component news

March 9, 1980 COMPANY CONFIDENTIAL Issue 279

An Overview of Lithium Batteries

Two types of lithium batteries have been developed and marketed in the United States. This article characterizes the batteries which are suitable for use in Tek instruments, with only points of interest included on the others. Broad classification includes primary and secondary batteries; further breakdown includes instrument, heart pacer, vehicular propulsion, stationary power and load leveling applications.

Presently, the most interesting are the primary instrument types, so this discussion begins with them.

Lithium Sulfur-Dioxide ($LiSO_2$) Cell

Construction The lithium/sulfur-dioxide cell is produced in this country by Mallory, Honeywell, and Power Conversions, Inc. in many different configurations. It consists of a lithium foil anode, a carbon-based cathode, a separator, a sulfur-dioxide rich organic electrolyte, and a nickel-plated steel casing. Many of the manufacturing processes are proprietary and unavailable for examination.

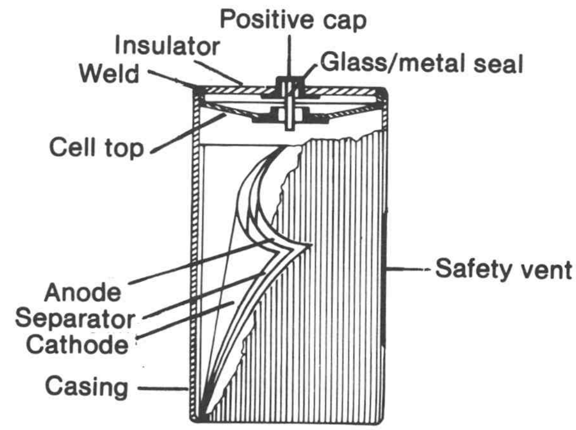
The basic chemical reaction is:

Anode: $2Li \rightarrow 2Li^+ + 2e^-$ $E°=2.8V$

Cathode: $2SO_2 + 2e^- \rightarrow S_2O_4^=$

Total cell reaction: $2Li + 2SO_2 \rightarrow Li_2S_2O_4\downarrow$

It is anode limited so the lithium is entirely used up. In practice this rarely happens, and some metallic lithium remains. The dithianide ($Li_2S_2O_4$) is insoluble in the electrolyte and precipitates at the cathode.



Construction of $LiSO_2$ cell

Performance Two outstanding characteristics of the $LiSO_2$ cell are long shelf life (10 years at 25°C) and high power density. Compared to the common carbon-zinc (Leclanche) cell, the $LiSO_2$ cell produced approximately six times the life of the carbon-zinc cell tested under identical conditions. Table 1 (page 2) compares the lithium cell with four popular primary cells.

continued on page 2

Also in this issue

Characteristic	Carbon Zinc	Manganese Alkaline	Mercury	Magnesium	Eternacell® Lithium
Shelf Life*					
Storage Temperature					
(70°F)	1-2 Yrs	1-2 Yrs.	2-3 Yrs.	5 Yrs.	10 Yrs.†
(130°F)	1.5 Mos.	2 Mos.	3 Mos.	7 Mos.	8 Yrs.†
Low Temperature Percent of (70°F) Capacity					
+20°F	5%	15%	0%	58%	96%
−20°F	0%	3%	0%	23%	85%
−40°F	0%	0%	0%	0%	60%
Watt-Hrs. Per Pound	19.5	26	40	36	125
Watt-Hrs. Per Cubic Inch	1.6	2.3	4,8	3.0	7.1

**Time in years or months that a cell will provide a minimum of 75% of its initial capacity at room temperature.*
†Projected

Table 1 — Comparison of five primary battery cells

Safety The chemical reaction given above for the $LiSO_2$ cell is, unfortunately, **not** all that takes place. In a situation where there is insufficient CO_2, the following reactions occur:

$$2Li + 2CH_3Cn = (CH_2{-}CN)^- + Li^+ + CH_4 + LiCN$$

$$CH_3CN + (CH_2 - CN)^- = (CH_3 - CN - CH_2CN)^-$$

for a total reaction of :

$$2Li + 3CH_3CN = LiCN + CH_4 + (CH_3CN{-}CH_2CN)^- + Li^+$$

This reaction is exothermic! In addition, at temperatures above 130°C, methane (CH_4) and SO_2 may react exothermically, and above 150°C the cathode discharge product ($Li_2S_2O_4$) may decompose exothermically. At such temperatures a considerable pressure may develop within the cell, and CH_4 vented to the atmosphere will flame even in the presence of CO_2. Similar side reactions occur in cases where a different solvent/solute combination is used in $LiCO_2$ cells. However, the same troublesome compounds are generated.

In a previous **Component News** article (see Issue 276, page 6), a violent accident was reported in which a lithium battery was involved. A reasonably accurate assumption is that the battery of 72 cells may have been constructed of $LiSO_2$ cells. Reactions such as those listed above can happen under forced discharge conditions whether they are due to external or internal shorts. We will never know which may have caused the violent explosion recounted in the report.

In this case, it was assumed that the battery involved was new. However, two papers given at the Power Sources Conference reported explosions occurring in completely discharged cells!

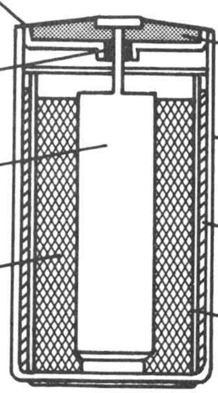
Please note that this is a primary cell. Manufacturers warn against recharging them. The maximum current allowed is 30μA. At this time we strongly recommend that the $LiSO_2$ cell **not** be used in an application where it will float on a power supply.

The cost of materials is 0.53¢/watt-hour.

continued on page 3

Lithium Thionyl Chloride ($LiSOCl_2$) Cell

Construction Another popular primary lithium battery is manufactured by Tadiran in Israel and by GTE, Honeywell and others in the USA. The sizes range from ½AA to large prismatic cells. The basic cell consists of a lithium anode, a carbon cathode, a non-aqueous inorganic electrolyte and a nickel-plated steel enclosure.



Construction of LiSOCl2 cell

Performance The $LiSOCl_2$ cell produces the highest power density of the two popular lithium batteries. Below is another comparison chart taken from a data sheet.

Safety There have been many studies concerning the safety of this cell because it is considered less safe than the $LiSO_2$ cell. It was demonstrated from differential thermal analysis (DTA) studies that there are several constituents of the $LiSOCl_2$ cell which could create a thermal runaway when heated to a suitable temperature, say above 100°C. Two of these constituents are lithium and sulfur.

There are two recognized chemical reactions for this cell:

$$4Li + 2SOCl_2 \rightarrow SO_2 + 4LiCl + S,\ E° = 3.4V$$

and

$$8Li + 3SOCl_2 \rightarrow 2S + Li_2SO_3 + 6LiCl$$

Many side reactions occur during discharge resulting in the following chemical species known or presumed to be present:

- Lithium (Li)
- Thionyl Chloride ($SOCl_2$)
- Lithium Aluminum Perchloride ($LiAlCl_4$)
- Sulfur (S)
- Sulfur-dioxide (SO_2)
- Lithium Chloride (LiCl)
- Lithium Sulphate ($LiSO_3$)
- Lithium Sulphide (LiS^3)
- Glass
- Carbon
- Teflon
- Nickel
- Kovar
- Trace impurities (H_2O, etc.)

