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Computing Today
Z80 vs 6502

Electronics Today International

January 1984

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PROJECT

ZX81 A to D Converter
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PROJECT

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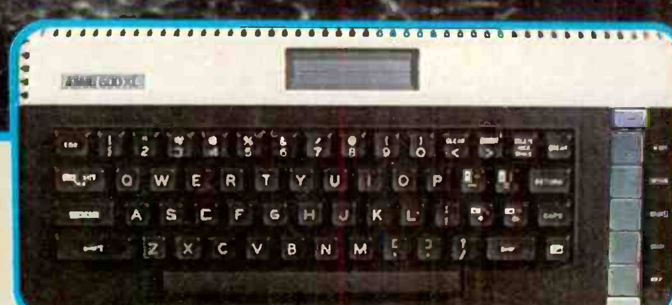
Computer Review
Atari 600XL



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The Magazine for Electronics & Computing Enthusiasts

Electronics Today INTERNATIONAL

January 1984
Vol. 8 No. 1
ISSN 0703-8984

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Features

Projects

Our Cover

An embarrassed man who's glad about SARSAT is fished from the water, page 32. Photo courtesy of the U.S. Coast Guard. The Atari 600XL gets a workout on page 40 ; photo by Bill Markwick.

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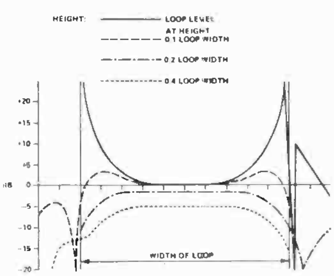

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Columns, News and Information

ADVERTISERS' INDEX

NEWSSTAND DISTRIBUTION:
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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. ETI 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 0.1uF 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.

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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 on PCBs and kits. Similarly do not ask PCB suppliers for help with projects.

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for your information

Test Instruments

Omnitronix has recently announced two new test instruments: a field strength meter from Leader and an insulation tester from Kyoritsu.

The Leader LFC 945 field strength meter contains a peak level detector, built-in loudspeaker for monitoring, taut band semi-logarithmic meter wide dynamic range and RF and AC signal separator for cable distribution systems. It covers the FM and CATV bands as well as VHF and UHF. The LFC 945 may also be operated from an auto battery (11.5-17V).

The Kyoritsu model no. 3301, a four function compact battery

operated insulation tester with 250V, 500V, 1000V rated voltage ranges performs insulation tests from 50M to 2000M. The model 3301 also provides illumination for dim locations and can be used as a 600V AC voltmeter with an accuracy of + 3%.

For more information please write: Omnitronix Ltd., 2410 Dunwin Dr., Unit 4, Mississauga, Ont. L5L 1J9, (416) 828-6221. Telex 06-22324.

In a record-setting experiment, conducted by Bell Labs in Holmdel, N.J., late last summer, laser light pulsing hundreds of millions of times each second travelled unboosted through 100 miles of hair-thin glass fiber.

These results may lead to future generations of practical, high-capacity lightwave communications systems that could carry huge amounts of voice, data, video and graphics over lightguide fiber across continents and under oceans. At the 420 million bit-per-second rate of the experiment, the entire text of forty full-length novels could be sent in one second, and the longer the allowable distance between signal boosters, the more economical the transmission.

The experiment was done with glass fiber that guides light in a core region about a tenth the thickness of a human hair. This "single-mode" lightguide fiber formed a test system with a cleaved coupled-cavity laser, which emits ultrapure light at 1.5 microns (a wavelength where light loss in the fiber is very low) and an improved avalanche photodiode detector.

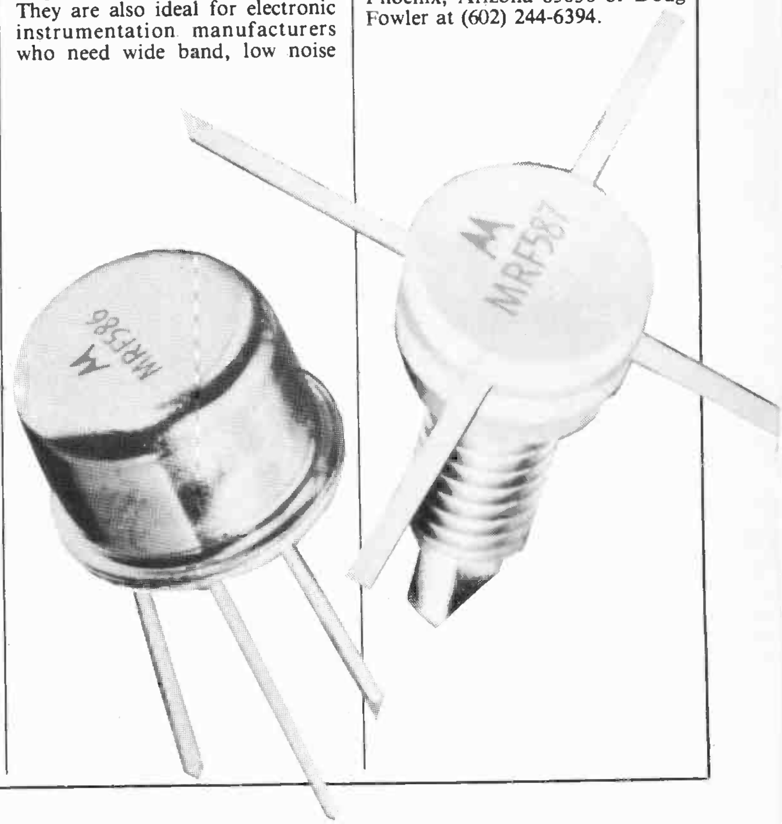
CATV RF Transistors

Motorola has introduced two new CATV RF transistors, the MRF586 and MRF 587. These devices have guaranteed functional tests, such as noise figure and gain associated with noise figure. They are designed and characterized to be direct replacements for TRW's LT1001A and LT2001.

The primary applications for the MRF586 and MRF587 are cable television distribution amplifiers and set top converters. They are also ideal for electronic instrumentation manufacturers who need wide band, low noise amplifiers up to 500 MHz.

Pricing in bulk is US$2.20 for the MRF586 and $9.55 for the MRF587. Sample quantities are immediately available from warehouse stock, and production quantities will be available both from the factory and through authorized Motorola distributors in approximately 6 weeks from date of order.

For further information, contact: Motorola Semiconductor Products Inc., P.O. Box 20912, Phoenix, Arizona 85036 or Doug Fowler at (602) 244-6394.



ETI Magazine is Published by:

Moorshead Publications
Editorial and Advertising Offices
Suite 601, 25 Overlea Boulevard,
Toronto, Ontario, M4H 1B1
Telephone (416) 423-3262

Publisher: Halvor W. Moorshead
Editor: Bill Markwick
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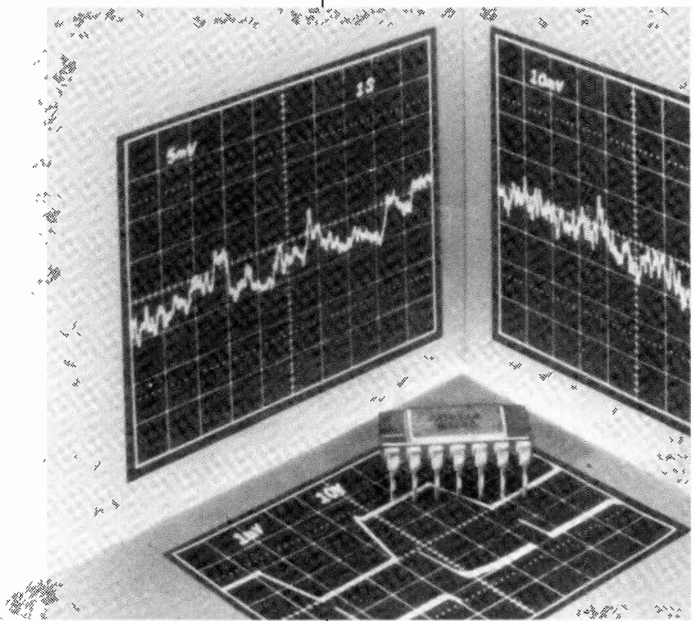
for your information

Instrumentation Amplifier



Analog Devices, Inc. has introduced what is claimed to be the world's most accurate instrumentation amplifier. Designed for high precision applications, the AD624 delivers maximum ±0.001% nonlinearity, maximum ±10ppm/°C gain tempco, and maximum 0.2uV peak-to-peak input noise and 10uV p-p output noise. To eliminate the additional cost and drift errors associated with external gain-setting resistors, the AD624 provides 15 different pin-programmable gains. The combination of these specifications and pin-programmable flexibility make the AD624 the best instrumentation amplifier available for low-level transducer interfacing applications.

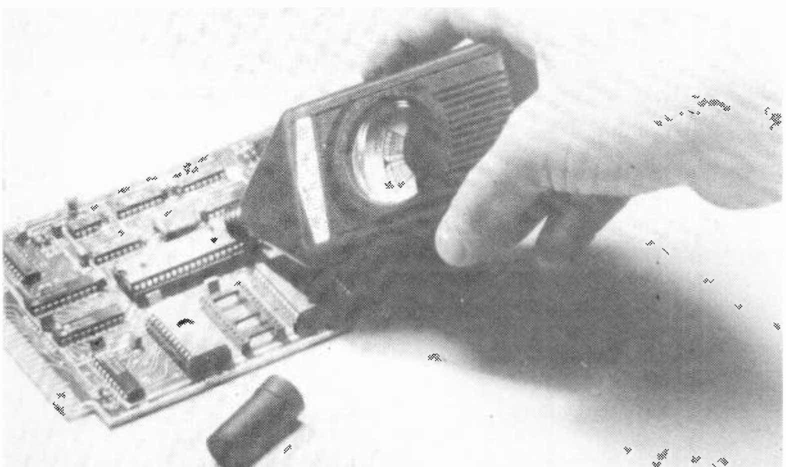
For further information, contact Steve Miller, Analog Devices Semiconductor, 804 Woburn Street, Wilmington, MA 01887. (617) 935-5565.

Thermal Component Tester

A new, low cost, electronic test instrument called Thermoprobe is designed to quickly identify dead active components on printed circuit boards without direct contact.

The solid-state device consists of a thermistor probe connected to a modified wheatstone bridge circuit and is designed to measure minute temperature changes of 1/25 of a degree Fahrenheit (1/45°C). Since dead resistors, transformers, diodes or ICs do not emit heat they can be quickly identified on the unit's built-in meter as the thermistor probe is moved in close proximity to them.

For more information on the US$21.95 Metrifast Thermoprobe, contact Metrifast, 51 South Denton Avenue, New Hyde Park, New York 11040.



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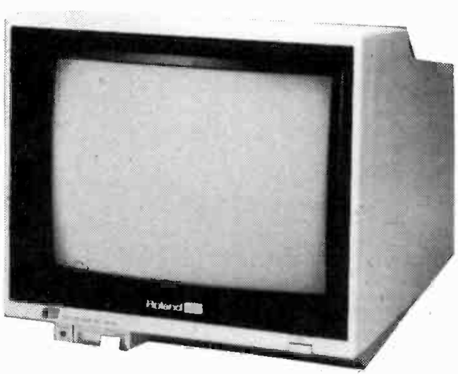

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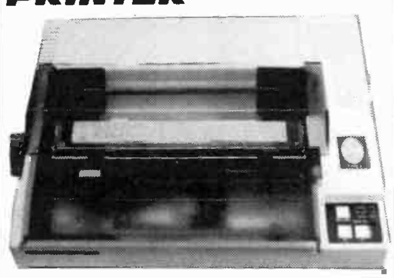

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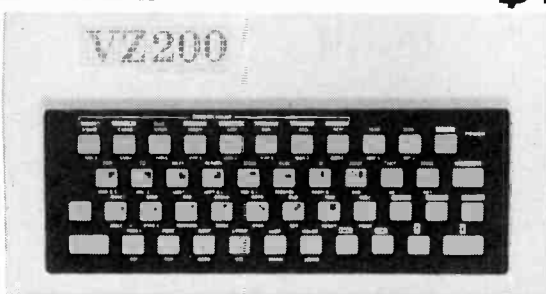

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Keyboard: fully detachable keyboard, function compatability with IBM PC keyboard * transmit : serial 1/P * 95 keys * 10 function keys * 15 numerical keys * 57 alpha/num keys * 8 cursor control * 5 other keys.

Disk Drive: The PC301 comes with 2, 5¼ double sided, double density disk drives * unformatted -media 500K bytes track 6520 bytes * formatted (16 sector, IBM format) media 327K bytes, track 4096 bytes.

Operating System: * provides you with microsoft MS DOS, allowing purchase of prewritten and designing of software packages. MS DOS 2.0 & 1.1 can run on COPAM PC 301.

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Induction Loops

Do you know what it's like not to be able to hear what's going on at a concert or a meeting? Vivian Capel describes a British system that will enable many hearing-aid users to find out what they've been missing.

PERSONS WITH normal hearing rarely appreciate the problems associated with the condition of those who are not so blessed. Hearing aids don't restore normal hearing. Owing to the inverse square law which governs sound propagation, microphones are much more sensitive to nearby sounds than distant ones. The human ear seems able to do a certain amount of filtering out of unwanted sounds that hearing aids are not capable of. The result is that a hearing-aid user is very suceptible to unwanted, distracting sounds.

Another effect experienced by hearing-aid users is that sound from a public address system sounds hollow, and it is difficult to distinguish the syllables. This is due to the reflections and reverberations set up in the auditorium. Here two ears come to the rescue of those with normal hearing because the reflected sound is of random phase, while the direct arrives in-phase. So our ears ignore much of the reverberation and concentrate on the direct sound.

Faced with these problems, hearing-aid users often try turning up the gain to make the sound more intelligible. Of course it doesn't work, in fact it makes matters worse, as the rustles, coughs and other sundry noises now become deafening. In despair, many turn off their aids altogether and try to hear with what limited natural hearing they have.

Plugged-in Audience?

Ideally, anyone hard of hearing should be plugged in directly to the PA system so that they receive only the sound from the stage microphones minus auditorium reverberation and without the audience noises. In the past some attempt has been made to do this in certain halls where a section would be reserved for deaf people, with a number of audio outlets for headphones.

Such arrangements were fraught with problems. One was that the users might have to be segregated from their friends, which made them self-conscious. Another was the constant damage done to the headphones and wiring; it was common for users to forget they were wearing headphones and stand up and move away while still connected! Yet another problem was the regular disappearance of loaned headsets.

All these drawbacks can be overcome by the installation of a magnetic loop around the periphery of the whole auditorium which is fed from the PA system. The PA output can then be received by anyone with a suitable hearing-aid within the area. So there is no segregation, the users can sit where they like; there is no wiring or connections to worry about so no maintenance problems; and the users can still hear if they move from their seats.

Hearing-Aids

What then about the receivers? Special headphone sets with built-in amplifiers and induction pick-up coils have been made by firms such as Beyer, Eagle and others for some time. However, for this application these are not necessary. Since 1974, all National Health Service and many North American hearing-aids have a selector switch which has two positions marked M and T. In the M position, the internal microphone is switched on for normal usage. The T position is for telephone use and it disconnects the microphone and switches in an induction coil. This responds to the magnetic field of some telephone earpieces and thus enables the user to hear the telephone without double transduction, that is sound generated by the earpiece being converted back to an electrical signal by the hearing-aid microphone. This greatly improves the quality and intelligibility of the sound heard.

When switched to the T position, the normal hearing-aid becomes an ideal receiver for a magnetic induction-loop sound system. The coil is mounted vertically, which is in the same plane as a loop wired around a hall, and so achieves maximum signal pickup.

From the management's point of view, this means no separate hearing devices to be supplied, with their repair liability and disappearances.

From the user's standpoint, there is no fuss over having to obtain and return an aid. The aid can be switched from normal to T at the start of the performance and back again at the end, in an instant. All extraneous noises are cut out, in fact in some cases users can hear better than those with normal hearing! A further big advantage is that the volume can be individually adjusted to suit the particular user, as he or she would do when using the aid normally.

Though many privately-sold hearing-aids incorporate a telephone switch, not all do. Those worn inside the ear lack the facility, as there is simply no extra room for a coil and switch. Some others have an induction coil but no switch so that both microphone and coil output are heard at the same time. This is less satisfactory than being able to switch the microphone out, but providing the signal from the loop is high, it is not too great a drawback.

Looping the Loop

Designing a loop is reasonably straightforward, being a matter of taking the area to be covered and the length of the longest side, then calculating the cable resistance, number of turns, and amplifier power to produce the required field strength.

The ideal strength is that which presents a signal to the hearing-aid which is comparable to the output of the internal microphone. Too weak a signal is not desirable as this would mean users having to turn the gain well up, which would make the noise of the internal amplifier noticeable. There is a British Standard (BS 6083 Part 4: 1981) which specifies the optimum strength as 100 mA in a single-turn loop of 1 metre diameter.

This highlights a basic factor, that it is the current and the number of turns that influence the resulting field in any given size of loop. Because the hearing aids will require negligible power from the magnetic field, the voltage required is only that needed to drive the required current through the resistance of the loop. If the resistance can be made very low, the necessary current can be achieved with only a small voltage, hence with minimum power. However, as the field strength is proportional to the product of the current

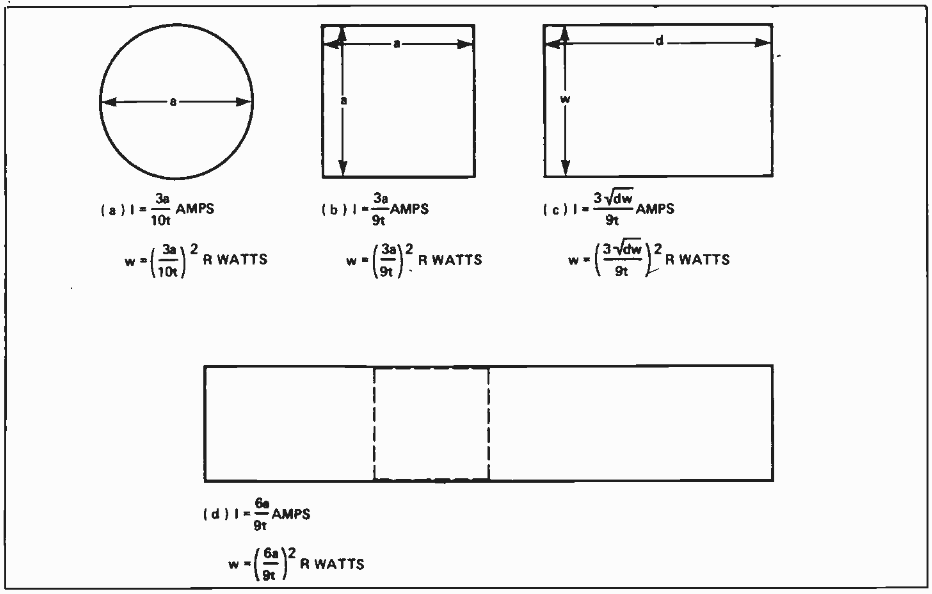


Fig. 1. Formulae for current and power requirement for loops of various shapes.

and the number of turns, it can be an advantage to increase the turns even though this also increases the resistance.

The specified current of 100 mA/metre is for the average signal, but peaks will exceed this, especially with music. The British Standard recommends allowing for peaks of 12 dB above average, which increases the current requirement by four times. If dynamic range compression is used in the feed amplifier, this could be reduced. However, if the system is to be used mainly for speech, then only much lower peaks need be accommodated. In practice, allowance for 6 dB peaks, or twice the average, has been found to be adequate. However, to ensure a good safety margin, the following calculations assume peaks of 10 dB, or three times average.

If the average current in amps is a/10 (where a is the diameter of the loop in metres), the peak is 3a/10. With the exception of the Albert Hall, few halls are circular. A square loop needs slightly more current to provide the same field, about 112 mA for a square of side 1 metre, so the formula becomes $I = 3a/9$ amps.

However, most halls are rectangular. Doing the calculation properly would be complicated, but for practical purposes we can work out a close figure for halls with a length of no more than 1½ times the width. This can be done by multiplying length and width to give the area, then finding the square root to give the side of a square of equal area. So our formula becomes $I = 3\sqrt{dw}/9$, where d is the length and w the width.

In the case of long narrow areas, things are rather different. With a square loop, each side contributes equally to the field. But if we take a square section, somewhere near the middle of a long narrow loop, the sides are too far way to have much effect. So only two of the four sides of the square are generating any field. Hence the field is approximately half what it would be with a square loop of the same width in the central portions, rising to around three-quarters in the parts adjacent to the sides.

Choosing The Cable

The above calculations apply for a single-turn loop, but there is no reason why several turns cannot be used to advantage. As you would expect, the current required is divided by the number of turns, so the formula becomes 3a/9t for a square loop (where t is the number of turns).

A convenient method of wiring multi-turn loops is to use multi-conductor cable and connect the conductors in series using a junction box or terminal strip. Thus a single loop of standard three-conductor cable gives a three-turn circuit without actually running three separate turns around the area.

Now we must match the loop resistance to the output of the amplifier. If a separate amplifier having a four-ohm output is used, the loop should equal this or be a little higher, say five ohms. This is about the lowest resistance that can normally be matched to a standard power amplifier.

Table 1 gives the resistance per 100 metres of a single wire of various gauge cables. One of the most commonly used is 20 AWG, three-conductor which has a resistance of 3R3 per conductor or 10R total. The heavier gauge 18 can also be used if the run is long and resistance high as a result. This comes out at 2R1 per conductor or 6R3 for three conductors.

The first step, then, is to measure the total length of the run. This must include detours around door or window frames, and recesses. For a medium-sized hall, a run of around 80 metres is a common average. This gives about 8 ohms for 3x20 AWG which matches nicely with an 8R output amplifier. Any value below this needs a 4R output, even though it may be closer to 8R, because the load should never go below the rated impedance of the amplifier. It is a matter of juggling the gauge and number of turns to produce the desired resistance for the measured length. Never add a series resistor to make up a value, as this not only wastes power, but also has an adverse effect on the loop performance.

Amplifier Power

Although the production of the magnetic field is not a function of power out of current alone, a certain voltage is required to produce the necessary current, hence power is expended. So, what power will be needed from the amplifier?

The formula for calculating power is $W = I^2R$, where the symbols used have the usual meanings.

Combining this with the earlier formula we get:

$$W = (3a \div 9t)^2 R$$

If we remember that R depends on the number of turns, and write $R = rt$, where r is the resistance per turn, then we can re-write the formula for the power as:

$$W = (3a \div 9)^2 \times r \div t$$

which shows that the more turns we use, the less power is necessary to drive the loop.

Let us look at an example to illustrate. Supposing a hall having 18m as the root of its area and needing 80m of cable to enclose, is wired with 20 gauge. The resistance for a two-turn loop would be from the table, 5.33 ohms, and for a three-turn loop, 7.99 ohms.

For the two-turn loop we have:

$$W = ((3 \times 18) \div (9 \times 2))^2 \times 5.33 = 48 \text{ watts}$$

In the case of the three-turn loop:

$$W = ((3 \times 18) \div (9 \times 3))^2 \times 7.99 = 32 \text{ watts}$$

Table 1

AWG (Copper)	Resistance per 100m
12	0R52
14	0R83
16	1R32
18	2R09
20	3R33
22	5R30
24	8R42

With 18 gauge cable, the resistance for two-turns is 3R34. The three-turn cable has a resistance of 5.02 ohms. So using the above formula we have:

$$W = ((3 \times 18) \div (9 \times 2))^2 \times 3.34 = 30 \text{ watts}$$

two-turns, and for three-turns:

$$W = ((3 \times 18) \div (9 \times 3))^2 \times 5.02 = 20 \text{ watts}$$

Amplifiers

A separate amplifier fed from the 'line out' socket of the existing PA amplifier is the most flexible and satisfactory means of supplying a loop. The power rating can be chosen from the formula already described. However, in some cases, it is possible to take a feed from the output of the PA amplifier already installed.

If it is a proper PA amplifier, it will have a 100 V output tap, and this should be used with a suitable matching transformer. The main requirement is that the amplifier has sufficient power to supply both the loop and the speakers. With many PA systems there is an ample reserve; it is not uncommon to find 80-100 watt amplifiers feeding speakers tapped at 25-40 watts.

100 V Outputs

A word of explanation regarding 100 V operation and transformer power tappings would not be amiss here. A 100 V output is a much more convenient method of connecting mixed loads than working out their impedances, when connected in parallel, and ensuring that they do not fall below that of the amplifier tap being used. Each load has its own matching transformer which enables each one to be individually adjusted.

The 100 V is the output voltage obtained when the amplifier is delivering its full rated power. From the formula:

$$Z = E^2/W$$

it can be seen that the actual impedance of this tap depends on the wattage rating of the amplifier, for a 50-watt amplifier it is 200 ohms, for a 100-watt, 100 ohms, and so on.

The transformers used for matching PA speakers to the 100 V output have a secondary rated in ohms: 4, 8, 16, or often all of these via tappings. These are connected to a speaker of the appropriate impedance. The primary has tappings rated in watts so that when a particular tapping is selected, the specified wattages will be taken from the 100 V output and fed to the speaker.

So you can have a mixed bag of speakers all set to different powers to suit different locations in the PA system, and the only calculation necessary is to add up all the tappings and make sure that the total does not exceed the power rating of the amplifier. Much easier than calculating parallel impedances!

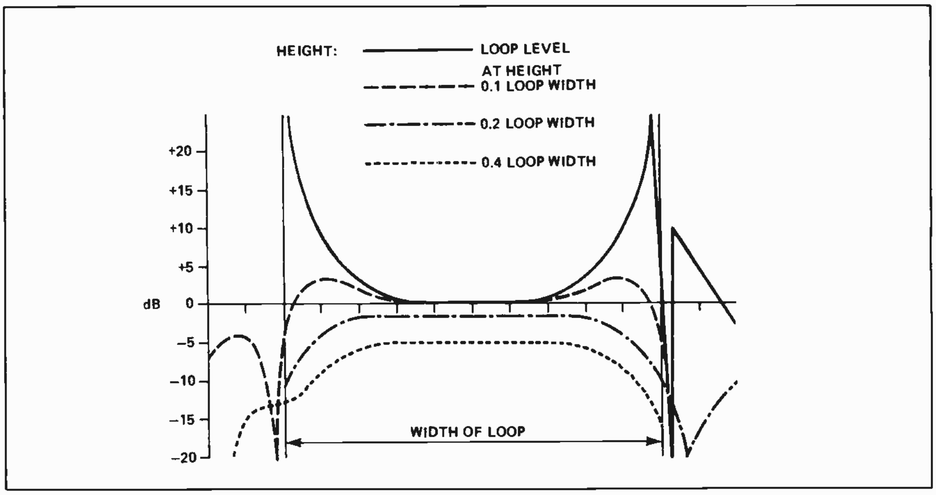


Fig. 2. Vertical field distributions for different heights above (or below) the loop level.

The 100 V Loop

The loop is taken to the appropriate secondary tapping on the 100 V transformer, and the primary tapped to give the required wattage.

Some installations in small halls may not have a PA amplifier with 100 V output, and the speaker system may be operating at low impedance from an ordinary amplifier. In this case there is less room for manoeuvering, but if there is plenty of amplifier power to spare, it may be possible if the impedances work out right.

Field Distribution

So much for the electrical features; now we will consider the magnetic field and its distribution. If the loop is level with the receiving devices, and we start at the middle of the loop, the vertical component of the field rises gradually as we move toward the walls supporting the loop. At about halfway between the centre and the walls, it shoots up dramatically to + 22 dB or thereabouts, at a point close to the loop. Then it drops to a null point actually just over the loop at the boundary wall. Beyond this, outside the loop, it rises again to about + 10 dB, then falls linearly. This is shown by the solid line in Fig. 2.

Obviously this is not entirely satisfactory, as there are wide differences in field strength across the loop which would call for different gain levels in the user's hearing-aids according to their positions. If instead, the loop is displaced vertically so that it is above or below the level of the hearing-aid coils, the distribution curve can be made more even. Figure 2 also shows vertical components of field distributions for displacements of one-tenths, two-tenths and four-tenths of the loop width.

Of all these curves, the one obtained from the one-tenth displacement is the most satisfactory, and usually it is the most convenient. For a hall 10 metres wide, which is a fair average for a medium-sized hall, the required displacement will be one metre. For seated users, this would put the loop near the floor, which is a practical place to mount it. It could be at floor level, especially if the hall is wider, as the positioning is by no means critical.

The loop could just as well be run above the hearing-aid level, and in some cases this may prove to be more practical. This could be rather conspicuous, however, and may detract from the decor. In both cases, running the loop over door frames or around other relatively small objects will make little difference to the field level in the body of the hall, though it may cause local anomalies.

Vertical displacement of the loop from the level of the receivers causes a lower signal which should be compensated for by an increase in the loop current, hence power supplied by the amplifier. Table 2 gives the ratios of displacement in units of loop-width with the multiplying factors for current and power. For the one-tenth displacement, the power is only 1.2 times and can be ignored. For larger displacements though, the power requirements increase drastically. So this is a further reason for keeping the loop to the one-tenth level.

Table 2

Ratio h/a	Multiply current by	Multiply power by
.1	1.1	1.2
.2	1.25	1.6
.3	1.5	2.25
.4	2.0	4.0
.5	2.5	6.25
.6	3.25	10.6
.7	4.25	18.0
.8	5.5	30.2
.9	7.0	49.0
1.0	8.5	72.2

Null and Overspill

It may be wondered why there is a null point as the receiver passes over the loop, or at greater height, just beyond the loop. It is not that the total field disappears, just the vertical component. If the receiver coil is placed horizontally instead of vertically, then there will be maximum pickup over the loop wire, and minimum within the loop, the opposite of normal. One user was heard to complain that the sound faded out to zero when he bent down to pick up something from the floor. This was, of course, because the hearing-aid coil was tilted through 90° to the horizontal.

Overspill (the magnetic field outside the loop) is unaffected by normal building materials, but falls off linearly with distance. Beyond about a quarter of the loop width, it drops to too low a level for practical use. Even this, though, can be useful. In one case a delighted user related how he could still hear what was going on during a visit to the washroom in the foyer!

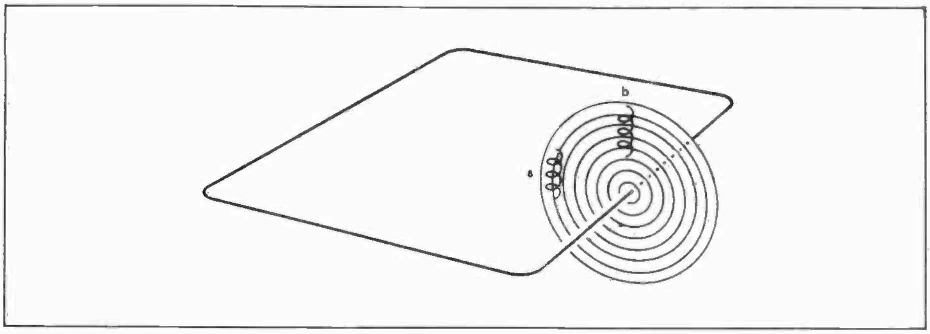


Fig. 3. Field null: at point a, the field is entirely vertical; at point b, the field is entirely horizontal.

In The Home

There is no reason why the same technique should not be used in the home of a person with hearing difficulties, to enable them to listen to records, for example. The major problem will be getting a loop with a sufficiently high resistance to be fed by a domestic amplifier; however, this difficulty can be overcome by using several turns of fairly thin wire.

Listening to the television this way poses the added difficulty of coupling the output from the TV to the amplifier. Unless your TV has a special output socket, as a few of the more enlightened manufacturers have taken to including, the best solution is to use a TV sound tuner.

ETI

Accurate Rise Time Measurements

Given up trying to measure how long it takes to get up in the morning? Maybe D.E. Patrick can help.

MANY NEOPHYTES, experimenters, and even experienced technicians often make gross errors when attempting to determine the rise times of circuits, amplifiers, signal generators, etcetera. However, while a rise time measurement is often as important as a frequency response measurement, what you see on your scope is not what you may get. We'll see why and how to get it right in moment. Further, knowing either rise time or frequency response (also bandwidth), we can calculate one from the other in RC limited circuits with Gaussian responses.

Displayed Rise Time

Now, if you applied the signal of a square wave generator to your scope as in Figure 1 and got the waveform shown, with the scope's time base set at 50 ns/div, what's the generator's rise time?

Well, where rise time is generally measured along the leading edge between 10% and 90% of the displayed peak value, the displayed rise time is 100 nanoseconds, ie, two scope divisions at a time base setting of 50 ns/div. Now, you might infer from what you see that the signal generator's rise time was 100 ns. But, the signal generator's actual rise time may be significantly different than the displayed value. Assuming both scope and signal generator to be working properly, and ignoring a possible typical 3% scope error, what went wrong?

Determining Actual Rise Time

Well, you can't make an accurate measurement of rise time without considering the rise time of the scope probe and the scope. Also, to determine the true rise time, you can't simply sum the signal generator, scope, and probe rise times. You have to take the square root of the sum of the squares. Thus,

$t_{ra} = (t_{rd}^2 - T_{rp}^2 - t_{rs}^2)$ $\qquad t_{rp}$ = probe rise time

where t_{ra} = actual rise time, t_{rs} = scope rise time

t_{rd} = displayed rise time

Here's an example: t_{rd} = 100 ns, t_{rp} = 15 ns, and t_{rs} = 35 ns. What's the t_{ra} or actual signal generator rise time?

$$t_{ra} = (100^2 - 15^2 - 35^2)^{1/2} = 92.47 \text{ ns.}$$

Therefore, we have an error of 7.6%, which is significant. Error increases with longer scope and probe rise times and decreases with shorter scope and probe rise times.

Using the above formula, you can determine the actual rise time (t_{ra}) from displayed rise time (t_{rd}).

Bandwidth Versus Rise Time

In Figure 1, the leading edge rises linearly from 10% to 90% points. This is called a Gaussian response, where if an ideal step response is applied to an amplifier, etc., the frequency response is RC limited. Now, an ideal step response with zero rise time is a hypothetical construct and doesn't exist in the real world. But neither does an ideal amplifier, because if one did exist, when we applied an ideal step response to it, the output would also be ideal, with an instantaneous transition.

In any case, since all amplifiers and electronic circuits have capacitance and resistance, when we have a Gaussian response, rise time and frequency are related and can be expressed as bandwidth or frequency response.

$BW = .35/t_r$

where BW = frequency bandwidth in MHz,

t_r = rise time in microseconds,

0.35 = a constant we'll discuss in a moment.

In a general purpose scope with a 10 MHz bandwidth, its rise time

$$t_r = 0.35/BW$$
$$= (.35/1.0 \times 10^7)$$
$$= 35 \text{ ns or } .035 \text{ us.}$$

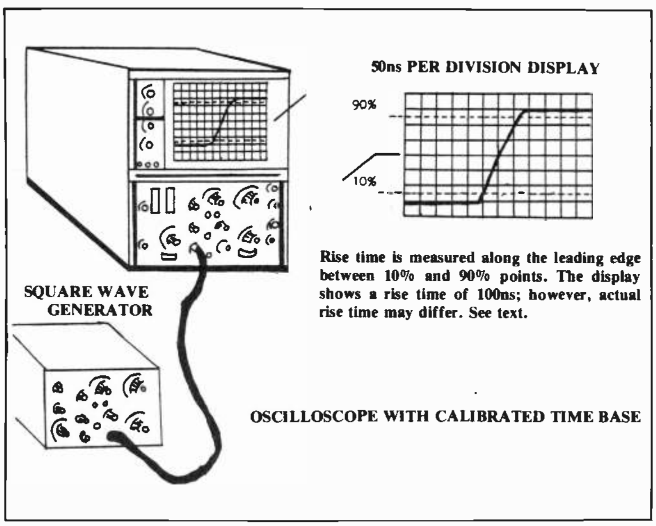


Figure 1: Typical pulse rise time display

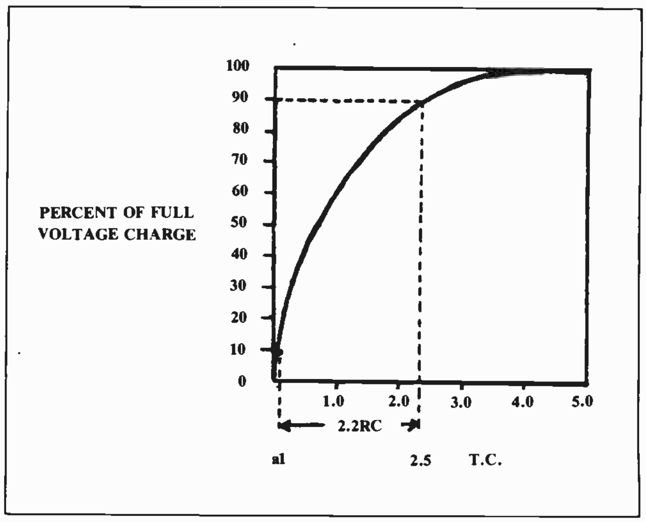


Figure 2: Typical plot of charging capacitor in a series RC circuit.

