component news

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Intel Magnetics 1M-bit bubble memory evaluated

The Intel Magnetics 7110 is a very high density 1M-bit non-volatile, solid state memory utilizing magnetic bubble technology. In our evaluation of the 7110, we investigated several aspects of the bubble system, including:

- ☐ the software command set,
- ☐ data reliability and error rates,
- ☐ powerfail protection,
- ☐ timing, and
- ☐ bubble detection.

This preliminary report discusses our results on powerfail, timing and bubble detection, as well as indicating some potential problems uncovered using the 7110.

The Intel Magnetics bubble memory system consists of six single chip devices, including the 7220 bubble memory controller (BMC). The other devices required for a minimal 128K-byte system include the 7242 dual formatter/sense amplifier (FSA), the 7230 current pulse generator (CPG), the 7250 coil pre-driver and two 7254 quad drive transistors (see Figure 1). The data was compiled using the following devices in our bubble system:

7110-1 — 7ck5
7242 — G-step
7230 — S-6531
7220 — D-step
7250 — 939B2
7254 — 7914 prototype (2)

All external powerfail and synchronization was designed based on preliminary 7220BRD (board) requirements.

Powerfail

In order to remain non-volatile, the power-down or reset of the bubble memory must be synchronized to the rotation of the magnetic drive field of the bubble. The 7110 block replicate architecture also allows a powerfail or reset to occur without having to bring data back around from "major loops" (as with earlier bubble devices). The shutdown of the drive field must be orderly to assure bubble integrity.

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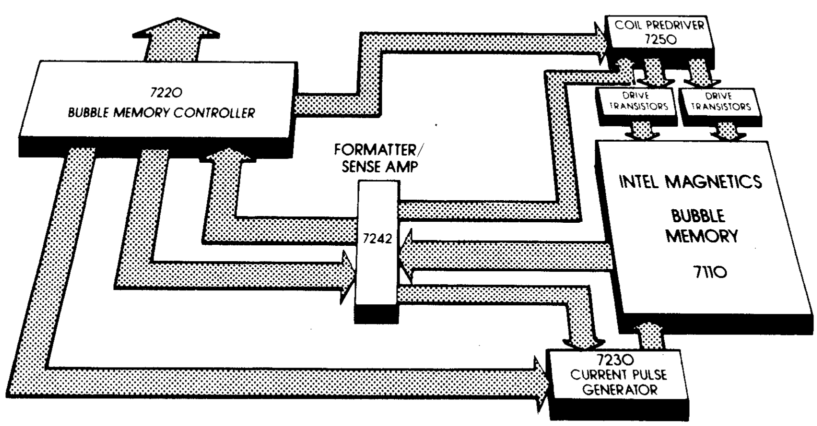

Figure 1 — Block diagram of the 128K-byte system

Also in this issue

The waveform in Figure 2 shows X+/ and Y−/ drive coil phase timing signals when a powerfail is detected. The response of the 7220 is to reset the outputs of the 7250 and turn off the drive transistors (7254) at the proper phase. About 110μS elapsed from the time the 7230 CPG detected power-down to the orderly shutdown of the coil drive field.

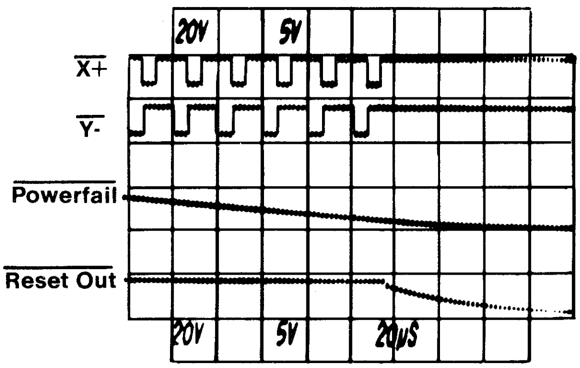

Figure 2

The waveform in Figure 3 shows the X+/ and Y−/ timing signals along with the drive coil current (10mV/mA). The peak current in the X (inside) coil was 1.1 amps. In the Y (outside) coil the current was 1.4 amps.

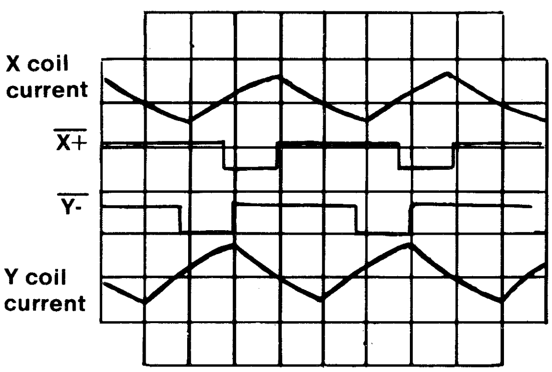

Figure 3

Figure 4 is a Lissajous figure produced by the drive field X and Y coils. The vertical line shows the zero phase angle where the coil current (and the magnetic drive field) turns off during a power off sequence. This corresponds to the start and stop of the field rotation. The phase angle increases in a counter-clockwise rotation. The peak of the X coil current occurs at 378 degrees or 18 degrees after the 0 degree phase angle.

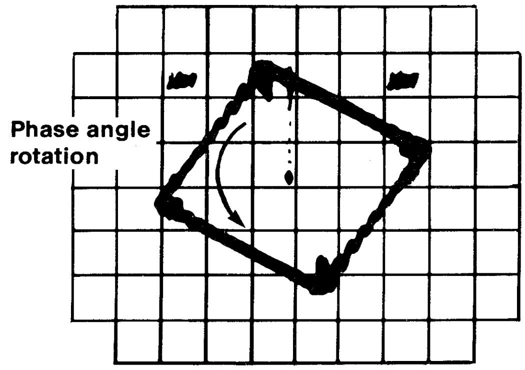

Figure 4 — Lissajous of X and Y coil currents

The powerfail detection in the early versions of the 7230 depends on the voltage drop across a pair of resistors (or diodes) in series with the Vdd (+12 volts) and Vcc (+5 volts) inputs. Our powerfail threshold was found to be +4.89 volts for Vcc (97.8%) and +10.68 volts for Vdd (89.0%). The S-6590 version of the 7230 does not require these external components and should more closely match the 94% threshold indicated by Intel Magnetics.

Timing

All timing required for operation of the 7110 is supplied by the 7220 bubble memory controller. Because communication between the 7220 and the 7110 is synchronized to the drive field, the timing is often specified in degrees of rotation rather than in time. For comparison and convenience, the timing for various signals for the 7220 is given both in degrees and time in Table 1 (page 3).

Figure 5 (page 3) shows the read timing during the initialize command. The TM.A/ (cut/) and TM.B/ (transfer/) timing signals are used to generate the two-level pulse necessary for replication of the bubbles from the storage loops to the output track. The read cycle cut and transfer signals occur at 270° (or 15μS) from the beginning of the field rotation.

The two-level pulse used for cut and transfer during replication of bubbles is defined in Figure 6. The write cycle cut and transfer pulses alternate from odd to even quadrants in alternate field rotations. Figure 7 depicts the end of the "odd" cycle and the start of an "even" cycle.

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Signal	Start		Width		End	
	Degrees	Time	Degrees	Time	Degrees	Time
X+/	270	15μS	108	6μS	378	21μS
Y+/	0	0μS	108	6μS	108	6μS
X−/	90	5μS	108	6μS	198	11μS
Y−/	180	10μS	108	6μS	288	16μS
TM.A/(ODD)	270	15μS	4.5	250nS	274.5	15.25μS
TM.A/(EVEN)	90	5μS	4.5	250nS	94.5	5.25μS
TM.B/(ODD)	270	15μS	90	5μS	360	20μS
TM.B/(EVEN)	90	5μS	90	5μS	180	10μS
BOOT.EN/	252	14μS	108	6μS	360	20μS
REP.EN/	252	14μS	108	6μS	360	20μS
SWAP.EN/	180	10μS	517	28.7μS	687	38.7μS
BOOT.SW.EN/	180	10μS	DC*		180	10μS
SHIFTCLK(RD)/	186.75	10.4μS	99	5.5μS	285.8	15.9μS
SHIFTCLK(WR)/	72	4μS	288	16μS	360	20μS
* Stays low for 4118 field rotations when writing bootloop						

