Electronics Today

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November 1985

Canada's Magazine for Electronics & Computing Enthusiasts

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In the centre of this issue of Electronics Today, we are proud to present our 1986 catalogue; this catalogue also appears in the November issues of Computing Now! and Software Now! It will also appear in the December issue of Computers in Education.

Even though the prices of our products shown in the catalogue are as current as possible, we advise you to check our ads each month in Electronics Today and Computing Now!

We have done our best to include as much of our extensive product and parts range as possible but space limitations have prevented us from describing our entire store selection. If you want anything in the computer or electronics area, please check with us.

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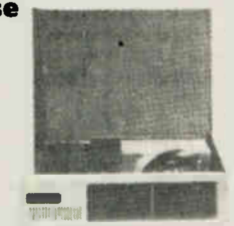

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Electronics Today

November 1985

Vol. 9 No. 11

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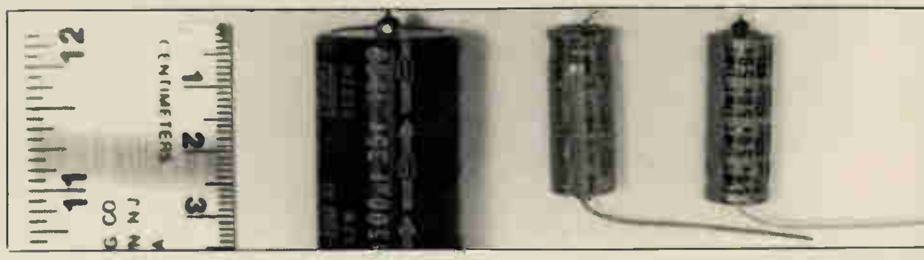

Our Cover

Illustrating our look at testbench tools, the background photograph of tools was provided courtesy of Len Finkler; the circuit holder was photographed by Ed Zapletal.

Audit Bureau of Circulations

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For Your Information

Spike Arrester

A six-outlet power bar which includes a spike arrester circuit is available from WT Devices. It's constructed from extruded aluminum and has a circuit breaker and an illuminated power switch. The protection circuit consists of a spike-clipping thyrector across the line and a triac in series with the loads; the triac will switch off only at a zero-crossing of the AC input, preventing inductive surges. It's rated a 120VAC, 15A. Contact them at 5536 Montevideo Drive, Unit 18, Mississauga, Ontario L5N 2P4.

Circle No. 60 on Reader Service Card.

SmarTeam Modem

The SmarTeam 103/212A modem is a 300/1200 baud stand-alone unit with auto-answer, auto-dial, auto-speed, and full or half-duplex operation. It runs PC Talk, CrossTalk, Smartcom II and its own Teamtalk for the PC as well as Macteam for the Macintosh. The suggested list price is $495. The exclusive Canadian distributor is Budgetron Inc., 1320 Shawson Drive, Unit 1, Mississauga, Ontario L4W 1C3, (416) 673-7800.

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Jerome and Francis Co. Ltd., representatives of oceanographic and electronic instrumentation, have enlarged their operations and moved to 1869 Welch St., North Vancouver, BC V7P 1B7. The telephone number remains the same: (604) 986-1286.

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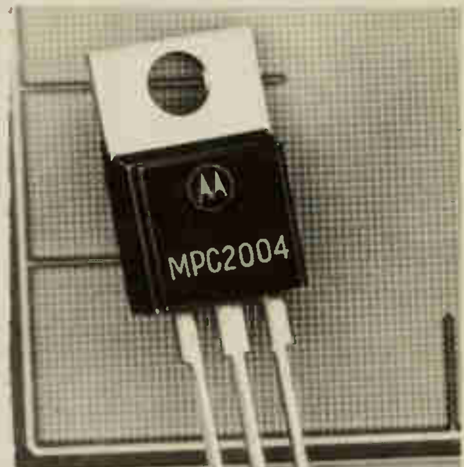

OV/OT Protection

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continued on page 24

Liability
While every effort has been made to ensure that all constructional projects referred to in this magazine will operate as indicated efficiently and properly and that all necessary components are available, no responsibility whatsoever is accepted in respect of the failure for any reason at all of the project to operate efficiently or at all whether due to any fault in the design or otherwise and no responsibility is accepted for the failure to obtain component parts in respect of any such project. Further no responsibility is accepted in respect of any injury or damage caused by any fault in design of any such project as aforesaid.

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We can supply photocopies of any article published in Electronics Today Canada; the charge is $2.00 per article, regardless of length. Please specify both issue and article.

Component Notation and Units
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. Electronics Today has opted for sooner!

Firstly decimal points are dropped and substituted with the multiplier; thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1 uF is 100nF, 5600pF is 5n6. Other examples are 5.6pF = 5p6 and 0.5pF = 0p5.

Resistors are treated similarly: 1.8Mohms is 1M8, 56kohms is the same, 4.7kohms is 4k7, 100ohms is 100R and 5.6ohms is 5R6.

PCB Suppliers
ETI magazine does NOT supply PCBs or kits but we do issue manufacturing permits for companies to manufacture boards and kits to our designs. Contact the following companies when ordering boards.

Please note we do not keep track of what is available from who so please don't contact us for information PCBs and kits. Similarly do not ask PCB suppliers for help with projects.

K.S.K. Associates, P.O. Box 266, Milton, Ont. L9T 4N9.

B–C–D Electronics, P.O. Box 6326, Stn. F, Hamilton, Ont. L9C 6L9.

Wentworth Electronics, R.R. No. 1 Waterdown, Ont. L0R 2H0.

Danocinths Inc., P.O. Box 261, Westland MI 48185 USA.

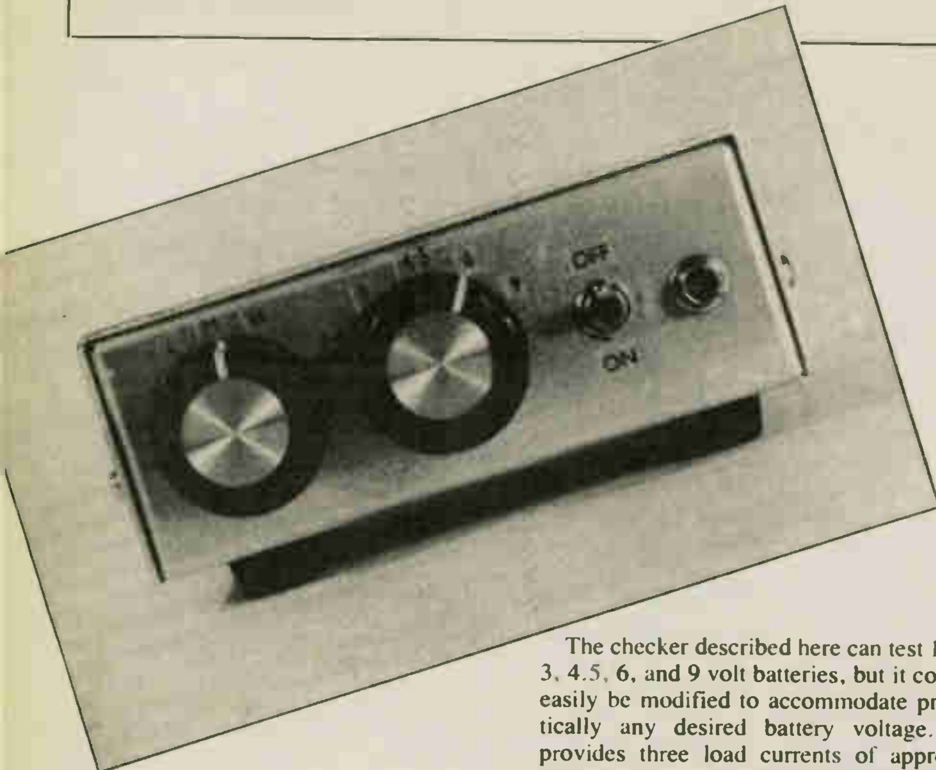
Arkon Electronics Ltd., 409 Queen Street W., Toronto, Ont., M5V 2A5.

Spectrum Electronics, 14 Knightswood Crescent, Brantford, Ontario N3R 7E6.

Household Battery Checker

Testing ordinary dry cell batteries with a multimeter is deceptive, because the normal load current is not present. This battery checker provides the right environment for checking them accurately.

By Robert Schmidt



BEING PRESENTED with batteries to be tested is somewhat of an occupational hazard for any electronics hobbyist. It would seem that this would be a deceptively easy task to perform; a simple voltage check with a multimeter is all that is required. A voltage test will confirm that a battery is exhausted if the measured voltage is well below the stated battery voltage, say about 75% or less. On the other hand, the battery might produce a potential which is quite close to its rated voltage, but could nevertheless be completely unusable in most pieces of equipment.

The cause of ambiguous results of this kind is the drop in battery voltage which occurs when high load currents are drawn. A battery might provide a perfectly respectable voltage when removed from the equipment in which it has been used, but could give as little as 50% of its rated voltage when replaced in the equipment and put to use.

One way around the problem is to always measure the voltage while the battery is in the equipment and the latter is operating, so that a loaded reading is obtained and any voltage drop the loading produces will be readily apparent. Although this might seem like the ideal solution it's not possible if you are only given the batteries and not the equipment from which they were taken, and in practice it can often be difficult to measure the battery voltage under operating conditions. This is just about impossible with flashlights for example. A more practical approach is to measure the voltage while using a resistor to load the battery with an appropriate current drain or, better still, to build a proper battery checker.

The checker described here can test 1.5, 3, 4.5, 6, and 9 volt batteries, but it could easily be modified to accommodate practically any desired battery voltage. It provides three load currents of approximately 8, 25, and 100 milliamps, which suits everything from a small radio battery to a large torch cell. The unit is very simple to operate, and a LED is used to indicate whether or not the battery under test is serviceable or exhausted.

Internal Resistance

The drop in voltage that occurs is something that can be rather puzzling to beginners in electronics, but it always occurs when power is drawn from any voltage source, including such things as the output of a hi-fi amplifier or the supply from an AC outlet. The cause of the voltage drop is internal resistance within the voltage source. Fig. 1 shows a voltage source loaded with a resistance Rb. Ra represents the internal resistance of the battery, and although in reality this is a resistance within the fabric of the battery, and dispersed throughout the battery, the effect is just the same as if it was a resistor connected in series with one of the output leads.

In this example the internal resistance is 10R, and the load resistance is 90R. By a straightforward potential divided action, one tenth of the battery voltage is dropped across the internal resistance, causing the output voltage to drop from 9 volts to 8.1 volts. Although these figures are only given as a simple mathematical example, a voltage drop of this order is quite typical for a 9 volt radio battery when it is operated at high volume levels. With a small 9 volt battery when nearing exhaustion the internal resistance can be as much as 50R. For something like a freshly charged high capacity NiCad battery the internal resistance could be as low as a few milliohms. Internal resistance is an important factor since it limits the maximum voltage and current that a battery can provide, and it renders certain types of battery unusable in some applications. A small radio battery could not provide the high currents needed to drive flashlight bulbs for instance.

Checker Operation

There are really two separate sections in the circuit; one to place a controlled load on the battery, and the other to check whether or not the battery voltage is higher than a certain threshold level. The load is provided by a constant current generator. This is more convenient than using a load resistor as it prevents any significant change in load current even with very large changes in the battery voltage. This avoids the need to have numerous switched load resistors with a separate resistor for each test voltage, and a separate set of resistors for each load current. As explained previously, three load currents are provided so that the current drain can be matched to suit the capacity of the test battery.

The voltage tester is built around a voltage comparator and a highly stable 1.15 volt reference source. The output of the precision voltage source is connected to the inverting input of the voltage comparator. The output of the comparator goes to virtually the negative supply potential if inverting (-) input is at a higher voltage than the non-inverting (+) input, or to virtually the full positive supply potential if the comparative input levels are reversed. An indicator LED is connected from the output of the voltage comparator to the positive supply rail. The LED therefore switches on if the non-inverting input is taken below 1.15 volts, or switches off if the non-invert-

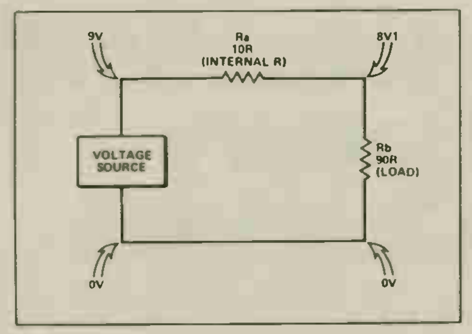


Fig. 1 A diagram representing the voltage drop when a voltage source is loaded.

ing input is taken to a higher potential than 1.15 volts.

The non-inverting input is fed with the output voltage of the battery, but via an attenuator which reduces the battery voltage to a suitable level. For instance, a 6 volt battery when under load and in usable condition would provide a potential of about 5 volts or more. The attenuator resistors would therefore have values calculated to give an output voltage of 1.15 volts with an input potential of 5 volts. If the battery voltage was above the 5 volt threshold level the voltage fed to the comparator would be more than 1.15 volts and the LED indicator would switch off to indicate that the battery was serviceable. If the battery potential was below the 5 volt threshold then the input voltage to the comparator would be less than 1.15 volts, and the LED would stay lit up to indicate that the battery was exhausted.

There is a very narrow range of battery voltages that gives an indeterminate output state from the comparator and something less than full brightness from the LED indicator. If the LED should only partially switch off it is best to take this as an indication that the battery is no longer reliable and to replace it, but in use an indeterminate LED stage may never be obtained as the range of voltages that give this effect is so restricted. It is more likely that the LED would switch off initially, and then turn on again as the battery voltage gradually falls below the threshold level under load. Again, it is probably best to take this as an indication that the battery is no longer usable and to renew it.

In practice there are five switched resistors in the upper arm of the attenuator, enabling the unit to check batteries of five different voltages. A current generator is included at the output of the comparator, but this merely sets the LED current at a suitable figure and does not play any active role in the operation of the unit.

Circuit Operation

A precision voltage detector integrated circuit (IC1) is at the heart of the unit, and it permits a very simple circuit to be used.

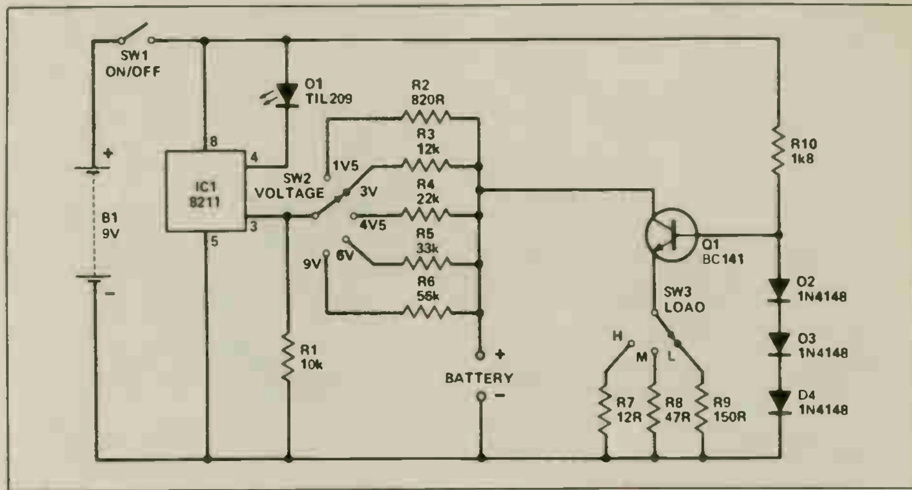


Fig. 2 The circuit is built around IC1, a precision voltage detector which gives a reliable reference voltage against which the battery voltage is checked.

The full circuit diagram of the checker appears in Figure 2.

IC1 contains the reference voltage generator, voltage comparator, and the constant current generator which sets the 'on' current of LED indicator D1 at a nominal figure of 7 milliamps. The attenuator is formed by R1 and whichever one of the five switched resistors (R2 to R6) is selected using SW2. For the record, the theoretical threshold voltages are 1.2443, 2.53, 3.68, 4.945 and 7.95 volts. R1 to R6 are all closer tolerance (1%) resistors, and coupled with the precision of the reference source of IC1 this gives good accuracy and reliable results without the need for any adjustment to the finished unit.

The circuit is not powered from the battery under test, but is powered from its own internal 9 volt battery. This gives better reliability and enables a wider battery voltage range to be accommodated. It is quite easy to calculate the series resistor value for voltages not included here if you wish to change the battery voltages covered by the unit. Simply multiply the required threshold voltage by 8.7 and then deduct 10. This gives the value of the series resistor in kilohms. It is unlikely that the required value will coincide precisely with a preferred value, and it is then a matter of either choosing the nearest preferred value or making up the required value from two or three resistors connected in series. Remember that the loaded output voltage of a battery which is in usable condition but nearing exhaustion is generally about 15% or so less than its stated output voltage.

The constant current generator which provides the load for the test battery uses Q1 in a conventional constant current generator circuit. R10 and the series of three diodes provide a potential of about 1.9 volts at the base of Q1, and taking into account the voltage drop across the base-emitter junction of Q1 this gives a potential of about 1.2 volts across the emitter resistor selected using SW3. The three switched resistors (R7 to R9) give three different emitter currents. The battery under test feeds direct into the collector circuit of Q1, and as the collector current of a transistor is virtually identical to the emitter current, the current drain on the battery is mainly determined by the emitter resistance of Q1 and is largely independent of the test battery's voltage.

In Use

When the completed unit is switched on the LED indicator should light up. If it does not, switch off immediately and thoroughly recheck the wiring (including the polarity of D1 which can only light up if connected properly).

continued on page 60

PARTS LIST

Resistors
(All 0.4W 1% metal film)

R1	10k
R2	820R
R3	12k
R4	22k
R5	33k
R6	56k
R7	12R
R8	47R
R9	150R
R10	1k8

Semiconductros

IC1	8211
Q1	2N2297
D1	TL209 or similar panel LED
D2,3,4	1N4148

Miscellaneous

SW1	SPST sub-min toggle switch
SW2	6 way 2 pole rotary with end stop (set for 5 way)
SW3	3 way 4 pole rotary
B1	9 volt

Printed circuit board; case about 133 x 102 x 38mm, two control knob, battery connectory, 8 pin DIL IC holder, 3.5mm jack socket and test leads, wire solder etc.

The Electronics Today Camera Contest

Win a Minolta Maxxum, the only 35mm camera with autofocus built-in. Micro-processor control of exposure for perfect point-and-shoot.

Our previous electronics trivia contest was so successful, we've adapted the idea for this one. This time we've put it in multiple-choice format. There are no trick questions.

Contest Rules

1. For each question, circle the answer that you think is correct.
2. Fill out the form below and mail it to us. If you don't want to cut the magazine, you can use a photocopy or send us the answers in a letter.
3. Only one entry, please. The last contest overloaded the post office so much, they had to borrow the editor's car.
4. Any persons associated with the contest, including employees (and their families) of Moorshead Publications are precluded from entering.
5. The prize will be awarded as described. No correspondence will be entered into regarding this contest.
6. The winner will be notified by mail or telephone within seven days of judging. The winner and correct answers will be published in the January, 1986 issue.
7. The winner will be selected by drawing an entry from the correct answers received.
8. The deadline for entries is December 15, 1985.

The Electronics Today Camera Contest

1. When the base of a transistor is the same voltage as the emitter, the transistor is:
a) saturated
b) operating normally
c) cut off

2. A circuit in which a single amplifier acts as both a sound IF amplifier and an audio amplifier is called:
a) an impossibility
b) a reflex-amplifier circuit
c) a reflectodyne circuit
d) an amplidyne

3. A ferrite bead behaves like:
a) an inductor
b) a temperature sensing resistor
c) a neutrode

4. Which amplifier configuration can be used to match a high impedance to a low impedance?
a) grounded base
b) grounded gate
c) emitter follower

5. Removing the capacitor across an emitter resistor in a transistor amplifer will:
a) increase the gain of the amplifier
b) increase the amplifier frequency response
c) lower the input impedance

Mail your entries to:
Moorshead Publications
Electronics Today Camera Contest
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Toronto, Ontario M4H 1B1

Name ____________________

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Town/City __________ Province __________ Postal Code __________

Telephone: Area Code ______ Number __________

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Automatic Test Equipment

A look at automatic test equipment and techniques used to implement it.

By W.P. Bond

AUTOMATIC test equipment has been around in one form or another for nearly three decades. In recent years, the introduction of LSI and VLSI circuits has totally changed the requirements for ATE, especially since the equipment and procedures must meet the needs of volume production. Cost is perhaps the most important consideration today, and this must be understood in relation to the two general types of test procedure: functional and in-circuit testing.

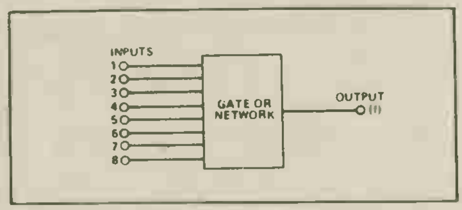


Fig. 1. 256 patterns would be needed to test every input combination.

Functional testing looks at all the functions of a circuit, taken in isolation from a whole system of which the circuit may be a part. The circuits involved, and of course the test procedures, can be digital or analog. Digital, or logic, circuits are simpler than analog circuits from the viewpoints of automatic testing. There are simple 'go/no-go' results obtainable from logic circuits, while analog devices need to be tested within a broad range of acceptable performances. It makes sense to begin an examination of ATE with logic circuits.

Some Logical Steps

There are four main categories of logic circuits:

– Combinational Logic: outputs are dependent solely on the present inputs.

– Sequential Logic: outputs are dependent on present inputs and on previous outputs, such as circuits with memory or feedback.

– Bus Structured Logic: combined circuitry of the above types on MPU-type boards with components connected by a bus-structure.

– Random Logic: combined circuitry without a bus-structure.

The testing procedure for any given circuit or circuit assembly will depend on the category it belongs to.

There are a number of other considerations that have to be kept in mind when devising test procedures, apart from the categorizing of the circuit concerned. Even in simple cases, functional testing may have to be uneconomically elaborate in order to detect all possible faults. The 8-input gate in **Fig. 1** would require 256 test patterns if all input conditions were to be covered. Such exhaustive testing (ET) very quickly becomes unwieldy, even with straightforward combinational circuits.

Most circuits are not straightforward. One particular problem is cased by the presence of redundant logic, often built-in for reliability. The circuit in **Fig. 2**, for example, includes a redundant gate (G2) which can be shown by simplifying the output function A.C + B.C + A.B using Boolean algebra or Karnaugh mapping. In this case, a fault in the redundant gate may mask faults in the non-redundant circuit

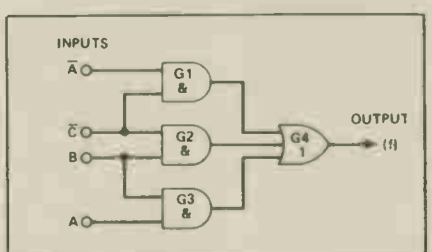


Fig. 2. Redundant gates can result in fault-masking.

elements. For example, in this case if the output from the redundant gate is permanently low (stuck at 0, or SA0), it will have no effect on the network output. But if it is permanently high, (stuck at 1, or SA1), then the network output will be permanently high regardless of what's happening on the other gates.

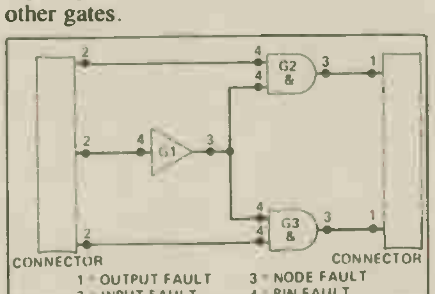
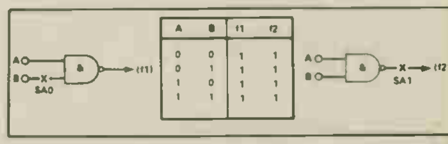


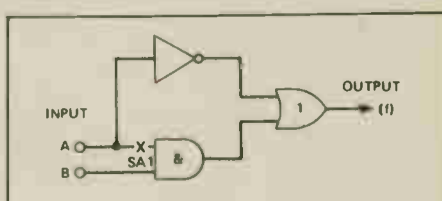
Fig. 3. Test points in a typical circuit section.



A	B	f1	f2
0	0	1	1
0	1	1	1
1	0	1	1
1	1	1	1

Fig. 4. Different fault, same truth table.

The typical test points are shown in **Fig. 3** for a sample circuit. From **Fig. 4**, it should be clear that the same symptoms an follow from a variety of faults. An SA0 pin fault on the B input to the NAND gate in the figure will be indistinguishable at the output from an SA1 node fault; the same input test patterns will result in the same outputs. To locate faults successfully, it is important to test the circuit in question at more points than its inputs and outputs. **Fig. 5** shows a small logic circuit with redundancy in which an SA1 pin fault would go undetected if the circuit were tested at inputs and outputs only. This sort of fault would be seen where an open circuit existed at the pin, since open inputs float high. Because of this, inputs tied to Vcc are sometimes classified as 'undetectable' for fault-finding purposes.



A	B	(f)
0	0	1
0	1	1
1	0	0
1	1	1

Fig. 5. The fault here is undetectable.

It's worth noting that there are two kinds of redundancy in circuits: fault-masking and self-checking. In the first, faults are masked by multiple circuits performing the same task. In the second, faulty circuits are switched out of the system and good circuits switched in to take their places.

Sequential logic presents the test procedure with yet more problems. **Fig. 6** shows a circuit configuration in which

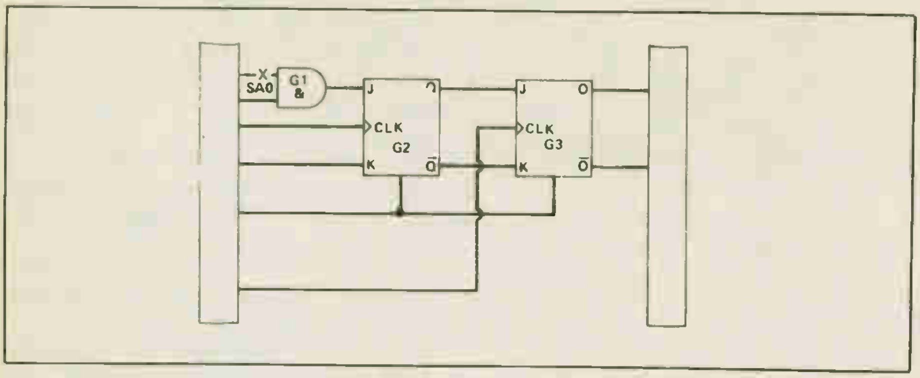


Fig. 6. A latent fault.

there is no direct path between the fault (SA0 at input 1) and any output. Here again, the importance of good 'test-pointing' becomes obvious. This requires a series of test patterns to 'walk' it to an output pin. The examples shown would require three consecutive test patterns to clock it through gates G2 and G3. With less than three test patterns, the fault would simply not appear at any output. The number of patterns required to propagate the fault to the output is called the degree of latency.

Changing inputs can give rise to their own problems. The commonest is called racing. Race hazards take the form of unwanted transients (signal spikes) caused at the output to a logic circuit when two or more inputs change at the same time. In **Fig. 7**, for example, inputs A and B are meant to change simultaneously from 1 and 0 respectively, to 0 and 1. If B reaches the 1 state slightly before A reaches the 0 state, then the output will display the negative-going spike as shown. Such glitches often occur in latching circuits with feedback: dividers, for example. Testing at the output can lead to spurious results in this situation. The simplest solution is to build in a time delay at the output test point greater than the propagation delay of the gate.

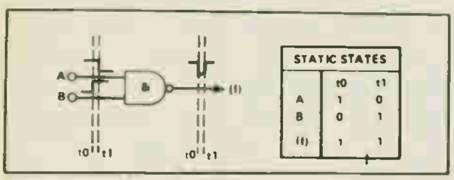


Fig. 7. Generating glitches.

Untestability

Testability must be designed into electronic modules if they are to be properly tested in the first place. Obvious though this sounds, it is all to often overlooked by circuit designers, perhaps because 'testability' itself is an awkward and ill-understood notion.

Testability implies not only the possibility of testing a module or circuit but also the existence of a set of guidelines aimed at maximizing test efficiency. Because of the specialized nature of individual complex analog designs, I will limit the present discussion to functional testing of static digital circuits, although the principles do not lose in generality. It's worth noting that functional testing, although perhaps more easily understandable, is actually more rigorous than in-circuit testing and as much as ten times more costly.

Test procedures can be considered to have three main aspects: initializing, observing and controlling. For a circuit to be testable, each of these aspects must be catered for.

Initializing: this is the process by which all nodes of the device under test (DUT) are set to known states after power-up and before test patterns are applied.

Observing: in the context of ATE, this means minimizing the amount of human intervention needed to identify faulty components. Observing entails the correct monitoring of a circuit and involves the provision of suitable test points in the design. Observability is the key to maximizing the effectiveness of ATE.

Controlling: for proper functional testing, the ATE must be capable of controlling the DUT, usually by means of an edge connector. If all functions of the DUT cannot be exercised, then testing will be inadequate.

In the Beginning

LSI designs are most commonly sequential and the failure to initialize can mean testing circuits in forbidden or indefinite states. There are four main factors in designing-in the ability to initialize a circuit:

– there should be access to deep sequential circuits, which is a criterion of observability.
– the should be a means of isolating or breaking feedback loops.
– there should be access to reset and preset lines in memory elements.
– in certain cases (for example, VLSI devices where there is no access to reset or preset lines) it should be possible to use software initialization.

Fig. 8 shows a simple sequential circuit, a counter or shift register for example, with and without testability built in. If appropriate test points have not been provided on power-up, all the memory elements f(1) to f(n) will be in an unknown state (an x-state). The output will be also be in an x-state. Without access to reset or preset, a 'homing sequence' would have to be provided by the tester. Further, if a fault existed, the failure could be observed at the output, but without the use of a guided probe routine and suitable test points, fault isolation would be impossible. This is a failure of observability or diagnostic visibility.

In the lower diagram, test points and a reset line have been provided. Since the reset line, in particular, is no longer wired to Vcc, we need only apply a clear signal to initialize the circuit, rather than go through the elaborate sequence of a homing sequence.

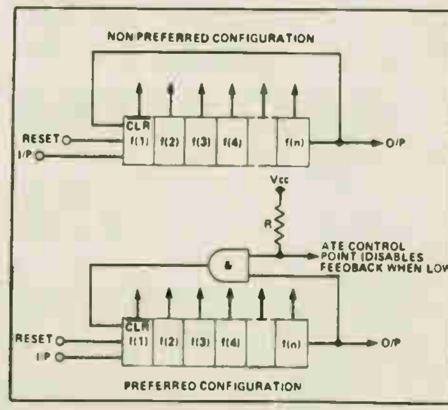


Fig. 8. Non-preferred and preferred sequential circuits.

In **Fig. 9**, a feedback loop has been introduced into the sequential circuit. Even if

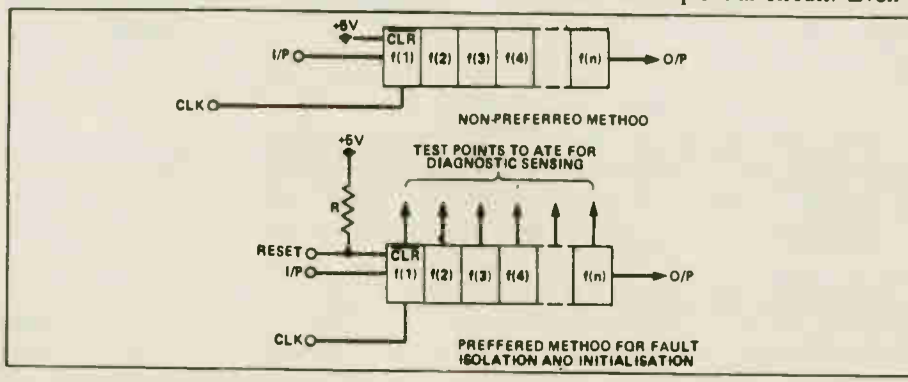


Fig. 9. Breaking a feedback loop.

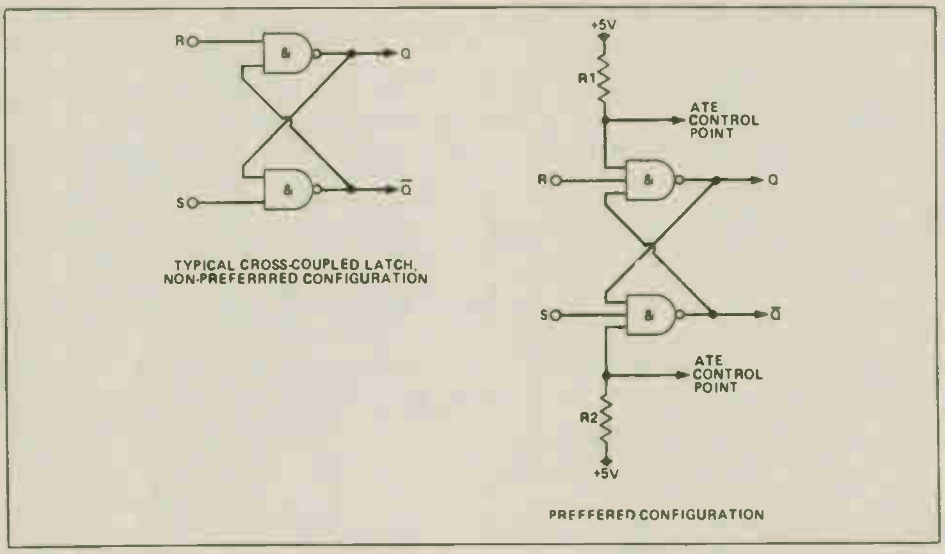


Fig. 10. Breaking the feedback loops in a latch.

test points and the reset line are accessible so that initialization does not require a homing sequence, the problem of fault diagnosis remains. Because of the feedback loop, a fault may be propagated to all points around the loop. To overcome this, the loop must be breakable. The lower diagram shows how this is done; when the control point goes low, the loop is broken.

In **Fig. 10**, a typical cross-coupled latch is shown. By itself, this poses no initialization problem, even though the circuit will power-up into an x-state. However, if such latches are deeply embedded in a circuit and if component gates are from different chips, there may be a serious test problem. The preferred method of control is to use three-input gates as components so that access points exist to break the feedback loops.

In general, initializing combinational circuits presents no problems since outputs are purely dependent on inputs. The first test pattern to be applied will set all nodes to a predetermined state. Initializing sequential circuits is always more complicated since such circuits contain x-states after power-up. These must be flushed out of the system before testing can begin. Since ATE programs must themselves be tested by means of a computer simulation or model circuit, a further problem is encountered. The model circuit will almost certainly power-up into a different state from any other model or real circuit.

A set of test patterns needs to be devised which, when applied to the DUT, will set it to a known state regardless of its initial condition. This is known as a synchronizing sequence. In a simulation test, the model is then put into the same condition using the same synchronizing sequence before testing proceeds.

The synchronizing sequence can act as a homing sequence in the absence of a reset line. A simple example might involve a synchronous counter, for example a 74163, in which all the data inputs are set low, the parallel load is enabled and the clock pulsed. Obviously, access to the reset would achieve the same object at a lower overhead.

The difference between a synchronizing

sequence and a homing sequence, in general, is that the synchronizing sequence is always the same in each particular, while the homing sequence involves an algorithm to modify its stages in the light of the circuit behaviour. Homing sequences are, in effect, programs with loops and branches and are commonly known by the abbreviation AHS which stands for 'adaptive homing sequence".

Figure 11 shows a standard divide-by-two circuit. While the right diagram illustrates a simpler arrangement from a test point of view in which initialization would require only a single-step synchronizing sequence (reset or preset directly), the left diagram shows a simpler circuit which can be handled by use of an AHS.

