COMPONENT NEWS
CAROLYN SCHLOETEL, editor
JACQUIE CALAME, associate editor
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High frequency parameters measured

Most transistors have been characterized at Tektronix by specifying DC (static) parameters. While low frequency parts normally carry both dynamic and DC parameter specifications, monitoring the DC parameters and capacitance has usually been sufficient to give adequate assurance that the dynamic specifications are also being met.

However, as the current gain-bandwidth product (F_t) approaches the GHz region, the measurement of high frequency parameters becomes more and more useful.

S-parameter method superior

For the benefit of those who have had little experience with scattering (S) parameters, this measurement utilizes a two-port network model. The device under test is placed in a 50Ω environment, as opposed to the short or open circuit environment of "h" parameters, which is virtually impossible to achieve at GHz frequencies.

S-parameter symbols, S_{11}, S_{22}, S_{21} and S_{12}, represent the input, output, forward transfer and reverse transfer characteristics as illustrated in Figure 1.

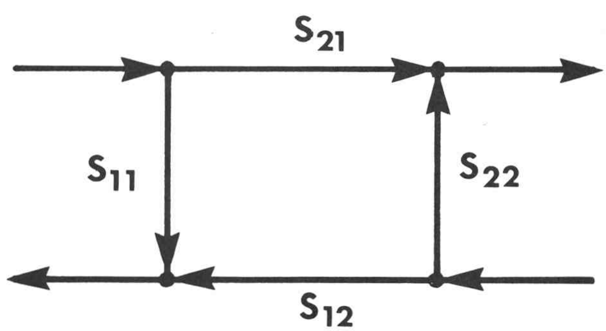

Figure 1 — Two-port model of a three terminal device

For my work to date, the transistor is biased in a common emitter circuit. The network analyzer system provides programmable bias voltages and currents, and a programmable frequency generator supplies either a single frequency or a swept frequency range. Data is taken at selected frequencies over a specified range, and is normally expressed as S-parameters. The S-parameters may be transformed by computer to y- or h-parameters later. A large assortment of software has been developed to display the date in many formats, such as maximum available gain, F_t, F_t vs. I_C, and F_{max}.

Characterization with Smith charts

The use of Smith charts is one way of displaying S-parameter data. The charts relate the device's impedance characteristics to frequency. By sweeping a frequency range, a pattern can be traced on the Smith chart which will give the actual impedance and its R, X_C and X_L components. The reactive component of impedance is capacitive on the lower half of the chart and inductive on the upper half, with pure resistance at the center. S_{11} and S_{22} are normally plotted on a Smith chart. S_{21} and S_{12}, however, are usually plotted on a polar chart, which relates the phase and magnitude of gain that the device produces for a given frequency.

The displays of high frequency performance on the Smith and polar charts can help the designer of broad band amplifiers design a stable circuit. $|S_{21}|^2$ is the conventional term used to express the transistor's insertion power gain at a specific frequency.

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Also in this issue

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Gain-bandwidth plots are useful

Another type of characterization possible with the network analyzer is the F_t vs. I_C plot. By programming a current range and a bias voltage, a plot of F_t vs. I_C may be automatically generated and produced on a hard copy. This plot for the 151-0472-00 is shown in Figure 2. F_t is specified for most of our small signal parts and is used as a minimal check on the transistor's high frequency performances.

A case in point

The most recent case that demonstrates the usefulness of these techniques involves the 151-0472-00. For the past four years there has been a shortage problem with this single-sourced part. Over a year ago, Solid State Scientific (SSS) was added as a second source to the Fairchild devices.

Soon, several problems arose with these devices. In one application the problem was identified as excessive h_{FE} even though the transistors met the specification. Adding a maximum h_{FE} limit solved that problem, but left other application problems unchanged. Differences in DC parameter measurements could not identify "good" and "bad" transistors.

High frequency characterization shows cause

With the aid of the network analyzer, the high frequency characteristics were mapped out for each device. The study included S-parameter data at varied voltages and currents, and plots of F_t vs. I_C. The results were compiled, and each vendor compared. Devices from Nippon Electric Company (NEC) were also evaluated.

With data in hand, the dramatic differences were noted between SSS and Fairchild parts through the S_{11} and S_{21} plots. The S_{11} plot reveals that SSS parts show a much higher input impedance which decreased rapidly with increasing frequency. In addition, the lower impedance of the Fairchild parts was nearly constant between 200 MHz and 2 GHz. The S_{21} graph shows the SSS parts to have little gain when compared to NEC and Fairchild. Note that these two graphs (Figures 3 and 4) show NEC devices have very comparable performance to Fairchild parts.

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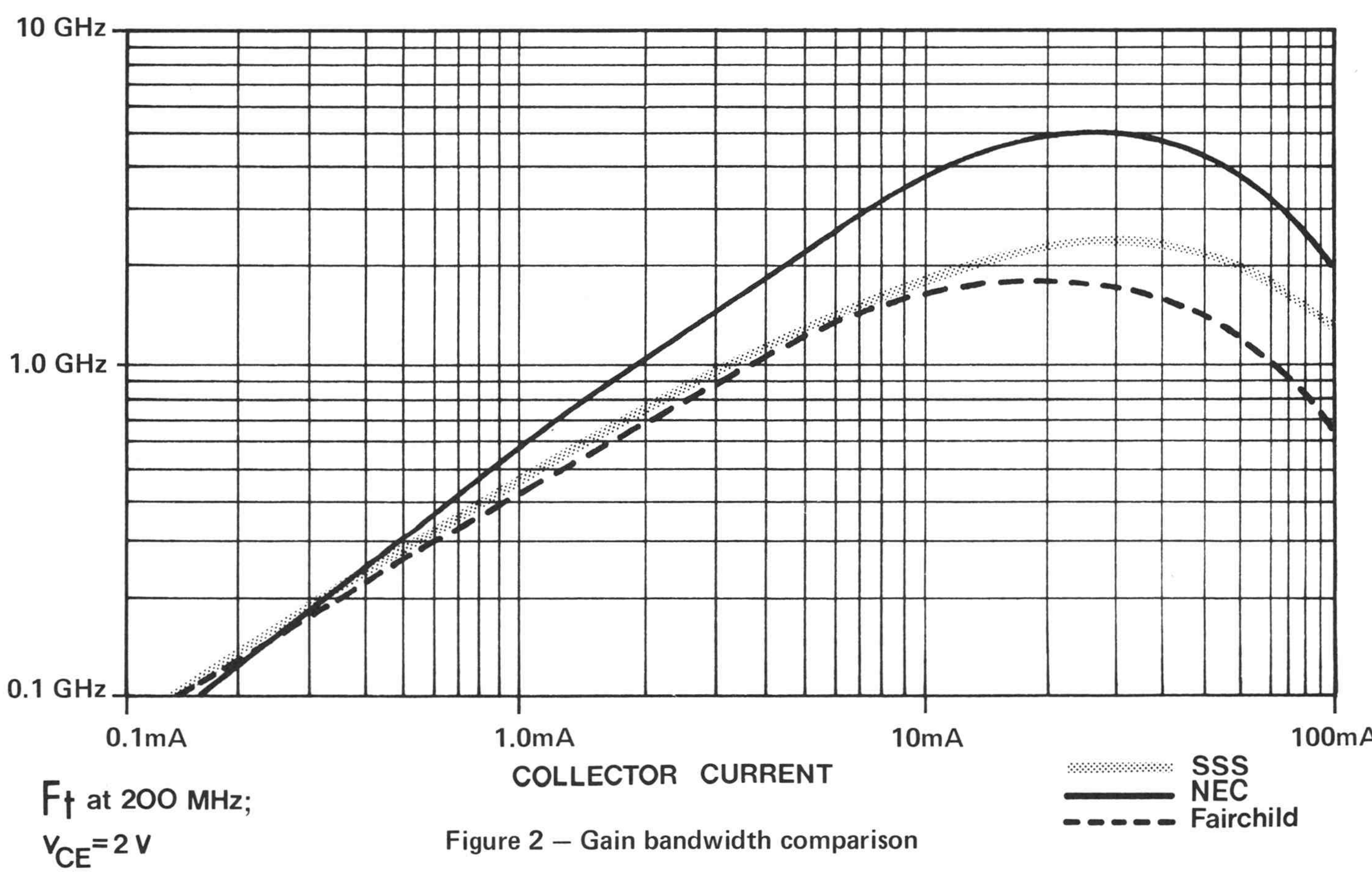

Figure 2 — Gain bandwidth comparison

continued from page 2

Results applied

The results of this characterization were applied to the 151-0472-00 specification in the form of Smith charts. The Smith chart of S_{11} and S_{22}, and the tabular values of S_{11}, S_{22}, S_{21} and S_{12} for several operating points were added to the spec. Nippon Electric parts were approved for a qualification order, and it is highly probable that these parts will work well in all our applications.