Table 1 — 7220BRD BMC timing

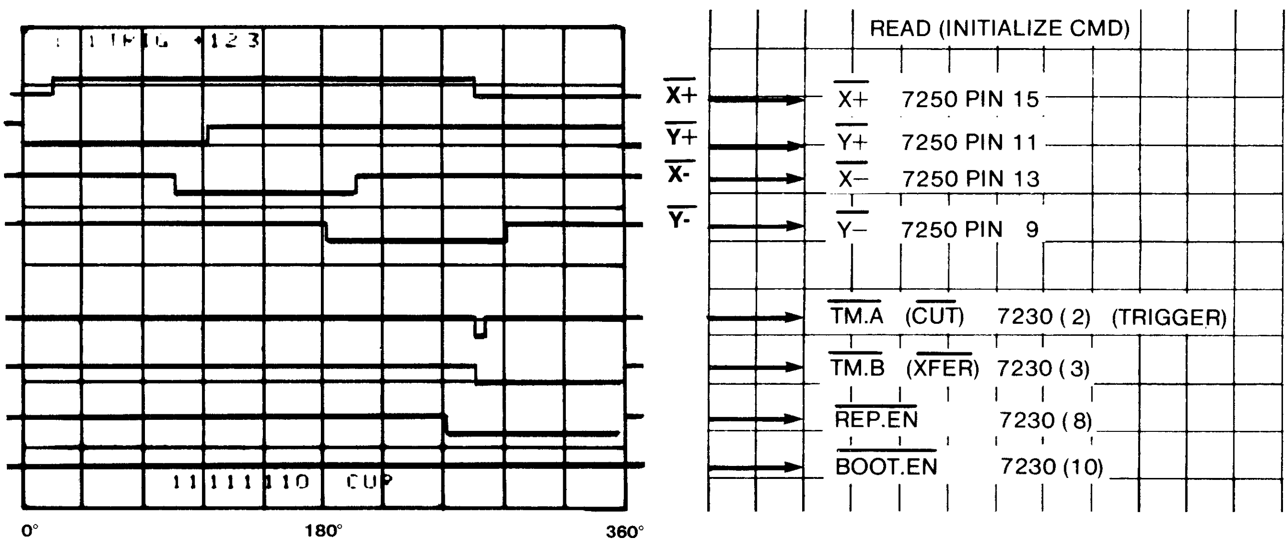

Figure 5

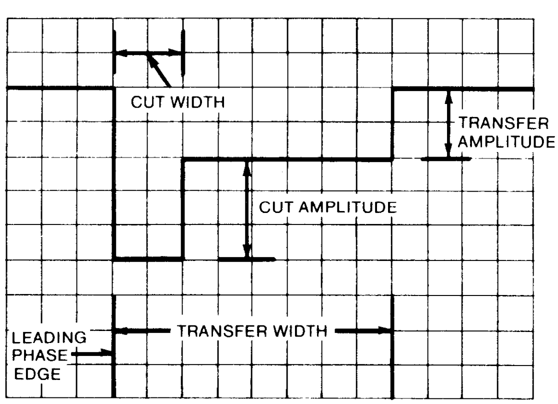

Figure 6

Actual replicate pulses are shown in Figure 8 (page 4). Each replicate causes data from all the storage loops to be replicated on the output track where they are transferred to the detectors. The cut pulse width was measured to be 180nS at 7.0 volts. The transfer pulse width was measured to be 5.0μS at 9.2 volts.

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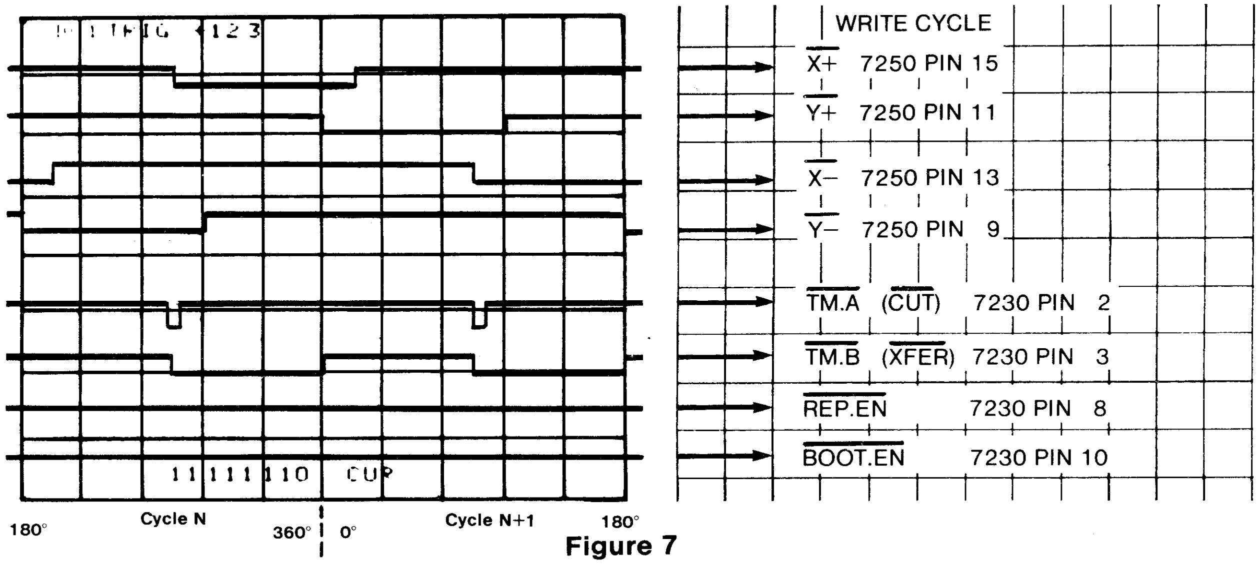

Figure 7

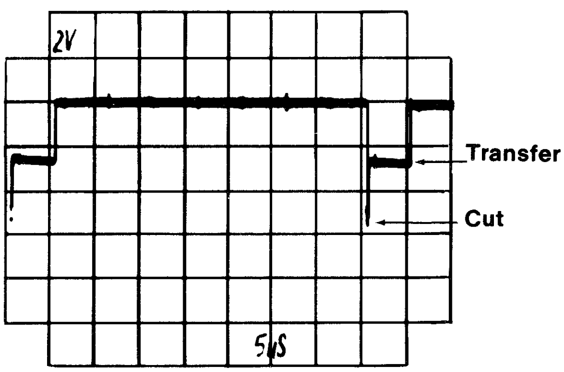

Figure 8 — Replicate during read

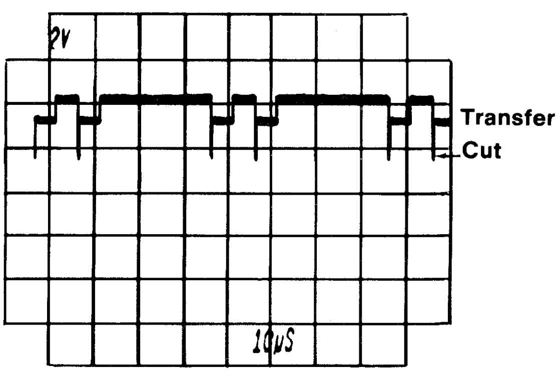

Figure 9 — Seed replicate during write

The 7110 bubble memory uses permanent "seed" bubbles to generate bubbles when writing. The generate is actually a replicate of the seed bubble. Figure 7 shows the timing of the generate of bubbles from seeds, and Figure 9 shows the actual waveforms. The cut pulse width was 180nS at 9.0 volts. The transfer pulse was measured to be 5.0µS at 11.0 volts.

The process of transferring data from the input track to the storage loops is called a swap. The waveform in Figure 10 shows a swap pulse during a write command. The new data is swapped onto the storage loops. The old data is swapped from the storage loops onto the input track where it is moved into the guardrail, which serves to annihilate the bubble. The swap pulse width was measured to be 28.8µS at 5.0 volts.

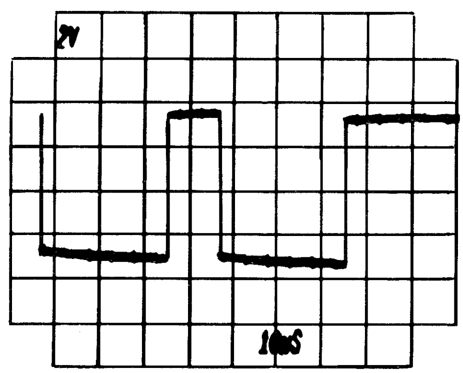

Figure 10 — Swap pulse

The waveform in Figure 11 (page 5) is the serial communication between the 7220 controller and the 7242 formatter/sense amp. The 7220 raises C/D to indicate a command is coming and simultaneously outputs a SYCNC/ pulse. The actual serial data is then transmitted on the DIO line. The 7242 FSA can execute 13 different commands, each being sent over the DIO line by the 7220 BMC.

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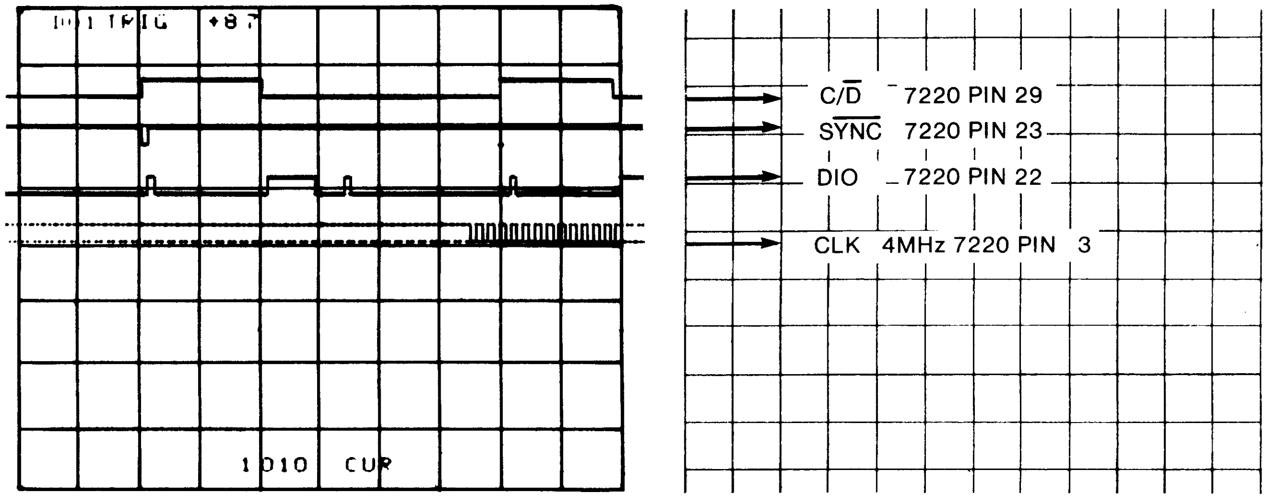

Figure 11 — Bubble controller-FSA serial communication

Bubble detection

The presence or absence of a bubble is detected by stretching the bubble and passing it over a magnetoresistive element in the detector of the bubble memory. The bubble is then sent into a guardrail and annihilated. In addition to the active magnetoresistive element there is a dummy element, and both are connected in bridge configuration (see Figure 12). The SHIFT.CLK/ signal is used to synchronize the movement of the bubble across the element, and for the actual detection. The waveform in Figure 13 (page 6) shows both the voltage when a bubble is present, and also when a bubble is not. We found the differential voltage between a "one" and a "zero" to be about 5.0mV. Intel Magnetics specifies the nominal voltage to be 8.0mV with 1.5mV of noise.