The following algorithm would provide a suitable sequence:

1. Set CLK to 0.
2. Set CLK to 1.
3. If Q is 0, go to step 1.
4. Return to test (output Q, known to be 1).

Bad design is the bane of the tester's life. An examination of unhelpful design is shown in **Fig. 12**, a section of an actual circuit used in a ship's navigation system. Basic principles should immediately suggest that it was bad practice to tie J, K, and the preset inputs on IC1 (the 7476). Even though the reset lines are available to the tester, close examination reveals another problem. Reset on the 7476 is asynchronous, that is, it works independently of the clock, while reset on the 74163 is synchronous; it needs a clock pulse to operate.

Since the clock pulse for the 74163 is derived from the 7476's Q output, the 163 will never receive a clock pulse when the 76's reset line is low. In other words, it'S impossible to reset both ICs at the same time. To make matters worse, there were no direct outputs available for the 163, all of which makes it very difficult to initialize the circuit.

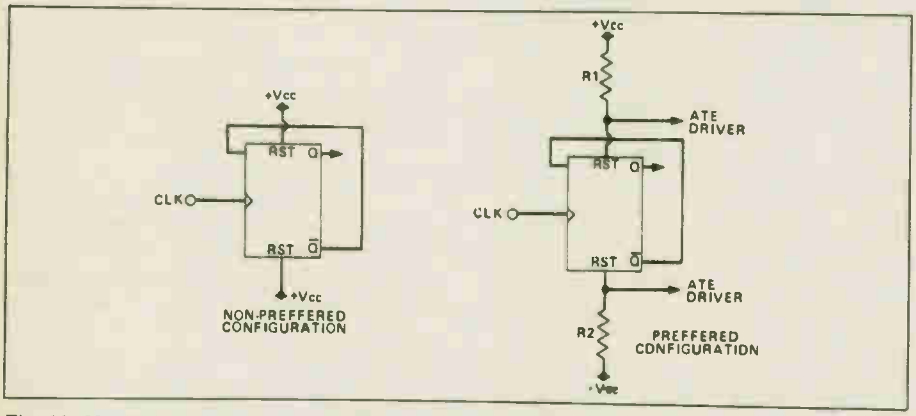


Fig. 11. Homing sequence versus synchronized sequence.

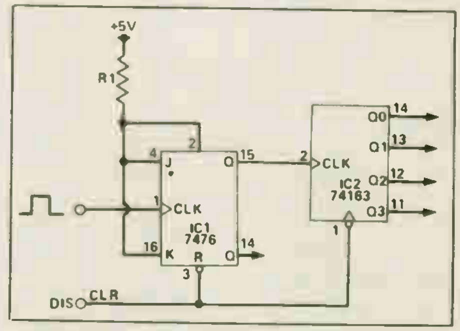


Fig. 12. An actual unhelpful design.

Now You See It

As has been suggested, the observability aspect of testing and the ability to initialize circuits are not totally separable. Observability is really a way of talking about the effectiveness of ATE, which is clearly influenced by the position with respect to initialization. It's already been shown how feedback loops and the lack of circuit isolation can make it impossible to achieve the desired degree of diagnostic resolution, to use the jargon.

There are three ways in which the circuit designer can improve the observability:
- by partitioning circuitry (by function, for example).
- by providing ways to break feedback loops.
- by providing a means of isolating faults (test points, etc).

Functional testers are in practice 'edge connector oriented' and good controllability requires careful attention to the board design of any circuit. Effective ATE must be able to readily and properly exercise every component on the board. Good design, from the test point of view, will reduce the number of steps that need to be taken in order to cover all detectable faults.

The controol functions that need to be available to the ATE can be grouped under five headings:
- Reset and preset inputs.
- Tri-state control lines, enable and disable signals.
- Feedback disable.
- Isolation and control inputs for free-running devices, in particular clocks.
- Synchronization signals, especially where microprocessor based modules are being tested, so that the DUT and ATE may be synchronized.

Reset and preset lines should never be tied together or hard-wired to Vcc or Gnd. They should be 'soft-wired' by use of pull-up or pull-down resistors to which test points are connected. CMOS inputs can be pulled high or low through an appropriate resistor because CMOS requires only very small bias currents to establish high or low states. TTL, however, can only be pulled high through a low-valued resistor because it requires quite a high current (about 2mA) to establish a low state. Active pulldowns should be used if overdriving is required. Passive resistors would have to be of too low a value for the ATE's drivers to source a high onto the input. For example, pulling four TTL inputs low would demand a resistor pulling 8mA across a maximum potential drp of 0.8V. It would have to be approximately 100 ohms.

Access to tri-state control lines is particularly important when testing memory boards or bit-slice processors in which circuit operation depends on ROM contents. Without access to the tri-state lines, it may be very difficult to control the circuit since the ROM contents ma make it impossible to exercise all the circuit nodes. The ATE must be able to override such memory-based constraints.

Feedback loops have been dealt with above, and the preferred method, shown in Fig. 9, requires no operator intervention but can be handled entirely by the ATE software. Of course, switches or links could be used instead.

Control of the free-running devices and synchronization can be treated as two sides of the same problem, since one relates to situations in which the ATE must control the DUT – to single-step through a sequence of states, perhaps – and the other to situations in which the ATE must simply proceed in step with the DUT.

In the first case, serious synchronization problems occur where a clock-controlled circuit is operating at a greater rate than the fastest operation of the ATE. Synchronization is best achieved if the use of multiple clocks is avoided wherever possible. Multiple-phase clocks present no problem, but multiple clocks cannot be synchronized with. If a multiple clock system cannot be avoided, it should derive each clock signal from a master clock, divided down. This allows a common point for each ATE to latch onto.

On The Bus

When testing bus-structured circuits, synchronization alone is not enough. The ATE must be ale to force the circuit's controlling microprocessor to relinquish control of its addresses and data buses.

If an MPU is used in conjunction with a Direct Memory Access (DMA) device, the DMA device must be capable of instructing the MPU to release its buses so that I/O or memory block transfers can take place without involving the MPU. Suitable control signals are available on many common MPUs which enable them to put their bus outputs in a high impedance state. Normally, a DMA controller would be used to handle the procedures involved.

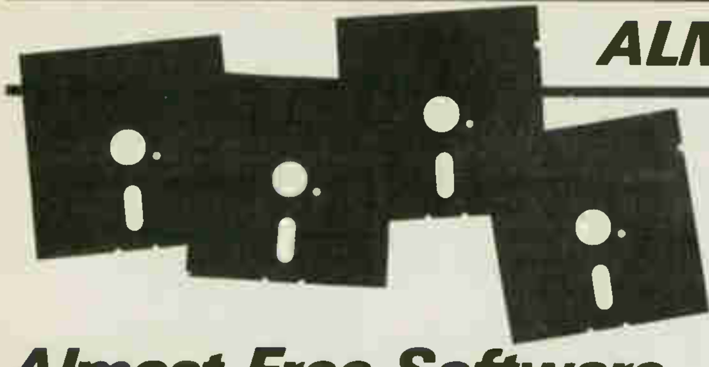
The Z80, for example, features a bus request line, BUSRQ, and the 8085 features a similar HOLD line which are used to flag the MPU when the DMA device is about to make a data transfer. On the next cycle, the MPU will finish its present task and flag the DMA device that it has released its buses, using the BUSAK and HOLDKL lines. The DMA device then takes control of the buses. MPUs that do not contain built-in tri-state buffers on the bus lines (the 6502, for example) must be augmented by external tri-state devices if they are to be used with DMA devices, or indeed, with ATE.

In the case of MPU-controlled bus-structured circuits, effective testing can only be achieved if the ATE has direct memory access either through control lines on the MPU itself or through enable/disable lines on external tri-state buffers.

So Far . . .

The requirements for testability apply equally to manual and automatic testing. While manual testing can proceed even with a badly thought-out circuit or module by the application of a little ingenuity, automatic testing is almost impossible with inadequate circuit design. In essence, the circuit designer's responsibility is to provide all the necessary test points and control lines to enable the ATE to track down all possible faults.

So far, we have dealt only with testing of digital boards. In a future article, we will turn our attention to in-circuit and analog testing. ■



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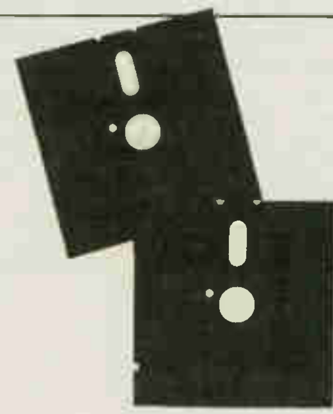

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MORTGAGE This is a very fancy mortgage amortization program which will produce a variety of amortization tables.

NSBASIC Large disk BASIC packages, such as MBASIC, are great . . . and very expensive. This one, however, is free . . . and every bit as powerful as many commercial programs. It's compatible with North Star BASIC, so you'll have no problem finding a manual for it.

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OIL. This is an interesting simulation of the workings of the oil industry. It can be approached as either a game or a fairly sophisticated model.

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DEBUG. The DDT debugger is good but this offers heaps of facilities that DDT can't and does symbolic debugging... it's almost like being able to step, trace and disasemble through your source listing.

DU87. The older DUU program does have some limitations. The version overcomes them all and adds some valuable capacities. It will adapt itself to any system. You can search map and dump disk sectors or files. It's invaluable in recovering damaged files too.

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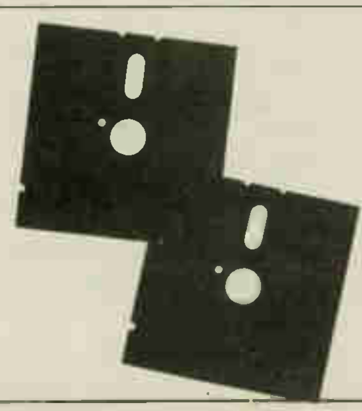
Picture Coder: All Apple HiRes pictures take up 36 sectors in their binary form. This program creates a textfile of a program in memory, squeezing out the zero bytes, that can later be EXECd into memory. The textfile often takes up less room on the disk.

DNA Tutorial: Operating under Integer BASIC, this program might appeal to 'clone' owners. In actuality, though, it's an interactive low-res graphics tutorial of DNA in its inherent forms. And you thought your Apple was only good for games...



Toad: Speaking of games, this program is an Applesoft BASIC implementation of 'Frogger' that can be controlled with either a joystick or the keyboard. The user's high scores are saved to disk.

Function Plotter: A fairly extensive Applesoft BASIC program that takes any inputted function and plots it on the HiRes Screen.

Data Disk Formatter: Apple DOS disks need not be bootable to be useful. This binary program formats a disk without setting DOS on the tracks, conserving useful disk space.

BASIC Trace: A program for the advanced Applesoft programmer, this file, when EXECd, displays the hexadecimal locations of each Applesoft line number of a program in memory.

Gemini Utility: A word processor pre-boot for Gemini printer users, this BASIC program initialises the printer's font or pitch before you boot your word processer.

Payments: This BASIC program allows you to keep track of payments and credits to and from up to 100 accounts on a single disk. A sample account is included.

Databox: A small but useful database program in Applesoft BASIC. Sample files are included to get you started.

Nullspace Invaders: A quick BASIC HiRes game testing coordination and judgement as you manipulate a monolith through mysterious gates.

Fine Print: The majority of this software has been obtained from on-line public access sources, and is therefore believed to be in the public domain. Any remaining programs were written in-house. The prices of the disks defer the cost of collecting the programs, debugging them, reproducing and mailing them, plus the cost of the media they're supplied on. The software itself is offered without charge.

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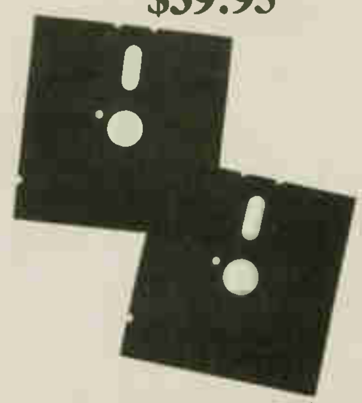

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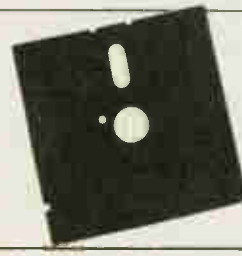

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SOLFE This is a small BASIC program that plays baroque music. While it has little practical use, it's just a kick to toodle with. It's also a fabulous tutorial on how to use BASICA's sound statements.

PC-TALK Telecommunications packages for the IBM PC are typically intricate, powerful and huge. This one is no exception. It has menus for everything and allows full control of all its parameters, even the really silly ones. It does file transfers in both ASCII dump and MODEM7/XMODEM protocols and comes with... get this... 119424 bytes of documentation.

SD This sorted directory program produces displays which are a lot more readable than those spewed out by typing DIR. It's essential to the continued maintenance of civilization as we know it.

FORTH This is a small FORTH in Microsoft BASIC. It's good if you want to get used to the ideas and concepts of FORTH... you can build on the primitives integral with the language.

LIFE This is an implementation of the classic ecology game written in 8088 assembler. While you may grow tired of watching the cells chewing on each other, in time the source will provide you with a powerful example of how to write code.

MAGDALEN This is another BASIC music program. We couldn't decide which of the two we've included here was the best trip, so we wound up putting them both on the disk. Ah... the joys of double sided drives.

CASHACC This is a fairly sophisticated cash acquisition and limited accounting package written in BASIC. It isn't exactly BPI, but it's a lot less expensive and suitable for use in most small business applications.

DATAFILE This is a simple data base manager written in... yes, trusty Microsoft BASIC.

UNWS Wordstar has this unusual propensity for setting the high order bits on some of the characters in the files it creates. Looks pretty weird when you try to do something other than Wordstar the file, doesn't it... Here's a utility to strip the bits and "unWordstar" the text. The assembler source for this one is provided.

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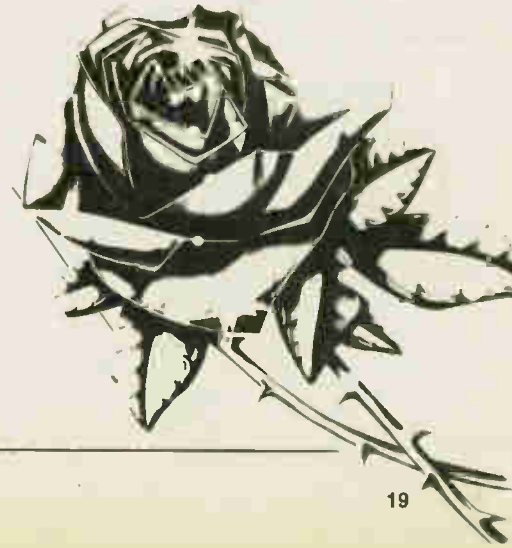

See Order Form Page 51

THE PRESENT controversy over Star Wars reminds this writer of Canada's early efforts in RDF (range and direction finding) research. At that time, it was the other way around: Canada was in the forefront of developing workable radar detection of ships and planes by the outbreak of World War II, while the US was the neophyte. But perhaps it was better for the Allied cause that the early Canadian effort was overtaken by subsequent events which saw the ascendancy of a third party: Britain.

The prelude to WWII saw the first halting steps to develop what was then essentially an experimental radio device to locate enemy aircraft. The halcyon years of radar, following the war's onset in 1939, were best illustrated by the Tizard Mission to North America. It was headed by Sir Henry Tizard of the UK in 1940, and he initially appeared to find Canada more appropriate for RDF research than the US, even if both countries provided a haven free from the bombs and destruction that was England in 1940. As W.E. Knowles Middleton said in his book *Radar Developments in Canada, NRC 1939-1946,* "while the principles of radar appear to be simple, the actual realization of a workable system calls for technical ability of a high order. In the first place, the reflected energy received from a target such as an aircraft at a distance of some tens of kilometres may be only 10^{-18} of that radiated, so that the transmitter has to be very powerful and the receiver extremely sensitive. In the second place, the entire apparatus must be rugged enough to resist weather, transport and rough handling. The fact that very effective apparatus was produced so quickly under wartime conditions demonstrates a remarkable competence in electrical and mechanical engineering, and no less remarkable dedication to the common cause."

Radar Supremacy in WWII

Canada almost became a world leader in the development of radar; a look at some of the early experiences.

By James W. Essex

RDF

We called it RDF both in Canada and Britain, a secret set of letters under which we hammered out a workable machine. We stuck to the original letters for several years into the war, until events hatched a new name for what became a decisive weapon. Britain adopted the American acronym of Radar (radio detection and ranging) while going on to develop higher and higher frequencies. There was also a closer liaison between the UK and the US following the Tizard Mission in the Fall of 1940, while Canada chose to develop an already outmoded design operating on a much lower frequency.

The frequencies of RDF, like the early days of radio, were constantly in a state of flux until the best ones were found. The more conservative researchers, like Canada, stayed with whatever worked,

while overseas research pushed back the barriers. As WWII progressed, Britain went still higher with RDF frequencies, reaching 3000MHz, or 10cm. Microwave RDF came at an opportune time, helping not only to turn the tide in the Allies' favour, particularly in the Battle of the Atlantic in 1942-43, but assisting the growing US fleet in operations against the Japanese in the Pacific. Canada had only one representative there in the closing years of the war, a gift from the Royal Navy: the HMCS *Uganda*, Canada's first and only cruiser to see service in the Pacific (the author served as a Radar Mechanic on board from commissioning in October, 1944 to the war's end in the Pacific, serving in all major theatres of the Pacific campaign). Of course, being a former Royal Navy warship, it carried British-built RDF equipment.

Microwave RDF

When Britain and the US embraced the as yet untried S-band magnetron with fervour, it set the standard we'd all eventually follow. But our Canadian enterprise wouldn't go easily despite the UK's obvious lead, epitomized by Britain's Type 271 microwave RDF. Even before the US was into it in a big way, Canada was considered to have a substantial lead over the US; this lead resulted in a fair amount of inertia at the top command levels, and Canada insisted on fitting corvettes with the Canadian-built RDF even though the microwave RDF was shown to be superior. Only when the tide of battle became desperate did authorities recant and accept the improved 271 from the British. To Canada's credit, we did eventually develop our own 3000MHz magnetron 10cm radar, but it wasn't completed until 1944 and was only operational by the war's end, too late to help.

It's interesting to note that when the Americans earlier saw our primitive research outside Ottawa, they wondered why we hadn't made a greater expenditure then. According to Middleton's book, "the American group said that if their organization had done as much and as satisfactory work as we had done in the last nine months, they would consider the construction of a million-dollar building on our farm justified". The two buildings Outside Ottawa early in the war cost $50,000, including a number of shacks and tents.

At the time, the best the US could do was a paltry ten watts from an experimental magnetron demonstrated to the Tizard Mission in 1940. We were still experimenting with relatively standard transmitter tubes. The British, on the other hand, presented the Americans with a magnetron that could push 10kW. On the basis of this, the famous microwave lab at the Massachusetts Institute of Technology was begun at Boston. This was the forerunner of what the Americans came to call Radar. It eclipsed Canada's embryo efforts before we got started; we stuck with a relatively primitive design using a frequency which today is approximately where Channel 11 is (this is dealt with in some length in my book, *Victory in the St. Lawrence, Canada's Unknown War*, describing the dismal performance of Canadian-built RDF in the Gulf of St. Lawrence in 1942).

The Navy

Canada's contribution began with our insistence on following our own independent course initiated by our Navy. This resulted in time spent on a costly, less efficient RDF than would have been the case had we followed Britain's lead. We might also have developed a better working relationship with Britain. Instead, closer liaison between the UK and the US followed, effectively bypassing Canada.

I recall when our first class of RDF recruits entered the University of Western Ontario in early 1941, where basic research was directed already in the 1.5 metre band, great store was placed in an improved RDF for our corvettes. The Yagi antenna (developed earlier by a Japanese physicist) was admirably suited for our use, both in dimensions and directivity. Weight was a consideration, as well as the ability to rotate independently of the ship, eliminating the need to maneuver, as was the case with fixed aerials. The relatively small dimensions of the yagi meant that mast-head mounting was possible, despite the myriad wires, cables and signal halyards.

Rotating the yagi was a problem; conduits had to make a 90 degree turn to enter the cabin, and the many cogwheels necessary to transmit the motion meant cramped quarters for the operator. It required a hefty steering wheel to turn; my first ship, the HMCS *Prince Robert* employed a used Chevrolet steering wheel, scrounged, I'm told, from a nearby auto wreckers in Victoria. *Prince Robert* was the first ship on the west coast to be outfitted with SW 1C RDF, just in time to escort the ill-fated Canadian garrison to Hong Kong later that year.

The *Robert's* 90-foot raked mast required climbing, even in inclement weather, to reach the petcock at the top of the yagi to 'blow out the line'. This was necessary whenever moisture penetrated, shorting the coaxial feed. In addition, the signals from the front and rear lobes of the yagi were almost equal in strength; only close comparisons of minute blip height would show if the target was ahead or astern.

It should be recalled that these limits had frightening consequences. The HMCS *Charlottetown* was torpedoed by the enemy right here in Canada, off Cap Chat on Gaspe's lower North Shore in 1942. Our RDF failed to detect the Nazi submarine's periscope; Canadian sailors paid the price and Canada lost a ship.

Following the evacuation of Dunkirk in May, 1940, it was decided to move much of the upcoming British research to North America. Tizard preferred "serving officers who had recently been in action and who had had some operational experience of radar or similar". Canada had a surfeit of officers who had already had war experience. With a little persuasion, we might have prevailed in radar research. But it was not to be: the cavity magnetron developed by the British was far superior to anything else, including the German Seetakt radar at 0.8 metres. However, it was fortunate for all of us that eventually the research won the day, even if Canada lost the chance for radar supremacy. ■

Designer's Notebook: Digital Sampling

THE WAVEFORM that is recovered from a digital sampling process is never quite the same as the waveform that went in. Analogue to digital and its opposite (D-to-A), break continuous waveforms into discontinuous elements. The trick is to get it as close as possible to the original. Without taking any special precautions, you'll certainly end up with a sound that's recognizable, but it'll be noisy and distorted. Why does it happen, and what can be done about it?

First of all, we have the problem that a fixed number of 'quantisation levels' are available according to the number of bits that will represent the sample digitally. We'd like each sample to equal the exact value of the analogue signal at the time. Instead, we must round it up or down to the nearest level for which a digital code is available. A 2V signal, for example, would be okay for an 8-bit sampler, but 2.005V would not.

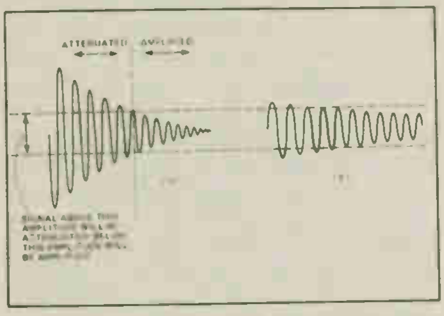

Fig. 1 (a) Input to compressor, and (b) the output from the compressor.

The result of the rounding process is known as quantisation noise and sounds very much like the kind of thermal noise hiss that any audio equipment will make to a greater or lesser extent. Intuitively, you can see why it sounds like noise by thinking of the difference between the true value of the audio signal and its quantised value as an extra and unwanted signal that is superimposed on the input.

For an arbitrary input, the value of this extra signal at each sampling will be random, in the sense that it will not be related in any obvious way to the harmonic structure of the input, will not repeat, and so on. There are certain inputs for which this will not be the case, but for general audio signals it's a reasonable way to look at the situation. The main difference between quantisation noise and thermal noise is that quantisation noise is only present when the sound is being reproduced, while thermal noise is there in the background all the time.

A look at the problems and solutions facing the designer of a digital sound sampler.

By Paul Chappel

For an 8-bit word length, the signal-to-noise ratio will be 48dB for a signal which is large enough to make use of all 256 available quantisation levels. This is certainly not hi-fi, but could be tolerated; a cheap domestic tape recorder will give similar results.

Unfortunately, the signal-to-noise ratio degrades very quickly as the amplitude of the input signal drops. For an input 20dB below the overload point (the point at which the A-D converter runs out of codes) the S/N ratio is a mere 28dB. Not too good. The reason for the degradation is fairly obvious; in the extreme case the input may be so small that it only alters the least significant bit in the binary code. The resulting variation between two possible output levels would not track all the nuances of the input with any degree of precision.

Companding

The simplest solution to this problem is to ask the user to adjust the input so that the ADC is operated as close as possible to its overload level without actually exceeding it. This is not as ridiculous as you might think. There are commercial samplers available that do this.

Assuming that the sound to be sampled can be repeated a few times to allow the input level to be adjusted, we are still left with the problem that as the sound decays the noise will increase. A piano note, for example, will begin with a high amplitude as the hammer strikes the string. The amplitude will then drop away quickly to a much lower sustain level. A sampler adjusted to accept the initial level would not give very good results during the sustain period.

Another possibility is to adjust the sound level electronically. Devices which do this are called companders (compressor/expanders) and are available ready made in the form of ICs. In essence, the compressor section will reduce the amplitude of signals that are above a certain pre-defined level and increase the amplitude of small signals, so that the range of amplitudes is close to a constant level (Fig. 1). Therefore, the output will have a substantially reduced, or compressed, dynamic range and the signal can be kept close to the overload point of the sampler at all times. The expander section returns the dynamic range to normal after the signal has been translated back into the analogue form.

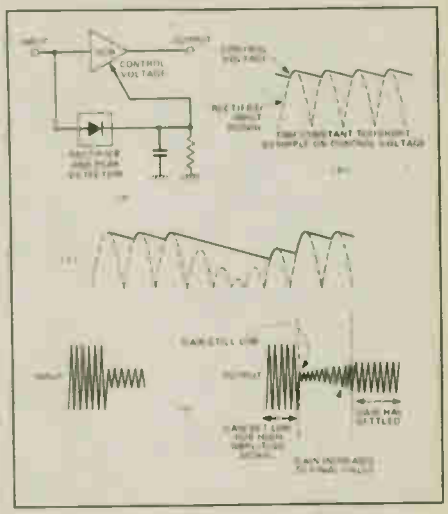

Fig. 2 There is a compromise between choosing too small a time constant, as in (b), and too long a time as in (c) and (d).

This is all very well in theory, but companders work by taking an average of the signal level and using this average to control a VCA which modifies the output level. The averaging process involves rectifying the input and integrating the result. A short time constant on the integrator will give an accurate average but will result in a good deal of ripple on the VCA control signal, while a long time constant gets rid of the ripple but will make the circuit slow to respond to amplitude changes (Fig.2).

As rapid changes of gain in the VCA cause considerable distortion, compander circuits tend to err on the side of a slightly longer time constant. The resulting amplitude changes cause an effect often described as 'breathing'.

Instead of modifying the signal envelope, as is the case with companders, another possibility is to modify the waveform itself. Imagine we have a circuit with a kind of 's-law' characteristic as in Fig.3. Any input to the circuit would be amplified much more around the zero-crossing part than it would be at its peaks. An input of varying amplitude would still be compressed, but this time the compression would be achieved by altering the shape of the wave rather than shrinking it as a

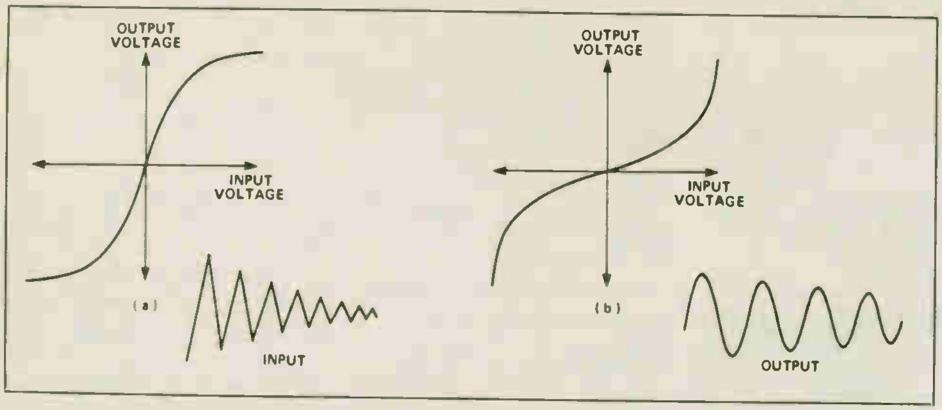

Fig. 3 (a) 'S'-law transfer characteristic. (b) The characteristic needed to restore the original signal. The waveforms show a triangular wave of diminishing amplitude before and after processing by (a). Note that the output changes far less in amplitude than the input.

whole. The waveform would end up very distorted, but could be restored to its original glory by a circuit with the inverse characteristic.

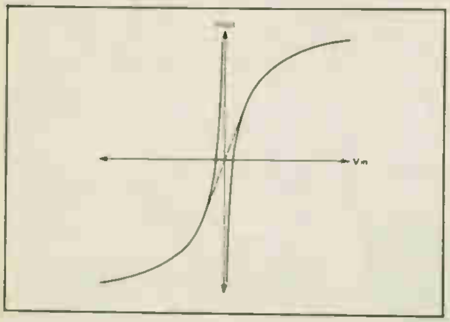

Fig. 4 Making an 'S'-law function from one curves. Note that if transistor junctions are used, the curves are offset along the Vin axis and will actually pass through the origin.

A circuit of this nature is not easy to construct as the inverse circuit must be a very precise match to the compressor. I have a feeling that something along these lines could be made by leaving out the integrating capacitors on a compander IC, but I haven't really looked into it.

Fig. 4 shows the curves simulated by a circuit using the base-emitter junctions of a pair of transistors with a bit of trickery to carry the function across the centre. The results were encouraging, but much more difficult to compensate for the temperature variations than I had anticipated. Log amplifiers exist in IC form (with temperature compensation) but they only work in two quadrants: you get the right hand side of Fig. 4 or the left, but not both.

However, all this is short-circuited by the fact that a similar kind of compression can be performed by the ADC. Just tuck the previous ideas away in the back of your mind for a moment because I'd like to approach the idea of 'digital companding' from a slightly different angle.

Resolution

The obvious way to increase the dynamic range of the sampling process is to use a high resolution ADC. A 12-bit ADC will give 4096 quantisation levels and a S/N of 72dB at best; for a 16-bit ADC we have over 65,000 levels and a maximum S/N ratio of 96dB. If we're using 8-bit words to store the data we can't use a 12 or 16-bit ADC (assuming we could afford the 16-bit devices) and using two words for each sample would halve our sample time. Bearing in mind that we want to avoid the degraded S/N for low signal levels, suppose we do this instead:

Around the OV level, we pretend we've got a 12-bit ADC and space the quantisation levels accordingly so that they are 0.025% of full scale apart. After the first eight levels, 0.05% of full scale apart. The next eight levels will be 0.1% FS apart, the next eight 0.2% FS, and so on. The resolution around OV is now excellent. The penalty is that in the final section which takes care of the wave peaks the resolution is only equivalent to a 5-bit ADC. There are two very strong points in favour of this as opposed to linear conversion. First of all, audio signals generally have an amplitude spectrum concentrated in small signals rather than large ones and will often have crest factors (the ratio of peak to RMS amplitude) of five or more. Secondly, the human ear is much more sensitive to any inaccuracies of the wave around the zero-crossing point than it is to slight variations in the peaks. At the end of the day, the justification for this type of conversion is that it sounds so much better!

In IC form, there are two versions of the companding DAC. The first follows a law known as u255, developed by Bell Laboratories. The idealised law is:

$$Y = 0.18 \ln(1 + uX)$$

where u has the value 255 for an 8-bit converter. This law is approximated by seven 'chords' which double in step size as described above. The rival system, the A-law, approximates the function:

Y + 0.18 (1 + lnAX) for 1/A (see ms pg 29)

Where A has the value 87.6 for an 8-bit converter.

In both these cases, X is the analogue signal level as a fraction of full-scale. The formulae give the magnitude of the signal levels; a sign bit in the DAC is used to say whether they are above or below zero.

The main difference between the two laws is that the approximation of the A-law results in the first two 'chords' having the same step size, so the maximum resolution is only equivalent to an 11-bit linear DAC.

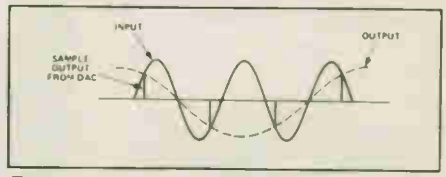

Fig 5 Alias distortion.

To tie in with the earlier idea of modifying the waveform with an 'S-law' analogue circuit, just imagine that the sample in memory from the variable-step ADC was fed out through an ordinary DAC. With allowances for the chord approximation, the waveform would look just as if it had been processed by the analogue 'S-law' circuit.

The advantage of companding during A-D and D-A conversion is that the technology required is just the same as that needed to produce a 12-bit DAC, which is not very difficult these days. To get the same degree of precision in a non-linear analogue circuit would be virtually impossible.

Sampling Rates

A well-known rule of thumb is the need to sample at more than twice the rate of the highest frequency component of any waveform that is to be reproduced; i.e., the famous Nyquist theorem. If you disobey the rule, you let yourself in for a dose of the dreaded alias distortion.

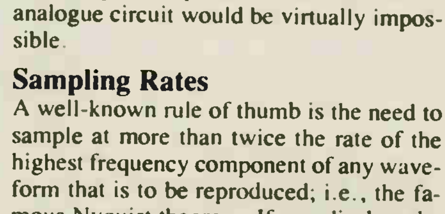

Fig. 6 The frequency spectrum of the input signal (a) and the output from the DAC, (b), showing the additional frequency components generated by sampling.

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Longwaves

If, like most of us, you think that radio transmissions all work with very high frequencies, you'll be surprised to find out how much is happening below 500kHz, and even more surprised to find out that the spectrum extends all the way down to 9kHz. **"The World Below 500 Kilohertz"**, a book by L. Peter Carron, Jr., details the commercial and non-commercial uses of low frequencies, as well as technical advice on how to listen to the low bands. There are navigation beacons, maritime voice bands, and military communications; you can also listen to natural generators such as earthquakes or solar flares. It's a fascinating book, a 64-page softcover available from the author for $5.50 US. Contact: L.P. Carron Publishers, 205 Ridgewood Road, Easton, PA 18042, (215) 250-8898.

Power Entry Modules

Schurter Power Entry Modules provide a quick-disconnect feature for power cords. They're available with single or double fuses, a voltage selector switch and a lighted or unlighted power switch, depending on the model. All models are UL and CSA approved. Now you can add the power cord to the list of peripherals that you lose. From Lenbrook Electronics, Unit 1, 111 Esna Park Drive, Markham, Ontario L3R 1H2, (416) 477-7722.

Digital Electronics

Newport Electronics announces the Quanta Series 2000 digital panel meters for thermocouple types J, K, and T. Signal conditioning provides cold-junction compensation, linearization and sensor-break detection; there are options for analog outputs and control outputs such as isolated or parallel BCD. For more information, contact Metermaster division of R.H. Nichols Co. Ltd., 80 Vinyl Court, Woodbridge, Ontario L4L 4A3, (416) 851-8871.

Thyristor Handbook

Motorola's new Thyristor Handbook, DL137, contains over 600 pages of information on triacs, SCRs, GTOs, triggers, etc. It includes theory and applications, cross references, selector guides, and a complete set of Motorola data sheets. There are sections on driver circuits, mounting, reliability and new technologies. Available from all Motorola sales offices and distributors.

Temperature Monitor

An intriguing way for manufacturers to monitor temperature during an industrial process: the Ball Corporation of Colorado sells a gadget called the Datatrace, consisting of a monitoring device about two inches long by one inch in diameter. The device is packaged along with the product (inside a can or bottle, say) and passed through the processing methods. Then the device is retrieved is inserted into the playback console; a computer reads out up to 1000 time/temperature data points. The device can be reset and reused; battery life is about 1000 hours. So if you open a can of soup and find one of these, contact the Ball Corporation, 9300 West 108th Circle, Westminster, Colorado 80020, (303) 4460-5259.