Future problems and solutions

The component qualification process is long and expensive. By taking advantage of the network analyzer system and convenient software developed in Tek Labs, we can significantly improve the probability that qualifying orders will be successful.

Thus high frequency characteristics, when coupled with the DC parameters, form a complete characterization package which can be effectively applied to specifications, and can be used as a tool for qualifying transistors.

For more information

If you have any questions about high frequency characterization, please contact me at 58-299, ext. 7461.

Matt Porter
Component Engineering

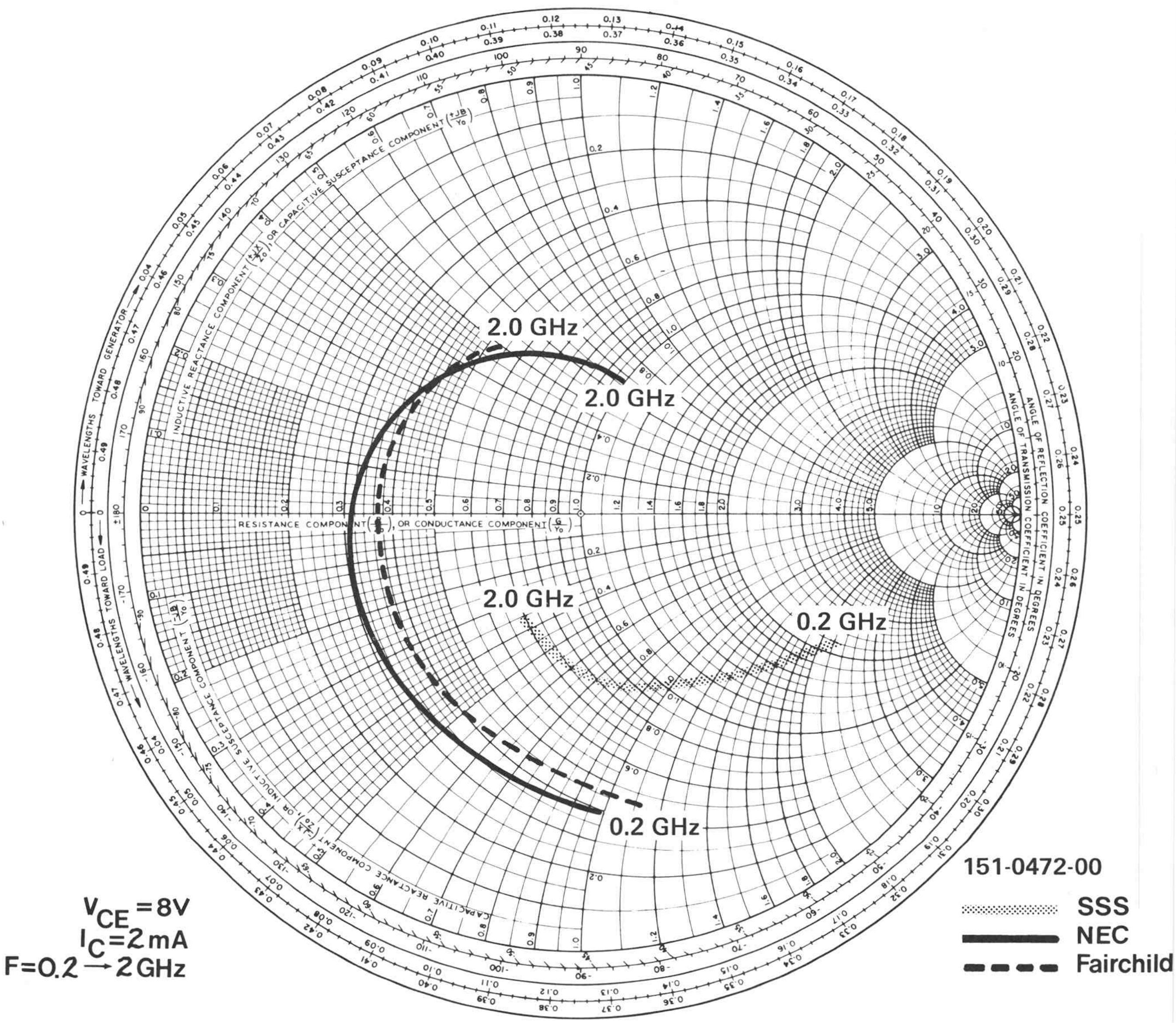

Figure 3 — Input impedance comparison (Smith chart of S_{11}) *continued on page 4*

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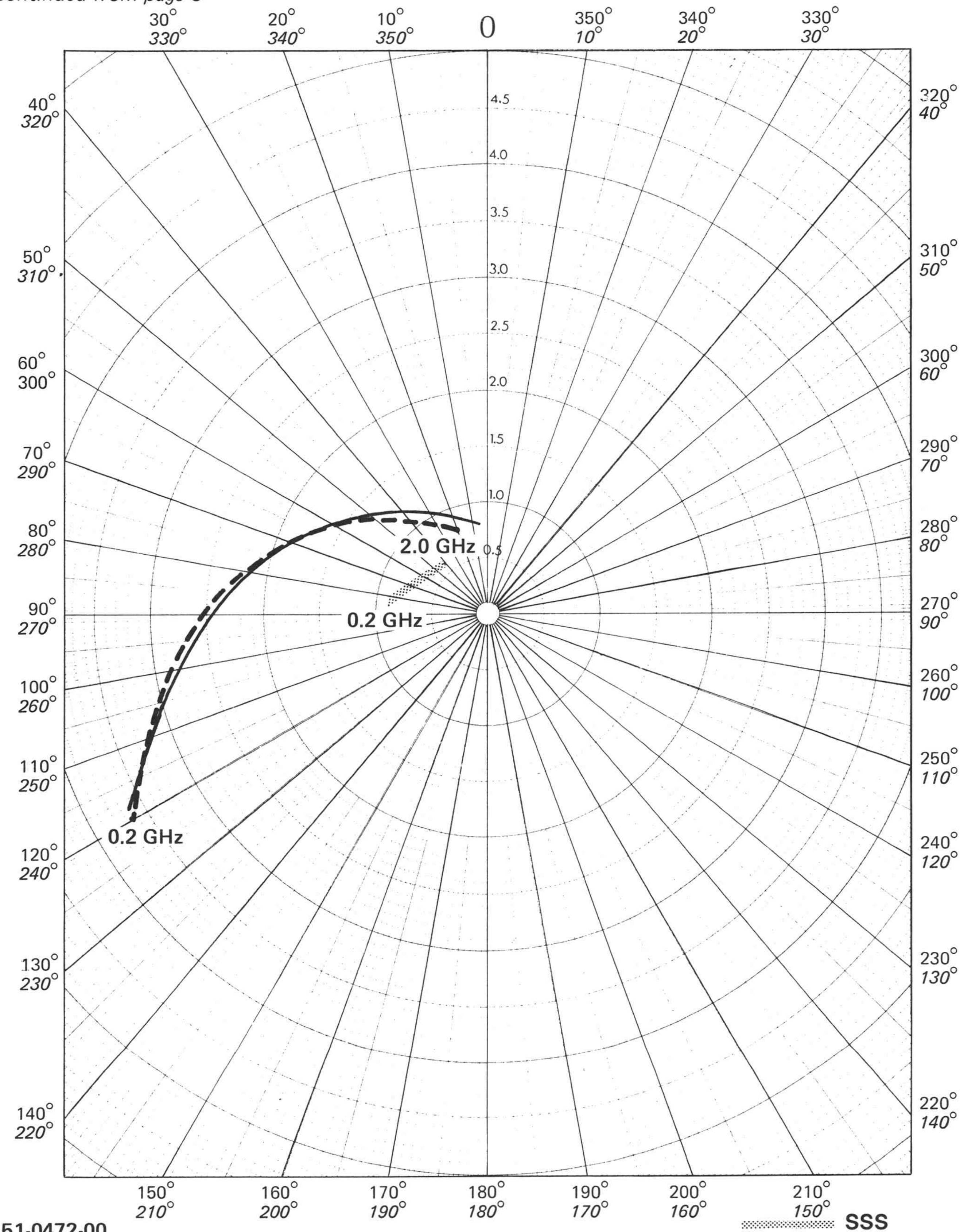


151-0472-00

V_{CE} = 8V
I_C = 2mA
F = 0.2 ⟶ 2.0 GHz

Figure 4 – Forward transfer ratio (polar plot of S_{21})

Tek Labs develop high voltage DMOS/FET

The Semiconductor Research Laboratory in Tek Labs has developed a high-voltage DMOS-FET (called the D211) to drive their EL-flat panel. The D211 is designed for EL-flat panel driver, hard copy printer and other high-voltage circuit applications. A tentative specification for the D211 follows:

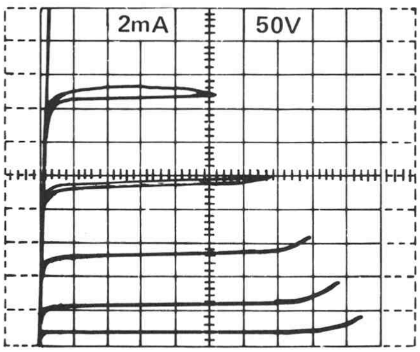
Structure—n-channel enhancement DMOS-FET
Applications—high-voltage matrix driver and high-voltage switching circuits
Outline—can (TO-5)
Absolute maximum ratings (T_a = 25°C)—

Drain to source voltage, V_{DS}	500 V (V_{GB} = 0 V)
Gate to substrate voltage, V_{GB}	25 V
Drain to substrate voltage, V_{DB}	35 V
Drain to current, I_D	25 mA
Channel power dissipation, P_{ch}	1 W
Channel temperature, T_{ch}	80°C
Storage temperature, T_{stg}	-50∿125°C

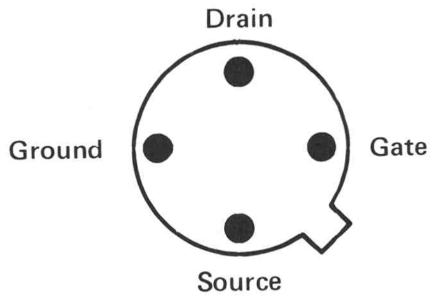
Electrical characteristics (T_a = 25°C)—

Item	Condition	Min.	Standard	Max.	Unit
Drain Voltage, V_{DS}	— — — — —	— —	200	500	V
Drain Current, I_D	V_{DS}=200,V_G-V_{TH}=8V	— —	10	— —	mA
On Resistance, R_{on}	I_D=10 mA	— —	20	50	kΩ
Transconductance, G_m	— — — — —	8	10	— —	mΩ
Threshold Voltage, V_{TH}	I_{DS}=1μA,V_{DS}=10V	— —	1.5∿2.5 (n-channel)	— —	V
Parasitic Threshold, V_{PTH}	I_{DS}=1μA	12	15	— —	V

This device is also available for n-channel enhancement mode in a TO-5 case. For more detailed information, contact Shuichi Sato (50-327), ext. 6005.



Typical DC characteristics



Pin Arrangement
D211 (TO-5, four pins)

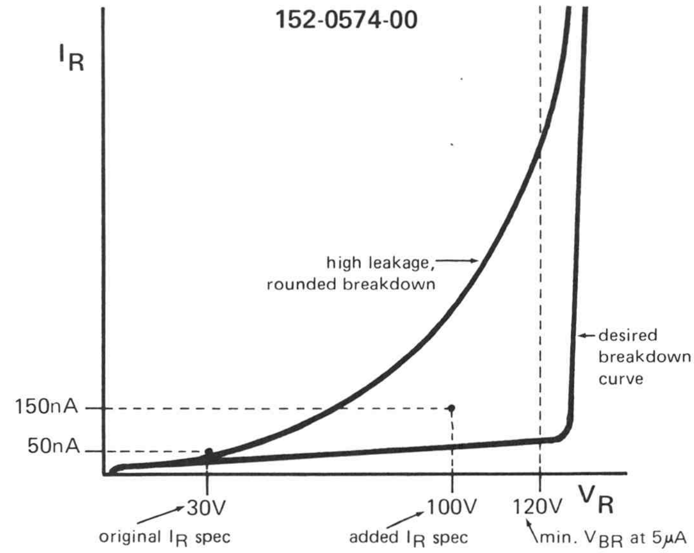
Tighter spec controls diode leakage current

During the evaluation of samples of part numbers 152-0233-00, 152-0245-00 and 152-0574-00 it became apparent that our specifications were not controlling the leakage current at the high reverse voltages which these diodes are intended to be used.

For example, the leakage current of the 152-0574-00 was specified at 30V to be 50nA maximum, but the maximum usable working voltage is 100V. Parts could meet this specification and possibly have leakages up to a 1μA or more at the maximum working voltage. These parts would be unusable in many applications and their reliability would be questionable. The high leakage current and rounded breakdown is illustrated in the figure at right.

To eliminate this problem an additional leakage spec has been established which specifies a maximum leakage at the maximum working voltage (shown in table below).

For additional information, contact Gary Sargeant, ext. 5345.



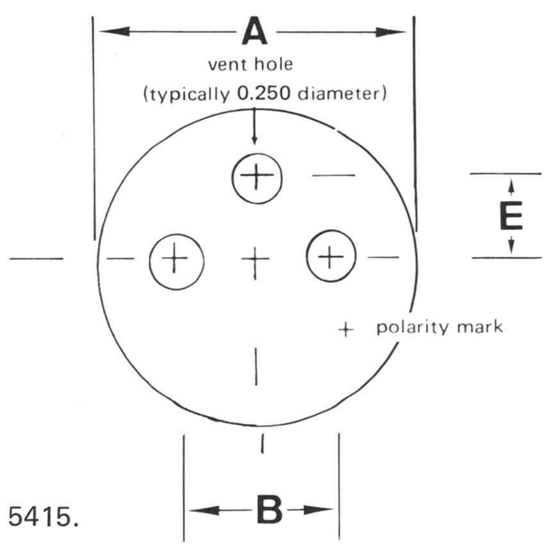
	(Original I_R spec) Max I_R at V_R	(Added I_R spec) Max I_R at $V_{working}$	V_{BR} Min
152-0245-00	10nA at 5V	30nA at 40V	50V
152-0233-00	50nA at 30V	150nA at 80V	100V
152-0574-00	50nA at 30V	150nA at 100V	120V

Check terminal/vent hole locations on caps

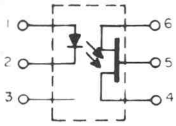
The location of the electrical terminals and vent hole on computer grade electrolytic capacitors has become an important consideration. Originally, the dimensions were not critical, because the devices were mounted through a metal chassis with a clamp holding them in place. With more of these caps now being mounted on circuit boards, we are particularly concerned with the terminal mounting location, and the positioning of the vent hole for UL safety considerations.

The specified dimensions (in inches) are shown below.

A (nominal)	B (±0.016)	E (±0.031)
1.375	0.500	0.406/0.281 (max/min)
1.750	0.750	0.406
2.000	0.875	0.500
2.500	1.125	0.625
3.000	1.250	0.750



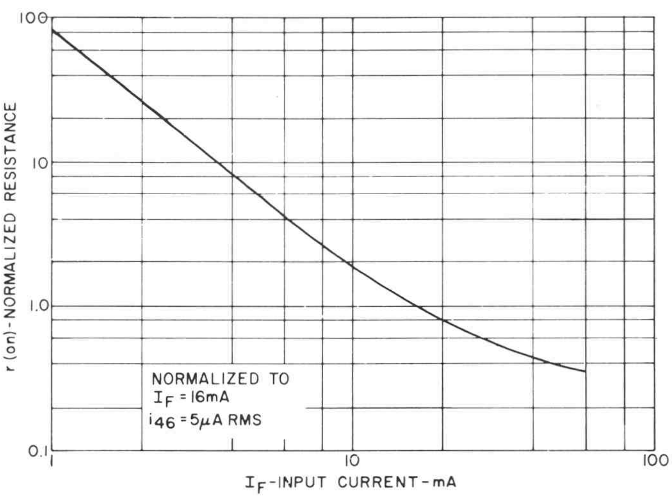
For more information, please contact Merle Hendricks, ext. 5415.



Optically isolated bilateral FET released

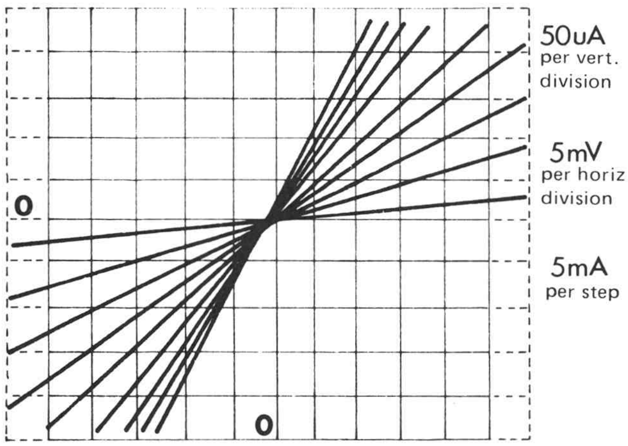
An optically isolated bilateral FET has just been announced by General Electric's Semiconductor Products Department. This new device was designed and developed by Bob Chen, now working for Tektronix as manager of Passive Components Engineering.