Continued on page 51

Non-Volatile Memories

Intel Corp. has introduced two non-volatile semiconductor memory devices that include on-chip circuitry to prevent accidental erasure of stored information.

The 16k 2817A is an electrically erasable read-only memory (E^2 PROM) and the 4k 2004 is a non-volatile random-access memory (NVRAM). Each is designed for applications in which protecting data already stored on the chip is critical and in which software and information changes take place frequently.

Both chips assure data integrity. Data protection circuitry prevents erroneous responses to voltage and circuit instabilities that can corrupt data or software — notably the possible occurrence of unwanted store operations when the system's power is turned on or shut off.

The 2004 NVRAM consists of a 512 by 8-bit static RAM backed up, bit-for-bit, by an E^2PROM array. With read and write access times as fast as 200 nanoseconds, the chip is aimed at applications that need to quickly store large blocks of information when power is lost, or that require numerous write cycles.

The 2048 x 8 bit 2817A E^2 PROM is suited to read-mostly applications, such as user-entered and changeable programs, character fonts, etc.

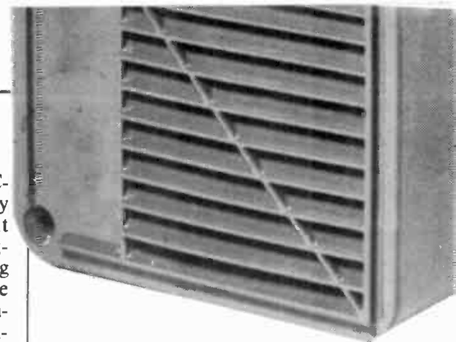
For information contact Intel Corp., Lit. Dept. Wll, 3065 Bowers Ave., Santa Clara, CA 95051.

The newly-introduced laserdisc games that have been taking the country's arcades by storm could be the key to unlocking the door of success for the consumer videodisc industry, says a report from International Resource Development Inc.

While the present offerings are somewhat elementary, according to IRD, their success in the marketplace bodes well for the more sophisticated versions that are sure to appear. IRD claims that games could come along that superimpose images of the player (taken by a video camera) and feed them through a computer onto the frames of an interactive videodisc so that the player would actually appear "inside" the game. "With the Hollywood-quality visual effects that enhanced laserdisc games can offer, this would be like making a movie that stars the player," observes Joan de Regt of IRD. "If the kids like the laserdisc games that are out now, wait 'til they see the ones that are coming."

Whether or not the success of these videodisc-based arcade games will have a positive effect on the home videodisc market remains to be seen, however, says IRD. Most of the laserdisc arcade games will use at least two videodisc players and a microcomputer to achieve the rapid response time and variety of choices necessary for a best-seller. Since this is a prohibitively-expensive combination for most consumers to buy, the report expects that the home versions of these games will be far less sophisticated.

Heavy-Duty Loudspeaker



The Atlas Sound SVT and VT-Series heavy-duty loudspeakers are now ULC approved for the Canadian market. They are ideally suited for mobile intercoms, security and monitoring alarms, and as an accessory for radio telephone and facility access control.

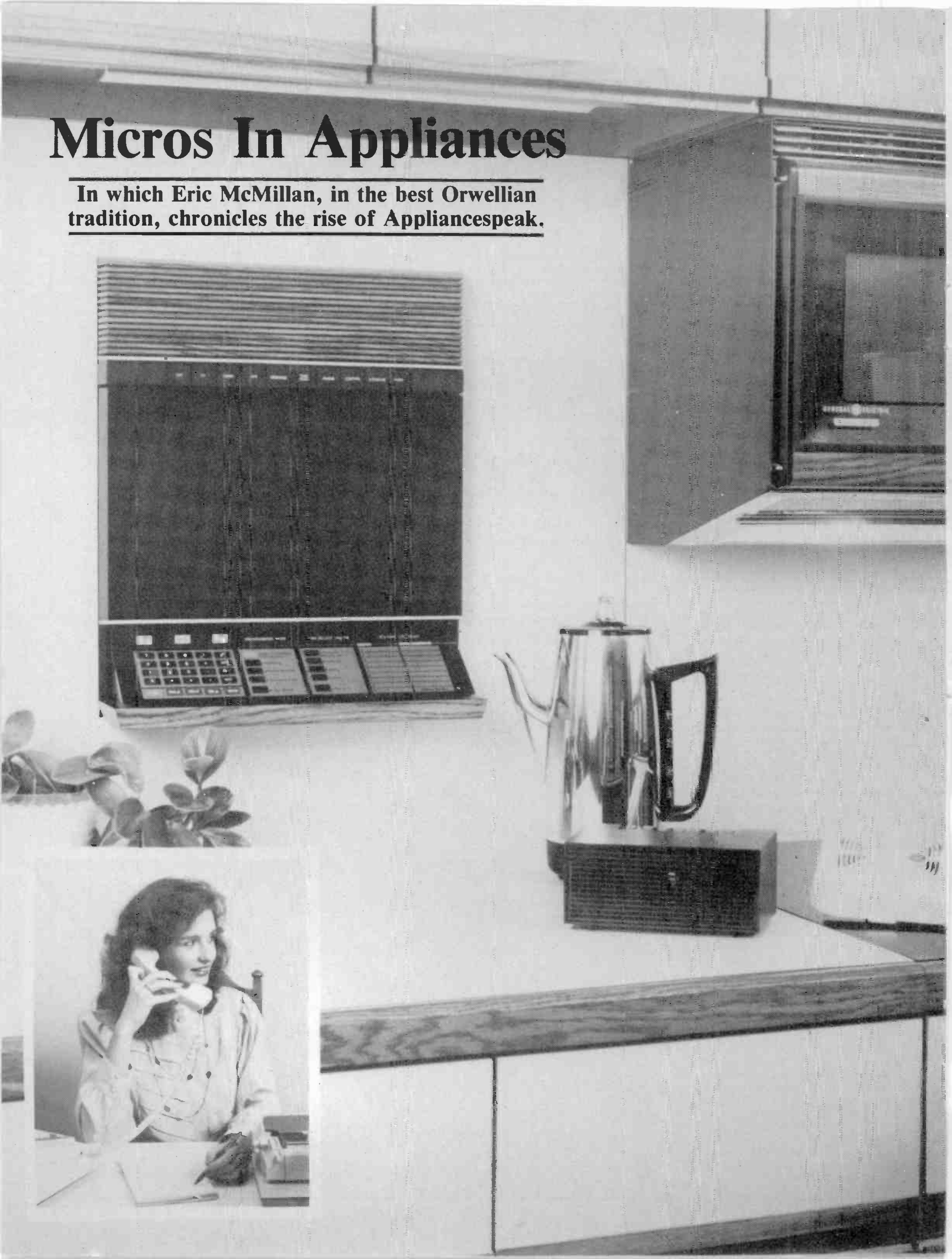
An Atlas Sound integral re-entrant dome built into the housing provides optimum protection from mechanical damage and concentrates acoustic efficiency in output and intelligibility. Per ULC-lising requirements, the specially treated environment-resistant loudspeaker assembly and its rugged weather-sealed Noryl housing assure dependable performance under the most demanding installation conditions, such as exposure to moisture, temperature variations, corrosive atmosphere and vibration.

A full complement of optional matching accessories is available for surface and semi-recessed mounting, weather-proof installation, fully recessed mounting (SVTF models) or bi-directional use.

Atlas Sound is represented and stocked by Atlas Electronics Limited, 50 Wingold Avenue, Toronto, Ontario. For further information contact: Bruce Petty at (416) 789-7761.

Micros In Appliances

In which Eric McMillan, in the best Orwellian tradition, chronicles the rise of Appliancespeak.



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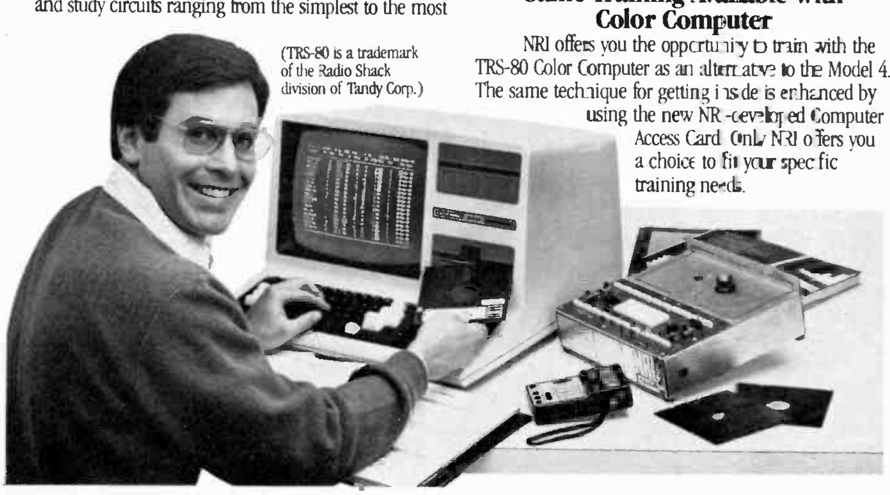

(TRS-80 is a trademark of the Radio Shack division of Tandy Corp.)

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GOOD MORNING, SIR. IT is time to rise.
"Grmpf, fmstf ... what day is it?"
It is 6:45 a.m., Monday, October 24. You have one hour and fifteen minutes to worktime, sir.
"Okay, clock. Coffee-maker, make me two cups."
Please choose strong, medium or weak blend.
"Better make it strong. What have we got for breakfast, fridge?"
The inventory includes one box of Frosted Cocoa Crispies and half a grapefruit.
"So much for breakfast —"
Attention. A call is coming through on line one.
"I can't handle it now, phone. Take a message —"
Please give instructions for tonight's roast.
"Okay, oven. Thaw as long as it takes, cook at 350 for two hours and —"
Excuse me, the morning news begins in one minute.
"Thank you, radio —"
This is the alarm. A basement window is broken. This is the alarm ...
Attention. A call is coming ...
Warning, there is no coffee left in the coffee-maker ...
... your schedule for today ...
... one hour to worktime ...

Such conversations between drowsy humans and alert machines may become common as the new generation of household appliances invades our homes.

Some of these "smart" appliances have already been introduced and accepted. Others have been shown in prototype at consumer electronic shows and many are still on the drawing boards.

In 1981, "appliances that think for themselves" were announced as having arrived. Words like "smart" and "thinking" should be used with caution, however. Most of the appliances so far introduced have a low level of intelligence, even by microcomputer standards. The function of the microprocessor in appliances to date has generally been to memorize a few commands, make rudimentary calculations, and set a mechanism to work in the necessary sequence.

Extending its decision-making powers, some machines use a sensing device to send signals to the microprocessor during operations. A microwave oven, for example, may test the temperature of the food to determine whether to turn the heat up or down. Certain clothes dryers from General Electric and Maytag contain moisture detectors to shut off the machine when the clothes are dry.

Despite their currently low capabilities, however, the prospect of microprocessors doing much more around the house is real. The electronic household operated from a central control, a unified communications system (TV, phones, radio from a single source), and appliances that converse with the user — they could be just a few years away.

Microchips and Megabucks

"All the technology is here, it's just a matter of justifying the cost," says Tom Gleason of Gleason Technical Services, an electronics consulting and repair firm having wide experience with microporcessors in industry. Manufacturers are looking into integrated systems seriously, says Gleason.

For years now centrally controlled lighting has been possible for people with microcomputers, the necessary interfaces, and a program.

Even without a computer you can buy a system to control lights, telephones and other electrical appliances — advertised as a home security device.

BSR was the first to market a system by which signals are sent out from a central control through the house wiring to plug-in modules connected to each appliance under control. DAK Industries is among the many companies that have since come out with compatible versions of the BSR system. Its system includes an alarm memory that triggers lights, sirens, or anything else if the homeowner suspects a burglary is in progress. Modules can be directed to turn on the coffee-maker at a specified hour, dim the lights selectively, and turn down the heat or air-conditioning automatically when nobody is home.

"Most experts agree that verbal interaction with home products is a coming phenomenon."

Another system, made by the California company Anova Electronics, can be operated by the owner over the phone. Sixteen appliances are directed by coded messages tapped on a push-button phone or beeped over a dial phone. Besides appliance control, services include security alert, medical-emergency signalling, phone answering, automatic dialing and digital time-keeping.

Although these systems are quite practical for the time being, they are still a long way from the completely integrated household. They can't let you make the morning coffee from your bed unless you already prepared the coffee, filter, and water the night before. You can't give remote detailed instructions to your microwave oven — you can only have it turned on.

Two big obstacles to the totally integrated system are standardization and expense. Anyone involved in home computers, video or other consumer electronics knows about the first problem. Interfacing just two products can be difficult enough. Achieving industry standards for an entire house full of equipment may be impossible for many years to come.

A more crucial consideration for manufacturers, however, may be consumer resistance due to pricing. As Gleason points out, the advent of the electronic cottage will be hastened or delayed by the state of the economy.

The microprocessor found in most appliances uses either an EPROM (Erasable Programmable ROM) chip with the required program written onto it or a chip designed specifically for the appliance in question. When an EPROM is used, most of the chip's capacity may be wasted because it offers much more memory — sometimes as much as 16K — than a single home appliance requires.

In quantities of hundreds of thousands, chips can be custom-made as cheaply as a few dollars each. But when the board, keypad and other components are included, the electronic controls can account for 20 percent of the cost of an appliance.

Most experts agree that verbal interaction with home products is a coming phenomenon. But Gleason guesses that voice synthesis and recognition will become available within the next five years only if companies can produce it without adding more than 10 percent to a product's price, thus overcoming consumer restraint in a depressed economy.

Everything's Talking At Me

Voice synthesis was introduced in a home product with the children's electronic learning game Speak and Spell in 1979. The manufacturer, Texas Instruments, went on to use speech in its computers. A solid-state speech synthesizer was used in conjunction with software for the TI-99/4A home computer to teach basic academic skills and to enhance a variety of games. The TI Professional Computer has gone further with voice recognition of simple commands and a database for natural language queries.

Examples of speech synthesis are cropping up in more mundane household products.

Clock radios don't just keep time anymore, they tell you the time verbally.

Seiko has just come out with a watch with a microchip that stores an eight second message to play back at a predetermined time.

Some calculators from Sharp and Panasonic give answers in synthesized voices.

Matsushita's Show and Talk microwave oven not only displays menus and instructions on a six-inch colour monitor but it accepts spoken instructions, responds with spoken confirmation and announces cooking stages.

But although the technology exists to turn almost everything in your house into a chatterbox and eavesdropper, most microprocessors have more pragmatic domestic uses at the moment — mainly to replace or augment conventional electromechanical processes. In top-of-the-line dishwashers and washing machines, for instance, they program the length of wash cycles, the temperature of water, the number of fills and any auxiliary cycles.

While these options are not new, the number of them available on a single machine is. Electromechanical devices would have to be large and unwieldy to provide the range of choices made possible by miniaturized circuits.

Microprocessors also allow designers to add functions that wouldn't have been feasible previously. Whirlpool, for example, has incorporated a check into some washing machines to prevent consumers from programming mistakes that could damage clothes.

"Microprocessors allow designers to add functions that wouldn't have been feasible previously."

The degree of market penetration by products with microprocessors varies from appliance to appliance. A technical liaison manager for Camco Inc., which handles General Electric and Hotpoint products in Canada, estimates about 40 percent of microwave ovens in the stores today contain microchips whereas only five to ten percent of dishwashers and ranges are in this category as yet.

Genius in the Kitchen

Microwave ovens with microprocessors have some unique features.

GE's Model JX2300 is typical of the more sophisticated types on the market now. This microwave automatically sets defrosting time and power levels. A sophisticated humidity sensor measures steam emitted by the cooking food in order that the microprocessor can calculate remaining cooking time and set the required power level. When the cooking is completed the food is automatically kept at a simmering temperature of 180 degrees.

Panasonic's Genius series of microwaves simplifies the programming process. Once you indicate the kind of food (including pasta, various meats and vegetables), you need only touch a single button and the sensor controls automatically determine the power levels and times to take the food through the defrosting, cooking and warming stages.

The Toshiba ER899 is an example of a microwave that takes programming a step further by eliminating the need to press keys at all. Specially-designed recipe cards marked with cooking instructions are read directly into the machine.

The Dimension 3, using Panasonic's Genius auto sensor control, points up another development in cooking appliances: the combination of different modes of cooking. This model can use microwaves or convection heat or a combination of the two. In the combination mode the microwave setting is automatically calculated. In ranges of the future we can expect to find more combinations of convection, microwave and

Continued on page 46

ZX Analogue-to-Digital Converter

PROJECT

Expand the consciousness of your computer and let it sample the delights of the real world with this low-cost ADC.

by Rory Holmes

HOW ABOUT a fast, eight-channel, eight-bit analogue-to-digital converter, all in one small box that plugs neatly onto the back of your Sinclair computer and costs about $30? A rhetorical question, really, because that's what we're presenting in this article. The applications for this project are numerous since A-to-D converters allow your computer access to the 'real world': and the real world, as data acquisition experts call it, is anything which varies smoothly and continuously, such as temperature, sound level, voltage, position, speed and so on. Eight channels of analogue input data, each with a resolution of one part in 256, will open up a whole new field of applications for your computer and programs. For example, some of the things you might consider include real-time graphs for multi-variable displays, eight-channel spectrum analyzers, VU meters for recording work, process control programs, central heating control, potentiometer-type joystick inputs (up to four sets of two axes), weather station computers, waveform analysis by computer, aircraft simulations and so on. You might even be able to make good Sir Clive Sinclair's boast that the ZX81 could control a power station!

The ADC IC

Our analogue-to-digital converter is based around the new 7581 IC, a complete data acquisition system on a chip with some very handy features. The best of these features concerns the way in which data is made available to the host computer: by using a 'dual port RAM' and internal scanning logic the conversion process is made completely transparent to the user. Basically this means that the microprocessor need do nothing: the latest analogue data is always available and may be read from a small memory-mapped region of the computer's address space (eight consecutive bytes).

The chip will convert each channel in 50 microseconds and performs a complete conversion update of all eight channels in 400 microseconds. The analogue input voltage range is 0-10 V and these limits will correspond to 00 and FF Hex respectively.

The unit plugs into your computer via a double-sided edge connector, and, if you want, you can include a switch to enable the unit to switch between the ZX81 and the Spectrum port configurations. The eight analogue inputs enter the unit via a 15-pin 'D' type connector. The system derives its low-current 5 V supply directly from the expansion bus, so it will start functioning as soon as the computer is switched on, updating the analogue data at the chosen memory locations ready for PEEKing or machine code access.

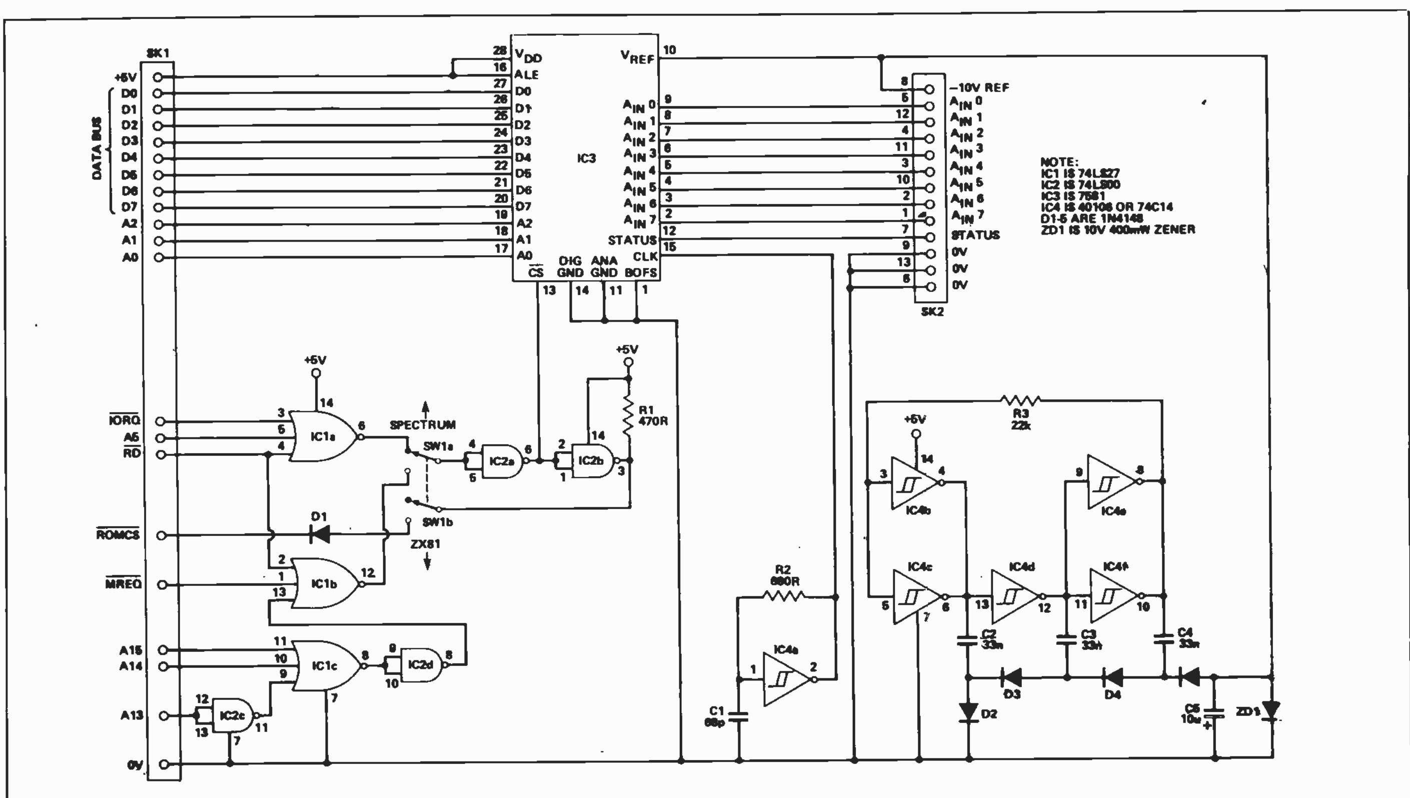


Fig. 1. Circuit diagram.

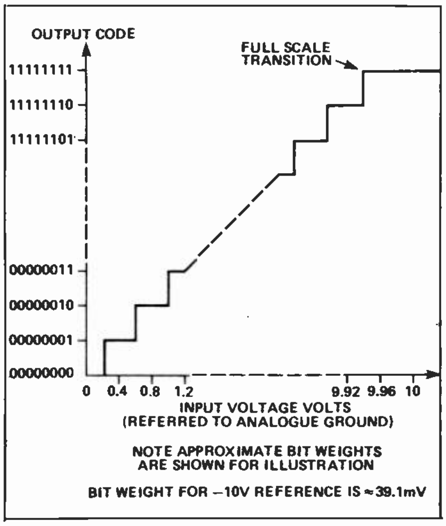


Fig. 2. Transfer characteristic diagram.

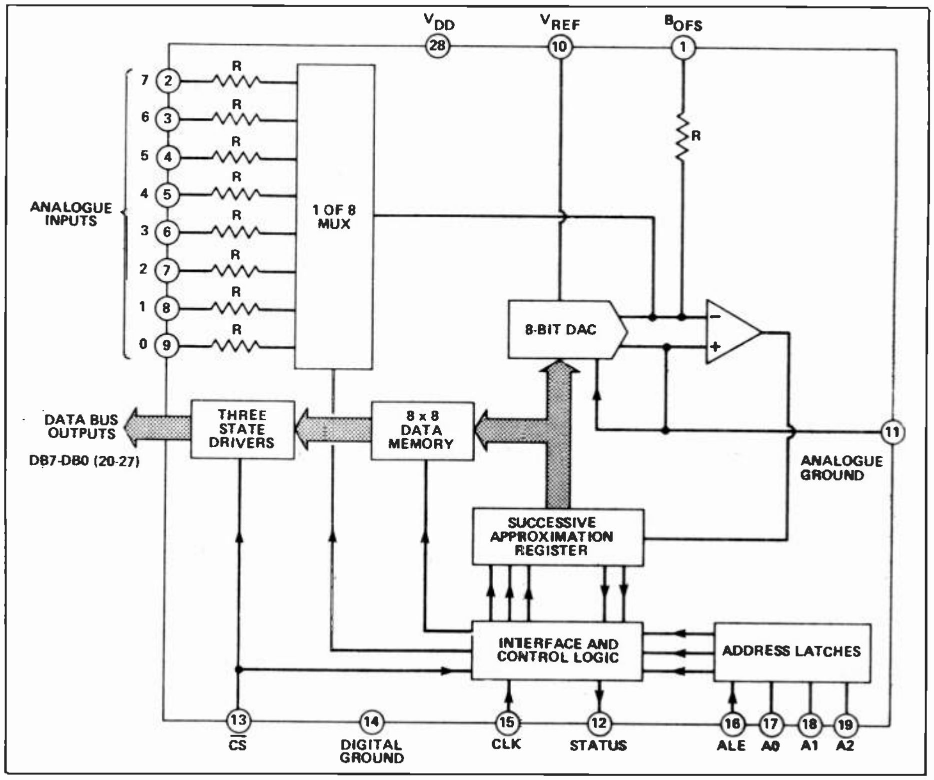


Fig. 3. Internal block diagram of the 7581.

There's no reason why this device couldn't be used with any other computer. All you have to do is find a handy unused hole in your system's address space and design suitable circuitry to decode the chosen range of addresses. This circuitry will replace the section of our circuit involving IC1 and 2.

Construction

The entire eight channel converter is built into a plastic Verocase to form a very neat and solid unit which plugs directly into the Sinclair expansion connector, either on the ZX81 or the Spectrum. A standard 15-way 'D' type socket allows access to the eight analogue inputs and a few other internal connections. This is a right-angled PCB-mounting type which is soldered directly to the track side of the PCB to reduce inter-wiring. Since the wire-wrap edge connector socket is also soldered to the PCB, the only part external to the PCB is the selector switch, which is optional. If you anticipate using only one computer then wire links can be used to replace the switch contacts at the appropriate overlay points.

The PCB should be assembled first, following the overlay diagram of Fig. 6. Don't forget the six wire links and take care over the orientation of the diodes and ICs. The 23-way edge connector must be mounted the right way round and with the polarizing key at position three. The edge socket must have long wire-wrapping pins so that when mounted it will protrude through the front of the box as illustrated by our prototype (see the photograph). The socket is mounted from the component side, and the pins should protrude about 2 mm through the track side for subsequent mounting of an optional edge connector plug (to allow other ZX add-ons to be plugged in). Ensure that the socket is square and parallel to the PCB before soldering the pins. A 43-way edge connector could also be used, provided it is sawn off at either end to leave the polarizing key at position three.

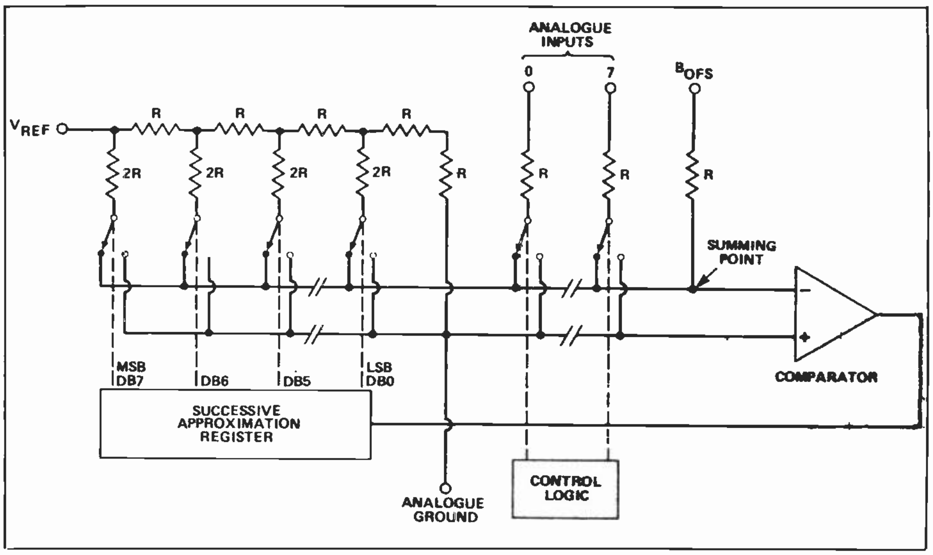
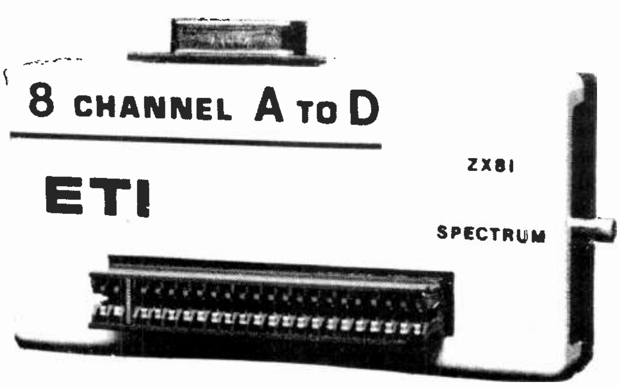


Fig. 4. The analogue input circuitry of the 7581.



Here you see the protruding edge socket.

The 'D' type socket should be left until last, when its right-angled pins can be inserted from the track side of the board and pushed home as far as possible. The soldering of this component is difficult but not impossible, providing a small soldering bit is used.

The PCB should be filed to the shape shown in the overlay diagram, since it has to fit into the lid section of the case: the two corner pillars which take the main case bolts will also need to be filed away slightly. At this stage, a slot should be cut in the appropriate position to take the connector socket so the assembled PCB can be fitted into the lid. It should sink down until the tops of the ICs touch the inside of the lid. The edge connector should now be almost clear of the slot and the diodes and capacitors should just clear the filed-down case pillar.

By mating up the two case halves, you can find the position for an appropriate slot to be cut in the base of the case to clear the 'D' type socket. If a switch is to be fitted this should be glued, using cyanoacrylate or epoxy glue, to the side of the base section as shown in our internal photographs: the switch contacts will just clear the PCB. On our prototype we fixed three large stick-on rubber feet into the base of the Verobox; these support the PCB at the correct height, and when the case halves are screwed together, they will hold the PCB firmly in place.

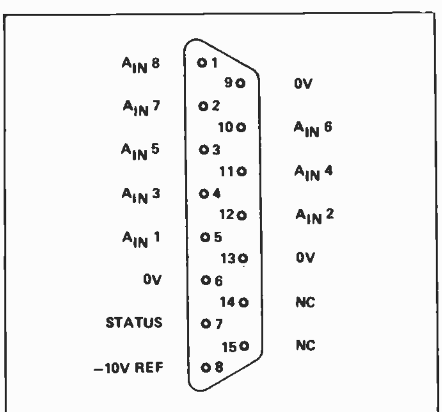


Fig. 7. Pinout for the 'D' type connector we used.

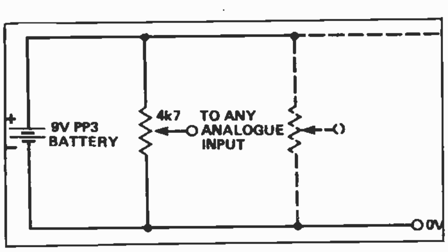


Fig. 8. How to connect pots for testing and when using the unit as a joystick port.

The diagram of Fig. 7 shows the pinout connection for the 'D' type socket; it's a good idea to draw this along with the corresponding address locations onto an adhesive label, which can then be stuck onto the back of the box. There are two unconnected pins on the socket which could be connected (using insulated wire links) to any other two signals, say +5 V and the master clock.

Having completed the assembly, the A-to-D converter may be plugged into a Sinclair computer and tested. One of the analogue inputs may be wired up to the simple pot circuit shown in Fig. 8 and the corresponding address location can be looked at via the computer. Table 1 shows the address locations for each input; the command PEEK addr is used for the ZX81 and the command IN addr for the Spectrum. For a 0 V input the memory byte will contain 0 while for the full 10 V input it will contain 255 or FF in Hex. The number (in eight-bit binary) will vary proportionately for all the voltages in between. A small program to continuously print out the value of all eight memory locations would help in the testing procedure.

After you are satisfied that the unit is working the programming options are practically limitless; eight real time voltage inputs continuously available to either BASIC or machine code programs!

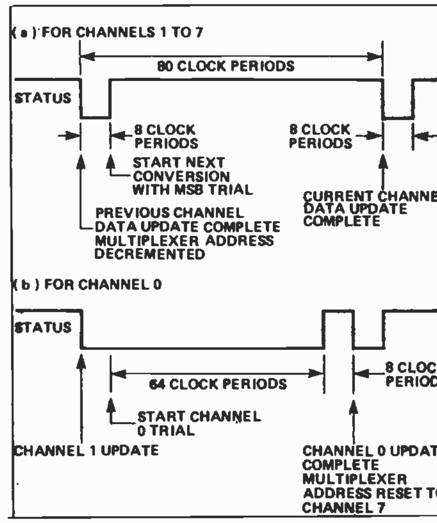


Fig. 5. Status signals.

TABLE 1

	ADDRESS LOCATIONS	
CHANNEL	ZX81	SPECTRUM
8	8199	65503
7	8198	65502
6	8197	65501
5	8196	65500
4	8195	65499
3	8194	65498
2	8193	65497
1	8192	65496

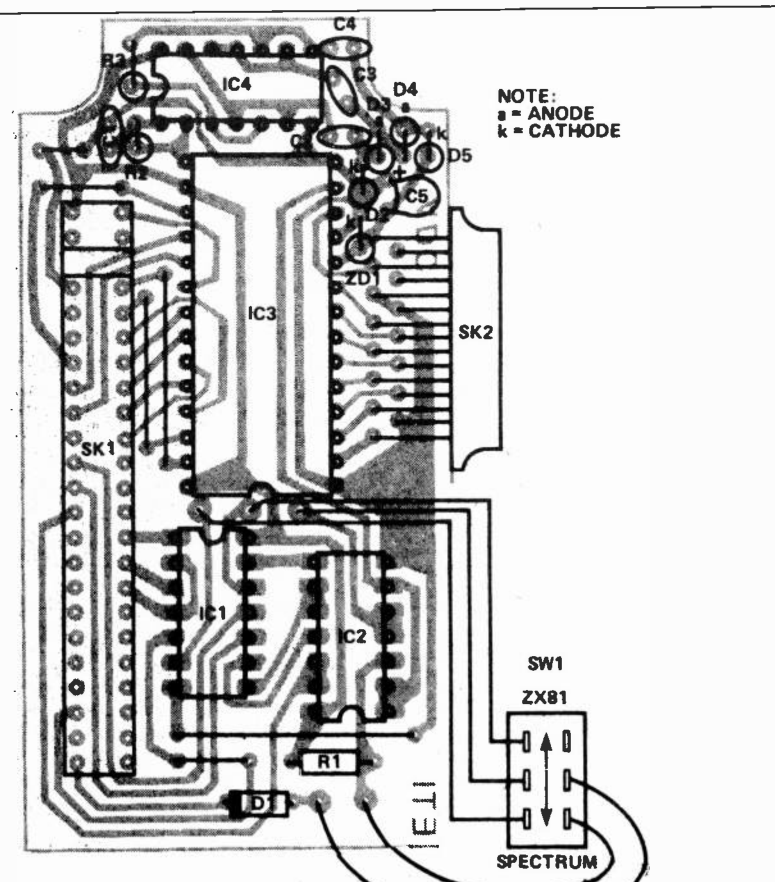


Fig. 6. Component overlay.

HOW IT WORKS

Figure 1 shows the complete circuit of the eight-channel analogue-to-digital converter. There are four separate parts to this circuit: the main converter device IC3, the master clock oscillator (a single CMOS gate), a negative voltage reference generator, and the address decoder. The 7581(IC3) is a complete eight-bit, eight-channel data acquisition system, designed for direct interface to microprocessor buses. The 7581 accepts eight analogue inputs and sequentially converts each input into an eight-bit binary word using the successive approximation technique. Results from the conversions are stored in an internal eight-bit eight-word 'dual port RAM'. The dual port RAM allows a microprocessor to access the analogue data independently of the internal updates; all the data acquisition is therefore transparent to the programmer. The analogue data appears to be permanently available in eight successive 'read only' RAM locations — you cannot write to these addresses.