Heath Laptop

Heath has announced a new laptop computer, the ZP-150, a diskless unit weighing 3.5kg and sporting a fold-down LCD display. The operating system is Microsoft WORKS, compatible with MS-DOS; the 224K of ROM contains a word processor, a database, a spreadsheet, telcom software, etc. Serial and parallel outputs are provided. From Heath dealers, or contact the Heath company, 1020 Islington Ave., Toronto, Ontario M8Z 5Z3, (416) 232-2686.

A Toronto Loblaws supermarket is testing a prototype electronic shelf price display system. An LCD readout on the shelf displays the price and can be toggled by the customer to give a unit price, such as cents per litre; the product is identified by a card on the LCD. The displays are interconnected with the checkout counter, "ensuring 100% consistency between prices marked and prices read by checkout." The release doesn't mention that it will make it easier for supermarkets to raise prices. Hourly, if they want.

According to a press release, the 10th World Computer Congress and Business Equipment show will be held in Dublin in September, 1986. The release also says that the number of computer companies manufacturing in Ireland makes it 'the Silicon Valley of Europe'. Canada has Kanata, Ontario ('Silicon Valley North') and Scotland has 'Silicon Glen'.

According to another release, Fairchild Semiconductor is opening a $100 million CMOS wafer-fabrication facility in Nagasaki, Japan; it will be constructed by 1986 and producing by 1987. The public relations writers must have been wrestling with themselves not to have called it 'Silicon Valley East' or similar.

CAD/CAM Graphics of Ottawa announce a new PCB artwork service called Artwork Express. It uses the Racal/Redac computerized PCB design system, said to be the most advanced system available, and is just part of their system which provides integrated and hybrid circuit board design, digitizing, plotting, N/C tapes, prototypes, drafting, documentation, etc. The Artwork Express service can also send the customer requirements from a Toronto office to the main equipment in Ottawa via modem, with a similar service for Montreal by the new year. For more information: CAD/CAM Graphics (1984) Ltd., 700 Industrial Ave., Ottawa, Ontario K1G 0Y9, (613) 526-0620.

Because gold doesn't corrode, it's the favourite coating for contacts in electronic equipment, but being a precious metal, it's subject to high prices and market fluctuations. There have been attempts at substituting for gold in the past, with varying levels of success. Now the Allied Corporation has produced a nickel-based alloy called Altraloy which it claims is the ideal replacement. It has excellent corrosion resistance, solderability, and can be plated on without an underplating. No mention was made about availability; if you'd like further information, you can contact their Corporate Technology Department at PO Box 2245R, Morristown, NJ 07960, (201) 455-5012.

Canada Remote Systems, the largest supplier of BBS public domain software, is now supporting the Apple Macintosh. Over 50 Mac disks will be online, giving a total of 20 megabytes of PD software. For more information, contact them at 4691 Dundas St. W., Islington, Ontario M9A 1A7, (416) 239-2835.

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Megabit ROM

A one-megabit ROM with an operating current of only 15mA and a standby current of 100uA from a single 5V source is available from Oki Semiconductor. It is organized into 131,072 eight-bit words and interfaces with most processors, including the 80C86/88. Access time is 250nS and the device is compatible with TTL. The 28-pin IC is available in 5000 lots at $23 US each. Oki Semiconductor, 650 North Mary Avenue, Sunnyvale, California 94086, (408) 720-1900.

Circle No. 56 on Reader Service Card.

continued on page 37

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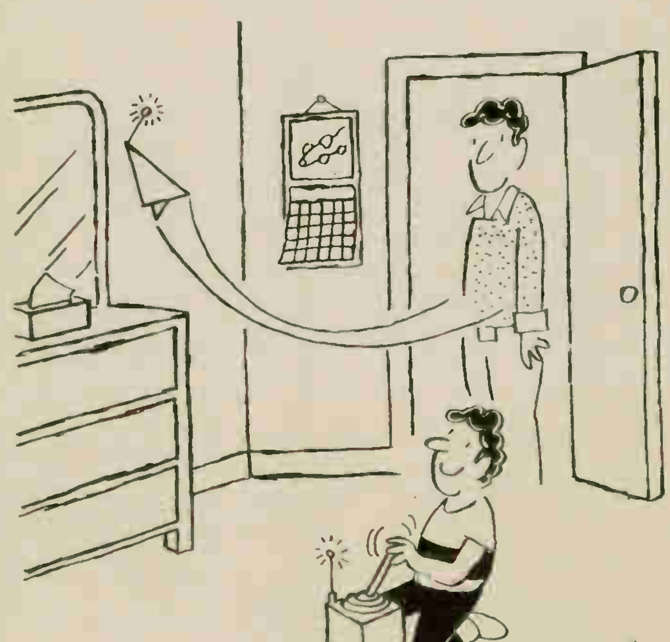

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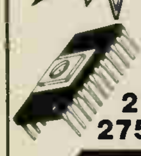

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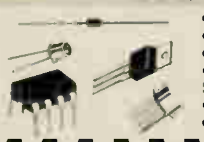

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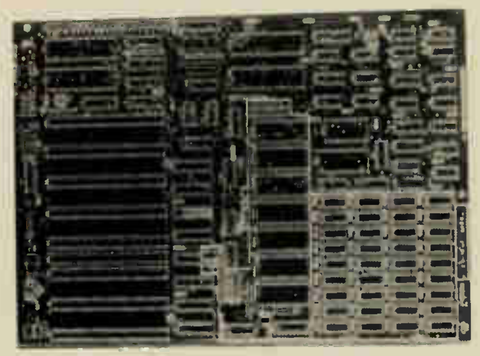

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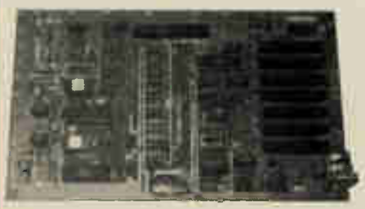

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continued from page 23

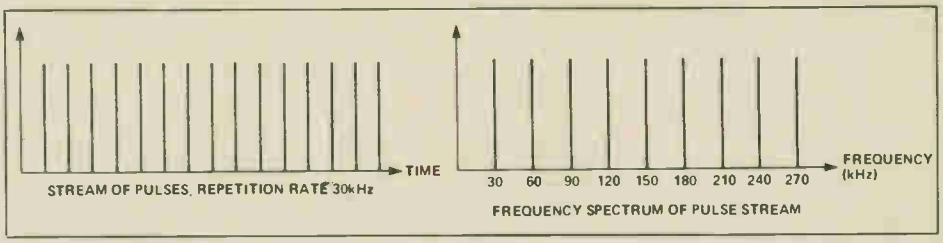


Fig. 7 A stream of sampling pulses and their frequency spectrum, which extends indefinitely.

Alias distortion is often presented as a kind of 'mistaken identity' of the sampled waveform (Fig. 5). This is OK for explaining how it might occur, but not much good for deciding what to do about it. A more enlightening view of the situation is to consider the frequency spectrum of the sampled wave, or the output from the DAC.

Two points before we start. First of all, the following discussion assumes that the output from the DAC represents the exact level of the input at the time of sampling. Any practical inaccuracies we have already put into the 'noise' pigeon-hole, and there they can stay for the time being. Secondly, it doesn't matter whether we use linear or log conversion. What we are getting out of the DAC is a stream of voltage levels representing the instantaneous value of the sampled wave, no matter what black magic was used to stuff it into the memory in between.

We'll start off with an analogue input which has a frequency spectrum as shown in Fig. 6a. After sampling at 30kHz, the output from the DAC will have a frequency spectrum as shown in Fig.6b. No doubt you've seen similar diagrams before. To get a feel for why it should be so, take a look at Fig. 7.

First of all we have a series of sampling pulses of zero duration. Not very practical? OK, I admit it, it's a mathematical fudge. But bear with me for a moment. It so happens that a string of pulses like that has a frequency spectrum consisting of evenly-spaced sine waves all with the same amplitude. Now, if I took just one of these sine waves and amplitude modulated it, remembering your AM theory, you'd expect to see sidebands on either side, right? And varying the amplitude of the sample pulses in accordance with the amplitude of the input is pretty much like amplitude modulation. Fig. 6b shows all the 'sidebands'. The argument has many holes, but the conclusions are OK.

So what happens when the DAC output consists of real pulses that have a finite width? Well, if I can lean on the previous rickety argument a little more, the unmodulated output spectrum from the DAC will now be a series of sine waves which diminish in amplitude as their frequency increases. So what we'd expect to see is the amplitude of the higher frequency 'sidebands' of the modulated spectrum decreasing in amplitude, too, as their frequency increases. This is exactly what happens.

The original spectrum of Fig. 6a is all we want to end up with, so it won't cause us any grief that the upper frequencies diminish in amplitude. We're going to filter them out anyway. What would cause us concern would be any alteration to the amplitude of the original spectrum, the part we want to keep.

At this point the intuitive argument col-

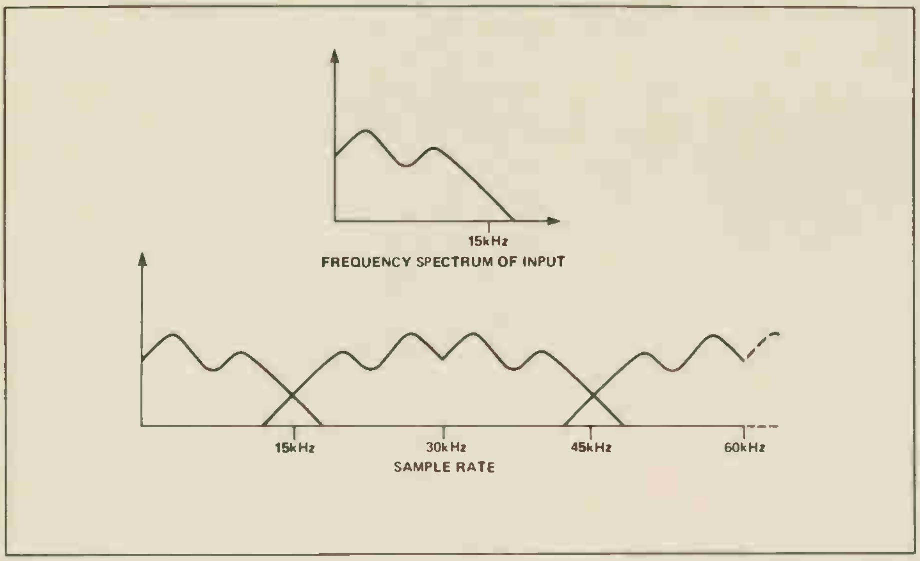


Fig. 8 The frequency spectrum of an input signal containing components above half the sampling frequency and the corresponding spectrum of the DAC output.

lapses under the strain and we must take account of the results of a full mathematical analysis. Yes, the amplitude of frequency components of the part of the spectrum we want to keep will diminish. The wider the output pulses from the DAC, the more significant this effect becomes. With a stair-step output from the DAC, which retains the previous output until another digital code comes along, the frequency response will gently roll off until, at half the sampling frequency, the output will be down by about 4dB. No need to panic, but it should be taken into account. Remember that this has got nothing to do with any filtering or whatever, we're just looking at the raw output from the DAC.

It seems sensible that if we're looking for perfection, the best thing to do would be to return the DAC output to zero in between sample outputs. Sad to say, this can cause more problems than it solves.

We've been looking at nice clean sterilized theory up to now. Unwanted odds and ends creep in, but they stay in their proper place and behave themselves and we know just what to do with them. When you actually come to build a circuit in real life, the results are much less predictable. For instance, DACs don't instantly jump to a new output level when a digital code is applied, they have a certain settling time and what happens at the output during that settling time is anybody's guess. Additional frequency components will be generated and they won't be in predictable places.

The answer is to make them small in comparison with the spectrum we want, which in essence means making the output hold time long in comparison with the settling time. In general, it is often better to put up with a predictable fall in performance that can be compensated for rather than to try correcting it at the expense of introducing factors that can't be removed.

To return to Fig. 6, although there is no frequency component at the input which is above half the sampling frequency, there are already unwanted frequencies from the DAC which occur within the audio range. If we could block off all frequencies above 10kHz at the input, the unwanted frequency spectrum would at least be above 10kHz. This is not very sensible. The unwanted frequencies could burn out tweeters or beat with the bias oscillator of a tape recorder and produce audible products, for instance. There is the more obvious problem of losing bandwidth for no particular reason. Output filtering is the answer here.

Figure 8 shows the situation when frequencies above half the sampling frequency are present at the input. The overlap of wanted and unwanted frequencies is our alias distortion. The practical result is a kind of harshness or coarseness in the reproduced sound. These frequencies could also be eliminated by filtering at the output, at the expense of a good deal of usable bandwidth. Far better to have a filter at the input to prevent frequencies above half the sample rate entering the system in the first place.

The result of all this is that although we could, at a pinch, get away with filters just at the input or output, the maximum system bandwidth and best possible sound will be achieved by filtering both. Obvious, you think? Well, maybe, but I recently saw a design for a fairly expensive self-contained unit with no input filtering whatsoever and a pathetic and totally inadequate 2-pole filter on the output. The designer claims it can 'also be used as a treble control'. Surprisingly often, designers of commercial equipment, who really ought to know better, try to get away with inadequate filtering or even no filters at all. ■

Tools for Electronics

Treat yourself to some of the gadgets available from a huge variety of testbench tools.

By Bill Markwick

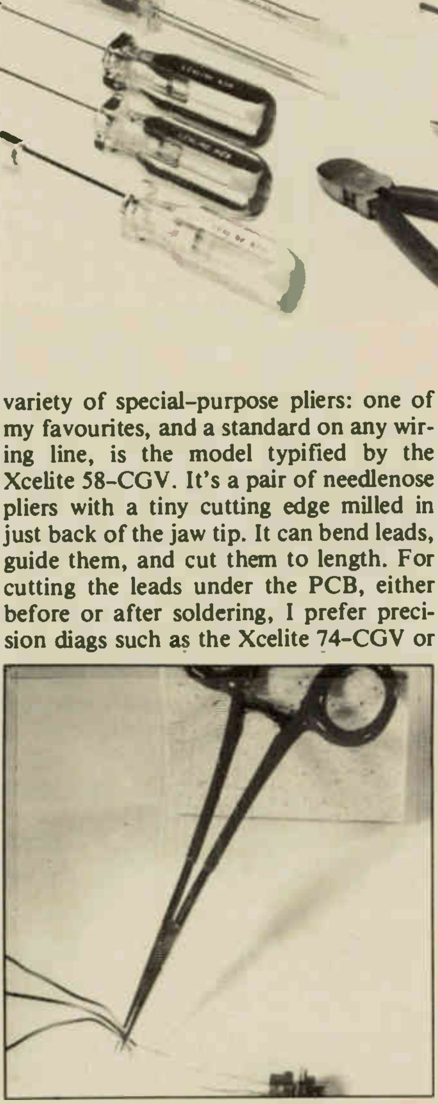
AFTER you get the testbench equipped with basics like the oscilloscope, generator and power supply, you might want to upgrade some the tools that you started out with. Lineman's pliers and Visegrips don't really make it when you're trying to pull 1/4 watt resistors out of a printed circuit. We didn't list retail sources for tools because there are so many, but if you have your heart set on something you can't find, there's a list at the end of distributors you can contact.

Pliers and Cutters

These are the tools you'll use the most, and the two main uses will be in stuffing a new PCB with parts and, if you're like me, pulling them back out again because you got the holes wrong.

Is there a difference between electronics pliers and the hardware store variety? You betcha. A pair of fine needlenose pliers will let you insert or remove the tiniest part from the most awkward of locations in a way unmatched by even the best of the hardware—store types; a pair of miniature diagonal cutters will nip off the excess component leads effortlessly, and very close to the PCB. If you have 200 leads to cut, not an unreasonable amount, your wrist will thank you for getting sharp, accurate cutters; the leads are also cut squarely and neatly, not squeezed apart.

In addition, makers of professional tools can supply you with an amazing variety of special-purpose pliers: one of my favourites, and a standard on any wiring line, is the model typified by the Xcelite 58-CGV. It's a pair of needlenose pliers with a tiny cutting edge milled in just back of the jaw tip. It can bend leads, guide them, and cut them to length. For cutting the leads under the PCB, either before or after soldering, I prefer precision diags such as the Xcelite 74-CGV or



A hemostat with locking clamps near the handles; there's nothing like them for very small parts.

Crescent 941-4SC. The jaws will cut close to the PCB surface in a way unmatched by any low-cost model. There are also special miniature shears especially for PCB lead cutting, such as the Lenline L1011.

If I haven't convinced you of the importance of good pliers and what a difference they make: borrow a pair and compare them to your $5 hardware store types, and you'll see what a good investment they are. Ummm, that brings up another point... precision tools cost a fair amount. You'll find that the best pliers and cutters are in the $15 to $25 range. On the other hand, they'll last and last; you can hand them down to your grandchildren and tell them that you once made your very own musical doorbell.

Weird Tools

Well, they aren't really weird. They're just unusual and a bit hard to find, but they simplify those annoying little tasks that require three hands and more patience than you've got at the time.

Among these are forceps and hemostats. You can fantasize that you're saving the day by taking out somebody's appendix in a submarine. Both forceps and hemostats are like extra-thin, extra-long needlenose pliers; the hemostats have a latch to hold them shut at various tensions. There's nothing like them for starting tiny nuts and bolts or grasping tiny leads for soldering or fishing for that microscopic washer you just dropped into the power supply. A typical example of forceps would be the Lenline CFM-5, an inexpensive curved model made of nylon (handy if you insist on tugging live wires); locking hemostats are typified by the Lenline 70-20C, a stainless steel curved type.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Printed Head	24 pin: overlapping
Print Speed	Letter quality: 54 CPS Draft quality 144 CPS (12 CPI) 120 CPS (10 CPI) Condensed print: 78 CPS (16.7 CPI)
Line Lengths:	132 Character per line (16.7 CPI) 96 Characters per line (12 CPI) 80 Characters per line (10 CPI)
Character Set	96 standard ASCII characters
Character Fonts	Letter quality 24 x 36 dot matrix (proportional spacing). Draft quality 24 x 9 dot matrix, condensed draft quality 24 x 9 dot matrix.
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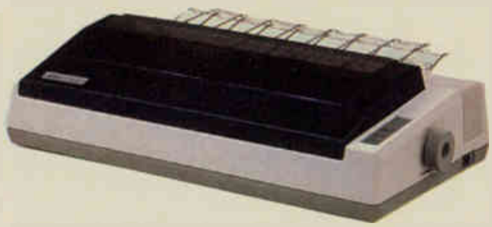

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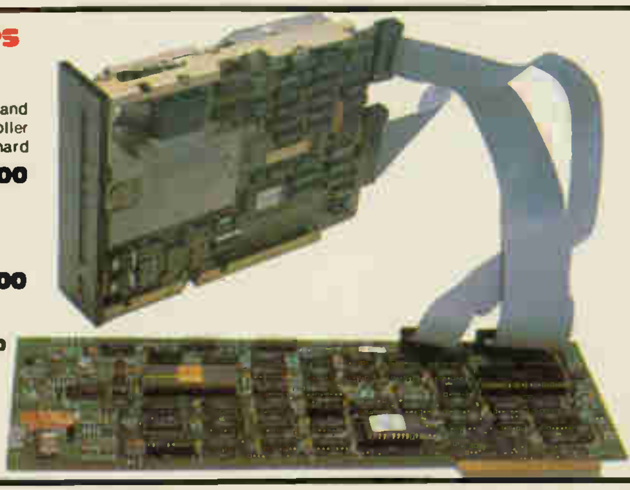

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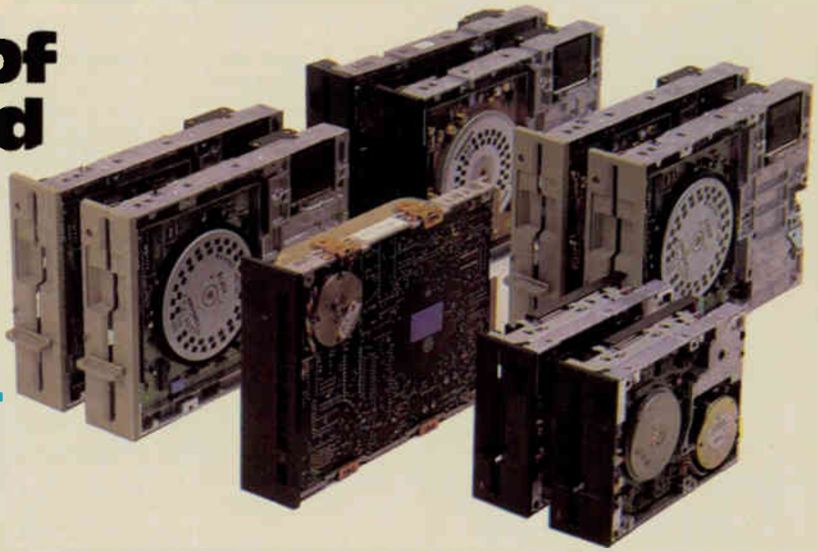

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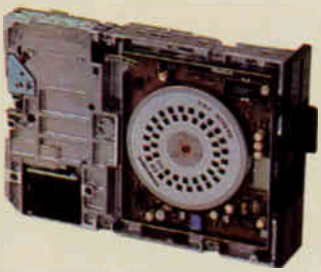

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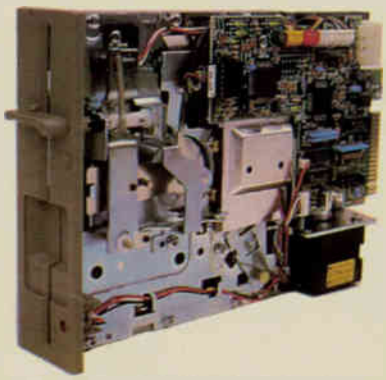

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Mbytes per Drive (RLL)	64.8	90.7	129.8
Bytes per Track (MFM)	10,416	10,416	10,416
Bytes per Track (RLL)	15,624	15,624	15,624
Heads per Surface	1	1	1
Data Surfaces	5	7	10
Cylinders per Drive	830	830	830

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Maximum	55.0

Quantity Discounts available.

The 8088 Controller and Trainer System

Based on the success of our Multiflex starter systems, we are proud to announce the arrival of the 8088 Controller and educational Trainer System. With the option to upgrade to a full IBM PC compatible, the starter system is the perfect education tool to learn 8088 based hardware and assembler code. It is also ideal for use as a complex, high speed industrial controller at an affordable price. This 8088 System consists of two boards. The first board (as seen in the picture) is the motherboard which can be used as a general purpose controller and contains the following:

- Socketed for 64K static RAM
- Socketed for 64K of EPROM
- RS232-C serial communications port
- Controller Port
- 300 baud modem
- 3 IBM PC compatible expansion slots (when the multifunction board is used)
- Wire Wrap area

The motherboard is a very versatile controller for which it is very easy to write software on the IBM PC/XT.

The second component is a console which connects to the motherboard via a ribbon cable. The console contains a display, hex keypad and another keypad containing function keys to perform memory block moves, register examination, the examination of I/O ports and a myriad of other functions. This board also contains an EPROM programmer.

A further multi-function board which has been designed specifically for the system to make it IBM PC compatible is available. This multi-function card contains a floppy diskette controller, DMA controller and up to 512K dynamic RAM.

Controller Board with 16K RAM (optionally expandable to 64K)
$250.00

Keyboard and Display Board with EPROM programmer and monitor software
$159.00

Multi-function Board with 64K RAM (expandable to 512K)
$250.00

SPECTACULAR GANG EPROM PROGRAMMER AND EMULATOR

Totally self-contained (has its own display, entry keypad and power supply).

Based on the Z-8 microprocessor.

Can program up to 8 EPROMs simultaneously (anywhere from one to 8 EPROMs at the same time with the information in its own memory or or master EPROM).

Each of the 8 EPROM programming sockets is individually buffered and isolated from one another providing protection in situations when there is a bad EPROM among the eight being programmed. Clearly indicates and singles out any defective or marginal EPROMs prior to or after programming.

After programming the unit does a full VERIFY routine of the EPROM (at a Max Vcc of 5.4V and at a Min Vcc of 4.5V) to ensure high reliability of your EPROMs. Very simple to use.

A standard unit contains 8x16K of on-board memory which is sufficient in most cases, but can easily optionally be upgraded to 8x64K of on-board memory.

The Gang Programmer can handle a wide selection of EPROMs: 2716. 2732, 2732A, P2732A, 2532, 2564, 2764, 27128,27128A and optionally upgradeable to handle 27256, 27512, 2758 and 2724.

Gives you option of entering the data which you want to be programmed on the EPROM through a built-in keypad and display into the EPROM programmer's built-in RAM or by downloading the data to be programmed by RS232 interface (110 to 9600 Baud). The RS232 is standard — not optional!

Data can be checked or modified, since you can examine any memory location of the programmers built-in RAM, this holds true even after you have down-loaded through the RS232 from your computer; you can check or modify the memory before finally programming it on your EPROMs.

Read Master EPROMs; you can plug in a programmed EPROM, dump it into the programmers RAM, check the contents on display by stepping through the memory and, if you wish, you can alter any location before copying to other EPROMs.

EPROM Programmer can also be (optionally) used as an EPROM emulator, saving hours of frustration, reprogramming and waiting.

Using the Emulator option, you can enter via the keyboard or down-load through the RS232 from your computer or development system, the information which you think is right for whatever project you are building. This is the same information which you would normally burn into an EPROM, plug into your new undebugged processor and moments later you realise that you forgot to enter a code or that you must add or delete some codes. This normally would mean waiting 20 minutes for erasing of the EPROM and reprogramming and wasting time.

Using the Emulator option, you simply plug in a 24 or 28 Pin buffered pod into the socket on your board where you would normally fit the EPROM, the difference being now that you can have all the information in the programmers RAM, connected to the pod by a ribbon cable and you can start your testing. If you wish to change, add, delete any codes, you can modify the contents of the programmers RAM using the keypad and display and continue testing moments later. Keep in mind that the RAM is protected from being accidentally altered.

Complete package with EPROM Emulator, 8 ZIF sockets, Gang Programmer with 16Kx8 of RAM and RS232 .... **$995.00**

Gang EPROM Programmer with 8 ZIF sockets, 16Kx8 RAM and RS232. without Emulator **$695.00**

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74LS05	Hex inverter O/C	45
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74LS09	Quad 2 input AND gate O/C	45
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74LS11	Triple 3 input AND gate O/C	45
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74LS133	13 input NAND gate	70
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74LS139	Dual 1 of 4 decoder/demultiplexer	68
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74LS147	10/4 priority encoder	2 00
74LS148	8 to 3 line priority encoder	2 15
74LS151	8 channel digital multiplexer	75
74LS153	Dual 4/1 multiplexer	75
74LS154	4 to 16 decoder multiplexer	1 05
74LS155	Decoder/demultiplexer	99
74LS156	Decoder/demultiplexer	85
74LS157	Quad selector/multiplexer	70
74LS158	Quad 2 input multiplexer (inverting)	75
74LS160	Decade counter with async clear	99
74LS161	Sync. 4 bit counter	95
74LS162	Sync. 4 bit counter	95
74LS163	Sync. 4 bit counter	95
74LS164	8 bit serial shift register	89
74LS165	Parallel load 8 bit shift register	1 08
84LS166	8 bit PISO shift register	1 95
74LS168	Up/down decade counter	2 25
74LS169	4 bit sync. binary counter	1 38
74LS170	4 x 4 register file	1 95
74LS173	4 bit tri state register	78
74LS174	Hex D flip flop with clear	80
74LS175	Quad D flip flop with clear	80
74LS181	4 bit ALU	2 75
74LS182	Look ahead carry	2 75
74LS190	Sync. up/down counter BCD	93
74LS191	Sync. up/down counter binary	93
74LS192	Binary up/down counter	93
74LS193	Binary up/down counter	93
74LS194	4 bit bi-directional shift register	93
74LS195	4 bit shift register	75
74LS196	Decade counter	1 50
74LS197	Presettable binary counter	1 05
74LS221	Dual monostable multivibrator	1 25
74LS240	Octal inverting bus driver	1 25
74LS241	Octal bus driver	1 25
74LS242	Quad inverting transceiver	1 20
74LS243	Quad transceiver	1 17
74LS244	Tri state octal driver	1 20
74LS245	Octal bus transciever	1 39
74LS247	BCD to 7 segment decoder driver	1 05
74LS248	BCD to 7 segment decoder driver	1 35
74LS249	BCD to 7 segment decoder driver	1 35
74LS251	Tristate data selector multiplexer	78
74LS253	Dual 4 bit multiplexer	75
74LS257	Quad 2 input multiplexer	80
74LS258	Quad 2-1 multiplexer	80
74LS259	8 bit addressable latch	1 30
74LS260	Dual 5 input NOR gate	79
74LS266	Quad 2 input XNOR O/C	50
74LS273	Octal D flip flop	1 18
74LS275	7 bit slice Wallace tree	5 55
74LS279	Quad S-R latches	59
74LS280	9 bit odd/even parity checker generator	3 25
74LS283	4 bit binary full adder	79
74LS289	64 bit RAM	6 25
74LS290	Decade counter	90
74LS293	4 bit binary counter	95
74LS295	4 bit shift register	1 50
74LS298	Quad 2 input multiplexer	1 12
74LS299	8 bit storage register	2 75
74LS320	Crystal oscillator	4 75
74LS321	Crystal oscillator	3 90
74LS322A	8 bit shift register	5 49
74LS323	8 bit bidirectional universal shift	3 49
74LS348	8 to 3 priority encoder	2 75
74LS352	Dual 4 bit multiplexer	1 05
74LS353	Dual 4 bit multiplexer	1 05
74LS354	Data selector multiplexer	4 75
74LS355	Data selector multiplexer	4 75
74LS356	Data selector multiplexer	4 75
74LS357	Data selector multiplexer	4 99
74LS365	Hex bus driver tri state	62
74LS366	Hex bus driver (inverted output)	62
74LS367	Hex bus driver	62
74LS368	Hex bus driver (inverted output)	62
74LS373	Octal transparent latch	1 20
74LS374	Octal dual flip flop	1 20
74LS375	4 bit bistable latch	65
74LS377	Octal D register	1 23
74LS378	Hex D register	1 85
74LS379	4 bit register	1 85
74LS380	Multi function octal generator	9 00
74LS384	8 bit multiplier	7 95
74LS386	Quad 2 input XOR gate	50
74LS390	Dual decade counter	1 28
74LS393	Dual 4 bit binary counter	1 12
74LS395	Tri state shift register	1 89
74LS396	Octal storage register	2 75
74LS398	Quad D flip flop	2 75
74LS399	Quad 2 input multiplexer with storage	1 45
74LS629	Voltage controlled oscillator	3 30
74LS612		28 00
74LS640	Octal bus transceiver	2 20
74LS641	Octal bus transceivers	3 20
74LS646NT	Octal bus transceivers AND registers	10 95
74LS647NT	Octal bus transceivers AND registers	10 95
74LS648NT	Octal bus transceivers AND registers	10 95
74LS652NT	Octal bus transceivers AND registers	10 95
74LS670	4 x 4 register file 3 state	1 85
74LS673	16 bit SISO shift reg	19 95
74LS682	8 bit magnitude comparator	3 99
74LS683	8 bit magnitude comparator open collector	3 99
74LS684	8 bit magnitude comparator, 3 state	3 99
74LS688	8 bit magnitude comparator, 3 state	3 99
74LS689	8 bit magnitude comparator open collector	5 35
74LS795	Octal buffer (81LS95), 3 State	1 29
74LS796	Octal buffer (81LS96), 3 State	1 29
74LS797	Octal buffer (81LS97), 3-State	1 29
74LS798	Octal buffer (81LS98), 3 State	1 29
74LS795	Octal buffer (81LS95), 3-State	1 29
74LS796	Octal buffer (81LS96), 3 State	1 29
74LS797	Octal buffer (81LS97), 3-State	1 29
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MEMORY

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4071	Quad 2 input OR gate	.36
4072	Dual 4 input OR gate	.34
4073	Triple 3 input gate	.34
4075	Triple 3 input OR gate	.34
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4526	4 bit binary divide by N counter	1.10
4527	BCD rate multiplier	1.10
4528	Dual retriggerable/resettable monostable	1.10
4529	Dual 4 channel mux	1.30
4530	Dual 5 input majority logic gate	1.05
4531	12 bit parity generator/checker	1.35
4532	8 bit priority encoder	1.35
4534	Real time 5 decade counter	7.50
4536	Programmable timer	2.37
4538	Dual precision monostable multivibrator	1.30
4539	Dual 4 channel digital multiplexer	1.25
4541	Quad 2 input analog mux	1.15
4543	BCD to 7 segment latch/decoder/driver	1.05
4553	3 digit BCD counter	2.89
4555	Dual binary 1 of 4 decoder	.63
4556	Dual binary 1 of 4 decoder	.75
4557	1-6 bit shift register	4.87
4558	BCD to 7 segment decoder	1.55
4560	NBCD adder	5.89
4561	9's complimenter	1.05
4562	128 bit static shift register	7.95
4566	Industrial time base generator	1.89
4568	Phase comparator/programmable counter	2.50
4572	Hex gate	.65
4573	Quad programmable op amp	3.43
4575	Quad programmable comparator	3.25
4580	4 x 4 multiport register	6.49
4581	4 bit A/U	2.25
4582	Carry look ahead generator	1.75
4583	Dual Schmitt trigger	.95
4584	Hex Schmitt trigger	.60
4585	4 bit magnitude comparator	.99
4702	Programmable bit rate generator	11.99

