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6605 memory failures analyzed

Recent reliability and application problems with the MCM6605 4K RAM (Tek P/N 156-0635-00) illustrate some of the typical frustrations that can arise when using dynamic memories.

The MCM6605 is a heavily used part in graphics systems and several other instruments with usage between 16 to 32 devices in the 4051. As in many microprocessor-based systems, the most common complex circuit is a memory chip.

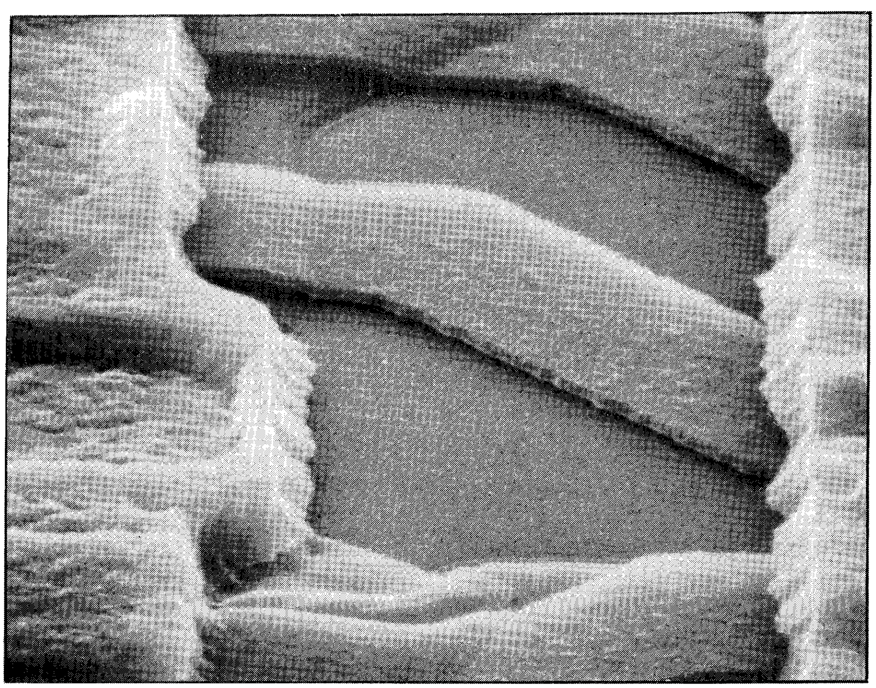
As a result, the reliability of the instrument is tied closely to the reliability of memory chips.

the problem

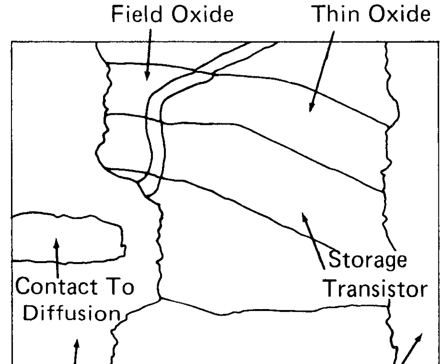
In spite of 100% electrical testing of these devices in Incoming Inspection, 156-0635-00 plant failure rates have run around 1 to 2%. This translates out to mean that every other 4051 has a memory problem in final test. Field failure rates also indicate a memory problem.

The number of reported plant and field failures prompted a review of the Intersil/Motorola chip design. Subsequent electrical testing revealed that failures were primarily caused by localized defects, most likely due to pin holes in the thin oxide.

continued on page 2



SEM photo of a typical data storage transistor (5k times magnification) shows no visible sign of a gate-oxide defect.



—Also in this issue—

Arrhenius failure model vs. failure data	page 11		New components listing	page 15
Fan, new DC brushless	10		Optical switch designed at Tek	12
Fluorocarbon ban affects Tektronix	6-7		Transistor selection guides developed	8-9

6605 memory failures

continued from page 1

Because of the low junction breakdown voltage, the usual method of testing with overvoltage to screen out weak devices is not possible. Additional complications were introduced by Intersil's discontinuation of the part and a mask shrink by Motorola. The Intersil action, in particular, led to the conclusion that the 6605 is now at the end of its useful life and will no longer be cost effective for our applications.

basic cell layout

The first step in looking at the problem was to trace out the device circuit itself. The basic cell used was the older three transistor cell design which stores data by charging up the gate capacitance. See Figure 1.

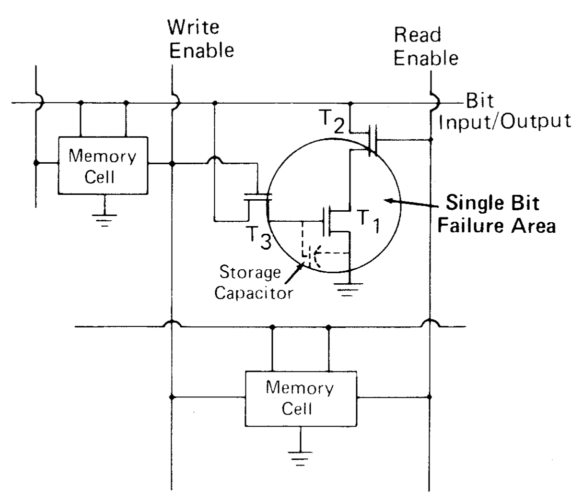


Figure 1 – Basic cell layout

In the normal operation of the cell, data is written into the cell when it is put on bit line and the write enable transistor (T_2) is turned on. The cell is read out by precharging the bit line high (approximately 12 volts) and turning on T_2. This will discharge the bit line if more than the threshold level is stored on T_1. In addition, to refresh the cell, you must turn off T_2 and turn on T_3.

There is one problem however; the data is now inverted. The memory array is set up to invert a whole row at one time. So that this poses no problems for the user, a reference cell is provided at the end of each row that is exclusive OR'd with both input and output data resistors to restore data to the proper sense.

The one advantage of this cell is the high output level resulting in better speed at lower power but the penalty is a 30% increase in basic cell size.

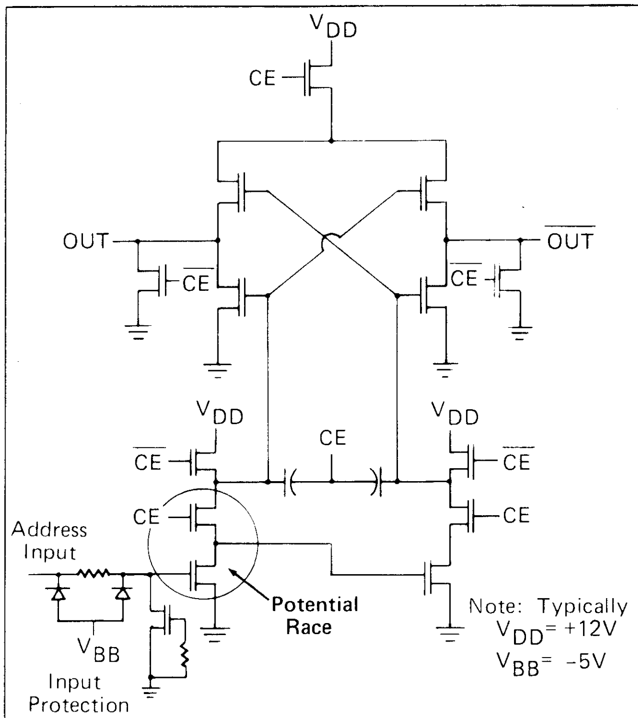


Figure 2 – Address buffer

Note that the only way for a single cell to fail is when transistor T_1 or one of the lines leading to it fail. If any other device failed, it will take a row or column with it.

address buffer

The only other area of special interest was the address buffer. In this circuit both the input signal and the chip enable signal are applied to MOS devices in series. See Figure 2.

The address input is specified for zero nsec data set-up time. This means that a change to the final state of the address input (see Figure 3) can occur at any time up until the chip enable voltage reaches two volts.

The devices met this specification under test if the waveform started from 3 volts. However, at 3.5 volts the RC time constant caused the devices to be several nanoseconds out of spec.