The new H11F optically couples the dependable efficient GaAs infrared emitting diode (IRED) to a silicon bilateral analog FET. The H11F retains GE's patented glass dielectric isolation and unique single-lead frame coupler construction.



RESISTANCE VS. INPUT CURRENT

The H11F series is designed to perform two major functions: as an isolated current-controlled linear variable resistor with <200Ω "on" resistance and >300MΩ "off" resistance; and as a fast (<15 μsec) bilateral analog switch featuring 60 volt peak-to-peak signal capability and extremely low offset voltage.



Typical low level output characteristics

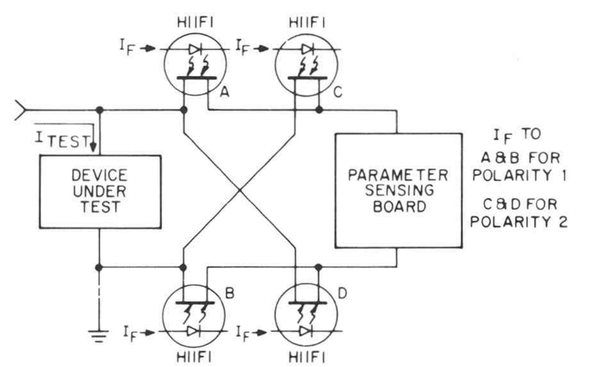
Typical applications of the H11F as a variable resistor include: distortion-free attenuation of low level signals, automatic gain control using an isolated AGC signal, and electronically adjusting active filter fine tuning or band switching. As an analog switch, the H11F can be applied in isolated sample and hold circuits, even where signal polarity is undefined. Additionally, it can be used for multiplexing both ac and dc signals.

Three types are offered: The H11F1, with a maximim resistance of 200Ω at 16mA IRED current; the H11F2 at 330Ω maximum resistance; and the H11F3 with 470Ω maximum resistance. All three types provide over 300MΩ resistance at zero IRED current.

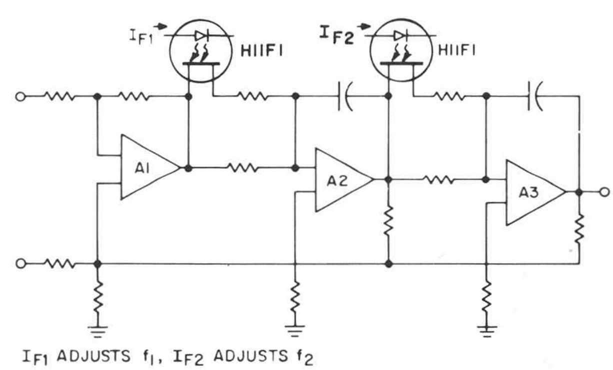
Prices start at 98¢ in 1k lot quantities. At this time, this device is single sourced.

For more information on the H11F series, contact **Bob Chen** on ext. 6389. Bob will be presenting a paper on this device at the IEEE Consumer Electronics conference in Chicago, June 5th.

APPLICATION EXAMPLES



TEST EQUIPMENT – KELVIN CONTACT POLARITY



ACTIVE FILTER FINE TUNING/BAND SWITCHING

GE releases board-mountable NiCds

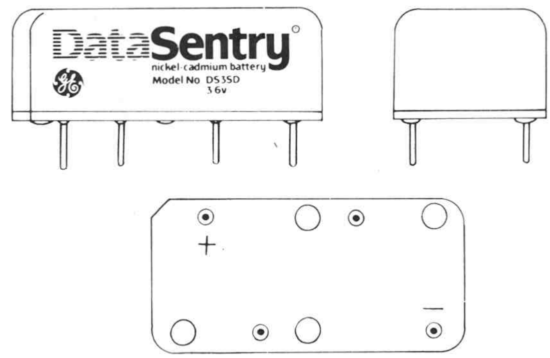
General Electric has introduced a new line of nickel-cadmium (NiCd) batteries.

The DataSentry batteries feature DIP compatible pins, solvent-resistant plastic cases and resealable safety vents. These parts are circuit board mountable.

The batteries can be used as a portable power supply or as a board-mounted standby power supply, with applications including: medical products, computer systems, microprocessor controls, single-chip microcomputers and volatile RAMs.

Specifications for both 2.4V and 3.6V rated batteries include the following:

For more information, please contact Byron Witt, ext. 5417.



Rated Capacity (AH) at 25°C

At 65mA	0.065
At 15mA	0.070

Charge Rate (mA) at 25°C

Maximum rate in overcharge	7
Minimum charge rate	4

Maximum Discharge (Amps) at 25°C

Continuous	0.650
Momentary (1 second)	6.50

Cell Temperature Limits*

Storage	-40° C to +50° C
Cell under discharge	-20 °C to +50 °C
Cell under charge at 7mA	+5° C to +50°C

Materials

Case...polyphenylene sulfide, glass filled, meets 94 V-O.

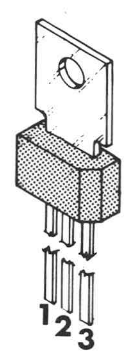
Pins...gold-plated nickel, 0.025 (.64) diameter.

*Temperatures Measured on Battery Case

TO-202 TRANSISTOR PIN-OUTS

Responding to numerous inquiries, below is a list of the proper pin-outs for the TO-202 plastic package.

TEK P/N	PIN 1	PIN 2	PIN 3
151-0331-00	E	B	C
151-0364-00	B	C	E
151-0365-00	B	C	E
151-0439-00	E	B	C
151-0440-00	E	B	C
151-0463-00	E	B	C
151-0496-00	E	B	C
151-0612-00	E	B	C
151-0615-00	E	B	C



The mounting tab is the collector for all styles

For more information, contact Jim Williamson (58-299), ext. 5345.

74LS00 life test results

Reliability tests on low power Schottky IC's have been completed. The test units were 74LS00 (156-0382-00) and 74LS390 (156-0910-00).

Parts were life tested at 150°C junction temperature (140°C ambient) with Vcc set at 5.5 volts. All inputs were connected to Vcc, and outputs were left open. Except where noted, packages tested were plastic.

The results are shown in Figure 1. Based on these results, the projected 74LS failure rates would be (in %/1000 hours at 70°C):

Raw Parts	0.16%
Electrically tested parts (no burn-in)	0.06%
Electrically tested parts with 100% burn-in	0.01%

The life test duration and stress was equivalent to about 25 years of part operation at 70 C (assuming 2000 hours usage per year).

Questions may arise as to the contribution of the 12 Signetics contamination-related failures to the failure rate calculation. While it is true that there may be a lot-related problem with that vendor, there is no guarantee that the same thing will not happen in the future to other vendors.

One proposal is to use lot sample reliability testing to eliminate bad lots. However, based on a vendor quote, the extra cost for lot sample reliability testing is 5¢ per part versus 8¢ for 100% burn-in. For this 3¢ differential, we feel 100% burn-in is justified.

recommendations

For lowest possible failure rates (0.01%/1000 hours) 100% burn-in (125°C, 160 hours), followed by electrical test, is recommended. See Figure 2 for suggested specification format. This has already been accepted by Motorola and Texas Instruments at 6¢ to 10¢ extra cost.

For intermediate reliability requirements (in range of 0.05%), at least 100% electrically tested parts should be used.

for more information

Call Steve Hui, ext. 6511 in Component Reliability Engineering if you have questions or need more information.

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Figure 1 — Life test results

Vendor	Part Type	Sample Size	Number of Failures			
			0 hrs.	16 hrs.	36 hrs.	96 hrs.
TI Cerdip	74LS00J	100	0	0	1	0
TI	74LS00N	100	3	0	0	0
Signetics	74LS00	100	1	12*	0	0
Motorola	74LS00	100	0	0	0	0
National	74LS00	98	0	0	0	0
Fairchild	74LS00	50	0	0	0	0
Motorola	74LS390	100	0	0	0	0
	Total	648	4	12	1	0

*All 12 failed for input high level leakage current but recovered after high temperature bakeout—indicative of mobile ion contamination.

Figure 2 — Suggested format for LSTTL reliability screened parts

Material: Tektronix part no. 156-0385-00

Inspection Criteria:

1. Temperature cycling, per MIL-STD-883A, method 1010, condition C.
2. Burn-in screen, per MIL-STD-883A method 1015, condition A, 125°C ambient for 160 hours. Use of condition F burn-in is permitted. Voltage applied to devices being screened shall be 5.5 volts.
3. Electrical test per requirements of 156-0385-00 at 25°C.
4. Electrical test (function only) at 100°C ambient.

Quality Levels:

Parts supplied to this specification shall meet the following quality levels when tested at Tektronix, Inc.