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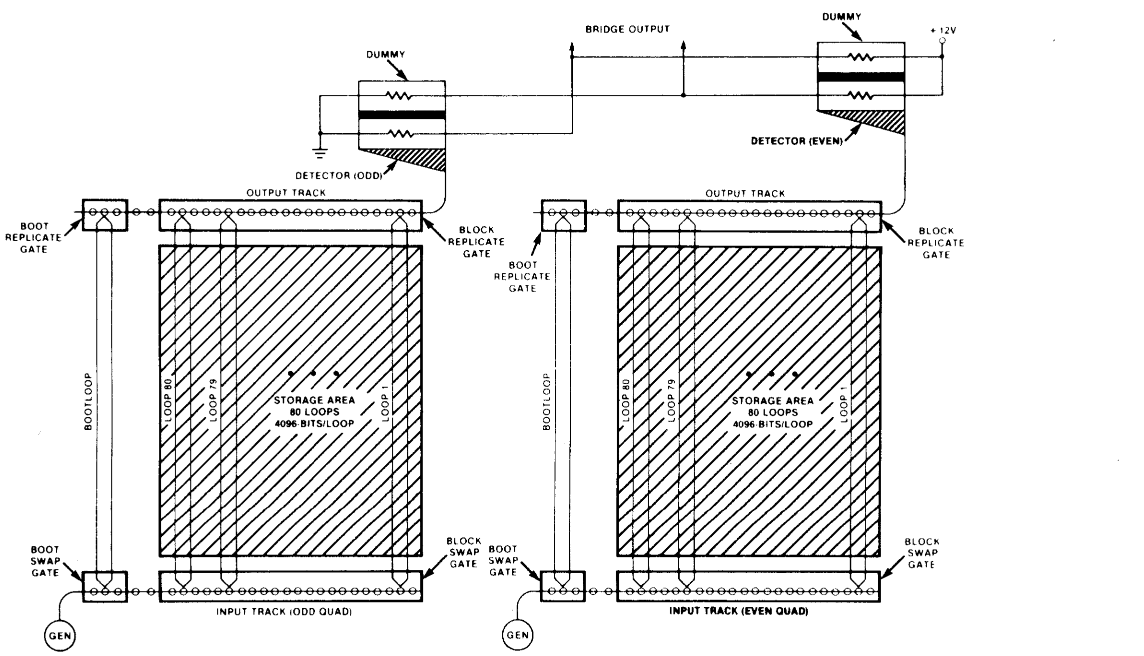

Figure 12 — 7110 bubble memory architecture (one half shown)

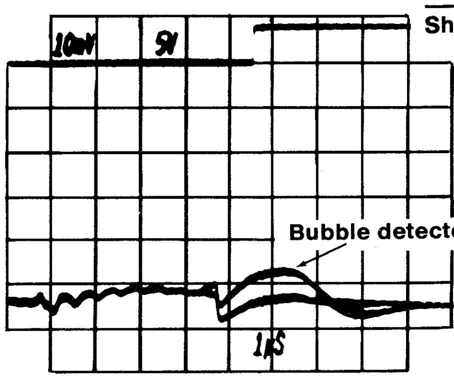

Figure 13

Potential problem areas

As soon as our evaluation of the Intel Magnetics 7110 began it was evident that this new technology was not fully mature. Every few months a new iteration of the devices was released. To date the Intel Magnetics bubble and its support components have gone through at least three iterations, and a potential user should be aware of this as he/she begins to seriously look at the 7110 (see Table 2). The bubble memory socket has also undergone several changes. The 7250 and 7254 appear to be unchanged.

Mixing these various components can be done but may cause problems — usually in the form of higher error rates (ranging from a few errors to continuous errors). Later versions do not require zero suppression feedback on the detector inputs. Also, some resistor values have been changed or are removed from the circuit.

The 7220BRD is a printed circuit board containing a 7220 controller and assorted external components along with a 40-pin connection on the bottom for plugging into a standard 40-pin socket. The 7220BRD is to be used as a plug-in replacement for the "final" 7220, because it incorporates all of the bus synchronization powerfail and reset synchronization that the D-step requires. Intel Magnetics guarantees the "final" version of the 7220 will be compatible with the 7220BRD. You can design around the 7220BRD, but it should be noted that the filtering and RC timing networks now supplied on the 7220BRD must be supplied externally when the "final" 7220 IC is installed.

Conclusion

Bubble memory technology has reached a level where it can be seriously viewed as a reliable, nonvolatile mass storage medium. The Intel Magnetics 7110 bubble memory has shown that it is a viable system, even with the many component revisions. Also, Intel Magnetics has indicated a dedication to supporting their product, and have provided much expertise in helping us bring up our own bubble system at Tek.

Because this is a new technology, new tools are being developed to more thoroughly evaluate the reliable operation of bubble memory systems. Memory and I/O Component Engineering will continue to develop the necessary evaluation techniques to enable us to fully characterize bubble memories, as well as support Tek users in product development. By next year the 7110 should be a well established component, ready for introduction into new Tektronix products.

Anyone wishing further information or help on bubble memories can contact me on ext. DR-2557.

Brad Benson
Memory and I/O Component Engineering

	7110 1M-bit Bubble	7242 Formatter Sense Amp	7230 Current Pulse Generator	7220 Controller
1979	7110 single letter or AA-BZ	B-step (ES)B	S-6392	———
1980	7110-1 CA-HZ	B-step (ES)B	S-6531	C-step, D-step
1981	7110-1 ZZ-JA	G-step (ES)	C-step S-6590	D-step, 7220BRD

Table 2

How much do those digits cost?

Our *Designer's Guide to Flat Panel Displays* does a good job of discussing various types of displays — LED, plasma, fluorescent, etc, and how they compare for such things as power consumption, viewing angle and brightness. One thing it does not discuss is price.

The four major types of display technologies are plasma display panels (PDPs), liquid crystal displays (LCDs), light-emitting diodes (LEDs) and vacuum fluorescent displays (VFDs). The following cost comparison will be limited to these four display types.

It's difficult to compare the price of different display technologies because, in order to be fair, one must compare displays with similar physical characteristics such as character height, number of characters, type of characters, etc. However, it's just not possible to select one of each of the four technologies with such things in common and give a 'dollar-per-digit' or 'dollar-per-character' figure to compare the display types. Therefore, a price comparison is made here by showing the average price of four or five popular configurations of each of the four display types.

NOTE: The following prices are for single units, some technologies permit volume pricing to lower the cost more rapidly.

The end cost is further complicated by the differences in driving circuitry, power supply costs, reliability and replacement costs. The display may also affect the marketability of the instrument because of its size, appearance, viewing angle, legibility in various light conditions and power consumption.

It's apparent that determining such things as the price and value of various displays can be complicated. If you need assistance with the selection of a display, contact me or consult the *Designer's Guide to Flat Panel Displays.* I have many copies of the guide available.

Al LaValle
78-552, ext. DR-2317

Description	Character Height (Inch)	Price ($)
LED		
1 digit, 7 segment	0.3	2.00 - 2.85
2 digit, 7 segment	0.5	3.00
8 digit, 7 segment	0.1	10.00
4 character dot matrix (with drive circuitry)	0.15	44.00
LCD		
3½ digit, 7 segment	0.5	14.00 - 25.00
6 digit, 7 segment	0.5	22.00 - 28.00
8 — 13 character dot matrix	0.175 - 0.250	25.00 - 40.00
40 character dot matrix (with drive circuitry)	0.175 - 0.250	115.00 - 150.00
PDP		
2 digit, 7 segment	0.33	6.00
6 digit, 7 segment	0.7	20.00
16 digit, 7 segment	0.4	50.00 - 80.00
16 character dot matrix/ 16 seg. (w/ drive circuitry)	0.5	170.00 - 200.00
40 character dot matrix (with drive circuitry)	0.25	230.00 - 250.00
VFD		
2 digit, 7 segment	0.3 - 0.4	5.85
5 digit, 7 segment	0.4	6.40
20 character dot matrix	0.3 - 0.5	33.60
20 character dot matrix (with drive circuitry)	0.2	255.00
40 character dot matrix (with drive circuitry)	0.2	300.00

Design change eliminates double triggering

The 555 timer is a versatile IC which has many uses in diverse applications. Due to this versatility, there is a large demand for the device, and many manufacturers sell parts called 555 timers that have the same pinouts. Despite this plethora of sources, only two manufacturers are currently qualified, and one of these was added to the PISL just two months ago. Also, the original designer of the 555 (Signetics) is not qualified at Tek. The reason for this peculiar state of affairs is at least partially revealed by Signetics in their application note for the 555:

> Double triggering of the TTL loads sometimes occurs. Why?
>
> Answer: Due to the high current capability and fast rise and fall times of the output, a totem pole structure different from the TTL classical structure was used. Near TTL threshold this output exhibits a crossover distortion which may double trigger logic. A 1000pF capacitor from the output to ground will eliminate any false triggering.