Other than the above, no close timing specifications were found. **continued on page 3**

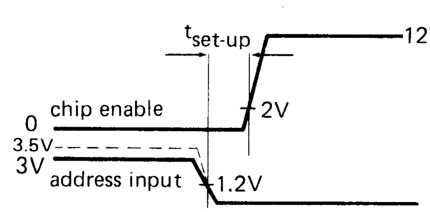


Figure 3 – Set-up time waveforms

6605 memory failures continued from page 2

device testing

After the review of basic circuitry was completed, electrical tests were performed. Quite a few standard patterns have been developed that have historically been used to detect errors. Patterns used on the MCM6605 include:

1. SCAN - simple run through
2. MARCH - standard address uniqueness test
3. SIMPLE READ—MODIFY—WRITE TEST- used to test this mode of operation.
4. GALPUT - used to test all possible two-state address transitions on read.
5. GALREC - similar to GALPAT except a write is alternated with read.
6. MASEST - shortened address speed test.

In addition, the refresh time was tested using a number of standard tests plus two that were tailored for the MCM6605. They are:

1. NO—FRESH - writes, pauses, then reads state of memory.
2. CHECKER BOARD REFRESH - writes a checker board of "1's" and "0's", pauses, then reads them.
3. T FRESH - takes the 6605's row flipping nature into account and tests with each column in the opposite state.
4. R FRESH - accounts for the fact that the high-order bits open an additional path to the column which is selected by the high-order bit (even though they are not used in refresh).

These patterns were not only used to test the functionality of the device but also as a dynamic test and DC parametric test of all parameters listed in the specification.

test results

One failure mode which quickly emerged as a significant cause of both plant and field failures was the hard failure of a single bit in the memory. Thirty field failures (18 Motorola, 12 Intersil) were analyzed with results shown in Table 1.

Table 1 — Analysis of 6605 field failures

Failure Mode	No. Failed
Single bit failure	5
Complete row failure	5
Complete column failure	2
Catastrophic (zapped)	6
Other types	3
Tested okay at 25°C	9

Subsequently, 157 plant rejects were analyzed for cause of failure (only Motorola parts in plants). Results showed some dependence on lot, but not a strong one. See Table 2 on page 4.

As mentioned earlier, the only way for a single bit to fail is when transistor T_1, or one of the lines leading to it (see enclosed area Figure 1) has failed. An entire column or row would fail if any other device had failed. Therefore, static discharges and other handling problems cannot cause single bit failures.

Further analysis of single bit failures indicates a process-related problem rather than a design problem due to the random distribution of failures over the chip, shown in Figure 4 on page 4.

failure mode

The most common and most likely cause of failure for this type of device is gate-oxide defects. This failure mode is reported to cause 22 to 66% of all failures [1] [2], depending on who is reporting them and what ground rules are used.

Gate-oxide defects have been particularly severe in a coplanar process such as is used for the MCM6605. In this process, a layer of silicon nitride is used to mask the growth of oxide in the device well. One suggested failure mode is the incomplete removal of the silicon nitride before the thin oxide is grown. Regardless of cause, the result is a thin oxide with a low breakdown voltage.

Considerable research has been devoted to the breakdown of thin oxide films. One of these reports has shown that a low current was detected before breakdown [3]. This would indicate that some refresh-related problems would occur before the part failed, and that the refresh time failures listed in Table 2 could be due to the same root cause.

The other interesting fact learned was that once the current reached a critical level the breakdown continued even if the part was cooled to liquid nitrogen temperatures.

The scanning electron microscope (SEM) in ICM Failure Analysis was used to examine the failed bit sites of the 6605 plant and field failures. The results were inconclusive but did not rule out an oxide rupture. As shown in the photograph on page 1, there was no visible sign of a gate-oxide defect even at 5K times magnification.

This was not surprising considering that a pin hole is probably less than 0.5μ inch diameter (oxide is typically 0.1μ inch thick). Since this would occur under a 0.3μ inches of polysilicon, there is a good chance that such a defect would not be visible on the surface. text continued on page 5

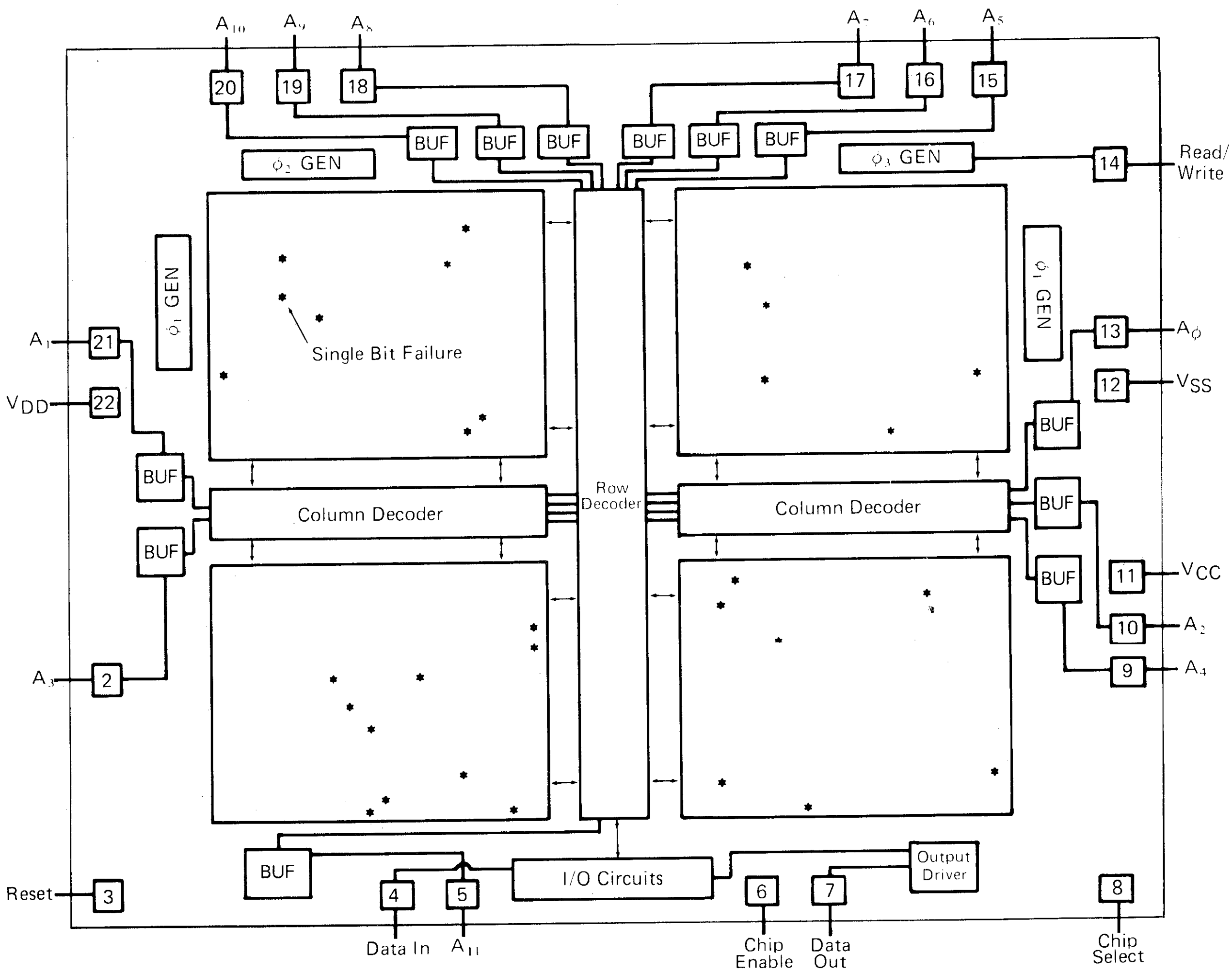
6605 memory failures

continued from page 3

Table 2 – Analysis of plant failures (all Motorola devices)

Date Code	No. Failed by Failure Mode							
	single bit	row A_0–A_4	column A_5–A_{11}	one address	refresh time	zapped	other	tested okay
early	5	2	0	1	3	2	3	4
7626	4	0	0	1	2	0	0	3
7627	1	0	0	1	0	3	2	2
7628	2	0	0	0	0	1	1	1
7629	9	4	0	1	1	2	1	6
7630	2	2	1	6	2	3	1	15
7631	4	2	0	1	4	3	2	2
7632	1	2	1	2	0	4	1	2
7633	5	0	0	2	1	3	1	12
Total	33	12	2	15	13	21	12	47

Figure 4 – Map showing random distribution of single bit failures (composite of 30). Each failure site is indicated by an asterisk (*).