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System	Nominal Voltage	Energy Density Wh/lb	Energy Density Wh/in^3	Temp. Range (°C)	Shelf Life
Tadiran Lithium/Inorganic Electrolyte	3.40	190	13.0	−55+75	Excellent
Lithium/Organic Electrolyte	2.80	140	8.0	−55+75	Excellent
Silver Oxide	1.50	60	8.0	0+55	Good
Magnesium	1.80	55	4.0	−30+70	Good
Mercury	1.35	45	6.0	0+55	Fair
Manganese Alkaline	1.50	35	3.0	−20+55	Fair
Carbon Zinc	1.50	25	1.5	−10+50	Poor

Table 2

In addition, transient species may be present as a result of the following reactions:

$$2Li+SOCl_2 \rightarrow 2LiCl+SO$$
$$2SO \rightarrow (SO)_2$$
$$(SO_2)+SO \rightarrow S_2O+SO_2$$
$$(S_2O)_x \rightarrow (S_mO)_n+SO_2$$
$$(SO)_2 \rightarrow S+SO_2$$

Any and all of the above species, along with the other chemical species that may have been formed by chemical interactions between the above-listed species, may be responsible for the initiation and propagation of the thermal runaway encountered in the $SOCl_2$ cells. Several studies suggest that the anode (Li)-limited $SOCl_2$ cell is hazardous and may explode without any warning signs. They also suggest that cathode (C)-limited cells appear to be safe because the carbon electrode potential decreases rapidly on forced discharge while the opposite is true with anode-limited cells.

Again it is reasonable to assume that the 72-cell battery reported on earlier may have been constructed of $LiSOCl_2$ cells as well as $LiSO_2$ cells. There is sufficient evidence of unsafe performance to preclude their use in Tek instruments.

The cost of materials is 0.23¢/watt hour.

Lithium Poly-Carbonmonofluoride (LiCF) Cell

There are three versions of this couple manufactured by Matsushita, Yardney and Eagle-Picher, with variations primarily in the electrolyte. The anode is metallic lithium, the cathode is teflon-bound polycarbon monofluoride, and an electrolyte of either lithium perchlorate ($LiClO_4$) or lithium hexafluoro-arsenate ($LiAsF_6$). The basic reaction is:

Cathode: $(CF)n + ne \rightarrow nC+nF^-$ $E° = 2.9V$
Anode: $nLi \rightarrow nLi^+ + ne$
Total: $(CF)n + nLi \rightarrow nC+nLiF$

Although no side reactions are mentioned in the literature, it is safe to assume that they do exist as in other lithium couples and will no doubt be uncovered in subsequent papers presented on this cell.

Performance The LiCF cell does not have as long a shelf life (about five years) as other lithium cells. The current drains permitted because of the solvent reduction are quite small, on the order of 3mA. One notable discharge characteristic is that the cell expands. Therefore, a case with good mechanical integrity must be used, and sufficient space must be provided for expansion in the instrument.

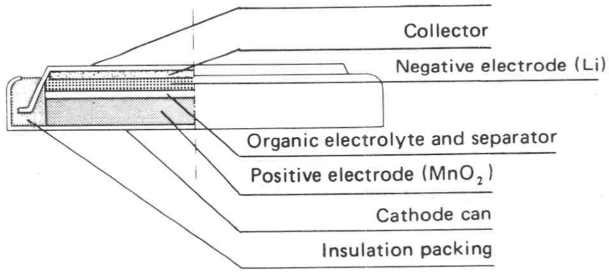
Safety The LiCF cell appears to be significantly more safe than other lithium cells. However, it is relatively new and we can only speculate what chemical species might exist in a partially discharged cell. Forced discharge does not form flammable gases when pressure causes it to vent.

Only a few sizes of the LiCF cell are manufactured with no apparent standardization of these sizes. They range from thin button cells, to cylindrical, to prismatic configurations.

The cost of materials is about 1.96¢/watt-hour.

Lithium Manganese Dioxide ($LiMnO_2$) Cell

Sanyo of Japan makes a variety of cells using the $LiMnO_2$ couple. It consists of a lithium anode, a paste or pressed MnO_2 cathode and an organic electrolyte. Three configurations of enclosures are used: a button, a cylindrical can and a package that looks like a tantalum capacitor. The latter is sold in this country in a lighted fishing lure.



Construction of button $LiMnO_2$ cell

continued on page 5

The basic reactions suggested are:

$$2Li+2MnO_2 \rightarrow Mn_2O_3+Li_2O \quad E=2.69V$$

$$\text{and } Li+\overset{IV}{Mn}O_2 \rightarrow \overset{III}{Mn}O_2(Li^+)$$

Because an organic electrolyte is used it can be assumed that side reactions may exist during discharge. The exact composition would have to be known to be able to formulate them. No assessment of safety can be made without further study.

The cost of materials is 0.45¢ per watt-hour.

Heart Pacer Cells

Heart pacer cells are generally of the "solid state" kind. The most widely used is the lithium/iodine (poly-2-vinylpyridine) cell. The iodine is rendered electronically conductive by the incorporation of several weight percent of poly-2-vinylpyridine to form a charge transfer complex cathode mixture. The electrolyte layer of lithium-iodide is formed in-situ by the direct combination of the active elements.

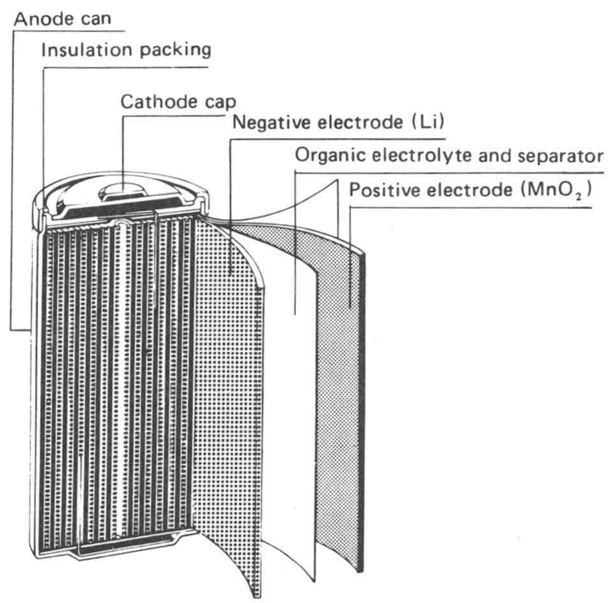
The resultant cell is basically solid state, although the cathode complex is initially semi-solid, solidifying during discharge. The lithium is oxidized and transported through the lithium iodide layer to the cathode where the product lithium iodide forms. Because of the mass transfer from anode to cathode, there is a slight shape change with discharge. The volume change is negative.

As in most lithium cells the open circuit terminal voltage is approximately three volts.

Arco Medical Products makes AA and ½AA sizes of $LiSOCl_2$ cells for implantation in heart pacers. This is a classic $LiSOCl_2$ cell except that they do not discuss the composition of the electrolyte. They make a very strong enclosure for the cell which, perhaps, allows them to claim 3½ years of safe operation.

Vehicular Propulsion

The extremely good power-to-weight ratio would seem to be a good recommendation of the lithium battery for this service. However, the high cost of that size battery and the emergence of the nickel-zinc battery (a much safer and cheaper battery) has overshadowed the lithium battery. If an electric car is made, it will most likely use a nickel-zinc battery.



Construction of cylindrical $LiMnO_2$ cell

Stationary Power and Load Leveling

Batteries for stationary power and load leveling are constructed from many different rechargeable lithium couples. Almost all are very large, high temperature batteries. An example is the LiS battery. It runs at 700°F and has a high power density and low impedance.