The solution offered by Signetics seems unsatisfactory at best, especially because it is possible to use the National Semiconductor and Silicon General parts without the addition of this capacitor.

Two questions are brought up by this mysterious situation — Just what does the Signetics part do that occasionally results in double triggering? And, how have National and Silicon General altered their designs to eliminate this problem?

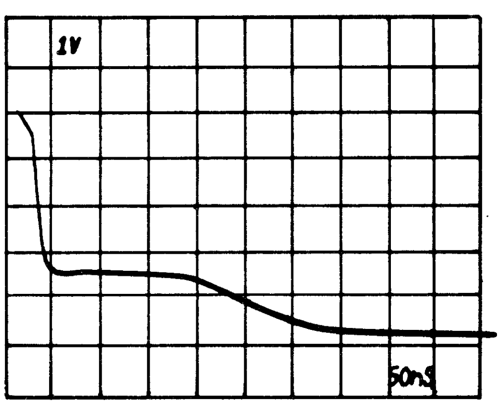

Figure 1a — Falling transition of Signetics 555 with 1K load to Vcc. Vcc = 5V.

Figure 1 reveals a plateau very near TTL's threshold voltage in the Signetics part's falling edge output waveform. The existence of this plateau is somewhat amazing in that the current necessary to drive a 1K load lies well within the 555's specifications. (Only a slightly more imaginative load is necessary to turn this plateau into a hill.)

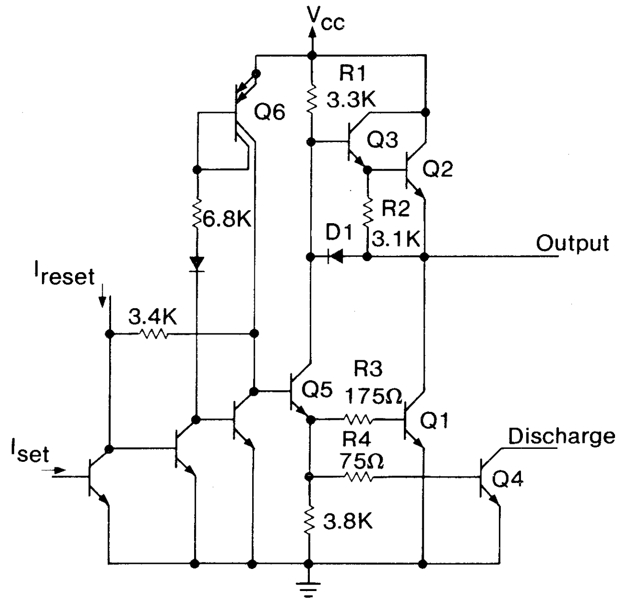

Figure 1b — Signetics 555 output and flip-flop stages

What non-"TTL classical" output stage was invented in order to create this macabre behavior? For the 555 to sink the large currents it is specified to, a significant amount of current must be supplied to the base of Q1 (see Figure 1b). To avoid having to always supply this current to Q1, even in applications where it is not necessary, Signetics devised the ingenious solution of including D1 in the output circuit so that when the output voltage rises high enough, extra base current is dumped into Q1 to keep the output from rising still higher.

This diode is actually the cause of Signetics' output plateau. Each of the three phases of the falling edge can be related to what is happening to D1. The initial rapid decrease of the output is brought about by D1 supplying significant current to the base of Q1. The plateau occurs when the output voltage has dropped to a low enough value and

continued on page 9

D1 starts to cut off. During this time, a reverse current occurs in the diode and no base current is available to Q1 or Q4, resulting in their cutoff. After D1's storage time — which is longer than might be expected due to the large ratio of forward-to-reverse current — has elapsed, Q1 and Q4 turn on again, however they no longer are receiving large base currents, so the final decay is quite slow.

A comparison of Figures 1a and 2a shows that National has achieved a significant reduction in the size of the output plateau. This improvement has been brought about by deriving the base drives of Q4 and Q5 independently and by the inclusion of D2. Empirical DC analysis reveals that, with D1 off, Q5 is capable of sinking five times more current in the National 555 than in the Signetics part. In addition, D2's presence in Q5's collector circuit increases the current available to the collector during switching. These two effects contribute to making the shut off of D1 far less catastrophic in the National part than in the Signetics 555.

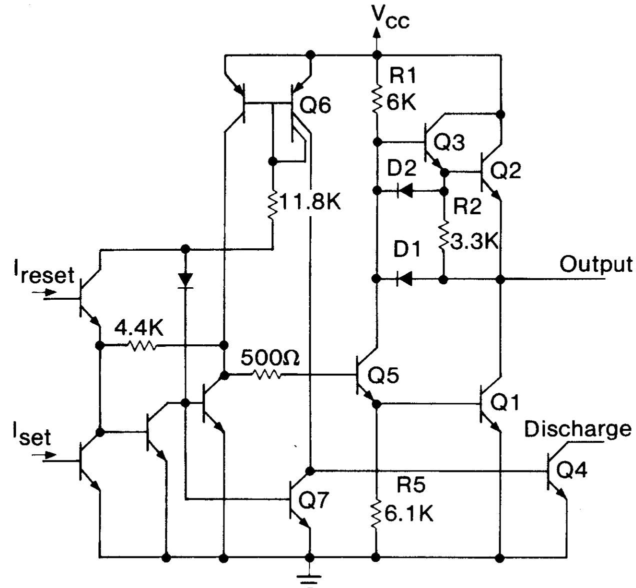

Figure 2b — National 555 output and flip-flop stages

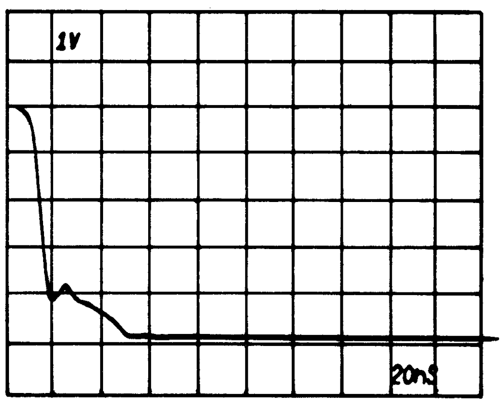

Figure 2a — Falling transition of National 555 with 1K load to Vcc. Vcc = 5V.

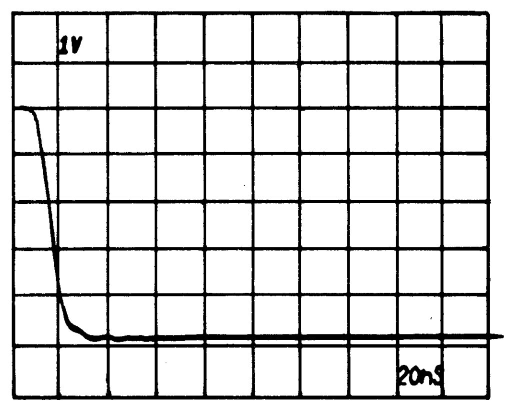

Figure 3a — Falling transition of Silicon General 555 with 1K load to Vcc. Vcc = 5V.

Figure 3a shows that Silicon General has totally eliminated the plateau from their 555's trailing edge. Figure 3b is slightly more revealing than 3a, and at least as curious as Figure 1a. Figure 3c shows that Silicon General also uses separate Q4-Q5 base drives, however, the more significant change is the replacement of R1 by an additional collector or Q6. The DC VCE-ZC curves for Q1 are almost identical to those of the Signetics part, but the increased capacitance on the collector of Q5 results in sufficient current being available to the base of Q1 to result in the output falling faster than the collector of Q5 (and D1 never turns on during switching).

After the collector of D5 discharges to its DC switched level, the output rises until D1 turns on, resulting in the bizarre wave shape in Figure 3b. Fortunately, TTL has an input impedance significantly larger than 200Ω.

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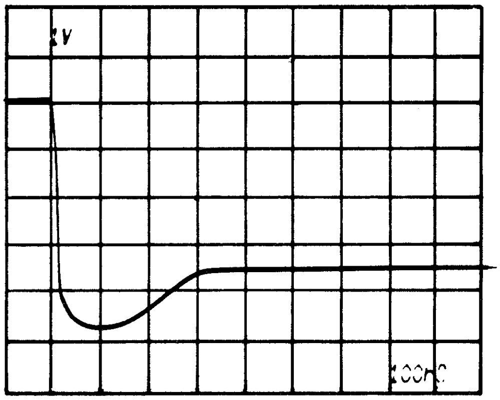


Figure 3b — Falling transition of Silicon General 555 with 200Ω load to Vcc. Vcc = 5V.