6605 memory failures

continued from page 4

Table 3 shows the gate area (in square mils) associated with each failure mode including single bit failures, assuming a local oxide rupture. The maximum and minimum areas are given to accommodate cases where a failure may be caused by one or more modes.

Assuming that all single bit failures are oxide defects, a projection of failures due to other modes can be drawn. This projection compares closely with the actual failures except for single address line failures and catastrophic failures, both of which could have resulted from static discharge or overvoltage.

Adding all the suspected oxide defects together, including refresh time problems, the result is 76 out of 108 failures or a gate-oxide defect failure rate of 70%. Based on this logic, we can assume that 6605 failures would be reduced by two-thirds if parts with possible oxide defects were eliminated.

screening

The obvious way to weed out devices with weak or defective oxides is to apply a 50% overvoltage. However, in the case of MCM6605, the normal junction breakdown voltage is 22 volts which is only 30% above 17 volts from V_{DD} to V_{BB}.

An alternate screening method is burn-in. Published reports, however, claim that this failure mode has a low temperature dependence [4]. The best approach may be a burn-in at 15 volts V_{DD}. Component Reliability Engineering will evaluate the effectiveness of such a burn-in by performing a life test.

suppliers

Intersil gave two reasons for discontinuing production of the MCM6605. First, the part was no longer profitable because the three transistor cell takes up too much area. This was compensated for by a speed advantage until MOSTEK introduced the MK4027.

The second reason given was the recent merger with AMS (Advanced Memory Systems). All MOS operations will be transferred to the former AMS plant but it was not worthwhile to transfer the 6605 since it appears to be at the end of its useful life.

Motorola introduced a new mask set (labeled 3WT) which is a 10% size reduction in the chip. This means only a 5% reduction in any linear dimensions.

Six samples of this new mask set have been evaluated. There doesn't seem to be any noticeable shift in DC or AC parameters. However, there was a 100mV drop in the maximum zero level from 1.2 to 1.1 volts. This parameter closely corresponds to threshold voltage and can be explained by short channel effects.

Intersil's mask set was already this size and operated in one system satisfactorily so we expect little performance change in Motorola's part. Note also that with a 10% chip reduction the gate area will also be reduced by 10%. If the process is similar, gate oxide failures should be reduced by 10%.

continued on page 6

Table 3 — Comparison of predicted and actual failure modes

	Single bit	Row	Column	One address bit	Catastrophic
Gate area (mil^2)					
min.	614.4	55.7	343.8	124.3	196.8
max.	1536.0	1025.3	383.8	212.3	196.8
Gate area in %					
min.	26	2	14	5	8
max.	65	44	16	9	8
Projected failures (based on 33 single bit failures)					
min.	33	1	7	3	4
max.	33	56	20	11	10
Actual failures	33	12	2	15	33

6605 memory failures continued from page 5

conclusions

In view of the single-source status, reliability problems and an outdated design, the MCM6605 should not be designed in any new instruments. Its use in existing products should be reviewed to consider the cost of a 100% burn-in screen.

Alternative devices include the 16-pin MK4027 4K RAM and MK4116 16K RAM. These devices appear to be the industry standard for the next few years.

In your future memory designs, note that most of the field failure problems associated with the oxide defect failure mode could be eliminated using error detection and correction circuits. All 33 single bit errors could be put in a system containing error correction and the system would still function correctly.

for more information

For further details contact Eric Peterson, ext. 6302, in Digital Component Engineering (39-015).

bibliography

[1] C.R. Barrett, R.C. Smith (Intel), **1976 International Electron Devices Meeting Technical Digest**, p.319

[2] T.L. Palfi (AMS), **1975 Semiconductor Test Symposium Digest of Papers**, p. 37

[3] D.Y. Yang, W.C. Johnson, M.A. Lampert (Princeton), **1975 Physics of Failure Symposium Proceedings**, P. 10

[4] Barrett, Smith, **op. cit.**

Fluorocarbon ban affects Tektronix

Beginning March 1, it will be illegal in Oregon to sell aerosol containers utilizing fluorocarbon propellants. The law affects a number of products purchased for use in Tektronix' manufacturing areas and for resale to our customers.

Although this legislation does not prohibit the **use** of fluorocarbon propelled products, legal advisors have determined that the purchase of these items outside the state of Oregon for use in Oregon would violate the "spirit", if not the letter, of the law. Therefore, Tektronix will gradually deplete its existing stock of these products and shift over to alternate propellants. No provision in the law prevents Tek from keeping and using its inventory on hand when the prohibition takes effect March 1. However, sales to customers will be discontinued and catalogs will delete covered products. An open-ended general mod (No. 31223) is being prepared to delete these P/N's.

To assist in the changeover, a list has been compiled of known aerosol products used at Tek (see page 7). Users of fluorocarbon propelled products (this includes Freon 11 and 12) should begin looking for alternate aerosol products. For assistance in locating these substitutes contact a Maintenance Repair Operations (MRO) buyer.

Products consisting only of a fluorocarbon compound (ie Quik-Freeze coolant and Genetron solvent) may not be covered by the new legislation. Work is underway to determine if these products are exempt.

If you know of any aerosol products not on the list, or for more information, contact Dick Borts in Production Purchasing (58-274), ext. 6196. For details on the mod being prepared, contact Maryletta Glasscock (55-714), ext. 5936.

Item	Part Number	Function	Usage (cans/yr) including customers
1	006-0173-01	cool	5137
2	006-0442-00	clean	2233
3	006-0172-00	lube	1889
4	006-1449-00	release	718
5	252-0203-02	paint	984
6	006-1926-00	dissolve	510
7	006-1014-00	lube	806
8	252-0092-00	paint	1000
9	006-0756-00	release	408
10	252-0187-01	paint	355
11	252-0217-01	paint	272
12	006-0619-00	release	216
13	006-1922-00	clean	95
14	006-1222-00	lube	102
15	006-0451-00	release	84
16	006-0457-00	coat	81
17	006-0352-00	release	12
18	006-1600-00	lube	19
			14921