The converter requires a master clock for its scanning logic and this is provided in our circuit by IC4a, a Schmitt inverter gate wired as a 1.6 MHz oscillator. Conversion of a single channel takes 80 clock periods, with a complete scan through all eight channels taking 640 clock periods. At 1.6 MHz this corresponds to 50 uS and 400 uS respectively.

The converter is wired in our circuit for simple unipolar conversion using a — 10 V reference supply. In this case the eight-bit word covers an analogue range of 0-10 V as illustrated in the transfer characteristic diagram of Fig. 2. The actual analogue input circuitry is shown in Fig. 4. An R-2R resistor ladder forms a multiplying DAC to perform the A-to-D conversion. Each input, including the reference input, has an impedance of about 20k. A status output is also available which allows an external device to identify which channel is being updated at a given moment: it provides a signal, synchronized to the master clock, which follows the scanning logic and pulses low for channel 0. The status signals as related to the master clock are shown in Fig. 5.

The reference voltage generator that provides — 10 V for IC3 is based on the voltage multiplier principle and allows a single 5 V supply to power the entire unit. The voltage tripler is constructed using CMOS Schmitt trigger inverters, and a capacitor-diode multiplier chain formed by C2-4 and D2-5. The inverters are connected as a self-oscillating ring running at several kilohertz to provide the AC square wave to the voltage multiplier. The tripler should give 15 V at the negative side of the smoothing capacitor C5 but due to diode and impedance losses this is reduced to about 12 V. The zener diode ZD1 is then used to clamp this voltage to the 10 V reference level.

IC1 and IC2 perform the address decoding and the slide switch SW1 selects either memory-mapped decoding for the ZX81, via IC1b, or I/O-mapped decoding for the ZX Spectrum, via IC1a. When the decoder is switched for the Spectrum, the states of the bus lines $\overline{IORQ}$ (I/O request), A5 (address bit 5), and $\overline{RD}$ (the read signal) are continuously monitored for logic lows. If they all go low together, then the Spectrum is performing an IN command, and the output of NOR gate IC1a will go high. This output is inverted by IC2a, which in turn takes the chip select pin of the converter (pin 13) to logic low. As the chip select goes low the data from IC3's internal memory (addressed by the three lower address bits A0, A1 and A2) is made available to the data bus for the read operation. Thus any of the eight-bit data words may be read at any time.

The rest of the gates in the decoder section are effectively ignored, and as far as the Spectrum is concerned, the A13, A14 and A15 inputs are connected to the wrong bus pins anyway.

When plugged into a ZX81, however, with the selector switch in its other position, these other gates become usefully active. With IC2c wired as an inverter, address bits A14 and A15 must be high and A13 low in order to take the output of IC1c to logic high: this means the second 8K address block is being selected. The output of IC1c is inverted by IC2d and fed to one input of IC1b, a NOR gate. The other two inputs of this gate monitor logic low states on the $\overline{MREQ}$ (memory request) and $\overline{RD}$ bus lines.

Thus the output of IC1b will only go high when the ZX81 is performing a memory read operation at a location between 8192 and 16383. The output of IC1b is fed to the chip select pin of IC3 via the selector switch and inverter as before. IC2b inverts and buffers the enable signal to drive the $\overline{ROMCS}$ line (linked via SW1b): consequently this line will go high through diode D1 whenever the interface is addressed and switch off the 8K ROM in the ZX81.

The 15 mA or so supply current for the TTL and CMOS is taken directly from the 5V supply rail on the ZX bus.

PARTS LIST

Resistors (all ¼W 5%)

R1	470R
R2	680R
R3	22k

Capacitors

C1	68p ceramic
C2-4	33n ceramic
C5	10u 16 V tantalum

Semiconductors

IC1	74LS27
IC2	74LS00
IC3	7581
IC4	40106B or 74C14
D1-5	1N4148
ZD1	10 V 400 mW zener

Miscellaneous

SW1	DPDT miniature slide switch
SK1	23-way double-sided edge connector
SK2	15-way right-angled PCB-mounting 'D' type socket
PCB;	case, etc.

ETI

Designer's Notebook

A new voltage regulator using a revolutionary IC fabrication technique has been introduced into the marketplace by National Semiconductor. It is the LM196/396, a 10 ampere adjustable voltage regulator in a TO-3 package. Though a bit pricey, it's cheaper and more reliable than adding current boosting circuitry to a 1.5 ampere regulator, and easier to install.

by Barry Davis

THIS NEW regulator has *all the protection features* that hobbyists have taken for granted in the lower power LM117/317 family. It is immune to blowout from excessive output current and all devices are 'burned-in' to guarantee the correct operation of the protection circuits under overload conditions.

The output voltage is adjustable over the range of 1.25 to 15 volts. *The maximum input-output voltage differential (V_{in} - V_{out}) is 20 volts,* and higher output voltages are possible providing that this parameter is not exceeded. A full load current of 10 amperes is available at all output voltages; however, the maximum power dissipation (70 watts) and the junction temperature must be watched closely. At a load current of 10 amperes, the maximum permissible V_{in} - V_{out} differential is 7 volts. Under these conditions the power dissipated is:

$$(V_{in} - V_{out}) \times I_{max} = 7 \times 10 = 70 \text{ watts.}$$

The features of the regulator are:

- 10 A guaranteed output current.
- 70 W maximum power dissipation.
- Adjustable output from 1.25 to 15 V.
- 100% burn-in thermal limit.
- Internal current power limiting.
- Input-output voltage differential is 20 V maximum.
- Dropout voltage is approximately 2.1 V.
- TO-3 Package.

The current limit and maximum power dissipation characteristics are shown in Figure 1a and 1b respectively.

Application Precautions

1. Heatsinking

The major limitation in the output current capability of the regulator is heatsinking. The regulator has extremely high power dissipation, 70 watts continuously, providing that the maximum junction temperature limit is not exceeded. These limits are:

LM 196 — -55°C to +150°C
LM 396 — 0°C to +125°C

Careful attention must be paid to *all* junction thermal resistances. A good heat-conductive paste *must* be used when mounting the regulator on the heatsink. The regulator must also be bolted down nice and tight. To ensure the selection of the correct heatsink, the procedure is as follows.

Calculate the *worst case continuous average power dissipation* in the regulator from the formula:

$$P = (V_{in} - V_{out}) \times I_{out}.$$

The voltage/current characteristics of the unregulated input must be accurate. A small change in input voltage can result in a large increase in the power dissipated by the regulator. For example, normal operating conditions are:

V_{out} = 10 V
V_{in} = 14 V
I_{out} = 10 A
P = (14 - 10) x 10
= 40 watts.

If the input voltage increases by 10% to 15.4 volts:

P = (15.4 - 10) x 10
= 54 watts

— *an increase in power dissipation of 35%.*

Therefore, the power supply circuit up to the regulator input (i.e., transformer, rectifier diodes, filter capacitor) plays an important role in the successful operation of the regulator itself. It should be built and tested to determine its average DC output voltage under full load with maximum input voltage. This circuit is shown in Figure 2.

The choice of C_F is also very important. At *high* current levels the capacitor ripple current (RMS) is two to three times the DC output current. If the capacitor has an equivalent series resistance (ESR) of 0.05 ohms, this can cause internal power dissipation (I^2R) of 20 to 45 watts at an output current of 10 amperes.

The life of the capacitor 'derates' with increase in operating temperature, and the choice of a small-value capacitor is asking for trouble (about 2000 *uF* is used for the LM 317 circuit). A value of some *2000 uF per ampere of load current*

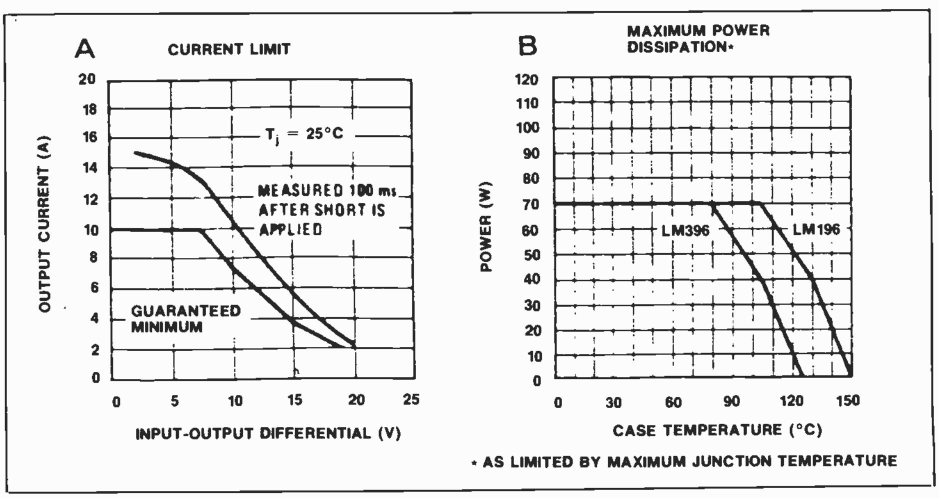


Fig. 1. Current limit and power dissipation.

Continued on page 29

HAMEG

20 MHz OSCILLOSCOPE HM203-4

Viewing Hoods — HZ47 $12.00

For HM203, HM204, HM605, HM705, HM808, HM312, HM412, HM512, and HM812

Scope Tester — HZ60 $63.75

The HZ60 provides a fast-rising (◄5ns) switchable 1kHz/1MHz square-wave generator for checking wide-band measuring amplifier systems and for probe compensation. Three BNC-outputs provide signals of $20mV_{pp}$, $0.2V_{pp}$ and $2V_{pp}$ ± 1%.

4-Channel Switch — HZ64 $585.00

Enables the simultaneous display of 4 individual signals or 2 sums or 2 differences of signal voltages on an oscilloscope. Channel switching can be selected for chopped or alternate mode. Each channel comprises a 12-step frequency-compensated input attenuator with 1 M ohm || 30pF input impedance. Sensitivity range 5mV — 20V/div.in 1-2-5 sequence. Bandwidth 4xDC-60MHz. Triggering (DC — 100MHz) is possible for each channel.
As an additional advantage, the input sensitivity of the oscilloscope can be increased by the 10x gain of the HZ64.

Component Tester — HZ65 SPECIAL $60.00

Indispensable for trouble-shooting in electronic circuits. Single component and in-circuit tests are both possible. The HZ65 operates with all scopes, which can be switched to X-Y operation (ext. horizontal deflection). Non-destructive tests can be carried out on almost all semiconductors, resistors, capacitors, and coils. Two sockets provide for quick testing of the 3 junction areas in any small power transistor. Other components are connected by using 2 banana jacks. Test leads supplied.

Examples of Test Displays:

Carrying Cases

For HM203-1 and HM203-3	HZ42	$66.00
For HM312, HM412, HM512, and HM705	HZ43	$48.00
For HM307, HZ62, and HZ64	HZ44	$39.00
For HM103	HZ45	$39.00
For HM204-4, HM204, and HM605	HZ46	$73.50

All prices are List. To order, send Certified Cheque or Money Order. Minimum order for post or C.O.D. is $25.00. All shipments are F.O.B. Downsview. Orders shipped within Ontario must include 7% Provincial Sales Tax. We accept VISA. Send card number, signature, expiry date along with name of bank.

VISA

Prices subject to change.

The already **excellent price/performance ratio** of the **HM203-4** has been improved even further. Both vertical amplifiers now incorporate **variable gain controls** and maximum input sensitivity is **2mv/cm** over the full bandwidth of the oscilloscope. Another new feature permits display of the **sum and difference** of two signals.

Triggering facilities have also been expanded. In addition to **line** and **TV** triggering, **HF** and **DC triggering** are now possible. The HM203-4 will **trigger** stably with a 5mm display height up to at least **40MHz**. Using the manual level control, even relatively complex signals can be stably triggered. An 8x10cm **internal graticule** permits **parallax-free viewing** over a wide angle. The effect of the earth's magnetic field upon horizontal trace position can be compensated for, externally, with a **trace rotation** control.

The **HM203-4** has a built-in **component tester**, which is especially useful in maintenance and servicing work. Among other applications, this device enables rapid, **in-circuit testing** of semiconductors. Test voltage and current are rated so that normal semiconductors or other components cannot be damaged. Test **results** are **displayed on the scope screen**.

The **HM203-4** was designed for **general purpose applications** in industry and service. Its many operating modes, front panel layout, and **ease of operation** also make it an ideal oscilloscope for use in training engineers and technicians.

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NEW

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MPF III

64K DYNAMIC RAM A full 64K of random access memory provides the power you need to store a wealth of data or run sophisticated programs. 20K of ROM is expandable to 24K to suit customer applications.

80 COLUMN VIDEO DISPLAY The standard 80 column display is double that of most personal computers. Upper and lower case characters can be simultaneously displayed. The display also features a screen editor with the capabilities to insert, delete, or clear the screen.

90 KEY ULTRASLIM DETACHABLE KEYBOARD Besides the conventional 56 main key layout, the MPF-III comes with a numeric keypad, special function keys and user function keys.

36 TONE SOUND GENERATION CHIP The MPF-III has a 36 tone sound generation chip that can be programmed according to your musical tastes. Sounds emmitted include piano, bell, gunfire, bombing or laser.

7 INTERFACES FOR A WIDE ARRAY OF I/O DEVICES The MPF-III has a standard 7 interface port configuration that gives you the ability to interface with disk drive, printer, cassette recorder, Z-80 CP/M card, Chinese character card and monitor or television.

3 EXPANSION PORTS FOR EASY EXPANDABILITY Designed with user flexibility in mind, the MPF-III offers 3 expansion slots for special user application.

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"MVM-12 12" Monochrome Video Monitor

Green $209.00
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* HIGH RESOLUTION 12" NON-GLARE SCREEN
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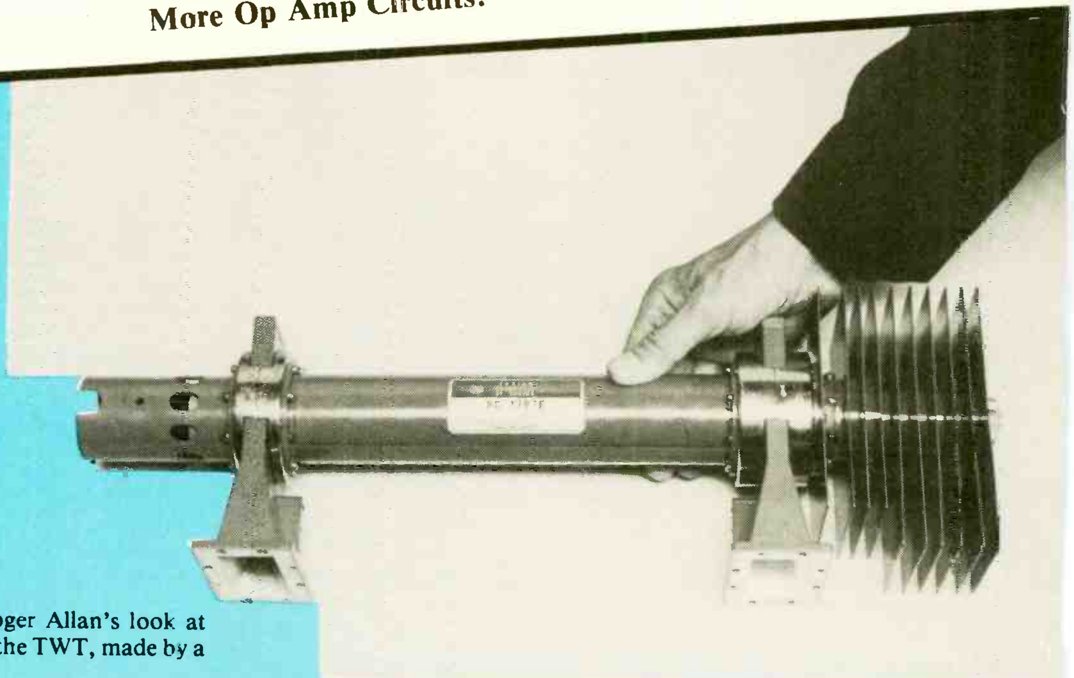


Travelling Wave Tubes

Travelling Wave Tubes
Delayed from last month, we present Roger Allan's look at one of the more exotic amplifiers around: the TWT, made by a specialist firm in Canada.

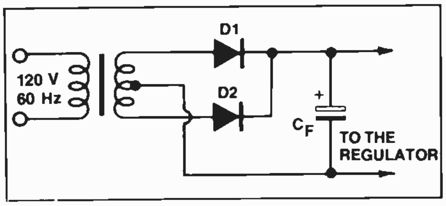


Fig. 2. Circuit prior to the regulator.

is the minimum recommended value. The large values of capacitor will have longer life and will also reduce the ripple level. This allows a lower DC input voltage to the regulator, which will result in savings in transformer and heatsink costs.

A further idea is to place several capacitors in parallel. This increases the capacitance, reduces the net series resistance and increases the heat dissipating area (by sharing it among the capacitors). Once the circuit in Figure 2 has been finalized and the average DC output voltage determined, the thermal resistance of the heatsink can be determined from the graphs in Figure 3, in degrees centigrade per watt (°C/W).

For conservative heatsinking, it is recommended that you choose T_A to be 35°C higher than anticipated.

The heatsink resistance generally falls into the range of 0.2°C/W - 1.5°C/W at a T_A = 60°C. These are *large* heatsinks such as Wakefield 423 or similar. These must be mounted for best convection cooling and could also be cooled by a fan.

2. Transformers

Correct transformer ratings are extremely important in high current supplies. If the secondary voltage is too high, power will be wasted and cause unnecessary power dissipation in the regulator. However, if the secondary voltage is too low, it may cause loss of regulation if the input voltage fluctuates excessively.

The following formula can be used to calculate the secondary voltage required using the circuit in Figure 2 (full wave centre tap).

$$V_{RMS} = \frac{V_{out} + V_{Reg} + V_{Rect} + V_{Ripple}}{\sqrt{2}} \times \frac{V_{Nom}}{V_{Low}} \times (1.1) \qquad (1)$$

1.1 is the factor accounting for load regulation of the transformer.
V_{out} = DC regulated output voltage.
V_{Reg} = Minimum V_{in} - V_{out}.
V_{Rect} = Voltage drop (forward) across the diode at 3 x I_{out}.
V_{Ripple} = Peak capacitor ripple voltage (½ p-p). i.e., $((5.3 \times 10^4) I_{out}) \div 2C$
V_{Nom} = Normal AC input (RMS).
V_{Low} = Minimum AC input (RMS).

The current rating required can be calculated from the formula:

$$I_{RMS} = I_{out} \times 1.2 \qquad (2)$$

Where I_{out} = DC output current.

Transposing formula (2) we can calculate the value of filter capacitor required:

$$C = \frac{(5.3 \times 10^3)\, I_{out}}{2 \times V_{Ripple}} \qquad (3)$$

The best way to appreciate these formulas in use is to calculate the values required for a power supply circuit. If we design a good mobile radio power supply, 13.8 volts at 10 amperes:

V_{out} = 13.8 V
I_{out} = 10 A
Assume V_{Reg} = 2.2 V, V_{Rect} = 1.2 V
V_{Ripple} = 2 V p-p, V_{Nom} = 120 V
V_{Low} = 110 V

Using formula (1)

$$V_{(RMS)} = \frac{13.8 + 2.2 + 1.2 + 1}{\sqrt{2}} \times \frac{120}{110} \times 1.1$$

$$= (18.2 \div \sqrt{2}) \times 1.09 \times 1.1$$

$$= 12.869 \times 1.09 \times 1.1$$
$$= 15.4 \text{ volts (RMS)}$$

Using formula (2)

$I_{(RMS)}$ = 10 x 1.2
= 12 amperes (RMS)

The transformer must therefore be 30 CT rated at 12 amperes. The centre tap will provide 15 volts secondary voltage for each diode.

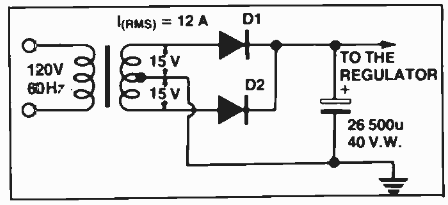


Fig. 4. Rectifier and filter circuit.

The size of the filter capacitor required can be calculated using formula (3):

$$C = \frac{(5.3 \times 10^3)\, 10}{2 \times 1} = 26500\ uF$$

The transformer, rectifier and filter circuit is now shown in Figure 4.

3. Diodes

The diodes used in the circuit must have a high DC current rating. The capacitor input filter draws high peak current pulses that are considerably higher than the average DC current. With a 10 ampere supply, the average current is 5 amperes. The current pulse's duration and amplitude result in a long-term diode heating of approximately 10 amperes DC. Therefore, the diodes should have a rating of at least 10-15 amperes. Also, the power supply may have to survive a short circuit and average current could rise to 15 amperes (see Figure 1a).

Another important factor in the choice of diode is the surge current at switch on. The peak *surge current* is about *10-20 times the DC output current* (i.e. 100-200 A for a 10 A supply). (Note: smaller transformers and filter capacitors may be used in lower current supplies. This will reduce the surge current; unless you are sure of the worst case surges, do not economize on diodes).

Stud-mounted diodes in a DO-4 or DO-5 package are recommended, such as IR 12F10B, IN3209 or 16F10 silicon rectifiers. Remember to choose the correct PIV for the type of transformer in use (PIV = $\sqrt{2}\, V_{Secondary}$).

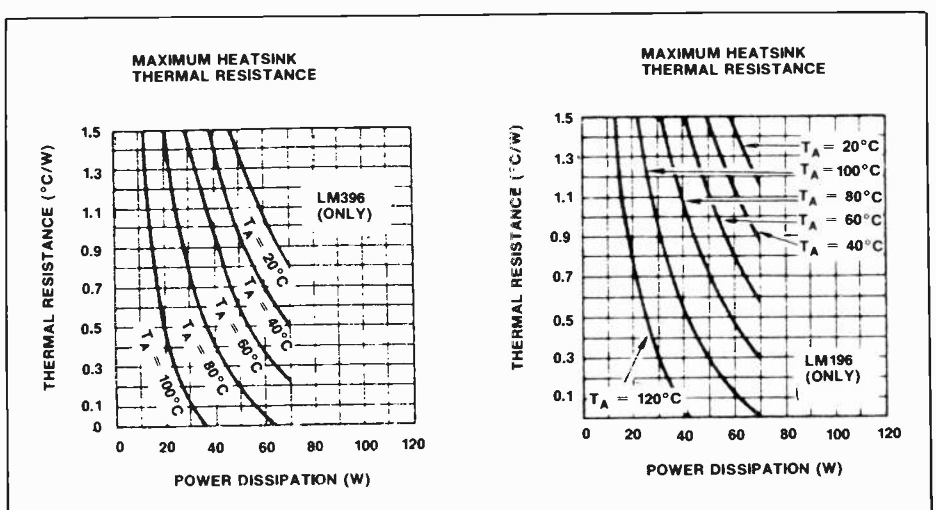


Fig. 3. Heatsink thermal resistance graphs (T_A = Ambient temperature).

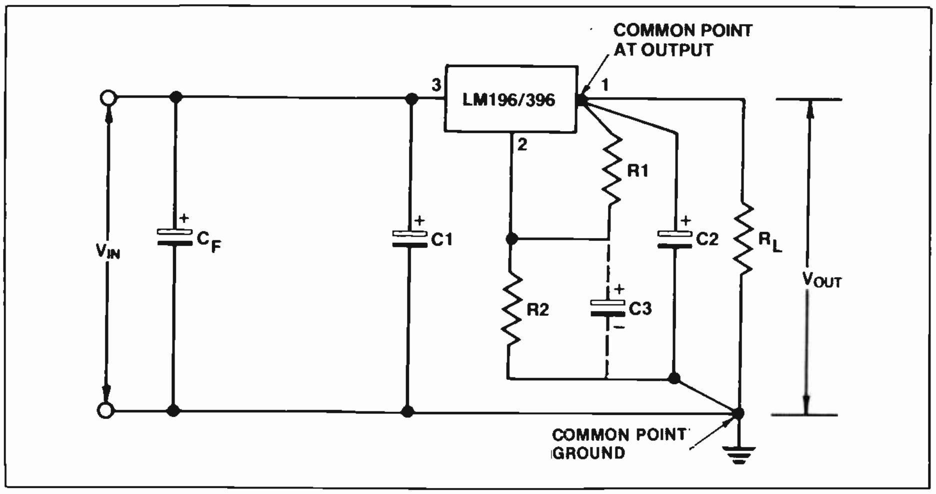


Fig. 5. Basic regulator, V_{out} = 1.25 (R1+R2)/R1.

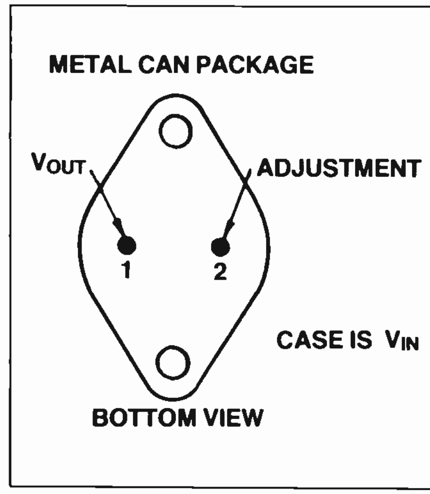


Fig. 6. Connection diagram.

4. Wiring
High load currents produce higher than normal voltage drops across the resistance of the wiring. It is suggested that 16-18 gauge wire be used for input and output connections, and that the length be kept to a minimum.

The two resistors used to set the output voltage level are connected:
1. directly to a common ground point and
2. directly to the output of the regulator as shown in Figure 5.

Components in Figure 5

C_F = Main filter capcitor 26,500 uF.

C1 = 4 *u* 7 tantalum. It is only necessary if the main filter capacitor is more than 150 mm away from the regulator. Connecting wire is 18 gauge or larger.

C2 = 4*u*7 tantalum. It is not absolutely necessary, but is recommended to maintain low output impedance at high frequencies.

C3 = 25*u*F. Improves ripple rejection, output impedance, and noise. (Capacitor C2 should be close to the regulator if C3 is used).

R1 = 120 ohms. It should be a wirewound or metal film resistor, tolerance 1% or better.

R2 = calculated to set V_{out}; the same type of resistor as R1.

The value of R2 can be calculated from the formula:

$R_2 = (V_{out} \div 1.25) \times R1 - R1$

Example:
V_{out} = 13.8 V
R1 = 120 ohms
R2 = (13.8 ÷ 1.25) x 120 - 120
= (11.04 x 120) - 120
= 1324.8 - 120
= 1204.8 ohms.

As stated earlier, the package is a TO-3 and the connections are shown in Figure 6.

The complete circuit can now be built, incorporating Figures 4 and 5. The circuit diagram of the final 13.8 V 10 A power supply is shown in Figure 7.

Component Values for Figure 7

T = 30 V CT at 12 amperes.
D1 = 16F10 DO-4 case.
D2 = 16F10 DO-4 case.
CF = 26500 uF 40 V (ideally, capacitors in parallel).
C1 = 25 uF 16 V.
C2 = 4u7 tantalum 16 V.
R1 = 120 ohms 1% metal film.
R2 = 1k2 1% metal film.
Reg = LM396 on a 6" heatsink.
V_{out} = 1.25 ((R1 + R2) ÷ R1)
= 1.25 ((120 + 1200) ÷ 120)
= 1.25 x 11
= 13.75 volts

A highly desirable situation would be to reduce the power dissipated by the regulator. This can be achieved by supplying part of the output current around the regulator as shown in Figure 8.

Resistor R3 is selected to supply a portion of the load current. In this case a *minimum load must always be maintained.* This prevents the regulated output from rising uncontrolled. The value of R3 must be greater than:

$$\frac{V_{max} - V_{out}}{I_{min}} \text{ ohms}$$

Where: V_{max} is worst case high input voltage.
I_{min} is the minimum load current.
Power rating must also be considered and R3 must be rated at a minimum of:

$$\frac{(V_{in} - V_{out})^2}{R3} \text{ watts}$$

This circuit configuration will reduce the regulator power dissipation by a factor of 2 to 3, if the minimum load current is about 50% of the full load current.

Precautions When Using R3

1. The power rating of R3 must be *increased* to $(V_{max})^2 \div$ R3 watts if continuous output short circuits are at all likely.
2. Under short circuit conditions, the *overall circuit* power dissipation increases by $(V_{in})^2 \div$ R3 watts.

The regulator and R3 will not be harmed (if R3 is the correct wattage), but the circuit components prior to the regulator (diodes, transformer) must be able to withstand the overload condition (i.e., the power rating is sufficient to handle the excess current).

The only problem with this technique is the large power rating required for resistor R3. If $V_{in} - V_{out}$ = 7 volts, and R3

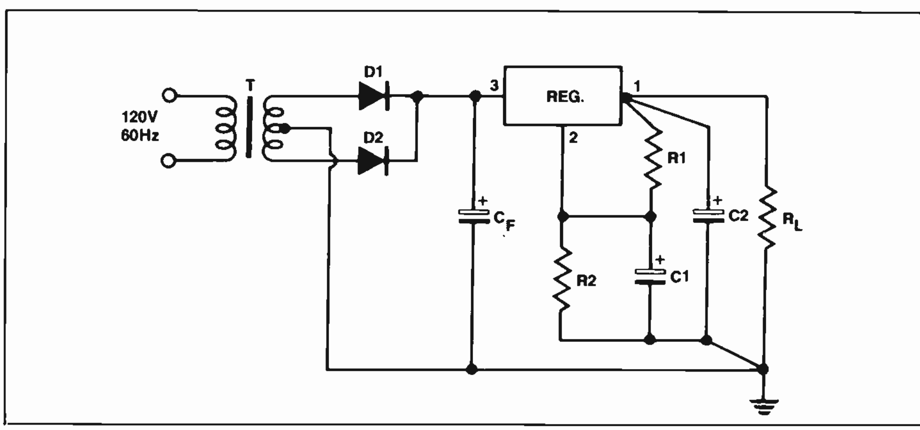


Fig. 7. A 13.8 volt 10 ampere power supply.

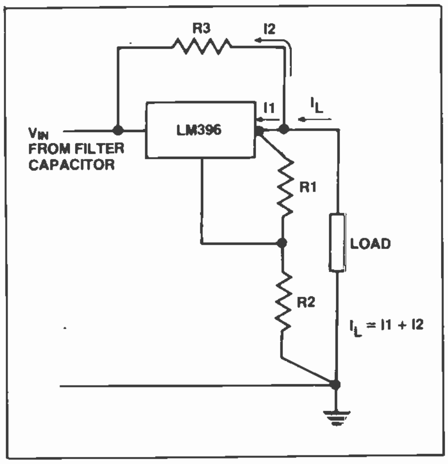


Fig. 8. Reducing regulator power dissipation.

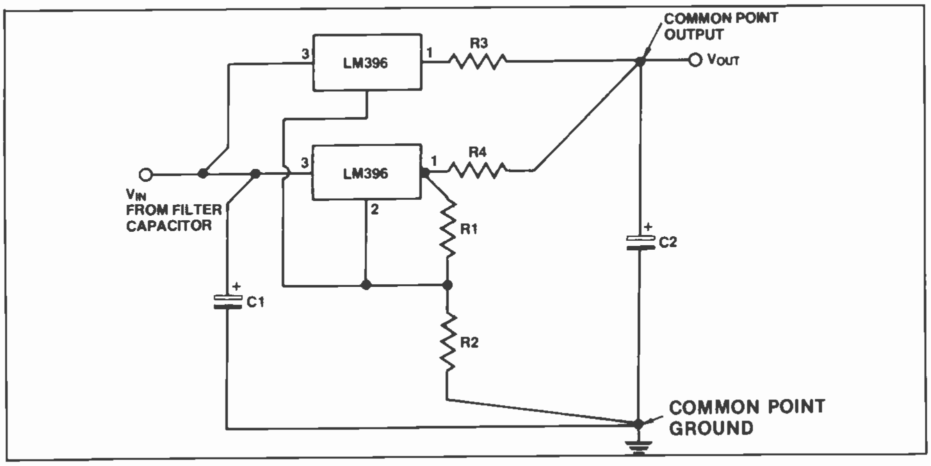


Fig. 9. Quasi-parallel regulators: R1 = 120 ohms; R2 chosen to set V_{out}; R3,R4 = 0.015 ohms; C1 = 4u7 tantalum; C2 = 100uF.

= 2 ohms, the power dissipated by the resistor is:

$7^2 \div 2 = 24.5$ watts

with 3.5 A of current passing through it.

High Current Output

Placing regulators in parallel is not recommended because they may not share the current equally. The regulator with the highest reference voltage will handle the highest current up to the time it current limits. Therefore, one regulator may be flat out handling 16 A, while the other is cool and calm passing only 2 A. Reliability cannot be guaranteed under these conditions because of the high junction temperature of regulator one.

However, if load regulation is not critical, the regulators may be connected quasi-parallel, as shown in Figure 9. This circuit will share current to within 1 ampere, and in the worst case, 3 amperes. However, the payoff is in the load regulation. It is degraded by 150 mV at 20 ampere loads, compared to about 20 mV with 10 ampere loads. This should not cause too much of a problem in higher voltage power supplies.

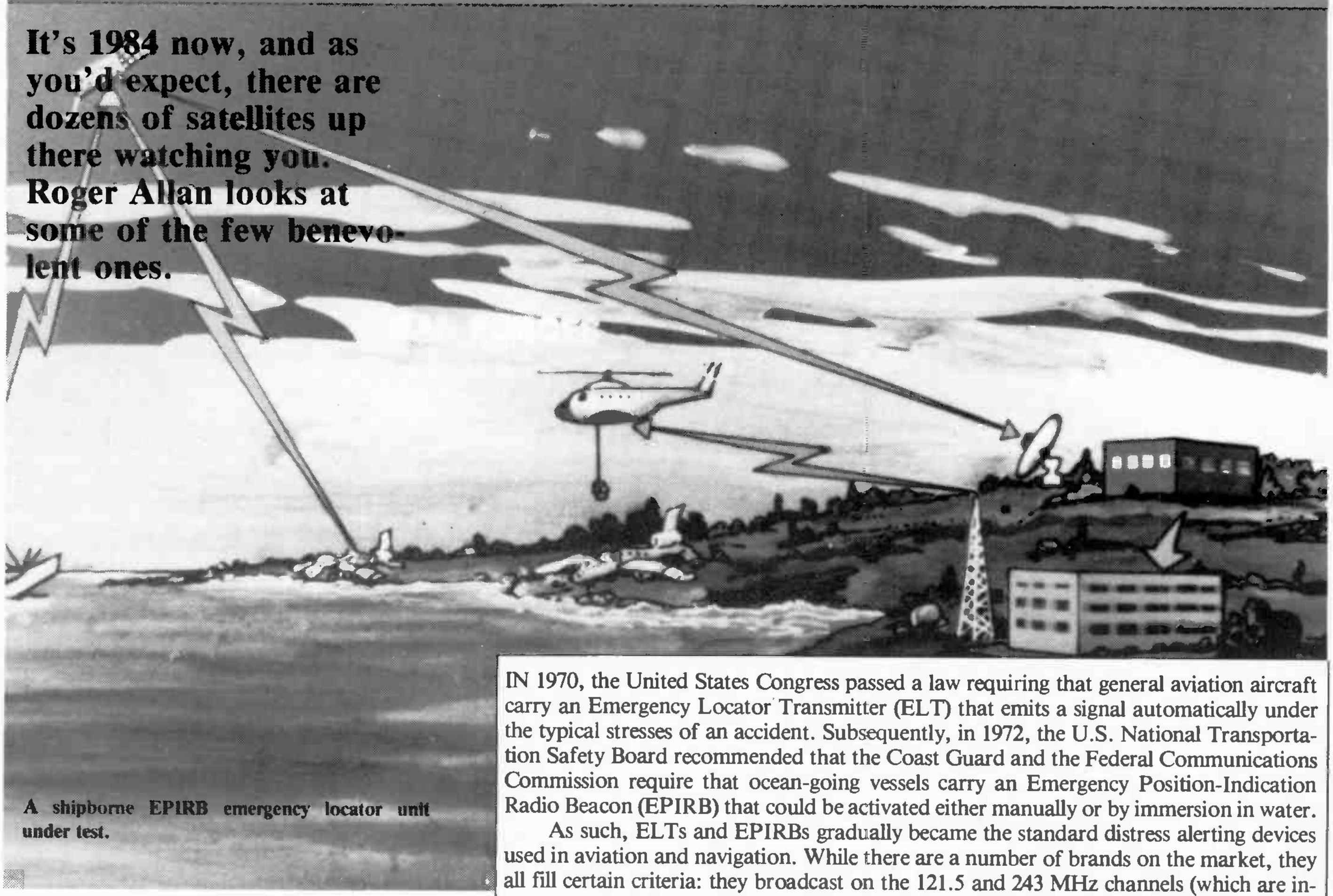
Acknowledgement

This article was made possible by the courtesy of National Semiconductor. Data and basic circuits were taken from their publication 'LM196/LM396 10 Amp Moose Adjustable Voltage Regulator'.