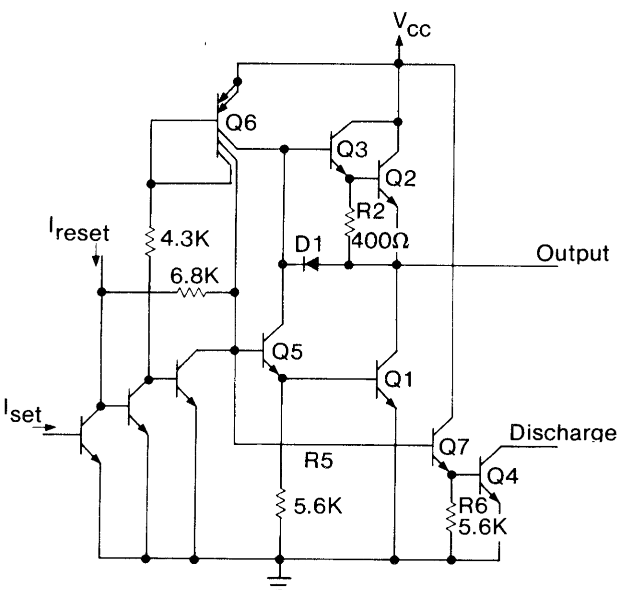


Figure 3c — Silicon General 555 output and flip-flop stages

Two approaches were taken in order to solve the problem of the Signetics 555 — National improved the DC current sinking capabilities, while Silicon General increased the AC current sinking capabilities. All of the output waveforms are less than ideal, though.

If you have any questions about this part, please contact me at 39-212, ext. DR-2940.

Eric Etheridge

New personnel in Reliability Information Services

Judy Schonard has joined our group as a Scientific Applications Programmer Analyst II. Judy will be responsible for the total Field Failure Data Base known as the 'Maxi.' Rosalyn Neuberger will continue to manage the 'Mini,' our on-line Field Failure Information System.

Judy will also be working with the European Service Record Project as well as helping Rosalyn develop an improved Plant Failure System in conjunction with the Communications Division.

Judy can be reached at 53-114, ext. MR-8007.

Clair Gruver
Reliability Information Services

Telephone/personnel changes in CTE

Effective immediately, the following telephone changes are in effect for the Component Test Engineering (CTE) group:

Dennis Crop ext. DR-1877 D/S 78-535
Allan Hawkinson ext. DR-2465 D/S 78-535
Jan Kuderna ext. DR-2483 D/S 78-535
Mike Rogers ext. DR-2460 D/S 78-535

In addition, four new employees have joined CTE. They are:

Mark Robertson (ext. DR-2463) — Performance Assurance Engineer I
Nick Nikolaou (ext. DR-2460) — Performance Assurance Engineer I
Gene Waltz (ext. DR-2478) — Performance Assurance Engineer I
Bill Pfeifer (ext. DR-1878) — Performance Assurance Engineer III

Jim Davis, manager
Component Test Engineering

Speech recognition system updated

Voice data entry (VDE) systems have been commercially available for several years. As advances continue to be made in the field of speech recognition, these systems are not only increasing in quality and sophisication, but they are becoming less expensive as well.

CE has recently upgraded and improved its VDE system so that it is now much faster (<½ second response time) and much more accurate (>99% recognition rate). This improved system is available to any interested groups for testing in new or existing applications.

The system, a Threshold 500 speech recognition system, is capable of recognizing isolated words or phrases up to two seconds in duration. The vocabulary size is limited to 64 words or phrases at any particular time, and the system must be trained for each individual operator. Training consists of the repetition of each word ten times, which provides for comparison and recognition of the phrases. Once training data has been entered, it may subsequently be stored and retrieved from tape or any other storage device. The capability also exists for retraining any number of words (from 1 to 64), while leaving the rest of the words unchanged.

The system consists of five main parts: a speech preprocessor, microcomputer and digital I/O interface (comprising the T500 terminal); a 16-character alphanumeric display; and a remote audio operator console.

The preprocessor accepts audio input from a noise cancelling microphone, extracts several speech parameters, converts them into logical signals and passes them on to the microcomputer. The microcomputer compares the received data to the training data which has been accumulated and stored in memory, and then determines which word was spoken. If a correlation is found, the appropriate output code is sent out over an RS-232 interface. The host computer may then make use of this output code, which is unique for each particular word that has been programmed into the T500. If no correlation is found, a reject indicator is lighted on the front panel of the display and no output code is generated or transmitted.

If you have any ideas on possible applications, or want more information about the system, please contact **Halsey Royden (ext. DR-2314).**

Modification corrects binding problem with extension shafts

If you have binding problems in instruments with knobs and shafts molded together, here is good news. The extension shafts have been slightly modified to correct the binding problem, and they are a direct replacement for the old type shaft. Also, the cost is reduced by half.

Ample quantities are available and you can use the part numbers listed below when you order. Instruments using these new shafts include the T900 and 442 instrument lines.

Old P/N	New P/N
384-1371-00	384-1371-05
384-1371-01	384-1371-06
384-1371-02	384-1371-07
384-1371-03	384-1371-08

Old style

New style

If you have any questions about this modification, please contact **Harvey Gjesdal (ext. DR-2986).**

8051 — Next generation microcomputer

The 8048 8 bit microcomputer was introduced in 1976 and has expanded into a family of ten parts. Most of these are variations on memory type and size, with the remainder being specialized subsets. The newest "member" of this family is Intel's 8051. An extensive redesign/new design has reduced or eliminated many of the 8048 limitations, and has provided almost an order of magnitude improvement in functions and speed.

Three 40-pin HMOS ICs will initially form the 8051 family. They are:

- ☐ 8031 — No program memory
- ☐ 8051 — ROM program memory
- ☐ 8751 — EPROM program memory

Intel is planning to begin production of the 8051 family during the first and second quarters of 1981. Production of the 8031 is slightly ahead, and some production samples may be available this quarter. Packing 60,000+ transistors on a 230 mil square die leaves open the possibility of problems, and these tentative dates could easily be set back.

While the 8051 is similar to the 8048, there are many significant differences (Figure 1 shows a block diagram of the 8051). A very noticeable hardware improvement is memory size. Internal program memory is 4K-bytes, and is externally expandable to 64K-bytes of directly accessible PROM/ROM (1K internal and 4K expandable for the 8048). 128 direct accessible RAM bytes are used as a Special Function Register area for arithmetic and data pointer registers. Internal user data memory is 128 bytes, with a "hole" available for a future 128 bytes. User RAM can be externally expanded to 64K-bytes in 256 byte indirect access pages (the 8048 has 64 bytes user RAM and is expandable to 320 bytes). Note that fully expanding would cost two 8 bit I/O ports, but not any speed.

Parallel I/O has been expanded to four, 8 bit quasi-bidirectional ports, with one port and some control pins multiplexed (27 I/O lines for the 8048). Also added is a serial port that can be soft configured as a full duplex UART. The five input priority interrupt system is very elaborate and allows programmable selection of level or transition triggering.

Two added or increased hardware features are two, 16 bit timers with three programmable operating modes and an ALU that adds, subtracts, multiplies and divides 8 bit unsigned numbers.

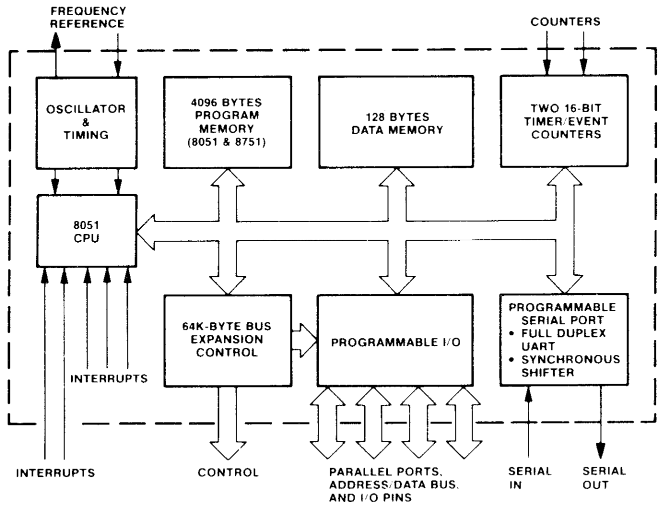


Figure 1 — 8051 block diagram

Another feature is a Boolean processor that allows flexible bit manipulation of 128 user RAM bits and some register bits.

Object Code for the 8048 is not equivalent to the 8051, but most of the 8048 instructions can be mapped directly to equivalent or similar functions. Replacement of a few instructions requires a short sequence of 8051 code. Intel's development package contains a conversion program that is supposed to handle the translation, except for some special hardware conditions like stack roll-over of the 8048.

The software of the 8051 allows 33 basic functions, and with addressing variations 111 opcodes are possible. One adressing mode is short (−128 to +127) program counter-relative branches, which allow relocatable code to be built. A form that will be good for data movement is direct-to-direct transfers, and a mode for lookup table referencing is also available. Operating at maximum speed (12MHz crystal), 64 instructions execute in 1μS, 45 in 2μS, and multiply and divide require 4μS.

Developmental support is the key to producing good microcomputer designs in a short time period. Support for the 8051 family will probably be similar to what is emerging at Tek for the 8048 (which has been part numbered for less than two years):

1. Tek 8000 series MDLs and emulators
2. Intel systems (mainly PROMTs)

continued on page 13

3. Computer Science Center's macro assembler (UNIMAC), linker and downloader
4. General prototype boards by designers
5. A testing board by Digital Component Engineering, general enough to read/program in a board bucket system

Figure 2 shows a summary of the major differences between the 8048 and the 8051. The evaluation of this component is in the initial stages, but the 8051 has a promising outlook if no major problems are encountered.