Rechargeable Lithium Batteries for Instruments

Electrochemica of California has developed a rechargeable cell which is not yet on the market, but uses a lithium anode and a new class of materials called sulphospinels as cathode. The electrolyte is a solution of aprotic (incapable of acting as a proton acceptor or proton donor or as an acid or a base) organic solvents with $LiAlCl_4$ as solutes.

continued on page 6

A word about sulphospinels. This new class of materials are chalcogenide compounds generally analogous to the face-centered cubic crystal spinels and ferrites. They have the general formula:

$$M_1^{II} M_2^{III} X_4$$

where X = S, Se, Te

M_1 = Divalent ions of Cu, Fe, Co, Ni, Mn, Zn

M_2 = Trivalent ions of Te, V, Cr, Fe, Co, Ni

These compounds offer a great variety of chemical substitutions for both cations and anions. Sulphospinels were chosen for this battery couple because they weigh less than other battery compounds. The interstitial reactions are:

$$\text{L li} + M^{II}M_2^{III}O\,S_4 \underset{\text{charge}}{\overset{\text{discharge }(2\bar{e})}{\rightleftharpoons}} Li_2M^{II}M_2^{II}OS_4$$

and possibly further:

$$1Li + Li_2M^{II}M^{I} \underset{\text{charge}}{\overset{\text{discharge }(1\bar{e})}{\rightleftharpoons}} Li_3M^{I}M_2^{II}S_2$$

The final cathode material used is $CuCo_2S_4$. This agrees with the first reaction equation. A performance chart is included below.

Discharge of $CuCo_2S^4$-Li Organic Electrolyte Li-Cells — Cycle No. 28 at R.T. and 4 Hr. Rate (GP. 17-17-1, 7)

Del. Cap. (mAH)	Cell Voltage
0.0	2.23-2.29
10.1	2.06-2.12
21.0	2.01-2.05
70.0	1.80-1.82
193.0	1.42-1.51
318.0	1.21-1.29
480.0 (= $2\bar{e}$/mole)	1.12-1.18
Chg. Voltage Range	1.40-2.30V
Av. Voltage/Storage Efficiency (1.5/1.9)	79%

The transition metal sulfur-lithium organic electrolyte rechargeable cell is a very attractive alternative to presently available cells. It will be watched with great interest to see if undesirable side ractions are present which might affect the safety of the cell.

In conclusion, it appears that the lithium battery does not present an attractive alternative to presently used primary cells at Tektronix. Considering cost, safety factors, multiple source capability and general availability, the presently used primary cells will meet our needs.

As stated before, the rechargeable cell will be watched with great interest. Considering the intense interest in the the safety problems associated with lithium batteries, these problems should be solved in the very near future.

For further information, contact **Byron Witt (58-299), ext. 5417.**

GPIB consulting service

Are you:

- implementing a GPIB interface?
- having trouble implementing a GPIB interface?
- searching for general assistance or information on GPIB?

Do you:

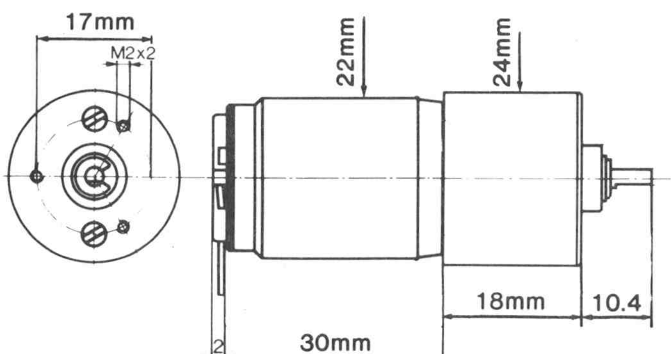
- have a solution to a current GPIB problem?
- have inputs on future GPIB systems features?

If so, then the Digital Products Coordination Group has a service to offer you. For details, contact **Jim Walker (ext. 5165), 50-473.**

DC micromotor assemblies part numbered

Two Escap motor assemblies are now being used in Tek products. One is a DC Servo motor used in a cartridge drive product (P/N 147-0054-00) and the other is a gear motor used to transport paper in a strip chart recorder (P/N 147-0055-00). Both of these motors have ironless rotors with stationary permanent magnets. The rotors are composed of and supported by the windings, thereby providing low inertia. This results in a shorter mechanical time constant and higher efficiency. (Efficiency equals the ratio of electrical power in, to mechanical power out.) These motors also have exceptional linear speed-torque characteristics, making them desirable in servoing applications.

The gear motor assembly is rated at 18V DC. Its diameter is 22 millimeters with a length from the gearbox to the end of motor housing of 50 millimeters. Its no-load speed is 128 rpm (64:1 gear ratio), and it will produce a continuous running torque of 14 ounce-inches with stall at 20 ounce-inches. The no-load current is 3mA. This motor assembly is presently being life tested. Life testing on a similar version of this motor gearbox assembly produced in excess of 1000 hours of operation under worst-case conditions.

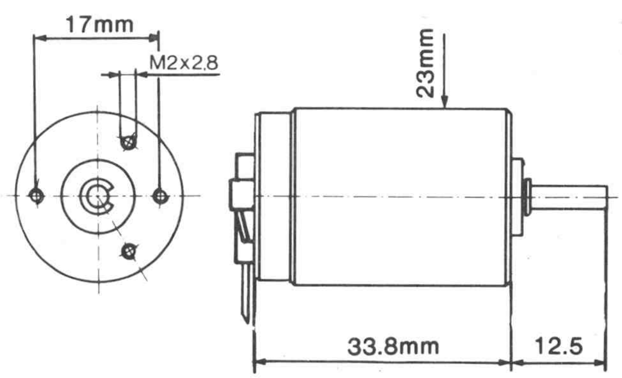


Scale: ~1:1

Gear motor — P/N 147-0055-00

When applying this motor gearbox assembly, it is important to have the gearbox oriented properly with respect to the sideload in order to achieve maximum life characteristics. This assembly sells for approximately $25 in quantities.

The Servo motor is rated at 12V DC. It is 23 millimeters in diameter and 34 millimeters long. The no-load current is 14mA and the motor is guaranteed to start with 300mV applied. It has a mechanical time constant of 19mS. This motor is physically very small for the torque output, compared to other motors in this size range. Presently, life tests are being performed on eight motors using the newly completed DC motor mass testing station. The motors will be tested for 5000 hours or until failure while operating under worst-case conditions.



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Servo motor — P/N 147-0054-00

If you have any questions or applications which might involve these motors, please contact **Bill Stadelman, ext. 7711.**

Corrections from Issue 278

There are two corrections from the last issue of **Component News.** In the lead article ("Poor Man's Disk Operating System") all references to the Sugart disk drive should have read **Shugart.** Also, in the article on conductive elastomers (page 6) the values in the materials comparison should be **$10^{-6}\Omega$-cm** not 10^{6}.

"Engineering Notebooks" renamed

For a number of years, the Patent and Trademark Department has issued "Engineering Notebooks" — bound notebooks having consecutive numbered pages — to engineers, scientists, and other technical personnel. These books are intended to provide a convenient place for recording information that may be needed later to prove when an invention was made, and who made it.

Probably because of the name, Engineering Notebooks (called Design and Computation Books by the supplier) are sometimes used for recording routine test data of little or no relevance to any new idea, concept, development, discovery or invention. In addition, some persons who don't consider themselves to be "engineers" have not used the notebooks when perhaps they should.