LINEAR

109	1A + 5V regulator	8.38
124	Quad op amp	3.95
139	Quad comparator	3.95
148	Quad op amp	5.50
300	General purpose op amp	4.10
301A	General purpose op amp	.50
305	Voltage regulator	1.15
306	Improved voltage comparator	1.50
307	Op amp	.60
308	Super beta op amp	.75
309	+ 5V regulator	1.89
310	Voltage follower	3.38
311	Voltage comparator	.80
317	3 terminal adjustable regulator	1.29
318	Precision high speed op amp	1.45
319	High speed dual comparator	1.89
323	3A + 5V regulator	5.19
324	Quad op amp	.58
337	3 terminal negative regulator	1.75
339	Quad comparator	.55
348	Quad low-power 741	.88
350	3A 3 term. positive adjust regulator	7.25
355	FET input op amp	.89
356	Monolithic J-FET input op amp	1.95
357	Monolithic J-FET input op amp (uncompensated)	1.95
358	Dual version of 324	.55
380	2W audio amp	1.10
393	Dual version of 339	.60
398	Sample and hold amplifier	5.94
555	Timer	.45
556	Dual timer	.82
558	Quad timer	1.90
567	Tone decoder	.95
709	Op amp	.78
710	Differential comparator	1.32
711	Dual channel differential comparator	.99
714	Precision op amp	4.45
715	High speed op amp	5.25
723	Voltage regulator	.59
725	Instrumentation op amp	2.99
733	Differential video amp	1.15
739	Dual high performance op amp	2.05
741	Operational amplifier	.59
747	Dual op amp	.75
748	Op amp	.65
749	Dual audio preamplifier	2.99
759	Power op amp	2.89
760	High speed differential comparator	11.95
776	Multi-purpose programmable op amp	1.10
796	Modulator/demodulator	3.25
1372	RF modulator	4.30
1436	High voltage op amp	4.49
1458	Dual op amp	.54
1488	Quad line driver	.59
1489	Quad RS232 line receiver	.59
1495	Multiplier	5.25
1496	Modulator/demodulator	1.35
1558	Dual op amp	1.99
1595	Four quad multiplier	7.78
1596	Modulator/demodulator	5.49
1800	Demodulator	8.25
1889	Video modulator	6.25
3900	Quad op amp	0.95
26LS29	Quad RS423 line driver	5.49
26LS30	Quad RS422/432 line driver	3.95
26LS31	Quad differential line driver RS422	2.30
26LS32	Quad differential line driver RS422	2.70
26LS33	Quad differential line driver RS422	2.45
3470	Floppy disk read amplifier	5.99
3486	Quad RS422/423 line receiver	2.25
3487	Quad line driver RS422	2.35
76477	Analog complex sound generator	5.00
76478	Analog complex sound generator c/w amp	6.90
76489	Microprocessor cont complex sound generator	8.30
8T26	Quad tri-state bus transceiver	1.75
8T28	Quad tri-state bus transceiver	1.50
TL070	Low noise bifet op amp	.86
TL071	Low noise bifet op amp	.78
TL072	Low noise bifet op amp	1.10
TL074	Low noise bifet op amp	1.95
TL075	Low noise bifet op amp	2.99
TL080	General purpose bifet op amp	.69
TL081	General purpose bifet op amp	.75
TL082	General purpose bifet op amp	.99
TL083	General purpose bifet op amp	2.50
TL084	General purpose bifet op amp	1.85
TL497	Switching voltage regulator	2.35
ULN2002	7 segment transistor array	1.00
ULN2003	7 segment transistor array	1.00
ULN2004	7 segment transistor array	1.00
XR200	Multifunction I C	67.95
XR205	Monolithic waveform generator	8.10
XR210	FSK modulator/demodulator	4.99
XR215	Phase lock loop	4.99
XR240	PCM repeater	11.95
XR320	Monolithic timing circuit	1.64
XR1310	Stereo demodulator	1.25
XR2206	Monolithic function generator	4.95
XR2207	Voltage controlled oscillator	2.75
XR2208	Operation multiplier	2.99
XR2209	Precision oscillator	3.25
XR2211	FSK demodulator/tone decoder	6.99
XR2212	Precision phase locked loop	8.99
XR2242	Long range timer	2.25
XR2567	Dual monolithic tone decoder	2.40
XR4739	Dual low noise op amp	1.55
XR14412	FSK modem system	8.75

7400 SERIES TTL

7400	Quad 2 input NAND gate	.49
7402	Quad 2 input NOR gate	.49
7403	Quad 2 input NAND gate O/C	.49
7404	Hex inverter	.55
7405	Hex inverter gate O/C	.54
7406	Hex inverter buffer/driver	.65
7407	Hex buffer/driver	.65
7408	Quad 2 input AND gate	.49
7409	Quad 2 input AND gate with O/C	.49
7410	Triple 3 input NAND gate	.49
7411	Triple 3 input AND gate	.39
7414	Hex Schmitt trigger	.65
7416	Hex inverter buffer/driver	.65
7417	Hex buffer/driver	.65
7420	Dual 4 input NAND gate	.50
7422	Dual 4 input NAND gate	.59
7423	Dual 2 input positive NOR gate	.59
7425	Dual 4 input NOR gate	.56
7426	Quad 2 input NAND gate	.56
7427	Triple 3 input NOR	.49
7430	8 input NAND gate	.65
7432	Quad 2 input gate	.53
7437	Quad 2 NAND buffer	.52
7438	Quad 2 input NAND buffer	.65
7439	Quad 2 input NAND buffer	.65
7440	Dual 4 input buffer	.69
7442	8 bit shift register	.79
7445	BCD-decimal to decoder-driver	1.29
7446	BCD-to 7 segment driver	1.58
7447	BCD-to 7 segment driver	1.58
7448	BCD-to 7 segment decoder/driver	1.56
7450	2-1 input and/or invert gate	.49
7451	And/or invert gate	.49
7454	4 wide and/or invert gate	.49
7474	Dual D flip flop	.76
7475	4 bit bistable latch	.76
7476	Dual JK master/slave flip flop	.69
7485	4 bit magnitude comparator	1.19
7486	Quad 2 input exclusive or gate	.75
7489	64 bit read/write memories	3.54
7490	Decade counter	.77
7491	8 bit shift register	.77
7492	Divide by 12 counter	.63
7493	4 bit binary counter	.63
7495	4 bit right shift/left shift register	.79
7496	5 bit shift register	.95
7497	Synchronous rate multiplier	2.75
74104	Gated JK master/slave flip/flop	1.45
74105	Gated JK master/slave flip/flop	1.45
74107	Dual JK flip flops with clear	.75
74109	Dual JK edge triggered F/F	.75
74120	Dual pulse Sync.	2.19
74121	Monostable multivibrator	.75
74122	Retriggerable one shot multivibrator	.95
74123	Dual retriggerable one shot	.67
74125	Tri-state quad bus buffer	.95
74126	Tri-state quad bus buffer	.95
74128	50-ohm line driver	.95
74132	Quad 2 input Schmitt	.95
74136	Exclusive or NAND gate	.92
74141	BCD to decimal decoder driver	1.79
74142	Counter/latch/decoder/driver	5.59
74143	Center decoder	6.95
74144	Center decoder	5.99
74145	BCD to decimal decoder driver	1.29
74147	10-4 priority encoder	2.45
74148	Priority encoder	1.59
74150	16 line to 1 line multiplexer	2.35
74151	8 channel digital multiplexer	.89
74153	dual 4-1 multiplexer	.89
74154	4 line to -16 decoder	1.99
74155	Decoder/demultiplexer	.79
74156	Decoder/demultiplexer	.99
74157	Quad 2 input multiplexer	.82
74159	4-16 decoder	2.10
74160	BCD decade counter, async reset	.89
74161	Synchronous 4 bit counter	1.09
74162	Sync. 4 bit counter	1.19
74163	Sync 4 bit counter	1.09
74164	8 bit serial shift register	1.09
74165	Parallel load 8-bit shift register	1.25
74166	8 bit shift register	1.79
74167	Sync rate multiplexer	4.65
74170	4 by 4 register file	2.99
74172	16 bit register file	8.75
74173	4 bit tri-state register	1.59
74174	Hex D flip flop with clear	1.19
74175	Quad D flip flop with clear	.89
74176	Presettable counter/latch decade	1.45
74177	Presettable counter/latch binary	1.45
74178	4 bit shift register	1.69
74179	4 bit parallel access shift register	1.75
74181	Arithmetic logic unit	3.55
74182	Look ahead carry generator	1.45
74184	Code convertor BCD to binary	3.55
74185	Binary to BCD convertor	3.50
74190	Synchronous up/down decade counter	1.29
74191	Up/down bi cntr.	1.29
74192	Binary up/down counter	1.09
74193	Binary up/down counter	1.09
74194	4 bit bi-directional shift register	1.25
74195	4 bit parallel access shift register	1.09
74196	Presettable decade counter	1.45
74197	Presettable binary counter	1.45
74198	8 bit shift register	2.19
74199	8 bit shift register	2.19
74221	Dual Monostable multivibrator	1.29
74251	Tri-state 8 input multiplexer	1.45
74259	8 bit addr latch	3.19
74273	Octal D-type flip flop	3.19
74276	Quad JK flip flop	3.75
74279	Quad shift register/latches	2.10
74283	4 bit binary full adder	1.78
74285	Tri-state 4 bit multiplexer	4.65
74365	Hex bus drivers 3 state output	.89
74366	4 bit binary full addr	.89
74367	Hex bus drivers/non inverted	.89
74368	Hex bus drivers inverted data	.89
74390	Dual decade counter	2.19
74393	Dual 4 bit binary counter	2.19

74ALS00 Advanced Low Power Schottky TTL

74ALS00	Quadruple 2 input POS NAND gate	57
74ALS02	Quadruple 2 input POS NOR gate	57
74ALS03	Quadruple 2 input POS NAND gate OC	57
74ALS04	Hex inverter	57
74ALS05	Hex inverter OC	57
74ALS08	Quadruple 2 input POS AND gate	57
74ALS09	Quadruple 2 input POS AND gate OC	57
74ALS10	Triple 3 input POS NAND gate	57
74ALS11	Triple 3 input POS AND gate	57
74ALS12	Triple 3 input POS NAND gate OC	57
74ALS15	Triple 3 input POS AND gate OC	57
74ALS20	Dual 4 input POS NAND gate	57
74ALS21	Dual 4 input pos AND gate	57
74ALS22	Dual 4 input POS NAND gate OC	57
74ALS27	Triple 3 input POS NOR gate	57
74ALS28	Quadruple 2 input POS NOR buffer	57
74ALS30	8 input POS NAND gate	57
74ALS32	Quadruple 2 input POS NOR gate	57
74ALS33	Quadruple 2 input POS NOR buffer OC	85
74ALS35	Hex non inverter with O/C output	58
74ALS37	Quadruple 2 input NAND buffer	67
74ALS38	Quadruple 2 input POS NAND buffer OC	67
74ALS51	Dual AND/invert gate	76
74ALS74	Dual D type POS edge triggered F/F	77
74ALS86	Quadruple 2 input exclusive OR gate	77
74ALS109	Dual JK positive edge triggered F/F	77
74ALS112	Dual JK NEG edge triggered Flip flop with preset and clear	76
74ALS113	Dual JK NEG edge triggered flip flop with preset	77
74ALS114	Dual JK NEG edge triggered FF/with preset, common, clear/clock	77
74ALS133	13 input POS NAND gate	67
74ALS136	Quad exclusive OR gate OC	77
74ALS138	3 to 8 line decoder/demultiplexer	1.19
74ALS139	Dual 1 of 4 decoder	1.85
74ALS151	Dual 4 line to 1 line data Selector/multiplexer	1.19
74ALS157	Quad 2 input multiplexer non inverting	1.55
74ALS160	Sync 4 bit counter	1.65
74ALS161	Sync 4 bit counter	1.65
74ALS162	Sync 4 bit counter	1.65
74ALS163	Sync 4 bit counter	1.65
74ALS169	4 bit up/down sync counter	1.65
74ALS174	Hex D type flip flop	1.19
74ALS175	Quad D type flip flop	1.19
74ALS190	Sync up/down counter (BCD)	1.55
74ALS191	Sync up/down counter (binary)	1.55
74ALS192	Sync up/down dual clock counter	1.55
74ALS193	Sync up/down dual clock counter	1.55
74ALS240	Octal buffer line driver/rec	2.19
74ALS241	Octal buffer line driver/rec	2.19
74ALS242	Quadruple bus transceiver	2.15
74ALS243	Quadruple bus transceiver	2.15
74ALS244	Octal buffer line drive/rec	2.19
74ALS245	Octal bus transceiver	2.45
74ALS251	Data selector/multiplexer	2.37
74ALS253	Dual data selector/multiplexer	2.37
74ALS257	Quad data selector/multiplexer	2.37
74ALS258	Quad data selector/multiplexer	2.37
74ALS273	Octal D type flip flop	2.35
74ALS299	8 bit bidrectional universal shift/storage register	5.45
74ALS352	Dual 4 line to line data selector/multiplexer	1.19
74ALS353	Dual 4 line to 1 line data selector/multiplexer	1.19
74ALS373	Octal D type latche	2.45
74ALS374	Octal D type flip flop	2.45
74ALS465	Octal buffer with 3 state output	2.45
74ALS466	Octal buffer with 3 state inverted output	2.45
74ALS467	Octal buffer with 3 state ouptut	2.45
74ALS468	Octal buffer with 3 state inverted output	2.45
74ALS518	8 bit magnitude comparator	3.75
74ALS519	8 bit Magnitude comparator	3.75
74ALS522	8 bit Magnitude comparator	7.57
74ALS533	Octal D type transparent latche	2.45
74ALS534	Octal D type edge triggered F/F	2.45
74ALS540	Octal buffer and line driver	2.19
74ALS541	Octal buffer and line driver	2.19

74SXX Series TTL

74S00	Quad 2 input NAND gate	.62
74S02	Quad 2 input NOR gate	.62
74S03	Quad 2 input NOR gate O/C	.75
74S04	Hex inverter	.62
74S05	Hex inverter O/C	.75
74S08	Quad 2 input AND gate	.62
74S09	Quad 2 input AND gate O/C	.79
74S10	Triple 3 input NAND gate	.79
74S11	Triple 3 input AND gate O/C	.79
74S15	Triple 3 input AND gate O/C	.79
74S20	Dual 4 input NAND gate	.62
74S22	Dual 4 input NAND gate O/C	.79
74S30	8 input NAND gate	.72
74S32	Quad 2 input NOR buffer	.62
74S37	Quad 2 input NAND buffer	2.49
74S38	Quad 2 input NAND buffer O/C	2.49
74S40	Dual 4 input NAND buffer	.99
74S74	Dual D flip flop	.79
74S85	4 bit magnitude comparator	2.50
74S86	Quad 2 input XOR gate	1.00
74S109	Dual JK positive edge triggered flip flop	2.50
74S112	Dual JK flip flop	1.69
74S113	Dual JK negative edge triggered flip flop	1.25
74S114	Dual JK negative edge triggered flip flop	1.45
74S124	Dual VCO	3.95
74S132	Quad 2 input Schmitt trigger NAND	2.20
74S138	3-8 decoder/multiplexer	1.99
74S139	Dual 2-4 decoder/multiplexer	1.99
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74S151	8 channel digital multiplexer	1.99
74S153	Dual 4-1 multiplexer	1.50
74S157	Quad 2 input multiplexer	1.59
74S158	Quad 2 input multiplexer	1.59
74S160	Decade counter with async clear	4.95
74S161	Sync 4 bit counter	4.95
74S162	Sync 4 bit counter	3.69
74S163	Sync 4 bit counter	2.75
74S168	4 bit up/down sync counter	7.44
74S169	4 bit sync counter	6.95
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74S182	Look ahead carry generator	3.75
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74S195	4 bit parallel access shift register	2.99
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74S197	Presettable binary counter	4.95
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74S251	Tri-state data selector multiplexer	2.65
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74S280		3.19
74S299	8 bit universal shift storage register	8.50
74S373	Octal D latch	2.90
74S374	Octal D latch	3.50

74F00 Series

74F00	Quad 2 input NAND gate	.73
74F02	Quad 2 input NOR gate	.73
74F04	Hex inverter	.73
74F08	Quad 2 input AND gate	.73
74F10	Triple 3 input NAND gate	.73
74F11	Triple 3 input AND gate	.73
74F20	Dual 4 input NAND gate	.73
74F32	Quad 2 input NOR gate	.88
74F74	Dual D type flip flop	.85
74F86	Quad exclusive OR gate	.99
74F109	Dual JK POS edge triggered flip flop	1.99
74F112	Dual JK NEG edge triggerad flip flop	1.79
74F113	Dual JK edge triggered flip flop	1.79
74F114	Dual JK NEG edge triggered flip flop	1.75
74F138	3 to 8 line decoder/multiplexer	1.79
74F139	Dual 1-4 decoder demultiplexer	1.79
74F148	8 to 3 line priority encoder	1.99
74F151	8 input multiplexer	1.75
74F153	Dual 4 input multiplexer	1.75
74F157	Quad 2 to 1 line data selector	1.75
74F158	Quad 2 input multiplexer	1.75
74F160	Synch presettable BCD decade counter	4.35
74F164	Serial in, parallel out shift register	2.95
74F174	Hex D flip flop	2.95
74F175	Quad D flip flop	3.79
74F181	4 bit ALU	6.75
74F182	Carry, look ahead generator	2.99
74F190	Up/down decade counter	4.35
74F191	Up/down binary counter	4.35
74F192	Up/down decade counter	5.25
74F193	Up/down binary counter	5.45
74F240	Octal buffer/line driver	3.19
74F241	Octal buffer/line driver	3.19
74F243	Quad bus transceiver 3S	6.49
74F244	Octal buffer/line driver/line receiver	3.19
74F245	Octal bidirectional transceiver	6.95
74F251	8 input multiplexer	1.75
74F253	Dual 4 input multiplexer	1.75
74F257	Quad 2 input multiplexer	1.75
74F258	Quad 2 input multiplexer	1.75
74F280	9 bit parity generator/checker	2.19
74F283	4 bit binary full adder	3.75
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74F353	Dual 4 input multiplexer	1.75
74F373	Octal transparent latch	4.35
74F374	Octal dual flip flop	4.35
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74F379	Quad parallel register	2.39
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74F382	4 bit ALU	6.19

Prices and Specifications subject to change without notice.

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- Voltage plus 5V at 5A, plus 12V at 2A, minus 12V at 0.5A and 0 to 12V at 2A.
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RFI filter and fuse on board
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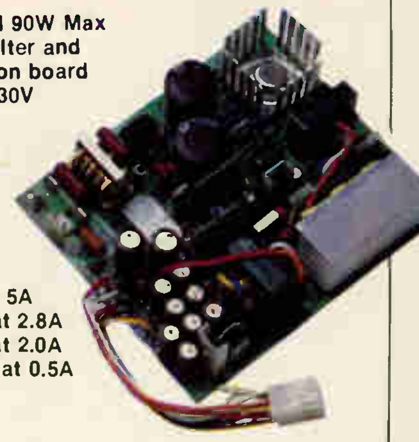

5V at 5A
12V at 2.8A
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DB25 Shell (Economy Type)	$0.95
DB25 Shell, High Quality	$1.99
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2N2222A	$ .50	2N3440	$1.10	2N3904	$ .19	2N4402	$ .25	MJ802	$4.50	MPSU56	$ .99	TIP125	$1.00
2N2270	$ .50	2N3442	$2.25	2N3905	$ .25	2N4403	$ .25	MJ2955	$1.83	PN2222A	$ .39	TIP142	$2.95
2N2369A	$ .50	2N3566	$ .78	2N3906	$ .26	2N4416	$1.40	MJ4502	$5.50	TIP29C	$ .70	TIP146	$2.98
2N2646	$1.42	2N3568	$ .78	2N4062	$ .66	2N4J53	$4.22	MJE340	$2.50	TIP30C	$ .70	TIP2955	$1.85
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2N2907A	$ .52	2N3642	$ .78	2N4123	$ .20	2N4891	$ .65	MPF102	$ .65	TIP32C	$1.10		
2N3053	$ .70	2N3643	$ .78	2N4124	$ .50	2N5245	$ .75	MPS6515	$ .42	TIP33C	$1.60		
2N3055	$1.69	2N3645	$ .78	2N4208	$ .87	2N5400	$ .27	MPSA05	$ .35	TIP34C	$1.85		
2N3117	$1.50	2N3703	$ .28	2N4222	$1.99	2N5457	$ .57	MPSA13	$ .35	TIP35C	$3.10		
2N3227	$4.18	2N3704	$ .31	2N4248	$ .65	2N5485	$ .57	MPSA14	$ .35	TIP41C	$1.15		
2N3250	$ .70	2N3705	$ .29	2N4250	$ .78	2N5770	$ .49	MPSA18	$ .35	TIP42C	$1.90		

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T-1 3/4 (Normal Size)

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35 LED Matrix 2 or 3	$9.95

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1N4007 1000V 1A	$ .11
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1N5404 400V 3A	$ .40
1N5406 600V 3A	$ .60

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1N914	$ .5
1N4148	$ .5
1N4448	$ .5

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1 Watt All Values 25 cents each.
Voltages Available
3.9, 4.3, 4.7, 5.1 5.6 6.2 7.5 8.2 9.1 10 12 13, 15, 16, 18, 20 22, 24, 27 30, 33, 36

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2N6337	$ .55
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TIC116D	$1.99
TIC126D	$1.99

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TIC226D	$1.87
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78H05 + 5V 5A	9 44
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78GUIC Adjust 1A	1 80
78HGASC Adjust 5A	11 47
78S40 Switching regulator	3 84

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3.3uF 25V	$ .35	47uF 10V	$1.25
3.3uF 35V	$ .40	47uF 25V	$2.70
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200			

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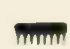

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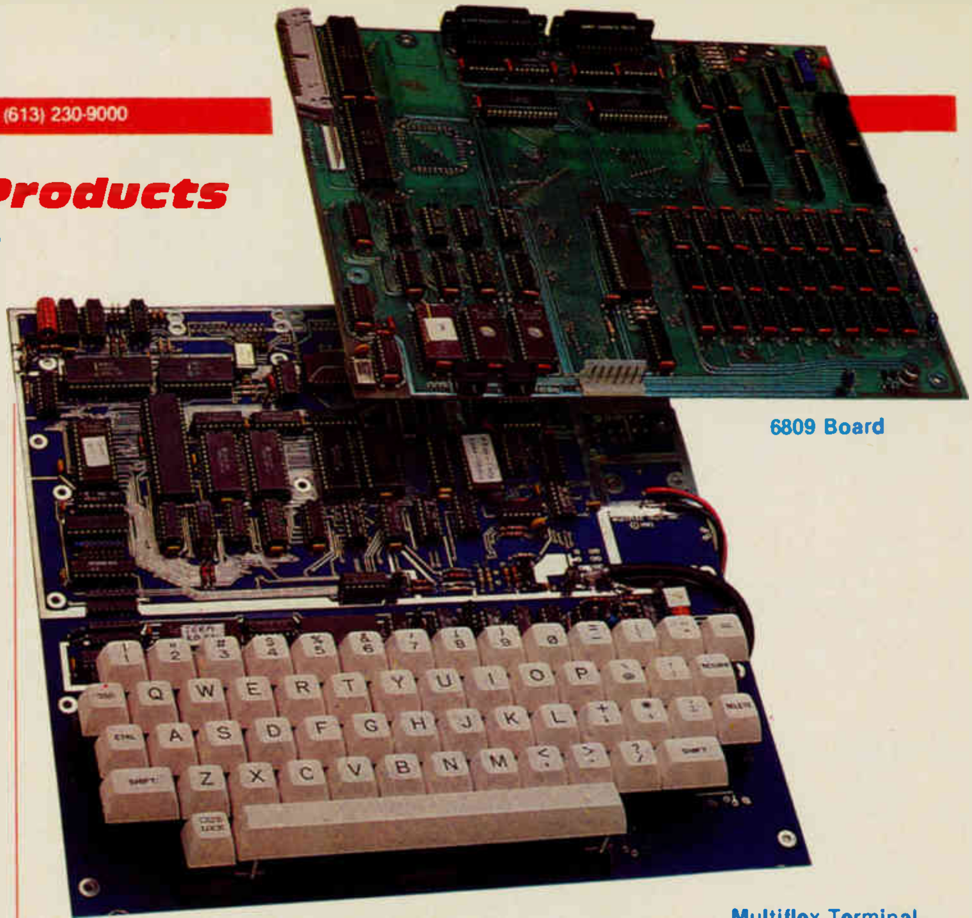
Multiflex Products



6809 Board

Multiflex Terminal

Multiflex Economy Video Display Terminal

Now available from MULTIFLEX is an economy video display terminal. Originally designed as a low cost access unit for our mail-ordering and bulletin board system, this terminal is a semi-intelligent system which is controlled by a Z80A microprocessor and a 6845 CRT controller chip. The keyboard is fully ASCII encoded and the character generator contains the full 128-character set as well as a 128-character alternate set both of which are in the 5x7 dot matrix format. The screen display is 80 characters by 24 lines if the unit is hooked to an external monitor. (Monitor not included). There are 3 software selectable attributes (dim, reverse video, and alternate character set) which can be chosen one at a time for the whole screen. The attribute can then be switched on and off for each individual character. A 2K buffer is provided for normal operation. However when the optional 6K memory upgrade is purchased, 4 screen pages can be loaded from the host machine, edited, locally, and then downloaded back to the host again saving on connect time and phone line bills. Also included are 2 RS232 ports: one for a modem and one so that a printer can be attached to the terminal. The baud rates on these ports are software programmable and can range from 110 to 9600 baud. With all these features, you would expect to pay a lot for this system, but all this is available to you, complete with an attractive case, for an extremely low price.

A&T board with keyboard (as picture top right) with one RS232 and 2K buffer
$169.00

Terminal Complete: Tested and 90 days warranty with 2 RS232 ports, 2K buffer case and power supply (Hydro approved)

$299.00

U of T 6809 Single Board Computer

The 6809 Single Board Computer, designed at the University of Toronto and distributed exclusively by EXCELTRONIX, is a compact hardware unit which was designed originally as a lab board for teaching students about microprocessor systems. Its many features, however, make it an ideal unit for stand-alone control applications or software development systems as well.

The system is designed around the Motorola MC6809 microprocessor. This is an 8-bit processor with full 16-bit internal architecture, 2 index registers, 2 stack pointers, 2 8-bit or 1 16-bit accumulators, a direct page register and a wide range of addressing modes, including a program-counter-relative mode. This mode allows the user to write completely position independent software, important in systems software development.

There is provision for up to 48K bytes of dynamic RAM on-board. The refreshing of this RAM is controlled by an 8202 Dynamic RAM Controller. This chip allows for completely transparant refreshing of the RAM (ie. no wait states to slow the system down). There is also provision for up to 12K of EPROM using 2532 chips.

There are 4 complete I/O circuits built onto the board. 2 of them are serial (RS232); one is used for a terminal (which is required for use of the board with the supplied monitor software), and the other one is user defineable, but it is set up to communicate with either a modem or a printer. Also on-board are 2 6522 VIA chips. These provide 2 parallel ports per chip along with 2 16-bit timer/counters. One of the parallel ports and one of the timers are use by the monitor software to provide a cassette interface (which operates at 300 baud). The second parallel port on that chip is wired into a connector which is ideal for interfacing a parallel printer or keyboard. The 2nd VIA is not used at all and is completely free for the user. For further expansion of the system, a fully buffered version of the CPU signals (data, address, control lines and a signal indicating whether or not the current address is located on the board) is available at a cable connector.

The software provided with the system is in a 2532 EPROM and allows the user to: test the memory; dump blocks of memory; examine and modify single memory locations; read or write from the cassette port; set and examine breakpoints; single step and/or execute machine language programs and set and examine the processor registers. All this is accomplished through a 9600-baud terminal interface (one of the serial ports) Included is a full screen editor/assembler which allows the user to work in 6809 assembly language rather than machine language. All this makes this board an ideal trainer, control unit or software development unit for just about anyone.

Includes U of T course documentation

A&T with 48K
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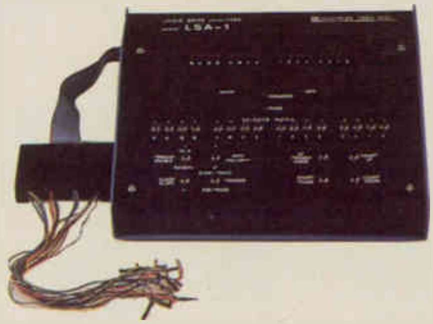
Multiflex Low-Cost Logic State Analyzer

Ideal for educational institutions and hobbyists.

You've just completed a microprocessor system, and it doesn't work. What next? You can use an oscilloscope to check for clock signals and the like, but if everything appears to be in order you can't go much further without sophisticated equipment. In these situations, professionals turn to their logic state analyzers, each of which cost thousands of dollars. MULTIFLEX has the answer for all those people who don't want to take a mortgage on their house just to get a computer working. The MULTIFLEX Logic State Analyzer has all the essential features of those more expensive units at a fraction of the cost. This is a high-quality piece of test equipment, suitable for industrial or scientific use, but its price is well within the price range of a hobbyist.

Easy to understand and operate, the Logic State Analyzer allows you to monitor 16 points in a digital system (ie. data and/or address bus, or control lines) which carry continually changing signals. You can select a bit pattern you expect will appear at these points. Once the pattern appears the Analyzer will trigger and record ("freeze") the next 1023 bit patterns so that they can be examined step by step even though data is no longer available in the unit being examined. For software development the Analyzer is invaluable, especially in dedicated systems. If you design a microprocessor system for a specific function, and you have no monitor, assembler or other such software, the best and often only way to debug the system is to use a logic analyzer. It will let you look closely at the data flow as a program is executing, or monitor the address lines to make sure that the instructions are being executed in the proper sequence. The various control lines such as memory read and write, DMA, interrupts, or enable and disable signals can also be examined. You can, of course, monitor any combination of these signals, such as the data bus and half of the address bus, or half of each plus 4 control lines. The combinations are endless.

Complete, assembled and tested
$369



Note from Industry to Educational Institutions:

At Multiflex we interview many technicians each year, from a variety of Colleges. Only a few applicants know what a Logic State analyzer is and even fewer know how to use one.

Yet in our industry, it is almost as important to know how to operate logic analyzers as it is to use an oscilloscope since the technician will need to use a logic or timing analyzer to trouble-shoot complex equipment.

We have spoken to many other companies and found that they are experiencing the same problems with technicians coming fresh fromCollege. So, we asked educational institutions why they don't teach this aspect of electronic engineering. The teachers are fully aware of the problem but explained that they cannot afford the high cost of logic analyzers; even those institutions which have them can afford only one or two which gives the students little chance to learn them.

Our LSA is a time-proven product which is considerably less expensive than the alternatives.

Here is your chance to prepare technicians for the real world!

EPROM Emulator

If you are a computer designer who values your time, you can't afford to be without this!

Did you ever write a piece of code, burn it into an EPROM, plugged it in and it didn't work?

Did you then go through the code (using an analyzer or your brain power) and then discover you left out some crucial Byte which caused the processor go the point of no return?

If the above holds true, how many EPROMs have you reprogrammed, erased and damaged? More important how many hours have you wasted?

Put an end to all the above problems and save time, money and frustration: Buy an EPROM Emulator.

It allows you to download over RS232 (at 300 to 9600 Baud) a program from your computer into the Emulator's memory (16Kx8) and then simply plug a 24 or 28 Pin header connected via ribbon cable to the Emulator in place of your EPROM and you have successfully emulated an EPROM.

If you need to change your code, simply change it on your computer, download to the Emulator's memory and you are back in business in seconds.

This stand-alone product emulates the following EPROMs: 2716, 2732, 2764 and 27128. Can be used with any computer with an RS232 interface.

This product is a must for any hardware development since it allows the user to test and modify EPROM data roughly 20 times faster than conventional methods.

The Emulator normally comes attractively packaged and contains its own power supply. However, to make it more affordable for beginners, we have separated the price into several categories:

1. Complete Emulator with 16Kx8 memory, attractively packaged with power supply. Fully assembled and tested with warranty. **$189.00**

2. As above but with 8Kx8 of memory **$159.00**

3. Emulator with 4K RAM, no housing or power supply (requires +5V at 1.5A Max, +/- 12V at 0.03A. Fully assembled and tested. **$99.00**

S100 Starter System

Complete, Assembled and Tested

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Options:

64K Dynamic RAM and Multiplexers **$19.95**

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DC to DC Converter Option . . **$29**

Extra S100 Connectors . . . **$5.95**

S100 Video Board **$149**

S100 Floppy Disk Controller **$199**

S100 256K RAM Card (with 256K) **$250**

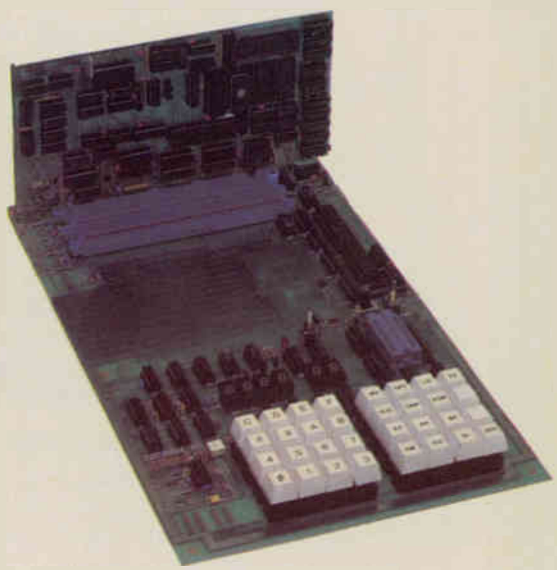
S100 CPU Board with 64K . . . **$149**

MULTIFLEX's Z80 computer is a versatile and expandable stand-alone computer system designed and built right here in Canada. It uses the newest technology to provide the user with the most capabilities for the smallest price-tag. Its adaptability to any situation and extremely low cost allow it to be used in many applications ranging from a trainer to a complete CP/M-based computer comparable to the best on the market, at a fraction of the price.

The actual layout of the system is a two board design. One board (the "motherboard") contains a 24-line parallel I/O chip for interfacing to the external world, an RS232C serial port with baud rates selectable from 110 to 9600 baud, a hex address and data display, a hex keypad, 14 monitor function keys, 2 user definable keys, a 40-chip wire wrap area with full access to all the bus signals, on-board provision for regulators so that the board can be supplied with standard S-100 voltages, an EPROM programmer which will handle 2708 (1Kx8), 2716 (2Kx8), 2732 (4Kx8) 2532 (4Kx8), 2764 (8Kx8) and the brand new 27128 (16Kx8) EPROMs, a DC-to-DC converter to supply the programming voltage to the EPROM programmer and four (4) slots for IEEE S-100 compatible boards for further expansion. This is an extremely useful and important feature as it allows expansion of the system with all boards using this industry-standard bus structure, which are available from MULTIFLEX, as well as from hundreds of manufacturers worldwide.

The other board is the CPU card. This card plugs into one of the S-100 slots on the motherboard and is IEEE 696/S-100 compatible with the full 24-bit address path to allow up to 16 megabytes of memory to be addressed. The processor used is the Z80 (running up to 6 MHz) and there is provision on-board for 64K of dynamic memory (using 4164 chips) which will operate without wait states. Provided for as well is a 2K to 32K (selectable in 2K blocks) common resident area in memory for use with multiple memory banks. There are also 4 sockets on board which will handle 2732 (4Kx8) or 2764 (8Kx8) EPROMs or the new 6116/2016 (2Kx8) static RAMs (all of which can be software deselected if desired) to allow the user complete versatility in setting up the board to meet his own specifications. Also on board is 1 parallel port with 24 lines of I/O and 3 16-bit counter/timers for applications which require the unit to keep track of real time. Another feature of the CPU board is that it was designed by our engineers to run the CP/M 2.2 disk operating system so that if a floppy disk controller board is added to the system a fully configured CP/M machine can be set up for a very low cost

The monitor software that comes with the kit is a well-written extensive package which allows the user to have complete versatility in machine language programming and execution as well as control of all the features on the board. The monitor functions include: examine/modify memory locations, memory block moves, compare 2 blocks of memory, examine CPU register, examine I/O ports, load and save from cassette calculate relative branch offsets, set breakpoints single step programs, execute programs, and program EPROMs. Each of these process is invoked by a single keypress. Also available to the use are 2 spare keys definable for special functions a required by specific applications and applicator programs.



The standard kit includes the CPU board with a Z80A (4HMz) processor, 2K of RAM (a 6116), and 4K of EMPROM (a 2732) as well as the motherboard with all the features mentioned above except the RS232C port and the DC-toDC converter. Also supplied are sockets for all IC's and 1 S-100 connector.