ETI

Cospas/Sarsat

It's 1984 now, and as you'd expect, there are dozens of satellites up there watching you. Roger Allan looks at some of the few benevolent ones.



A shipborne EPIRB emergency locator unit under test.

IN 1970, the United States Congress passed a law requiring that general aviation aircraft carry an Emergency Locator Transmitter (ELT) that emits a signal automatically under the typical stresses of an accident. Subsequently, in 1972, the U.S. National Transportation Safety Board recommended that the Coast Guard and the Federal Communications Commission require that ocean-going vessels carry an Emergency Position-Indication Radio Beacon (EPIRB) that could be activated either manually or by immersion in water.

As such, ELTs and EPIRBs gradually became the standard distress alerting devices used in aviation and navigation. While there are a number of brands on the market, they all fill certain criteria: they broadcast on the 121.5 and 243 MHz channels (which are internationally reserved for distress signals), are small, lightweight, shock resistant, self-energizing and are capable of operating for 48 hours of continuous broadcasting. To date, more than a quarter of a million have been installed.

However, to be successful, the distress signal must be received. While the International Civil Aviation Organization requires aircraft on long haul flights over water to monitor the emergency frequencies, the power of the ELTs and EPIRBs, plus the basic geometry of the earth, dictate that the aircraft receiving the signal must be in the line of sight of the distress situation. Specifically, this means that the aircraft must be within 300 km at most from the problem. Further, there was no requirement to monitor such signals over land, which meant (in the case of, for instance, a downed aircraft), the distress situation had to occur either on the perimeter of the airfield itself or within line of sight of the airfield's control tower. Not very usable.

International Accord

Recognizing this, the National Aeronautics and Space Administration (NASA) began exploring the possibility of using satellites for picking up distress signals. Concurrently, the Canadian Department of Communications (DoC) was conducting similar studies, arriving at the same conclusions as the Americans. As both the U.S. and Canada had similar problems in determining distress locations, they joined efforts under the SARSAT program in 1976. This was further expanded in 1977 when the French Centre National d'Etudes Spatiales joined, and later in 1980 by the Soviets. Subsequently, Britain and Norway have become party to the effort, with Finland and Bulgaria considering membership. The program is now divided into two complementary parts, one run by the western allies under SARSAT, and the other by the Soviets under the designation COSPAS. But first the problem.

The objective of the SARSAT project was to achieve international co-operation in search and rescue missions by demonstrating that equipment carried on satellites in low-altitude, high inclination (polar) orbits could greatly improve the detection and location of distress signals.

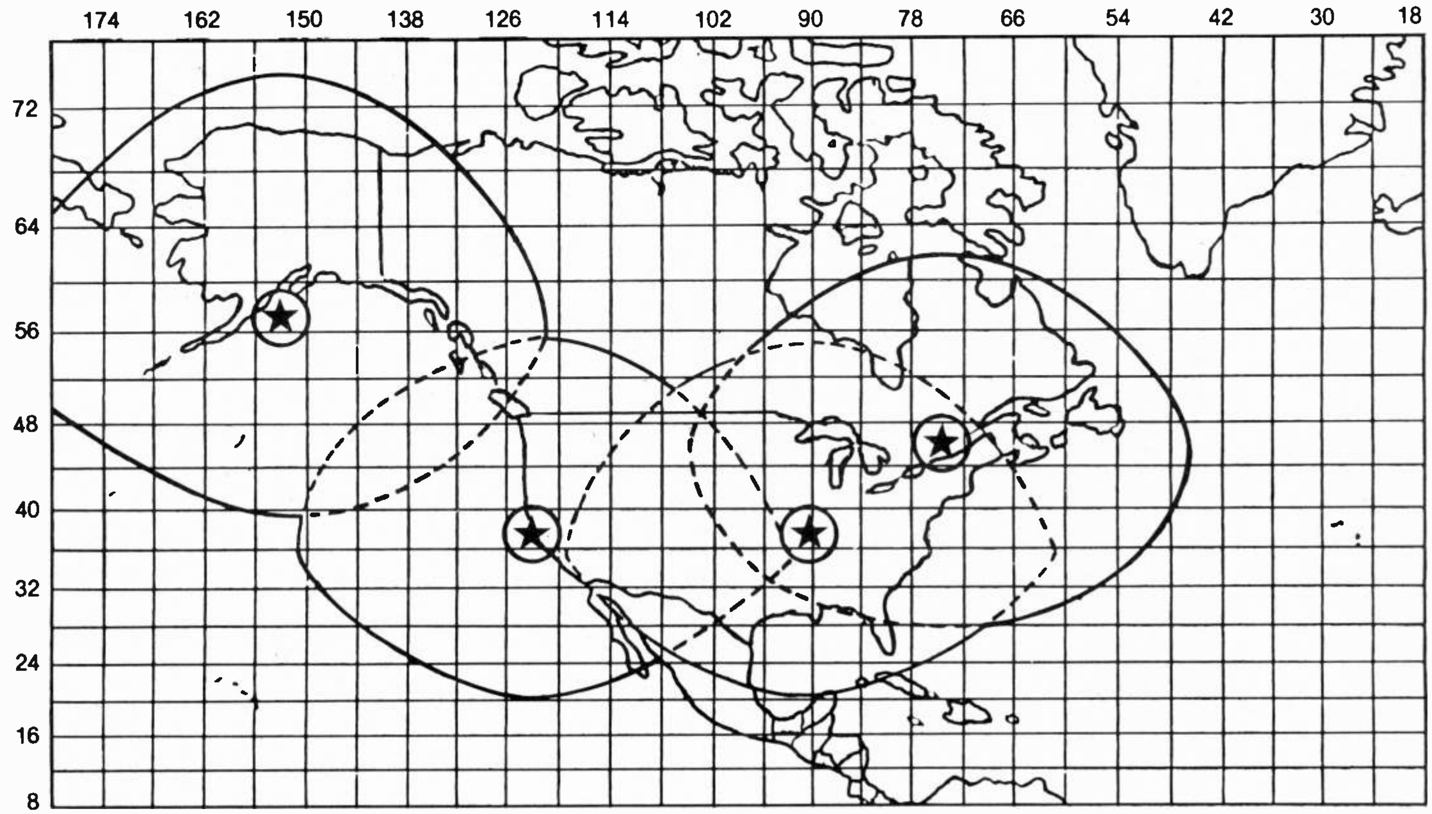
There are two segments to the project: space and ground. In the space segment, two "guest" instruments are to be placed on three spacecraft of the Advanced TIROS-N (ATN) series of National Oceanic and Atmospheric Administration's operational environmental satellites. These are better known as NOAA satellites with #8 bearing the first of the "guest" instruments having been launched in March of 1983. The first of the "guest" instruments is a SARSAT repeater, which will relay distress messages for ELTs and EPIRBs now in use directly to earth, thus providing regional time coverage. The second "guest" instrument, the data processor, will provide global as well as regional coverage for an advanced ELT/EPIRB design. In the ground station component, pick up stations are maintained in Ottawa, Canada; Scott Air Force Base, Illinois (run by the U.S. Air Force); at Point Ryes, California and Kodiak, Alaska (run by the U.S. Coast Guard); at Toulouse, France; at Tromso, Norway and at Lasham, England. These ground stations are known as Local User Terminals (LUTs).

The system concept behind this initial usage of ELTs and EPIRBs is quite straight forward. As the satellite passes over the emergency transmitters it perceives a Doppler shift. When the satellite approaches a transmitter it receives a frequency higher than that being transmitted, when the satellite is directly overhead the frequency is identical, and when the satellite is leaving the transmitter site the frequency becomes lower. Heard over a set of headphones, the sound is a distinct "whooping" noise. With a given pass of the satellite over an emergency transmitter, the Doppler data is recovered as an S-shaped curve of frequency versus time. The shape and slope of the Doppler curve, together with the location of the satellite at each point of the Doppler curve, are used to locate the emergency transmitter site. Because the satellite is in low altitude orbit passing over the North and South poles, it "sees" the entire earth in a 12 hour period. As such, an operational SARSAT system comprised of four satellites could detect a distress signal anywhere on earth within a few hours of it first being sent. The accuracy is approximately a radius of 20 km. Regretably, however, there are a very large number of false alarms — some 97% of all received messages. This is primarily due to the ELTs and EPIRBs being inadvertantly switched on without the pilot or skipper realizing it.

> **"A SARSAT system comprised of four satellites could detect a distress signal within a few hours with an accuracy of 20 km."**

Higher Technology

With the recognition that the power and frequency of the current ELTs and EPIRBs were not designed for transmission to satellites, but rather for line-of-sight to terrestrial pick-up devices, a second system is being developed and tested. It consists of increasing the ELT/EPIRB power and changing the frequency to 406 MHz, along with a coding of the message. The higher power will provide a more reliable link to the satellites, as well as providing a longer (100 hour) duration of signal transmission. The coding will inform the rescue forces of the type and identification of the distress "vehicle", and the nature of the distress. This change to 406 MHz has another advantage — the technology is proven, having been used for years for meterological recording, while the previous 121.5/243 MHz system was untried before being introduced on a mass scale.



North American SARSAT coverage.

The new system has other useful features. It will operate by transmitting for 440 milliseconds, then remain silent for approximately 50 seconds before repeating. The silent interval is changed slightly every cycle as insurance against two beacons repeatedly transmitting at the same instant. As such, between 200 and 400 distress signals can be determined simultaneously. Additionally, the coherent carrier portion of the transmission can be processed by an on-board signal processor which can accurately determine its frequency. This frequency wording, along with the decoded message, can then be stored in memory on the spacecraft and dumped to the next available LUT (when it comes within line of sight range). This not only greatly simplifies the LUT operation, but also eliminates the requirement for mutual visibility of the spacecraft and the LUT while the distress is taking place. Thus, full global coverage can be achieved with a relatively small number of low cost LUTs (approximately $650,000 each).

The Canadian connection is quite strong in this project. Spar Aerospace, in Montreal, is designing and building the NOAA spacecraft's 121.5/243 MHz and 406 MHz beacon signal and down-link L-band (1.5 MHz) transmitters while Canadian Astronautics in Ottawa is designing and building the extremely sophisticated digital processing and correlation processors.

Back Over the USSR

The Soviet involvement is complementary with the SARSAT operation. Known as COSPAS, the first operational vehicle was launched in June of 1982, nine months before the first NOAA satellite, with COSPAS II launched in March 1983, the same month as the first NOAA. Known as Cosmos 1383, the first satellite operates similarly to the SARSAT methods, but retransmits distress beacon signals only at 121.5 MHz, not at 243 MHz. To avoid technology transfer issues, the Soviets were provided only with operational requirements and they performed the required equipment designs themselves. They opted to install their COSPAS payload on one of their Transit-type navigation satellites, which is sufficiently power-limited that it cannot function as both a COSPAS (SARSAT) and a NAVSAT simultaneously. This means that the COSPAS functions could someday be preempted if the Soviets should need Cosmos 1383 to replace a failed NAVSAT.

COSPAS II (Cosmos 1397) broadcasts the processed 406 MHz and 121.5 MHz signal on the L-band using a transmitter output of 4 watts. The Spar-built transmitter on NOAA 8 radiates 8 watts to enable it also to transmit the 243 MHz signal and the unprocessed broadband 406 MHz signal. The unprocessed 406 MHz signal is transmitted to enable scientists to check the performance of the on-board signal processor and would

Satellite Scorecard

Since the first COSPAS/SARSAT system was placed in space a number of people have been rescued using the system, a fair number of them Canadians. For example:

— in September 1982 a Cessna 172 went down in British Columbia carrying three persons. Cosmos 1383 led rescuers to within 22.5 km of the downed aircraft.

— later in the same month a private plane went down 160 miles north of Montreal. One person died, one survived. Rescuers reached the scene 2½ hours after picking up the COSPAS signal.

— in February 1983 a ski-equipped Piper Super Cruiser on a round robin flight out of Hudson Hope, British Columbia went down in northern British Columbia with two persons on board. When reported overdue by Canadian officials, the ELT signals were picked up 2 hours later. A helicopter rescued the party the next day. They were not injured, but suffered from frostbite.

— later in the same month a Jet Ranger helicopter belonging to an oil company went down at sea off Newfoundland. Cosmos 1383 picked up signals on two passes, resulting in a company search party locating the chopper and pilot 2 hours later.

— in March 1983 a Cessna 183 went down near Sept Isle, Quebec, with one pilot and no passengers. French, Canadian, and U.S. stations picked up the COSPAS signal, and the pilot survived.

To date, some forty persons owe their lives to the system.

not be needed in a later operational version.

The Soviet COSPAS II system offers an operational advantage over the NOAA version. To minimize modification to the NOAA satellite design (it initially being designed for meterological purposes, with the SARSAT payload being added later as a "guest" instrument) and to decrease the weight of the SARSAT payload, the 406 MHz beacon data is stored on the same tape recorder used to store meterological data. It can therefore only be read out when the satellite is within range of a NOAA ground terminal. The Soviets have opted to provide a separate solid-state memory storage for the 406 MHz beacon data, which can be read out whenever COSPAS passes over a SARSAT or COSPAS local user terminal. The Soviets have three ground stations, at Moscow, Archangelsk, and Vladivostok. To date, their system is credited with saving fifteen lives, while the NOAA is credited with saving 28. The discrepancy is primarily due to the larger number of private aircraft and boats in the western world, each of which can potentially get into trouble.

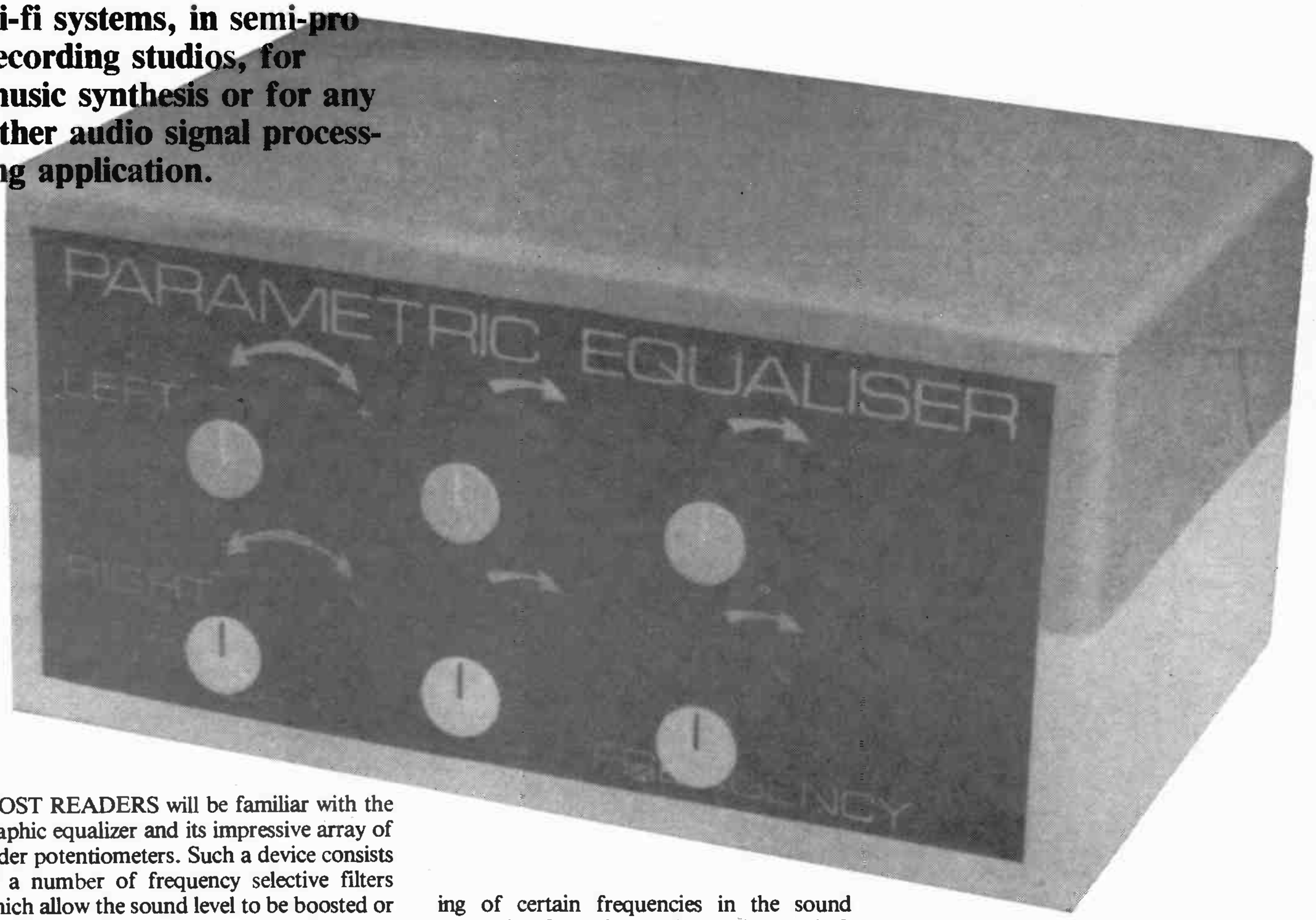
It is felt that by the end of the decade, when all the crinkles have been worked out of the system, and all ELTs and EPIRBs have been converted to the 406 MHz frequency, that a world wide, all weather emergency pin-pointing system will be in place, with an accuracy of 2 km.

The first Canadian satellite rescue, a downed Cessna in British Columbia, September 1982. ETI

Para-Q

PROJECT

A stereo parametric amplifier that can be used with hi-fi systems, in semi-pro recording studios, for music synthesis or for any other audio signal processing application.



MOST READERS will be familiar with the graphic equalizer and its impressive array of slider potentiometers. Such a device consists of a number of frequency selective filters which allow the sound level to be boosted or cut at specific frequencies. The 'graphic' part originates from the fact that the knobs of the slider pots give a graphical display of the way its frequency response has been set up. It is intriguing to notice how such units have been set up by their users and one of the most interesting seen recently had a 'V' shape on each channel which attenuated those frequencies to which the ear responds best and so effectively reduced 'loudness': the unit was connected to a tape recorder providing background music!

While a graphic equalizer can be useful, especially if it has a large number of filters, it does have two main deficiencies. In the first place, one of its objectives is to correct for deviations from a flat audio response, but nowadays even a modest hifi system will give good results, with the main deviations being caused by location of the sound system. That is, a comfortable living room will often cause absorption or boosting of certain frequencies in the sound emanating from the speakers. The usual effect is a frequency response curve displaying just two or three peaks or troughs, at least over the range 50Hz to 15kHz (the fall off outside this range is invariably due to the speakers). The first difficulty with a graphic equalizer which has relatively few bands is that the centre frequency of the filters will not correspond with one of the peaks or troughs you wish to correct. In these circumstances attempted correction may make matters worse.

The second difficulty is that the peaks and/or troughs are often very sharp, that is, the defect in the response only occurs over a fairly narrow band of frequencies, whereas a graphic equalizer generally boosts, or cuts, a wide range of frequencies. The latter is due to the need to set the 'Q' (quality factor) of the filters so that the gain of adjacent channels overlap. Trying to eliminate a sharp peak with a wideband filter can easily result in two troughs in the frequency response — again worsening matters.

A parametric equalizer overcomes the above deficiencies since it has the capability for adjusting both the frequency and Q over a large range, as well as having the gain control. Furthermore, in most situations the performance of a sophisticated graphic equalizer may be exceeded by two or three parametric equalizers per channel and even the stereo unit described in this article will yield very useful results.

The parametric equalizer described is a high performance unit suitable for use with even the most exotic hifi system. The prototype had a boost and cut range from zero to just over ± 20dB; a Q variable from 1 to 25; and a frequency range of 50Hz to 11kHz. The Gain and Q measurements were made at 1kHz but uniformity of response is good over the full frequency range. The latter range is ideal for most audio applications since one rarely wishes to treat frequencies below 50Hz, and an 11kHz top level reduces the risk of damaging tweeters if the equalizer is set to high boost at high frequencies (unless it is correcting for a trough in the response). The frequency range may, however, be easily altered as described later.

A high gain, high-Q parametric equalizer is particularly useful for 'correcting' recordings, and the most common alterations are boosting frequencies deficient in the original and cutting out an unwanted frequency, eg. a noise originating from one of the instruments.

Such equalizers are also ideal for electronic music applications. Firstly, for imitative synthesis it may be used as a so-called formant filter; that is, to boost a band, or bands, of frequencies which are characteristic of the instrument being simulated. These equalizers are now often used as an effects unit since the tone changes they can introduce are quite dramatic, especially at high gain levels.

Circuit

The complete circuit diagram for one channel of the parametric equalizer is shown in **Figure 1.** The key feature of the equalizer is a band pass filter which is constructed around ICs 3a, 3b, and 3c, arranged in what is known as a 'state variable' configuration. The band pass output is available at the output of IC3c and the centre frequency of the filter is governed by the integrating capacitors C7 and C8, plus the resistance provided by the ganged potentiometer RV3. With 1n5 capacitors the frequency range is 50Hz to 11kHz and this range may be altered by changing both C7 and C8. For example, if they are substituted by 1n, the frequency range would be 75Hz to 16.5kHz, while 2n capacitors would give a range of 35Hz to 7.5kHz.

Going back to the input stage, the main input is AC coupled to IC1, which is simply a buffer stage primarily to provide a low impedance to the gain control, RV1; R1 sets the input impedance of the circuit. The signal then passes to the output via the unity gain amplifier IC2 and, if switch SW1 is closed so as to ground the non-inverting input of IC2, the filter section will not have any effect.

The input to the filter is via RV1, one end of which is connected to the original non-inverted signal at the output of IC1 while the other end of the potentiometer connects to the inverted signal at the output of IC2. The signal input to the band pass filter comes from the wiper of RV1 while RV3 determines which frequency components are passed by the filter and fed back into the non-inverting input of IC2. Thus, if the wiper of RV1 is closer to the output of IC1 (the original signal), more of the selected frequency band of the original signal becomes added (boosted) onto the original signal at IC2. Likewise when RV1's wiper is close to the output of IC2 the effect will be to subtract (cut) the original signal in IC2. The effect is the same as a conventional graphic equalizer but the ability to adjust the frequency over the full range is a major advantage. Typical outputs with boost and cut are shown in **Figure 3.**

The other feature that has to be incorporated into a parametric equalizer is a variable Q; the higher the Q the more peak-

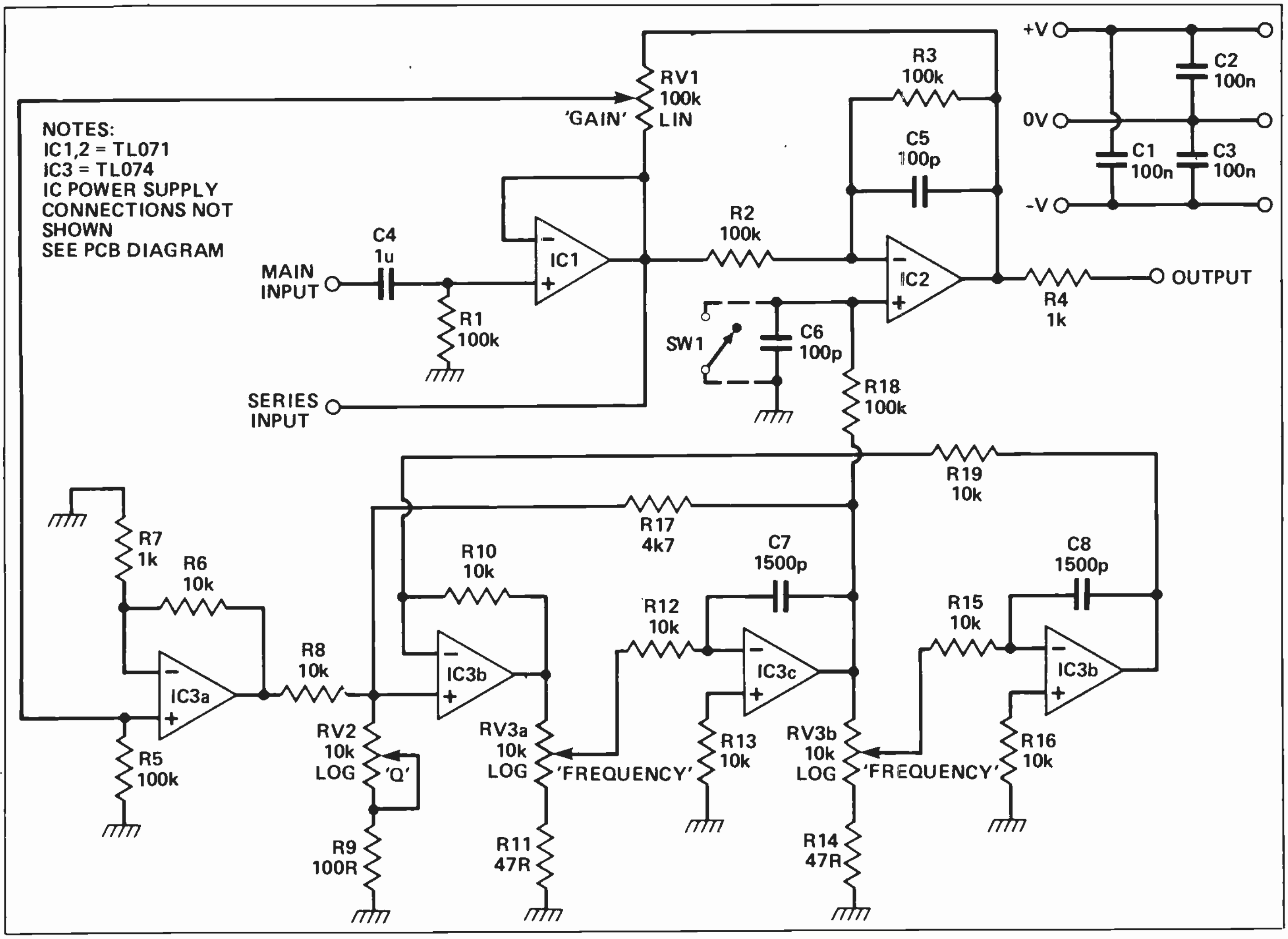


Figure 1. The circuit shown above is for one channel of the stereo pair. Switch SW1 is an optional bypass for the channel; several other modifications which alter the characteristics of the equaliser are described in the text.

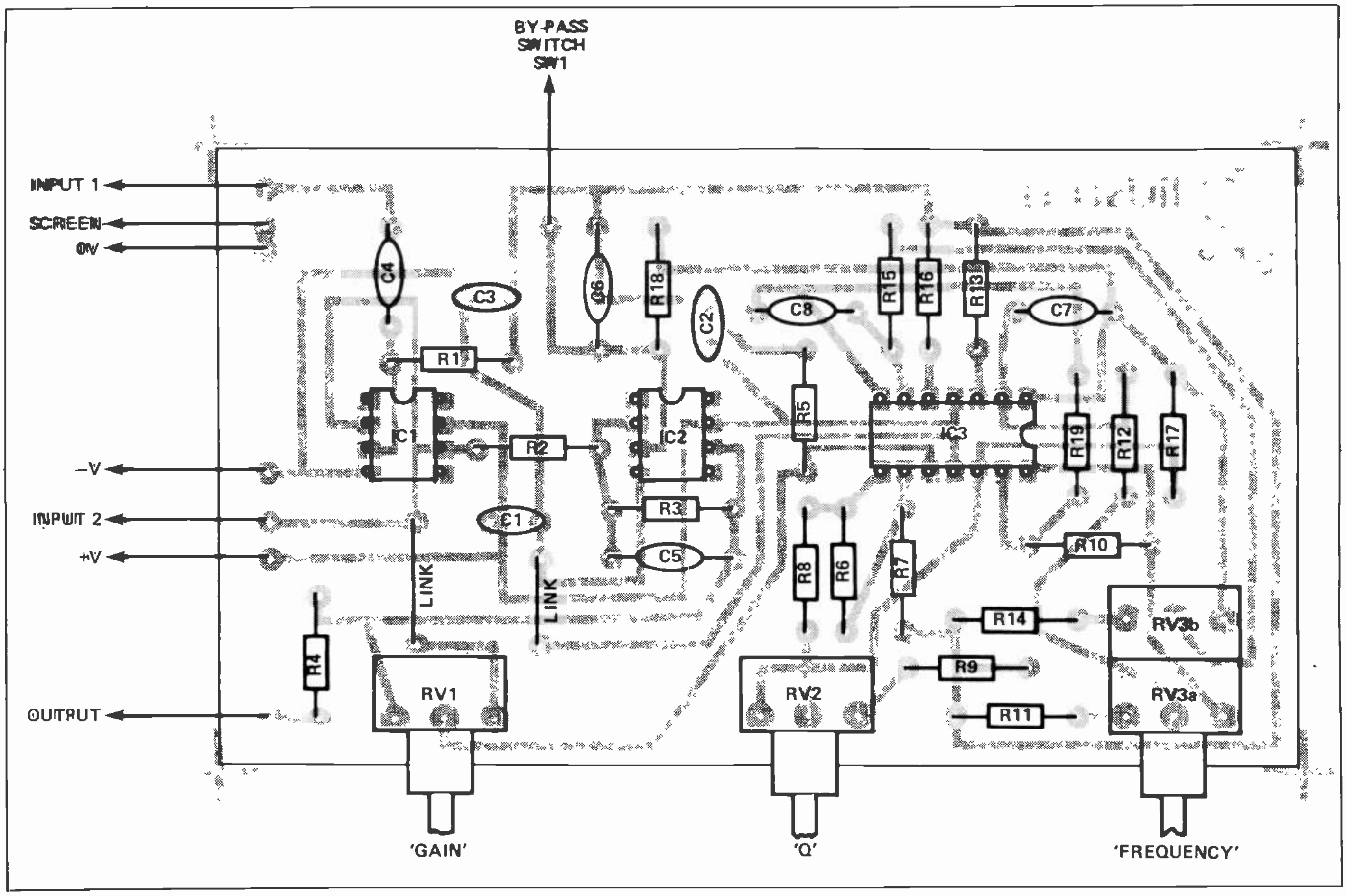


Figure 2. The printed circuit board accommodates the components for a single channel of equalisation. Two boards are required for the full stereo facility (see internal picture, next page) or any number can be connected in series using the series input (labelled input 2 in the diagram above).

ed the response from the filter. Increasing Q is obtained by increasing the amount of feedback and one of the main reasons for choosing a state variable filter is to obtain a high Q without causing the filter to oscillate. In the absence of RV2 and R9 the Q of the circuit would be determined by the ratio of R8 and R17 but altering these resistors would also alter the gain of the circuit unless the design is altered and dual potentiometers are incorporated to alter both resistor values. This problem is overcome by increasing the gain prior to R8 and then varying Q by attenuating the feedback signal using RV2.

Construction

All components, including the potentiometers, are mounted onto a printed circuit board and the component overlay is shown in **Figure 2.** The latter makes assembly about as simple as one can get for such a project, but there are several options available to the user which are discussed below.

Power Supplies. The parametric equalizer requires dual power supplies, and these can be anything from ±9V to ± 15V. At ± 15 volts the power consumption is about 12mA per rail per unit, and so the project would be suitable for battery operation. In the latter event a power switch should be fitted to conserve battery power when not in use, and one should also put a filter capacitor, say 47uF, across the supply lines. For a single, or stereo unit, an alternative is to pick up dual supplies from some other equipment. Lastly, one could incorporate an AC supply into the case, but if this option is used then carefully check the siting of the transformer before finalizing the lay-out since the filters may pick up and amplify the transformer 'hum'.

By-Pass Switch. A single pole, single throw switch may be connected from the points in **Figure 2** marked 'by-pass switch, SW1' and 'OV'. When the switch is closed the non-inverting input of IC2 is grounded and the original signal will pass through the equalizer unaffected by the settings of any potentiometers. This facility may be useful when using the unit in a hifi chain, since the effect of the settings may then be rapidly checked by switching SW1. The by-pass arrangement is also useful when the parametric equalizer is used as an effects unit for music. One switch may be used for several equalizers housed within the same case or the user may use a switch for each unit so that the effect

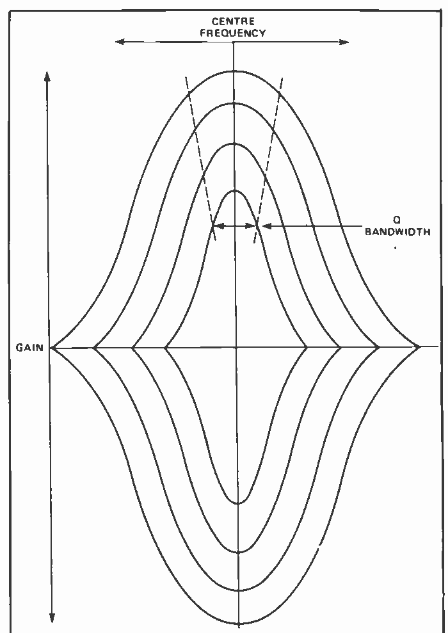


Figure 3. Much as this may look like Mick Jagger's lips, this is actually a graph of the Para-Q's response curves. Gain, Q and centre frequency can all be adjusted.

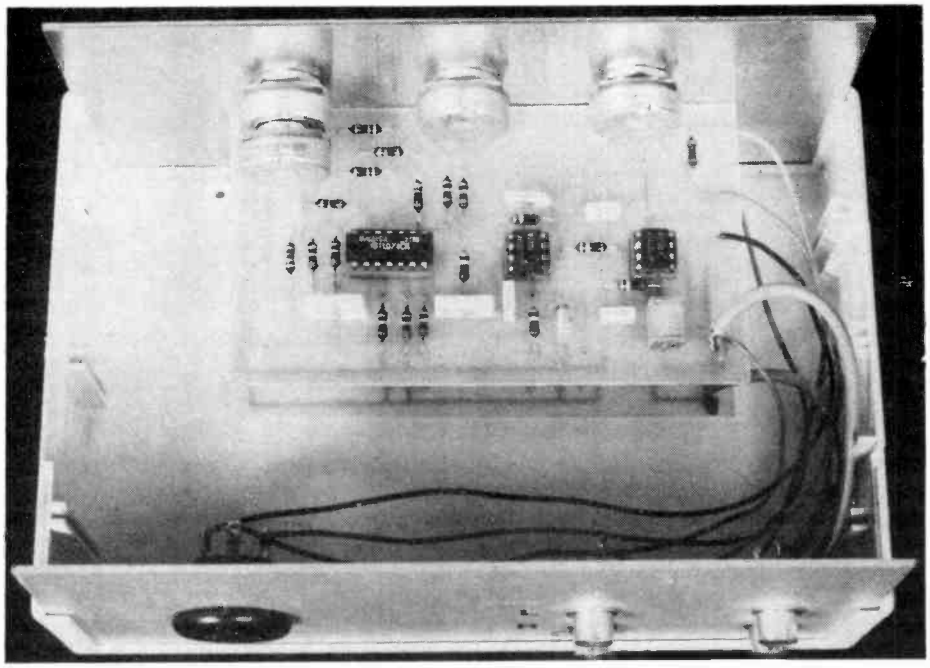


Table 1

Power Supply	Max Signal Input
±9V	400mV
±12V	530mV
±15V	700mV

of single units may be rapidly checked.

Number of Equalizers and Connecting Up. If a single equalizer is used in each signal path then the channel input connects to the point on **Figure 2** marked 'Main Input'; screened cable is preferred, with the screen going to the point marked 'screen' on the PCB overlay. The input socket(s) may be of any type to suit the user, for example, phono sockets, DIN socket, or jack sockets. The output is of low impedance and need not be screened within the housing of the equalizer, ie. from the point marked 'output' on the overlay to the output socket.

As already mentioned, three parametric equalizers will usually be more effective in a hifi system than a ten, or more, channel graphic equalizer. If more than one unit is connected up per channel then they are connected in series. The signal to the first unit connects with 'Main Input' as described above, but the 'output' of unit 1 goes to the 'Series Input' of unit 2 ('output' of unit 2 to 'series input' of unit 3 and so on) and the 'output' from the last unit goes to the output socket of the particular channel. The second and following units do not require components IC1, C4 and R1 and if the latter have already been installed then the unit will not work until IC1 has been removed from these additional equalizers.

When several equalizers are employed then the most convenient method of housing them will be with the PCBs arranged vertically. The distance between PCBs should be 33mm or greater and, for information, the distance between potentiometer centres is 38mm.

Continued on page 59

Atari 600XL Review

Looking at the latest in fancy whizzbangs for the proletariat, Anthony DeBoer finds it to be yet another piece of consumer technology.