	LTPD
100°C functional	2
25°C DC parameter tests	3
25°C AC parameters	7

Reliability Sample Tests:

Parts supplied to this specification shall be capable of passing the following reliability sample test:

1. Draw samples from lot and test for DC parameters and functional test at 25°C. Obtain 105 good units.
2. Place devices on life test per MIL-STD-883A, method 1005, condition A, at 145°C ambient for 336 hours. Applied voltage shall be 5.5 volts.
3. Retest all sample units at 25°C within 24 hours of completion of sample life test.
4. Lots with 1 or 0 failure shall be considered acceptable.

This reliability sample test shall be used when qualifying new vendors, requalifying existing vendors, or as a reliability acceptance test to determine lot acceptability.

Simplified VOTRAX speech synthesizer

The Vocal Interface Division of Federal Screw Works has recently brought out a "bare bones" version of their VOTRAX speech synthesizers. The purpose apparently is to explore this end of the market. They have greatly simplified the product to reduce cost; the question is whether they have gone too far.

The item is designated the Model VSK Voice Synthesizer, part number 1963. We have one of these and I have recently run evaluation tests on it. A copy of the report is available. Also, the device itself is available on loan if you would like to experiment with it.

The voice synthesizer is mounted in a single TM500 module. It requires five bits TTL parallel from a microprocessor to control it.

The device operates by synthesizing phonemes. A phoneme corresponds approximately to the vowels and the consonants. There are 63 phonemes in the synthesizer repertoire. To exercise the device there is a computer program, consisting of a succession of 5-bit signals to identify the next phoneme.

Call me if you need more information.

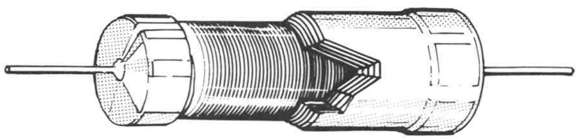
Jim Deer, ext. 7711
Component Engineering

Resistor pulse handling capabilities

Resistors have steady state power and voltage ratings which determine the maximum temperature they can withstand. Some resistors are capable of handling very high levels of power and voltage for five seconds or less. Because heat is energy -- the product of power and time -- this short time, higher power capability varies with the construction and design of the resistor.

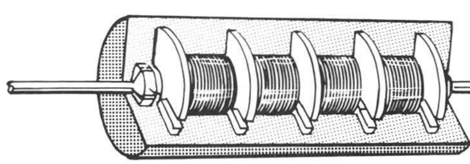
The four types of resistors described here have differing pulse capabilities.

Single layer wirewound



A single layer of wire or ribbon is wound on a ceramic core and welded to the endcaps. Multiple layers of silicone, a single coating of vitreous enamel, or a molded cover are applied for protection.

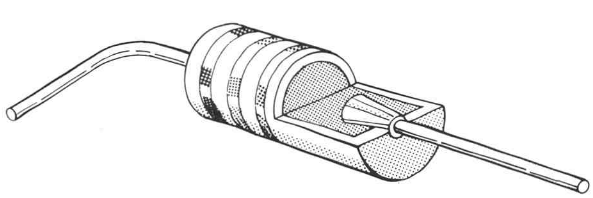
Bobbin wirewound



Insulated wire is wound on a single or multiple bobbin. The bobbin and pre-molded or molded cases are usually made from an epoxy material. The inner winding layers have a high thermal resistance to the leads or the outside coating and air. This resistor has many times the volume of a single layer, wound resistor, for the same power rating.

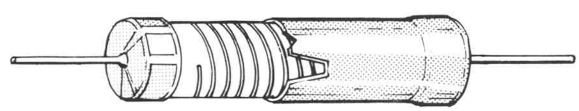
The inability to dissipate heat, and the voltage gradient between windings, prevent pulse ratings higher than the maximum rated voltage or power.

Hot molded carbon composition



A pre-molded case is filled with carbon, graphite, clay and binder material. The leads are inserted and the resistor is compressed, heated and then released again, through several cycles.

Film resistors



End terminations are usually deposited first on a resistor core. Then the resistor is formed by a resistive material coating. These include:

Metal: Vacuum deposited on the ceramic core. Film is 20 to 250 Å thick, with a moderate pulse capability.

Tin oxide: Chemical reaction between glass rods at a red heat, in a solution of tin chloride and antimony. Film is 100 to 10,000 Å thick, with the lowest pulse capability of any film resistor.

Carbon film: Red hot cores are coated when a carbonaceous material (i.e. natural gas, methane, etc.) is exposed to them in the absence of oxygen. The resultant carbon film is partially crystalline and partially amorphous. Film is approximately 100 Å thick with a moderate pulse capability.

Cermet or thick film: The metal oxide or conductor is mixed into a paste with a binder material, ground glass and a solvent. The material is screened on, in either a spiral or cylindrical pattern. Film is 0.01" thick, and has the highest pulse capabilities.

The coated core in film resistors is then tested and trimmed to a final resistance value by cutting through the film into the core. The cut can be made by either a mechanical wheel or a laser The resistance material is increased in path length to increase resistance.

Glass cores have a higher thermal resistance than ceramic ones. This reduces the pulse power capabilities of any glass substrate resistor. The carbon or metal film resistors have a very thin cross

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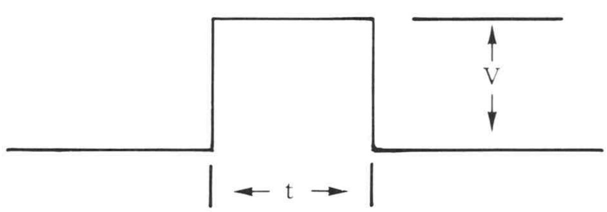
section with low thermal conductance but good bonding to the ceramic substrate which improves their pulse ratings. The cermet product has an intimate glassy bond to the substrate plus a large cross section which allows the highest pulse rating.

pulse power capabilities

The limit on the pulse power energy capability is the amount of heat the resistive film or wire can absorb without damage to the coating. Resistance change limits must be considered as well. On short pulses, the conductor thermal mass is the limiting factor. On longer pulses, the thermal conductivity of the various resistor parts limit the energy amount. On pulses exceeding five seconds, the total thermal mass of the resistor is the limiting factor.

short pulses

A single square wave pulse



where P = pulse power (watts)

V = pulse voltage (volts)

R = resistance (ohms)

t = pulse duration (seconds)

E = energy (watt-seconds or joules)

Example: A single square wave pulse with an amplitude of 100 volts for 1 millisecond applied to a 10 ohm resistor.

$$P = \frac{V^2}{R} = \frac{100^2}{10} = \frac{10000}{10} = 1000 \text{ watts}$$

$$E = Pt = (1000)(.001) = 1 \text{ watt-second}$$

After the energy has been calculated, divide this by the resistance, to get watt-seconds per ohm. Then go to the Energy Resistance Chart for Wirewound Resistors and choose the energy per ohm value, which is equal to or greater than the calculated value.

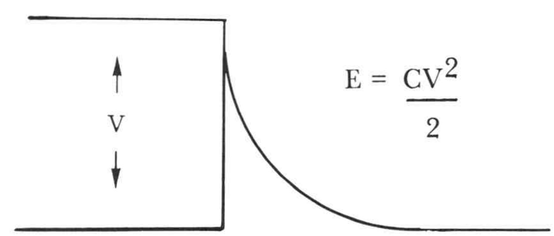
Next, follow across the chart to the right until the resistance value or a higher one is reached. The resistor size shown at the top of the column will be the smallest size capable of handling the pulse.

Example: What is the smallest size wirewound 10 ohm resistor that could handle 1 watt-second of energy?

$$\frac{E}{R} = \frac{1}{10} = \frac{0.1 \text{ watt-second}}{\text{ohm}}$$

The chart (Row 10) shows the next highest energy is 0.153 watt-seconds per ohm. The next highest value above 10 ohms is 21.1 ohms. This corresponds to the 3 watt size.

Another frequently encountered short pulse duration is the capacitor discharge. Here a capacitor is charged to a given voltage and then discharged through a resistor. The energy is calculated as follows:



where C = capacitance (farads)

V = voltage (volts)

E = energy (watt-seconds or joules)

Example: A 2 microfarad capacitor is charged to 400 volts and discharged into a 1k resistor.