Purchased supplies in aerosol cans

Part Number	Description	Propellant	MRO Buyer	Ext.
Adhesives				
TR-13736	#6096 Vac-U-Mount Adhesive 317	Non-Fluorocarbon	Jack Connor	6854
TR-13737	#6092 Photo-Mount Adhesive 317	Non-Fluorocarbon	Jack Connor	6854
TR-13118	Diagraph Quick Spray Labeling Adhesive, Sub 3-M	Non-Fluorocarbon	Jack Connor	6854
TR-00536	3-M #6065 Spray Mounting	Non-Fluorocarbon	Jack Connor	6854
Cleaners				
TR-03704	DuBois Glass Cleaner	Non-Fluorocarbon	Jack Connor	6854
TR-11032	Sprayway #40 Glass Cleaner	Fluorocarbon	Jack Connor	6854
006-1922-00	Electronic contact, MS-230	Freon 11 and 12	Joe Ackley	7302
006-0442-00	No-Noise Volume Control and Contact Cleaner	Freon 11 and 12	Joe Ackley	7302
006-1854-00	Magnetic Tape Head Cleaner MS-200	Freon 11 and 12	Joe Ackley	7302
TR-06021	Magi-Kleen Cleaner	Manufacturer change	Jack Connor	6854
Coating, Spray				
TR-03662	Clear Acrylic, Krylon #1304	Non-Fluorocarbon	Jack Connor	6854
TR-08214	Crystal Clear, Krylon #1303	Non-Fluorocarbon	Jack Connor	6854
TR-08301	Clear Finishing, Scotchcal #4900	Non-Fluorocarbon	Jack Connor	6854
TR-06027	Matte Finish (Non-Gloss), Krylon #1311	Non-Fluorocarbon	Jack Connor	6854
TR-11352	Workable Fixatif, Krylon #1306	Non-Fluorocarbon	Jack Connor	6854
Compound				
TR-00050	Anti-Static, Statikill	Manufacturer change	Jack Connor	6854
Coolant				
006-0173-01	Circuit-Quik Freeze	Freon 11 and 12	Joe Ackley	7302
006-0173-01	Sprayon Circuit Cooler #2003C	Freon 11 and 12	Joe Ackley	7302
Dressing				
TR-11284	Belt, Chesterton Spragrip	Fluorocarbon	Jack Connor	6854
Filtercoat				
006-0457-00	#418P Pressure-Koter	Freon 11 and 12	Joe Ackley	7302
Fluid				
TR-13123	Layout, Blue, Dykem	Freon 11 and 12	Jack Connor	6854
Lubricants				
006-1014-00	Fluorocarbon MS-122	Freon 11 and 12	Joe Ackley	7302
006-1600-00	LPS-1 Lubricant	Freon 11 and 12	Joe Ackley	7302
TR-05856	Mollycote G	Manufacturer change	Jack Connor	6854
TR-05859	Rust Solvo Penetrating Oil	Fluorocarbon	Jack Connor	6854
006-1222-00	Silicon 6%, Slix-it, Crown #8035	Freon 11 and 12	Joe Ackley	7302
006-0172-00	WD-40	Freon–Mfr. change	Joe Ackley	7302
Paint				
TR-09103	Green, Mist-Steelcase #56	Fluorocarbon	Jack Connor	6854
TR-02007	Red, Primer, Rust-Proof, Kerr #701	Non-Fluorocarbon	Jack Connor	6854
TR-09129	Sage, Desert-Steelcase #56	Fluorocarbon	Jack Connor	6854
TR-03606	Black, Flat-Krylon #1602	Non Fluorocarbon	Jack Connor	6854
TR-03605	Black, Glossy-Krylon #1601	Non-Fluorocarbon	Jack Connor	6854
TR-03612	Blue, Baby-Krylon #1902	Non-Fluorocarbon	Jack Connor	6854
TR-03611	Blue, Regal-Krylon #1901	Non-Fluorocarbon	Jack Connor	6854
TR-03617	Brass--Krylon #2202	Non-Fluorocarbon	Jack Connor	6854
TR-03620	Brown, Leather--Krylon #2501	Non-Fluorocarbon	Jack Connor	6854
TR-03616	Copper, Bright--Krylon #2201	Non-Fluorocarbon	Jack Connor	6854
TR-03609	Gold, Bright--Krylon #1701	Non-Fluorocarbon	Jack Connor	6854
TR-03613	Green, Hunter--Krylon #2001	Non-Fluorocarbon	Jack Connor	6854
TR-03608	Grey, Light--Krylon #1604	Non-Fluorocarbon	Jack Connor	6854
TR-03607	Grey, Machinery--Krylon #1603	Non-Fluorocarbon	Jack Connor	6854
TR-03618	Khaki, O.D.--Krylon #2301	Non-Fluorocarbon	Jack Connor	6854
TR-03619	Orange, Sunset--Krylon #2401	Non-Fluorocarbon	Jack Connor	6854
TR-03614	Red, Cherry--Krylon #2101	Non-Fluorocarbon	Jack Connor	6854
TR-02007	Rust Magic Metal Primer--Krylon #1317	Non-Fluorocarbon	Jack Connor	6854
TR-03603	Silver, Bright--Krylon #1401	Non-Fluorocarbon	Jack Connor	6854
TR-03604	White, Glossy--Krylon #1501	Non-Fluorocarbon	Jack Connor	6854
TR-03610	Yellow, Chrome--Krylon #1801	Non-Fluorocarbon	Jack Connor	6854
252-0092-00	Lacquer Touch-up, Blue Vinyl	Freon 12	Lloyd Davidson	7127
252-0187-01	Vinyl Paint, Grey	Freon 12	Lloyd Davidson	7127
252-0203-02	Vinyl Paint, Simi-gloss, Tektan	Freon 12	Lloyd Davidson	7127
252-0217-01	Vinyl Paint, TV Grey	Freon 12	Lloyd Davidson	7127
252-0235-01	Lacquer, Calculator Blue	Freon 12	Lloyd Davidson	7127
Polish				
006-1278-00	Furniture, Johnson's Shine-Up	Non-Fluorocarbon	Don Adams	6695
Release, Mold				
006-1449-00	Contour #1711	Freon 11 and 12	Joe Ackley	7302
006-0451-00	Crown #3034 with silicon	Freon 11 and 12	Joe Ackley	7302
006-0352-00	Crown #3070 without silicon	Freon 11 and 12	Joe Ackley	7302
006-0619-00	IMS Neutral Oil	Freon 11 and 12	Joe Ackley	7302
006-0756-00	IMS Zinc Stearate--Dry Powder	Freon 11 and 12	Joe Ackley	7302
TR-11932D	ARNCO	Fluorocarbon	Jack Connor	6854
Remover				
TR-11073	Lint and Dust, Air-It #11555-10	Non-Fluorocarbon	Jack Connor	6854
Solvent				
006-1926-00	Freon TF	Freon 11 and 12	Joe Ackley	7302
TR-13368	Freon TP-35	Freon 11 and 12	Jack Connor	6854
252-0120-00	Genetron #114	Freon 11 and 12	Joe Ackley	7302

Transistor selection guides developed

Component Reliability Engineering (CRE) has been investigating the proliferation of part numbers for discrete transistors used at Tektronix and developed the selection guides in the new issue of the **Semiconductor Parts Catalog** (January 1977).

Wherever needless duplication of part numbers exists, the task of monitoring quality and reliability is made unnecessarily difficult. The solutions found for one problem can usually be applied to many applications when using a standardized part.

explanation of selection guides

The sources of information used to generate the selection guides were 1) chip data books and drawings, 2) data sheets, 3) transistor cross-equivalency lists, and 4) vendor's transistor-to-chip type source lists. An excerpt from one of the charts is shown in Table 1.

The transistors are grouped by design intent (ie. low voltage RF amplifiers) and chip type. With the availability and electrical equivalency indicated for each vendor (National, Fairchild, Motorola and TI). The "popular industry data sheets" columns can be used for selecting transistor types not currently used at Tektronix.

Transistor equivalency was judged on the basis of: Is the vendor sourcing the same chip line for all the indicated 2N part numbers?

How similar are the different vendors' chip designs for a given 2N part number?

Other questions that arise include: 1) How accurate are the cross-equivalency lists? 2) What are the differences between the high and low voltage ends of a chip line? and, 3) What about subtle differences between the diffusion processes of the various vendors?

Lots can vary because of poor process control, sometimes affecting performance in a given application. Also, vendors presently have the option, almost without exception, to source a part from more than one chip line, or to redesign a chip line.

The approach CRE advocates to deal with the difficulties of lot and/or vendor variations includes:

1) The development of Incoming Inspection test specifications to control variations in process by specifying enough DC parameters with minimum and maximum limits.

2) The chip type and geometry will be specified on the Tek spec, and cannot be changed without submittal of a sample and approval by Tek.

3) Additional Incoming Inspection test equipment is needed to alleviate some of the present test limitations. Specifically, this would entail an extension of the high-speed test capabilities to include high-voltage, and high-current part types. Also, equipment is needed to measure RF gain/noise figures and high speed switching times for critical applications.