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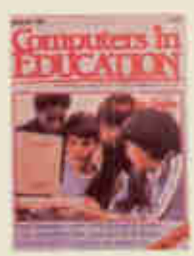

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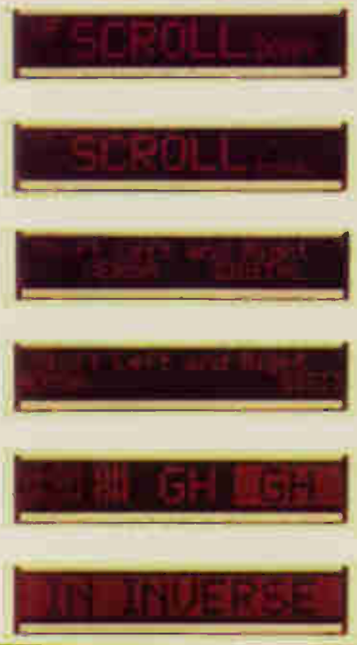
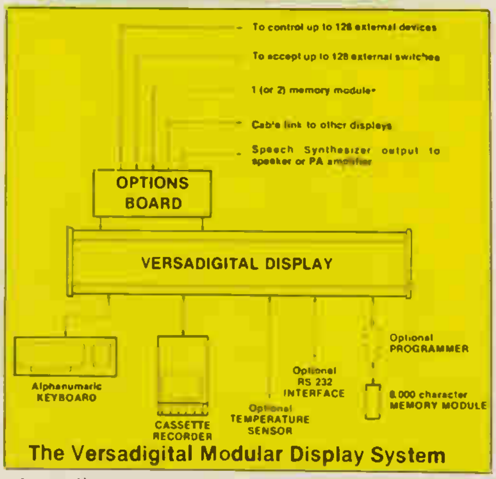
All prices are in Canadian funds, FST included **Please feel free to photocopy this order form**

Versadigital Signs

The sign that also talks





The Versadigital Modular Display System

Every business needs attention. In today's competitive marketplace you need to get the customers' attention and you need to get your message across - as boldly and as dynamically as possible.

Two versions are available, single and double row. Each row holds up to 21 standard characters and can be expanded to up to 42 characters. The LED (Light Emitting Diode) display is available in red (standard or extra bright), green and yellow. Standard, wide (2", upper and lower case) and bold tall (4", upper case) come with the display. All can be displayed normally or in inverse (black characters on a lit background) image format. You can even program your own characters and graphic symbols. As well as the standard LED display, larger, brighter incandescent light bulb displays can be built to your specifications. All programming features are retained, and the standard LED display is included for ease of programming.

A wide variety of features allow you to catch the public's attention — choose from Wipe-On and Wipe-Off, Spell-On, Flash and Blink, Shift left and right, Scroll up and Down — in any order and at individually selectable speeds.

Up to six different events can be displayed simultaneously within dynamically selectable boundaries. Up to 128 labelled messages can be stored within the units memory for display at any preselected time and date and in any order. 12,288 character memory is standard on the Versadigital Display. This can be expanded to 36,864 with optional external read only memory modules.

Text can be entered through the Display's own keyboard, from an ordinary cassette recorder, from optional external memory modules, or optionally over telephone lines, radio or infra-red link or over AC wiring. A comprehensive set of commands allow complete control over the display's facilities. A powerful word processor type editor lets you easily write, edit, run, save (on cassette) and transmit messages.

The Sign That Can Sell Your Product

Research has shown that digital displays can increase sales by up to 30%. The Versadigital Display virtually assures that figure by increasing the readers' involvement. An optional interface allows up to 128 switches to be connected to the Display, enabling customers to select specific messages without having to wait for the sign to cycle through its repertoire.

The optional External Accessory Interface allows you to write messages that actually point to the product being discussed. At selected points within your message you can program the Display to turn on an external light or a bell. Thus your message might be saying "You won't find these shoes anywhere else ..." and the Display will then activate a lamp high-lighting the product. Up to 128 external devices can be controlled in this fashion. This feature alone makes the Versadigital Display the most effective sales tool you can have.

Versadigital signs are in use throughout the Toronto subway system and Vancouver LRT. Send for reprint of article in Computing Now!, July 1984.

Versadigital Technology in conjunction with Multiflex Inc. also manufactures Time and Temperature displays and can build dynamic plaza maps to your specifications. Our extensive engineering experience enables us to design to a wide variety of situations. Whether it is modifying a current product, or designing new equipment, tell us what you need, we can deliver!

All prices in this catalogue are subject to change without notice.

Distributed by Exceltronix Inc.
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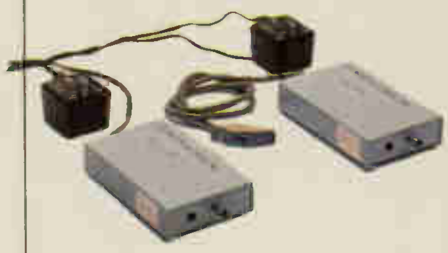
Digital Modem



DO YOU HAVE A PROBLEM? Lack of wires for two-way communications? Do you have a single coax cable between four floors of a building?

If the above holds true for you, as it may well do, if you wish to put equipment in some older Government buildings which were wired years ago, using a single coax to communicate between main frames and which may now be obsolete, you need our solution. If you want to communicate using RS232 between your computers and all you have is a single coax between rooms or floors or buildings, now you can do it without rewiring using our economical solution.

About a year ago we were approached by a Government agency asking if we could solve the problem described above. Well, we solved their problem economically, in fact it worked so well that they bought hundreds of units from us.

The Digital Modem consists of two boxes (approx. 6" x 4") and two wall adaptors. Now you can simply have the RS232 of your computer terminal or other devices plugged directly into one of our Digital Modem boxes (which has a wall plug adaptor to get its power) and you can run up to 800 feet over a single wire to another of our Digital Modem boxes (which again has its own CSA approved power supply) and you again plug in the RS232 DB25 connector to your equipment. Now you can communicate at 9600 Baud or faster (or slower) simultaneously in both directions using your existing single coax cable wiring.

Digital Modem Pair $350.00

(Two Boxes and two adaptors)
Quantity Discounts.
It works perfectly!

All prices and specifications in this catalogue are subject to change without notice. Please follow our ads monthly in Electronics Today and Computing Now!. Whatever market conditions exist, you will find our prices the most competitive in Canada.

If there was ever a fastener made to bedevil and frustrate the repairer, it's the snap ring or circlip. Those are those pesky little C-shaped rings with tiny holes in the ends, generally used to secure something by clamping into a groove in a shaft. You can dig and dig at them with needlenose pliers and what-have-you and they just spin and turn without coming off. It's worth the money to have the special pliers to remove them: the Hunter Model 444 has interchangeable tips that can take off any type of ring, internal or external, even at awkward angles. Also available: less expensive models for internal or external only.

Buy a burnisher! These are very thin strips of metal with fine diamond dust coated on them, and they'll clean corroded contacts of any kind without damaging the plating or the contact angle. Relays will last a lot longer if you use a burnisher instead of sandpaper, and they're better for cleaning sparkplugs than wadding up the abrasive strip off a matchbook. They're also hard to find: try asking an electronics retailer for the Lenline D-300 (medium) or D-400 (fine) or something similar.

Screwdrivers, etc.

There isn't much you can say about screwdrivers, except this: all types and models of screws should be instantly banned by government decree in favour of that wonderful Canadian invention, the Robertson square-headed screw. There's nothing like it.

You might want to invest in a low-cost set of jeweller's screwdrivers. They remove the tiniest of slot-head screws much better than your pocket knife. The cheaper ones won't take much torque without distorting, but you probably won't use them that much.

A set of Allen keys (also called hex head wrenches) is invaluable, not only for electronic assemblies, but for all sorts of machinery. You can get them as separate keys, as screwdrivers, and even as a single wrench with points that swing out like a sparkplug gap gauge. Definitely worth it, and if you encounter Allan screws much, you'll benefit from a set of screwdriver-types rather than the separate keys.

Nutdrivers (for ordinary nuts and bolts) are another worthwhile tool. Try tightening a transformer mounting bolt that's right next to the core, or try tightening a tiny 4-40 nut with a regular wrench. If you get three sizes to fit 4-40, 6-32 and 8-32 nuts, you're well covered for general uses.

Chemicals

Not exactly a tool, but indispensable for certain jobs. The most useful of the aerosols would be contact cleaner. It's marketed under names like Workman "Wissh", Tech Spray EZ Kleen, or Chemtronics Kontact Restorer. All good stuff, though all of them spell funny. Contact spray can restore dodgey switches, quiet noisy volume controls and get silicone heatsink guck off your fingers.

Second most used would probably be freezing spray. For some unfathomable reason, complex digital ICs which have died or gone erratic can be made to work for a short time by cooling them down a whole lot. Perhaps it physically shrinks

Freez-it from Chemtronics is typical of the many freezing sprays that will restart dead components for troubleshooting.

the substrate, healing tiny wounds. In any case, all the sprays work by squirting Freon onto the component; the rapid evaporation cools the part to about -50 degrees C. Another use is finding hairline cracks in PCB copper; the very cold copper will turn white from frost, outlining cracks. Defective passive components can also be identified by cooling. Look for names like Chemtronics Freez-it, Tech-Spray Minus 62, MG Super Cold Spray, Varah's Extra Cold, etc. I've never tried spraying a warm beer with it, but it might work.

If you've done repairs to a PCB, you should clean off the residue left from soldering, particularly in high impedance circuitry. There are various flux strippers available, such as Varah's Flux Remover, Tech Spray Light Duty Stripper, or one from Chemtronics with the notable name of Flux-Off.

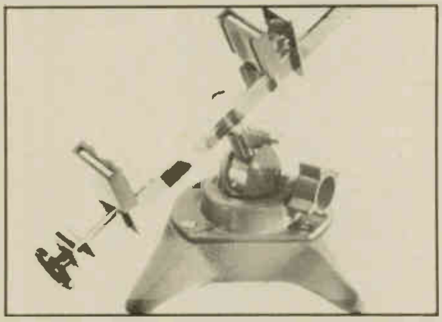
Other good stuff would be a general purpose lubricant spray (my favourite is WD-40), a general purpose solvent (white mineral spirits), high voltage silicone grease such as the GC brand (great for electronic ignition wiring) and a solvent such as methyl hydrate or acetone (good for cleaning off adhesive spills and so forth).

Holders

I used to let PCBs skid around the bench while I tried attaching probes, and then I'd turn them over and chase them around while I tried to extract dead components and solder in new ones. One day I splurged for a PCB holder and it made me wonder how I could have done without it. It's like, *luxury*. One of the simplest and least expensive (under $20) is the Double Hand Holder, Model 76030 from Active Components. It consists of a base holding a horizontal bar at the ends of which are two alligator clips.

Naturally, there's the problem of keeping components from falling out when you're stuffing a new board. You can always bend the leads, but this makes for difficult lead-snipping and a large solder blob. Lenline has a series of holders which can lower a sheet of foam onto the components, holding them in place while you turn the jig over and start soldering. They aren't inexpensive, with the 210 x 180 mm Model PCSS-1 running about $50, but they sure make life easier if you build any number of boards. The Panavise unit on our cover is the Model 315 Circuit Board Holder; it's meant to fit into the Panavise 300 series bases. The whole assembled gadget gives you all sorts of angles for assembling or repairing boards.

If you work on repairing whole units rather than individual boards, there are stands which can hold and rotate a complete computer, typewriter, etc. These are in the area of $350 from Panavise.



One of the many types of vises or clamps will ease building or repair.

A vise of some kind is indispensable, especially when you have to cut or drill something. That reminds me. They always ship volume controls with 2 or 3 inch shafts and you always have to saw them off. How many people mount controls 3 inches back from the front panel? Anyway, if you do only occasional hacking and hewing, I find the small imported hardware store vises are fine. On the other hand, if you're repairing or manufacturing as a business, there are more elegant solutions to gripping things, such as the Panavise series of vises that fit into various bases, such as vacuum bases, low-profile types, swivelling types, etc. Most of the fancy vises are in the $35 region, and most of the bases are $30–$40.

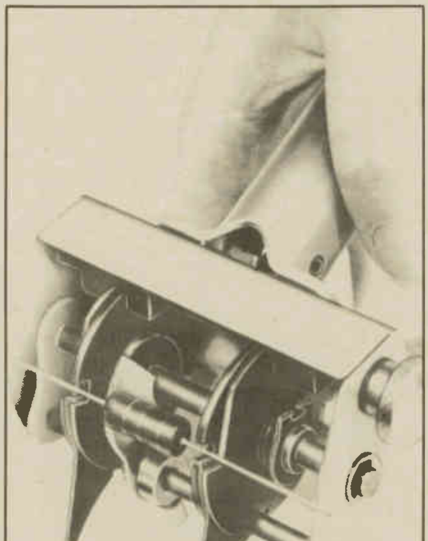
Making Holes

It's a challenge when you don't have a machine shop and you have to make holes larger than the ones you can drill with the old Black and Decker. The majority of chassis openings for electronics projects will be large round or rectangular holes for connectors or meters or similar gadgetry. The fastest way to drill round holes up to about 3/4 inch is the cone cutter, available from electronic suppliers or hardware chains such as Canadian Tire. It consists of a steel cone with a sharpened slot in it and a shank for mounting in power drills; they cut much faster than twist drills, particularly in aluminum. In fact, they cut a hole so fast you may need a depth stop on the drill.

The second way to make variously shaped holes is the Greenlee chassis punch. It's the most elegant way of making a precision hole, but also expensive ($15–$75, depending on size). The punches are available in round, square, keyed, D-shaped, and relay-socket shapes. First, you drill a pilot hole in the panel and thread on the punch and its backing die; then you tighten the bolt with a wrench and the punch is drawn into the die, easily cutting out the desired shape. It's slow, but the hole looks as if it had been punched out with a 50-ton press.

For larger holes, or even smaller ones if you don't care about rough edges, try one of the metal nibblers such as the GC 805, the Lenline Model 03, the Varah 66172, or the Adel Nibbling Tool. They're V-shaped with tiny jaws at the join, and take a small bite out of sheet metals up to about 1/16 thick. It takes a while to munch out a large opening, but it's sometimes the only way, especially if elbow room is limited.

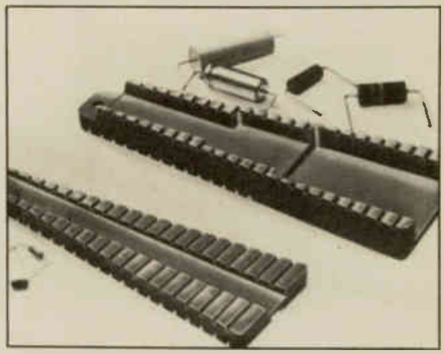
If you're working with a new chassis and have lots of room, try a hacksaw-type blade in an electric jigsaw; it'll cut large holes very quickly, though you might want to wear earplugs.



The Lenline PR2 adjustable lead bender makes for a faster, professional-looking PCB.

Wire Strippers

When you first begin the amazing, rewarding and fulfilling hobby of electronics, assuming you don't chuck it all out in the first few days, you probably started stripping insulation by carefully biting it away with sidecutters, or by using the famous Miller 100-series (the flat ones with the yellow handles; everybody has a pair). If you get into any kind of volume production at all, or even if you just want a bit of luxury, check out some of the fancier models. They look like a complex pair of pliers with hinged jaws; one set of jaws grips the wire and the other strips the ends. They're a bit more expensive than the manual types with prices in the $15–$75 range depending on quality, but it's the only way to face terminating a 100-pair cable. Look for models such as the GC Speedex or Speed-o-matic, or the Lenline 70-156A or STR23.



The fixed lead bender is available in various sizes for smaller jobs.

You can also get gadgets that will bend component leads before insertion into a PCB. If you only make the occasional board, these may be unnecessary, but if you're making any kind of quantity they not only speed things up, but make the finished work look a bit more elegant. The best deal for limited runs would be the simple jigs like the Lenline PD801. Then you can get fancier with the automatic models. They look a bit like the better wirestrippers, and have the advantage of being completely adjustable as to the spacing of the bends; one model is the Lenline PR-2.

Test Clips

You can always poke at test points with alligator clips or even paper clips, but you waste time and risk shorting things, particularly on DIP packages. There are lots of test probes and IC pullers available; so many, in fact, that I've run out of room to list them. There are probes that clip onto ICs for monitoring the pins, and clips with cables that let you run the IC away from the circuit for easy substituting. IC pullers are a necessity; you can't get an IC in and out of restricted quarters without bending the pins, and you'll find a large variety of pullers and inserters at any electronic tool dealers.

Solder, Desolder...

I accumulated so much material on this subject that it's going to have to wait for a future issue. In short, if you're still soldering with a pencil that looks like one of those woodburning-kit heaters, the delights of a real soldering station await you. You won't believe how much better the temperature-controlled types are.

As usual, I've run out of space. There are so many different kinds of tools for so many applications, it staggers the word processor. In future issues I'll be concentrating on specific areas of tool use; I'll start with a look at soldering/desoldering tools. ■

If you can't locate the tools mentioned, the distributor can give you a list of dealers:

Lenline: Len Finkler and Company, 80 Alexdon Road, Downsview, Ontario M3J 2B4, (416) 630-9103; also represent a wide range of tool companies: Edsyn, Lindstrom, American Beauty, Panavise, Miller, Platt, etc.

Varah's Direct, 504 Iroquois Rd., Oakville, Ontario L6H 3K4, (416) 842-8833; outlets in Edmonton, Calgary, Vancouver, Dartmouth, Nepean, and Winnipeg. Wide range of hand tools.

Electro-Sonic, 1100 Gordon Baker Road, Willowdale, Ontario M2H 3B3, (416) 494-1555; carry Lenline, Hunter, Miller, GC, OK, etc.

B.T.W. Electronics Parts, 1542 Warden Avenue, Scarborough, Ontario M1R 2S8, (416) 441-1733; carry Chemtronics, AP, GC, Lenline, OK, Vaco, etc.

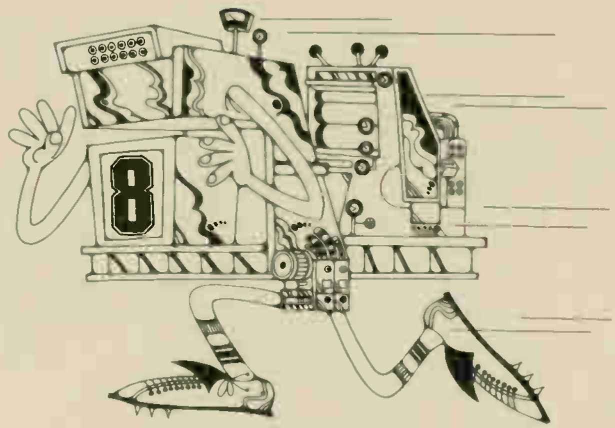
Lenbrook Electronics, Unit 1, 111 Esna Park Drive, Markham, Ontario L3R 1H2, (416) 477-7722; wide range of test clips, IC handling tools, Johnson probes, etc.

Electronic Supplies Inc., 306 Rexdale Blvd., Rexdale, Ontario M9W 1R6, (416) 741-4000; outlets in Chatham, London, Sarnia, and Windsor. Represent Cooper Group (Xcelite, Weller, Crescent, etc), Lenline.

Chemtronics: Paco Electronics, 20 Steelcase Rd. W., Unit 10, Markham, Ontario L3R 1B2, (416) 475-0740.
Active Division of Future Electronics, 5651 Rue Ferrier, Montreal, Quebec H4P 1N1, (514) 731-7441; outlets in Toronto, Downsview, Ottawa, Calgary, and Vancouver. A wide range of hand tools from Ungar, Vaco, GC, Cooper, etc.

If you still need help finding a retail store, the main distributor for Crescent, Xcelite, Nicholson, Weller, Wiss, Turner, etc. is Cooper Tool Group Ltd., 164 Innisfil St., Barrie, Ontario L4N 3E7, (705) 728-5564.

FAST SERVICE



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3DC3	7 70
3DF3	7 20
3DJ3	7 10
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6AR8	7 50
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6AUBA	3 30
6BA11	10 30
6BK4C	12 80
6EL4A	
6BL8	6 80
6BQ5	7 20
6BW11	10 85
6CA4	13 80
6CA7	13 60
6CB6A/	1 50
6CT6	
6CG3/	7 65
6BW3	
6CE3/	7 10
6CD3	
6CG7/	6 40
6PQ7	
6CG8A	7 70
6CJ3/	7 10
6DW4B	

4RA5	4 85
4LJ8	9 20
5AQ5	6 55
5AR4/	8 85
5GH8A/	6 60
PQ3501	6 60
5GJ7	7 50
5GS7	9 65
5LJ8	9 10
5U4GB	8 35
5AS4A	8 35
5Y3GT	7 85
6AD10	22 75
6AF9	20 30
6AG9	22 75
6AJ8	4 25
17DW4A	7 70
17JN6A	9 60
17JZ8	8 95
17KV6A	10 60
19CG3	7.15
34CG3	7 50
34CD3	7 50
34DK3	8 20
35C5	7 10

6CM3	8 30
6CW5	8 20
6DK3	8 05
6DH3	6 95
6DQ3	7 10
6DX8	7 95
6EA8	6 55
6EC4	8 60
6EH7	8 05
6EJ7	8 30
6EW6	5 95
6FM7	9 30
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6HS8	7 80
6HV5A	11 15
6HZ6	6 30
6J10/	12 20
6Z10	
6JA5	9 20
6JC5/	9 40
6JB5/	
6HE5	
6JC6A	7 05
6JD6	7 00
6JE6C/	11 30
6LQ6	
6JH5	13 60
6JS6C	11 10
6JW8/	6 70
ECF802	
6JZ8	9 85
6KD6	13 20
6XD8	9 00

38HE7	13 10
6HL8	9 65
6U10	8.75
6V6GTA	5.15
6X9	17 85
8AC10	8 80
8CG7/	7 30
8EQ7/	
8GJ7	7 95
8JV8	7 40
8LT8	8 45
9GH8A	6 85
9JW8	6 85
9WL8	9 70
10GF7	9 55
10GK6	7 50
10JA5	9 30
10KR8	8 20
11AF9	22 10
11Hn7	8 20
12AT7	6 70
12AU7A	5 90
12AX7A/	6 15
7025A	
12BE6	7 40

6XG6A/	15 25
ELS19	
6KT8	8 20
6L6GC	10 55
6LB6	13 30
6LF6	12 70
6LJ8	8 75
6LH8	6 55
6LR6	12 70
6LT8	8 75
6LU8	10 75
6LH6	30 70
6LX6	13 10
6LX8	6 65
LCF302	6 60
6MJ6	13 30
6LQ6	13 30
6JE6C	13 30
24JE6C	11 35
24LQ6	11 35
25CG3	7 10
25AX5	14 25
25JZ8	9 65
38HK7	12 80
40KG6A	16 70
42EC4	8 95
50C5	7 20

12BH7A	6 30
123Y7A	7 20
12BV7/	7 20
12DQ7	7 20
12CL3	6 80
13nW4	6 80
12GH7A	8 60
12HG7	8 60
12HL7	8 20
12MD8	8 95
13GF7	9 60
13Z10	12 60
13J10	12 60
15HF8	11 65
15A8	10 00
PC182	10 00
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continued from page 26

The Mitel Corporation of Kanata, Ontario, announced in September that the company's common shareholders voted in favour of the proposed British Telecom acquisition of 51 percent controlling interest. The cost to British Telecom at $8 per share was $320 million. Both companies confirmed that BT would exercise full management control as soon as the agreement becomes effective; the acquisition is conditional upon regulatory clearances in the UK and Canada.

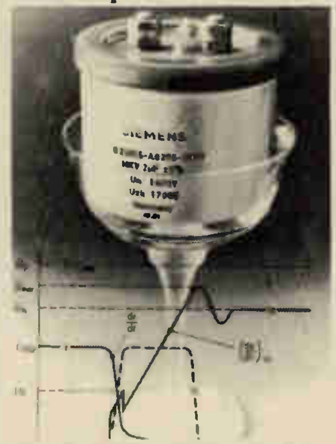
The Philips and Siemens companies of Europe are cooperating on the BICMOS project; the goal is to produce an IC containing both CMOS and bipolar transistors. The CMOS transistor is ideal for digital switching because of its very low quiescent and input currents, and the bipolar is better suited for analog circuits requiring low noise, good matching, and high current density. The chips would be used in A-D converters, memories, digital processing, etc.

RMS Digital Meter

Newport Electronics announces their Model 204B-RMS, a true RMS digital panel meter capable of handling signals with crest factors up to 3:1. The bandwidth is DC to 100KHz, allowing measurement of signals with both DC and AC components. A parallel BCD output is provided; peak and valley hold is available as an option. Contact Metermaster Division of R.H. Nichols Co. Ltd., 80 Vinyl Court, Woodbridge, Ontario L4L 4A3, (416) 851-8871.

Circle No. 55 on Reader Service Card.

GTO Capacitors



The new MKV B25855 capacitors from Siemens are for use with Gate-Turn-Off thyristors; their low inductance (30nH) and high peak currents (up to 2500A) make them ideal for damping capacitors. Contact Siemens Electric Ltd., 1180 Courtney Park Drive, Mississauga, Ontario L5T 1P2, (416) 673-1995.

Circle No. 54 on Reader Service Card.

Chip Clip

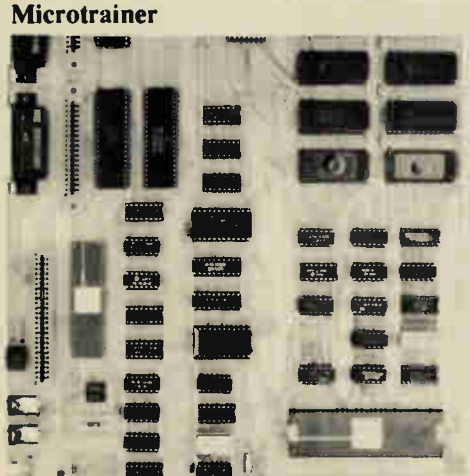
A low-profile chip clip for testing ICs in-circuit, the LPCC-16, is available from OK Industries. One end of a 24-inch cable is terminated with a 16-pin clip which clamps onto the IC under test; the other end has a 16-pin DIP plug used for connecting probes, etc. Contact Len Finkler and Co., 80 Alexdon Road, Downsview, Ontario M3J 2B4, (416) 630-9103.

Circle No. 53 on Reader Service Card.

Looking for a new computer to upgrade your Apple clone? Cray Canada has announced their new X-MP series, nine models of supercomputers suitable for large-scale processing of data from petroleum exploration, structural analysis, weather forecasting, etc. The top-of-the-line 416 has four CPUs and 16 megabytes of RAM, has ten times the performance of the Cray-1, and costs $16 million. It'll run Lotus and WordStar at the same time if you buy an extra RAM card.

continued on page 51

Microtrainer



The Microtrainer 68K is a 68000-based Single Board Computer designed especially for learning about microprocessors and microelectronics. It's used with on-board video circuitry and parallel keyboard interface, or it can be connected to a dumb terminal. It has two connectors for easy interfacing to experimenter boards. Memory can be expanded to 80K on-board; a cross-assembler to run on the IBM PC and several plug-in experimentor boards are available in a complete line of teaching hardware. Contact Waterloo Distance Education, Inc., PO Box 62, Waterloo, Ontario N2J 3Z6, (519) 884-4340.

Circle No. 52 on Reader Service Card.

Direct Injection Box

Clean up your on-stage sound with this low-cost, high and low impedance splitter.

By Andrew Armstrong

EVEN WITH the large number of electric musical instruments in use today, sound is still frequently transferred from instrument to PA system by means of a microphone. Electric guitarists often regard their stage amplifier as part of the instrument and wish the sound to include the distortions, cabinet resonances and even the microphone in the case of tube amplifier. This demands a microphone placed directly in front of the musician's loudspeaker, with all the consequent problems of distortion and increased risk of feedback.

Microphones have to be used in any case for vocalists and acoustic instruments, which makes it all the more important to avoid using them on electric instruments wherever possible so as to keep the risk of feedback to a minimum. Electric keyboards can usually be fed directly into the PA system, but an on-stage amplifier may still be required so that the sound can be heard by the musician and acoustic instruments may also need local amplification in the noisy environment of an amplified band.

The solution to some of these problems is a direct injection box, a unit which takes the incoming signal from the instrument (or from the microphone in the case of an acoustic instrument) and splits it to produce two outputs, one of which is fed to the main PA while the other is taken to a nearby amplifier and speaker controlled by the musician. A DI box (as they are generally known) usually has a high impedance input, a low impedance output for the mixer which is sometimes balanced, and either a high or low impedance output for the stage amplifier.

Well Balanced Design

This design is based around a very low noise dual op-amp which allows it to be used at low signal levels without significant noise problems. The gain is normally set at unity but a voltage gain of 2:1 can be achieved by making a few component changes. The unit operates from a single 9V battery and powers up automatically when a jack plug is inserted into the input socket. In addition, a low-voltage detector is included which lights an LED when the battery needs replacing.

The unbalanced output can be taken from the output of the first op-amp which gives a reasonably low impedance driver, or, if preferred, can be connected directly to the input. The advantage of this arrangement is that the unbalanced output will then continue to operate even if the unit develops a fault or the battery runs down. The input impedance of the DI box circuitry is quite high and will not excessively load a connection made in this way.

The mixer output is balanced and can either be used directly with high impedance balanced inputs or set at 600R by adding two 300R resistances. A circuit for a low impedance balanced input has also been included, as an add-on, to enable the unit to be used with equipment which does not already have a balanced input.

The normal type of balanced line to use for audio work is 600R. To be completely correct, the source resistance for each signal connection should be 300R and each one should be terminated with a 300R resistance to ground at the receiving end. In many cases, a high impedance is used at the receiving end and the sending end impedance is just 'low'.

As long as the signal level is suitable, this unit may be used as a proper 600R driver. The 5532 op-amp specified has very low noise, typically 5 $nV/\sqrt{Hz}$, so very low level signals may be used without a severe signal-to-noise penalty. The voltage swing which the op-amp can drive into 600R is somewhat less than it could drive into 10k for example, so, taking account of the reduced efficiency when operating from a single 9V supply rather than a dual 15V supply, signals of over two volts peak to peak may clip. When the battery is exhausted, the 5532 may only manage two volts peak to peak into a high impedance. This should be adequate for most purposes, but if it is not, the project may easily be adapted to give more output.

If the box is operated with 300R output resistors into a terminated 600R line, the output signal will be potted down by 2:1. To compensate for this, voltage gain is provided by the addition of optional components R4 and C2. Equally, if the input signal is of a very low level, adding these components will boost it to a level considerably above the of the interference picked up on the line. This is particularly useful to prevent buzz from phase controlled lights being audible on microphone circuits. For the purpose of driving a balanced line, a voltage gain of two times is required.

In order to gain the greatest benefit from the DI box, its output should be fed into a balanced (or differential) input. Unfortunately, the equipment you use it with may not have a differential input, but read on.

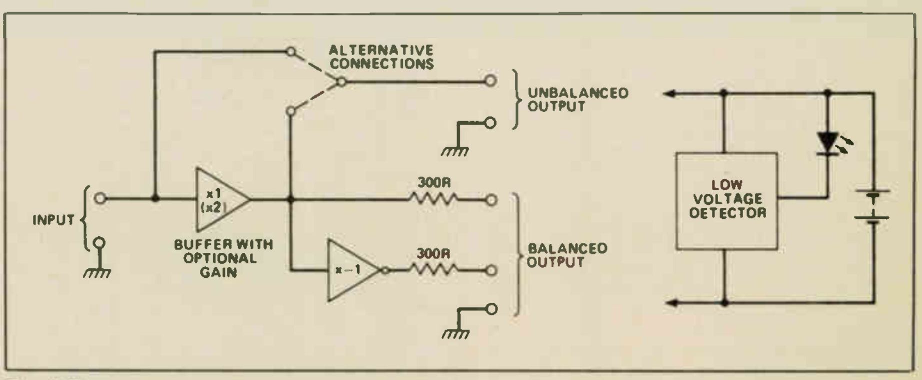


Fig. 1 The block diagram of the direct injection box.

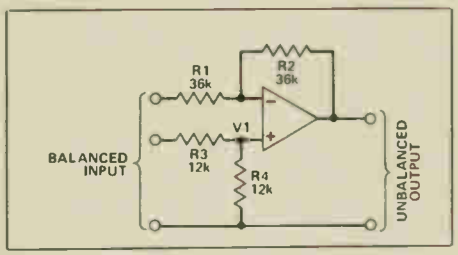


Fig. 2 A standard differential input arrangement.

The circuit in Fig.2 shows the conventional configuration of a differential receiver. Most text books show all four resistors in the circuit to be of equal value, but that is not always the best way to do things. At first glance, it would appear that the impedance on the non-inverting input is R3 + R4, while that on the inverting input is R1. This is not so. If the op-amp is working linearly (ie not clipping) then for all practical purposes, the voltage on the inverting input of the op-amp is the same as that on the non-inverting input.

First of all, the differential impedance of the circuit shown is correct, but the common mode impedance is not balanced. The addition of 300R load resistors will swamp any differences and the best performance will be obtained. The second reason is that the op-amp would be required to drive heavy currents into its feedback resistors if low value resistors were used around the op-amp, and this would restrict the output swing.

Power Consumption

The one drawback of the excellent NE5532 dual op-amp is that its current consumption is quoted as eight milliamps typical, sixteen maximum. If the DI box is to be used with reasonably large signals and not into a low impedance load, it may be preferable to use the LM358 op-amp in order to cut the power consumption. The gain bandwidth product of this device is only 1MHz, so there is not a lot of scope for providing voltage gain without the risk of slight degradation of sound quality.

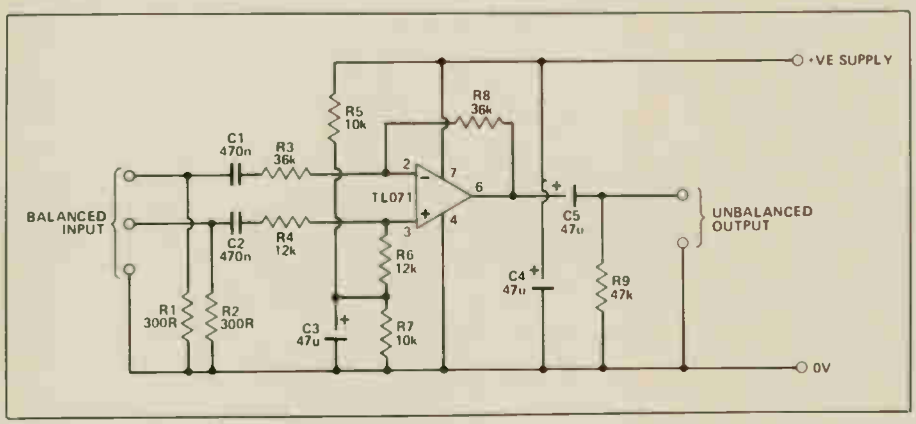


Fig. 3 A practical circuit for a differential input stage.

The non-inverting input has half the positive signal voltage, and since the inverting input has the same signal present, resistor R1 has a voltage across it equal to half the positive input signal plus the negative input signal. The signals are meant to be balanced, so the voltage across R1 is 1.5 times the negative input signal. The current flowing in this resistor is therefore 1.5 times as high as would be expected if R1 were feeding a virtual ground point, so the apparent impedance is 1/1.5 times the value of R1. Therefore R1 should have a value of 1.5 times the desired input impedance. Another way to visualize this is to think of the virtual ground point as being one third of the way along the resistor from the inverting op-amp input to the input signal.

The component values shown in this circuit are for a 48k input impedance, 24k on each line. should a 600R input impedance be required, it is best to use 300R resistors to load the input, rather than using very low value resistors around the op-amp. There are two reasons for this.

How it Works

IC1A works as a buffer with selectable gain, R4 and C2 being added only if voltage gain is required. The offset voltage on the inputs is minimized by having a similar net DC resistance on each input. The output of this buffer drives the in-phase output and also a unity gain inverter, IC1B, which in turn drives the other output. Both outputs have their impedance set by series resistors and are DC blocked by electrolytic capacitors. The capacitors are polarised by load resistors R11 and R12

The low battery detector is based on a purpose designed IC which contains a very low current band gap voltage reference, a comparator, and a current limited output drive circuit. For this reason, the LED needs no current limiting resistor.