From now on, Engineering Notebooks will be called **Invention Record Notebooks** to emphasize their true purpose. They should be used only for documenting new ideas, developments, discoveries and the like — "inventions". The date when an invention is first conceived and when it is reduced to practice are of vital importance. It is equally important that all contributors to the invention be identified and that the description be sufficiently clear and complete for someone else to be able to understand the invention. Any relevant sketches, diagrams, photos, etc. should be included. It is also important that the notebook pages be routinely witnessed. Accordingly, two associates who understand the recorded information should witness by signature and date every 5-10 pages, noting the witnessed pages.

The Invention Record Notebooks are Tektronix property, and are to be left with the user's immediate manager or returned to Patents and Trademarks, Y3-121, when the employee leaves the company or when the book is filled. In addition, they are considered confidential, and should be treated appropriately.

The notebooks are available at the following locations:

Y3 – Barbara Wall, ext. 8168
Walker Road – Eleanor Hess, ext. 1168
Wilsonville – Cheri Eckholt, ext. 3986
Building 50 – Kay Smith, ext. 4683

Note: The standard Invention Record Notebook is not suitable for use in clean rooms. A different version, however, identified by a black cover and the printed title, "Laboratory Notebook," is acceptable and may be obtained from:

Maureen Richardson, Tek Labs (50-431), ext. 6305

John LaRue
Y3-121, ext. 8167

New component engineers

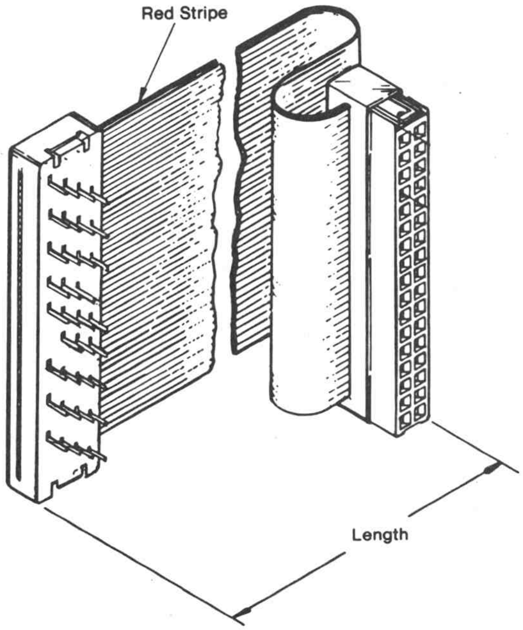
Halsey Royden III and Joseph Reshey have joined the Electromechanical Component Engineering group.

Halsey has component responsibility for keyboards, keycaps, keyswitch modules, lamps and lamp holders. He holds a BS (physics) degree from Stanford University. Halsey can be reached at 58-299, ext. 6365.

Joe has component responsibility for connectors, board interconnect systems with 0.025" square post systems, edge card connectors, and 0.045" square post systems. Joe has a BS (physics) degree from Albridge College and MS (physics) degree from Washington State University. He can be reached at 58-299, ext. 7264.

Bob Aguirre, manager
Electromechanical Comp. Eng.

Specifying flat cable assemblies



The majority of flat laminated cable assemblies at Tek are no longer being made by Wire Prep, but are being purchased from outside vendors. New designs for flat cable assemblies should be directed to Component Engineering.

If you have a new cable design, the following general specifications are suggested for simplicity and cost savings.

1. Length: specify in one-inch increments
2. Length tolerance: ± 0.500 inch
3. Marking: clear indication of placement for red stripe on cable (if necessary)
4. Strain relief: clear indication of strain relief (if desired)

The following is a breakdown (by connector type) of all Tek part numbered flat cable assemblies. For more information about these assemblies, request a specification from Reprographics (ext. 5577) or refer to page 15-24 of the Electromechanical parts catalog. If you need any more help, please contact **Elizabeth Doolittle (58-299), ext. 6520.**

Connectors	Conductors	Total Length (inches)	Part Number	Miscellaneous Notes
Socket/Socket				
Socket/Socket	26	1.25	175-2958-00	
Socket/Socket	26	3.25	175-1470-00	
Socket/Socket	26	32.00	175-2265-00	
Socket/Socket	26	40.00	175-2263-00	Socket connector in center
Socket/Socket	34	1.50	175-2238-00	
Socket/Socket	34	2.00	175-2456-00	
Socket/Socket	34	2.50	175-2752-00	Socket in center
Socket/Socket	34	2.50	175-1778-00	Strain relief
Socket/Socket	34	2.75	175-5093-00	
Socket/Socket	34	3.50	175-2700-00	
Socket/Socket	34	5.50	175-2443-00	
Socket/Socket	34	7.00	175-2236-00	
Socket/Socket	34	10.50	175-2090-00	
Socket/Socket	34	14.00	175-1725-00	
Socket/Socket	34	19.00	175-2429-00	Sockets oppose
Socket/Socket	34	19.25	175-2123-00	
Socket/Socket	34	21.50	175-2935-00	
Socket/Socket	34	22.50	175-2701-00	
Socket/Socket	34	25.50	175-2474-00	
Socket/Socket	34	30.00	175-1948-00	
Socket/Socket	34	31.00	175-2473-00	
Socket/Socket	40	2.50	175-2136-00	
Socket/Socket	40	3.50	175-2353-00	
Socket/Socket	40	10.50	175-2245-00	Strain reliefs (sockets oppose)
Socket/Socket	40	11.00	175-2879-00	Strain relief

continued on page 10

Connectors	Conductors	Total Length (inches)	Part Number	Miscellaneous Notes
Socket/Socket	40	12.00	175-2122-00	Ground plane
Socket/Socket	40	12.00	175-2120-00	
Socket/Socket	40	15.00	175-1978-00	
Socket/Socket	40	19.75	175-2266-00	Strain relief
Socket/Socket	40	24.50	175-2702-00	Strain relief
Socket/Socket	40	28.00	175-1991-00	
Socket/Socket	50	1.25	175-2237-00	
Socket/Socket	50	2.50	175-1726-00	
Socket/Socket	50	3.00	175-2442-00	Special ground plane
Socket/Socket	50	5.50	175-2857-00	Strain reliefs
Socket/Socket	50	6.50	175-5087-00	Socket in center
Socket/Socket	50	10.50	175-2744-00	Strain reliefs (sockets oppose)
Socket/Socket	50	15.00	175-1737-00	Strain reliefs
Socket/Socket	64	48.00	175-2683-00	Ground plane
Socket/Transition				
Transition/Socket	20	12.00	175-3121-00	Socket with strain relief
Transition/Socket	26	7.00	175-2878-00	
Transition/Socket	34	11.00	175-1413-00	
Socket/Transition	34	38.75	175-2279-00	Socket with strain relief
Transition/Socket	40	17.00	175-2259-00	Edgecard connector in middle
Socket/Transition	40	35.25	175-2280-00	Socket with strain relief
Transition/Socket	40	60.00	175-2655-00	
Transition/Socket	50	2.375	175-2649-00	
Transition/Socket	50	4.00	175-2650-00	
Socket/Card Edge				
Card Edge/Socket	34	15.00	175-2258-00	Socket with strain relief
Socket/Card Edge	50	6.75	175-2147-00	Socket with strain relief
Socket/Card Edge	50	14.00	012-0853-00	Ground plane
Card Edge/Socket	50	19.00	175-2699-00	Ground plane
Transition/Transition				
Transition/Transition	34	2.00	175-1254-00	
Transition/Transition	34	6.75	175-1518-00	Transition connector in middle
Transition/Transition	34	12.25	175-1250-00	
Transition/Transition	34	12.75	175-1252-00	
Transition/Transition	34	13.25	175-1253-00	
Transition/Transition	34	13.50	175-1249-00	
Transition/Transition	34	13.50	175-1244-00	Transition connector 1.75" from end
Transition/Transition	34	14.25	175-1245-00	Transition connector 1.75" from end
Transition/Transition	34	15.00	175-1251-00	Transition connector in middle
Transition/Transition	34	15.75	175-1247-00	
Transition/Transition	34	16.00	175-1246-00	
Transition/Transition	34	21.00	175-3123-00	Connectors oppose
Transition/Transition	34	31.25	175-1248-00	Two transition connectors in middle
Transition/Transition	50	20.00	175-3150-00	

Product Safety Note No. 38

12 February 1980

Subject: FCC requirements as to electromagnetic compatibility (and certain comments concerning compatibility requirements by West Germany).