4) For those parts where Tek is trying to qualify alternate sources, or seriously attempting to standardize from among several different part numbers, we will sample the manufacturing lines with weighted process spread samples.

a closer look: 2N918

Before finalizing the selection guides, we took a look at the 2N918, a very popular RF amplifier transistor. Table 2 summarizes the information obtained.

continued on page 9

Table 1

Transistor Type	Tektronix Part Number	Data Sheet	Pol.	√=Available from E Close Equiv. A Approx. Equiv.				Case Style	BV_{CEO} V (Min) Range	Application	Popular Industry Data Sheets			
				Natl	Fsc	Mot	TI				TO-92	(TO-72) TO-18	(TO-5) TO-39	Other
Low Voltage RF Amplifiers (Chip Size Range 10 x 15 mils)	151-0109-00 151-0283-00 151-0139-00 151-0198-00 151-0333-00 151-0471-00 151-0427-00 151-0225-00 151-0259-00 151-0427-00	2N918 2N918 2N918 MPS918 MPS918 2N5770 2N5770 2N3563 2N3563 2N3563	NPN	E√	E√	A√	√	TO-72A TO-72A TO-77 TO-92 TO-92 TO-92 TO-92 TO-106 TO-106 TO-92	15	UHF/VHF Amplifier/ Oscillator,900 MHz f_t	2N5770	(2N918)		

Table 2

Tek PN	Data Sheet	Approved Vendors	Samples in Stock?	Usage/Year	"common type" geometry
151-0109-00	2N918	Motorola	Yes	2K	Yes
		Fairchild	No		------
151-0109-01	2N918	Fairchild	No		------
151-0139-00	2N918	Motorola	Yes	3.5K	Yes
		Fairchild	No		------
		Teledyne	Yes		Yes
151-0175-00	2N3652	G.E.	Yes	3K	Possibly
151-0198-00	MPS918	Motorola	Yes	82K	No
151-0225-00	2N3563	Teledyne	Yes	102K	Yes
151-0259-00	2N3563	Fairchild	Yes	70K	Yes
		National	No		------
151-0283-00	2N918	Motorola	No	36K	------
		Fairchild	Yes		Yes
151-0333-00	MPS918	Motorola	Yes	72K	No
151-0427-00	2N3563	Fairchild	Yes	88K	Yes
	or 2N5770	National	Yes		Yes
151-0471-00	2N5770	Fairchild	Yes	31K	Yes

continued from page 8

A good illustration of the "common type" 2N918 geometry comes from the TI chip data book. See Figure 1.

Motorola's chip data book showed that two different geometries were being used to manufacture 2N918 parts. Upon investigation, we found a third geometry type not shown in the data book. See Figure 2. However, I rate Motorola's device as an approximate equivalent to other vendors' parts.

A cursory examination of the Tek specs for the part numbers listed in Table 2 fails to reveal many major differences in requirements from a standard 2N918 spec. The following exceptions were noted:

Most of the Tek specs appear to be one of a variety of relaxations of the 2N918 spec. Some specs set slightly higher h_{FE}'s. Most specs impose a couple of leakages. The 151-0139-00, 151-0225-00 and 151-0283-00 show some spec limit changes, indicating a more limited parts selection than the average 2N918 spread.

Perhaps a more tightly defined spec, better Incoming Inspection capabilities and more worst-case circuit design would enable standardization of even as critical a part as this RF amplifier. Advantages may include a lower unit part cost, better sourcing with alternate vendors and improved monitoring and correction of reliability problems.

for more information

If you have any comments, questions or suggestions concerning transistor standardization and reliability, contact me on ext. 6511.

Roy Leventhal

Figure 1 — TI geometry 2N918

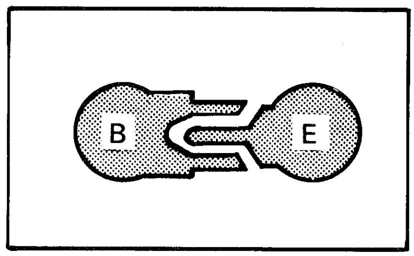
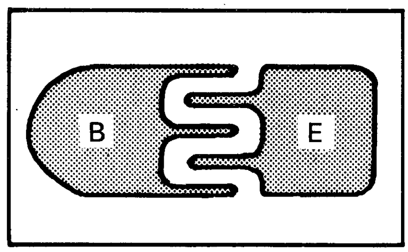
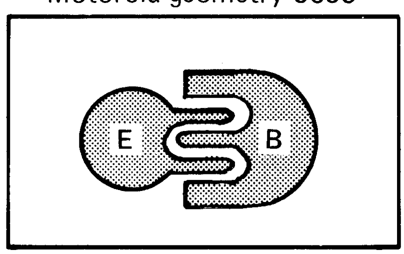


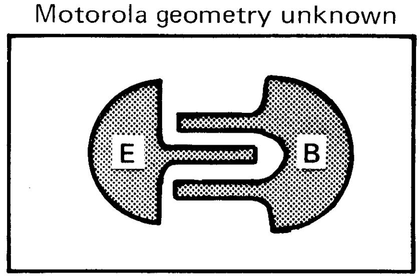
Figure 2 — Motorola geometry 5028



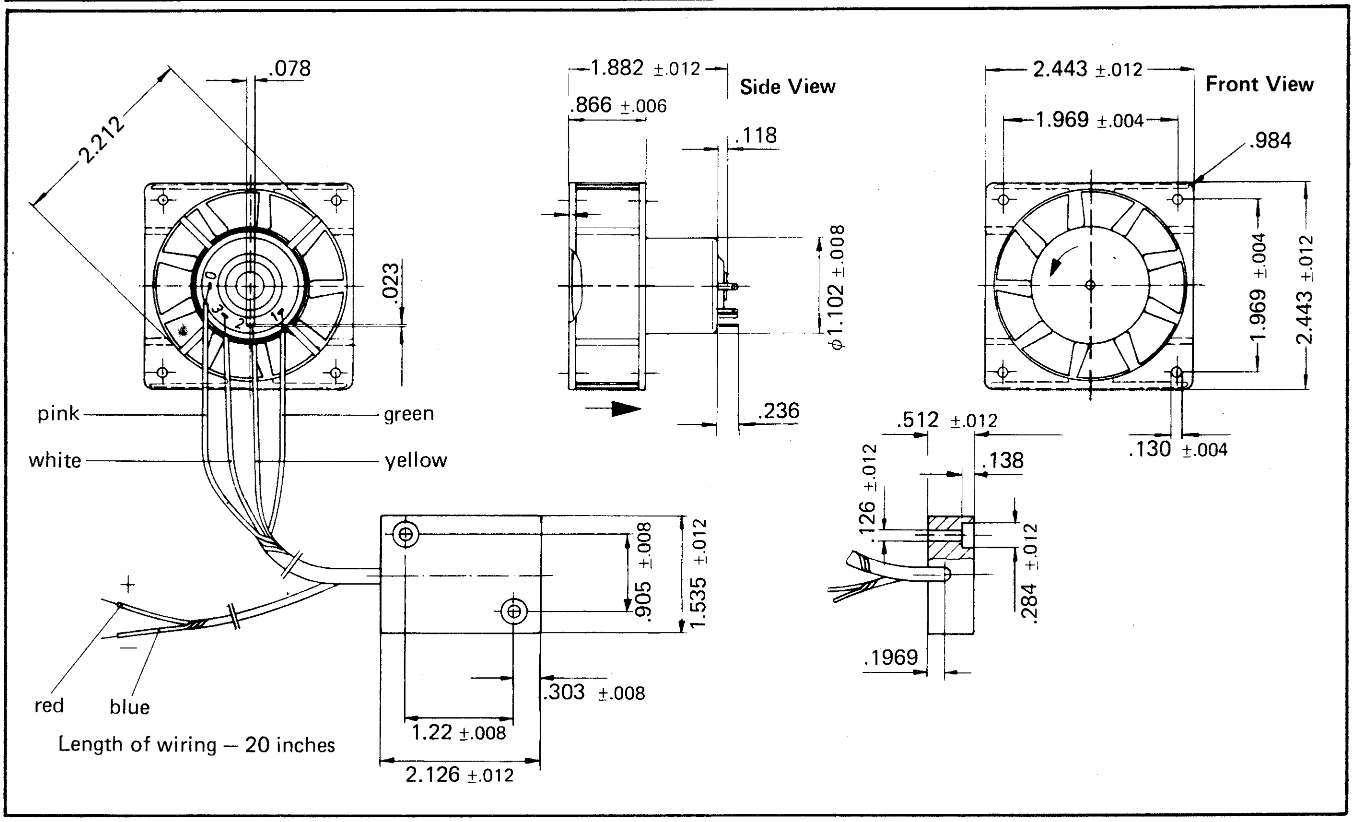
Motorola geometry 5095



Motorola geometry unknown



All chips are 10 X 15 mils.



New brushless DC fan part-numbered

A small, brushless DC fan assembly has been Tek part-numbered. This fan assembly is made by Buehler Company and has a 2.5" square mounting surface with a total length of approximately 2 inches. The motor operates within a voltage range of 9 to 16 VDC. Air flow is 37 CFM at 6000 RPM in free air (see drawing).