4X	Internal program memory	(4K-bytes)
16X	Expandable program memory	(64K-bytes)
2X	Internal data memory	(128 bytes)
20X	Expandable data memory	(64K-bytes)
2X	Register banks	(4)
	More I/O pins	
2½X to 10X	Execution speed	
1.4X	Die size	
	Not directly object code compatible	
	Not pin compatible	
	Additional instructions	
	Additional addressing modes	

Figure 2 — 8051 vs. 8048

If you have any questions or need more information on the 8048/8051 family, please contact me at 78-573, ext. DR-2319.

Ken Smith
Digital Component Engineering

Instrument and component field failure information

Field failure information by instrument and/or by component was discussed in a previous issue of *Component News* (see issue 283, page 7-8). We emphasized that a multi-user, on-line Field Failure System is being maintained. This system, developed by Rosalyn Neuberger, contains all warranty services from the previous 13 periods.

The response for access to this information has been super! We offer classes to inform potential users of the data base content, then an actual hands-on demonstration on how to access and use the information is provided. A manual is also available which guides the user through the process.

We intend to initiate a 'follow-up' session. If, in the meantime, current users have any questions, we want to hear from you. We need to know if the manual is satisfactory, if you are using various options, having problems, need more training, added capabilities, etc.

To date, we have conducted 15 classes and authorized 79 users to the system. Still, others who have a need for instrument and component failure information need to be contacted. Please help spread the word.

To schedule a class, call Brenda Humes on ext. MR-8004. To help solve an application problem or offer suggestions, call Rich Wood on ext. MR-8004.

Clair Gruver
Reliability Information Services

7000 Series cable connectors changed

7000 Series instruments having cable connectors with large stresses have recently been changed to a locking connector. In order to release the connector from the pins, the connector itself must be gripped and backed off. Pulling on the cable will only increase the lock on the pins.

Under vibration testing the locking connectors held while regular harmonica connectors fell off. The following instruments are using the locking connectors:

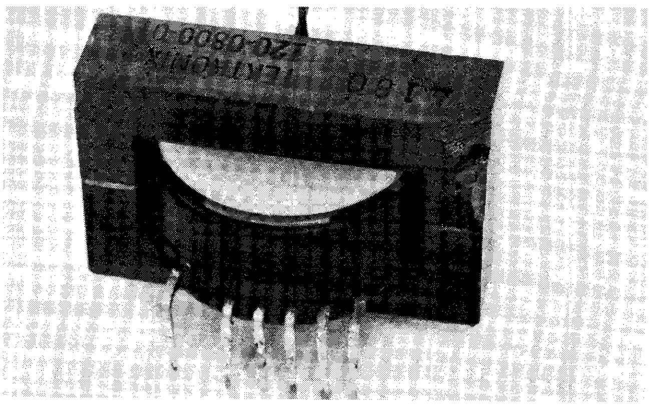
7104 — between main interface and power supply
7603 — between Z-axis amplifier and high voltage circuit board
7613 — between Z-axis amplifier and high voltage circuit board
7704A — between main interface and power supply
7834 — between main interface and power supply
7854 — between main interface and power supply
7904 — between LV regulator circuit board and power supply

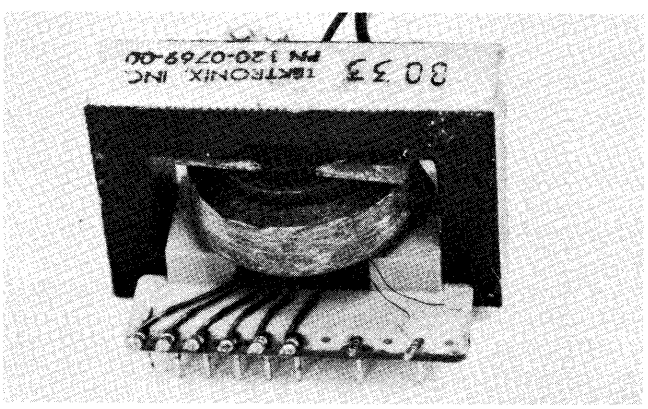
If you have any questions about these new connectors, please contact me at 39-285, ext. DR-3122.

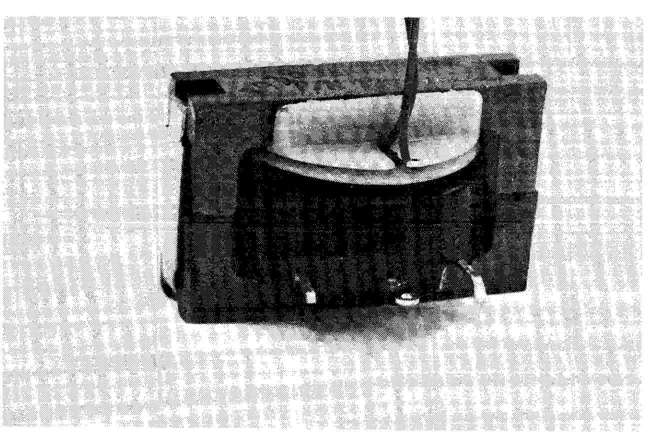
Jean Trent
Evaluation Engineer

Magnetics — Handle with care

Thousands of dollars worth of magnetic components, especially high voltage transformers, are being returned to the SPECs transformer production area for damaged cores (see Photo 1), broken wires (see Photo 2) and terminal damage (see Photo 3). A high percentage of these returns are due to improper handling after they leave the SPECs manufacturing area.







High voltage transformers are individually wrapped to protect them until they are ready to use. This wrapping material should *never* be removed until the transformer is ready for installation onto a circuit board. The wrapping insulation ensures that the cores, wires and terminals are protected when they come into contact with other objects.

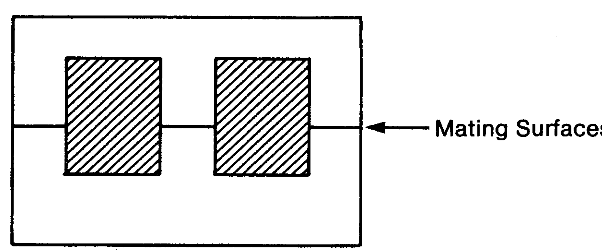
The ferrite core material is very brittle and will chip and break easily. However, transformers do not have to be chip-free to be usable. The following "Core Damage on HV Transformers" is a guide to determining if a transformer with a chipped core is acceptable.

Remember, too, that magnetic components have unprotected wire leads and windings (36-40 AWG). If they are handled carelessly, damaged parts will be the result. And, because high voltage transformers cost between $2.50 and $12.00 each, it would benefit us all to "HANDLE WITH CARE."

Gary Moen, SPECs Production Engineering
19-182, ext. 5810

Core Damage on HV Transformers

The transformer area is receiving HV transformers back from user areas for chipped and nicked cores that don't warrant rejection. The following should be used as a guide in determining if the core should be rejected for electrical or aesthetic reasons.



"E Core"

1. Mating surfaces — More than 5% of area missing:

   approximate size ☐

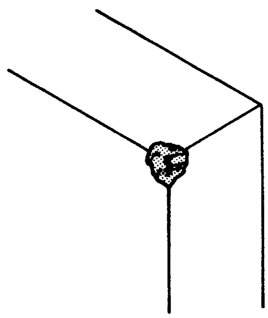
continued on page 15

2. Front, top and side surfaces — 3/16" X 3/16" chip allowed:

approximate size 
with depth no deeper than 1/32"

3. Corners — 1/8" X 1/8" X 3/16" chip allowed (any one side may be 3/16"):

approximate size 
with depth no deeper than 1/16"



4. Multi chips per surface are allowed providing the total area is no more than twice the area of the surface shown above.

Laminated panel and tag documentation

In order for us to buy only the best quality laminations for our panels and ID tags, a technical specification has been written (one for each panel type and tag) to include Tek acceptance criteria and technical procurement requirements. The technical specification will be attached to every Tek part drawing and will be treated as one controlling document for that particular component.

Once Reprographics receives a mylar Tek drawing from the design group, a "Drawing Type Design" sticker will be attached to it. The drawing type designation sticker will tell the reader that there is a PISL available for this part number and that the particular component is a Safety Controlled part (if this is applicable).

Here are some important things to remember concerning this documentation change:

- ☐ A revision to the Tek drawing or CE specification changes the revision letter of the entire package.
  — An Engineering Change Order (ECO) changes the drawing until the part turns regular.
  — A Documentation Request Form (DRF) changes the CE specification.
- ☐ Distribution requires the total package.
- ☐ Turn Regular (TR) requires four signatures with CE in production slot.
- ☐ Final NPI check requires total package — to be checked by the design group.
- ☐ Attach a note to inform Reprographics of instrument (mylar title block "First Used On").
- ☐ Tek drawing needs "Drawing Type Design" sticker.

Similar guidelines concerning the proper assembly directions and use of this documentation will be incorporated in the new *NPI Guidebook*. If you have any further questions or if you want copies of the proposed CE technical specifications, contact **Bella Geotina (ext. DR-2315).**

CRE telephone changes

New Danray phone numbers have been assigned to Component Reliability Engineering and are operational as of March 12. Delivery station for the group is 58-061.