Note: We are indebted to Herb Zajac, Tek Environmental Labs, for much of these data and for the attached graphs.

Effective July 1, 1980, FCC begins enforcing new regulations:

Definition of computing device — (Note that there are two definitions.) (1) This is a device or system that generates and uses radio-frequency energy to perform data processing functions, such as electric computations, operations, transformations, recording, filing, storage, retrieval and transfer. (2) A device or system that generates timing signals or pulses at rates exceeding 10 kilohertz and uses digital techniques. (A transmitter or other device which is specifically covered elsewhere is not encompassed by this definition.)

Definition of Class A computing device — A computing device that is intended for use in a commercial, industrial or business environment. A computing device which is widely marketed for use by the general public is excluded from this class of computing device.

Definition of Class B computing device — A computing device that is widely marketed for use in a home or residential environment. Electronic games, personal computers, calculators and similar electronic devices which are widely marketed for use by the general public are also covered by this definition.

Specifications —

Radiated radio-frequency interference will be limited as follows:

Class A Computing Devices:

Frequency (MHz)	Distance (meters)	Maximum field strength (μV/m)
30 - 88	30	30
68 - 216	30	50
216 - 1000	30	70

Class B Computing Devices:

Frequency (MHz)	Distance (meters)	Maximum field strength (μV/m)
30 - 88	3	100
68 - 216	3	150
216 - 1000	3	200

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Conducted radio-frequency interference will be limited as follows:

Frequency (MHz)	Maximum rf line voltage (dB above 1 μV) Class A	Class B
0.45 - 1.6	60.0	48
1.60 - 30.0	69.5	48

Certification:

FCC will require certification for:

1. Electronic games of all types.
2. Personal computers, excluding personal calculators and digital watches.
3. Any device intended to be connected to a TV receiver or TV interface device.

Labeling:

Class A equipment **must** be labeled:

"This equipment complies with the requirements for a Class A computing device in FCC Rules, Part 15, Subpart J. Operation of this device in a residential area may cause harmful interference requiring the user to take whatever steps may be necessary to correct the interference."

Class B equipment **may** be labeled at the manufacturer's option:

"This equipment has been tested and found to comply with the technical specifications in Part 15, of FCC Rules, for a Class B computing device."

FCC Class A rules are less stringent than the IEC requirements promulgated by VDE in Germany. FCC Class B rules are more stringent than VDE 0875.

FCC limits interference frequencies from 0.45 to 30 megahertz, while VDE limits interference frequencies from 0.15 to 30 megahertz.

An important point: The FCC requirements apply to devices that you and I perhaps **would not immediately consider to be "computing devices."**

Example: Consider an oscilloscope. It would be a rare oscilloscope that did not handle frequencies higher than 10 kilohertz. And a great many oscilloscopes have digital circuits for some purposes — readouts, signal processing, etc. Further, oscilloscopes are commonly for commercial, industrial or business purposes. So right away the oscilloscope becomes a Class A Computing Device. This might be startling, but nevertheless the Rules of the FCC do apply so we have to limit the interference and we have to put the markings required for Class A devices on the oscilloscope. The same things are true of a wide variety of other products, astonishing as it might seem.

Consult Tektronix Environmental Laboratories for technical details and for measurements.

Eddie Richmond

Product Safety
41-400
Town Center Ext. 258

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Figure 1 — Conducted Emissions

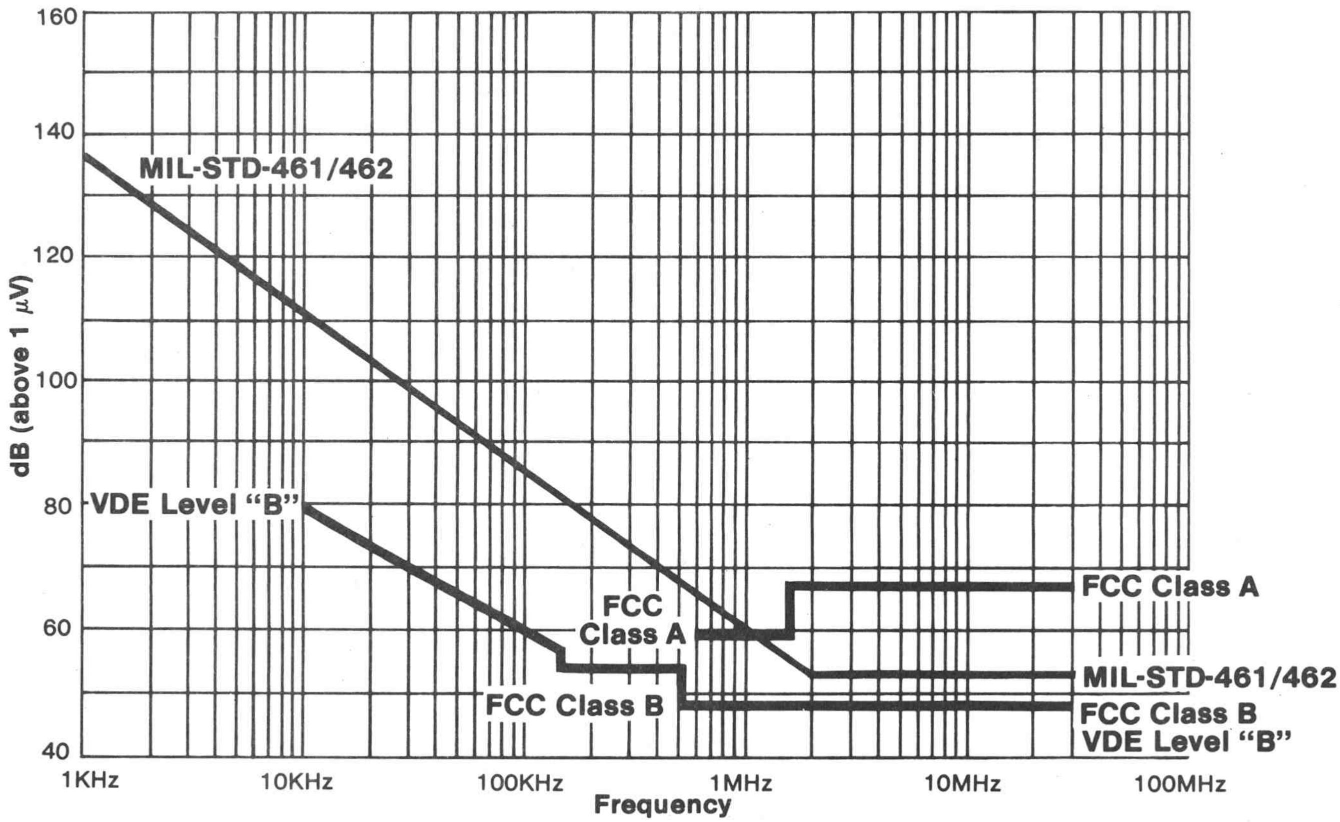
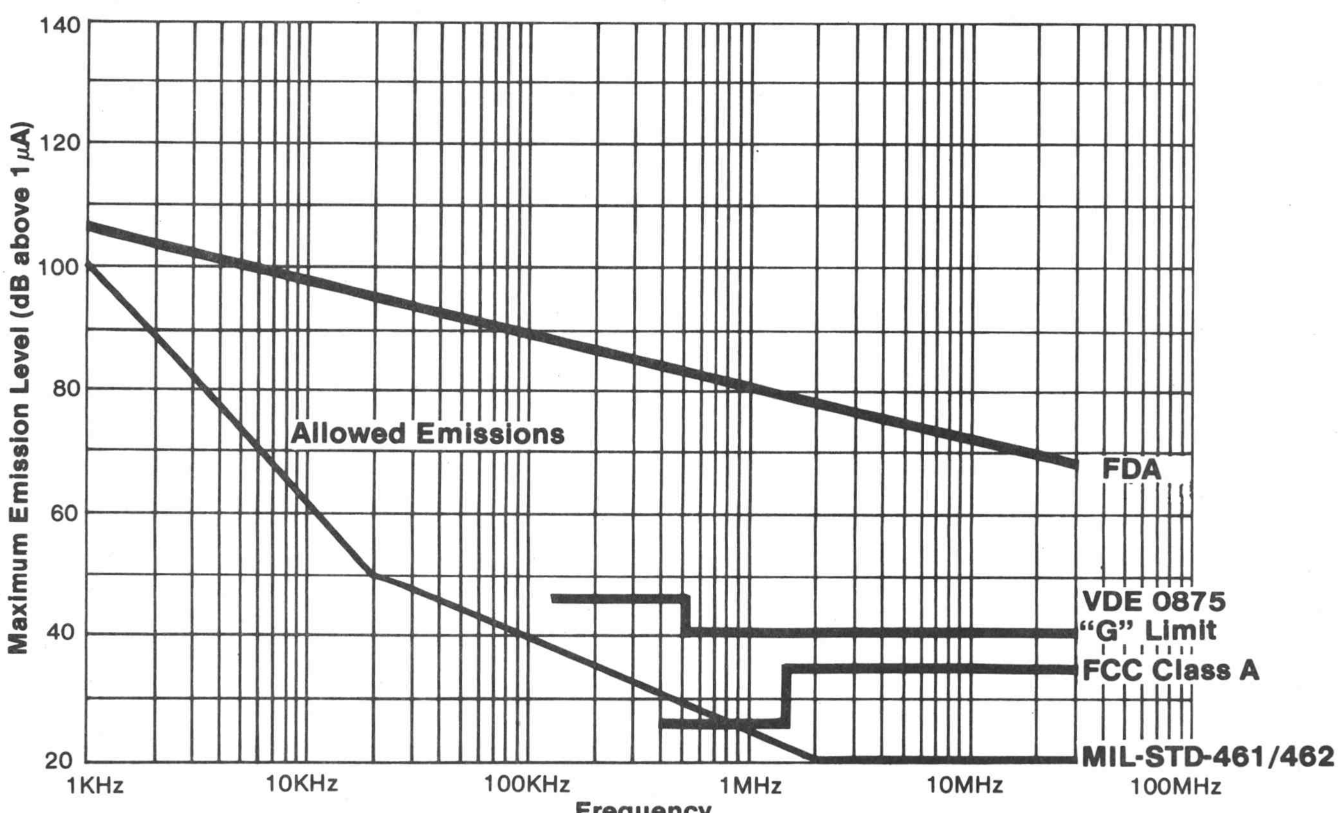