ONCE UPON a time, a computer with a cartridge slot hit the market. Upon arriving there, it found that many of the machines already there also had cartridge slots. This in itself is in no way significant, but from the fact that this is this month's computer review article, you might (rightly) have already guessed that this particular machine, the new Atari 600XL, is going to be the focus of the article. Besides, most people look at the pictures and read the captions first, anyway.

For the actually affordable price of $249, Atari (or the place you buy the computer from), gives you a computer with (gasp!) a *real* keyboard. The space bar is at the bottom where it should be, it has shift keys on not one but both sides, and every one of the keys actually goes down when you hit it and back up again afterwards. ZX-81 owners, eat your hearts out.

To dampen your enthusiasm slightly and prevent you from drooling all over the machine (it makes the keycaps sticky and gross), the 600XL has an external power supply, guaranteed to trip up cats and small children and otherwise get in the way. The computer's case is solidly built of genuine plastic, and looks like you could play football with it if your quarterback could but get a decent spin on it. If you're the non-violent type, it should at least survive the average fall. The off-white and dark-brown thing even looks fairly elegant.

The Hard Facts

The Atari's hardware is much what you'd expect: you can plug in joysticks, you get graphics on your TV set, and the cartridge goes in somewhere. Atari will sell you either a cassette "Program Recorder" or a disk drive to save your own programs on, and printers and other peripherals can also be interfaced.

Actually, the hardware is fairly well thought out. The cartridge slot has a pair of little metal doors that keep your pet gerbils out of the slot when you're using the built-in BASIC instead of a cartridge (although admittedly a feature that wouldn't be as useful on a machine that couldn't run at all

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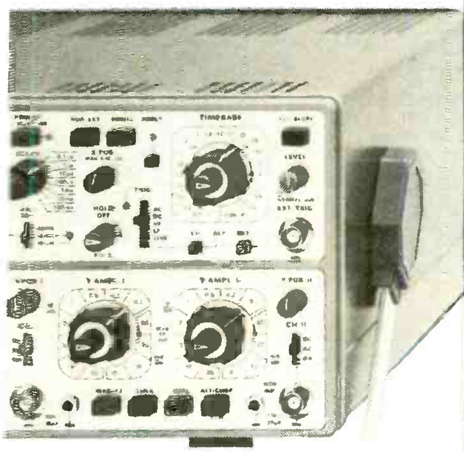

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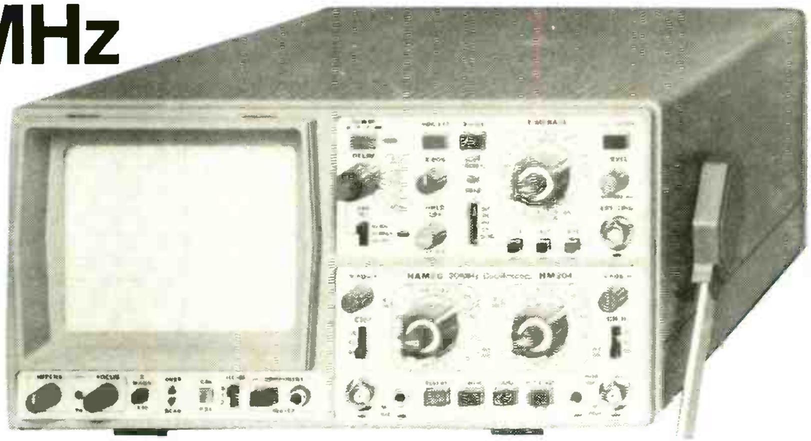

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without one of some sort), and the Atari cartridges themselves also have little covers that pop down when you pull them out, thus keeping greasy fingers off the PC board tracks. The one Activision cartridge that came with the review machine wasn't nearly as nice, having no such cover (although I must admit I might be biased because, playing the game on that cartridge, our typesetter beat me by two lousy points).

The joystick connections are on the side of the machine, and the joysticks themselves are solid if somewhat stiff. They're reliable, however, and you won't be distracted somewhere deep in the Caverns of Mars by a joystick that won't respond.

The back of the machine bears connections marked peripheral, parallel bus, switch box (which goes on the back of your TV), and power in. There are also switches for power on/off and channel 2/3. No monitor connection is provided, which is okay if you want to use the TV set you use for blasting aliens to watch network sex and violence on as well (most video games skip the sex and give you pure violence), but which is not good if you want to give the Atari its own monitor on a full-time basis and skip the RF modulation/demodulation part.

Other than the fact that the cover on the parallel bus connector was loose, and that a power switch located on the power supply instead of on the computer might have made more sense, things in the hardware department looked good.

The Atari's graphics capability was quite impressive, having a resolution of 320 x 192 pixels in one mode and 16 colours at 80 x 192 pixels in another of its 16 modes. One can choose both colour and luminance, plot points, draw lines, and retrieve the value of any point (or character, in text mode) on the screen. There is also a split-screen capability, allowing text and graphics to appear together. Unlike other microcomputers on the market, the Atari has no sprites, which makes really fast animated graphics impossible, at least from BASIC, but it still holds its own, especially at its price. Needless to say, the word "colour" was misspelled throughout the documentation, and in the computer itself, but not much else could honestly be expected from a computer that hails from the part of the world between the 49th parallel and Mexico.

There is 16k of RAM in the machine, of which BASIC claims 13326 bytes free on power-up, although up to 8k can be taken up by the high-resolution graphics modes. This RAM is ample for the temporary storage requirements of software on ROM cartridges, and for most BASIC programs, provided that those using graphics aren't too big, but isn't quite the 48 or 64k that larger, more expensive computers have. Atari does, however, offer a memory expansion.

The computer has many special keys, in-

A Tale of Two Microchips: Z80 vs 6502

by Anthony DeBoer

NOT INCREDIBLY long ago, in a galaxy not discernably different from our own, there were two chips. Both were fairly large, as such things went, having forty pins each, and both were done up in a fairly new-wave shade of black. They were intended by their designers to accomplish quite similar functions, and were in fact competitors.

In the left corner, we have that old standby, the 6502, CPU chip for the Apple, the Atom, and various other machines following in alphabetic sequence. Over in the right corner is the Z-80, the main mover for a host of CP/M machines, not to mention the redoubtable Apple Z-80 card, and others.

The two chips have many similarities. Both are 8-bit CPUs, capable of addressing 64K of memory. This means that both have 8 data pins, 16 address pins, and one pin each for ground and +5 volts, which leaves 14 pins for the clock and various control signals. As we notice from the Apple and others, the differences between the two are not sufficient to prevent both from being used on the same system.

Speaking Softly

In software, however, the differences are more apparent. The owner of a 6502-based system with a Z-80 / CP/M option will notice that code for one chip will not run on the other. This is because the instruction sets for the chips are completely different. Both accept 8-bit instructions, but a given 8 bits for one chip will do something completely different on the other. For example, the Z-80's NOP (do-nothing) instruction is 00 hex, but on the 6502 that same 00 byte would be a BRK, a forced software interrupt. The 6502's NOP is EA hex, which the Z-80 takes as a conditional jump. Some identically-named instructions even have completely different functions. For example, the BIT instruction on the 6502 texts a whole byte, usually an I/O port, while the Z-80's BIT instruction tests a specific bit, usually in a register. Although some instructions have direct equivalents on the other chip, both CPUs have many instructions that have no equivalent on the other.

The 6502 uses exclusively what is called memory-mapped I/O. This means that all I/O ports appear as memory locations within the 64K that the chip can address. This is also possible with the Z-80, but this chip can also address up to 256 I/O ports via separate control lines, using IN and OUT instructions.

Internals

Internally, the 6502 has three 8-bit registers, designated A, X, and Y. It can add and subtract memory locations to and from the A register, using the X and Y index registers to help specify the address. For example, LDA 500, X tells it to load the A register with the contents of memory location 500+X. More complex addressing modes are possible, such as LDA (50),Y, which tells it to go to locations 50 and 51, get the address stored there, add Y to that, get the byte at the resulting address, and put that in A. Most work is done with memory, especially with page zero, the first 256 locations, which can be addressed with special 2-byte instructions, instead of with the usual 3 required for memory addressing. This page is therefore extensively used as scratchpad RAM, storing frequently-used system variables.

The Z-80, on the other hand, is based on the older Intel 8080 chip, the original microcomputer CPU that revolutionized the industry. Virtually all code for the 8080 (and this includes all of CP/M) will run on the Z-80. The newer Zilog chip introduced many new instructions and capabilities, and a completely new set of mnemonic codes. The Intel codes LDAX, STAX, LXI, LHLD, SHLD, LDA, STA, MOV, and MVI all became simply LD, for example, eliminating a major source of programmer frustration. Note, however, that the new Z-80 instructions that do not exist on the 8080 cannot be directly programmed if you are using an 8080 assembler, like CP/M's ASM. Also, regular CP/M code does not take advantage of these operations, in order to maintain compatibility with older machines using the 8080.

In contrast to the 6502, the Z-80 is a register-oriented CPU, having no less than fourteen 8-bit working registers, along with two 16-bit index registers. The 8-bit registers come in two sets, each consisting of A, B, C, D, E, H, and L registers. They can also be used as 16-bit registers, designated as the BC, DE, and HL register pairs. The index registers are called IX and IY.

Algorithms for the Z-80 tend to be done almost entirely in registers instead of with scratchpad RAM, 6502 style. The Z-80 can add two 16-bit values directly, unlike the 6502, which has to do it as two 8-bit additions. In many ways, the Z-80 is almost a 16-bit CPU. On the other hand, the Z-80 does not have the addressing capabilities of the 6502 or its special page zero RAM facility. To retrieve data with this chip, one generally has to get the desired address into a register pair and then load the data thereby into the A register.

Addressing Data

The two chips, as noted, use quite different schemes for addressing data in memory. With the 6502, if one has a table or array beginning at, say, location 500, one uses an instruction like LDA 500,X to get at the Xth element. It's that simple. With the Z-80, on the other hand, one has to compute, in 16 bits, the address of the element desired, and then retrieve it. For example, if one has the value "X" in the E register, one would clear the D register (thus setting up X as a 16-bit value in DE), load the address 500 into HL, and add DE to HL, which will now contain the address. One can now load via that into A (or any other register). It runs like this:

```
LD   D,0
LD   HL,500
ADD  HL,DE
LD   A,(HL)
```

or, for CP/M's ASM, which uses the more obscure Intel 8080 mnemonics:

```
MVI  D,0
LXI  H,500
DAD  D
MOV  A,M
```

```
      Z-80 version           !      6502 version       ;   Comments
   --------------------------!-------------------------;-------------
   LD    IX,0000             !       LDX  #0           ;   Zero out partial product
                             !       STX  $42          ;
                             !       STX  $43          ;
   LD    B,16                !       LDY  #16          ;   Loop counter: 16 times around
                             !                         ;
LOOP: ADD IX,IX              ! LOOP  LDX  #3           ;   Shift 32 bits left
   ADC   HL,HL               !       CLC               ;
                             ! SHFT  ROL  $40,X        ;
                             !       DEX               ;
                             !       BPL  SHFT         ;
   JR    NC,NO               !       BCC  NO           ;   Jump if a zero came out
                             !                         ;
   ADD   IX,DE               !       LDX  #1           ;   Add in multiplier (16 bits)
                             !       CLC               ;
                             ! ADD   LDA  $42,X        ;
                             !       ADC  $44,X        ;
                             !       STA  $42,X        ;
                             !       DEX               ;
                             !       BPL  ADD          ;
   JR    NC,NO               !       BCC  NO           ;   Carry to upper 16 bits?
                             !                         ;
   INC   HL                  !       INC  $41          ;   Yes: Increment upper 16 by 1
                             !       BNE  NO           ;
                             !       INC  $40          ;
                             !                         ;
NO: DJNZ LOOP                ! NO    DEY               ;   End of loop: around again?
                             !       BNE  LOOP         ;
   RET                       !       RTS               ;   All done, return.
```

Figure 1: 16-bit multiplication routines compared.

As you can see, this really slows down the Z-80. However, if the array is longer than 256 bytes, then the 6502 code to pull out a given bytes becomes even worse than this, while the Z-80 code remains much the same. It should be added, too, that one will frequently want to look at each location in an array in order. With the Z-80, you simply load a register pair with the base address, and then load the accumulator via this pair and increment the register pair each time around the loop. The 6502, on the other hand, would use the simple X-register method, incrementing it, for anything up to 256 bytes, but again has to use more complex code for anything bigger. In addition, the Z-80 has a group of special fast instructions for moving blocks of memory or for finding a given byte in a block. In short, the 6502 is better for small bits of data and textbook examples, but only the Z-80 can make great hulking masses of data quiver.

Watch them Multiply

Another example that will illustrate the differences between the chips is a 16-bit integer multiply. As one might expect, there's more to multiplication than just saying "A=B*C" in BASIC. Computer multiplication is done much the same way as you were taught how to do it way back in the third grade, with the exceptions that now we have 16 bits instead of three or four digits, and that we proceed from left to right instead of right to left, and double our partial result by shifting it left each time around.

The Z-80 version would use registers exclusively, not using any scratchpad memory. At the start, the two operands would be in the DE and HL registers, and when it is done, the result (note that it can be as long as 32 bits) is in the IX and HL registers (HL holding the more significant bits). The code is on the left side of figure 1.

The 6502 version, on the other hand, would make extensive use of scratchpad memory in page zero. As you can see from the listing, it looks much more extensive and difficult to program. This time around, HL becomes locations 40 and 41, IX becomes 42 and 43, and DE becomes 44 and 45. Most of the additional code handles 16-bit operations like shifting and addition that the Z-80 does directly.

The 6502 algorithm can be expanded fairly easily to handle as many bytes as are necessary, but a 32 by 32-bit multiply is about as much as one can shoehorn into the Z-80's registers. A larger multiply would require some real tricks from a Z-80 programmer, but it should still be faster than its 6502 equivalent.

One misconception that should be cleared up: a 4 MHz Z-80 is in fact running no faster than a 1 MHz 6502. The 250 nanosecond cycle time that the 4 MHz clock gives the Z-80 is the time of one "t-state", an internal CPU cycle, of which there can be from three to five per memory cycle, depending on the instruction being executed. The 1 MHz 6502, on the other hand, has a constant one microsecond (1000 nanosecond) memory cycle time. The Z-80's main advantage over the 6502 is its more powerful instruction set. Both chips employ a technique of reading in the next instruction while they are still working on the previous one, so they are equal on that count.

No BASIC Difference

It should be noted that what has been said up to this point makes virtually no difference to a BASIC programmer. If you're not planning to program in assembler, don't bother choosing a computer on the basis of which CPU it uses. The people who made BASIC (or any other packaged software) work on a given machine will have done all the assembly language programming necessary, so that the user doesn't have to worry about addressing modes, CPU flags, and the like. The differences between the CPUs are, however, of great interest to those intrepid souls who intend to program them directly.

ETI

Designing Microsystems Part 5

In this article Owen Bishop examines RAM. If you seek enlightenment about horned ruminants, however, read no further. Sorry about that joke.

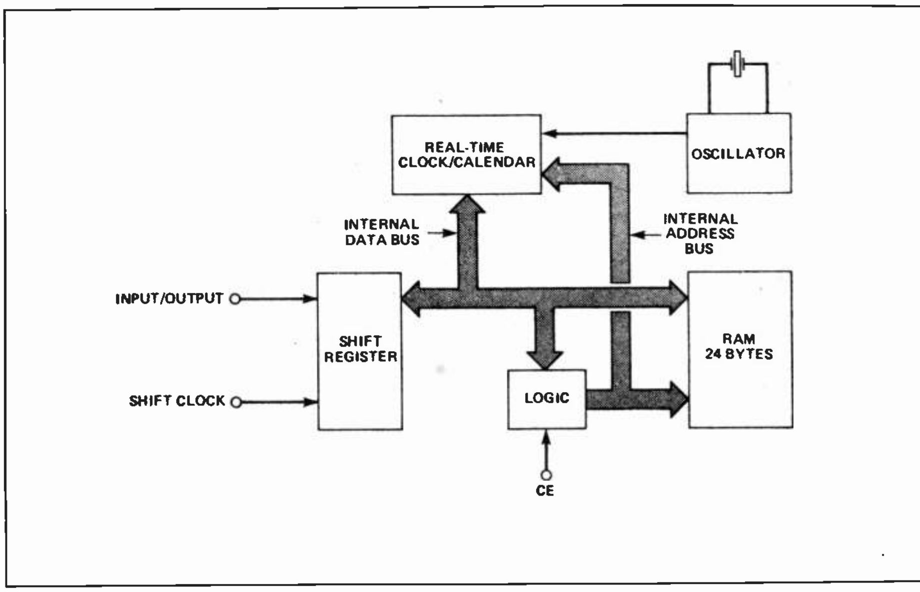

Fig. 1. Simplified block diagram of the Mostek MK3805 clock/RAM.

STRICTLY SPEAKING, random access memory (or RAM, for short) includes every part of a computer's memory which can be read to obtain information and can be written into to store information. In other words, everything that is not ROM (read-only memory — see last month's article) is RAM. This RAM includes not only the arrays of ICs in which information is stored by solid-state circuitry, but also any magnetic cassette tape-recorder or disc drive which may be connected to the micro. Tape recorders and disc drives will be considered in Part 8 of this series, becuase, both in form and in function, they are entirely different from the solid-state devices on the computer board. Most people nowadays take the term RAM to cover only the ICs and not the magnetic storage devices.

The name 'random access memory' is a curious one and something of a misnomer. 'Random access' means that the computer can go instantly to any memory cell (a bit) or any group of eight memory cells (a byte) and read from it or write into it. The computer can skip from one location to another according to the program. The situation is analogous to the *random access file,* used in data base systems, and usually stored on disc or tape. The computer can find any location within the file almost instantly and read from it or write to it, without affecting the adjacent locations. This contrasts with the *serial access file,* in which every location in the file must be read from or written into in order, from the beginning of the file to the end.

While the use of the term 'random access' (as opposed to 'serial access') is fairly clear in connection with files, even so, it is unlikely that the computer would be accessing items in the file purely on a chance or random basis. It usually has a very precise notion of which location it should access on any one occasion. The term 'random access' is even more unsuitable in connection with memory. The computer can, and frequently does, skip about from one part of ROM to another, particularly if there is a BASIC interpreter in ROM and it has to go to a different section of ROM to process each command. So ROM is accessed in the same fashion as RAM, and the term RAM makes an inapplicable distinction. A better pair of terms would be ROM (read-only memory) and RAWM (read and write memory), but it seems that we are saddled with RAM and must continue to use it despite its illogicality. A strange anomaly in the world of logical machines!

Where Do You Use RAM ...

The essence of RAM is that it is alterable. You can store information in it, alter parts of the information if required, or replace it altogether with an entirely new set of information. Some of the main uses of RAM in a micro are:

Scratch-pad: This is a (usually) small area of memory reserved for holding information about the state of the system, or where the computer 'jots down' the intermediate results of a series of calculations, ready to be picked up again at some later stage. The scratch-pad can hold such information as the address where the table of variables begins. This is called a *pointer* to the variable table. There will also be a pointer to the location of the first line of the stored BASIC program, and to other important locations in RAM.

Some locations in the scratch-pad may hold parameters connected with the operation of the system, such as the positions of the margins of the graphics display areas on the monitor screen, the current screen position of the cursor (that small flashing rectangle which moves around the screen as you type), or the name of the key most recently pressed. There may also be 'flags', which are bytes that indicate certain states of the system. For example, INVFLG, at address 0032 hex in the Apple, holds the value -1 if the screen is to display normal text, 0 for flashing text and +1 for inverse text.

In 6502-based micros, such as the Apple, the scratch-pad is usually located at the bottom of memory (the early addresses 0000 to 00FF). This allows the monitor to take advantage of the faster and simpler zero-page addressing featured by the 6502, as mentioned previously. In other micros, the scratch-pad may be at the bottom or top, but is usually not in the middle, where it could easily be overwritten by loaded programs.

Tables of variables. This may include arrays and strings, for use in the program.

The program itself. This may be in BASIC or some other high-level language, or in machine code. Often small machine-code programs (such as editing or renumbering programs) can be tucked away at one end of RAM, where they will not be disturbed

Continued on page 52

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Rise times for 15, 20, 35, 45, 60, 75, and 100 MHz scopes are 23, 17.5, 10, 7.8, 5.8, 4.7, and 3.5ns approximately, respecitvely, just for reference. Also, for old scopes like Tektronix's 545 and Lavoie's LA-265 with rise times of .01 us, we can calculate BW = $(.35/t_r)$ = .35/.01us = 35 MHz going the other way.

So, we can see why many experienced technicians hold on to cheaper, older Tek, HP, et al scopes instead of trading them in on newer more expensive solid state scopes, trading off performance at comparable cost.

For example, take a Tek 545 or Lavoie LA-265, which can be purchased on the surplus market for under $250. Now, aside from the fact that you get delayed triggered sweep and all the rest, assume your scope mainframe, plug-in pre-amp, and probe have .01 us, .01 us, .01 us, and .005 us rise times. Then, with a displayed rise time (t_{rd}) of 100 ns,

$$t_{ra} = (t_{rd}^2 - t_{rs}^2 - t_{rsp}^2 - t_{rp})$$

where t_{ra} = actual rise time,
t_{rd} = displayed rise time,
t_{rs} = scope main frame rise time,
t_{rsp} = scope plug rise time, and
t_{rp} = probe rise time.

Plugging in the typical numbers given,

$$t_{ra} = (100^2 - 10^2 - 10^2 - 5^2)$$
$$= (9775)^{1/2}$$
$$= 98.87 \text{ ns.}$$

Therefore, we have an error in the 1% range, which presents no significant error, especially when you consider most scopes have typical built-in errors in excess of 1% in any case. However, for smaller and smaller rise times, the error increases, and must be taken account of. This is especially true when measuring rise and fall times in even reasonably fast logic families, such as TTL and LSTTL stuff.

.35 Constantly

The 0.35 constant used above comes from two interesting factors that bear some study. First, RC rise time = t_r = 2.2 RC which comes from the time constant curve for a charging capacitor in a series RC circuit when an ideal step pulse is applied. (See Figure 2) Now, when the 10% and 90% points of Fig. 1 are marked off, corresponding RC values are 0.1 RC and 2.3 RC. The difference between these values is 2.2 RC, the 10% to 90% rise time points in Figure 1. Figure 2 refers only to the RC limiting in a circuit, so don't confuse it with Gaussian response in Figure 1.

Second, the 3 db down corner frequencies from the mid-range point is defined as

$$F_c = \frac{1}{2 \text{ pi } RC}$$

Transpose this into

$$RC = \frac{1}{2 \text{ pi } F_c}$$

Now, take this value for RC and substitute it into

t_r = 2.2 RC.
which gives us

$$t_r = 2.2 \left(\frac{1}{2 \text{ pi } F_c}\right)$$
$$= 2.2/6.28 \, F_c$$
$$= 0.35/F_c$$

Thus, we see that 0.35 = $(t_r)(F_c)$. And since F_c = frequency response = BW, we can write 0.35 = (t_r) (BW) or BW = $.35/t_r$, which brings us back to where we started, ending this little ditty. ETI by the main program.

The video RAM. This is an area of RAM set aside for holding information about what is to be displayed on the screen. The video RAM is usually near the lower end of memory, perhaps just above the scratch-pad. More about this in Part 7.

Buffer RAM. These are sections of memory reserved for holding data temporarily before it is transferred somewhere else. For example, when you type in a line of program, your keystrokes are stored in a *line buffer.* When you press 'Return' or 'Enter' the line you have just typed is transferred from the buffer to the next vacant locations in the area where the program is being stored. Buffers are useful when data is to be transferred rapidly between the micro and a peripheral device such as a printer or disk drive. A block of incoming information, such as the contents of a file on disc, are held in a file buffer in RAM. It is then available for use by the main program, and can be replaced by information from other files in due course.

. . . And How Much Do You Need?

The amount of RAM a system requires depends on how many of the functions listed above are to be implemented. A microprocessor control system (such as that fitted in an automatic washing machine) will have its program in ROM (or PROM). The washing machine has no video, and needs no variable table or RAM buffers, but it may need a scratch-pad on which to keep account of the settings of the controls or the stage it has reached in processing the washing. It needs a very small RAM, simply as a scratch-pad. An IC such as the Mostek MK3805 (Fig. 1) provides just 24 bytes of RAM. The chip also includes a real-time clock-calendar.

At the other extreme, many personal computers come with between 16K and 48K of RAM, and can be expanded up to 64K or even more. The great advantage of this is that lengthy programs can be loaded, making it possible for the computer to run anything from a sophisticated accounts program, to a complex and perplexing adventure game. It is the steady decline in the cost of RAM IC's which has led to the increasing power and hence increasing popularity of the personal microcomputer. Nowadays, the typical micro has enough RAM to do things which formerly only an expensive mini could do. In 1974, the only RAM IC's available on the hobby market were the TTL 7481 and 7489. The 7489 cost about ten dollars, and contained 64 bits (16 four-bit words). In spite of inflation we can today buy a 64 kilobit IC for roughly the same price.

Bipolar Bistables = Bits

The 7481 and 7489 are early examples of RAM based on bipolar transistors. The 7481 (Fig. 2) has 16 bits, each individually addressable. Each bit is represented by a flip-flop (Fig. 3). Readers will recognize the familiar cross-connected configuration of the transistors, but the triple emitters are a distinctive feature.

Each flip-flop can be in one of two stages, one of which represents a stored '0' and the other a stored '1'. In Fig. 3, the flip-flop represents '1' when Q1 is on and '0' when Q1 is off. The address lines X and Y are normally low, and the current through the 'on' transistor (Q1 in this example) flows to the address lines. To address any particular flip-flop, the corresponding lines for row and column are made high. The result of this is that for the addressed flip-flop, both X and Y lines become high. For the other flip-flops, at least one of X and Y is low.

Let us follow the way the stored data is read from the flip-flop. Figure 4 shows what happens. When both address lines go high, the current (if any) through the transistor, can no longer flow to the address lines. Instead, it is diverted to the bit line, in this example the '1' bit line. The current is detected by the sense amplifier, the output of which falls from its normal state ('1') to '0'. No current is flowing through Q2, so the '0' bit line and its amplifier are unaffected. It needs only a logic gate and buffer to output the signal from the sense amplifiers to the data bus of the computer. Reading has no effect on the contents of the flip-flop. Q1 stays on due to the current flowing to the '1' bit line. Q2 is off and stays off.

Now let us look at the write operation (Fig. 5). Inputs to the write buffers are normally low. To write a '0' at the flip-flop, we apply a 'high' voltage to the '0' write buffer and make the appropriate address lines high. The buffers are inverters, so their output is not normally '0'. Now the output on the '0' bit line changes to '0'. Q2 is able to conduct because of the low level on the '0' bit line. Consequently, the flip-flop changes state, the stored '1' being replaced by a '0'. Had we tried to write a '1' to this flip-flop, the flip-flop would have remained in its previous state.

Figure 6 shows another way in which bipolar transistors may be used in RAM. There is only one address line, common to four or more flip-flops holding the data of one nibble (four bits) or one byte. Apart

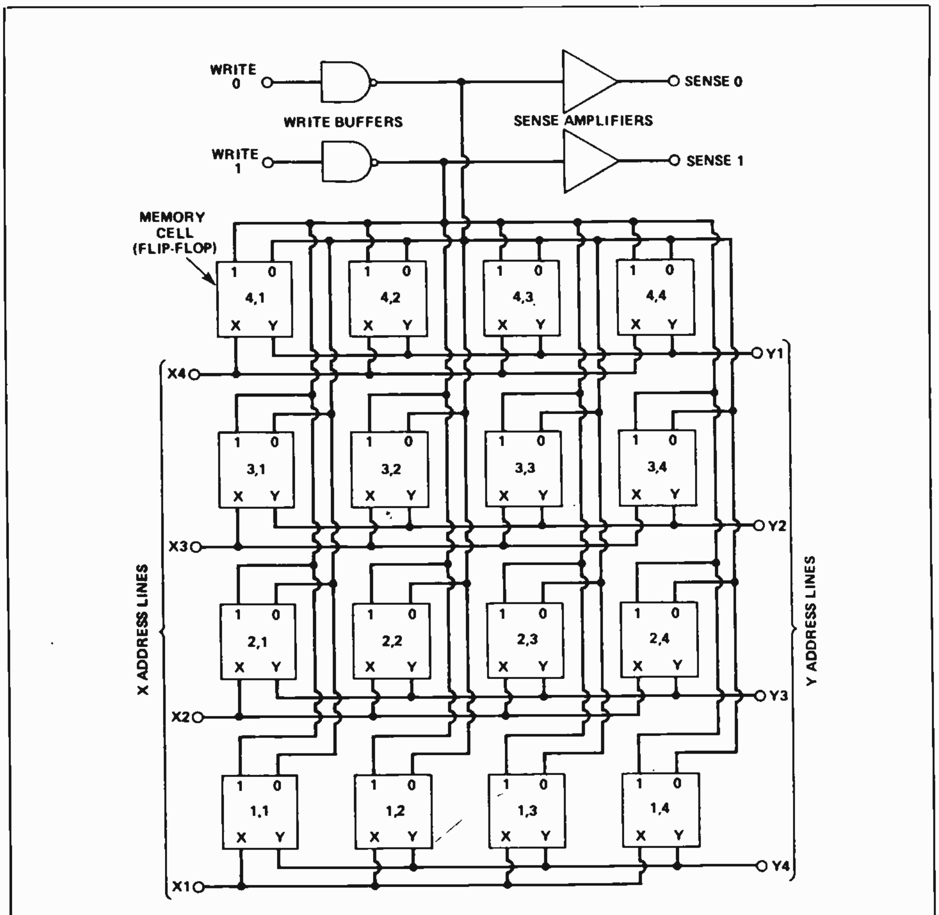

Fig. 2 Block diagram of the 7481 16-bit RAM.

form this, the operation is very similar to that of the flip-flop described above.

A Static RAM Gathers MOS

The use of MOS transistors allows more flip-flops to be packed on the chip, thus making the building of really large memory arrays much simpler and cheaper. Just as important is the fact that MOS has much lower power requirements than bipolar circuitry. One transistor of each bipolar flip-flop is always in the conducting state, so even a small RAM IC continuously draws a current that is tens of milliamps. Supplying current to a large bipolar RAM and dissipating the heat generated are major problems. Nevertheless bipolar RAM has the advantage of very high speed of access (of the order of 20 nanoseconds). It is favoured in input and output buffers of main-frame computers where large amounts of data have to be transferred at high speed between the computer and peripherals, such as hard disc drives.

By contrast, MOS circuits require hardly any current while in the quiescent state. The 5101 CMOS RAM (Fig. 7) draws only 10 uA while quiescent. Even when it is being read from or written into at maximum rate, the currrent requirement never exceeds 25 mA. The price for low current consumption is paid in longer access times — on the order of 450 nanoseconds — though some MOS RAMs are faster. However, longer access time is no disadvantage for the typical micro.

Figure 8 shows a typical MOS memory cell. It has the same general stucture and connections as its bipolar counterpart, except that it employs two transistors (Q3, Q4) to act as drain resistors. These are easier to fabricate on the chip than ordinary resistors would be.

One of the distinguishing features of solid-state RAM is that it loses all stored information when the power is switched off. Provided that the power supply to the mciro has provision for covering brief interruptions of the power supply, this is not a problem. In portable computers which are to be used in the field, and in pocket calculators, it may be desirable that stored information be retained while the power is off. To retain the information in RAM, some kind of battery back-up is needed for the RAM section of the computer circuit, though power to the display and peripherals can be completely shut off. Here again, MOS circuity has its advantage of microamp power consumption in the quiescent state (i.e., when not being used). A small battery retains information in memory for weeks or months. The 5101 has the additional feature of requiring only a 2 V supply to retain memory, though it normally operates on 5 V.

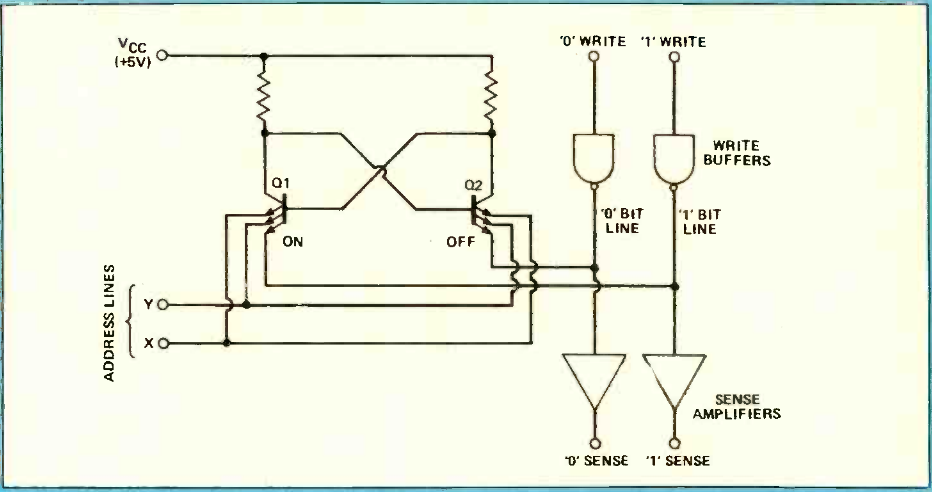

Fig. 3. A memory cell of the 7481 RAM, with bit line amplifiers and buffers.

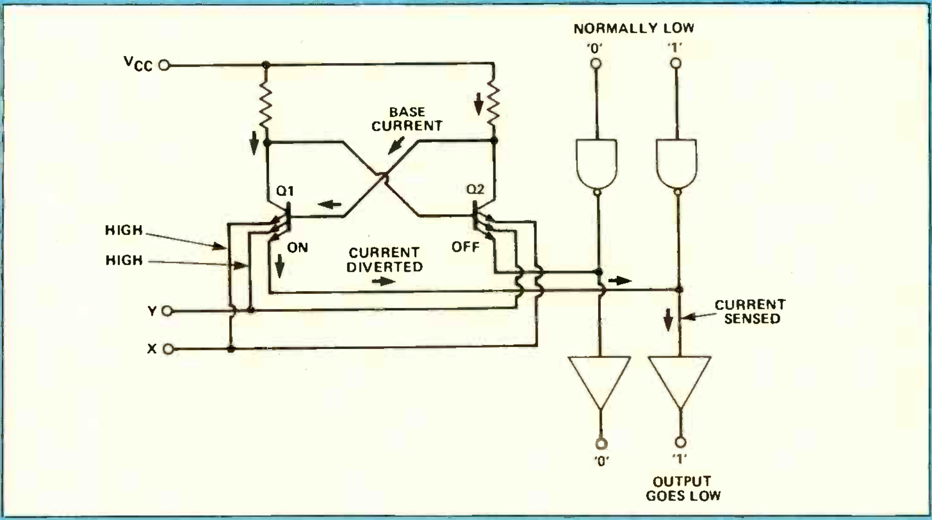

Fig. 4 Reading from a TTL memory set at 1.

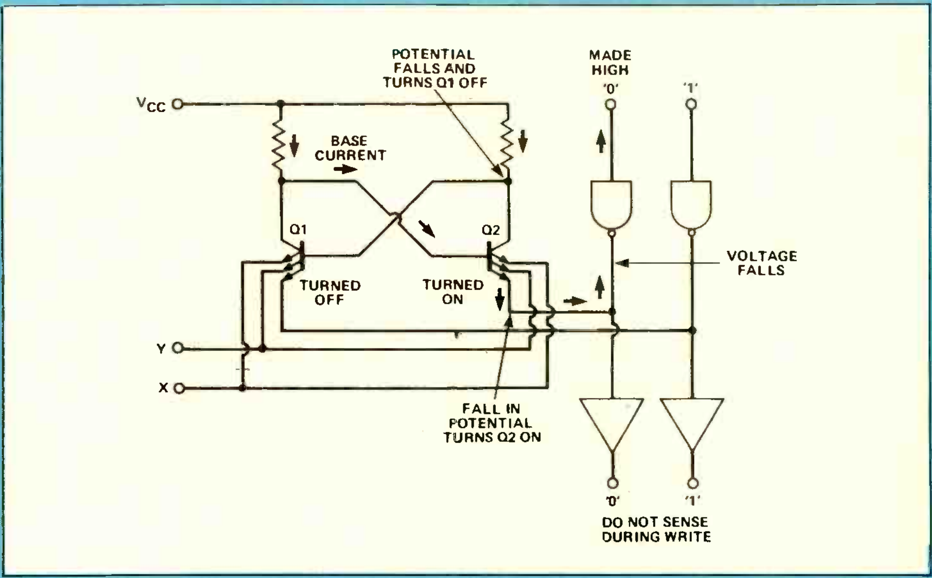

Fig. 5. Writing 0 into the memory cell previously holding 1.