The energy is:

$$E = \frac{CV^2}{2} = \frac{(2 \text{ X } 10^6)(400)^2}{2} =$$

$$(1 \text{ X } 10^{-6})(16 \text{ X } 10^4) = 0.16 \text{ watt-seconds}$$

What is the smallest resistor that will handle this pulse?

continued on page 13

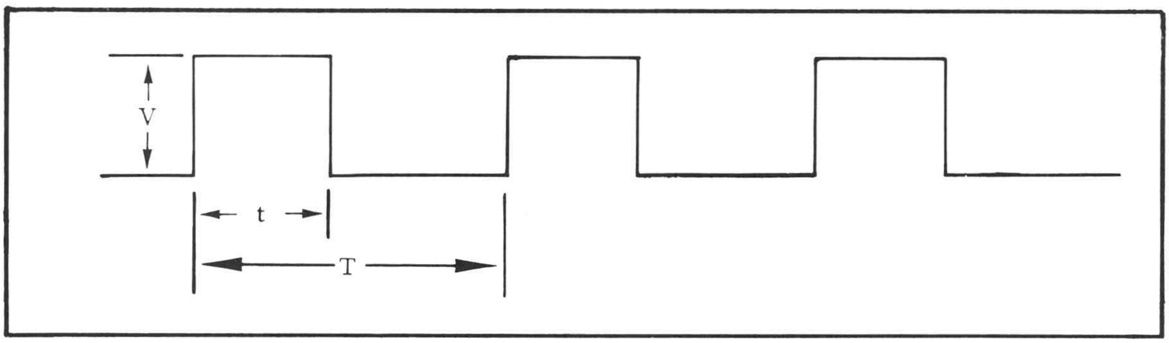
Divide the energy by the resistance.

$$\frac{E}{R} = \frac{0.16}{1 \times 10^{-3}} = 0.16 \times 10^{-3} = 160 \times 10^{-6} \frac{\text{watt-seconds}}{\text{ohms}}$$

The next highest energy per ohm found in the chart (Row 4) is 221 X 10^{-6}. The next highest value above 1k is 1420 ohms. This is in the 1W column.

equally spaced repetitive pulses

The average power, as well as the individual pulse energy, must be considered.



The pulse power, $P = \frac{V^2}{R}$ is calculated for a single pulse.

The energy of a single pulse is represented by E = Pt.

The average power is calculated as follows:

$$P_A = \frac{Pt}{T}$$

P_A = average power (watts)

P = pulse power (watts)

t = pulse width (seconds)

T = cycle time (seconds)

A new energy, based on the summation of pulse energy and the contribution due to the average power is computed:

$$E_{AP} = E\left(1 + \frac{P_A}{P_R}\right)$$

Where E_{AP} = pulse energy + average power energy (watt-seconds):

E = pulse energy (watt-seconds)

P_A = average power (watts)

P_R = rated power (watts) (selected size)

$\frac{E_{AP}}{R}$ = energy per ohm

Find the resistor size chosen for P_R.

Follow down the column to an equal value, or a greater value than the one being chosen.

Follow across that row to the left and note the energy per ohm.

If the energy per ohm in the chart is **greater than** that calculated, the resistor size is satisfactory. If the energy per ohm in the chart is **less than** that calculated, a larger size must be chosen.

continued on page 14

Example: A series of equally spaced square wave pulses having an amplitude of 200 volts, a pulse width of 20 milliseconds, and a cycle time of 20 seconds is applied to a 100 ohm resistor. Will a 5W handle this? The pulse power is:

$$P = \frac{V^2}{R} = \frac{(200)^2}{100} = \frac{4 \text{ X } 10^4}{1 \text{ X } 10^2} = 400 \text{ watts}$$

The pulse energy is:

$$E = Pt = 400 \text{ X } .02 = 8 \text{ watt seconds}$$

The average power is:

$$P_A = \frac{Pt}{T} = (400)\,\frac{(20 \text{ X } 10^3)}{20} = 0.4 \text{ watts}$$

The energy due to the pulse and average power is:

$$E_{AP} = E\left(1 + \frac{P_A}{P_R}\right) = 8\left(1 + \frac{.4}{5}\right) = 8.64 \text{ watt-seconds.}$$

The energy per ohm is:

$$\frac{E_{AP}}{R} = \frac{8.64}{100} = \frac{0.0864 \text{ watt-seconds}}{\text{ohm}}$$

In the energy resistance chart (Row 9), the next higher value above 100 ohms is 116 ohms. Following the row to the left, the energy per ohm is 0.090, which is sufficient to handle the energy.

long pulses

For long pulses, much of the heat is dissipated in the core, winding film, leads, and coating.

To find the power overload for a five second pulse, use the resistor short-time overload rating. Wirewound resistors 4 watts and larger are 10-times rated power. For smaller sizes, five times the rated power. Carbon composition and film resistors use 6.25 times rated power, not to exceed twice the rated maximum working voltage (see the chart on page 5-43 of the November, 1977, Resistor and Capacitor Catalog).

To find the overload capability for one to five seconds, change the overload power to energy by multiplying by five seconds, and divide by the pulse width in seconds to find the power.

For pulse durations between 100 milliseconds and 1 second, use the 1 second computed overload power.

Example: How much power can a five watt wirewound resistor handle for two seconds?

The short term overload rating is 50 watts for five seconds, with the energy capability of 250 watt-seconds.

For two seconds, the power capability is 250/2 = 125 watts.

voltage limitations

Short pulse, wirewound resistors have been tested up to 20kV per inch, using 20 microsecond pulses with energy levels below the resistor's maximum rating. Hot molded composition resistors have been tested at 5kV without dielectric breakdown. The energy was kept below the resistor energy rating. Carbon film, metal film, tin oxide and cermet axial lead resistors have a limited pulse power rating.

Tin oxide on a glass substrate has the least capability, while cermet or thick film on ceramic has the best energy withstand capabilities. Typically, the maximum rating is 2.5 times the power rated voltage not to exceed two times the energy rating chart for hot molded carbon rated maximum voltage. This five second limit is the short-time overload test.

For pulses 100 milliseconds to 5 seconds, the recommended maximum overload is $\sqrt{10}$, times the maximum working voltage for a four watt size wirewound resistor and larger, and $\sqrt{5}$, times the maximum working voltage for smaller sizes. The long pulse rating on hot molded carbon composition resistors approach the constant power condition. The constant energy level and repetition rate should be applied not to exceed the rated power. The averaging should be done over a time period shorter than the thermal time constant of the resistor.

Don't use hot molded carbon composition resistor power capabilities to protect circuits or components. The power level necessary to open the resistor safely is unpredictable. The phenolic body and some of the resistive materials are flammable.

One carbon film manufacturer tests pulse characteristics to this specification: An ac, 60 Hz test potential of 4 times the rated continuous work-

continued on page 15

ing voltage, but not to exceed 750 volts, shall be applied 1 second on, and 25 seconds off for 10,000 cycles. The resistance change shall not exceed 2.5%.

Another carbon film manufacturer tested 1/2W, 100 ohm resistors to 14V DC for two minutes (1.56W). The resistance change did not exceed +5% or -10%.

A metal film company gives a 50 times rated power for 500 milliseconds. The change in resistance will not exceed 0.02%.

There is no industry standard for pulse power ratings or for testing methods. The manufacturers refer to statements such as this from **Allen-Bradley**:

"For circuit applications where pulses or transients whose peak values exceed steady state ratings are experienced, tests should be made to determine the suitability of the resistors being considered for use.

In general, such tests should include life tests for at least 1000 hours under conditions which accurately represent the peak value, pulse waveform and repetition rate, under the environmental conditions which must be met. Tests under more severe conditions are recommended to establish the safety factors involved, bearing in mind that every type of resistor can be seriously damaged or completely destroyed if the stress levels are raised sufficiently. Such tests may be made by use of a noninductive capacitor of suitable capacitance value and voltage rating, charged at successively higher voltages and discharged each time through the resistor under test, arranging the circuitry for a minimum and consistent inductance value. Resistance measurements should be made, initially and after each capacitor discharge, by uniform method."

protection

If a circuit, component or board is to be protected from damage by an overpowered resistor, use a resistor designed to protect. The three main types for this service are fusible, flame-proof and fire-proof.

The fusible resistor is UL recognized under document 492.2 and manufactured by TRW-IRC. Part numbers 308-0764-00 and 308-0788-00 are this resistor type. They are designed to open from an overload without causing a flame. A paper tissue (Kimwipe 900-S) shall not ignite when resting across or beneath the unit tested.

The second type, flame-proof, has a conformal ceramic coating that cannot burn or support combustion. The resistor will get hot from power overloads and can be destroyed by overpowering, but the by-products will not burn. Part numbers from 3 watts to 10 watts are being used (see page 4-2 of the Resistor and Capacitor Catalog, November, 1977). This type coating is available on precision metal film, carbon film and power film resistors.

The third type of resistor has a pre-molded round or square ceramic container. The lead egress area is cemented or soldered closed so no material can escape. None of these devices are part numbered at Tek.