Figure 2 — Maximum Conducted Narrowband Emission Level (1KHz – 30MHz)



continued on page 14

Figure 3 — Radiated Emissions at 10 Meters

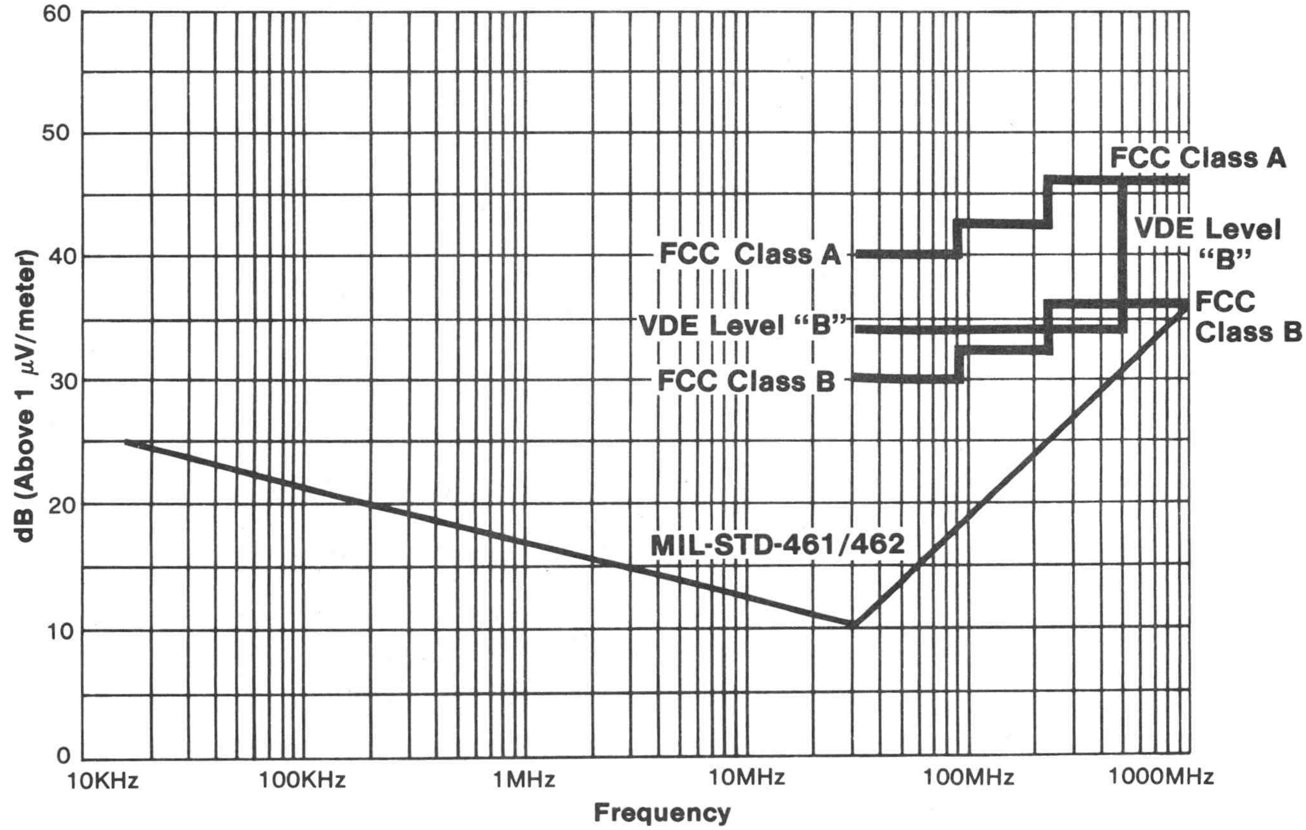
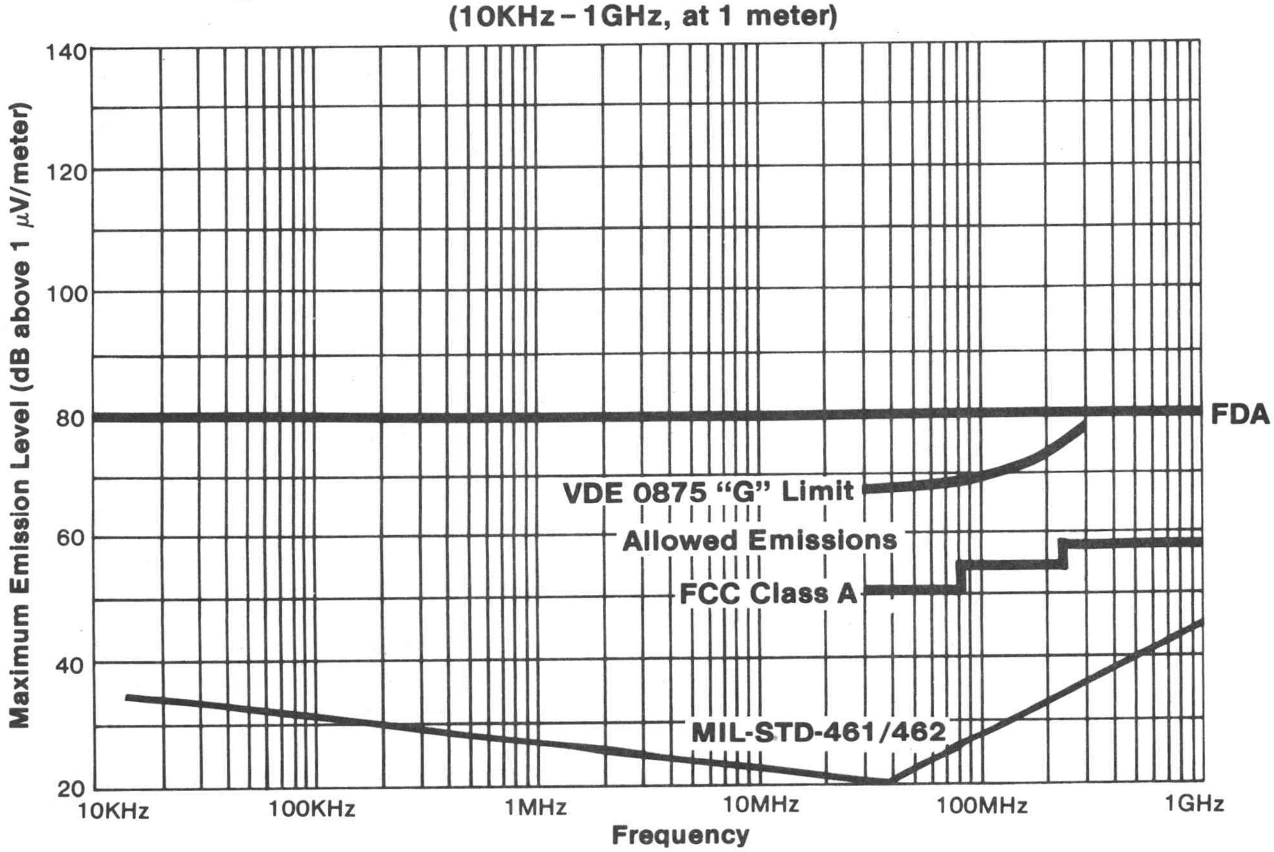