Ron Schwartz	DR-1605
Lanita Daffern	1604
Art Fraser	1607
Lynn Kung	1610
Dan Harris	1611
Barbara Hutchens	1608
Norm Sanneman	1606

Coax voltage rating upgraded

The specification for Tek P/N 175-1043-00 (a 95-ohm coax cable) has been upgraded to 80°C and 150 volts. This change has been possible because the vendor, ITT Suprenant, is able to build the cable under a different UL style number (1760). The wall thickness and outer diameter will not change.

If you have any questions, please contact **Elizabeth Doolittle (ext. DR-2309).**

Benefits of low ESR aluminum electrolytic caps

Editor's Note: This is the first in a series of three articles concerning ESR and aluminum electrolytic capacitors. Part II will discuss capacitor life and wearout mechanisms, and Part III will describe a new line of low ESR aluminum caps.

New designs of aluminum electrolytic capacitors are now available that have very low series resistance, low series inductance and really tremendous ripple current ratings, in addition to a long operating life. Aluminum caps are the only ones that offer capacitances ranging from 1μF to over 100,000μF at voltages ranging from 2 to 450VDC.

One important use for these capacitors has been as filters in 60Hz power supplies, but most new power supplies operate at 15KHz to 50KHz and will approach 200KHz in the future. To meet the requirements of these new applications, cap manufacturers have developed several new low ESR lines, with the most useful being a single-ended (radial lead) line that has a non-aqueous electrolyte.

Electrolytic cap composition

An aluminum electrolytic capacitor is composed of: the aluminum anode with an electrochemically formed oxide layer (Al_2O_3) around it; the absorbent paper spacer and electrolyte; and the metal cathode (see Figure 1). The metal anode is one plate of the capacitor, the aluminum oxide is the dielectric, and the electrolyte is the second plate of the cap. The only function of the metal cathode plate is to serve as a low resistance contact to the electrolyte (which is the actual cathode).

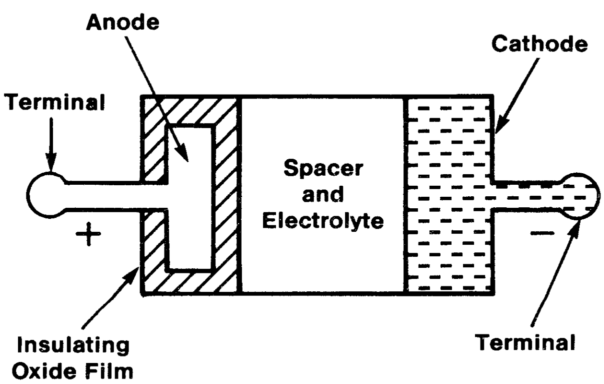
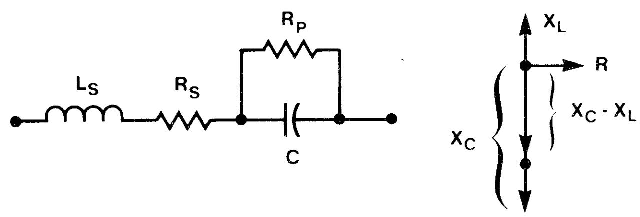


Figure 1 — Polarized electrolytic capacitor

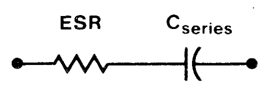
The common method of producing aluminum electrolytic caps is to roll two long strips of thin, very pure aluminum foil into a cylinder, with the absorbent paper separator layer between. The anode foil has been previously anodized to form the required thickness of aluminum oxide. This assembly is then impregnated with the conductive electrolyte and assembled in a can with an insulated header to, hopefully, prevent electrolyte leakage.

Of all the various types of capacitors, the aluminum is the furthest from the ideal lossless capacitor.



C — lossless capacitor
R_S — series resistance
R_P — parallel resistance or DC leakage
L_S — series inductance

This circuit readily resolves to:



where ESR represents the lumped value of R_S and R_P, and C_S, the equivalent series capacitance takes into account both C and L_S at the test frequency.

One method of specifying ESR is DF, which is defined as the ratio of ESR to capacitive reactance or $DF = ESR/X_C$. This usually ranges from 8% to 25% for conventional aluminums, and 3% to 10% for low ESR aluminums. ESRs under 100mΩ (0.1Ω) are considered low, and some special caps have ESRs near 1mΩ.

The series LCR circuit of a real world capacitor has an impedance vs. frequency curve similar to Figure 2. This capacitor has low ESR and low series inductance, and thus has a 73KHz resonant frequency. Most aluminum caps have a resonant frequency between 5 and 300KHz.

continued on page 17

At a frequency of 50KHz, this capacitor has a capacitive reactance of 6.4mΩ, an inductive reactance of 2.8mΩ, and an ESR of 30mΩ. Thus, the capacitor looks mostly like a resistor, and the ESR will determine the magnitude of the ripple voltage across this part. It should be noted that the inductive reactance is becoming significant at this frequency, and becomes the predominant component above the resonant point at 75KHz.

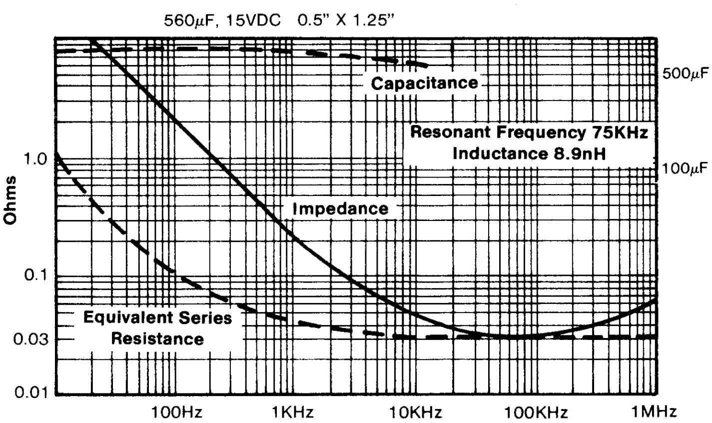


Figure 2 — Typical frequency response of Mallory VPR (similar to 290-0945-00)

Equivalent series resistance (ESR)

The ESR of a capacitor is a major factor in determining the ripple voltage across the cap, and in setting the limit of the maximum ripple current through the cap. The three major components of ESR in an electrolytic capacitor are:

- ☐ Dielectric losses
- ☐ Foil losses
- ☐ Electrolyte and paper spacer losses

The losses in the aluminum oxide dielectric are proportional to oxide thickness, and oxide thickness is a functional formation voltage.

Most capacitors use aluminum foil that has been etched to increase its capacitance by a factor of 30 or more for low voltage capacitors. The technology to do this has been steadily improved so it is now possible to make caps that are one or two case sizes smaller than 5 or 10 years ago.

The etching process produces deep pits and tunnels in the foil, and high frequency currents tend to skip over these. In addition to this effect, the capacitor tends to act as a lossey transmission line at high frequencies, and these cause a loss of effective capacitance with increasing frequency. Typical capacitors will lose 15% to 50% of their capacitance between 120Hz and 10KHz.

The dielectric loss is frequency dependent and this causes the ESR to decrease with increasing frequency until a minimum is reached between 10KHz and 100KHz (see Figure 3). After this point, the ESR increases due to skin effect. The ESR minimum is usually very broad and this makes the ESR curve flatten out at about 10KHz and stay flat until 100KHz to 200KHz.

In low voltage capacitors (up to about 40V), the oxide film resistance is a small part of the total ESR. In high voltage caps the oxide film resistance may easily be more than half of the total ESR. The oxide film resistance is the one loss that cannot be reduced by design changes.

Foil losses are the result of resistance in the anode and cathode foils, in the tabs and terminals, and contact resistance between the foil, tabs and terminals. Total resistance in the last two areas is usually 0.2mΩ to 4.0mΩ, which is negligible in most capacitors. Foil resistance is proportional to foil length and inversely proportional to foil width and thickness. The total foil loss can be controlled by proper design. It will be a small percentage of the total ESR in physically small caps and in high voltage capacitors. In low voltage and physically large caps the foil resistance can be large and design features such as multiple tabs, thicker foil or swaging the turns of foil together can be used to limit the ESR.

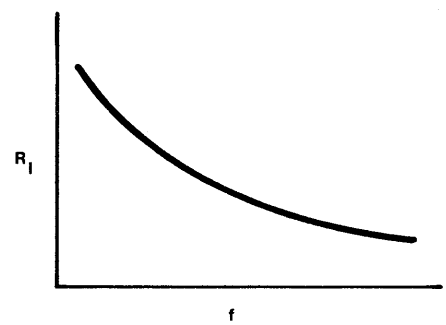


Figure 3

The third major source of resistance is the electrolyte and the paper spacer used to separate the foils. Loose, open types of paper give lower ESRs; thicker paper gives higher ESRs and longer life because a greater volume of electrolyte is present. The fiber size and shape also influence ESR.

continued on page 18

Higher voltage caps must have higher resistivity electrolytes to prevent voltage breakdown, but this also causes higher ESR. Electrolyte resistivity decreases as temperature increases, which means lower ESRs at higher temperatures. This can also cause severe problems with very high ESRs at low temperature. At -20°C a conventional electrolytic capacitor may have 2 to 10 times its +25°C ESR. Conventional electrolytes have a slight resistivity increase with frequency, and non-aqueous ones have a slight decrease with frequency.

The electrolyte system used in conventional caps is an ethylene glycol/borate solution with various additives. This time-proven system works well at moderate temperatures, but it degrades rapidly above 85°C. Its low temperature resistivity is very high, and at high temperatures it has a high vapor pressure which causes increased electrolyte permeation through the seal and also a higher chance of electrolyte leakage.