Accompanying the motor is an electronic box comprised of the phase switching and feedback circuits. These circuits eliminate the need for using brushes and commutator bars to switch the phases at the correct time. The motor has built-in oil reservoirs at both bearings which the manufacturer states will extend the motor life past 5000 hours in a 75°C environment.

This fan assembly is very efficient for its physical size, air flow and power dissipation (2.4 Watts at 12 VDC input) requirements. The fan assembly with electronic package sells for approximately $20 each in quantities of 1000.

For more details, see Bill Stadelman, (58-299) ext. 6365.

Description of CP4165 controller

The CP4165 controller is a Tek-manufactured minicomputer that is fully compatible with TEK SPS BASIC software and Digital Equipment Corp. (DEC) PDP11/03 software.

The standard CP4165 is equipped with a 16-bit processor module (DEC's KD 11-F), 28K words of dynamic memory, a combination serial interface/ ROM bootstrap/bus termination board and short term battery back-up. DEC peripherals designed for the PDP11/03, with certain bus location restrictions, are compatible with the CP4165. The controller is housed in a 5¼" high rack mountable enclosure. Optional CP-bus and IEEE-488 bus interfaces may be obtained.

Customer availability is scheduled for Week 25. D-phase output is scheduled during Week 12.

The standard cost of the CP4165 with 28K memory is $7500. Option 31 (IEEE-488 interface) will be available by Fall 1977. Option 32 (CP-bus interface) is currently available at an added cost of $500.

For more information contact Dave Nelson, SPS Marketing, ext. 6925.

Failure data verifies Arrhenius model

The Arrhenius model is used to determine the temperature acceleration effect on failure rates (**Component News** No. 239). This model has been verified by accelerated life tests but until recently had not been checked against field failure data.

Several transistor examples have now been checked. The model shows reasonably good agreement with the field data (to the extent that the field data can be trusted).

The model states that the acceleration factor for failure rate is expressed by:

$$AF = \exp \frac{EA}{K} \left(\frac{1}{T_R} - \frac{1}{T}\right)$$

Where T_R is a reference temperature at which the failure rate is known,
T is some other temperature,
k is Boltzmann's constant
and E_A is the activation energy in electron volts.

Previous researchers have found the activation energy for surface related and bond failure mechanisms to be in the range of 1 to 1.1 eV.

Using field failure data to verify this model is statistically difficult because of the variance in the frequency of failure reporting and also the difficulty in determining the average actual use conditions of the part (namely the junction temperature). Imputing two significant figures from this data is probably questionable. Keep these cautions in mind when considering the data shown in Table 1.

Extrapolation of the failure rates shown in Table 1 down to a 60°C junction temperature would indicate a base failure rate of 0.01%/year. This is lower by a factor of 4 than the base failure rate for transistors (assumed in the cost benefit model described in **Component News** No. 239.) However, the 0.04%/year figure used in that article was computed over a wide range of part types and usage conditions, rather than only two example cases.

The RELY Computer Program (Comp. News No. 232) for parts count reliability prediction has a feature which permits computing the temperature dependence of instrument MTBF (contributed by semiconductors). This feature has been modified somewhat according to the findings explained in this article (namely, the base failure rate has been reduced).

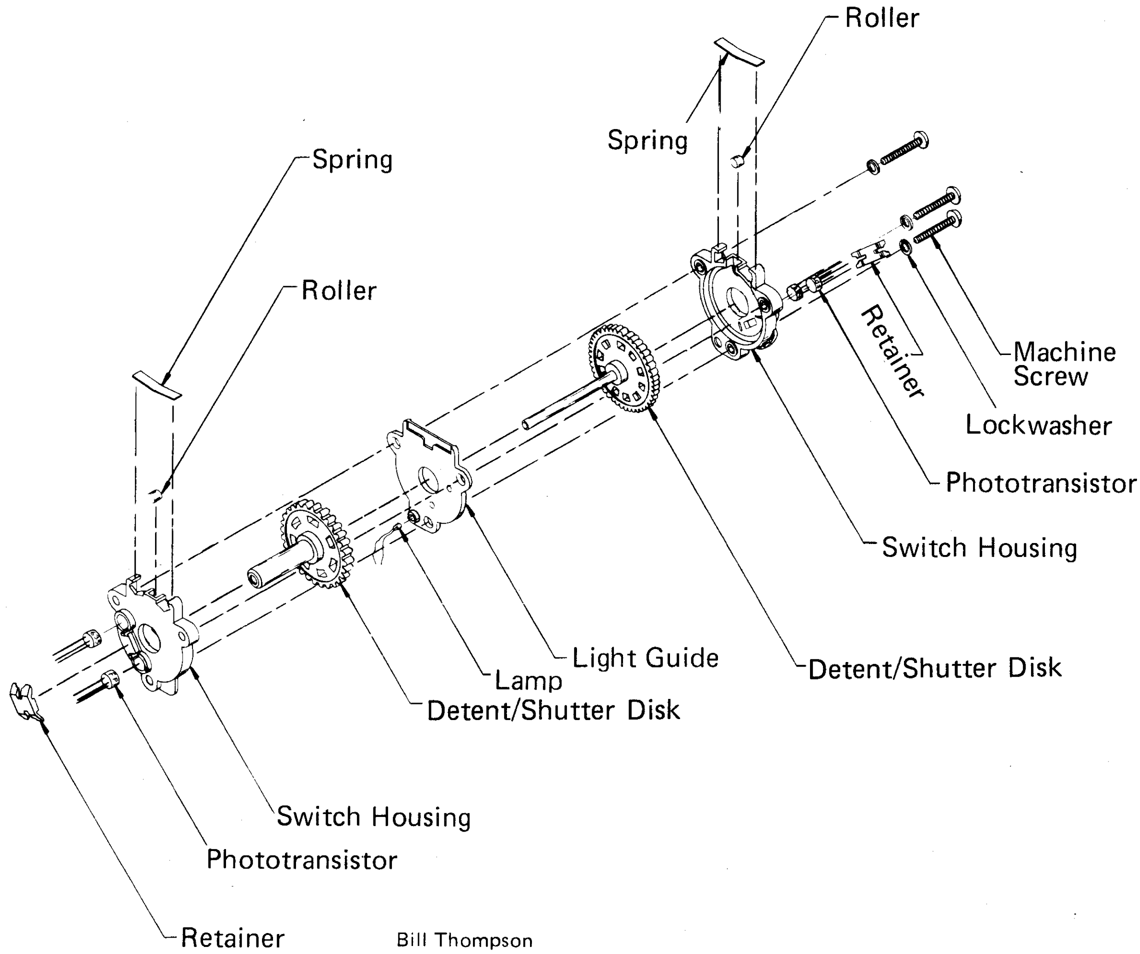
Table 1. Failure Rate Data Comparison

Part Type	Instrument	Application	Junction Temp.°C	Failure Rate %/Year	Ratio	Failure* Rate Ratio Using Model
151-0446	465	Vert. Output	90	.07	1	1
151-0446	5440	Vert. Output	100	.2	2.8	2.6
151-0127	465	Sweep. Gen.	75	.08	1	1
151-0127	455	Vert. Output	85	.22	2.75	2.8
151-0127	T922	Vert. Output	90	.36	4.5	4.5

Notes: Junction temperature data assumes instrument external ambient of 25°C; data derived with assistance of G. Ermini and H. Bloom. T922 data based on half-year average instrument age.

*Model calculations assumed 1.1 eV activation energy.

For more information or comments, contact Ron Schwartz, Component Reliability Engineering, ext. 6511.



Tek designs optical switch

An optical switch, Tek P/N 263-0027-00, has been developed for use in the CG551P calibration generator. The switch, perhaps better described as a "bidirectional incremental shaft position encoder" is a dual unit with concentric shafts for both coarse and fine adjustments.

A light guide collects light from an incandescent lamp and reflects it outward in four beams (two for each unit of the switch). The reflected light is either blocked or allowed to pass, depending on the positions of detent/shutter disks which rotate with the shafts. Phototransistors, placed in windowed receptacles of the housings, detect the presence or absence of light.