Figure 4 — Maximum Radiated Narrowband Emission Level (10KHz - 1GHz, at 1 meter)



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, ext.
151-0271-00	**TI**	**Small signal, PNP transistor**	**Matt Porter, 7461**

Recently, several different problems with this part have caused slow downs (and shut downs) on some assembly lines.

The problems started last summer when Texas Instruments, who is our only source, changed from their pin-circle TO-92 to the standard, in-line TO-92 package. This change in package, in itself, did not cause any problems, but soon after we started receiving these new parts users complained of higher emitter resistance which decreased circuit gain. Several reasons for this affect were discussed, and later on failure analysis showed the parts to have a mask misalignment of the passivation layer. Due to this misalignment the base and emitter bonds were poor in some cases and had resistive contacts.

This misalignment was seen in several lots and caused the effective emitter resistance to rise by only a few ohms, but was enough to cause severe problems throughout the company. A solution was implemented to screen out these parts at Incoming Inspection, and a new test was written into the spec to screen future shipments. 31,700 parts were removed from the warehouse and held in Quality Control due to this screen.

Everything looked good until our next shipment arrived from TI. A new problem arose when this new lot was given its minimum reliability burn-in test. This lot (43,000 parts) scored high in failures – 100% gross contamination was the cause.

The situation has come down to this:

(1) The lot(s) that failed the incoming burn-in were returned to the vendor.
(2) All parts that were screened out for high emitter resistance were put back into the warehouse.
(3) Future lots from TI are in question.
(4) Motorola has been approached to supply this part. They sent us some preliminary samples which performed satisfactorily in about 90% of our using areas. Circuits using these parts above 15mA at 1 to 2V will, however, experience problems. Motorola will be shipping Tek approximately 100,000 of these parts at the end of March.
(5) Some areas could use the 151-0434-00 as a substitute. This is the same chip as the 151-0271-00, but in a TO-72 package.

There is no short term solution available to everyone. Some users can switch to the 151-0434-00, but samples will get short as demand goes up. We currently use two other parts that should **not** be used as replacements. They are:

151-0369-00	Single sourced to TI. Same chip (2N4260-61) as the 151-0271-00. The same reliability problems will be seen in this part as seen in the -0271-.
151-0202-00	TO-72. High cost (>$2) due to selected parameters. Same chip as 151-0271-00.

This shortage also affects the following part numbers which are selected from the 151-0271-00: 153-0606-00, 153-0609-00, 153-0623-00, 153-0644-00, 153-0645-00.

Any areas that have not seen the replacements are urged to contact either Art Leacock (ext. 2487) or Jackie Sherrill (ext. 2481).

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Tek P/N	Vendor	Description of part	Who to contact, ext.

✓ **290-0299-01 Union Carbide Axial lead tantalum capacitor Don Anderson, 2545**

This is a 330μF, 10V hermetically sealed axial lead solid tantalum capacitor that is burned-in to an "M" level failure rate. The -01 part is now single sourced, and due to availability problems we are changing all -01 applications to the -00 part. The -00 part now costs almost $5 (compared to $2 in Sept. 1979) and will reach $5.50 by the end of this year. Therefore, we strongly recommend replacing this part with an equivalent aluminum electrolytic (cost $0.25) if possible.

✓ **151-0632-00 Motorola MJE13007 NPN 400V TO-220 "Switchmode" power transistor Jim Williamson, 5345**

This power transistor has recently undergone process changes to increase $V_{CEO(SUS)}$ yields. This necessitates several changes to our specification:

Parameter	Present Specification	Changed to
hFE @ $I_C = 2A$ $V_{CE} = 5V$	8 min., 40 max.	8 min., 50 max.
hFE @ $I_C = 5A$ $V_{CE} = 5V$	6 min., 30 max.	5 min., 30 max.
$V_{CE(SAT)}$ @ $I_C = 5A$ $I_B = 1A$ $T_C = 25°C$	1.5V max.	2.0V max.
$T_C = 100°C$	2.0V max.	4.0V max.

Using areas should notify Art Leacock in Manufacturing Engineering if these changes could pose a problem.

✓ **156-0018-00 et.al. Motorola RTL product line Jim Howe, 6303**

Motorola has announced its plans to discontinue production of the RTL (Resistor-Transistor Logic) product line by mid-1981. The Motorola part numbers affected are: MC815-826, MC864-988, MC900-929, MC974-999, and MC9801-9825.

Motorola will conduct "business as usual" through December 1980. Life time buys will be accepted beginning January 1980, and continue through December 1980, for delivery prior to July 1, 1981.