Resistor voltage ratings

Resistor Types	Power Rating, in watts				
	1/8	1/4	1/2	1	2
AB & Carbon Film	150	250	350	500	750
AB & Carbon Film short time overload; 5 seconds maximum	200	400	700	1000	1000
Metal film	300	350	500	500	750
Metal film short term overload; 5 seconds maximum	600	700	1000	1000	1500

Energy resistance chart for wirewound resistors				
Energy per Ω Joules or Watt-seconds	1w	3w	4w	5w
(1) 13.9×10^{-6}	10.4k	24.5k	47.1k	90.9k
(2) 39.3×10^{-6}	4630	10.89k	20.69k	40.4k
(3) 90.6×10^{-6}	2740	6550	11.09k	24.5k
(4) 221×10^{-6}	1420	3370	6570	12.7k
(5) 850×10^{-6}	487	1150	2260	4310
(6) 5.67×10^{-3}	134	313	617	1160
(7) 12.7×10^{-3}	71.1	168	310	622
(8) 56.7×10^{-3}	24.2	57.8	111	215
(9) 0.090	13.3	31.6	51.0	116
(10) 0.153	8.52	21.1	40.8	78.5
(11) 0.943	2.31	5.46	10.6	20.3
(12) 5.98	0.591	1.41	2.15	5.24
(13) 13.2	0.268	0.681	1.35	2.52
(14) 20.9	0.121	0.297	0.591	1.12
(15) 41.8		0.121	0.209	0.487
(16) 67.7			0.196	0.380
(17) 166.8				0.114

Pulse Power Rating for A-B

Rated watts	A-B type	Many pulse watt-seconds	Single pulse watt-seconds			Thermal time constant
		Rupture probability				
		withstand millions	10%	50%	90%	seconds
1/8	BB	0.14	0.72	0.9	1.08	4
1/4	CB	0.56	2.8	3.5	4.2	8
1/2	EB	2.24	11.2	14.0	16.8	16
1	GB	8.9	44.0	55.0	66.0	32
2	HB	12.8	64.0	80.0	96.0	64

Rated watts	Pulse energy capability (watt-seconds)	Equivalent energy source
1/8	0.45	2 μF at 670V
1/4	1.8	10 μF at 600V
1/2	6.4	32 μF at 630V
1	16.0	32 μF at 1000V
2	44.0	32 μF at 1650V

For more information on resistor pulse handling capabilities, please contact Ray Powell, ext. 6520.

Plant and field failure information base

Product and component failure information is available to you by request and/or automatic routing. The data base consists of Plant and Field reports as well as the Reliability Test lab failures.

We maintain the past year's failures in an active file with history stored back to the beginning of 1970. Requests for information are processed at night following input, and reports sent out the next day.

Information is available in five standard outputs:

- **Listing**—gives listing of all fields of data record. Generally output is in serial number, part number, or circuit symbol order for instruments and in instrument order for part numbers.
- **Lot Plot**—simply tally program, such as number of reports of each transistor part number either in part number order or by numbers of reports, in decreasing order.
- **Maps**—the map is a matrix-type display with choices of circuit symbol, date, or failure code on the vertical and model number or 100 serial number blocks on the horizontal.
- **Time-To-Failure**—this display looks at the difference (in weeks) from date of sale to date of failure report. Display is for 60 weeks.
- **Sales/Fails**—shows number of instrument failures occuring so far in the group of instruments sold for periods listed.

Information is also available in many options. A special request will get you:

- **Sub-sorted Listings**—listings with multiple fields sorted such as the 465 sub-sorted to circuit symbol order within part number order.
- **Multi-Instrument Plots**—if you're curious how a package performs, ask for a Multi-Instrument Plot such as 7904, 7B80, 7B85, 7A26, 7D15, or what would be expected to fail if you had a 465, 475A, TM503, PS501, etc. in your inventory of instruments.
- **Graphics**—X-Y plots by hand and machine.

A menu of data displays is available by request (call Brenda on ext. 5279).

We are developing "on-line" information for anyone having clearance, a Tek terminal and modem. The intent here is to allow you instant feedback on numbers of failures, where they are failing, mod monitoring, whether a part should be designed in, etc. Each user will be allowed access to portions of the data which falls into his or her responsibility. Of course, total data is available through our group.

As we are a service group, we welcome your inputs and they influence services we offer. If you can, drop by and see our operation, or, we'll be glad to come talk to you and/or your group about reporting and reports.

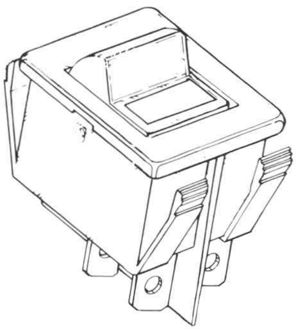
Requests for information are handled by Rich Wood and Don Allen, both at ext. 5794.

Clair Gruver
Reliability Information Group Manager

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
260-1804-00	Carling	Power Switch	Joe Joncas, 6365



Due to a number of problems, the 260-1804-00 power switch is *no longer recommended for new design.* This lighted rocker switch has become one of our most troublesome parts, with a failure rate of 1.2% over the last year.

The most persistant problem occurs with the light bulb and the bulb leads. Excessive lead length has caused many shorts, and several parts have had to be replaced in the field because of open bulbs. These switches have also exhibited intermittent contacts and missing insulators. There is no other source for this part.

Because of this situation, I recommend that lighted switches be used *only if the bulbs are easily replaceable.* The 260-1842-00 or 260-1902-00 switches are suitable alternatives to the 260-1804-00 part.

Tek P/N	Vendor	Description of Part	Who to contact
no Tek P/N	Motorola	GPIA	Jim Howe, 5698

Mike Mihalic, TM500 design engineer, recently discovered that the 68488 General Purpose Interface Adaptor (GPIA) seems to have a problem implementing the Acceptor Handshake (AH) function.

The problem, which has been confirmed by Component Engineering, occurs when the circuit fails to enter the ANRS (Acceptor Not Ready State) within the 200 nS limit required in IEEE-488.

Rather, it enters ANRS on the first Enable pulse going positive following the assertion of Attention. Motorola has been informed of the problem. More information is forthcoming.

References: IEEE-488-1975 pp 21 and 53.

Eyelets available to repair circuit boards

We are setting up a special stock of flanged eyelets for repairing damaged circuit board runs and thru-holes This is being done to reduce the number of small quantity, special orders.

The eyelets will be purchased unplated (copper or brass) and then copper-tin-zinc plated by Electrochem. We strongly recommend that unplated parts **not** be used due to probable corrosion problems.

The following part numbers will make repair possible on most hole combinations—

006-2767-01	0.047" OD x 0.093" Lg.	(small)
006-2768-01	0.059" OD x 0.093" Lg.	(medium)
006-2766-01	0.089" OD x 0.093" Lg.	(large)
006-2769-01	0.148" OD x 0.132" Lg.	(super)

Eyelets will be stocked in quantities of 1000 per bag, and should be ordered in multiples of 1000 only. Stock will be available April 20, 1978.

For more information, please contact Neill Martin, Manufacturing Engineering, ext. 7642.

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 that may be seen at Technical Standards and ordered

DOD-STD-1678 (Nov 1977) Fiber Optics Test Methods and Instrumentation
FED. STD. 123D (Jan 1975) Marking For Shipment (Civil Agencies)
ISO 1978 Catalog ($22.50)
ISO Directory of International Standardizing Bodies
MIL-C-81511E(AS) (May 1977) Connectors, Electrical, Circular, High Density, Quick Disconnect, Environment Resisting: And Accessories
MIL-C-87115 (Dec 1977) Coating, Immersion Zinc Flake/Chromate Dispersion
MIL-H-87111(USAF) (Nov 1977) Heat Sinks, Semiconductor Devices
MIL-I-85080(AS) (Nov 1977) Insulation Sleeving, Electrical, Non-Heat Shrinkable.
MIL-I-85080/(AS) (Nov 1977) Insulation Sleeving, Electrical Nonheat Shrink, Polyvinyl Chloride, Flexible Non-Crosslinked
MIL-I-85080/2(AS) (Nov 1977) Insulation Sleeving, Electrical, Nonheat Shrink, Silicone Rubber, Flexible
MIL-M-63041B(TM) (Aug 1976) Manuals, Technical: Preparation of Depot Maintenance Work Requirements
MIL-O-83804(USAF) (Nov 1977) Oscilloscope (AN/USM-426(V)), 250 Megahertz (MHz), General Purpose
MIL-R-6106H (Dec 1977) Relays, Electromagnetic (Including Established Reliability (ER) Types
MIL-R-83401/1D (Dec 1977) Resistor Network, Fixed, Film, Style RZ010
MIL-S-83734B (Dec 1977) Sockets, Plug-In Electronic Components
MIL-STD-1519(USAF) (Sep 1971) Test Requirements Document, Preparation of
MIL-T-49136 (EL)(Nov 1977) Test Set, Countermeasures Set AN/ALM-178
QQ-A-250/8E (Dec 1970) Aluminum Alloy 5052, Plate and Sheet

new and revised standards that can be ordered by Technical Standards

ANSI B32.5-1977 Preferred Metric Sizes for Tubular Metal Products other than Pipe ($2.50)
ANSI B32.6-1977 Preferred Metric Equivalents of Inch Sizes for Tubular Metal Products other than Pipe ($2.50)
ANSI/UL 894 Electric Switches for use in Hazardous Locations, Class I, Groups A, B, C, and D; and Class II, Groups E, F, and G, Safety Standard for ($3.50)
ANSI X11.1-1977 Mumps Language Standard ($5.00). This standard contains a three-part description of various aspects of the MUMPS computer programming language. Part I, the MUMPS Language Specification, consists of a stylized English narrative definition of the MUMPS language. Part II, the MUMPS Transition Diagrams, represents a formal definition of the language described in Part I, employing a form of line drawings to illustrate syntactic and semantic rules governing each of the language elements. Part III, the MUMPS Portability Requirements, identifies constraints on the implementation and use of the language for the benefit of parties interested in achieving MUMPS application code portability.
ANSI X3.4-1977 Code for Information Interchange ($4.50)
ANSI X3.55-1977 Unrecorded Magnetic Tape Cartridge for Information Interchange, 0.250 inch (6.30 mm), 1600 bpi (63 bpmm), Phase Encoded ($5.50)

For information on the above publications, call Carol Schober, Technical Standards, ext. 7976.