The positionings between the housing windows and the detent/shutter disks are such that one, and only one, phototransistor changes state each time a shaft is rotated one detent. This produces a Gray Code signal which can be analyzed by electronic circuitry to detect the direction and amount of rotation.

Cost of the switch is estimated to be in the $5 range.

For additional information please contact George Pratt, Switch Design, ext. 5531.

Seminars & Announcements

GPIB user's group formed

Several groups within Tektronix are engaged in the use of test and measurement instruments controlled by the General Purpose Interface Bus (IEEE STD 488). Unlike the designer of GPIB compatible instruments who must be intimately acquainted with minute details of the three wire handshake, state diagrams, etc., these users are more interested in what instruments are available, what restrictions and limitations exist, and how to program the controller.

The incidental user soon finds that to dig out and understand the relevant information requires an amount of time which might better be devoted to the primary test and measurement task. As usual in such cases, the best source of knowledge is an informed colleague. To this end, an informal "User's Group" has been formed for the purpose of information exchange. The group currently meets for a short session at 8 a.m. Wednesdays in room B, building 58.

If you are interested in participating, call Elmar Wefers, ext. 6412, or Jim Deer, ext. 6365.

High-speed logic family

Fairchild Semiconductor's high-speed logic family is now more attractive for use at Tektronix. Signetics Inc. has announced that they will be second-sourcing the Fairchild F100K series of super high-speed logic devices. Their plans include the introduction of 27 SSI and MSI devices and three memories.

Production of these components should begin in the third quarter of 1977, and all devices should be available before the end of 1979. The parts will be manufactured by RTC of France, another subsidiary of Phillips.

For more details contact Dave Sutherland (39-015), ext. 6301.

Surge tester available

A surge tester is available from Component Evaluation. This device makes it possible to evaluate the inrush characteristics of an instrument. Thus, it is easier to select fuses, switches and other components to be used in the instrument.

With the surge tester you will need a storage oscilloscope, three coaxial cables and a short power cord. There are three outputs from the surge tester; current (1A/10mV), voltage (10V/V), and trigger.

There are two modes by which the surge tester will turn on the line — continuous and one-half cycle only. The continuous mode permits turn on at any phase angle from 0° to 360° and the line will stay on. The "one-half cycle only" mode will turn the line on at any phase angle from 0° to 180° and will turn the line off at 180°. Using the "one-half cycle only" mode permits the power transformer to be magnetically polarized. This will produce the largest surge from a transformer power supply. The continuous mode is useful for evaluating our high efficiency power supplies. Turning on the line at 90° typically will give the largest surge current to charge the input capacitors.

Mailing list on computer

The mailing list for **Component News** has now been entered on a master computer file which will generate the mailing labels for each issue. If you have moved or we have an incorrect address, please contact the mailroom on ext. 5407 or call Gloria Colestock, Technical Communications, ext. 6867.

Connector recommendation

Connector P/N 131-1784-00 is **definitely** not recommended for use in new designs.

For details contact Larry Berry (58-299), ext. 5417.

U.S. field failure reporting trend

Year	Total Reports	Component Related (%)	CRT (%)	Work (%)
1976	37,389	81.46	9.59	8.95
1975	31,329	75.83	15.65	8.52
1974	23,515	80.02	9.21	10.77
1973	19,918	76.15	11.19	12.66

data compiled by Clair Gruver, Reliability Engineering (58-176), ext. 5279

TECHNICAL STANDARDS

new publications on file

ANSI Z129.1 – 1976 The Precautionary Labeling of Hazardous Industrial Chemicals
ASME Y14 Report (1976) Digital Representation of Physical Object Shapes
CSA Preliminary Standards –
- Z299.1 – 1975 Quality Assurance Program Requirements
- Z299.2 – 1975 Quality Control Program Requirements
- Z299.3 – 1975 Quality Verification Program Requirements
- Z299.4 – 1975 Inspection Program Requirements

EIA RS–423 (1975) Electrical Characteristics of Unbalanced Voltage Digital Interface Circuits
EIA RS–429/IPC–FC–218B (ANSI C83.110–1976) Industry Standard for Connectors, Electrical Flat Cable Type
IEC 351–1 Expression of the Properties of Cathode-Ray Oscilloscopes–Part I: General; Part 2: Storage Oscilloscopes, 1976.
ISO 1155–1973 (E) Information Processing–Use of Longitudinal Parity to Detect Errors in Information Messages
Metric Fastener Standards 1976 – by Industrial Fasteners Institute
MIL–STD–1693 (YD) (1976) Fabrication Welding and Inspection of Hyperbaric Chambers and Other Critical Land-Based Structures
MIL –STD–35–90 (MI) (1976) Automated Engineering Document Preparation System; Paint, Varnish, Lacquer and Enamel
MIL–STD–35–111 (MI) (1976) Automated Engineering Document Preparation System, Insulation, Electrical
NBS Vol. 79A Jan. to Dec. 1975, Physics and Chemicstry Section A, Journal of Research
UL1410 Standard for Television Receivers and Video Products–Revision pages (Jan 1977)

new part number standard

062-1736-00, Communications Standard, Glossary of Technical Terms. This glossary is a reformat and update of alpha standard A-101. It contains terms relating to Cathode Ray, Optical, Spectrum Analyzer, Oscillator, Sampling Scope, Digital and General Purpose Lab Scope. Copies are available from Reprographics (ext. 5577).

drawing labels

Technical Standards has a supply of metric stick-on labels for metric drawings. Call ext. 7976 to obtain a supply.

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

The McDonnell Douglas Corporation has combined material from the American National Metric Council, the International SI Standard, the American National Standard, the DOD SI Standard, and the NASA SI Standard, into a 41 page Metric (SI) Manual. This manual is now available to the public.

We have reviewed this publication and purchased one for Technical Standards. The convenience of having extensive categorized tables of basic and derived units, guidelines for conversion, and both an alphabetic and a classified listing of conversion units makes this an excellent "first line" reference work for the use of the SI Metric System. Copies may be ordered through Technical Standards for $5 by calling Carol Schober, ext. 7976.

Chuck Sullivan, Technical Standards

ComponentNews NewComponents

This page will be a regular feature in future issues of Component News. It 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. For details on these devices contact the appropriate evaluation engineer.