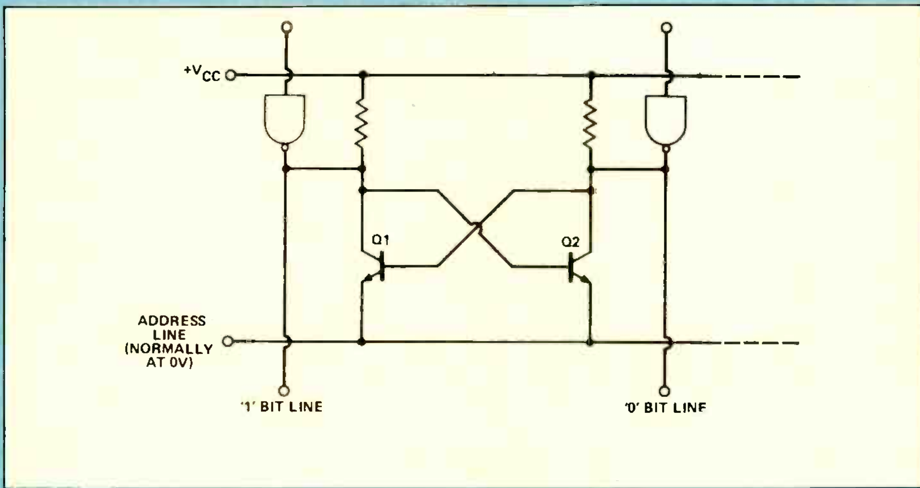

Fig. 6. Another design for a memory cell, using bipolar transistors.

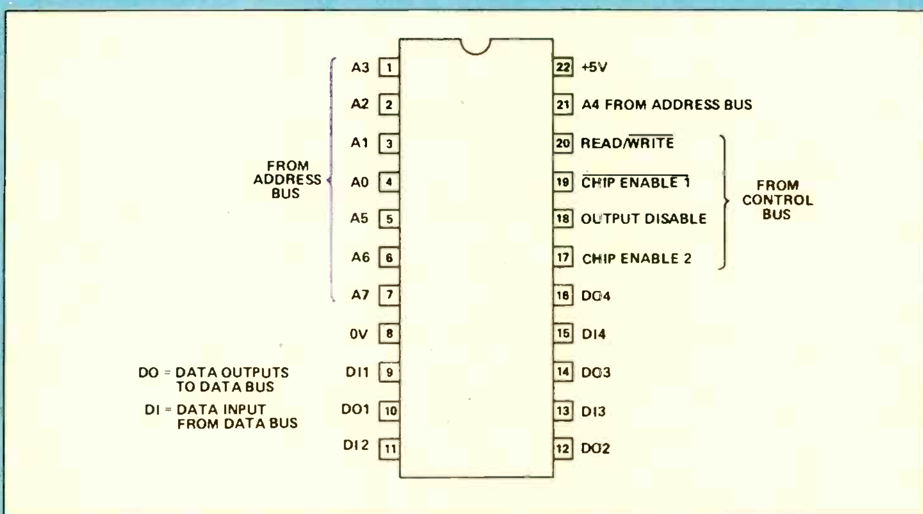

Fig. 7. Pin outline of the 5101 CMOS static RAM.

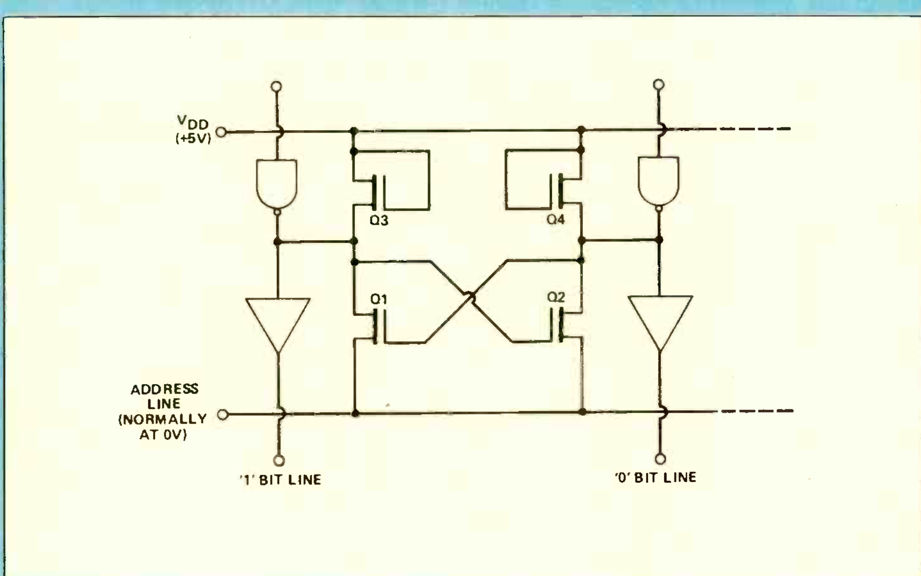

Fig. 8 An NMOS static RAM memory cell.

A Wee DRAM? It's Refreshing

The devices described above all belong to the class known as static RAM. Once a flip-flop has been set to a given state, it remains in that state until the power is removed. It is *static.*

Modern micros also employ an entirely different type of RAM called *dynamic* RAM. The characteristic of this is that a memory cell does not hold its information indefinitely. After a while (a few milliseconds) the stored information fades away. If information is to be retained, it must be renewed or 'refreshed' periodically.

Figure 9 shows the circuit of a typical memory cell. Eight such cells are connected to a single address line, which is normally held low (0 V). The eight cells hold the eight bits which make up a single byte of information. Decoding logic within the IC ensures that the address line goes high (+5 V) when the address of the byte of which this cell is a part, is present on the address bus of the computer. Each of the eight cells is connected to a different bit line, one corresponding to each line of the data bus. Note that there is only a single bit line, not a '0' bit line and a '1' bit line.

When data is to be written into the cell, the address line goes high, turning on the transistor. If the bit line connected to that transistor is at 0 V, a potential difference of 12 V develops across the capacitor. If the bit line is at 5 V, the potential difference is only 7 V. The address line then goes low again and the potential across the capacitor remains. The effect of this operation is that the information is now stored on the capacitor. The information can be altered by making the address line high, with a different level present on the bit line.

The information can be read by making the address line high, once more connecting the capacitor to the bit line. Charge present on the capacitor is shared with a sense amplifier connected to the bit line. The amplifier outputs a '1' or '0' to the corresponding line of the data bus.

Left to itself, the capacitor would gradually lose its charge through leakage. It also loses some of its charge every time it is read. Figure 10 shows how the charge is refreshed. The 'switches' are in fact transistors in the control circuits of the IC. When both switches are set to position B, they feed back the output of the sense amplifier to the bit line. This is positive feedback so the amplified output instantly restores the charge to its correct value.

The need to refresh RAM every few milliseconds imposes an additional task on the MPU, but the advantages of dynamic RAM (see later) are such that this is acceptable for a system with *large*

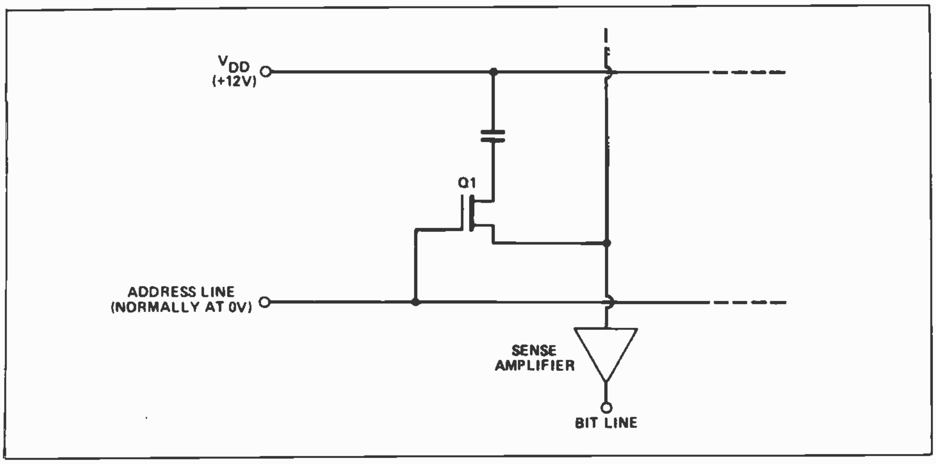

Fig. 9 A MOS dynamic RAM memory cell.

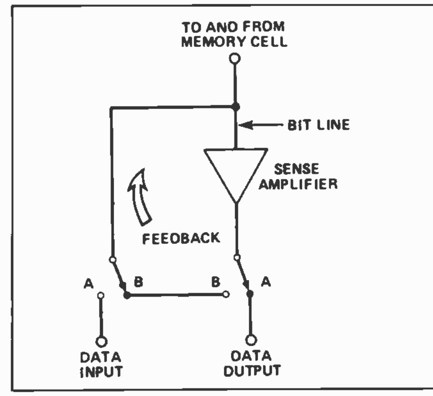

Fig. 10 Dynamic RAM control switching, shown set for data output, Feedback applied when both switches are set to B.

amounts of RAM. Some microprocessors, such as the Z80, provide a special $\overline{RFSH}$ output which goes low during the second half of each of code fetch cycle. During the first half of this cycle the MPU reads an instruction from ROM or RAM. During the second half of the cycle it is busily processing the instruction internally before acting upon it. This is then a suitable time for the RAM to be refreshed. The RFSH signal, in conjunction with the $\overline{MREQ}$ (memory request, which also goes low while $\overline{RFSH}$ is low) can be used in various ways to instruct the RAM ICs to refresh themselves. To see how this is done, let us look at a commonly used dynamic RAM (or DRAM), the 4116.

Dynamic RAM Gives Denser Data

This IC well illustrates the great advantage of dynamic RAM. The cells have so few components (compare Figs. 8 and 9) that they can be densely packed on the chip, giving us enormous numbers of cells in a single IC at relatively low cost. The 4116 (Fig. 11) is only a 16-pin device yet it can hold 16 kilobits of information. These are organised as 16K individually addressable bits. In practice we would take eight such ICs and operate them in parallel to obtain 16 kilo*bytes* of memory, one IC corresponding to each bit in the byte (Fig. 12).

A 16K RAM can cover addresses

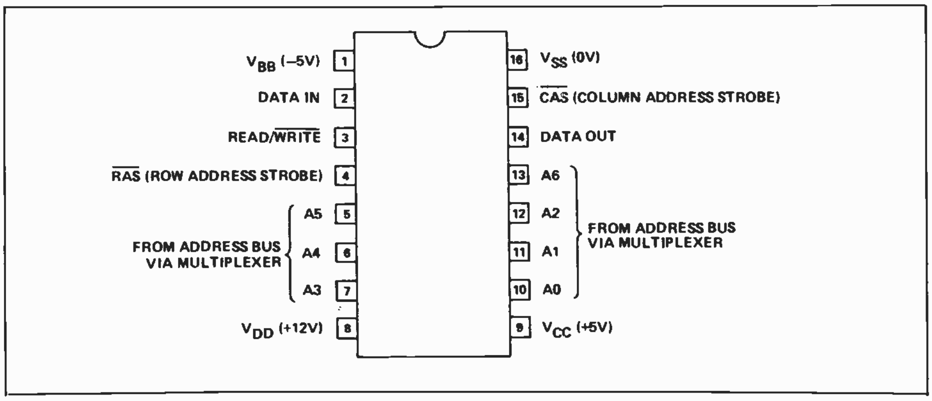

Fig. 11. (Above) Pin connections of the 4116 dynamic RAM.

from 0000 to 3FFF (in hexadecimal); in binary this is from 00 0000 0000 0000 to 11 1111 1111 1111.

This means that 14 address lines are required to specify an address. A quick check of Fig. 11 reveals that the 4116 has only seven address input pins! Of course, if the IC had to have 14 address pins, it would need 23 pins altogether, making it physically much larger. We are up against one of the limiting factors with integration. No matter how much circuitry we can cram on to a chip measuring only a few millimetres across, connections to the world outside *must* be relatively large and relatively widely spaced. The case and the pins take up far more board space than the actual chip. Having larger ICs means that we can accommodate correspondingly fewer of them on the computer board, so throwing away some of the advantage gained by high-density packing on the chip. The use of seven address pins instead of 14 keeps IC size down yet requires only a little additional logic in the addressing system.

The addressing system is controlled by three signals (Fig. 13); RAS (row address strobe), CAS (column address strobe) and MUX (multiplex). These are obtained from the RFSH (if available), MREQ, RD or WR outputs of the MPU in various ways by a simple logic circuit. In a 16K RAM there is only one row and one column, and RAS is identical to MREQ. It goes low whenever a read or write operation is in progress. When RAS goes low the multiplexer (controlled by MUX) already has the lines A0 to A6 connected to the RAM ICs. The low half of the required address is thus loaded into each IC. Remember that we are trying to load the same address into each of the

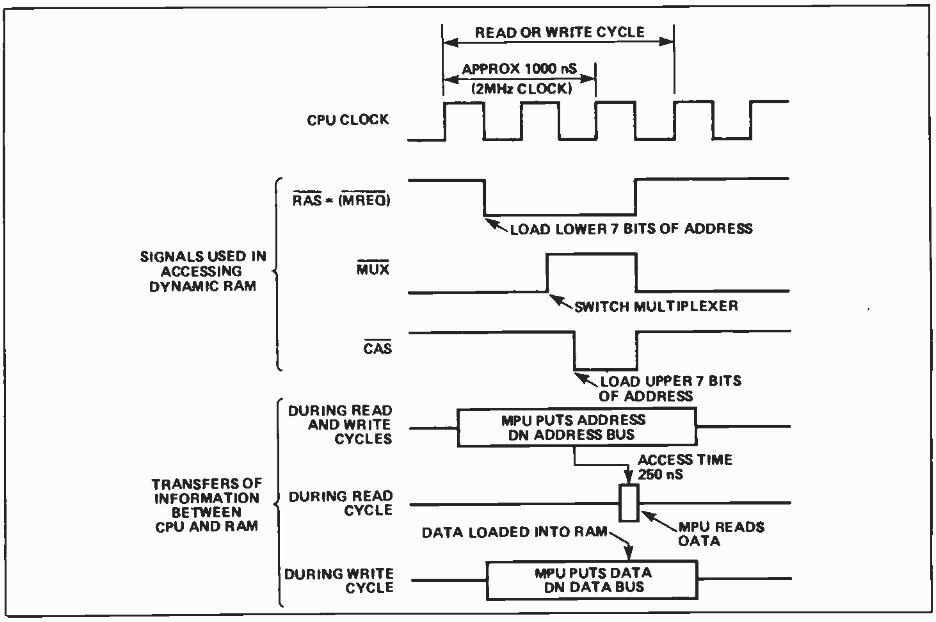

Fig. 13. (Above) Reading or writing to dynamic RAM.

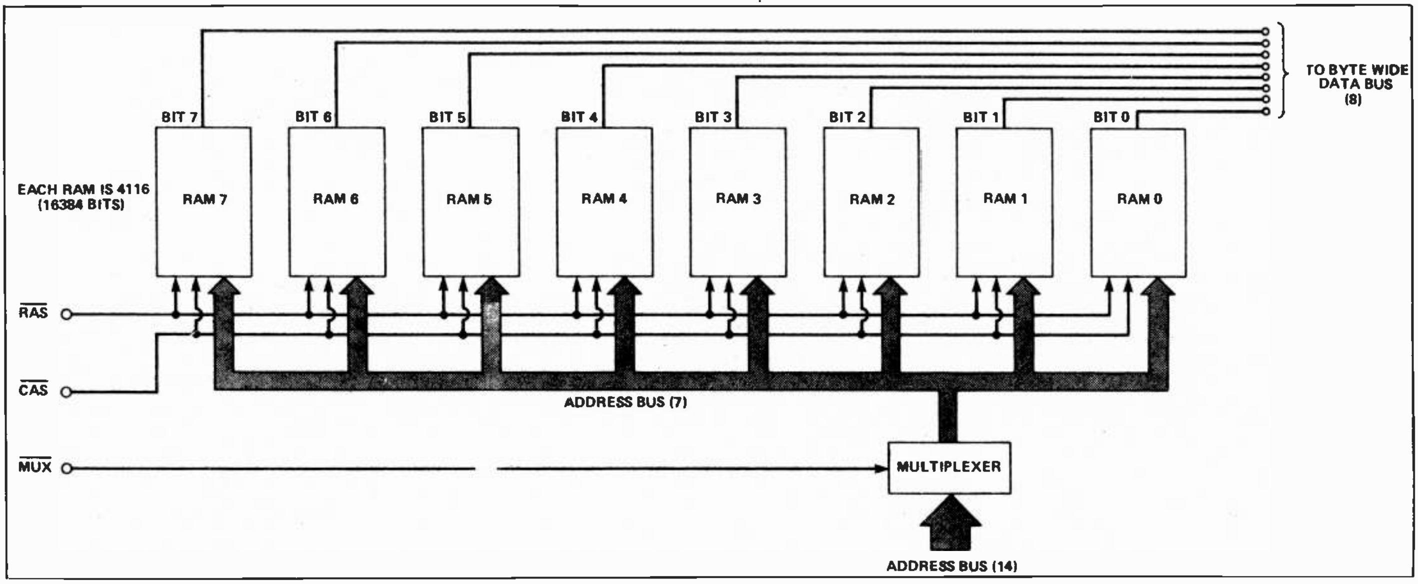

Fig. 12. (Below) Block diagram of 16K of dynamic RAM.

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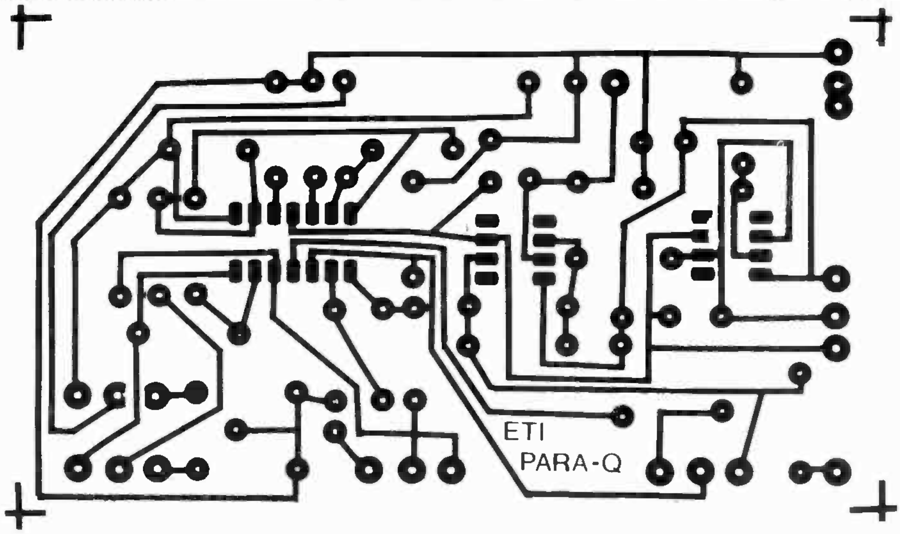

In Use

With the gain control in the mid position, or the by-pass point connected to ground, the parametric equalizer has unity gain, that is, the level of the signal out is the same as the level of the signal in. The input signal should, therefore, be pre-amplified and with many audio amplifiers the monitor output is the appropriate point to use. Alternatively, when the equalizer is used for tape/cassette recording it may be installed in the signal line to the recorder.

The signal level which can be used is partly governed by the power supply and partly by application. For hifi and many recording situations, the cut and boost control is only set to a level which will compensate for deficiencies in frequency response so as to ensure a nominally flat response. In these circumstances the unit will cope with signal levels likely to be encountered in such systems irrespective of the power supply used. If, however, the equalizer is used for special effects and gain is set at either extreme then the maximum signal levels shown in **Table 1** are recommended in order to avoid clipping.

As regards setting of the controls, without having access to audio analysing equipment, you will have to start off by using an equalizer channel in much the same way as you use tone controls at present, that is, adjusting them by ear. Start with the Q control at, or near, minimum and then adjust gain gradually either way from the centre position and then slowly rotate the frequency control clockwise. You will be amazed by the results and will soon learn the best settings for your system. Note that when Q is increased the effect of the gain control is generally less marked since the band of frequencies being boosted or cut is much narrower and therefore not so noticeable to the ear unless it is centred on some constant frequency in the sound.

ETI

PARTS LIST

Although a stereo parametric equalizer is illustrated, the reader may wish to use only one unit as an effects unit, or several for a hi fi system. In view of this we show the basic set of components for a single unit and the choice of connectors and control knobs is left to the reader.

Resistors (¼ watt, 5% carbon film)

R1,2,3,5,18	100k
R4,7	1k0
R6,8,10,12,13, 15,16,19	10k
R9	100R
R11,14	47R
R17	4k7

Potentiometers

RV1	100k lin. carbon, PCB mount
RV2	10k log carbon, PCB mount
RV3	10k + 10k dual log carbon, PCB mount

Capacitors

C1,2,3	100n polyester
C4	1u0 polyester
C5,6	100p polystyrene
C7,8	1n5 polycarbonate

Semiconductors

IC1,2	TL 071 JFET low noise op-amp
IC3	TL 074 JFET low noise quad op-amp

Miscellaneous

8-pin DIP sockets (2); 14-pin DIP socket; PCB, wire, solder, etc.

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ADDRESS CORRECTION

For classified ad which ran in ETI Nov/83 for **INFOTECH 2000 ENR.**, 4653 Lacombe, Montreal, Quebec, H3W 1R4.

Book Review

CP/M Simplified

This book, according to the blurb on its back cover, is a "clear, practical guide to the CP/M microcomputer operating system", covering both regular CP/M and the MP/M multi-user version. Aimed primarily at business users, it assumes no prior computing knowledge. However, the book falls far short of its goal, as technical inaccuracies abound. The novice who intends to break into computing with this book will be confused, and in some cases misled, by this tome.

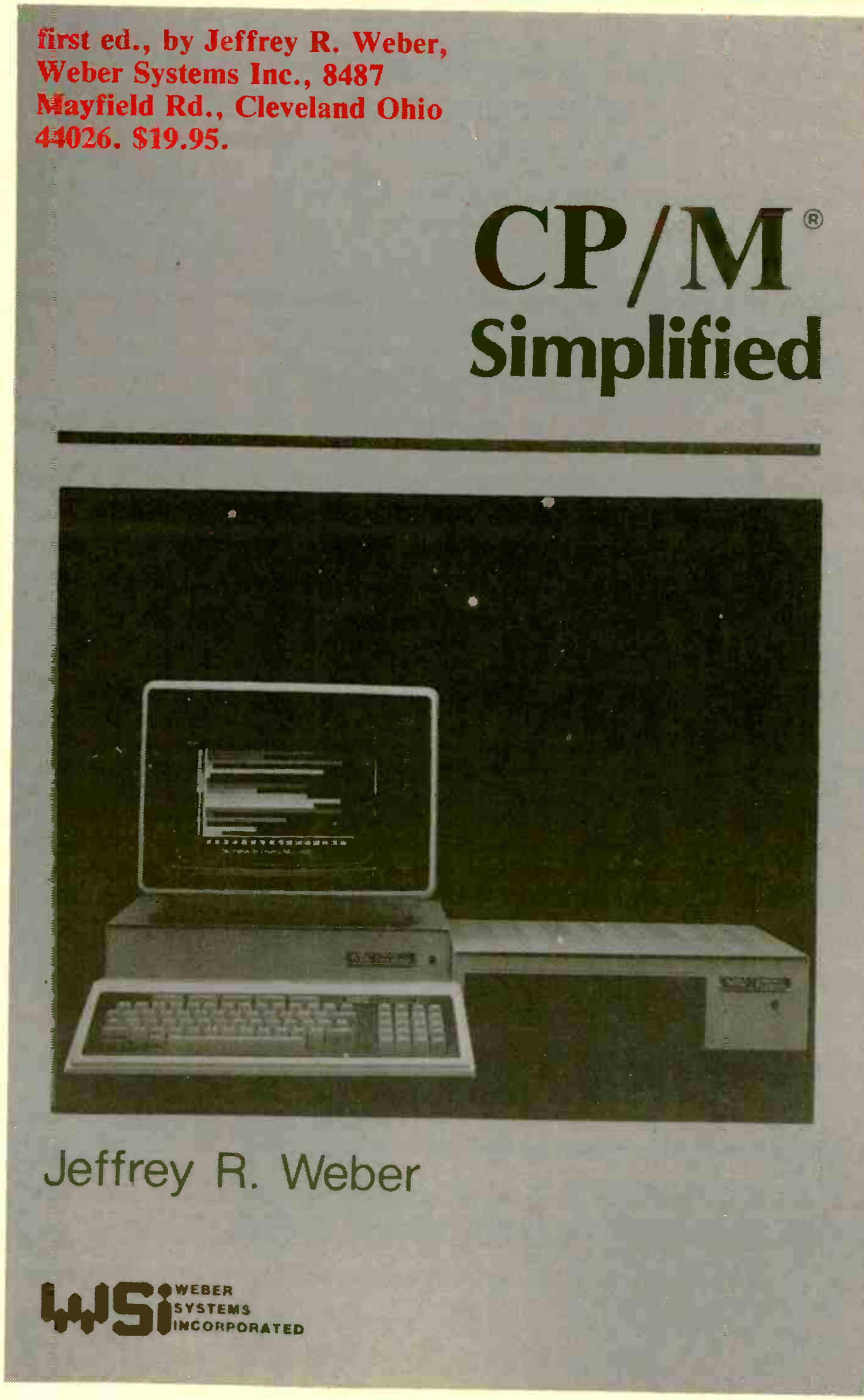
Most of the problems with the book are minor, trivial annoyances, such as misspellings, syntax errors in examples, and the like. There are, however, some serious problems. At one point, the author gives an example in which the filename used is too long for CP/M. At another point, he explains how to find the bottom of CP/M, but anyone who uses his formula will soon find himself overwriting the operating system, an error that can be quite reasonably fatal. Other technical information given is simply wrong. He claims at one point, for example, that the SYSGEN utility works only under MP/M.

The author himself appears to be in the business of selling business applications software (the major clue being the plug for his company on page 18), and the book reads in places as if it were written as a guide for purchasers or potential purchasers of his products. The book covers information that the user of a system would need to know, such as how to set up and start the system, how to use the system utilities to copy files and so on, and how to maintain the computer (keep magnets away from disks, make sure you don't run out of paper for the printer, allow adequate ventilation, keep backup copies of your files, and other such folk wisdom). The chapters on the internal operation of CP/M and on the CBASIC programming language (his apparent favorite) are overviews, too technical for a non-programmer and not technical enough for a programmer.

As the book stands, it is quite definitely not worth being used, since one cannot trust in the veracity of the information given. A second edition, cleaning up the errors and inconsistencies, would be a considerable improvement over this first edition.

by Anthony DeBoer

first ed., by Jeffrey R. Weber, Weber Systems Inc., 8487 Mayfield Rd., Cleveland Ohio 44026. $19.95.



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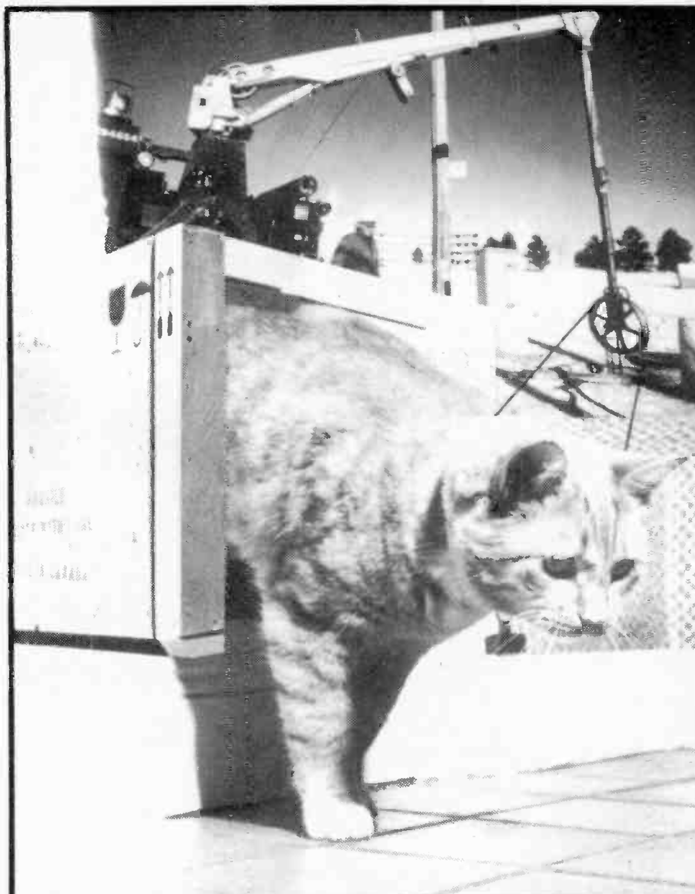

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The Digger

PROJECT

Phil Walker presents a device which, while not actually being very useful for digging holes, does do a fairly reasonable job as a digital oscilloscope trigger.

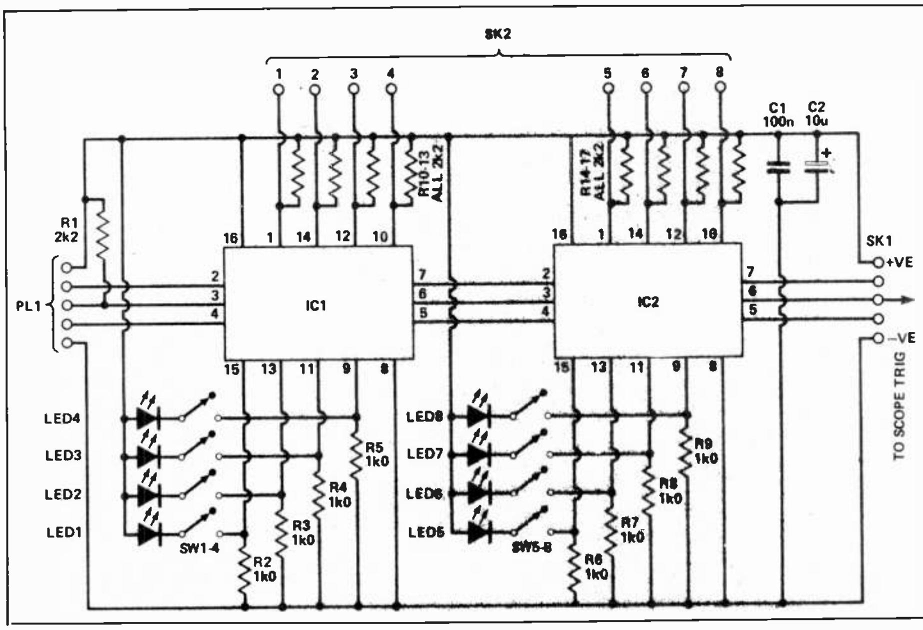


Fig. 1. Circuit diagram, PL1 and SK1 are used when two or more units are cascaded, SK2 is the 8-bit input.

THE ETI Digger is a very simple device which will make fault-finding on digital circuits much easier. The basic unit is an eight bit comparator which provides an output signal whenever the input signal is the same as that set up on the unit's switches. The unit as described will handle up to eight logic inputs which will probably be sufficient for most purposes. However, it is designed so that additional units may be plugged into the first to expand the total capability in blocks of eight.

Use

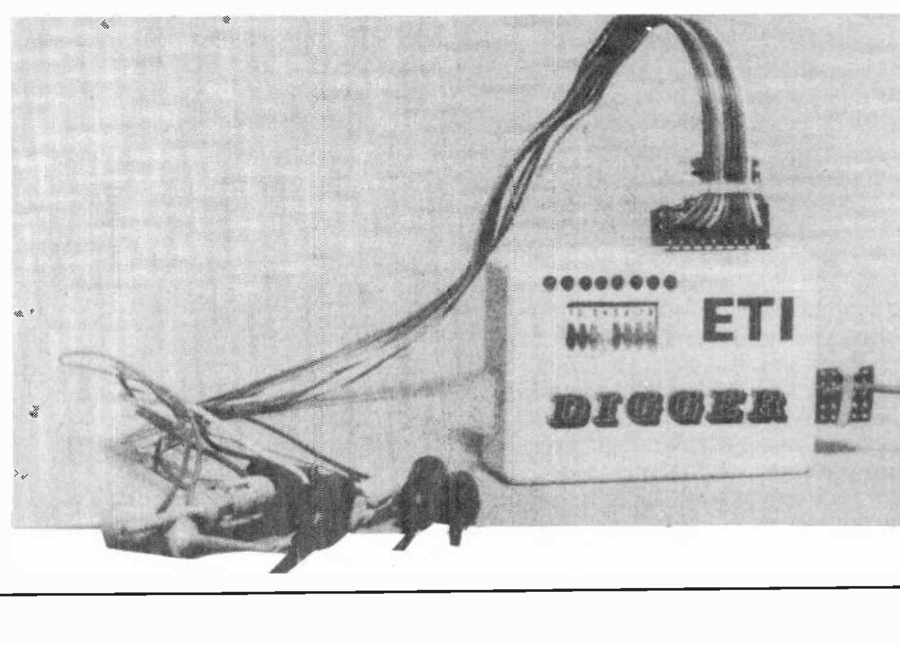
The unit must be provided with a normal TTL type + 5 volt power supply (probably conveniently derived from the equipment under test). The output can then be taken to the external trigger input of your oscilloscope. In case you hadn't guessed, your next move is to set the scope to external trigger; you may have to adjust the trigger controls for best results, especially if the circuit under test contains ripple counters. The reason for this is that signal propogation delays in the devices will cause glitches in the output from the Digger unit. This is not a fault, as the input conditions are in fact true, even if only for a short time. Actually this property of the Digger could be quite useful if you suspect this action in your own circuit.

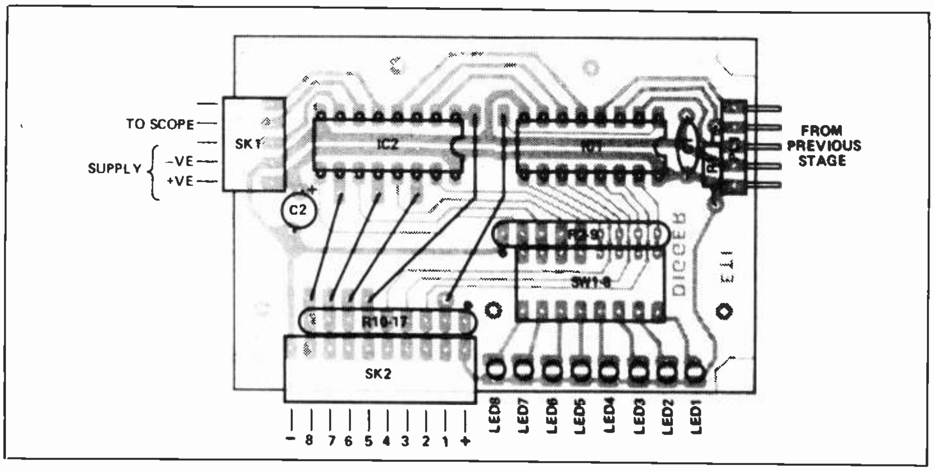
The leads from the device can be connected to the test circuit in any order but remember to set the switches in the corresponding order or your results will be wrong. It is a good idea to use the input nearest the output as a clock input, as this will eliminate a good many ambiguities. Don't forget to set any unused input channels to HIGH or the unit will not trigger!

The Circuit

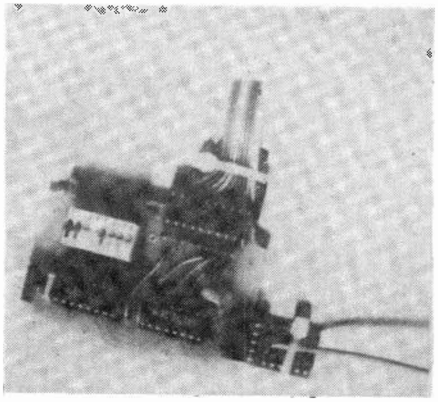
The circuit for this device is very simple. Most of the work is done by the two ICs which are 74LS85 devices. These are TTL four bit magnitude comparators, and give outputs which show whether one of the two four-bit binary numbers presented to their inputs is equal to, greater than, or less than the other. In addition to the normal inputs, there is also a set of inputs which take the outputs from another similar device. When these are connected, the final output depends on all the comparisons of all the inputs to the devices connected in this way.

The rest of the circuit is devoted to providing the requisite comparison inputs to the ICs and giving a visible indication of it. The method of doing this is to use resistors to hold the inputs normally at a low level, but with switches that can force them high via an LED which will light up to show that it has been selected. The logic inputs from the test circuit are provided with pull up resistors so as to define unused inputs.





Overlay of the Digger.