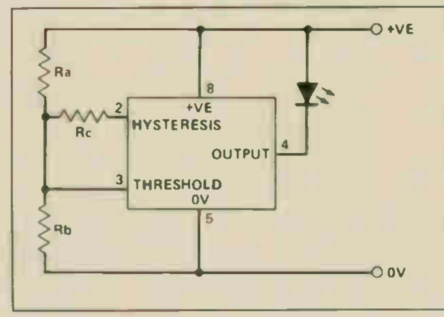


Fig. 4 The low voltage warning circuit using the 8211 micro power sensor.

Another alternative would be the TL072 which has a gain bandwidth product of 3MHz and a noise figure of 18nv/$\sqrt{\text{Hz}}$, both of which are quite acceptable. This is a BiFET device, so it would be possible to use a very high input impedance if necessary, a megohm for example. The maximum current consumption of this is 5mA total, so the battery life should be reasonable.

If the application requires substantial voltage drive into a 600R load, the DI box may be constructed with 25V rated electrolytic capacitors and powered from two 9V batteries in series. There is not room in the case of the prototype unit for another battery, so a large sized case would have to be used. The low battery warning would have to be recalculated to work at a different voltage as well, of course, in order to give warning before the unit stopped working correctly, rather than afterwards.

Low Battery Alarm

This part of the circuit uses the 8211 micropower sensor. This handy chip draws a quiescent current of about 25uA and provides a current limited LED drive which switches on when the voltage on its threshold input falls below 0.15 volts. Referring to Fig. 4, the threshold voltage for the LED to switch off is given by the formula:

$$V = 1.15 \times \frac{Ra + Rb}{Rb} \text{ volts}$$

Hysteresis is added by Rc (R14 in the final circuit), but if this is not required pin 2 should be left open circuit.

The addition of hysteresis does not affect the switch off voltage but the switch on voltage is lowered. This voltage is calculated from the formula:

$$V = \left(\frac{Ra \times Rc}{Ra + Rc} + Rb\right) \times \frac{1.15}{Rb}$$

The component values specified in the circuit diagram give nominal switching voltages of 6.55 (off) and 5.60 (on). If this end of life voltage is too low, it may be raised by reducing Rb in the sensing circuit.

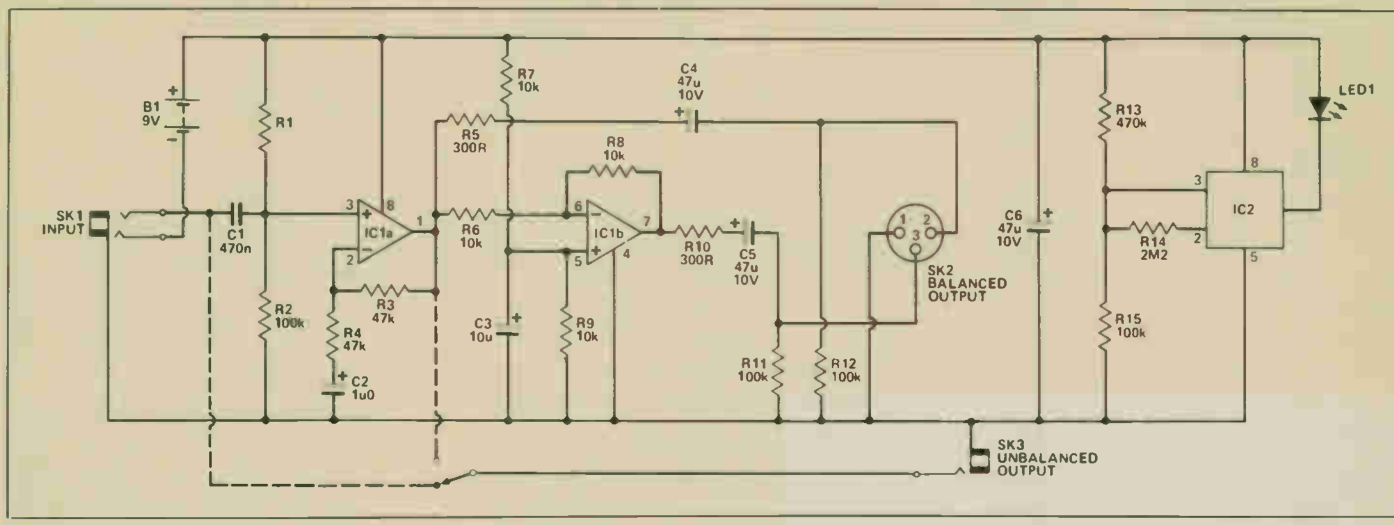


Fig. 5 Complete circuit diagram of the direct injection box.

Construction

Before starting to assemble the DI box, you must decide which of the various circuit options you wish to incorporate. Some of these will affect your choice of components while others, like the choice of unbalanced output take-off point, will only involve wiring changes. The components which may be affected are all marked in the parts list. SK1 is specified as a stereo jack socket even though the signal is mono, the extra connection is used to connect the battery negative to the PCB when the input is plugged in. The rest of the assembly is straightforward; Fig. 7 shows the suggested layout within the case.

Testing

If a regulated power supply is available it should be used for initial testing. Set the power supply to about 4V, if the LED does not light, then reverse its connections and try again. Once the LED works, increase the voltage until the LED goes off, then reduce it until the LED switches on again. Measure the voltage and check that it is about 5.6V. Individual units may vary due to component tolerance, but if the voltage is not acceptable the value of R13 or R15 should be changed.

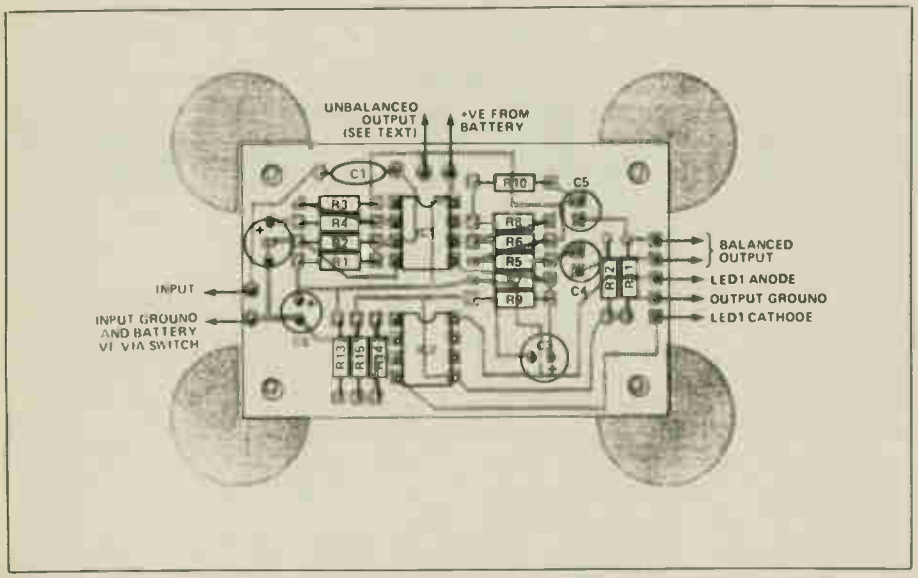
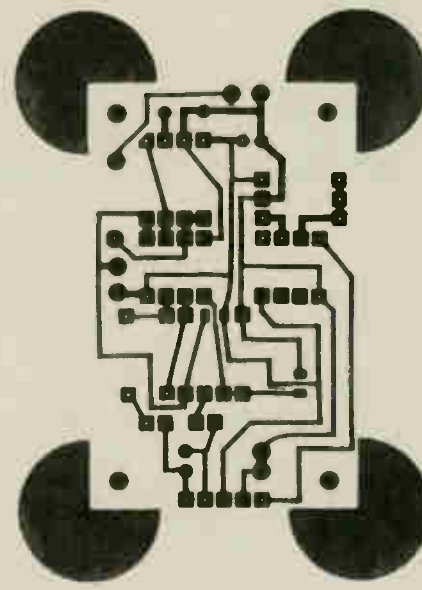


Fig. 6 The component overlay for DI box.



PCB for the DI box.

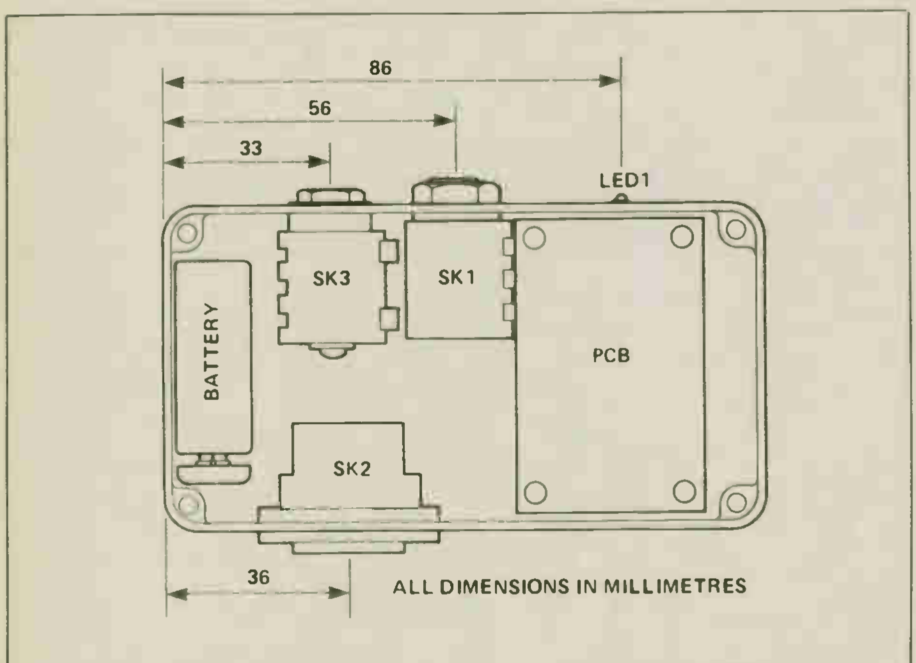


Fig. 7 Layout of the major components within the case.

Now apply 9V, either from a battery or from the power supply, and use a voltmeter to check that the op-amp output pins are at about 4.5V and that the outputs are at 0V. If they are not, the most likely fault is a reversed electrolytic capacitor. Finally, connect up a signal source and a suitable amplifier and check that everything works correctly and that the sound is what it should be.

A practical circuit for a differential input is shown in Fig. 3. The 300R input resistors are optional but should be included if the input is connected to a 600R balanced output. The power may be drawn from any DC source with a voltage in the range 6-30V or a dual rail supply could be used and the biasing component omitted. If the arrangement is to be battery powered, it might be an idea to include a low voltage monitor of the type used in the main DI box.

Parts List

Resitors
(¼ W 5% unless otherwise stated)

R1,2,11,12,15	100k
R3	47k
R4	47k (see text)
R5,10	300R 1%
R6, 8	10k 1%
R7,9	10k
R13	470k
R14	2M2 (see text)

Capacitors

C1	470n polyster
C2	1u0 tantalum (see text)
C3	10u 10V radial electrolytic
C4,5,6	47u10V radial electrolytic

Semiconductors

IC1	NE5532 dual op-amp
IC2	ICL8211 micropower sensor

Miscellaneous

SK1	¼" stereo jack socket
SK2	XLR 3-pole chassis plug (XLR-3-32 or equivalent)
SK3	¼" mono jack socket

PCB: die cast box, approx 110 x 60 x 30mm; panel-mounting bush for LED1; battery connector; nuts and bolts to mount SK2 and the PCB.

Computing Today

Z80 Design Part 6

More interfacing with the Z80. Hooking up to relays, motors, lamps etc.

By Hagen Kornberger

RELAYS can be used to control a great number of devices such as lamps, motors, and other high current devices. Fig.10 shows the driver circuit needed for a typical relay. Five volt relays are available and some are even packaged with pin spacing the same as IC's so they can be placed in sockets; other relays require higher coil voltages so an extra power supply is necessary.

The maximum load that can be placed on the relay depends on the switch contact ratings. Fig. 11 shows how two relays are used turn a motor on and off and change the direction as well. However relays have some disadvantages. They have a slow response time, are mechanical and therefore suffer in reliability, and they tend to generate quite a bit of unacceptable radio frequency interference.

Solid state switches can replace relays and eliminate the disadvantages. Power transistors can be used to switch high current DC motors, lamps, etc, and SCR's and TRIAC's can be used to control AC devices. In cases where the load voltage is to be isolated from the computer voltage, such as line operated loads, opto-isolators are available.

Turning on and off a DC load with a power transistor is quite the same as lighting an LED with a driver transistor. However, if the current is large an additional driver transistor will be required to drive the power transistor. If the load current is 1 amp and the gain of the transistor is 10 (typical for power transistors), then a base current of 100ma is required to drive the transistor into saturation. Driving the transistor into saturation is important as this keeps the power dissipation of the transistor down. Fig. 12 shows a power transistor switch and the appropriate calculations for the resistors.

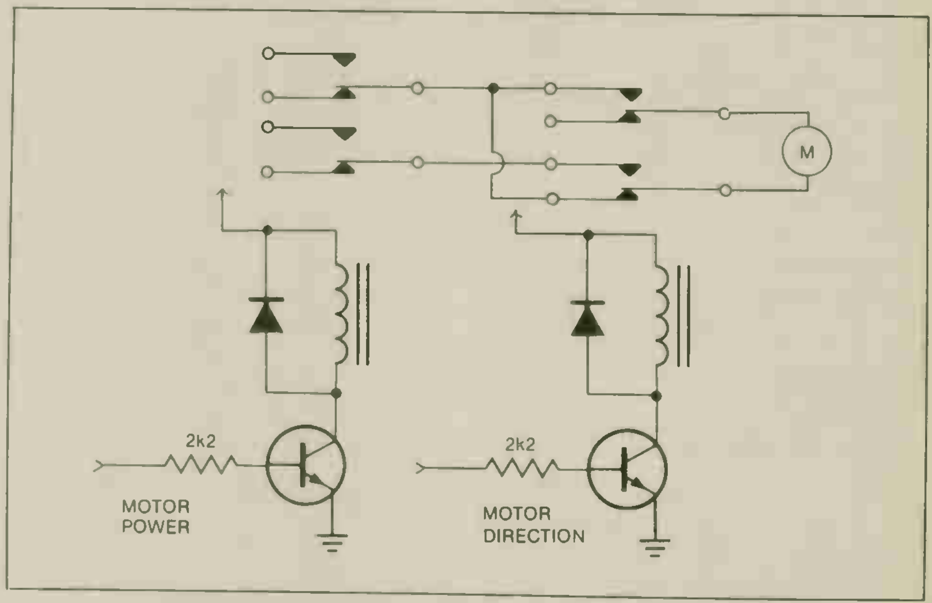


Fig. 11 Circuit details for the relay control of a motor.

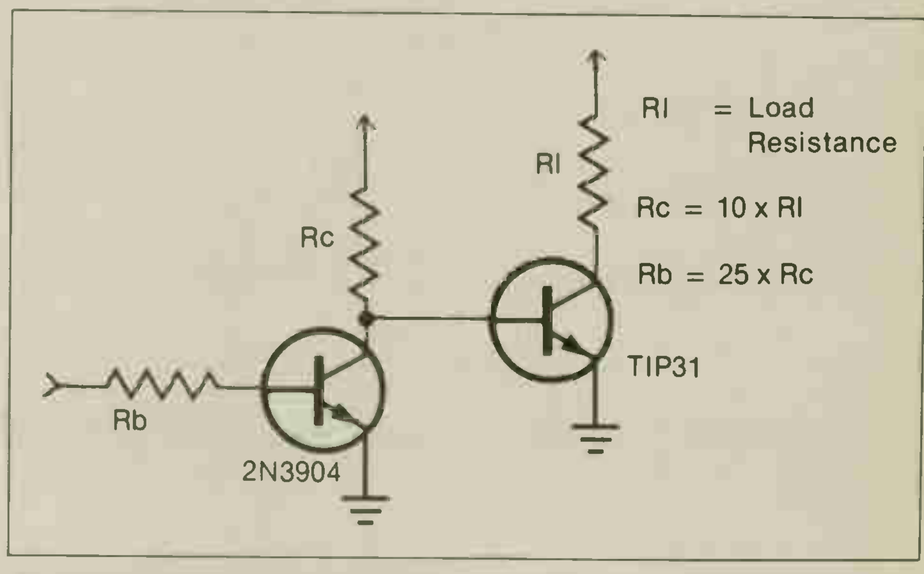


Fig. 12 Circuit diagram for a power transistor switch.

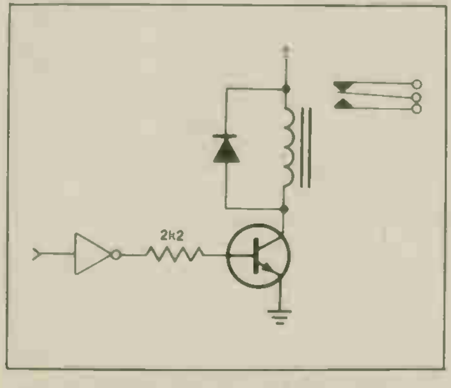


Fig. 10 Details of a relay driver circuit.

Varying the speed of DC motors is quite easily done. For full speed the motor is turned on and left on; for no speed, or stop, the motor is simply turned off. For speeds in between, the motor is shut on and off rapidly. The speed of the motor depends on the duty cycle or the ratio of the time when the motor is on to when the motor is off. A 50 percent duty cycle makes the motor go at medium speed.

Changing the direction of the motor is quite easily done. Fig. 13 shows the schematic of a four power transistor switch quite commonly referred as a power-H driver. The advantage of this type of circuit over others is the need for only a single polarity power supply. Two output bits are need to define the speed and direction of the motor.

For precision movement a stepper motor is required. Stepper motors are operated by pulsing them, meaning that each time a pulse is applied, the motor turns a certain number of degrees. Four windings inside the motor make the motor turn. The windings are pulsed in sequence and depending on the direction of the sequence, they make the motor turn forward or in reverse. IC's are available to drive the stepper motors but the Z80, with the appropriate software, is quite capable of handling this task. Fig. 14 shows the schematic of the driver circuit.

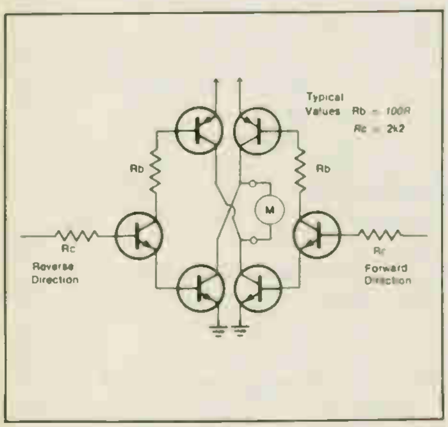


Fig. 13 The circuit of the Power-H driver.

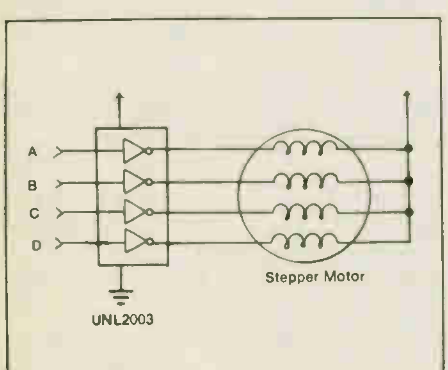


Fig. 14 The stepper motor driver.

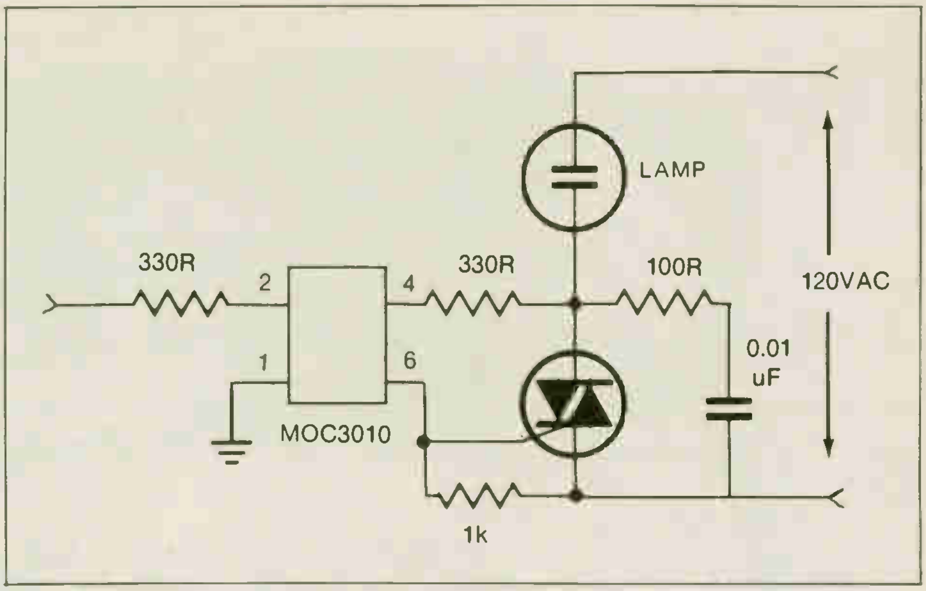


Fig. 15 Circuit diagram of a Triac switch.

To switch AC devices, triacs are commonly used. These offer the advantage of switching on for the full wave of an AC cycle as opposed to SCRs. Triacs are usually used in conjunction with triac output opto-isolators to isolate the CPU from the power line. Fig. 15 uses an MOC3010 opto-isolator IC readily available from Radio Shack (cat. no. 276-134).

Generating Sound

Producing an electronic *beep* with a fixed duration and frequency, and with minimum Z80 intervention, can be done with a single 556 timer as shown in Fig. 16. The first section of the timer is a one-shot multivibrator, and the second section is an astable multivibrator. By pulsing the trigger input of the one-shot multivibrator, a beep with a duration and frequency selected by the components will be heard on the speaker.

Generating a variety of frequencies can be done with software. In this case only an output amplifier is needed for the sound to be heard on the loudspeaker. Generating a specific frequency is a simple matter of using a timing loop in between the on-off transition period. Changing the characteristic of the sound can be done by altering the duty cycle of the waveform.

Output Ports

Although the PIO is quite convenient to use it is quite costly when multiple output ports are required. Fig. 17 shows an 8 bit output port wired up using the 74LS374 8 bit D-type flip-flop. The output port is addressed at 80 hex. Seven more output ports can be wired up without additional address decoding.

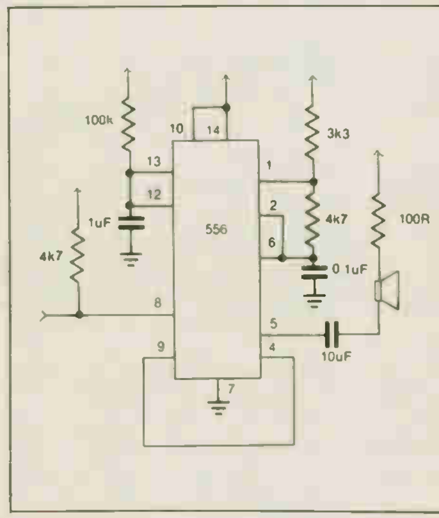


Fig. 16 Circuit to generate a 100ms beep.

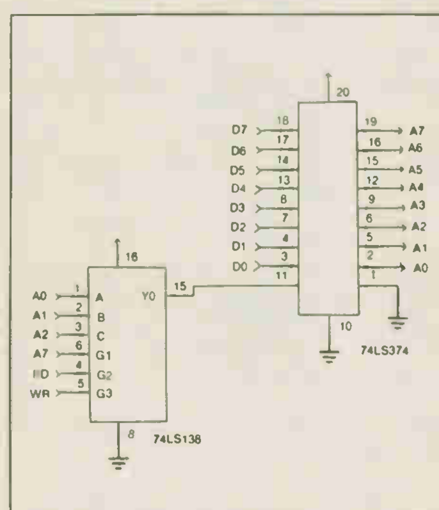


Fig. 17 Details of the alternate output port using the 74LS138 and 74LS374.

Zopan 1404A Function Generator

A low cost 3-waveform generator for most testbench needs arrives from Poland.

By Bill Markwick

FUNCTION Generators are handy things to have around; their advantages include several types of waveforms, wide frequency range and excellent amplitude stability. The Zopan 1404A is manufactured in Warsaw, Poland, and is being offered to the Canadian market by KB Electronics of Oakville. Its features include a very wide frequency range from .05Hz to 1MHz in seven overlapping decade ranges, pushbutton switching, and a single-square-triangle 600 ohm output via a BNC jack.

The function generator works by creating a ramp voltage, usually by charging a capacitor with a constant-current source. This ramp is turned into a triangle by having a voltage comparator discharge the capacitor via another CCS when the ramp voltage reaches a prescribed limit. The big advantage to this method is that you can easily change frequency by voltage-controlling the capacitor's charging rate. Square waves are easily obtained by triggering a gate on the triangle's zero crossing, and sine waves are produced (usually) by passing the triangle through a non- linear element such as a diode matrix or the base-emitter section of a differential amp; this produces a fair amount of distortion in the sine - the Zopan is listed at less than 3%, 10Hz to 50KHz, rising to less than 5% up to 1MHz. This is adequate for most testing other than distortion measurements.

This method of generation also lends itself to controlling the amplitude and frequency by external voltages, and the Zopan has BNC inputs for voltage control of both. It also has two waveform controls for symmetry (of the square wave) and DC offset (of all three). Symmetry is the ratio of a rectangular wave's positive side to its negative side, useful for checking the response of logic circuit inputs to waveforms with duty cycles other than the usual 50%. The offset control applies a DC voltage of up to plus and minus 5V to the signal for testing circuits that aren't at ground potential.

The output voltage is listed as a nominal 10V, but this requires some clarification. The sinewave showed a level of 11V peak-to-peak, or 3.9V RMS, with the output unloaded. The triangle was 12Vpp and the square was 14Vpp. These values fell to half when a 600 ohm resistor was connected across the output.

The frequency stability is rated at plus or minus .5% short-term, and plus or minus 1% over seven hours. The amplitude stability wasn't specified, but pushing the range buttons over the full frequency span caused an amplitude change of tiny fractions of a dB, and these may have been caused by the test equipment itself. Great for instant checking of audio amp response.

The voltage control of frequency, while not extremely widerange, will be useful in testing filters and other frequency-sensitive circuits. The application of a voltage from zero to -8V caused a frequency variation of 28:1 on each range. Similarly, the amplitude jack was suited to modulating the output waveform with another signal, or DC, but had the odd effect of noticeably increasing the sinewave distortion, though it didn't bother the square or triangle; perhaps the distortion could be trimmed to a lower value with the internal adjustments.

There were no switches to defeat the symmetry or offset adjust, making it necessary to use a DC voltmeter to zero the output. But then, that's what keeps the cost down.

Looking inside the unit, which is easily done by removing four screws and sliding out the metal frame, reveals a neat, well-planned construction. Except for one IC, the unit uses discrete transistors throughout, which may confirm suspicions that eastern countries are behind the west in IC production. The other components seem to be Polish-made, though the calibration trimpots looked like Philips types.

In short, the Zopan 1404A fills the bill for a low-cost versatile signal source. It's presently retailing for $289.95. Contact: ■

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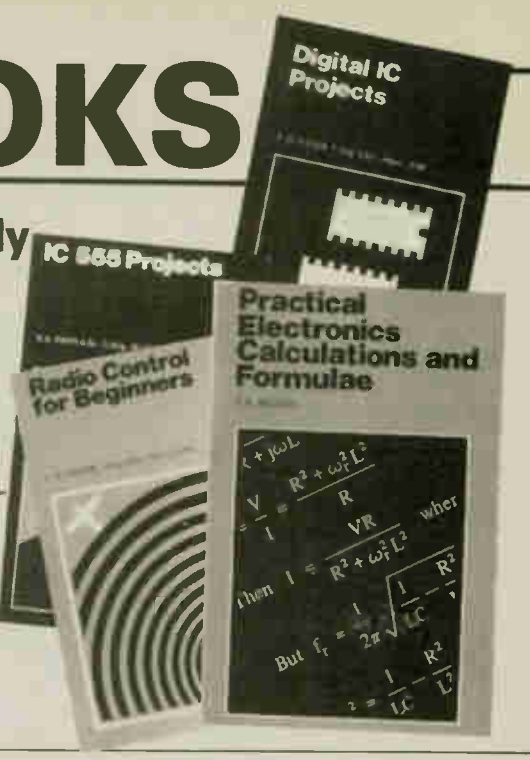

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Helps the reader make the best use of the Sinclair QL's almost unlimited range of features. Complements the manufacturer's handbook.

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This book deals mainly with TTL type chips such as the 7400 series. Simple projects and a complete practical construction of a Logic Test Circuit Set are included as well as details for a more complicated Digital Counter Timer project.

BP130: MICRO INTERFACING CIRUITS - BOOK 1 $8.55
Aimed at those who have some previous knowledge of electronics, but not necessarily an extensive one; the basis of the book is to help the individual understand the principles of interfacing circuits to microprocessor equipment.

BP131: MICRO INTERFACING CIRCUITS - BOOK 2 $8.55
Intended to carry on from Book 1, this book deals with practical applications beyond the parallel and serial interface. 'Real world' interfacing such as sound and speech generators, temperature and optical sensors, and motor controls are discussed using practical circuit descriptions.

BP111: AUDIO $13.25
This one is ideal for readers who want to really get into sound. A wide range of material is covered from analysis of the sound wave, mechanisms of hearing, room acoustics, microphones and loudspeakers, amplifiers, and magnetic disc recording.

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ADRIAN MICHAELS $21.95
Find equivalents and cross-references for both popular and unusual integrated circuits. Shows details of functions, manufacturer, country of origin, pinouts, etc.; includes National, Motorola, Fairchild, Harris, Motorola, Intersil, Philips, ADC, AMD, SGS, Teledyne, and many other European, American and Japanese brands.

BP156: AN INTRODUCTION TO QL MACHINE CODE $7.75
The powerful Sinclair QL microcomputer has some outstanding capabilities in terms of its internal structure. With a 32-bit architecture, the QL has a large address range, advanced instructions which include multiplication and division. These features give the budding machine code programmer a good start at advanced programming methods. This book assumes no previous knowledge of either the 68008 or machine code programming.

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This book carries on from its predecessor and provides a further selection of useful circuits, mainly of a simple nature; the book will be well within the capabilities of the beginner and more advanced constructor.

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ELECTRONIC THEORY

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The aim of this series of books can be stated quite simply — it is to provide an inexpensive introduction to modern electronics so that the reader will start on the right road by thoroughly understanding the fundamental principles involved.

Although written especially for readers with no more than ordinary arithmetical skills, the use of mathematics is not avoided, and all the mathematics required is taught as the reader progresses.

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BOOK 1. This book contains all the fundamental theory necessary to lead to a full understanding of the simple electronic circuit and its main components.

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BOOK 3. Follows on semiconductor technology leading up to transistors and integrated circuits.

BOOK 4. A complete description of the internal workings of microprocessor.

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PROJECTS

BP48: ELECTRONIC PROJECTS FOR BEGINNERS $ 7.75
F G RAYER, T.Eng (CEI), Assoc IERE
Another book written by the very experienced author — Mr F.G. Rayer — and in it the newcomer to electronics will find a wide range of easily made projects. Also, there are a considerable number of actual component and wiring layouts to aid the beginner.

Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering and, thus, avoid the need for a soldering iron.

Also, many of the later projects can be built along the lines as those in the 'No Soldering' section so this may considerably increase the scope of projects which the newcomer can build and use.

BP37: 50 PROJECTS USING RELAYS, SCR's & TRIACS $ 7.75
F G RAYER, T.Eng (CEI), Assoc.IERE
Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of applications in electronics today. This book gives tried and practical working circuits which should present the minimum of difficulty for the enthusiast to construct. In most of the circuits there is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation of them to individual needs.

BP221: 28 TESTED TRANSISTOR PROJECTS
R.TORRENS $5.00
Mr. Richard Torrens is a well experienced electronics development engineer and has designed, developed, built and tested the many useful and interesting circuits included in this book. The projects themselves can be split down into simpler building blocks, which are shown separated by boxes in the circuits for ease of description and also to enable any reader who wishes to combine boxes from different projects to realise ideas of his own.

BP71: ELECTRONIC HOUSEHOLD PROJECTS $7.20
R A PENFOLD
Some of the most useful and popular electronic construction projects are those that can be used in or around the home. The circuits range from such things as 2 Tone Door Buzzer, Intercom, through Smoke or Gas Detectors to Baby and Freezer Alarms.

BP73: REMOTE CONTROL PROJECTS $8.10
OWEN BISHOP
This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control. Full explanations have been given so that the reader can fully understand how the circuits work and can more easily see how to modify them for other purposes, depending on personal requirements. Not only are radio control systems considered but also infra-red, visible light and ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

BP90: AUDIO PROJECTS $7.60
F G RAYER
Covers in detail the construction of a wide range of audio projects. The text has been divided into preamplifiers and mixers, power amplifiers, tone controls and matching and miscellaneous projects.

BP74: ELECTRONIC MUSIC PROJECTS $7.20
R A PENFOLD
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser Units, Tremelo Generator etc.

BP44: IC 555 PROJECTS $ 7.75
E A PARR, B Sc.,C.Eng., M.I.E.E.
Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP82: ELECTRONIC PROJECTS USING SOLAR CELLS $7.75
A collection of simple circuits which have applications in and around the home using the energy of the sun to power them. The book deals with practical solar power supplies including voltage doubler and tripler circuits, as well as a number of projects.