Vendor	No.	Description	when available	Tek P/N	approx. cost	engineer to contact
		analog devices				
Motorola	MR751	6A Rect., 100V, axial lead	now	152-0659-00	$ .45	Gary Sargeant
Motorola	MR856	3A Rect.,600V, Fast Recovery	now	152-0661-00	.75	Gary Sargeant
Motorola	———	5V ± 1% zener, 400mW	now	152-0662-00	.49	Gary Sargeant
HP	5082-2800	70V Schottky signal diode	now	152-0664-00	.70	Gary Sargeant
Motorola	MV109	Hyper-abrupt varicap, 29pF	now	152-0665-00	.65	Gary Sargeant
GI	WO8M	Small bridge rect., 800V, ¾A	now	152-0666-00	.50	Gary Sargeant
Motorola	———	3.0V ± 2% zener, 400mW	now	152-0667-00	.45	Gary Sargeant
GI	KBPC 802	6A bridge rect., 200V	now	152-0668-00	.90	Gary Sargeant
Motorola	1N5380B	120V ± 5% zener, 5W	now	152-0669-00	1.50	Gary Sargeant
Varo	———	Schottky rect., 35V,3A	now	152-0670-00	3.57	Gary Sargeant
TRW	———	Very-fast rect., 3A, 50V	now	152-0672-00	2.00	Gary Sargeant
Motorola	MVAM 115	Hyper-abrupt varicap, 480pF	now	152-0673-00	1.25	Gary Sargeant
HP/Alpha	———	Beam lead Schottky, 18 GHz	now	152-0675-00	4.00	Gary Sargeant
GI/Sensitron	———	1200V rect., 3A	now	152-0676-00	1.50	Gary Sargeant
GHz Devices	———	Snap-off diode chip, 150pS	now	152-0678-00	2.90	Gary Sargeant
TI	TL430	Programmable TC zener	now	———	.53	Gary Sargeant
Motorola	MC3420	Switching regulator control	now	———	4.–5.	John Hereford
Motorola	MC3423	Overvoltage detector	now	———	1.50	John Hereford
Motorola	MC3405	Dual op amp & dual comparator	Feb.	———	2.00	John Hereford
Siliconix	L144	Micropower triple op-amp *	now	———	4.00	Jack George
Siliconix	L161	Micropower quad comparator *	now	———	2.00	Jack George
		*both operate with ±1.5 volt supply				
Siliconix	LD130	3-digit DVM chip	now	———	6.50	Jack George
Motorola	MC14433	3½-digit DVM chip	now	———	6.75	Jack George
Motorola	MC3410C	10 Bit D/A converter	now	———	6.50	Jack George
National	DA1200	12 Bit D/A converter	Feb.	———	20.00	Jack George
National	MM5357	8 Bit A/D converter	now	———	6.00	Jack George
		digital devices				
TI	74LS374	Octal D-flip flop (3-state)	March	———	———	Wilton Hart
TI	74LS26	Quad 2-Input NAND (high voltage)	now	156-0970-00	.38	Wilton Hart
TI	74LS173	Quad D register (3-state)	now	156-0951-00	.80	Wilton Hart
TI	74LS241	Octal 3-state driver	now	156-0955-00	1.23	Wilton Hart
TI	74LS244	Octal 3-state driver	now	156-0956-00	1.23	Wilton Hart
TI	74LS169	4-Bit binary counter—syn. res.	now	156-0957-00	.80	Wilton Hart
TI	74LS85	4-Bit magnitude comparator	now	156-0953-00	.82	Wilton Hart
National	———	16K CMOS hybrid RAM	now	———	300.00	Wilton Hart
National	74C10	Triple 3-input NAND gate	now	156-0938-00	.34	Wilton Hart
National	74C00	Quad 2-input NAND gate	now	156-0931-00	1.10	Wilton Hart
Signetics	8252708	8K PROM (1K x 8)	May	156-0973-00	18.00	Dave Sutherland
Intel	8080A	8-bit microprocessor	now	156-0954-00	10.50	Carl Teale
TI	9900	16-bit microprocessor (single source)	now	156-0935-00	85.00	Carl Teale
		electromechanical devices				
Chicago Switch	24-420-120	Slide Switch, DPDT Solder flow & wash	now	———	.50	Joe Joncas
Oak	Communicator series	Rotary Switch, up to 60 position	now	———	2.–3.	Joe Joncas
Digitran	37000 Series	Rotary Switch, 24 & 40 position	soon	———	2.–4.	Joe Joncas

Care and feeding of calculator batteries

NiCd calculator batteries perform best when used as portable devices without the AC line adapter. To insure long life and full capacity, read the instructions included with your calculator and follow the recommendations.

Calculator batteries should be cycled: discharge fully, (terminal voltage not less than 1V), then recharge completely. Observe the low voltage indicator in the instructions for your particular calculator. Repeated discharging and recharging to the same partial level may develop a memory in the cell, making the battery deliver at less than capacity. If the cell is run to a partial discharge state only a few times, one complete discharge will remove this memory.

When a battery pack fails to accept a charge (generally indicated by a short operating life), the individual cells should be discharged through a 5Ω resistor on **each** cell. Discharge the cells to less then ½V. Then, charge the battery according to the instructions. This should restore the charge balance in the pack.

If this procedure fails to restore the battery to near capacity, one or more cells may need to be replaced. When replacing cells the capacity should be equalized as explained above.

Basically, there are two types of calculator battery chargers — quick charge (restores pack in 4 - 6 hours) and normal charge (restores in 14 - 16 hours). Calculators requiring a quick charge rate should not be left on indefinitely. This runs the battery pack into excessive overcharge.

A good rule of thumb, in either case, is to terminate the charge cycle when a perceptable rise in temperature occurs in the pack.

Tek does not part number or carry replacement battery packs for calculators. For replacement details contact a Maintenance Repair Operations (M (MRO) buyer. For additional battery information contact Byron Witt (58-299), ext. 5417.

Ribbon cables part-numbered

The following flat ribbon cables have recently been Tek part-numbered:

Tek P/N	No. of conductors	Construction	Rating (Volt/Temp)	UL Style
175-5058-00	20	No. 28 (7 X 36)	300/105°C	2651 FR–1
175-1525-00	26	No. 28 (7 X 36)	300/105°C	2651 FR–1
175-1084-00	34	No. 28 (7 X 36)	300/105°C	2651 FR–1
175-1941-00	40	No. 28 (7 X 36)	300/105°C	2651 FR–1
175-1689-00	50	No. 28 (7 X 36)	300/105°C	2651 FR–1

For more information contact Norm Babcock (58-299), ext. 5417.

COMPONENT EVALUATION ENGINEER LISTING

Information concerning purchased components can be obtained by contacting the Component Evaluation engineer listed below. The Electromechanical group is located at **58-299** (all others at 39-015).

ATTENUATORS	Norm Babcock 5417
BATTERIES	Byron Witt 5417
BULBS, lamps and holders	Byron Witt 5417
CABLES	Norm Babcock 5417
CAPACITORS	
ceramic, mica	Ray Powell 6520
electro., film, variable	Merle Hendricks 5415
high-voltage	Harry Ford 6520
COILS	Byron Witt 5417
CONNECTORS	Larry Berry 5417
CORES, FERRITE	Byron Witt 5417
CRYSTALS	Byron Witt 5417
DIODES	
LED's, photo	Louis Mahn 6389
all others	Gary Sargeant 5345
FANS	Bill Stadelman 6365
FET's	Jerry Willard 7461
FILTERS	
air	Rod Christiansen 5417
light	Jim Deer 6365
line	Norm Babcock 5417/Herb Zajac 7887
FUSES, FUSEHOLDERS	Joe Joncas 6365
GASKETS, shielding	Norm Babcock 5417
HARDWARE	Rod Christiansen 5417
HEAT SINKS	Jerry Willard 7461
INDUCTORS	Byron Witt 5417
INTEGRATED CIRCUITS	**see microcircuits**
KEYBOARDS	Jim Deer 6365
KNOBS	Rod Christiansen 5417
LAMPS, LAMP SOCKETS	Byron Witt 5417
LIGHT-EMITTING DIODES	Louis Mahn 6389
MAGNETIC TAPES	Byron Witt 5417
MECHANICAL PARTS	Rod Christiansen 5417
METERS	
general	Joe Joncas 6365
digital panel	Louis Mahn 6389
MICROCIRCUITS	
ECL, Schottky	Dave Sutherland 6301
CMOS, low-power Schottky	Wilton Hart 6303
MICROCIRCUITS, continued	
comparators, converters, linear	Jack George 6700
memories	Eric Peterson 6302
op amps, regulators	John Hereford 6700
TTL	Bob Voll 6302
MICROPROCESSORS	Carl Teale 6301
peripherals	Bill Pfeifer 6302
MICROWAVE components	Byron Witt 5417
MOTORS and generators	Bill Stadelman 6365
MULTIPLIERS, high-voltage	Gary Sargeant 5345
OSCILLATORS	Byron Witt 5417
POTENTIOMETERS	Gene Single 5302
POWER CORDS	Norm Babcock 5417
READOUT DEVICES	Louis Mahn 6389
RELAYS, mech. & solid state	Paul Johnson 6365
RESISTORS	
fixed	Ray Powell 6520
variable	Gene Single 5302
SCR's, SCS's	Joe Joncas 6365
SHIELDS	Byron Witt 5417
SLEEVES, INSULATING	Norm Babcock 5417
SOCKETS	
crystal, lamp	Byron Witt 5417
all others	Larry Berry 5417
SWITCHES	
general, solid-state	Jim Deer/Joe Joncas 6365
reed	Paul Johnson 6365
TERMINAL PINS	Larry Berry 5417
TERMINATIONS	Norm Babcock 5417
THERMISTERS	Ray Powell 6520
TRANSDUCERS	Byron Witt 5417
TRANSFORMERS	Byron Witt 5417
TRANSISTORS	
field-effect, power	Jerry Willard 7461
small signals, arrays	Neal Sorensen 7711
triacs, unijunctions	Joe Joncas 6365
TUBES, voltage reference	Gary Sargeant 5345
TUBING, plastic insulating	Norm Babcock 5417
WIRE	Norm Babcock 5417

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Dick Dunipace 39 311