The Digger itself, less case.

Construction

Construction of the PCB is quite simple so long as the ICs are inserted the right way around. The LEDs and capacitors must likewise be put in correctly. If you are going to use resistor packs as we did, the end with the dot or similar mark is the common terminal. Verify this with a meter if in doubt. If you use discrete resistors, mount them vertically and join all the top ends to the common terminal with a piece of stripped solid wire.

It will be necessary to use a 16 pin wire-wrap type socket for the DIP switch so that it can be positioned through a hole in the box. The LED leads will probably be long enough without extension. We would also recommend using ordinary sockets for IC1 and 2.

There are 5 links to insert on the board, as marked on the overlay, which connect the inputs to SK2. Use thin insulated wire for these. Mounting the PCB in the box is a little tricky. First make sure that the corners have been cut off at the marks shown and check that the board will fit into the box. We found it easier to fit the PCB upside-down in the box (with the track side facing the lid), so that only a little of the side walls have to be cut away to allow SK1, 2 and PL1 to fit. Also, a rectangular cut-out must be made in the bottom of the box to allow SW1-8 through. Finally, eight 3 mm holes should be drilled for the LED's.

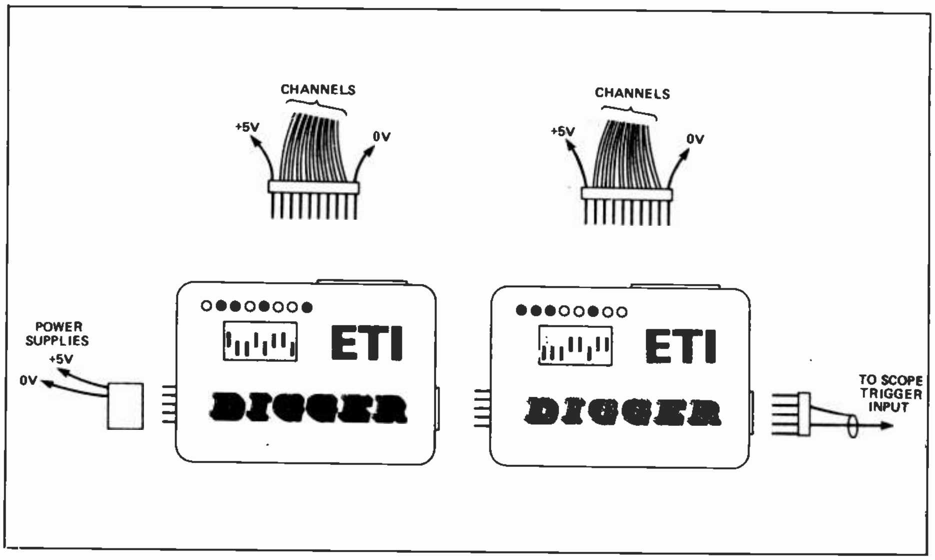
The PCB can now be bolted to the lid and the box put together. Connections to the outside world are made via the plugs and sockets. If you use right-angled plug parts, then a small piece of Veroboard soldered to them makes a solid connector. The socket should be a socket housing with crimp terminals.

For greatest convenience the power connections can be made via the free socket and PL1 while the trigger output goes from SK1. The switch can be mounted either way round in its socket allowing you the option of the test leads coming out of the top or bottom of the device, while the switch position is still up for high, for example.

HOW IT WORKS

Not much to say here really. The LED, switch and resistor combination on four inputs to each IC provides a low when the switch is open and a high when it is closed. Also when the switch is closed the LED will light showing that a high has been selected for that channel.

When the logic input pattern on the input pins matches that on the switches the output from each IC will change state and thus trigger a scope connected to the final output. The outputs from one IC will directly drive the cascade inputs of another and so extend the width of the comparison. The inputs from the test circuit are provided with pull up resistors so any unused input will appear as a high and this must be set on the corresponding switch. C1 and C2 are present to decouple the supply rails. R1 is a pull up for the "=" cascade input.



Two or more Diggers can be cascaded.

PARTS LIST

RESISTORS (¼ W 5% carbon film unless stated)

R1	2k2
R2-9	1k0 (SIP resistor pack 8 x 1k0)
R10-17	2k2 (SIP resistor pack 8 x 2k2)

CAPACITORS

C1	100nF ceramic
C2	10uF 16 V electrolytic

SEMICONDUCTORS

IC1, 2	74LS85
LED1-8	3 mm red LED

MISCELLANEOUS

SW1-8	8 pole SPST DIP switch

10 way PCB socket 0.1" spacing; 5 way PCB socket, 0.1" spacing; 5 way rt. angle PCB plug 0.1" spacing; box; PCB; 10, 5 way free plugs and 5 way socket for above.

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A grab bag of challenging and useful semiconductor projects for the hobbyist, experimenter, and student. The projects 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.

110 CMOS DIGITAL IC PROJECTS
MARSTON
HB23 **$11.75**
Outlines the operating characteristics of CMOS digital ICs and then presents and discusses 110 CMOS digital IC circuits ranging from inverter gate and logic circuits to electronic alarm circuits. Ideal for amateurs, students and professional engineers.

BP76: POWER SUPPLY PROJECTS **$7.30**
R.A. PENFOLD
Line power supplies are an essential part of many electronics projects. The purpose of this book is to give a number of power supply designs, including simple unstabilised types, fixed voltage regulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits.

There are other types of power supply and a number of these are dealt with in the final chapter, including a cassette power supply, Ni-Cad battery charger, voltage step up circuit and a simple inverter.

BP84: DIGITAL IC PROJECTS **$8.10**
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 **$7.55**
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.

BP73: REMOTE CONTROL PROJECTS **$8.60**
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.

BP99: MINI—MATRIX BOARD PROJECTS **$8.10**
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 **$8.10**
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.

Tab1431: DIGITAL ELECTRONIC PROJECTS **$21.45**
Build a deluxe code oscillator, a digital game called Climb-the-Mountain, a clock with alarm, a metric measuring wheel, a modular decade counter, even a 14-note music generator. 17 projects in all.

BP107: 30 SOLDERLESS BREADBOARD PROJECTS — BOOK 1 **$9.35**
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.

See order form in this issue. All prices include shipping. No sales tax applies.

ETI book shelf

BP106: MODERN OP-AMP PROJECTS $8.10
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

BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1 $8.25
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 $9.35
R.A. PENFOLD
70 plus circuits based on modern components aimed at those with some experience.

The GIANT HANDBOOK OF ELECTRONIC CIRCUITS
TAB No.1300 $28.45
About as twice as thick as the Webster's dictionary, and having many more circuit diagrams, this book is ideal for any experimenter who wants to keep amused for several centuries. If there isn't a circuit for it in here, you should have no difficulty convincing yourself you don't really want to build it.

BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS $5.50
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 $5.90
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.

BP42: 50 SIMPLE L.E.D. CIRCUITS $3.55
R.N. SOAR
The author of this book, Mr. R.N. Soar, has compiled 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components — the Light Emitting Diode (L.E.D.). A useful book for the library of both beginner and more advanced enthusiast alike.

BP82: ELECTRONIC PROJECTS USING SOLAR CELLS $8.10
OWEN BISHOP
The book contains simple circuits, almost all of which operate at low voltage and low currents, making them suitable for being powered by a small array of silicon cells. The projects cover a wide range from a bicyle speedometer to a novelty 'Duck Shoot'; a number of power supply circuits are included.

BP37: 50 PROJECTS USING RELAYS, SCR's & TRIACS $5.50
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.

BP24: 50 PROJECTS USING IC741 $4.25
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 $8.20
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.

BP44: IC 555 PROJECTS $7.55
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.

BP65: SINGLE IC PROJECTS $6.55
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.

BP97: IC PROJECTS FOR BEGINNERS $8.10
F.G. RAYER
Covers power supplies, radio, audio, oscillators, timers and switches. Aimed at the less experienced reader, the components used are popular and inexpensive.

BP88: HOW TO USE OP AMPS $9.35
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.

IC ARRAY COOKBOOK
JUNG
H826 $14.25
A practical handbook aimed at solving electronic circuit application problems by using IC arrays. An IC array, unlike specific-purpose ICs, is made up of uncommitted IC active devices, such as transistors, resistors, etc. This book covers the basic types of such ICs and illustrates with examples how to design with them. Circuit examples are included, as well as general design information useful in applying arrays.

BP50: IC LM3900 PROJECTS $5.90
H.KYBETT,B.Sc., C.Eng.
The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses, and is more than just a collection of simple circuits or projects.

Simple basic working circuits are used to introduce this IC. The LM3900 can do much more than is shown here, this is just an introduction. Imagination is the only limitation with this useful and versatile device. But first the reader must know the basics and that is what this book is all about.

223: 50 PROJECTS USING IC CA3130 $5.50
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.

224: 50 CMOS IC PROJECTS $4.25
R.A. PENFOLD
CMOS IC's are probably the most versatile range of digital devices for use by the amateur enthusiast. They are suitable for an extraordinary wide range of applications and are also some of the most inexpensive and easily available types of IC.

Mr. R.A. Penfold has designed and developed a number of interesting and useful projects which are divided into four general categories: I — Multivibrators II — Amplifiers and Oscillators III — Trigger Devices IV — Special Devices.

THE ACTIVE FILTER HANDBOOK
TAB No.1133 $14.45
Whatever your field — computing, communications, audio, electronic music or whatever — you will find this book the ideal reference for active filter design.

The book introduces filters and their uses. The basic math is discussed so that the reader can tell where all design equations come from. The book also presents many practical circuits including a graphic equalizer, computer tape interface and more.

DIGITAL ICS — HOW THEY WORK AND HOW TO USE THEM
AB004 $11.45
An excellent primer on the fundamentals of digital electronics. This book discusses the nature of gates and related concepts and also deals with the problems inherent to practical digital circuits.

MASTER HANDBOOK OF 1001 PRACTICAL CIRCUITS
TAB No.800 $20.45
MASTER HANDBOOK OF 1001 MORE PRACTICAL CIRCUITS
TAB No.804 $24.45
Here are transistor and IC circuits for just about any application you might have. An ideal source book for the engineer, technician or hobbyist. Circuits are classified according to function, and all sections appear in alphabetical order.

THE MASTER IC COOKBOOK
TAB No.1199 $18.45
If you've ever tried to find specs for a so called 'standard' chip, then you'll appreciate this book. C.L. Hallmark has compiled specs and pinout for most types of ICs that you'd ever want to use.

ELECTRONIC DESIGN WITH OFF THE SHELF INTEGRATED CIRCUITS
AB016 $13.45
This practical handbook enables you to take advantage of the vast range of applications made possible by integrated circuits. The book tells how, in step by step fashion, to select components and how to combine them into functional electronic systems. If you want to stop being a "cookbook hobbyist", then this is the book for you.

BP117: PRACTICAL ELECTRONIC BUILDING BLOCKS BOOK 1 $8.10
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.

PH253: ELECTRONIC DESIGN WITH OFF-THE-SHELF INTEGRATED CIRCUITS
Z. MEIKEIN & P. TACKRAY $13.45
A real help for do-it-yourselfers, this handy guide tells professionals and hobbyists alike, how to take components off the shelves, arrange them into circuitry, and make any system perform its desired function.

AUDIO

BP90: AUDIO PROJECTS $8.10
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.

205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES $3.55
B.B. BABANI
This book gives data for building most types of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams for every construction showing the dimensions necessary.

BP47: MOBILE DISCOTHEQUE HANDBOOK $5.90
COLIN CARSON
The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy. Many people have wasted a "small fortune" on poor, unnecessary or badly matched apparatus.

The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco" gear.

HOW TO BUILD A SMALL BUDGET RECORDING STUDIO FROM SCRATCH. . .
TAB No.1166 $16.45
The author, F. Alton Everest, has gotten studios together several times, and presents twelve complete, tested designs for a wide variety of applications. If all you own is a mono cassette recorder, you don't need this book. If you don't want your new four track to wind up sounding like one, though, you shouldn't be without it.

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING $5.50
M.K. BERRY
Electronic music is the new music of the Twentieth Century. It plays a large part in "pop" and "rock" music and, in fact, there is scarcely a group without some sort of synthesiser or other effects generator.

This book sets out to show how electronic music can be made at home with the simplest and most inexpensive of equipment. It then describes how the sounds are generated and how these may be recorded to build up the final composition.

BP74: ELECTRONIC MUSIC PROJECTS $7.70
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.

See order form in this issue. All prices include shipping. No sales tax applies.

Electronics

BP81: ELECTRONIC SYNTHESISER PROJECTS $7.30
M.K. BERRY
One of the most fascinating and rewarding applications of electronics is in electronic music and there is hardly a group today without some sort of synthesiser or effects generator. Although an electronic synthesiser is quite a complex piece of electronic equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

ELECTRONIC MUSIC SYNTHESIZERS
TAB No.1167 $11.45
If you're fascinated by the potential of electronics in the field of music, then this is the book for you. Included is data on synthesizers in general as well as particular models. There is also a chapter on the various accessories that are available.

Tab1364: DESIGNING, BUILDING AND TESTING YOUR OWN SPEAKER SYSTEM ... WITH PROJECTS $14.45
Covers the theory of speaker construction and describes a variety of plans for speaker system projects ranging from simple setups to complex multi-driver systems. Enclosure design is covered in very good detail.

BP68: CHOOSING AND USING YOUR HI-FI $7.25
MAURICE L. JAY
The main aim of this book is to provide the reader with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of hi-fi equipment now on the market.

Help is given to the reader in understanding the equipment he is interested in buying and the author also gives his own opinion of the minimum standards and specifications one should look for. The book also offers helpful advice on how to use your hi-fi properly so as to realise its potential. A Glossary of terms is also included.

TEST EQUIPMENT

BP75: ELECTRONIC TEST EQUIPMENT CONSTRUCTION $7.30
F.G. RAYER, T.Eng. (CEI), Assoc. IERE
This book covers in detail the construction of a wide range of test equipment for both the Electronics Hobbyists and Radio Amateur. Included are projects ranging from an FET Amplified Voltmeter and Resistance Bridge to a Field Strength Indicator and Heterodyne Frequency Meter. Not only can the home constructor enjoy building the equipment but the finished projects can also be usefully utilised in the furtherance of his hobby.

99 TEST EQUIPMENT PROJECTS YOU CAN BUILD
TAB No.805 $16.45
An excellent source book for the hobbyist who wants to build up his work bench inexpensively. Projects range from a simple signal tracer to a 50MHz frequency counter. There are circuits to measure just about any electrical quantity: voltage, current, capacitance, impedance and more. The variety is endless and includes just about anything you could wish for!

HOW TO GET THE MOST OUT OF LOW COST TEST EQUIPMENT
AB017 $10.45
Whether you want to get your vintage 1960 'TestRite'signal generator working, or you've got something to measure with nothing to measure it with, this is the book for you. The author discusses how to maximize the usefulness of cheap test gear, how to upgrade old equipment, and effective test set ups.

THE POWER SUPPLY HANDBOOK
TAB No.806 $16.45
A complete one stop reference for hobbyists and engineers. Contains high and low voltage power supplies of every conceivable type as well mobile and portable units.

PH246: ELECTRONIC TEST EQUIPMENT $20.45
Covers analog and digital meters, oscilloscopes, frequency generation and measurement, and special measuring instruments.

Tab1532: THE COMPLETE BOOK OF OSCILLOSCOPES $20.45
This totally up-to-date handbook is both an in-depth reference source and a practical applications guide. Information is included on both ordinary service and laboratory 'scopes, waveform analysis, vectors, vectorscopes, high and low frequency analysis, sampling, storage, digital scopes, and signature analysis. The author, Stan Prentiss is one of the leading technical writers in the U.S.

INTERRELATED INTEGRATED ELECTRONICS CIRCUITS FOR THE RADIO AMATEUR, TECHNICIAN, HOBBYIST AND CB'ER
MENDELSON
HB29 $11.45
This book provides a variety of appealing projects that can be constructed by anyone from the hobbyist to the engineer. Construction details, layouts, and photographs are provided to simplify duplication. While most of the circuits are shown on printed circuit boards, every one can be duplicated on hand-wired, perforated boards. Each project is related to another projects so that several may be combined into a single package. The projects, divided into five major groups, include CMOS audio modules, passive devices tohelp in benchwork, test instruments, and games.

BASIC CARRIER TELEPHONY, THIRD EDITION
TALLEY
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A basic course in the principles and applications of carrier telephony and its place in the overall communications picture. It is abundantly illustrated, with questions and problems throughout, and requires a minimum of mathematics.

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Literally everything the amateur or professional musician needs to know to properly maintain his instruments, plus all the how-to's for making repairs from simple tuning to major overhauls.

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING $8.10
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.

ELECTRONIC TROUBLESHOOTING HANDBOOK
AB019 $12.45
This workbench guide can show you how to pinpoint circuit troubles in minutes, how to test anything electronic, and how to get the most out of low cost test equipment. You can use any and all of the time-saving shortcuts to rapidly locate and repair all types of electronic equipment malfunctions.

COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS
AB018 $10.45
A complete guide on how to read and understand schematic diagrams. The book teaches how to recognize basic circuits and identify component functions. Useful for technicians and hobbyists who want to avoid a lot of headscratching.

REFERENCE

BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE $12.25
ADRIAN MICHAELS
This book will help the reader to find possible substitutes for a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer selection of modern transistors. Also shown are the material type, polarity, manufacturer and use. The Equivalents are sub-divided into European, American and Japanese. The products of over 100 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. Fantastic value for the amount of information it contains.

BP108: INTERNATIONAL DIODE EQUIVALENTS GUIDE
ADRIAN MICHAELS $8.35
This book is designed to help the user in finding possible substitutes for a large user orientated selection of the many different types of semiconductor diodes that are available today. Besides simple rectifier diodes also included are Zener diodes, LEDs, Diacs Triacs, Thyristors, Photo diodes and Display diodes.

BP1: FIRST BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES $2.80
B.B. BABANI
This guide covers many thousands of transistors showing possible alternatives and equivalents. Covers transistors made in Great Britain, USA, Japan, Germany, France, Europe, Hong Kong, and includes types produced by more than 120 different manufacturers.

BP14: SECOND BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES $4.80
B.B. BABANI
The "First Book of Transistor Equivalents" has had to be reprinted 15 times. The "Second Book" produced in the same style as the first book, in no way duplicates any of the data presented in it. The "Second Book" contains only additional material and the two books complement each other and make available some of the most complete and extensive information in this field. The interchangeability data covers semiconductors, manufactured in Great Britain, USA, Germany, France, Poland, Italy, East Germany, Belgium, Austria, Netherlands and many other countries.

TOWER'S INTERNATIONAL OP-AMP LINEAR IC SELECTOR
TAB No.1216 $13.45
This book contains a wealth of useful data on over 5,000 Op-amps and linear ICs — both pinouts and essential characteristics. A comprehensive series of appendices contain information on specs, manufacturers, case outlines and so on.

CMOS DATABOOK
TAB No.984 $9.95
There are several books around with this title, but most are just collections of manufacturers' data sheets. This one, by Bill Hunter, explains all the intricacies of this useful family of logic devices . . . the missing link in getting your own designs working properly. Highly recommended to anyone working with digital circuits.

Tab1538: ELECTRONIC DATABOOK — 3RD EDITION $30.00
Any electronic job will be easier and less time consuming when you have instant access to exactly the nomogram, table, chart or formula you need, when you need it. All this and much more is included in this completely revised and updated version of one of the most respected information source in the electronics field. Generously indexed, this handbook is divided into six sections: Frequency Data; Communication; Passive Components; Active Components; Mathematical Data; Formulas and Symbols and Physical Data.

Tab1516: TOWERS INTERNATIONAL MICROPROCESSOR SELECTOR $31.45
Towers Selector books have gained an international reputation for completeness and usefulness. This volume gives you all the data you will normally need to select the right chip.

ROBOTICS

THE COMPLETE HANDBOOK OF ROBOTICS
TAB No.1071 $16.45
All the information you need to build a walking, talking mechanical friend appears in this book. Your robot can take many forms and various options — light, sound, and proximity sensors — are covered in depth.

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BUILD YOUR OWN WORKING ROBOT
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Contains complete plans — mechanical, schematics, logic diagrams and wiring diagrams — for building Buster. Buster is a sophisticated experiment in cybernetics you can build in stages. There are two phases involved: first Buster is leash led, dependent on his creator for guidance; the second phase makes Buster more independent and able to get out of tough situations.

VIDEO

BP100: AN INTRODUCTION TO VIDEO
D.K. MATHEWSON $8.10
Presents in as non-technical a way as possible how a video recorder works and how to get the best out of it and its accessories. Among the items discussed are the pros and cons of the various systems, copying and editing, international tape exchange and understanding specifications.

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Covers such aspects as where to buy, problems in setting up your TVRO station and how to solve them, antenna siting and equipment selection.

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A complete handbook for the video enthusiast. You'll learn about how the systems work and how to choose as well as take a technical look at the inside workings. There are also sections on making your own video recordings.

MISCELLANEOUS

BP101: HOW TO IDENTIFY UNMARKED IC'S $2.70
K.H. RECORR
Originally published as a feature in 'Radio Electronics', this chart shows how to record the particular signature of an unmarked IC using a test meter, this information can then be used with manufacturer's data to establish the application.

AUDIO AND VIDEO INTERFERENCE CURES
KAHANER
HB21 $9.45
A practical work about interference causes and cures that affect TV, radio, hi-fi, CB, and other devices. Provides all the information needed to stop interference. Schematic wiring diagrams of filters for all types of receivers and transmitters are included. Also, it supplies simple filter diagrams to eliminate radio and TV interference caused by noisy home appliances, neon lights, motors, etc.

BASIC TELEPHONE SWITCHING SYSTEMS
TALLEY
HB27 $16.00
The Revised Second Edition of this book, for trainee and engineer alike, includes updated statistical data on telephone stations, and new and improved signaling methods and switching techniques. It also includes E & M signaling interface for electronic central offices and automatic number identification methods used in step-by-step, panel and crossbar central offices.

See order form in this issue. All prices include shipping. No sales tax applies.

Charles Proteus Steinmetz

An experimenter and teacher who took the guesswork out of electrical design.

Ian Sinclair

YOU CAN BE FORGIVEN if you've never heard of Charles Steinmetz, because neither his name nor his achievements are well-known today. Nevertheless, his contribution to electricity, and hence to electronics, has had a profound influence on us all, making possible advances that we now take for granted. Of all the famous names we have looked at so far, that of Steinmetz seems at first glance least connected with modern electronics, because most of his work was concerned with large electric motors, but, as often happens, a piece of research which expands useful knowledge often affects work which is carried out years later, and in an entirely different field.

Steinmetz was born in Breslau, Germany, in 1865 (the town is now called Wroclaw, and has been part of Poland since the occupation of Eastern Europe by the USSR after the Second World War). He was christened Karl August Rudolf, and was handicapped from birth by a severe spinal deformity, which may have had the effect of turning him to academic studies at times when his classmates were playing football. His education progressed to the Technical High School in Berlin, and from there, in 1892, to University, where he started to make a name for himself as a brilliant researcher and equally as a committed Social Democrat. It was this second activity which drew him to the attention of the ruling authorities, and it is ironic to think that if he were active in his home town right now, the Polish authorities would probably take the same line.

After several brushes with the Government, he emigrated, like so many others at the time, to the USA to find freedom of expression and action. Shortly after arriving, he anglicised his name to Charles Proteus — Proteus having been a college nickname.

His reputation as a researcher had preceded him, and he was employed almost at once by the firm of Eickemeyer and Osterheld, an electrical manufacturing company with interests in electric motors, transformers and power transmission. Once established, he founded a small research laboratory which soon became very well-known in the industry. It was at this laboratory that he discovered the effect of magnetic hysteresis.

Hysteresis Lesson

Now magnetic hysteresis isn't a subject you learn about nowadays unless you have specialized interests. This is a pity, because it deprives many of their first glimpse of real-life physics, as distinct from the neat and tidy world of theory. Let me explain the subject in outline.

When you stretch a spring, its length increases, and the amount of force that you need to keep the spring stretched depends on how far you have stretched it. Unless you stretch the spring too far, it will always return to its original length when you release it. This simple fact was discovered by Hooke in the seventeenth century, and is called Hooke's Law. A lot of laws in physics are like this one — one quantity is proportional to another, so that a graph of the extension of a spring for example, plotted against the stretching force, is a straight line (**Figure 1**). This type of relationship is called linear.

If you over-stretch the spring, however, its length is permanently changed, and the graph of extension plotted against force looks more complicated. The graph now has two lines, one for increasing force, the other for decreasing force (**Figure 2**). A shape of this type is called a 'hysteresis' curve, and it implies, in this example, that the spring does not return to its original length.

Until Steinmetz investigated the magnetization of iron, everyone assumed that when a coil of insulated wire was wrapped round a piece of iron, and an electric current passed through the wire, then the magnetism of the iron would depend on the amount of current through the wire, and the relationship would be linear, or almost so. They expected, in other words, that a graph of magnetic strength plotted against current would be a straight line. By the late 1880s, it was becoming obvious that this assumption just could not be sustained. There was, for example, no way in which the performance of an electric motor could be predicted using these simple ideas about magnetism, and the magnetism of the iron in the motor was the only missing link in the theory. The only way that a manufacturer could get data on the likely performance of a new electric motor design was to build a prototype and test it! At a time when the uses of electricity, and in particular the uses of electric motors, were expanding rapidly, this was unsatisfactory, rapidly becoming intolerable because the use of AC in power transmission, strongly urged by many engineers, demanded the use of transformers — and there was no theory governing the design of the most important part of a transformer, its magnetic core.

Round the Bend

Steinmetz set to work investigating the magnetism of iron and its alloys, using the type of equipment illustrated in **Figure 3**. The details have been omitted, but the principle was that a measured current was passed through the coil surrounding the magnetic specimen, and the strength of the magnetism measured (by a system which Steinmetz had devised). The measurements enabled him to draw a graph of magnetic strength (what we would now call the flux density) against the current flowing in the coil (proportional to what we now call magnetizing force). He started with com-

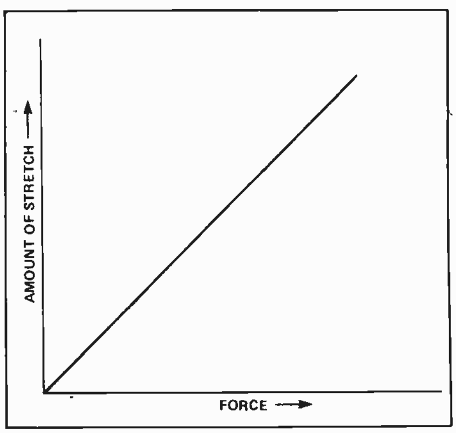


Figure 1. The graph for stretching a spring — providing you don't overstretch it!

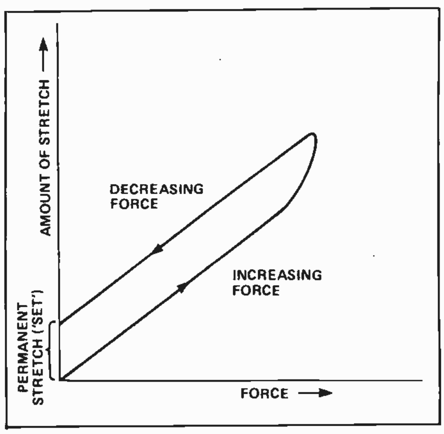


Figure 2. The 'hysteresis' graph shape that results from overstretching.

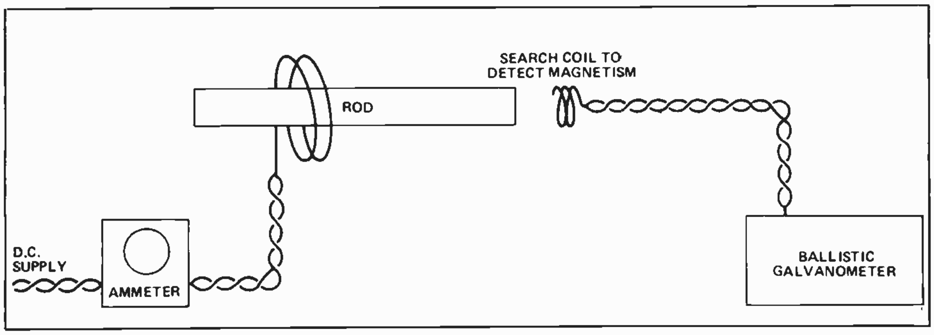


Figure 3. The Steinmetz apparatus, simplified. The rod was magnetized by the current flowing in the large coil, and the amount of magnetism detected by the smaller coil in conjunction with a ballistic galvanometer.

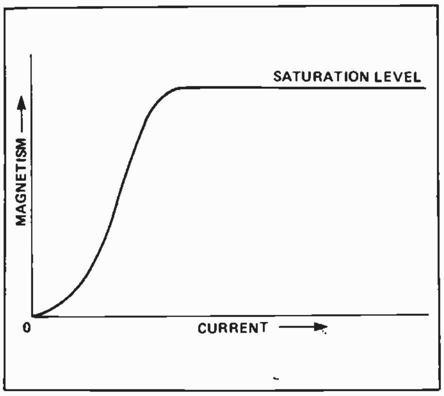


Figure 4. The first part of the magnetizing curve for iron.

pletely demagnetized iron, and found that as the current increased, the magnetic strength also increased, following a curved graph line shaped rather like an 'S', to a maximum magnetic strength, which he termed 'magnetic saturation' (**Figure 4**). When the current was reduced, however, a different set of graph points was obtained, so that the graph for decreasing current followed a different path. This path (**Figure 5**) showed that when the current was reduced to zero, the iron remained magnetized (the amount is called the 'remanence'). Steinmetz found that the magnetism could be reduced to zero only by reversing the direction of the current in the coil and holding it at some definite value, called the 'coercive force'. By taking the value of the reversed current to the amount that caused the magnetism to saturate again he produced the now-familiar hysteresis curve for iron (**Figure 6**).

The consequences of this work were enormous. The area inside the loop-shaped curve is proportional to the amount of energy that has to be used to magnetize and demagnetize the material, and this energy causes the iron to become hot. Previously, it had been thought that the heating of electric motors and transformers was due only to the current flowing through the wires (and to eddy currents), but Steinmetz's work clearly showed that the magnetic material was as much to blame. He went on to show that the shape and size (area) of the hysteresis curve could be greatly affected by the composition of an iron alloy, and, even more importantly, on its previous treatment, such as heating, previous magnetization, mechanical strain, and so on.

For the first time, electric motors could be designed and perform to specification, and transformers could be wound which would not overheat. The way was open for the invention of magnetic recording by Poulsen, and subsequent research which led to the discovery of ferrite materials such as are now used for coil cores and for aerials in pocket radios. Even if Steinmetz had done nothing more on this work, he would have deserved to be remembered, and his classic

Continued on page 75

Designing Micros *Continued from page 58*

eight ICs so as to access the eight bits corresponding to the same byte.

Next MUX goes high. This switches the multiplexer IC so that the RAM ICs are now connected to lines A7 to A13. An instant later CAS goes low and the upper seven bits of the address are loaded into each IC. The RAM ICs now hold the complete address and, after a short delay, the appropriate bit can be read or written in the usual way.

In a larger RAM we may have two or more sets (columns) of eight ICs, each with its own CAS line. The appropriate CAS line is selected by decoding the two upper address lines (A14 and A15) and combining them with the CAS signal from the MPU. Columns which are not being addressed will receive and store the lower seven bits of any address as a result of the RAS signal which all ICs receive. Only the addressed column will receive a CAS signal and respond to a read or write operation. For other configurations of memory, it may be necessary to have several RAS and CAS lines to bring different memory blocks into operation by row and by column.

The RAS input to the 4116 has an additional function, that of refreshing RAM. When RAS goes low, the internal switches are thrown so as to refresh every cell in the IC. Thus during every read or write operation to RAM *all* ICs are refreshed while the low half of the address is being loaded. The RAS signal operates for *all* read and write operations, whether these are to RAM or ROM. Thus, even while the MPU is reading a program from its monitor or resident language in ROM, it is still causing its RAM to be refreshed regularly.

One-Chip RAM

The majority of current micros have a 16-bit address bus and are therefore able to address up to 64K. This must include ROM too, so it would be uneconomical and somewhat complicated to use a 64K RAM IC with part of it overlapping ROM. However, with the 64K chip coming into full production (a forecast of 140 million 64K RAM ICs in 1983) for use in minis and mainframes, we may expect to find them in frequent use in micros before long.

With all the address decoding on the chip, the design of the computer board is correspondingly simplified. It has been reported in New Scientist (8 July 1982) that the British firm Inmos has just produced its first 64K DRAM which shows a number of interesting features. One feature is that it automatically refreshes itself, so eliminating the need for special refresh circuitry on the computer board. Also, it operates twice as fast as the 4116.

Another features is that the RAM carries eight spare rows of memory cells and eight spare columns. Making very complicated circuits on a single chip has the advantage that the connections between different units (eg between RAM and multiplexing and decoding circuits) are all on the chip and do not have to be taken out through terminal pins. This means that the IC need have fewer pins in proportion to the amount of circuitry it contains. Against this is the fact that as we increase the areas of silicon on which the chip is made and as we increase the number of components put there, the chance of blemishes and faults rises steeply. It is common to manufacture dozens of chips on a single slice of silicon and, after testing them individually, to reject a high percentage. Obviously a high rejection rate puts up the final cost of the product. With eight spare rows and columns of memory cells, the spare ones can be connected in place of faulty ones after the RAM has been tested in manufacture. This means that the rejection rate falls and eventually the cost of the product can be reduced. ETI

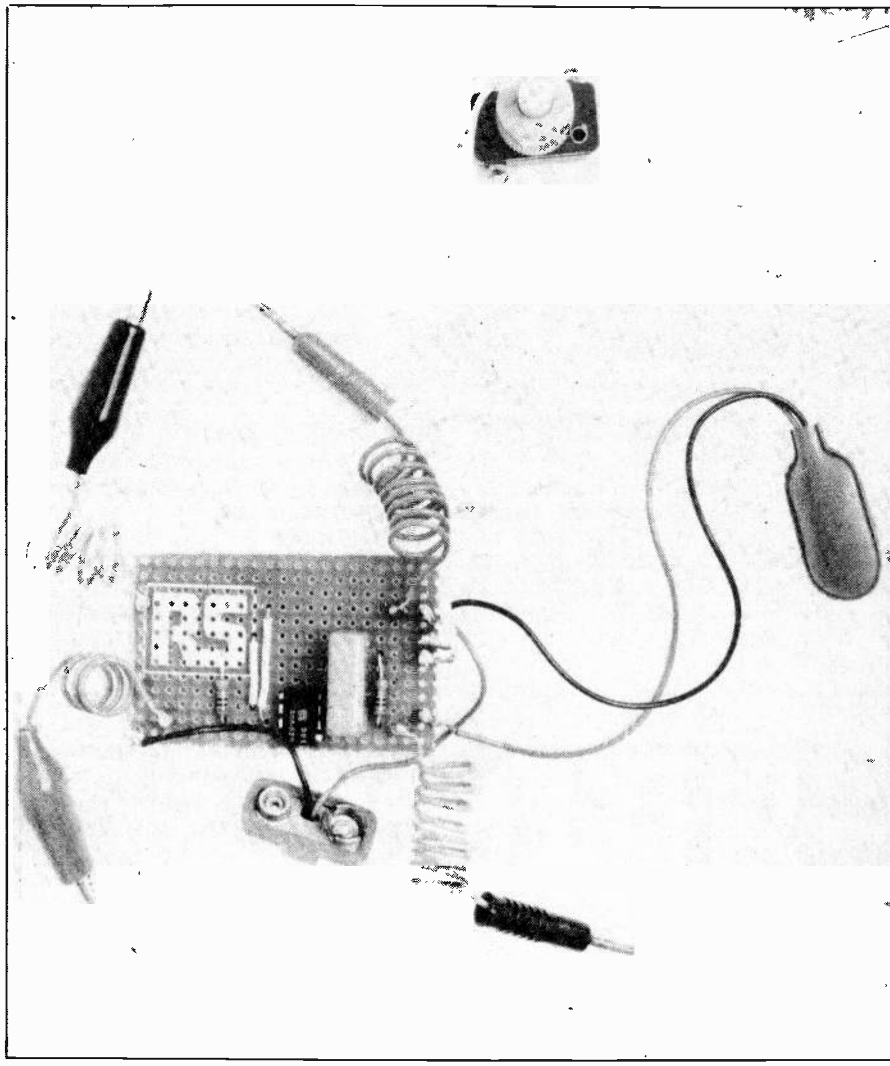
No. 2: Voltage Follow-and-Hold Circuit

ONCE in a while, and probably more often, it is necessary to measure a voltage which is changing rapidly — but trying to follow the needle of the voltmeter by eye and read it at *just* the right instant is tension-generating, to say the least! And if your eye cannot follow the needle, it is likely that the needle cannot follow the rapidly changing input voltage either, so whatever reading you have struggled to obtain will be doubly in error. This circuit, however, gives your eye *and* the needle a breathing-space in which to catch up with the changing voltage. Pressing the button, it takes a sample of the input voltage at any instant; the circuit then holds the sampled voltage while the needle of the meter comes to rest, and your eye has time to take the scale reading with all the accuracy you need.