In the last ten years a new electrolyte system has been developed that uses dimethyl formamide (DMF) as the basic solvent, with additives used to increase conductivity and protect the aluminum oxide dielectric from undesirable reactions. The DMF-based electrolyte, also known as a non-aqueous electrolyte, usually gives a lower ESR because of its low resistivity, better low temperature characteristics, longer life, lower DCL and better shelf life. Most non-aqueous caps are rated at 105°C max operating temperature instead of 85°C, and this allows a much higher ripple current because of the higher allowed core temperature. This electrolyte is slightly more expensive and also requires a higher quality can seal because it attacks some common seal materials.

Equivalent series inductance

The second major parasitic element in a capacitor is its series inductance. This ranges from under 1nH to hundreds of nH for some multisection units. The resulting inductive reactance is insignificant at power line frequencies, but it can become the major component of the impedance of the capacitor at switching power supply frequencies. For example, consider a single ended, low ESR non-aqueous cap with the following parameters: C = 10,000μF, L = 11.5nH, resonant frequency = 11KHz, ESR (at 10KHz) = 5mΩ, 16WVDC rating in a 1" X 3⅝" package (similar to the 290-0930-00).

At a frequency of 100KHz the impedance is composed of an inductive reactance of 7.2mΩ and an ESR of about 6mΩ, so you now have a poor inductor instead of a good capacitor. With low inductance capacitors great care must be taken to see that the circuit wiring does not add excessive inductance. A 1" length of #20 wire has about 20nH of inductance and this has an inductive reactance of 12mΩ at 100KHz.

The series inductance of a wound capacitor section is usually 1nH or less if it is tabbed correctly. This is due to the fact that the foils are very wide, in very close proximity to each other, and if both foils are tabbed at the same point, they carry equal and opposite currents that cancel most inductance. In aluminum capacitors, most of the series inductance is contributed by the tabs (internal leads) and terminals.

Axial lead capacitors have high series inductance (50nH or more) because they have a long cathode tab that is crumpled up in the bottom of the can. A large can printed circuit board mount (type C & D) cap will have 40 to 100nH, and a conventional computer grade (screw terminal) cap will have 20 to 30nH. A multi-tabbed computer grade capacitor has about 15nH of inductance, and also has a lower ESR from all the tabs in parallel.

There is a new type of single ended, low ESR, non-aqueous capacitor that is made by several manufacturers (such as the Sprague 672D, the Mallory VPR or the Sangamo 301). A small can size has about 5 to 10nH of inductance, and a larger one about 10 to 25nH. Two other types of low ESR and series inductance caps are the 4-terminal with about 1nH, and the stacked foil with an inductance of 1nH or less — the lowest ESR of any aluminum capacitor.

For more information

If you have any questions about ESR or series inductance of capacitors, please contact me at 78-552, ext. DR-2545.

Don Anderson
Optoelectronic and Passive CE

TECHNICAL STANDARDS

The function of Technical Standards is to identify, describe, and document standard processes, procedures, and practices within the Tektronix complex, and to ensure these standards are consistent with established national and international standards. Technical Standards also provides a central repository for standards and specifications required at Tektronix.

New documents (copies may be ordered from Technical Standards, 58-306)

MIL-E-85246	Electronic Circuit Modules, General Specification for
MIL-HDBK-979	Data Sheets for "NASA Standard Parts"
MIL-T-55207B	Test Set Electrical **Cable:** AN/GSM-45
IEEE STD 683	IEEE Recommended Practice for **Block Transfers in CAMAC Systems**
IEEE STD 758	Subroutines for **CAMAC**
IEEE STD 726	Real-Time **BASIC for CAMAC**
MIL-S-3950F	Amendment 2 — **Switches, Toggle,** Environmentally Sealed
MIL-C-3885E	Electrical **Cable** Assemblies and **Cord Assemblies**
IEC 625-1	An Interface System for Programmable Measuring Instruments (Byte Serial, Bit Parallel)
IEC 625-2	An Interface System for Programmable Measuring Instruments (Byte Serial, Bit Parallel) Part 2: Code and format conventions
DOD-STD-1686	**Electrostatic Discharge Control Program** for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
IEC 668	**Dimensions** of **Panel Areas** and **Cut-outs** for Panel and Rack-mount Industrial-process Measurement and Control Instruments
MIL-STD-1589B	**JOVIAL** Programming Language
ECMA	(European Computer Manufacturers Association) **Measurement of Airborne Noise** Emitted by Computer and Business Equipment
OSHA	U. S. Department of Labor, **Noise Control.** A guide for workers and employers
MIL-C-58104	**Protective Cover** for Parts and Equipment

CAD/CAM Glossary This glossary has been updated to assist CAD/CAM professionals. The definitions are not "idealized." They reflect the current spoken and written language of today's CAD/CAM leaders. This glossary has been designed to overlap as little as possible with the existing glossaries of computer terms from around the world.

IPC Technical Papers

IPC-TP-333	Voltage Clearance Recommendations for Printed Boards
IPC-TP-338	Printed Wiring Board Development — The Automated Factory
IPC-TP-339	Computer-Aided Process Preparation for PWBs
IPC-TP-340	Processing Thin Laminate, Copper Nickel Plated Innerlayers with VIA Holes, for Impedance-Controlled Precision Multilayer Boards.
IPC-TP-341	Silicone Rubber Presspads for Multilayer Lamination
IPC-TP-342	Design and Processing Details for Reliable High Power Hybrid Packages
IPC-TP-343	Drying PWBs after Cleaning
IPC-TP-347	RTG Test Method for Gold Plating
IPC-TP-348	Processing Double-Sided and Multilayer Backplanes "From Copper Laminate to Wire Wrap in One Not so Easy Step"
IPC-TP-349	Analysis of Plated-Thru-Hole Problem
IPC-TP-350	Dry Film Photoresist Performance on Electroless Copper Surfaces
IPC-TP-351	Chemical Cleaning: An Alternative to Mechanical Scrubbing
IPC-TP-353	Another Look at Drilling Rigid Epoxy/Glass Laminate
IPC-TP-354	The Advantages of Electrochemically Deburring PWBs

New Tektronix Standard 062-4735-00

New standard will be issued (062-4735-00) Plastic Laminated Panels and Tags Standard — Material, Environmental, Test Methods. This standard defines test methods, qualification and acceptance tests, for plastic laminated panels and tags used in Tektronix instruments, including those in which switches are an integral part of the panel.

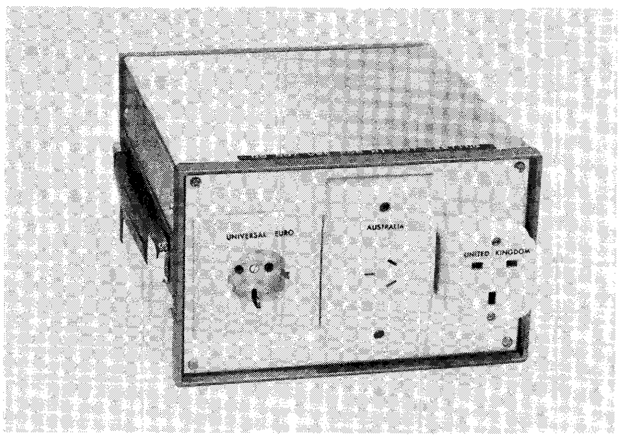
To Holders of 062-4193-00, Hardware Standard, Press Mount Fasteners, Standard and Rivet Type: Please add 20 Nov 80 in the date column of the list of changes page of this standard.

For information on any of these standards, please contact Technical Standards (58-306, ext. 5768).

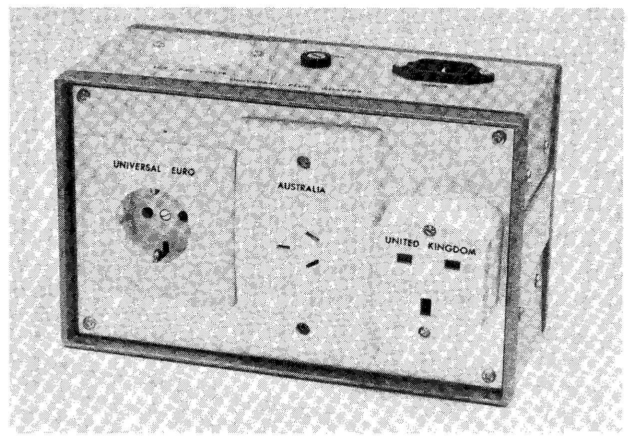
Adapters available for optional power cord testing

Adapters for testing instruments equipped with one of the optional power cords are available from Ed Wesel, Product Safety Engineering, ext. 5068. Costs are $354 for the universal 250-volt supply adapter, and $200 for the universal plug adapter. Please allow two to six weeks for delivery.

NOTE: This announcement supercedes all information pertaining to optional power cord adapters on page 4 of the September 1979 issue of *ManuFACTuring.*



250-volt supply adapter — Designed for 120-volt input and 250-volt output. This adapter contains receptacles for power cord options. DO NOT use with a hi-pot tester.



Universal plug adapter — Designed so input equals output. This adapter is for use with a hi-pot tester. It includes receptacle for power cord options plus standard 3-wire plugs for attachment to a hi-pot tester.

COMPONENT NEWS
MICHAEL A MIHALIK
92-515

component news

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