BABANI BOOKS

BP49: POPULAR ELECTRONIC PROJECTS $7.75
R.A. PENFOLD
Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to interest most electronics constructors. The projects selected cover a very wide range and are divided into four basic types Radio Projects, Audio Projects, Household Projects and Test Equipment

BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS
R.A. PENFOLD $7.60
Projects, fifteen in all, which use a 12V supply are the basis of this book. Included are projects on Windscreen Wiper Control, Courtesy Light Delay, Battery Monitor, Cassette Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, Depth Warning and Shaver Inverter

BP95: MODEL RAILWAY PROJECTS $7.60
Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects covered include controllers, signals and sound effects stripboard layouts are provided for each project

BP93: ELECTRONIC TIMER PROJECTS $7.60
F.G. RAYER
Windscreen wiper delay, darkroom timer and metronome projects are included. Some of the more complex circuits are made up from simpler sub-circuits which are dealt with individually

BP113: 30 Solderless Breadboard Projects-Book 2
R.A. Penfold $8.85
A companion to BP107. Describes a variety of projects that can be built on plug-in breadboards using CMOS logic IC's. Each project contains a schematic, parts list and operational notes

BP104: Electronic Science Projects
Owen Bishop $8.85
Contains 12 electronic projects with a strong scientific flavour. Includes Simple Colour Temperature Meter, Infra-Red Laser, Electronic clock regulated by a resonating spring, a 'Scope with a solid state display, pH meter and electrocardiograph

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING $7.60
R.A. PENFOLD
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects

BP84: DIGITAL IC PROJECTS $7.60
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
This book contains both simple and more advanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects can be built and tested section by section and this should help avoid or correct faults that could otherwise be troublesome. An ideal book for both beginner and more advanced enthusiast alike

BP67: COUNTER DRIVER AND NUMERAL DISPLAY PROJECTS $7.05
F.G. RAYER, T.Eng.(CEI), Assoc. IERE
Numeral indicating devices have come very much to the forefront in recent years and will, undoubtedly find increasing applications in all sorts of equipment. With present day integrated circuits, it is easy to count, divide and display numerically the electrical pulses obtained from a great range of driver circuits

In this book many applications and projects using various types of numeral displays, popular counter and driver IC s etc are considered

BP99: MINI — MATRIX BOARD PROJECTS $7.60
R.A. PENFOLD
Twenty useful projects which can all be built on a 24 x 10 hole matrix board with copper strips. Includes Doorbuzzer, Low-voltage Alarm, AM Radio, Signal Generator, Projector Timer, Guitar Headphone Amp, Transistor Checker and more

BP103: MULTI-CIRCUIT BOARD PROJECTS $7.60
R.A. PENFOLD
This book allows the reader to build 21 fairly simple electronic projects, all of which may be constructed on the same printed circuit board. Wherever possible the same components have been used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects or by re-using the components and P C B all of the projects

BP107: 30 SOLDERLESS BREADBOARD PROJECTS — BOOK 1 $8.85
R.A. PENFOLD
A "Solderless Breadboard" is simply a special board on which electronic circuits can be built and tested. The components used are just plugged in and unplugged as desired. The 30 projects featured in this book have been specially designed to be built on a "Verobloc" breadboard. Wherever possible the components used are common to several projects, hence with only a modest number of reasonably inexpensive components it is possible to build in turn, every project shown

BP106: MODERN OP-AMP PROJECTS $7.60
R.A. PENFOLD
Features a wide range of constructional projects which make use of op amps including low noise, low distortion, ultra high input impedance, high slew rate and high output current types

CIRCUITS

How to Design Electronic Projects
BP127 $8.95
Although information on standard circuit blocks is available, there is less information on combing these circuit parts together. This title does just that. Practical examples are used and each is analysed to show what each does and how to apply this to other designs

Audio Amplifier Construction
BP122 $8.95
A wide circuits is given, from low noise microphone and tape head preamps to a 100W MOSFET type. There is also the circuit for 12V bridge amp giving 18W. Circuit board or stripboard layout are included. Most of the circuits are well within the capabilities for even those with limited experience

BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1 $7.75
R.A. PENFOLD
Another book by the very popular author, Mr R A Penfold, who has designed and developed a large number of various circuits. These are grouped under the following general headings, Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Project Circuits and Miscellaneous Circuits

BP98: POPULAR ELECTRONIC CIRCUITS, BOOK 2 $8.85
R.A. PENFOLD
70 plus circuits based on modern components aimed at those with some experience

BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS $6.75
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
Field effect transistors (FETs), find application in a wide variety of circuits. The projects described here include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home

This book contains something of particular interest for every class of enthusiast — short wave listener, radio amateur, experimenter or audio devotee

BP87: SIMPLE L.E.D. CIRCUITS $5.40
R.N. SOAR
Since it first appeared in 1977 Mr R N Soar's book has proved very popular. The author has developed a further range of circuits and these are included in Book 2. Projects include a Transistor Tester, Various Voltage Regulators, Testers and so on

BP24: 50 PROJECTS USING IC 74- $6.75
A unique book containing ... projects that can be simply constructed ... op amp and a few components. Origin... d in Germany, this book will be an valuable ass... hobbyist

SOLD OUT

BP88: HOW TO USE OP AMPS $8.85
E.A. PARR
A designer's guide covering several op amps, serving as a source book of circuits and a reference book for design calculations. The approach has been made as non-mathematical as possible

BP65: SINGLE IC PROJECTS $6.05
R.A.PENFOLD
There is now a vast range of ICs available to the amateur market the majority of which are not necessarily designed for use in a single application and can offer unlimited possibilities. All the projects contained in this book are simple to construct and are based on a single IC. A few projects employ one or two transistors in addition to an IC but in most cases the IC is the only active device used

223: 50 PROJECTS USING IC CA3130 $5.00
R.A.PENFOLD
In this book, the author has designed and developed a number of interesting and useful projects which are divided into five general categories I — Audio Projects II — R F Projects III — Test Equipment IV — Household Projects V — Miscellaneous Projects

BP117: PRACTICAL ELECTRONIC BUILDING BLOCKS BOOK 1 $7.60
Virtually any electronic circuit will be found to consist of a number of distinct stages when analysed. Some circuits inevitably have unusual stages using specialised circuitry, but in most cases circuits are built up from building blocks of standard types

This book is designed to aid electronics enthusiasts who like to experiment with circuits and produce their own projects rather than simply follow published project designs

The circuits for a number of useful building blocks are included in this book. Where relevant, details of how to change the parameters of each circuit are given so that they can easily be modified to suit individual requirements

BP102: THE 6809 COMPANION $7.60
Written for machine language programmers who want to expand their knowledge of microprocessors. Outlines history, architecture, addressing modes, and the instruction set of the 6809 microprocessor. The book also covers such topics as converting programs from the 6800, program style, and specifics of 6809 hardware and software availability

BP118: PRACTICAL ELECTRONIC BUILDING BLOCKS - Book 2
R.A. PENFOLD $7.60
This sequel to BP117 is written to help the reader create and experiment with his own circuits by combining standard type circuit building blocks. Circuits concerned with generating signals were covered in Book 1, this one deals with processing signals. Amplifiers and filters account for most of the book but comparators, Schmitt triggers and other circuits are covered

BP24: 50 PROJECTS USING IC741 $6.75
RUDI & UWE REDMER
This book originally published in Germany by TOPP, has achieved phenomenal sales on the Continent and Babani decided, in view of the fact that the integrated circuit used in this book is inexpensive to buy, to make this unique book available to the English speaking reader. Translated from the original German with copious notes, data and circuitry, a "must" for everyone whatever their interest in electronics

BP83: VMOS PROJECTS $7.70
R.A. PENFOLD
Although modern bipolar power transistors give excellent results in a wide range of applications, they are not without their drawbacks or limitations. This book will primarily be concerned with VMOS power FETs although power MOSFETs will be dealt with in the chapter on audio circuits. A number of varied and interesting projects are covered under the main headings of Audio Circuits, Sound Generator Circuits, DC Control Circuits and Signal Control Circuits

RADIO AND COMMUNICATIONS

BP96: CB PROJECTS $7.60
R.A. PENFOLD
Projects include speech processor, aerial booster, cordless mike aerial and harmonic filters, field strength meter, power supply, CB receiver and more

BP222: SOLID STATE SHORT WAVE RECEIVER FOR BEGINNERS $47.60
R.A. PENFOLD
In this book, R A Penfold has designed and developed several modern solid state short wave receiver circuits that will give a fairly high level of performance, despite the fact that they use only relatively few and inexpensive components

BP91: AN INTRODUCTION TO RADIO DXing $7.60
This book is divided into two main sections one to amateur band reception, the other to broadcast bands. Advice is given to suitable equipment and techniques. A number of related constructional projects are described

BP105: AERIAL PROJECTS $7.60
R.A. PENFOLD
The subject of aerials is vast but in this book the author has considered practical designs including active, loop and ferrite aerials, which give good performances and are reasonably simple and inexpensive to build. The complex theory and math of aerial design are avoided

OTHER PUBLISHERS

PH121: HARDWARE INTERFACING WITH THE TRS-80
J UFFENBECK (1983) $19.45
TRS 80 Model I and Model III owners now have a book to help them understand how to use their personal computers to monitor and control electronics interfaces between the computer and the home or industrial environment Contains 14 hands on experiments using BASIC

SB22026 POLISHING YOUR APPLE® $7.45
Clearly written highly practical, concise assembly of all procedures needed for writing, disk-filing, and printing programs with an Apple II Postively ends your searchs through endless manuals to find the routine you need! Should be in the hands of every new Apple user, regardless of experience level Ideal for Apple classrooms too!

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Here's plain English introduction to the world of microcomputers — it's capabilities parts and functions and how you can use one Numerous projects demonstrate operating principles and lead to the construction of an actual working computer capable of performing many useful functions

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A circuit for every occasion You'll find all the circuits you're looking for in this 532 page volume The 932 circuits are broken down according to specific functions and in six categories It's literally a cornucopia of ideas, projects, and designs that you can build now

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A wealth of information on hardware, software etc for the Mac Included are such topics as making your desktop more efficient improving your productivity with the Mac, getting the most from your mouse how the 6800 microprocessor works and much, much more

PH131: ZAP! POW! BOOM!
ARCADE GAMES FOR THE VIC 20
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Move through the maze eating dots with MAZEMAN Sail through space zapping the ASTROIDS Outshoot the fastest draw in town GUNFIGHT Owners of the VIC 20 can now play these games — and more — simply by following the programs outlined in this handy guide

THE BASIC COOKBOOK.
TAB No 1055: $10.45
BASIC is a surprisingly powerful language if you understand it completely This book, picks up where most manufactuers' documentation gives up With it, any computer owner can develop programs to make the most out of his or her machine

HANDBOOK OF MICROPROCESSOR APPLICATIONS
TAB No. 1203 $16.45
Highly recommended reading for those who are interested in microprocessors as a means of a accomplishing a specific task The author discusses two individual microprocessors the 1802 and the 6800 and how they can be put to use in real world applications

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TAB No. 1271 $16.45
A useful handbook for computerists interested in using their machine in linear applications Topics discussed include voltage references, op-amps for data conversion, analogue switching and multiplexing and more

HOW TO BUILD YOUR OWN WORKING MICROCOMPUTER
TAB No. 1200 $16.45
An excellent reference or how-to manual on building your own microcomputer All aspects of hardware and software are developed as well as many practical circuits

PH180: 1984 CANADIAN BUSINESS GUIDE TO MICROCOMPUTERS
K. DORRICOTT $11.95
Written by the managing director of Deloitte, Haskins & Sells a Canadian partnership of public accountants and other professional advisors to management, this hook is one of the most complete comprehensive guides to microcomputers available Starting with a general overview of microcomputers and their business applications, the author helps you assess your computer needs, compares and evaluates computer systems and application packages, and gives you tips on "doing it right" A must for anyone thinking of purchasing a microcomputer for business

COMPUTER PROGRAMS IN BASIC
AB01 $15.45
A catalogue of over 1,600 fully indexed BASIC computer programs with applications in Business, Math, Games and more This book lists available software what it does, where to get it and how to adapt it to your machine

PH217: BASIC COMPUTER PROGRAMMING FOR KIDS
P. CASSIDY & J. CLOSE $16.45
Fully illustrated with photographs and drawings this book teaches the reader the history of computers and computing and gently introduces binary mathematics and the basic theory of how computers work Written in an easy conversational tone

PHS1: PASCAL FOR THE APPLE
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A step by step introduction to Pascal for Apple II and Apple II Plus users The package of text and software diskette provides readers with worthwhile and interesting programs which can be run immdiately and the results studied Includes over 200 exercises with full solutions Book/Disk Package

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PHS7: START WITH BASIC FOR THE COMMODORE VIC 20
D. MONRO $33.45
This book/cassette package shows the reader how easy it really is to create programs using the full capacity of the machine Includes helpful exercises and step by step instructions to put the full power of the VIC 20 at the user's finger tips Book/Cassette Package

SB21822: ENHANCING YOUR APPLE® II — VOLUME 1
D. LANCASTER $25.50
Who but Mother Nature or Don Lancaster could successfully enhance an Apple? YOU can with help from Volume 1 in Don's newest series for Sams Among other things you'll learn (1) to mix text LORES and HIRES together anywhere on the screen in any combination (2) how to make a new wire modification that will open up whole new worlds of 3-D graphics and other special effects plus (3) a fast and easy way to tear apart and understand somebody else's machine language program Other goodies abound!

PH106: PROGRAMMING TIPS AND TECHNIQUES FOR THE APPLE II
J. CAMPBELL (1983) $23.45
An advanced exploration of the intricacies of structured programming Further develops the skills necessary to solve programming problems Special chapter on sound and graphics which discusses both high and low resolution graphics for the Apple II

HB131: THE BEGINNER'S GUIDE TO BUYING A PERSONAL COMPUTER $6.45
Written for the potentially interested computer buyer in non-technical language this affordable book explains the terminology of personal computers the problems and variables to be discussed and discovered while making that initial buying decision The book does not make recommendations but does present a great deal of information about the range of hardware available from the largest personal computing manufacturers Readers discover the meaning and impact of screen displays tape cassette storage and disk storage graphics and resolution and much more Comparison charts clearly define standard and optional features of all the current mass market personal computers

DESIGNING MICROCOMPUTER SYSTEMS
HB18: $18.95
POOCH AND CHATTERGY
This book provides both hobbyists and electronic engineers with the background information necessary to build microcomputer systems It discusses the hardware aspects of microcomputer systems Timing devices are provided to explain sequences of operations in detail Then the book goes on to describe three of the most popular microcomputer families the Intel 8080 Zilog Z 80 and Motorola 6800 Also covered are designs of interfaces for peripheral devices and information of building microcomputer systems from kits

S100 BUS HANDBOOK
HB19: $26.00
BURSKY
Here is a comprehensive book that exclusively discusses S 100 bus computer systems and how they are organized The book covers computer fundamentals basic electronics and the parts of the computer Individual chapters discuss the CPU memory input output bulk memory devices and specialized peripheral controllers It explains all the operating details of commonly available S-100 systems Schematic drawings

110 THYRISTOR PROJECTS USING SCRs AND TRIACS
MARSTON
HB22 $13.45
A grab bag of challenging and useful semiconductor projects for the hobbyist experimenter and student The project range from simple burglar fire and water level alarms to sophisticated power control devices for electric tools and trains Integrated circuits are incorporated wherever their use reduces project costs

PH104: ACCOUNTANT'S BASIC PROGRAMMING FOR THE APPLE II
A PARKER & J. STEWART (1983) $20.45
Shows the reader how to program the Apple II to perform a variety of accounting functions such as payroll accounts payable, accounts receivable tax inventory customer statements and more

HOW TO PROFIT FROM YOUR PERSONAL COMPUTER: PROFESSIONAL, BUSINESS, AND HOME APPLICATIONS
LEWIS
HB01 $18.95
Describes the uses of personal computers in common business applications such as accounting managing inventory sorting mailing lists and many others The discussion includes terms notations and techniques commonly used by programmers A full glossary of terms

AN INTRODUCTION TO MICROPROCESSORS EXPERIMENTS IN DIGITAL TECHNOLOGY
HB07 $18.95
SMITH
A "learn by doing" guide to the use of integrated circuits provides a foundation for the underlying hardware actions of programming statements Emphasis is placed on how digital circuitry compares with analog circuitry Begins with the simplest gates and timers then introduces the fundamental parts of ICs detailing the benefits and pitfalls of major IC families and continues with coverage of the ultimate in integrated complexity — the microprocessor

MICROCOMPUTERS AND THE 3 R'S
DOERR
HB09 $16.45
This book educates educators, on the various ways computers especially microcomputers can be used in the classroom It describes microcomputers how to organize a computer based program the five instructional application types (with examples from subjects such as the hard sciences life sciences English history and government) and resources listings of today's products The oook includes preprogrammed examples to start up a microcomputer program while chapters on resources and products direct the reader to useful additional information All programs are written in the BASIC language

HB107: GRAPHICS COOKBOOK FOR THE APPLE
WADSWORTH
HB107 $15.95
Learn how to use your Apple II to "paint" shapes, objects, and letters in low resolution graphics The author provides a library of microcomputer graphics including such multicoloured illustrations as robots and flying saucers, trees sailboats and colourful picture backgrounds Contains complete annotated Applesoft BASIC programs to draw all the pictures described in the book as well as suggestions for improving programming techniques

HB116: THE BASIC CONVERSIONS HANDBOOK FOR APPLE™, TRS-80™, and PET™ USERS
BRAIN BANK $14.50
A complete guide to converting Apple II and PET programs to TRS 80 TRS 80 and PET programs to Apple II and TRS 80 and Apple II programs to PET Equivalent commands are listed for TRS 80 BASIC (Model I Level II) Applesoft BASIC and PET BASIC as well as variations for TRS 80 Model III and Apple Integer BASIC Also describes variations in graphics capabilities

SARGON: A COMPUTER CHESS PROGRAM
SPRACKLEN
HB12 $27.50
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Electronics from the Start Part 5

A continued look at capacitors, specficially electrolytic types. They pack high value of capacitance into a small space.

By Nick Bellenberg

Electrolytic capacitors enable us to use large values of capacitance and voltage, while keeping the physical volume of the components themselves relatively small. Ordinary foil type electrolytic capacitors have two sheets of aluminum foil wound in a spiral (similar to non-electrolytic types). The difference here is that the paper dielectric which separates the conductive plates is impregnated with an electrolyte **(Fig. 1)**. Through the chemical process of electrolysis, like that which takes place in a battery or electroplating process, the electrolyte causes a thin film (approx. 10^{-4}mm in depth) of aluminum oxide to be deposited on one of the aluminum foils. This process is known as **forming (Fig. 2)**, and the oxide layer acts as an electrically strong dielectric, meaning that it can resist very high voltages in relation to its thickness.

In **Figs. 3** and **4** you can see that the capacitor's outer aluminum can has a crease or band around one end. This is to indicate the positive pole of the capacitor. This positive pole exists because during the forming process the oxide layer is only deposited on the anode (the plate connected to the positive side of the power source used). From this point on, the capacitor must be oriented correctly in circuit. The positive terminal (anode) to the positive side of the circuit, and the negative terminal (cathode) to the negative voltage.

If the capacitor is not oriented properly in the circuit, the dielectric film can break down and in some cases the whole device will explode. The explosion is caused by a gas being given off by the electrolyte, which causes pressure to build up eventually rupturing the component's casing or blowing the end off.

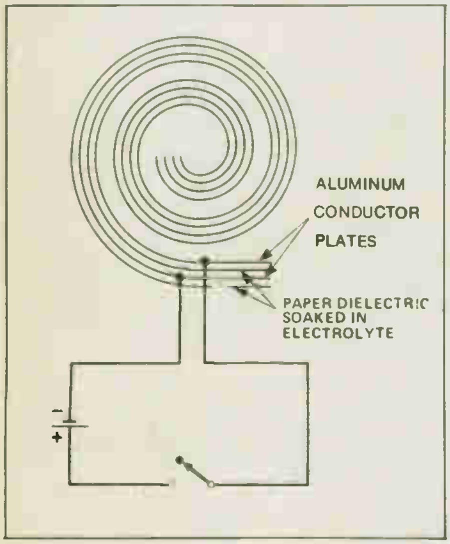

Fig. 1 Making an electrolytic capacitor: a layer of aluminum oxide is formed on the plates by electrolysis. This acts as a strong dielectric.

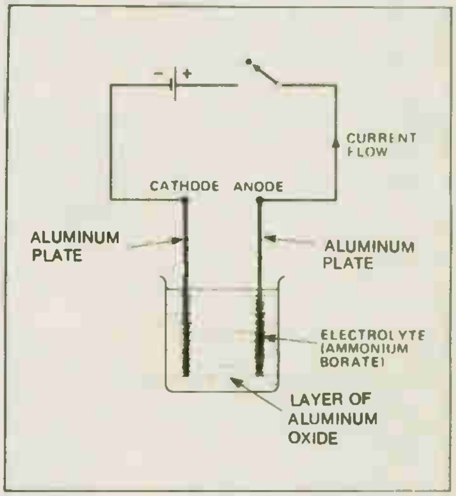

Fig. 2 The chemical process of electrolysis: putting a current through the electrolyte causes aluminum oxide to form on the anode plate.

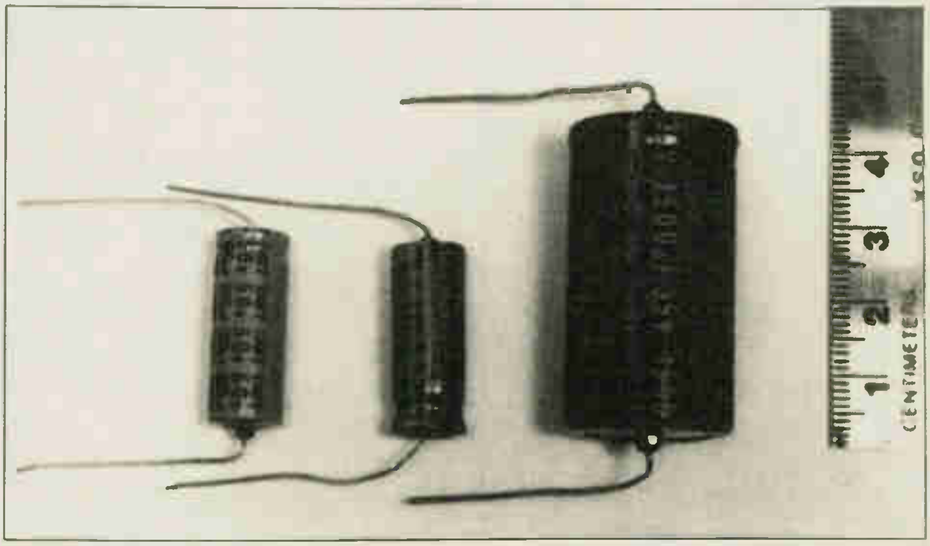

Fig. 3 Three axial electrolytics. From left to right, 100uF, 50V; 220uF, 40V; 1500uF.

Polarization

Electrolytic capacitors are therefore said to be **polarized**. Large alternating voltages (AC) must never be applied to these types of capacitor, although variable voltages are permissable as long as the positive lead of the component is not subjected to negative potentials.

As well as being able to withstand relatively high voltages, electrolytic capacitors also have the advantage of being self-healing if the dielectric oxide layer is broken by a voltage surge or dielectric weakness. This is because after the voltage overload is removed, the action of electrolysis will occur again and reconstruct the oxide layer.

Figures 3 and 4 show a variety of capacitance, voltage rating, and size. Note the two different methods in which the connecting leads are attached to the capacitors.

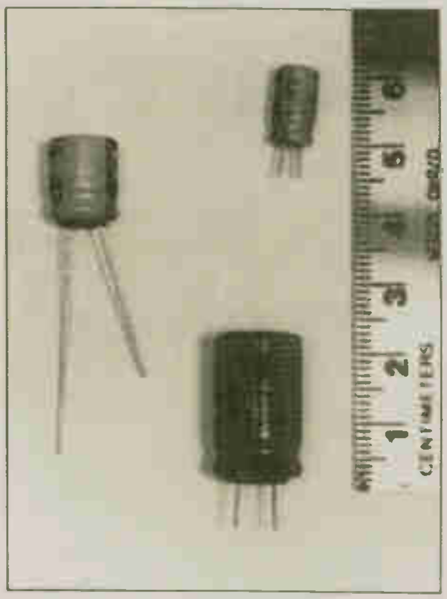

Fig. 4 Three radial devices

The components with a connecting lead at each end are known as **axial** devices (Fig. 3), while those which have leads coming from the same end are known as radial devices (Fig. 4).

The capacitors shown are manufactured in such small sizes by an etching technique that is applied to the foil plates. Etching the plates roughens their surfaces, thereby increasing the overall surface area. This means that the overall dimensions of a given foil can be made smaller than they would be if it was perfectly smooth.

One disadvantage of electrolytic capacitors, though, is that they have a very wide tolerance: typically ±20% or −10+50%. In other words, the actual capacitances of components can be quite a great deal different to the rated values. This also means that when an electrolytic capacitor is chosen for a circuit, those available from a typical supplier's catalogue should always be able to fit the bill. In this case the nearest capacitance to the one needed, and the equal or next largest voltage should be chosen. Suppose a circuit that you have designed calls for a 70uF capacitor rated at 10V. Looking at a supplier's list, the actual capacitor to choose would be the 60uF 16V one.

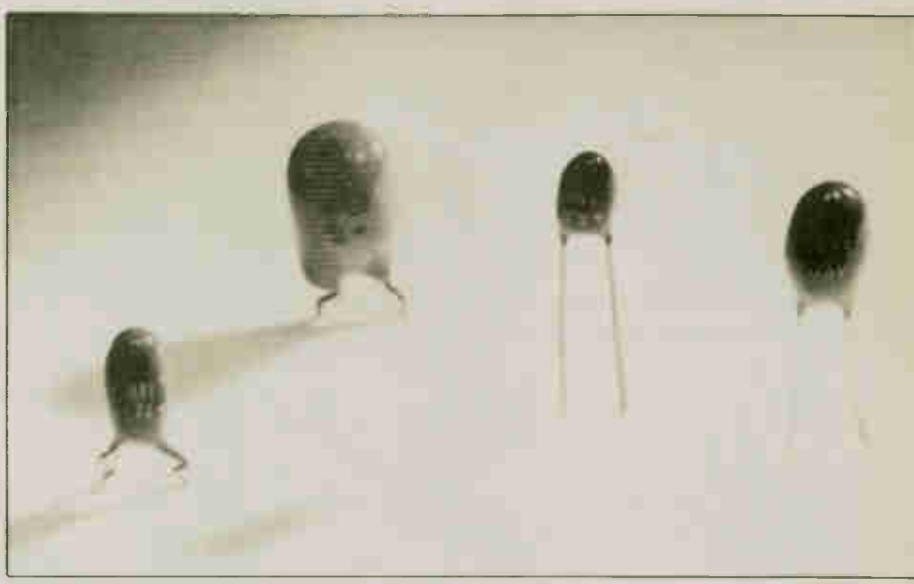

Fig. 5 Various tantalum bead capacitors. The long lead indicates the positive connection.

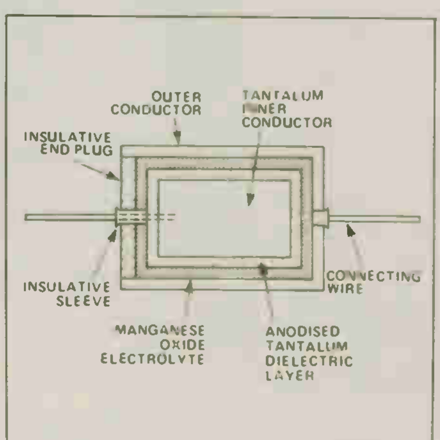

Fig. 6 A schematic of a tantalum bead capacitor: the electrolytic is manganese oxide.

Other Types

Fig. 5 shows a variety, tiny, tantalum bead electrolytic capacitors. Tantalum is a metal of very high purity and its oxidization by electrolysis means that tantalum capacitors work in a similar manner to aluminum foil types. **Fig. 6** shows a schematic diagram of tantalum capacitor with a manganese oxide electrolyte.

These components have the advantage of providing high capacitance in very small packages. However, working voltages are

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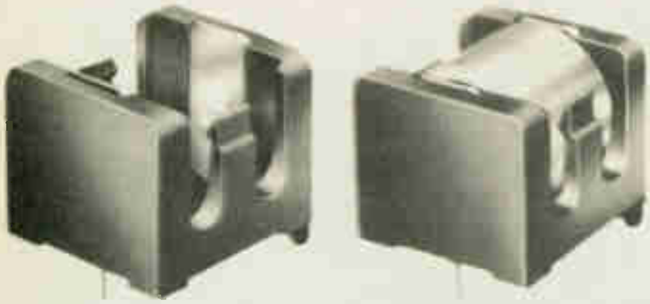
Battery Holder



The new, under 1/2" high BH-1/3N single cell battery holder from Memory Protection Devices accepts all standard 1/3N 3V lithium cylinder cells. Its low profile permits PCB stacking and eliminates the need for soldering in the battery. Contact Memory Protection Devices, 320 Broad Hollow Road, Farmingdale, NY 11735, (516) 454-0340.

Last month we looked at a software solution to error correcting in RAM; the program could compensate for bits which had changed state due to cosmic radiation or particle decay. Now the University of Southern California is experimenting with a hardware solution; Dr. John Choma of the School of Engineering decided that since a CMOS memory cell is actually two transistors fused together, a barrier could be inserted between them. An oxide trench is fabricated between the transistors to prevent undesirable currents from flowing in the semiconductor bulk. Test devices show no latch-up.

A new low-cost audio mixer from Promark of England is available in Canada. It permits eight, four and two track track mixing. Insertion points allow a wide range of effects; LED meters are provided for monitoring of levels. Operational understanding is aided by clear signal paths leading to colour-coded connectors, and the comprehensive owner's manual covers everything from making your own leads to the finer points of eight-track mixdown.
Contact Heinl Electronics, 16 Mary Street, Aurora, Ontario L4G 3W8, (416) 773-1511.

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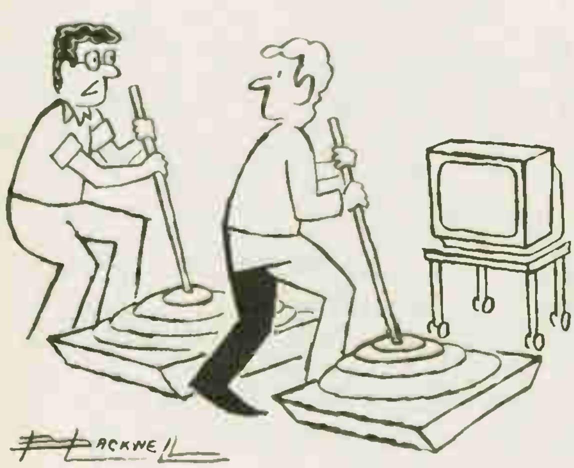

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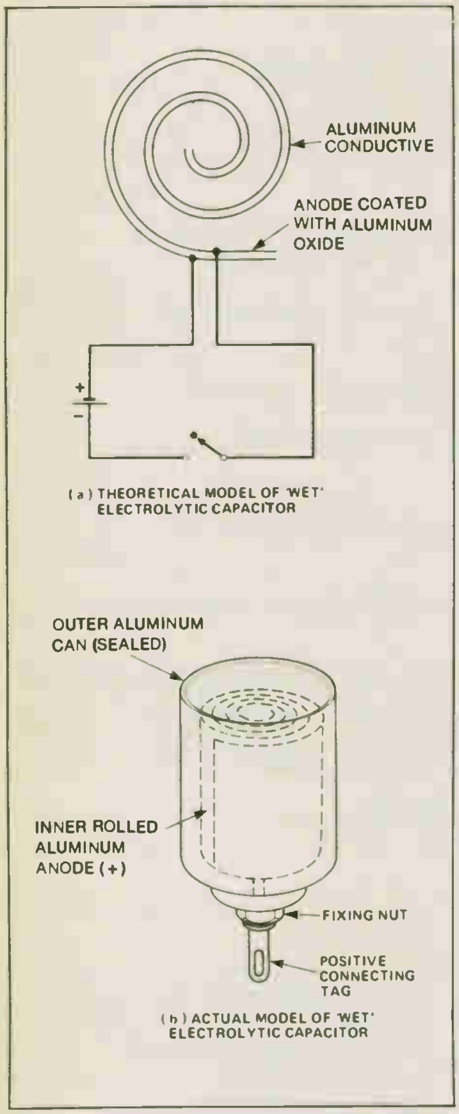


Fig. 7 A theoretical (a) and an actual representation (b) of a wet capacitor. The nut provides a negative connection to the chassis.

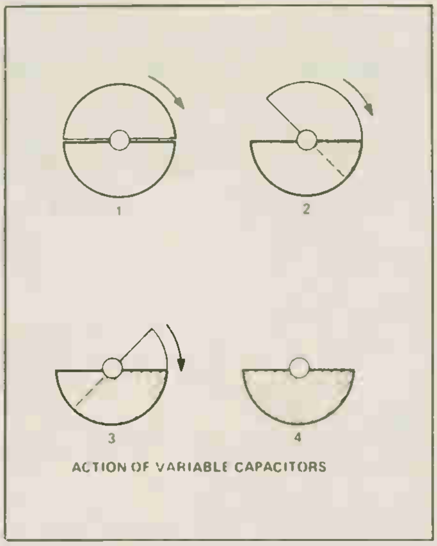


Fig. 8 Adjusting a vaned capacitor: as the area of overlap increases, so the capacitance varies from 0 to maximum.

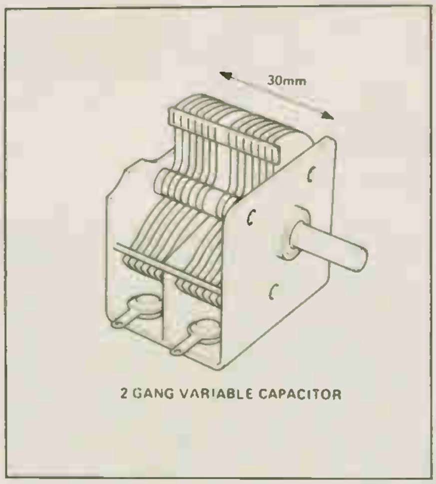


Fig. 9 A dual-ganged capacitor with two controls and multiple plates.

limited to around 35V. The tolerance of tantalum bead capacitors is typically ±20% and values from 0uF to 100uF are available.

Aluminum types also exist that use an electrolyte, with no tissue paper layers for it to soak into. These are called *wet* capacitors and **Fig. 7** shows the device in its theoretical form (a) and actual form (b). Here, the inner rolled up aluminum foil is oxidized by the electrolyte and as such is the anode plate.

The aluminum can in which this is contained acts as the cathode plate and is filled with the electrolyte. The positive connection comes through the insulator in the can's bottom, while the fixing nut on the bottom of the can provides the negative connection. These electrolytics are generally quite bulky (typically 100mm high and 35mm in diameter) and are usually used to *smooth* power supplies and as such have high voltage and capacitance ratings. Tolerances typically run at +80%-20%. In summing electrolytics, they give us high capacitance and voltage values in physically small packages. On the down side, they have a very wide tolerance range, must only be used with DC supplies, and have a tendancy for the electrolyte to dry out in high temperatures, affecting their action adversely.

Variable Capacitors

Variable capacitors are non-electrolytic and take two forms: preset and manually variable.

Manually variable capacitors are commonly used in the tuning sections of radios. As we know, capacitance can be varied by altering the overlapping area of the two

Table 1
Attributes and applications of different capacitors

Type	Properties	Applications
Paper	Cheap, general purpose capacitors with a reasonable capacitance to size ratio.	General purpose.
Plastic:		
Polystyrene	High insulation resistance; low losses; small.	General purpose and charge storage; Filters.
Polycarbonate	Miniature; self healing.	Miniature general purpose.
Ceramic:		
Low permittivity	Low dissipation	Low voltage applications
Medium permittivity	High capacitance to size ratio.	
High permittivity	Large capacitance to size ratio; voltage and temperature sensitive.	Temperature correction components
Mica	Highly stable, low dissipation	General purpose.
Electrolytic:		
Aluminum	Polarised devices; very large capacitance to size ratio; limited lift and temperature range.	Smoothing circuits; General purpose.
Tantalum	Small, expensive, polarised, highly reliable.	Where reliability and/or size is a priority.
Variable:		
Manual	Variable within certain limits.	Tuning circuits.
Preset	Variable within certain limits.	Tuning circuits

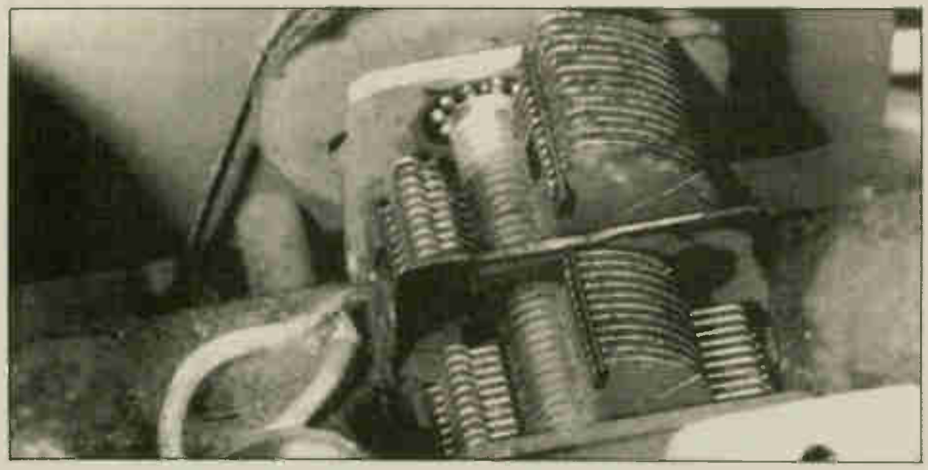


Fig. 10 A variable tuning capacitor from a RCA Victor model VR-41 radio, circa 1940.

Fig. 11 A preset trimmer with six conductive plates.