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ANSI X3.56-1977 Recorded Magnetic Tape Cartridge for Information Interchange 4 Track, 0.250 inch (6.30 mm), .1600 bpi (63 bpmm), Phase Encoded ($44.25)
IEC 536 (1976) Classification of Electrical and Electronic Equipment with Regard to Protection Against Electric Shock ($6.40)
ISO 1302-1974 Technical Drawings—Method of Indicating Surface Texture on Drawings ($9)
NEMA FU 1-1978 Low-Voltage Cartridge Fuses—The American National Standard for Low-Voltage Cartridge Fuses 600 Volts or Less, C97.1-1972 ($5), has been approved by NEM and constitutes Part I of this NEMA Publication No. FU 1-1972 (R1977), with the addition of the following:
5.4 Markings
(8) Time delay or dual element

new and revised 062 part number standards (now available from Reprographics, ext. 5577)

062-3716-00 COMPONENT IDENTIFICATION MARKING STANDARDS—Transistors and Diodes. The purpose of this standard is to establish procedures for marking of transistors and diodes supplied to Tektronix.

062-3109-00 Documentation Standards Technical Standards, Procedures and Formats. This describes the procedures attendant to the production of Technical Standards and the format in which these standards are presented.

Tek standard provides focal point for high level interface development

Tektronix Standard 062-1780-01, commonly known as GPIB Codes and Formats, issued in March 1977, provides a well-defined, unambiguous structure for data sent on IEEE Standard 488-1975 Bus. Its primary objective is to increase the interface compatibility among products manufactured by Tektronix and other device manufacturers. Since its original issuance as a replacement for 062-1780-00, it has been heavily utilized as the basis for further discussion and development of cost and time-saving device-dependent coding. For further information, contact Maris Graube, ext. 6234.

Indices of Technical Standards files available

The following people now have computer indices to all the standards in the Technical Standards files: Don Blem (Walker Road), Del Williams (Wilsonville) and Roger Haight (International).

The indices are arranged in both organizational and subject sequence, and cover industry, national, international, military and organizational standards.

If you need an identified standard, look in the organizational listings to see if we have it. If you want to know what standards are available on a subject, look at the subject lists to identify which organizational standard may be of most help to you.

To find out where the index in your area is located, call the individual listed above.

Carol Schober, Technical Standards

Product Safety Note No. 34
27 March 1978

Subject: Certain BRH-required markings for products classed as TV receivers.

1. BRH (Bureau of Radiological Health), of DHEW (Department of Health, Education, and Welfare), requires us to report products classed as "TV receivers." These are products that can display a TV picture.

2. Examples of Tek products classed as TV receivers:

650A	652A	655A	670A	620
650A-1	652A-1	655A-1	670A-1	634
651A	653A	656A	671A	4027
651A-1	653A-1	656A-1	690	There may be others.

3. Many of the models have already been reported. We have to report before we introduce the product into commerce.

   In the report we have to quote the actual markings and state where each marking appears on the product. This Product Safety Note deals only with BRH-required markings -- not other required markings such as fuse data and supply-voltage settings.

4. **Rear-panel certification.**

   Product complies, as of date of manufacture, with applicable DHEW standards under the radiation control for Health and Safety Act of 1968.

5. **Rear-panel date-of-manufacture marking.** (Example)

   MANUFACTURED FEBRUARY 1980

   Don't abbreviate **anything.** Show year as four-digit number.

6. **Critical-component warning.** --If the report on the product identifies critical component(s), include the following marking, clearly legible under servicing conditions (preferably inside the product):

   X-Radiation Warning: Operation with defective or incorrectly relaced parts or after improper servicing may produce hazardous X-radiation. See instruction manual. Specified CRT Anode Voltage ___ KV

7. **Manuals information on critical components.** -- If the report identifies critical components(s), the manuals should contain information on their replacement -- usually including a statement that these components should be obtained from Tek.

   If applicable the manual should include the statement that anode-voltage measurement with a voltmeter is dangerous and is discouraged. Information in such cases should include data on how to determine, from the display, whether the anode voltage is essentially correct.

Eddie Richmond
Eddie Richmond
Product Safety Engineer
Mail Station 58-262; Ext. 7374

Peter Perkins
Peter E. Perkins
Product Safety Engineering Manager
Mail Station 58-262; Ext. 7374

ComponentNews NewComponents

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				
Signetics	NE5018	Converter, D/A, 8-bit, microprocessor compatible	now	no P/N	$ 5.85	Don Gladden, 6700
Signetics	NE5008	Multiplying D/A, 8-bit, high speed	now	no P/N	2.40	Don Gladden, 6700
Signetics	NE5009	Multiplying D/A, 8-bit, high speed	now	no P/N	1.85	Don Gladden, 6700
Prec. Mono.	SMP-81F	Sample & hold amp., high accuracy	now	no P/N	3.15	Don Gladden, 6700
Raytheon	4200	High accuracy sample and hold amp.	now	no P/N	1.80	Don Gladden, 6700
Fairchild	μA78S40	Universal switching regulator subsystem (16-pin DIP)	now	no P/N	1.85	Jim Williamson, 5345
HP	5082-0087	Schottky Diode Chip, 20V	now	152-0710-00	0.25	Gary Sargeant, 5345
Motorola	MDA3504	Bridge Rectifier, 35A, 400V	now	152-0713-00	2.10	Gary Sargeant, 5345
TRW	1N6098	Schottky Rectifier, 50A, 40V	now	152-0714-00	5.00	Gary Sargeant, 5345
Amperex	BYW29-100	Fast 35nS Rect. 7A, 100V, TO-220	now	no P/N	1.00	Gary Sargeant, 5345
Amperex	BYW 30-100	Fast 35nS Rect. 12A, 100V, DO-4	now	no P/N	1.90	Gary Sargeant, 5345
Motorola	78L12ACG	+12V Regulator, 100mA, TO-39	now	156-1160-00	0.40	Chris Martinez, 6700
Motorola	79L12ACG	-12V Regulator, 100mA, TO-39	now	156-1207-00	0.46	Chris Martinez, 6700
TI	78M05	+5V Reg. 500mA, TO-202, low cost	now	no P/N	0.45	Chris Martinez, 6700
TI	78M15	+15V Reg. 500mA, TO-202, low cost	now	no P/N	0.45	Chris Martinez, 6700
TI	78M18	+18V Reg. 500mA, TO-202, low cost	now	no P/N	0.45	Chris Martinez, 6700
TI	79M12	-12V Reg. 500mA, TO-202, low cost	now	no P/N	0.45	Chris Martinez, 6700
		electromechanical devices				
GE		2.4V NiCd battery	now	no P/N	2.76	Byron Witt, 5417
GE		3.6V NiCd battery	now	no P/N	4.14	Byron Witt, 5417
TRW		Film capacitor 1.0μF; ±10%, 400V	now	285-1177-00	0.85	Merle Hendricks, 5415
Electronic Concepts		3.5Amps RMS @ 25 KHz				
Mallory		420μF, 200V aluminum electrolytic (ckt bd mt)	—	290-0835-00	—	Merle Hendricks, 5415
Bourns		7 res 150Ω ±2% 14 pin	May	307-0623-00	0.30	Ray Powell, 6520
A-B		270MΩ ±30% ¼ watt	April	307-0620-00	0.30	Ray Powell, 6520
Caddock		1K, 10K, 3.6K, 5.7K, 11.5K 6 res. SIP	May	307-1131-00	2.00	Ray Powell, 6520
Beckman		13 res 2KΩ ±5% 14DIP	May	307-0624-00	—	Ray Powell, 6520
Beckman		7 res 150Ω ±2% 14DIP	May	307-0625-00	—	Ray Powell, 6520

COMPONENT NEWS

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