The Tektronix part numbers affected by this phase-out are:

156-0018-00 (MC817)
156-0019-00 (MC822)
156-0020-00 (MC824)
156-0021-00 (MC889)
156-0064-00 (MC867)
156-0028-00 (MC826)
156-0050-00 (MC825)

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Tek P/N	Vendor	Description of part	Who to contact, ext.
156-0122-00 156-0251-00 et.al.	TI, Signetics	All metal can op amps and comparators	Willie Rempfer, 6700

TI and Signetics are discontinuing all metal can op amps and comparators. TI will fill no more orders and Signetics will honor orders only through December 1980, according to their sales reps. Other vendors (National, Motorola, Analog Devices, etc.) expressed a commitment to support metal can parts although economics favor production of DIP packages.

Most of the discontinued parts can be provided by other vendors, although use of metal cans in new designs is not recommended unless no DIP alternative is available.

Two parts will be losing their only source and each have only one possible alternate. While use of metal can parts in general is discouraged, we strongly recommend against use of these two:

(1) 156-0251-xx (NE529K) is single sourced to Signetics. National's LM361H is in the qualification process now. No one else makes it.

(2) 156-0122-xx (NE531T) is single sourced to Signetics. Raytheon RC4531TE is in the qualification process now. No one else makes it.

TECHNICAL STANDARDS

The function of Technical Standards is to identify, describe, and document standard processes, procedures, and practices within the Tektronix complex, and to ensure 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 (41-260)

New publications available from Technical Standards

NBS 507 Special publication. Standardization in Support of Development.
MIL-C-81706 Amendment 5. Chemical Conversion Materials for Coating Aluminum and Aluminum Alloys.
MIL-STD-1562B (Superseding MIL-STD-1562A). Lists of Standard Microcircuits.
NEMA LD 3-1975, High-pressure Decorative Laminates, Revision No. 4

28th Annual Conference Proceedings of the Standards Engineers Society (SES) 1979. This publication contains papers presented by standards people from ASTM, EPA (Environmental Protection Agency), Westinghouse Electric Co., Caterpillar Tractor, U.S. Office of Defense and Research Engineering, General Electric Co., Standard Council of Canada, General Motors, Monsanto Research, Massey-Ferguson, Inc., Carrier Corporation, and others.

Subjects covered include: Paint Systems and Paints, Air Quality Standards, Group Technology, Parts Coding, Referred Numbers, Metric Limits and Fits, Component Standardization, Metric Laws and Practices in International Trade, Coating Materials, and Metric Fasteners.

This book may be borrowed for one week. Call Technical Standards, Town Center ext. 241.

ComponentNewsNewComponents

Vendor	Number	Description	When Available	Tek P/N	Approx. Cost.	Engineer to contact, ext.
		digital devices				
Motorola	68000	Microprocessor, 16-bit, 64-pin DIP	now	156-1445-00	$150.00	Carl Teale, 7148
Rockwell	6504	Microprocessor, 8-bit, 28-pin DIP	now	156-1482-00	7.00	Carl Teale, 7148
		electromechanical devices				
AMP	1-480698-0	Connector, 2-circuit, mate-n-lock, plug HSG	now	204-0866-00	—	Peter Butler, 5417
AMP	1-460699-0	Connector, 2-circuit, mate-n-lock cap HSG	now	204-0865-00	—	Peter Butler, 5417
AMP	350561-3	Connector, pin contact, mate-n-lock	now	131-2456-00	—	Peter Butler, 5417
AMP	350570-3	Connector, socket contact, mate-n-lock	now	131-2455-00	—	Peter Butler, 5417
AMP	2-520083-2	Connector, 0.110 x 0.020 th. insulated tab receptacle 18-22 AWG	now	131-2436-00	—	Peter Butler, 5417
AMP	531017-4	Connector, 28/56 edgecard, Z1F, 0.156" centers	now	131-2499-00	—	Peter Butler, 5417
Escap	23L21-213E	DC motor, 23mm 12VDC ironless rotor	—	147-0054-00	15.00	Bill Stadelman, 7711
Escap	22C-11-207	DC motor, 24mm, 18VDC, ironless rotor, w/64:1 ratio DC motor gearbox	—	147-0055-00	25.00	Bill Stadelman, 7711
		optoelectronic and passive devices				
Nichicon	ULB	Capacitor, 1000μF, 16V aluminum electrolytic, single-ended	now	290-0921-00	—	Don Anderson, 5415
United Chemi-Con	SM	Capacitor, 1000μF, 50V, aluminum electrolytic, single-ended	now	290-0922-00	—	Don Anderson, 5415
Mallory	VPR	Capacitor, 2100μF, 40V, aluminum electrolytic, single-ended, low ESR, 7.5A RMS ripple current	—	290-0925-00	—	Don Anderson, 5415
Mallory	VPR	Capacitor, 6600μF, 12V, aluminum electrolytic, single-ended, low ESR, 7.2A RMS ripple current	—	290-0929-00	—	Don Anderson, 5415
Mallory	VPR	Capacitor, 11,000μF, 12V, aluminum electrolytic, single-ended, low ESR, 9.8A RMS ripple current	—	290-0930-00	—	Don Anderson, 5415
Mallory	VPR	Capacitor, 540μF, 25V, aluminum electrolytic, single-ended, low ESR, 2.3A RMS ripple current	—	290-0931-00	—	Don Anderson, 5415
Mallory	VPR	Capacitor, 390μF, 15V, aluminum electrolytic, single-ended, low ESR, 1.3A ripple current	—	290-0932-00	—	Don Anderson, 5415
TRW	X363UW	Capacitor, 0.292μF, 400VDC metallized polypropylene	—	285-1211-00	—	Don Anderson, 5415
TRW	X363UW	Capacitor, 1.46μF, 400VDC, metallized polypropylene	—	285-1212-00	—	Don Anderson, 5415

Which part should you use?

Over the past few years several of our most popular small signal transistors have been almost identically specified. Here are two examples:

	Tek P/Ns	Sources
2N3904	151-0190-00	Fairchild, Motorola, National, TI
	and	
	151-0224-00	Fairchild, TI
2N3906	151-0188-00	Fairchild, Motorola, National, TI
	and	
	151-0220-00	Fairchild, National

For the 2N3904, no significant differences can be found by comparing our specifications. In effect, we are buying the same part under two different part numbers.

The 2N3906 does have some minor differences which will affect circuit performance in only the most stringent applications. The major difference is the gain-bandwith products. The 151-0188-00 is a 250MHz part where the -0220- is a 600MHz part. Besides this parameter the two parts are almost identically specified. The 600MHz part has been difficult to obtain, though. Of the four vendors listed, only one has been able to supply it consistently. National has also had trouble in the past, and periodically has requested that we relax the spec.

The question has still not been answered. . .What part should you use? Because the specs are identical for the 2N3904, the answer is easy. Use the 151-0190-00, because with four sources it would be extremely unlikely to have a shortage. Also, with four competing vendors, the best possible price can be achieved.

For the 2N3906 the answer is a little more complicated, but start by looking at your needs. If you absolutely require more bandwith, the 151-0220-00 is the choice. However, in making that choice you also take the risk of shortages and line shut downs. Why? Because 600MHz is a selected parameter which cannot be achieved by every vendor. The safer choice would be the 151-0188-00. This is almost a standard 2N3906, and has plenty of sources.

So, which one should you use? For the 2N3904, use the 151-0190-00. For the 2N3906, use the 151-0188-00. If you have any further questions, please contact me at 58-299, ext. 7461.

Matt Porter

Richard Dunipace
92-701

component news

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