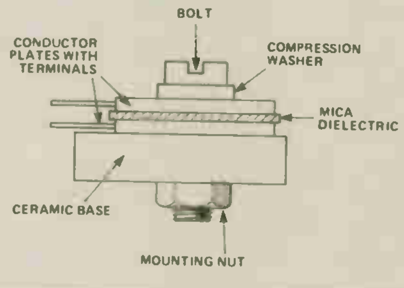


Fig. 12 The construction of a compression preset trimmer.

plates or by altering the thickness of the dielectric between them. Manually variable capacitors work by varying the area of the overlapping plates. **Fig. 8** is a graphic representation of how this works. One of two semicircular plates is fixed to the central spindle. Rotating the spindle moves the one plate over the other.

In reality, more than two plates, more commonly known as vanes, are used, as in **Fig. 9**. This is a dual ganged variable capacitor, which means that the front and back sections are separate, so that they can be possibly used for different wavebands of a radio. For example, the front section of this one is variable from 10 to 208pF, and the rear section goes from 8pF5 to 176pF. The variable capacitor shown in **Fig. 10** is from an early 1940s RCA radio.

Miniature preset trimmer capacitors come in various forms. Those which are used in small portable AM radios for example, may have as many as four separate tuning sections. Other types such as the one in **Fig. 11** have six conductive plates attached to one spindle (screw).

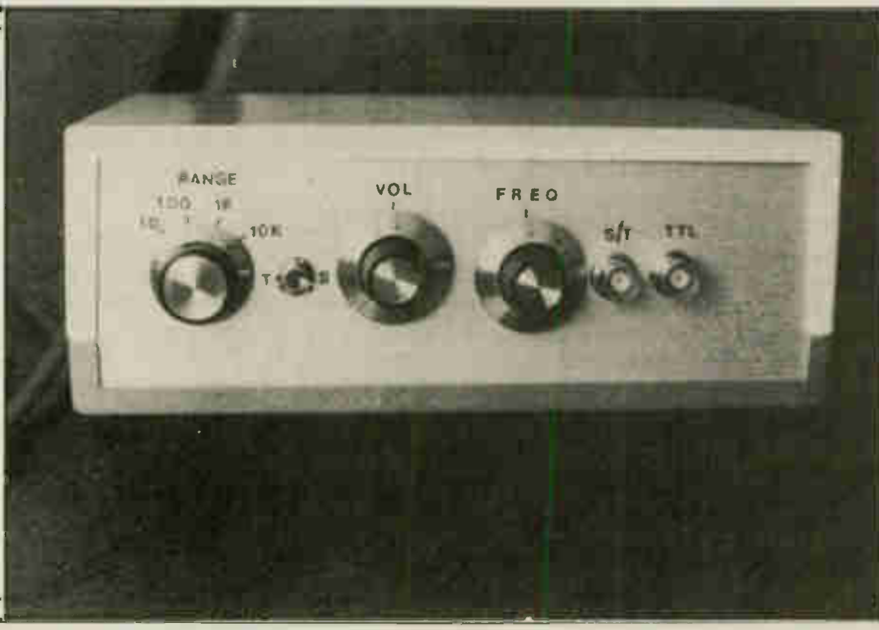
Compression trimmers work by altering the thickness of the dielectric between the plates by compressing it to different depths. **Fig. 12** illustrates the make-up of such a preset capacitor.

We have now covered the most common types of capacitor which you are likely to encounter; **Table 1** lists the characteristics and uses of these types. ■

Audio Frequency Signal Generator

Using a dedicated IC, a signal generator giving a choice of three signal sources is not expensive to build.

By David Silvester



After the purchase of a multimeter one of the most useful pieces of test equipment to construct is an audio frequency signal generator. The signal generator described here provides two simultaneous outputs, a TTL compatible source running from 0 to +5V and a second providing either sine or triangular wave outputs symmetrical around zero volts.

All three waveforms may be used for amplifier testing, the triangular waveform being especially suitable for examining crossover distortion in class B amplifiers. A 'volume control' is provided for the sine and triangle waveforms while the TTL waveform is fixed. If the constructor requires a low output power a separate attenuator will need to be provided.

Now that dedicated waveform generator chips are available, and providing no sophisticated requirements have to be met, a signal source can be built for a reasonable price. A frequency range of 10 to 100,000 Hz was chosen although the frequency range of the 8038 waveform generator IC used in the project is 0.001 Hz to 300kHz, with output voltages related to the supply voltage. The sine wave is derived from a triangular waveform by the use of a non-linear network within the IC and consequently is more distorted than the output from a pure sine wave generator. This distortion of about 0.5% appears as blips on the sine wave peaks but although this distortion is too high to enable the generator to be used for audio power amplifier distortion testing, it is most likely that it will be used as a signal source for amplifier repairs. In this case where the fault causes only half of the waveform to be amplified, the small amount of distortion produced by the signal generator can be ignored.

Circuit Description

Figure 1 shows the full circuit diagram of the signal generator. IC1 is the ICL8038 waveform generator chip that is the heart of the whole unit, it produces the basic three waveforms in the following manner. An external capacitor C1 to C5, selected by SW1 and connected to pin 10 of IC1 is charged and discharged by two current sources whose charge and discharge currents are selected by the resistance of R4 and R5. During the charge cycle the voltage across the capacitor increases linearly with time, and falls linearly with time during discharge. In addition two voltage comparators monitor the voltage across the capacitor and switch from charge to discharge at 2/3 supply voltage and from discharge to charge at 1/3 supply voltage. The voltage across the capacitor is a triangula wave with equal rise and fall times if R4 and R5 are of the same value. This voltage is sent via a buffer amplifier to the triangle wave output pin 3. There is no reason why the charge and discharge times need be the same and the waveform generator can be used to produce sawtooth waveforms of varying rise and fall times.

The switching of the two current sources gives a useful signal to provide the square wave output. However the IC's output is an open collector transistor and needs a resistor connected between IC1 pin 9 and the positive supply. The output voltage will vary between the lowest supply voltage (-12V) to the voltage of the positive power supply, +12V in our case. We cannot directly connect the resistor from the IC to the 5V supply as the output will still be from −12 to +5 volts. R1, R2, R3, D1, Q2, and the +5 volt regulator IC5 are used to provide level shifting to give the TTL compatibility above zero volts. Diode D1 provides protection for the transistor when the output of IC1 pin 9 is at – 12V, since by conducting it will hold the base only 0V6 below zero while damage to the transistor will not occur until the base-emitter voltage exceeds – 5V. The sine wave signal as stated earlier is derived from the triangular wave output and the circuit includes R6, R7, RV2, and RV3 to allow alterations to the non-linear elements in the IC to reduce the distortion to its lowest value. An oscilloscope is an asset in setting up the sine distortion pots and with the completed signal generator makes a highly efficient fault diagnosis setup. However if one is not available the two potentiometers may be set to their mid point with only a small residual distortion being left on the sine wave.

The sine or triangular wave output is selected by SW2, but as IC1's output is of high impedance at this point a 100k potentiometer is used as a volume control and is followed by a unity gain buffer with high input impedance (IC2). The 100R resistor R8 is connected between the output of IC2 and the output socket to provide some protection against accidental overloads. The switch SW1 selects a range of capacitors from 2.2uF to 220 pF to provide the five decade ranges needed. An extra range of 1 to 10Hz was included in the prototype. To give complete frequency coverage a second control signal to the current sources sharing the capacitors is provided by RV1, and Q1 and the output from IC1 pin 7. The linearly varying voltage from RV1 produces a linear frequency change from all of the outputs. With the system shown all of the decade ranges can be covered in full with some overlap to allow for component tolerances.

The power supply unit relies on easily available 78L and 79L integrated circuit regulators. The 120VAC input is transformed to 15-0-15V by Q1, rectified by BR1 and smoothed by capacitors C9 and C10. The regulator chips are fed from these capacitors and give outputs of +12V, +5V and – 12V being followed by further capacitors C6, C7 and C8 to give additional smoothing.

Construction

As all of the components are mounted on the single PCB, construction is extremely simple (Fig. 2). The two integrated circuit sockets should be mounted first as these aid in locating the position of the other components. *Do not insert the ICs at this stage.* Note that the transformer is a PC mounting type. If a suitable transformer cannot be found, a standard open frame type such as one from the Hammond 166 series can be wired to the PC. A suitable substitute is the 166 F30 available from Electro Sonic, 1100 Gordon Baker Rd, Willowdale Ont., M2H 3B3, (416) 494-1555. The two potentiometers have their leads bent to lower their bodies towards the board and ensure that the mounting nuts are beyond the board edge (Fig. 3).

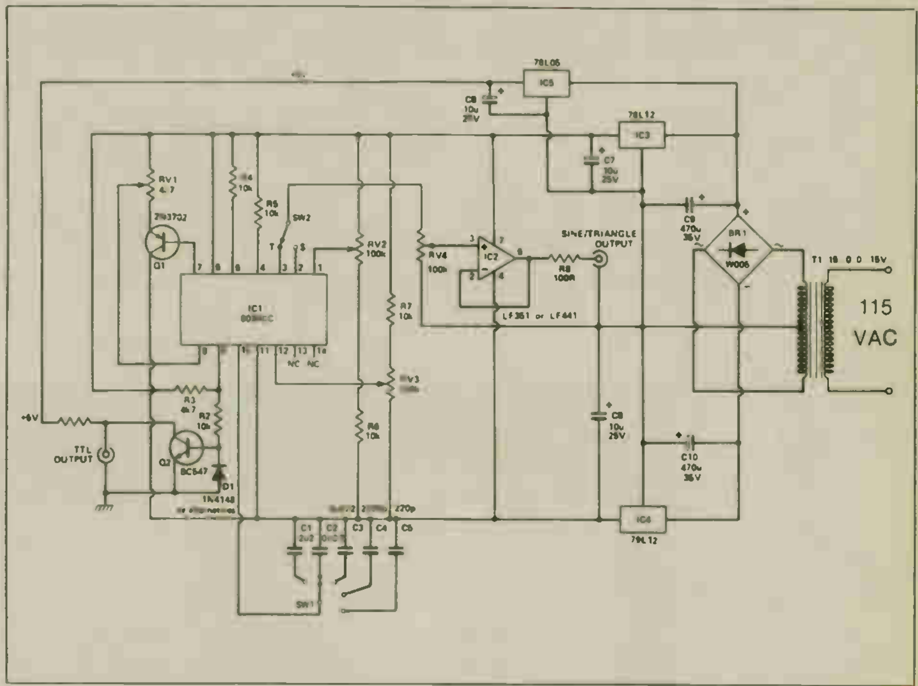


Fig. 1 The circuit of the signal generator. The heart of the design is the 8038 signal generator chip.

PARTS LIST

Resistors

R1,3	4.7k
R2,4,5,6,7	10k
R8	100R

Potentiometers

RV1	4.7k Lin pot
RV2,3	100k skeleton preset
RV4	100k Lin pot

Capacitors

C1	2.2uF
C2	OuF22 polyester
C3	OuF022 polyester electro or polyester
C4	2200pF polycarbonate
C5	220pF polycarbonate
C6,7,8	10uF 25V tantalum bead
C9,10	470uF 35V electro

Semiconductors

IC1	8038CC
IC2	LF351 or LF441
IC3	78L12
IC4	79L12
IC5	78L05
Br1	W005 Motorola MDA202 or similar 1A, 200V bridge rectifier
Q1	2N3702
Q2	2N5818
D1	1N4148, 1N914 or 1N916 diode

Miscellaneous

T1	Transformer 15-0-15V 200mA PCB mounting
SW1	1 by 12 way rotary switch
SW2	Miniature single pole changeover

BNC . sockets; Verobox 202; knobs x 3; AC cable and grommet:

Testing

Connect the AC to the PCB but ensure that IC1 and IC2 are not inserted. Check the voltages at the output of the three regulator ICs. After checking this, turn off the power supply and allow the voltage to fall to zero before inserting IC1 and IC2. The output may now be examined on an oscilloscope if this is available and RV2 and RV3 rotated to obtain minimum distortion. If an oscilloscope is not available then these two resistors should be set to mid-point.

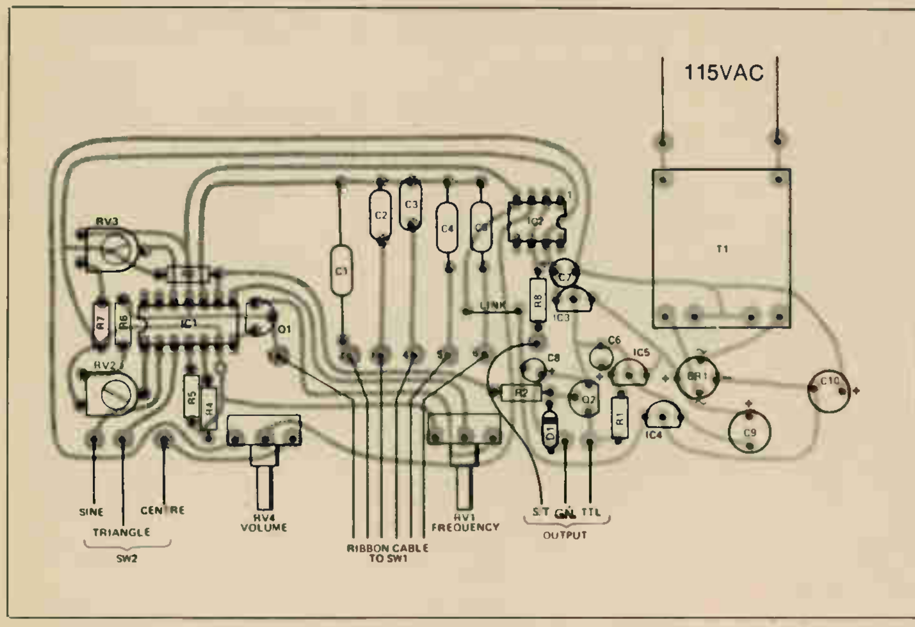
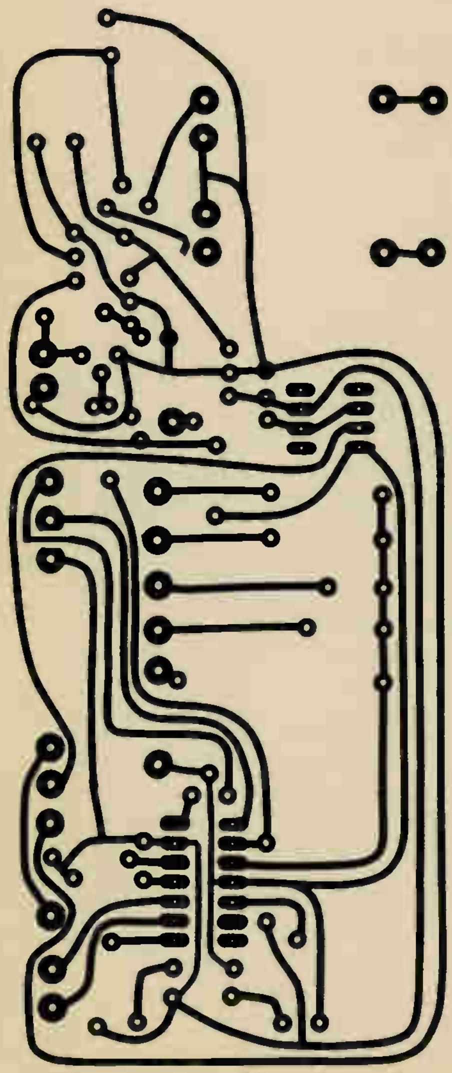


Fig. 2 The PCB overlay. Note that IC1 and IC2 should not be inserted until testing has commenced.



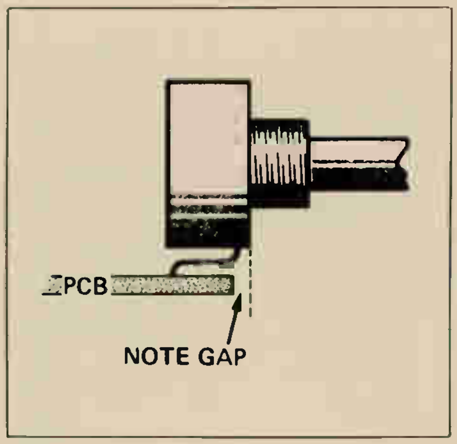


Fig. 3 The pots should be bent slightly forward to bring the panel nuts clear of the edge of the PCB. ■

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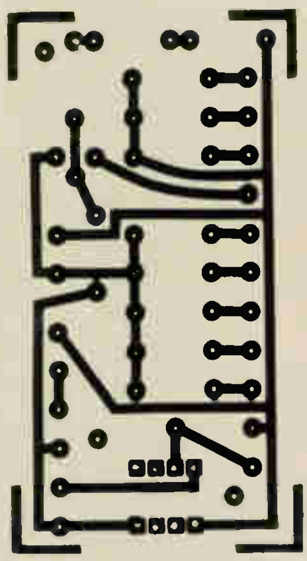

The PCB for the Battery checker.

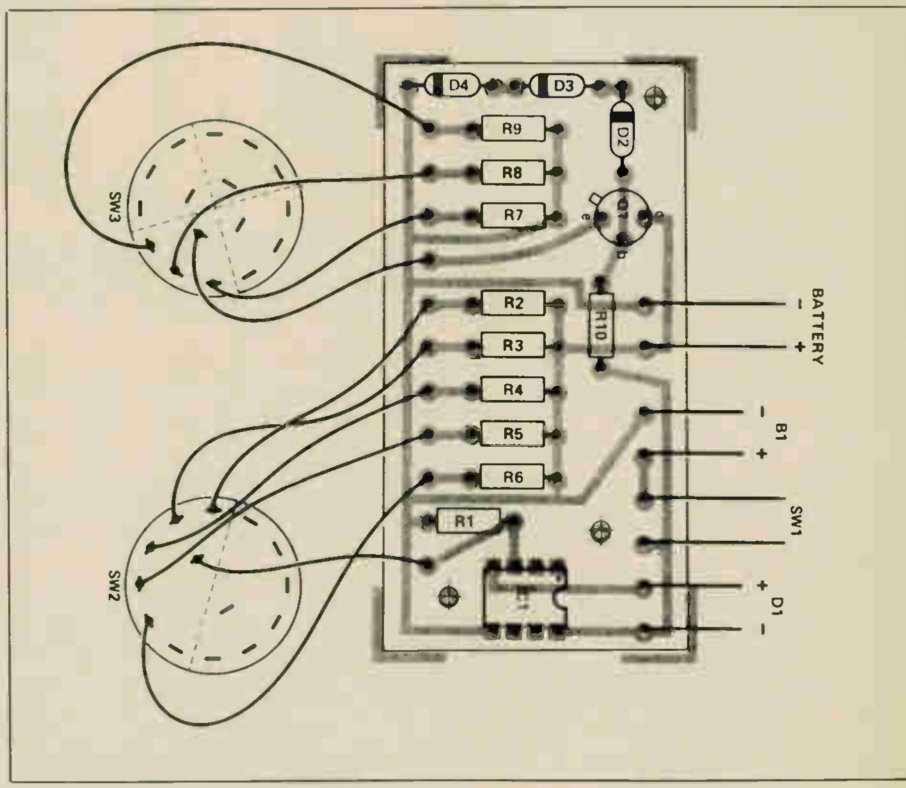

Fig. 3 The PCB layout. Use an IC socket to protect the 8211. The battery under test is connected via leads to a jack socket on the rear of the case.

If D1 does switch on, try connecting a fresh battery to the input of the unit with SW2 and SW3 set at appropriate positions. This should, of course, result in D1 switching off while the battery is connected. If you should inadvertently connect a battery to the unit with SW2 at the wrong voltage setting this will not result in any damage to the checker provided the battery has a nominal voltage of 9 volts or less.

The load current used depends on the capacity of the battery you are testing. 1.5 volt cells are capable of quite high load currents and should be tested with SW3 in the 'high' position, as should high capacity 9 volt batteries and types that are really just comprised of series connected 1.5 volt cells. Medium sized 9 volt batteries require a 'medium' load current, and small 216-types require a 'low' load current setting.

Battery checking is perhaps more of an art than a science, and things are not always straightforward. I have two calculators which run from regular size 9 volt batteries, one an LCD type which requires very little current and the other a LED type which consumes a moderately high current. When the battery in the LCD calculator seems to be failing it does in fact seem to be perfectly satisfactory when subjected to any accepted form of battery checking, and will happily power the LED calculator for months. One might expect an almost exhausted battery from the LED calculator to power the low current LCD type for some time before failing completely, but not the other way round. The cause of this paradox seems to be that the display circuit of the LCD calculator is very voltage conscious, and fails to operate properly once the battery voltage has fallen slightly due to normal ageing, even though there is still plenty of power left in the battery. The moral of the story is that when testing batteries, where possible, you should take into account the requirements of the equipment they are used to power. Some circuits require reasonably fresh batteries in order to function well, others will operate from batteries which, by most standards, are flat. Although with the current high cost of batteries it is tempting to squeeze every last bit of power from them, it is not a good idea to use virtually exhausted cells which could leak and ruin expensive electronics. ■

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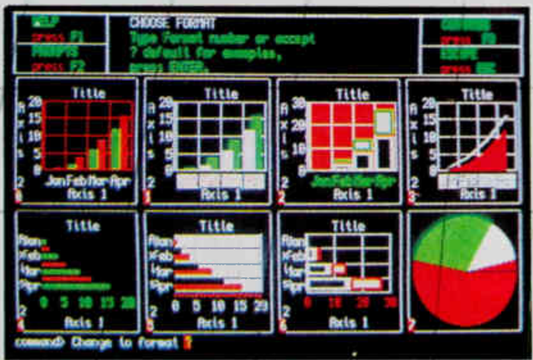

WORDPROCESSING
QL Quill is a total word processing package featuring: on-screen, step-by-step HELP menus, word wrap, full delete options, including cut-and-paste; wide view documents; boldface; superscript, subscript, underlining; hyphenations; overwrites; and will combine with data from other QL programs.

SPREADSHEET
QL Abacus provides instantaneous 'what if' spreadsheet manipulation functions featuring: single stroke assignable function keys; spreadsheet linkage; multiple-windows; text justification; scroll windows, and single name reference to rows, columns and cells.

DATABASE MANAGEMENT
QL Archive is an extremely sophisticated yet easy to use filing system featuring: 84 single command words for queries, cross-references and file searches; easy statistical and accounting calculations; screen editor for report formats, and complete HELP menus.

GRAPHICS
QL Easel produces spectacular color graphics. The program features: design handling and scaling either automatically or under user-control; text addition or deletion; nine graph styles; data manipulation and evaluation using command math functions and formulas, and complete HELP menus.

Select More QL Software Here

LANGUAGES & UTILITIES

QL ASSEMBLER. Converts M68000 assembly language sources files into QL-compatible binary files. Includes multi-tasking full screen editor which can run simultaneously with SuperBASIC **$99.95**

QL MONITOR. Machine Code monitor. **$69.95**

QL TOOLKIT Over 70 programs and extensions to SuperBASIC. Includes print spooling, improved file access (full random input/output command), job control (allows management of multitasking) and SuperBASIC screen editor. **$74.95**

BCPL. QL compiler ideal for systems programming, writing utilities, games and applications. Generated native 68000 code. Easy QDOS interface. Link separately compiled segments. Can be linked with Pascal or Assembler. **$149.95**

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PASCAL. True single pass compiler producing native 68000 code meeting ISO 7185 standard. Direct addressing of full QL address space. Key routines on ROM for speed and convenience. **$199.95**

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QDOS BOSS. Examine and change any sector of data on a microdrive cartridge. Print or display on screen in hex or ascii. DOS utility "shell" simplifies QDOS functions and commands. **$79.95**

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SUNDIAL. 15-year calendar, appointment scheduler and daily diary. Up to 20 events each day can be stored, and accessed by searching on date, time, and name — or combination of the three. Bonus on-screen calculator. **$79.95**

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CANADIAN INCOME TAX GUIDE — 1985 **$79.95**

QL CHESS. Developed by PSION. Features high resolution display, animated 3-D graphics, 28 levels of play from novice to champion. Opening book of nearly 4000 moves, HINT and TAKE-BACK functions, and the option to play a human opponent or the computer. **$84.95**

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QL PROJECT PLANNER. Divides complex activities into critically important stages to help in the planning and monitoring. When you decide on a starting time, it tells you when each activity must start and finish and when the project will be completed. **$110.00**

QL ENTREPRENEUR. Uses a 'what if' format to help develop a workable business plan. Break-even point. Cash flow forecast. Balance sheet and profit and loss statement. Builds your skills and techniques. **$110.00**

HARDWARE EXPANSIONS
Coming soon are 256K and 512K memory expansion boards and a disk drive interface.

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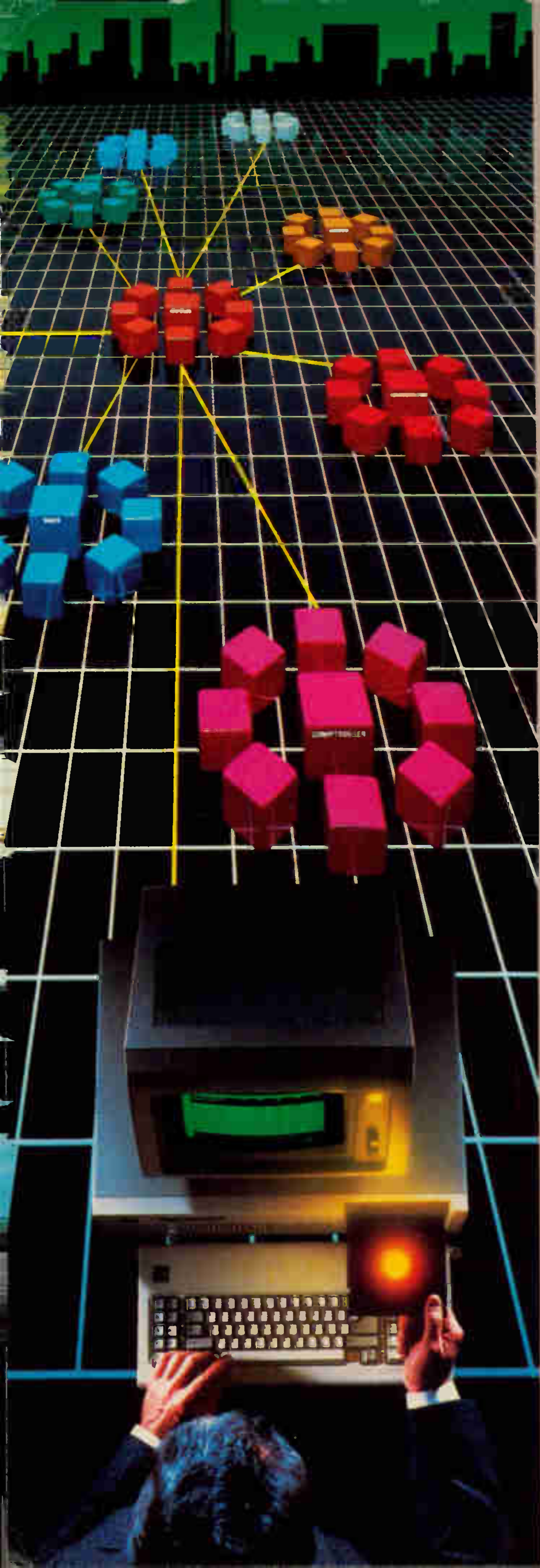
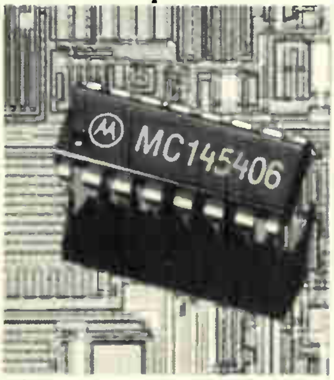


continued from page 58

RS232C Chip



The Motorola MC145406 is a silicon-gate CMOS IC that provides both driver and receiver; TTL logic signals are level-shifted to the RS232 format at the output, and RS232 input signals are converted to TTL. Hysteresis in the receivers aids in the reception of noisy signals. From Motorola dealers, or contact Motorola Semiconductors, MOS Logic and Analog Integrated Circuits Division, PO Box 6000, Austin, Texas 78762.

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Interview

Electronics Today was fortunate in being able to interview Rodney J. Packham, president of Packham and Stuffem, a company which has had an enormous influence on the computer and electronics industry.

ET: Could you tell us something about your profession?

Rodney: Of course. We're the people who fit the foam packing around computers and peripherals and test equipment.

ET: Tell us more about it.

Rodney: Well, it wasn't easy when we first started. We just fit hunks of foam into the box, but it was too easy for people to put everything back into the box if they wanted to. Then we tried foam peanuts. They're not bad, because they spray all over the room when you take the product out, but people with patience could still get them back in.

We decided on a high-tech approach. We started making foam packing inserts with up to 37 pieces, each piece made to tolerances of a millionth of an inch. That worked.

ET: What motivated all this?

Rodney: You know where the warranty says "must be returned in original box"? Well, this way it's impossible for people to ever do it, and returns are down enormously. We have it worked out for computers, for instance, so that you have to insert the body, the keyboard, the power cord, and the manual in exactly the right slots all at the same time or it won't go in the box.

ET: Any plans for the future?

Rodney: We're trying to eliminate precision manufacture by using expanding foam: as soon as you slide it out of the box, a chemical is released that expands the packing by 20 percent.

ET: Best of luck in your endeavours.

Rodney: Thank you.

Users of electronic typewriters will soon be able to access Telecom Canada's Teletex network with an add-on module, the TexCom 2400, containing a screen, memory, software, disk drive and 2400-baud modem. A letter quality document can be sent anywhere from one terminal to another in about 10 seconds, bout 40 times faster than Telex. The unit will retail this fall for about $3950. Hmmm. That's about ten times what an electronic typewriter costs, or about what a compatible with the works costs. For more information: Telecom Canada, 770-410 Laurier Avenue W., Ottawa, Ontario (613) 560-3030.

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The Heath Company is offering two new educational courses, 'Computer Servicing — Peripherals' and 'Computer Servicing — Maintainence'. They're the latest additions to the Heathkit/Zenith computer servicing series. Required hardware is the EWS-100 Microcomputer Trainer. For a catalog or more information, contact the Heath Company, 1020 Islington Avenue, Dept. 3100, Toronto, Ontario M8Z 5Z3, (416) 232-2686.

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The I&CS Seminar/Show is featuring sensors and transducers in industrial control. There'll be shows, exhibits and sensors covering both hardware and data acquisition techniques. It'll be held December 4-6, 1985, at the Carlton Place Hotel, 33 Carlson Court, Toronto, Ontario M9W 6H5. The hotel is (416) 675-1234, and the show people are: I&CS Seminars, Box G, 59 Water St., Hingham, MA 02043, (617) 749-1122. 'I'm going to Toronto, dear, to look at thermistors.' Uh huh.

A newly formed Canadian company, Revelations Research of Mississauga, Ontario, has purchased a Control Data Cyber 205 supercomputer, and plans to use it 'to conduct detailed research into fifth generation or artificial intelligence that will allow the development of a computer system capable of simulating the thought functions of the human brain through the use of neural network arrays.' Holy Moses. Does Isaac Asimov know about this?

Someone said that magazine editors could be replaced by computers; when the time comes here at ET, let's hope the boss buys a Revelations Research and not a ZX81.

There's more than meets the eye to a telephone line sense relay, me lad. You need piles of isolation, lots of sensitivity, and no disturbing the line balance while you're at it. If you'd like to know when a receiver has gone off-hook, the Elec-Trol TLS1A18A10 Telephone Line Sense Relay is placed in series with the line and operates a dry reed switch when the loop exceeds 18mA. There's 1500V isolation and 63dB balance provided. It's from Zentronics outlets, or contact them at 8 Tilbury Court, Brampton, Ontario L6T 3T4, (416) 451-9600.

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Macintosh Digitizer

GTCO Corporation has a digitizer for the Macintosh computer which they call the Macintizer. Not bad. Most companies call their new products the CGHK45-234-T083-N. It consists of a pad and a stylus; the stylus position is detected electromagnetically, eliminating preventative maintainence from dirt or contamination. A mouse with crosshairs is also available. It works with MacDraw, MacPaint, and all other Macintosh software because its cable goes in place of the Mac's mouse. From Interworld Electronics and Computer Industries Ltd., 1442 Pemberton Ave., North Vancouver, BC V7P 2S1, (604) 984-4171.

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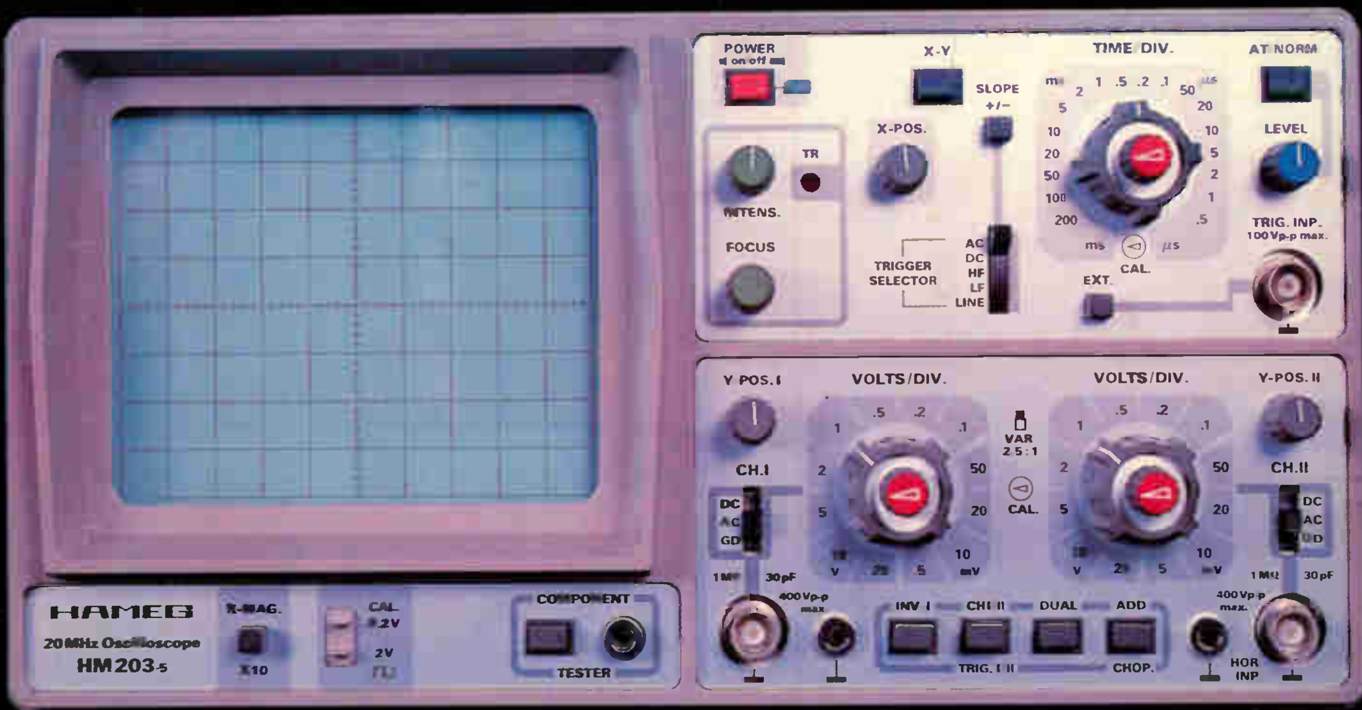
The **BEST** is still "made in West Germany"

HAMEG model **HM203-5**



The 20MHz Oscilloscope that outsells all others in Western Europe. The model **HM203-5** is available complete with two switchable (X1–X10) probes. This CSA approved Oscilloscope is covered by a **two year** parts and labour warranty.

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