductor ribbon cable	K+
131-1782-00	Side-entry receptacle for 14 0.045-dia. pins; 0.156 centers, circuit board mount	I-
131-1783-00	12 0.045-dia pins on nylon carrier strip; 0.156 centers; circuit board mount	I-
131-1784-00	Edge-board connector; 15/30 contacts; 0.156 centers; flow-solder tails	J+
131-1789-00	Right-angle header receptacle; 2 x 10 0.025-dia pins; 0.100 x 0.100 grid; mates with 2 x 10 "Quickie" plug on 20-conductor ribbon cable	K+
131-1791-00	Edge-board connector; 25/50 contacts; 0.100 centers; wire-wrap tails	G
131-1794-00	LEMO plug; 3 male and 3 female contacts in 12 mm snap-lock shell	L
131-1795-00	Side-entry receptacle for 12 0.045-dia pins; 0.156 centers; circuit board mount	G
131-1803-00	Series SMA female receptacle; solder-pot tail; rear mount	E+
131-1804-00	Series N female receptacle; solder to 0.141-dia semi-rigid cable	H-
131-1806-00	31 short right-angle 0.025 sq. pins on notched carrier strip; 0.150 centers; stack with 131-1807-00 to form 0.150 x 0.150 grid	H
131-1807-00	31 long right-angle 0.025 sq. pins on notched carrier strip; 0.150 centers; stack with 131-1806-00	H+
131-1811-00	10 short right-angle 0.025 sq. pins on notched carrier strip; 0.150 centers; stack with 131-1812-00	G+
131-1812-00	10 long right-angle 0.025 sq. pins on notched carrier strip; 0.150 centers; stack with 131-1811-00	H
131-1813-00	"Quickie" plug; 2 x 20 female contacts on 0.100 x 0.100 grid; terminates 40-conductor ribbon cable	K+

WIRE, ELECTRICAL (section 13)

175-1597-00	stranded, 24 AWG, 5kV, UL	175-1745-00	stranded, 18 AWG, 6.5kV, UL
175-1689-00	50 conductor, 28 AWG, flat	175-1767-00	stranded, 16 AWG, 300 V, UL
175-1728-00	solid, 26 AWG, 3kV	175-5025-00	stranded, 22 AWG, 30kV, UL

INSULATION, SLEEVING, ELEC (section 13)

plain	
162-0673-00	acrylic-coated fiberglass, gray, 0.069 nom ID
shrinkable	
162-0672-00	polyolefin, transparent, 0.255 nom ID
162-0676-00	irradiated polyolefin, black, 0.750 nom ID, UL

CABLE ASSEMBLY, POWER (section 13)

161-0107-00	3-wire, male, 93-inch, IEC	161-0108-00	3-wire, male, 98-inch