The Circuit

The output of the circuit (Figure 5) follows the input voltage as long as the button is held pressed. When the button is released, the output remains constant at whatever value it had at the instant of release. When the button is pressed again, the output immediately becomes the same as the input voltage. The operation of the circuit is diagrammed in Figure 6.

The op-amp is connected as an inverting amplifier with unity gain and with the button pressed, output follows input except that it is inverted. Now an op-amp is stable when there is no potential difference between its two input terminals, but since the non-inverting (+ve) input is wired to 0 V, the inverting input must also be at 0 V if the circuit is to be stable. So given an input of, say +2 V, a current of 200 uA flows toward the inverting input, by way of the input resistor R1. The amplifier input has extremely high resistance so almost no current enters it, but instead, flows on through R2 and *into* pin 6 of the op-amp. Since R1 has the same



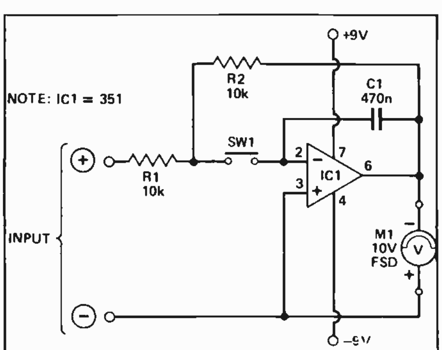


Fig. 5. The follow-and-hold circuit.

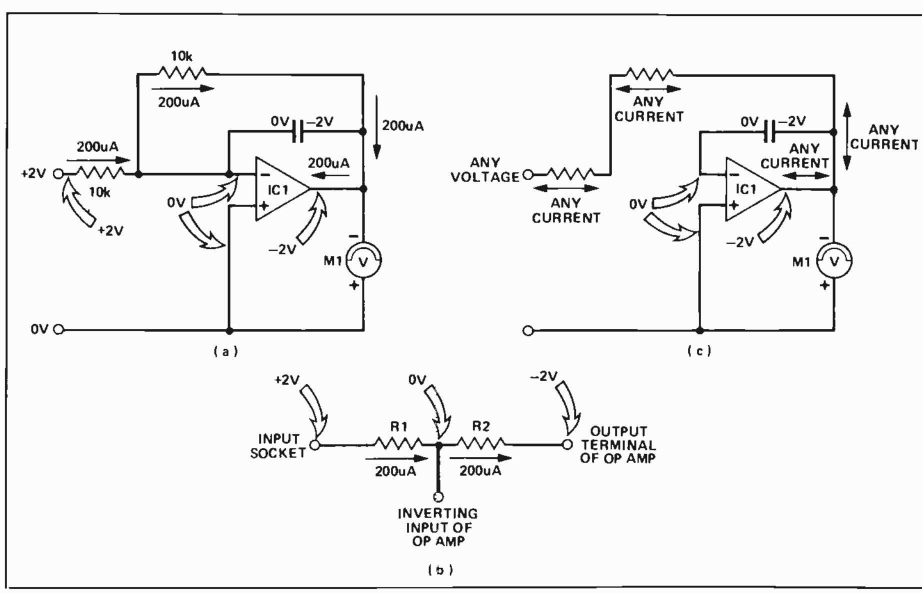


Fig. 6. (above). How it works; (a) with + 2V on the input, a current of 200 uA flows into the op-amp output pin; (b) this causes voltage drops of 2V across each resistor, so that the inverting input is at 0 V, the output at -2 V and the op-amp is stable; (c) in "hold", changes at the input cannot effect the op-amp output.

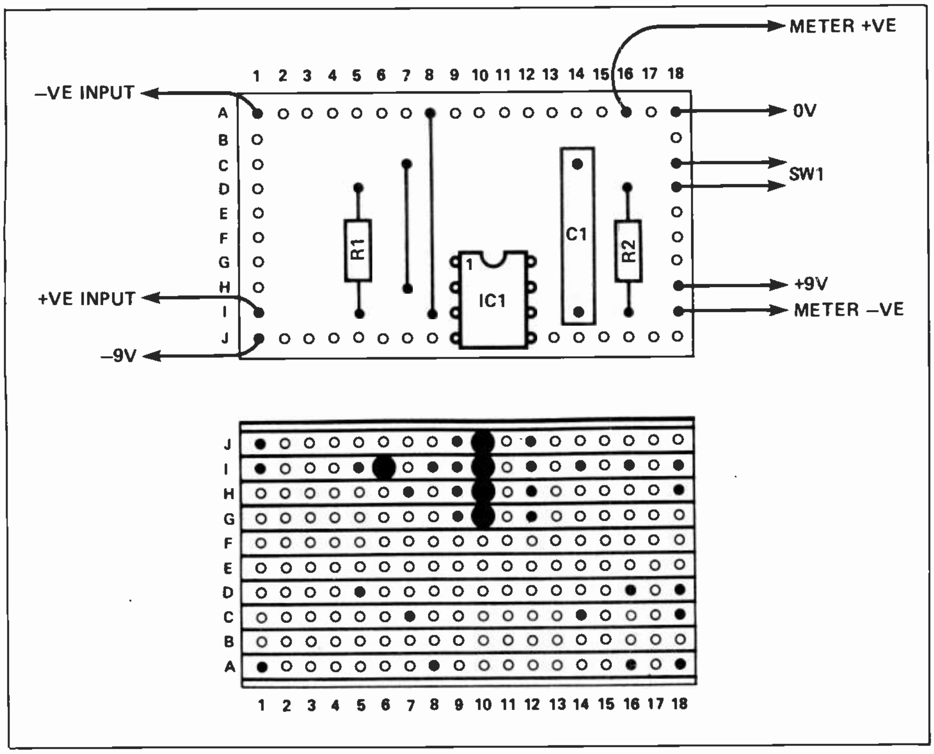


Fig. 7. The Veraboard component overlay (top) and the track-side view (bottom), showing the positions where the strips are cut.

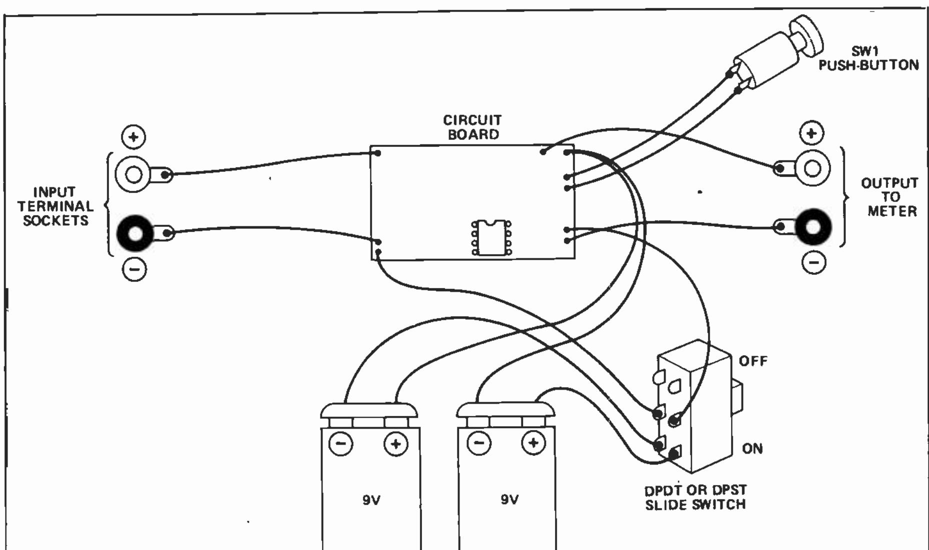


Fig. 8. Wiring the external components to the Veraboard.

value as R2, and the same current flows through each; the voltage difference across each resistor is the same (Figure 6b). Therefore, with a drop of 2 V across each resistor, the output potential is -2 V, the potential at the inverting output is 0 V and the op-amp is stable. In this state, one side of capacitor C1 is a 0 V and the other is at -2 V; there is 2 V across it.

When the button is released, the circuit becomes as shown in Figure 6c. The input to the circuit may change, either increasing or decreasing in voltage, and a varying current may flow in either direction through R1, R2 and into or out of the output terminal of the op-amp — but the output of the op-amp is entirely unaffected by this! The potential at its inverting input is held at 0 V because of C1 and, since this is still the same as the potential at its non-inverting terminal, the amplifier is stable; it maintains an output potential of -2 V.

The capacitor retains its charge for a long time, since there is no way in which a large current can flow from one side of the capacitor to the other. The plates of C1 are effectively insulated from each other by the dielectric, which has a resistance of 20,000M or more, while leakage into the amplifier is very small too, since the input impedance is 10^{12}R — a million megohms! — and this high input impedance is the reason for choosing a JFET op-amp for the circuit. With such high resistances, a charge of 2 V on C1 takes 47 seconds to drop just a hundredth of a volt. This should give you (and the meter) plenty of time to cope!

The circuit described has unity gain, so meter readings are equal to input voltages, though increasing the value of R2, you can make the circuit amplify the voltages as well as hold them. The amplification is set by the ratio R2/R1; for example, if you replace R2 with 100k, the op-amp amplifies ten times.

The reason for choosing the 531 in preference to other JFET op-amps is that it has a very high slew rate (rate of change of output voltage) of 13V/us, which compared with the rate of 0V5/us for the 741, makes it a good device for rapidly sampling changing voltages.

Operating the multimeter on the 10 V range means that offset null adjustments (see Pop-Amps No. 1) are less important and an offset potentiometer is not needed.

Construction

There are so few components that construction of the circuit takes only a few minutes. The component layout is shown in Figure 7. Whether you decide to mount it in a case is a matter of preference. If you have a 10 V meter to spare, you can mount this on the case; it does not need to have a high coil resistance, so a cheap one will do. Otherwise, plug your multimeter into the circuit, using the two sockets indicated.

PARTS LIST

Resistors (All ¼ Watt 1% carbon)
R1,2 10k

Capacitors
C1 470n polycarbonate

Semiconductors
IC1 7611 CMOS op-amp

Miscellaneous
2.5 mm stripboard, 48 x 25 mm; 6 x 1 mm terminal pins; 2 x 4 mm red sockets, 2 x black; push-to-make switch; DPDT switch; 2 x 9 V battery connectors; optional case; wire, solder, etc.

No. 3: Millivoltmeter

THE millivoltmeter is a circuit with a high input impedance, to allow you to measure potentials from just under 1 volt down to tenths of a millivolt.

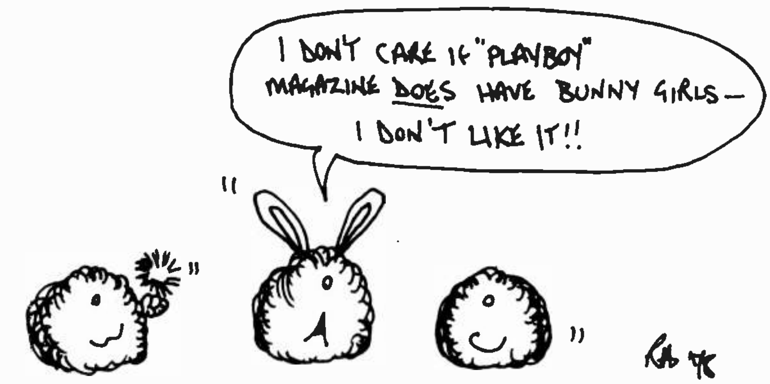
In the diagram (Figure 9a), the amplifier (represented by a triangle) has two inputs (+ve and -ve) and one ouput. It needs a balanced power supply (V+ and V-) provided by two 9 V batteries. A power supply of +18 V can be used with the potential divider network of Figure 9b, but better operation is obtained by using a regulator IC to provide a balanced supply from a single-rail. All voltages are measured with respect to the common 0 V battery connection.

The 741 has two offset null terminals (pins 1 and 8) with which we can adjust the output voltage to exactly 0 V when both inputs are at equal voltage. The input terminals are temporarily connected together and RV1 is adjusted until the output at pin 6 is 0 V.

Voltage Amplifier

Like all op-amps, the 741 is an amplifier with the capability of very high gain. Without the feedback resistor, its gain (the open-loop gain) is as high as 200,000 or more. There is, of course, the limit that the output voltage cannot exceed the supply voltage in either direction. In practice, the output does not quite reach either supply voltage; the swing is approximately ±8 V. Within this range, a small input voltage is amplified so that it becomes large enough to be read on a low-cost multimeter.

The non-inverting (+ve) input is tied to 0 V through R4. The op-amp will have zero output voltage when its inverting (-ve) input (at pin 2) is also at 0 V; in this state no current flows through R5. When a voltage is applied to the positive input terminal, a current will flow through one of the resistors R1-R3. Suppose the voltage here is 0V5 and SW2 is in the position shown. With pin 2 at 0 V, the resulting current through R1 is 0.6 uA. The potential at pin 2 now begins to rise and the output of the op-amp swings negative. It continues to swing negative, pulling the entire current flowing through R1 and through R5 to the output terminal, thus maintaining a 'virtual ground' at the inverting input. To make a current of 0.6 uA flow through R1 and through an 8M2 resistor requires a voltage of 5 volts, so, for an input of 0V5, the output must swing to -5 V. This means that there is tenfold voltage amplification — but note that the output voltage is *negative*. However, the meter is connected to display this as a positive voltage.



With a feedback resistor in the circuit, the gain of the amplifier is precisely determined by the ratio of the feedback resistance to the input resistance. In the example above, R5/R1 = 10, which gives tenfold gain. If SW1 is switched, the gain becomes 100 or 1000 respectively. If 5% tolerance resistors were to be used, one resistor might be up to 5% larger than its nominal value and the other might be 5% smaller. The ratio, and hence the calculated gain, could therefore be up to 10% in error in either direction, so to obtain reasonable accuracy it is important to use 1% or 2% resistors.

The input impedance of this circuit is the value of the input resistor that is switched into circuit. With R1 in circuit, the maximum output voltage that can be read is about 8 V, equivalent to 0V8 input. Thus the input impedance is just over 8M2 in parallel with 2M (the input impedance of IC1), which gives 1M6, or 2M0 per volt FSD, which is considerably higher than that of a low-cost multimeter; the same figure applies in the other ranges, so we have the twin benefits of greater sensitivity and high impedance.

Using the Circuit

Connect the circuit to the multimeter, switched to 10 V or 15 V DC range. Connect the power supply to the circuit. If you have not already done so previously, adjust RV1 for zero output with pins 2 and 3 shorted together. Switch SW2 to the position shown. The meter now covers the range 0-0V8. Read the meter and divide the reading by 10 to obtain the value of the input voltage. If the reading is low, switch to the second (0-0V88) or third position (0-0V008). If batteries are used as the power supply, remember to switch off or disconnect them when the circuit is not being used.

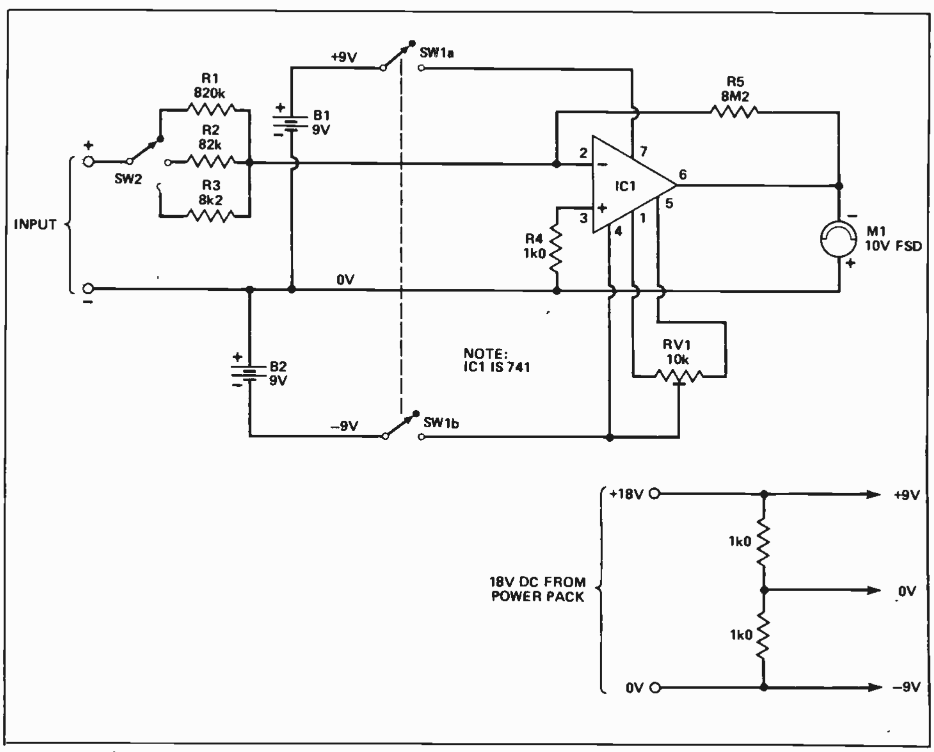


Fig. 9. (a) the Millivoltmeter circuit; RV1 is used to adjust the offset to zero; (b) how to power any Pop-Amp circuit from a + 18 V single rail supply.

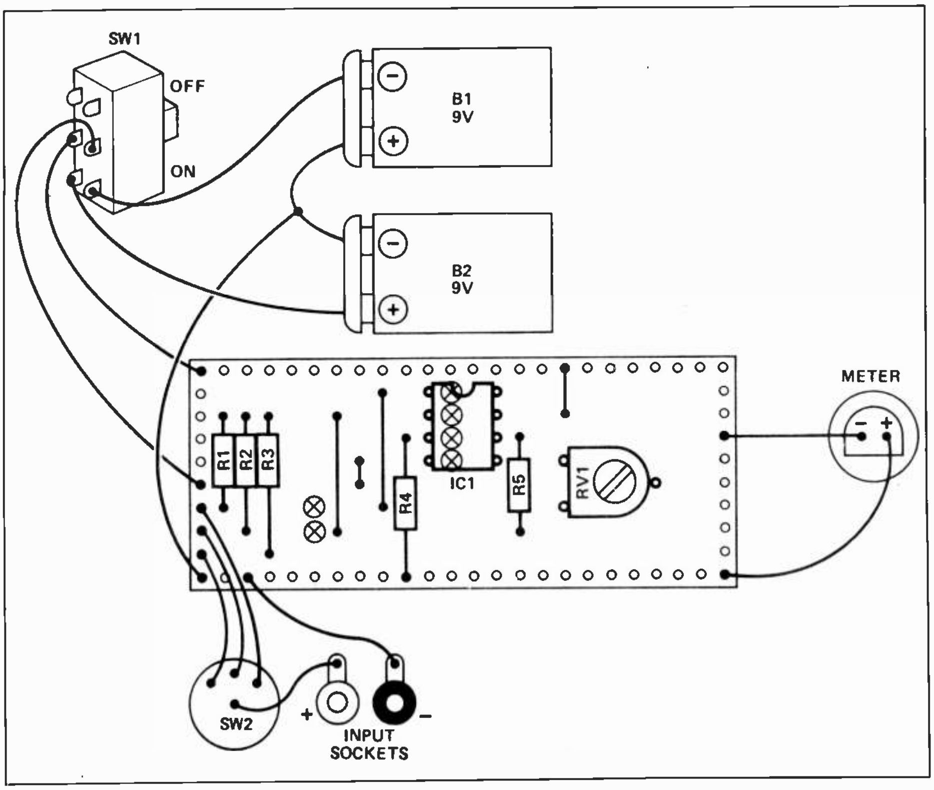


Fig. 10. The Millivoltmeter component layout. The track cut positions are shown viewed from the top.

PARTS LIST

Resistors (¼ watt % metal film, except as noted)

R1	820k
R2	82k
R3	8k2
R4	1k ¼ watt 5% carbon

Potentiometers

RV1	10k min. horiz. preset

Semiconductors

IC1	741 op-amp

Miscellaneous

M1	10 V FSD meter
SW1	DPST toggle or slide switch
SW2	3-way rotary switch

Stripboard, 63 x 25 mm (24 hole x 10 strips); 2 x 9 V battery clips; 4 x 4 mm sockets; 9 x 1 mm terminal pins; wire, solder, etc.

ETI

Charles Steimetz *Continued from page71*

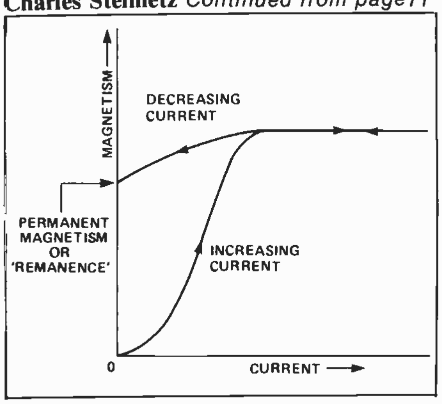


Figure 5. The hysteresis effect — as current is reduced from the saturation level, a different curve is traced, and with zero current, the iron remains magnetized.

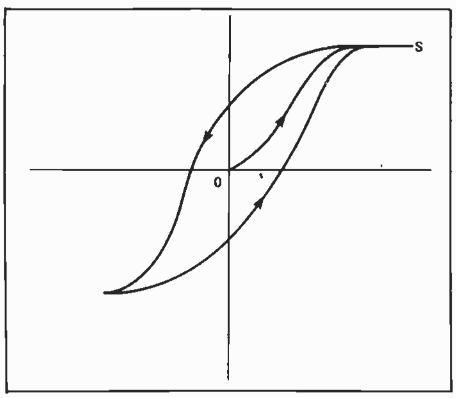


Figure 6. The complete hysteresis loop — the first part, marked OS, is seen only when starting with completely demagnetized material and is never traced again in the course of a measurement of this kind.

paper of 1892 is well worth reading in reprint form.

It Doesn't Add Up . . .

He contributed much more, however. When he arrived in the USA, he was amazed and dismayed to find that engineers, brought up in the British tradition, were almost incapable of making elementary calculations on alternating current circuits, and he undertook, virtually singlehanded, to raise the level of mathematical education to the standard which by then was common on the European continent, Britain excepted. He invented a new method of expressing AC calculations (the j-vector method) which is still in use, and, finding that engineers didn't understand it or even appreciate its advantages, he set about writing, in 1897, a textbook of Engineering Mathematics which did more to improve the education of engineers than any other single step in the decade.

Steinmetz's reputation by that time was such that when General Electric purchased the firm of Eickemeyer and Osterheld, Steinmetz was regarded as the main asset, and the most valuable single part of the deal. His work for GE included a new theory of transients (voltage pulses) which resulted in greatly improved ways of protecting transmission lines against switching surges and lightning strikes. The same theory was later used by the early workers on radar to predict the action of pulses in their circuits. Always an experimenter as well as a brilliant theorist, Steinmetz designed a pulse generator, for testing lines, which would even nowadays be regarded as someing special — 100kV at 10kA for 1 ns! This giant insulation-cracker was used to test lines for transient behaviour — and one nanosecond is as transient as you can get.

He continued working for GE, living in their bachelor accommodation surrounded by dozens of pet small animals of every kind, and a hothouse full of his special joy, orchids. He appears to have been idolised by his fellow-workers as that very rare type, a near-genius who was at the same time a very warm and friendly personality, and who would help anyone to the best of his ability. He died in 1923, having amassed no fortune, won few of the glittering prizes that most academics covet, and not even honoured by having his name used for a unit or a device. The admiration of his colleagues and the increasing value of his contributions to electrical science were reward enough for Charles Steinmetz.

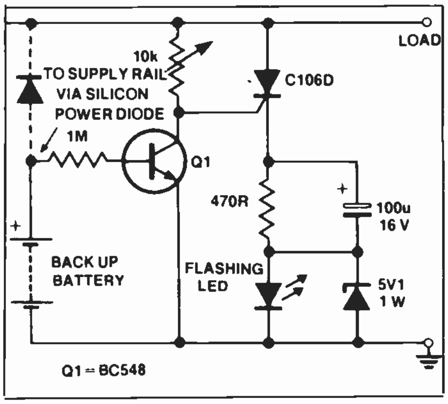
ETI

TECH TIPS

Battery watchdog
by C.W. Catherwood

In most equipment where there is a battery back-up, there is no indication of the condition of the battery.

The battery may lie around forgotten until it is eventually required, but then you find that it is no longer serviceable and may even have leaked corrosive acid damaging



components and the pc board.

This is a simple circuit which indicates a dying battery in a battery back-up system. It only uses a few components and the small pc board can be easily incorporated into most equipment.

Q1 and the 10k preset potentiometer form an adjustable voltage divider. It is controlled by the base current of Q1 via the 1M resistor and the value set on the 10k potentiometer.

The voltage on the divider feeds the gate of the SCR, switching it on. The SCR then conducts through the flashing LED, indicating an unserviceable battery.

The zener diode maintains the five volts required by the flashing LED. The electrolytic capacitor across the series dropping resistor forms an RC network which determines the flashrate.

The voltage of the battery which is to be tested can be determined by adjusting the 10k potentiometer. This could be done by using an adjustable power supply in place of the battery.

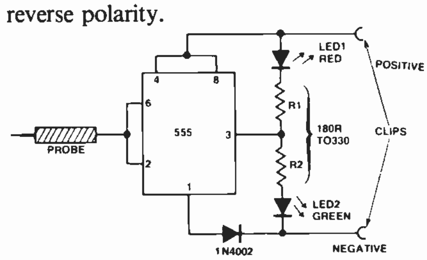
Positive-negative probe
by David Pye

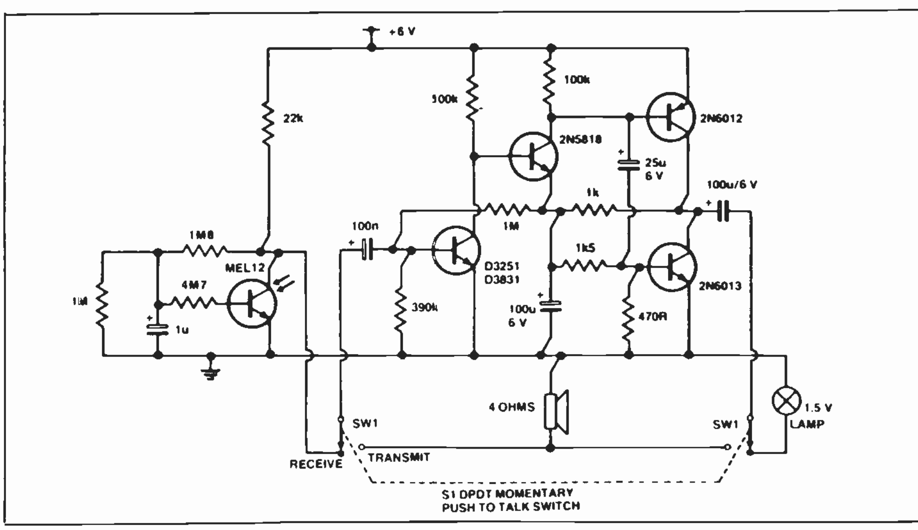
This simple circuit acts as a simple substitute for a voltmeter.

In many cases all that you want to know is whether a reading is positive or negative. This is particularly useful in car or motorcycle electrical repairs and, as the unit can be made extremely small, it will fit in any tool kit.

It will fit in a small plastic pill container, operate on any voltage between 5 V and 15 V and is quite cheap as it only requires a few components.

When the positive and negative clips are connected to the circuit both LEDs will light. Then when the probe touches a positive point the green LED is extinguished, leaving the red LED on, signifying positive. Touching the probe to a negative point extinguishes the red, leaving the green LED on. The 1N4002 is a protective diode for reverse polarity.





Flashlight communicator
by Chris McRae

This simple, portable, visuality-aligned transceiver is quite effective and can be easily built into a flashlight.

The lamp current, modulated at an audio frequency, modulates the light beam. The light beam is detected by a photodarlington transistor and drives a small speaker for audio output.

The lamp is driven by an acsignal which cuts the RMS voltage to about one-third of the six volts, which is why a 1.5 V bulb is used in a 6 V circuit.

The photodarlington can be mounted on the axis of the beam or you may get better sensitivity by placing it so that it faces the reflector of the flashlight just above the bulb (the bulb filament is at the focal point of the reflector).

Fidelity is not high due to the low pass characteristics of the bulb filament, but I have been able to have intelligible conversations at distances up to 30 metres.

We offer our most humble apologies for printing the preceding Tech Tip in our December issue without the accompanying schematic.

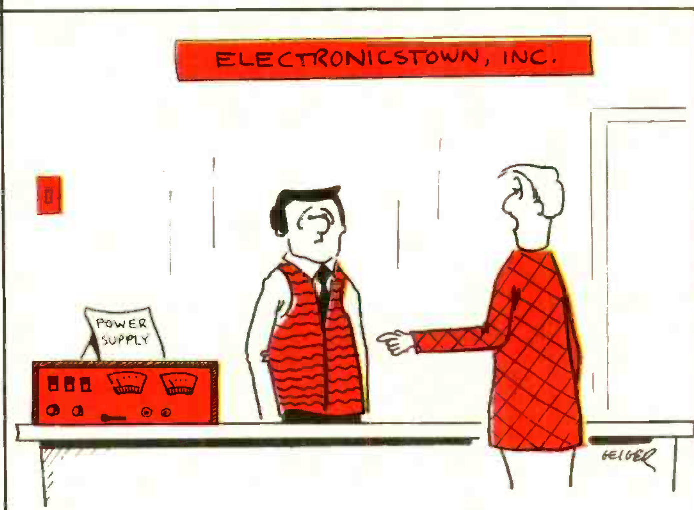
ETI

The Fun of Electronics

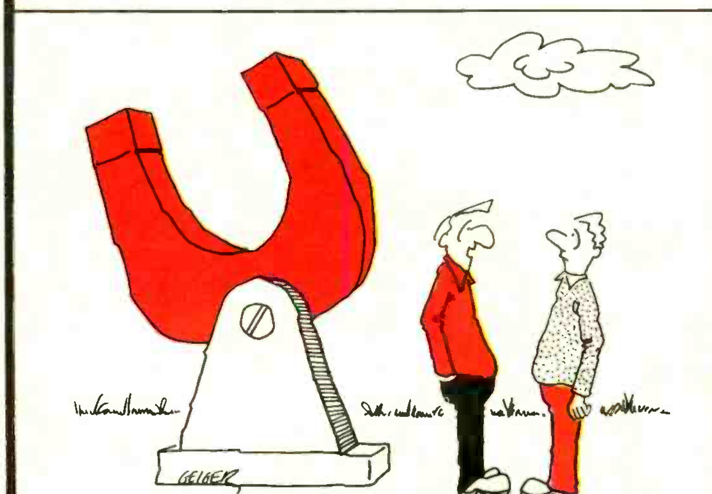
"Well, look at that! You seem to be resonant at 5 kHz."

"So you don't think there's any market at all for digital shoes?"

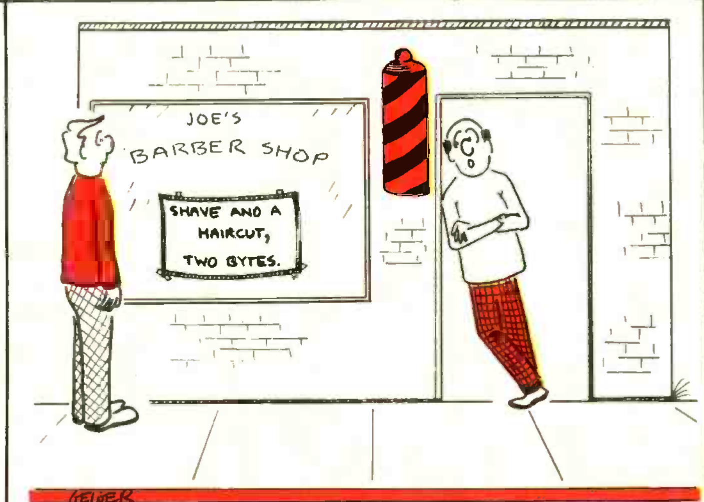
"Ever since the storm blew my antenna into the lake, I've been getting transmissions from some station that calls itself 'Radio Atlantis'.



"I'll take one of those. Got any Wealth and Fame supplies?"



"Instead of just pulling in satellite TV signals, I'm going to pull in the whole satellite."



"Inflation."

UNITRON 2200 CASE

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Case only 49.95
Keyboard case only $19.95
Numeric Keyboard, curly cord, case $119.95
Keyboard and case are fully 6502 compatible.

IBM PC™ LOOK-A-LIKE CASE

Make your Apple™ or 6502 machine look like an IBM PC™. This attractive metal case with ABS front bezel looks just like you-know-who, but is punched internally to take all the 6502 Mother boards, power supplies etc that are now sold. Our black beauty power supply fits in just right with the power connector and switch accessable at the right hand side. In addition the case holds 2 standard disc drives (4 slim lines) with all holes pre-punched. There is also a cut-out for a 4¼ inch muffin fan inside. Look at the photo, it really looks good $159.95
● Keyboard Case .... $ 29.95

SYSTEM SAVIOUR

2 grounded 3 wire switched sockets, pilot light, surge protector and on-off switch to turn off your system and two plugged in items $55.95

POWER SUPPLY

Our Famous "BLACK BEAUTY" power supply, now reduced in price but not in quality. Our ratings are 5V-5A; 12V-2.5A; -5A-½A; -12V-½A for real. Make sure that any other power supply that lays claim to this rating actually does so. Labels are cheap and we have seen many of the old silver power supplies unchanged except for the label. Easily beats all the rest $99.95

SOLID ABS CASE

NUMERIC

$59.95

Parts ELECTRONIC COMPUTER Galore

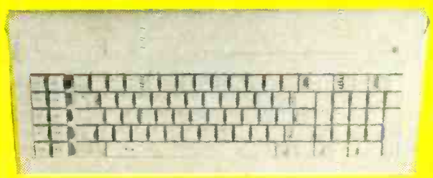
316 College St., Toronto. M5T 1S3
(416) 925-1105 (416) 925-8291

OUR 6502 BOARD

Now only $29.95 still with all the versatility of the original and a full 8 slots.

NOTE: The great deal offering our 6502 PCB and any 4 peripherals for $57.00 is still in effect. (Excludes the 128K card and wildcard)

NEW FROM MAXISWITCH™



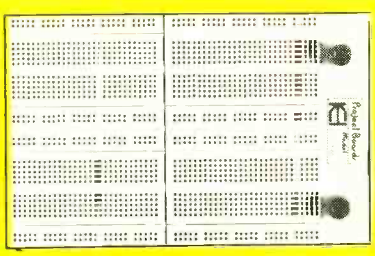
The finest most cost effective keyboard for the IBMtmPC or the APPLEtm that we have ever seen. The IBM model has all of the standard features of the IBM KB plus an improved return key for true typewriter emulation (For word-processing) Full N key roll-over, auto-repeat and more. The APPLE version has a lot more than the run of the mill APPLE keyboard, 10 function keys, cursor pad, numeric pad, and 21 preprogrammed commands to save a lot of typing. Just like the picture and just as pretty.

ONLY $199.95

Please specify APPLE, or IBM PC, XT

NOTE: Complements our IBM look-alike case exactly.

PROJECT BOARD



Have you ever tried to get an economical protoboard and had a shock? Well look at this, a good quality protoboard at a 30-40% saving. The KH-408 has 1560 holes on a std 0.1" grid for IC's and a sturdy plastic base with two binding posts for power, an excellent buy for the student.

$38.00

PERIPHERAL CARDS

New low prices.

A) Z-80 Wired n tested .... $59.95..Bare PCB $12.95
B) 80 Col Wired n tested .. $74.95..Bare PCB .. $12.95
C) 16K Wired n tested .... $59.95..Bare PCB $12.95
D) Disc Wired n tested ... $69.95..Bare PCB ... $12.95
E) Shamrock 13/16 sector disk Wired n tested .. $79.95
F) Apple™ Prototype card, all WW holes $12.95
G) Apple™ Prototype card, power bussed $14.95
H) Wildcard™, Wired n tested.$59.95.Bare PCB $12.95
I) 128K Wired n tested, no IC's $69.95
With 64K . $149.94, 128K . $239.95, PCB $24.95

GREAT DEAL

THE GREAT DEAL CARRIES ON FOREVER AND GETS BETTER

Our proven 6502 motherboard plus a numeric case plus a black beauty power supply plus a numeric keyboard plus any 4 bare pcb (except 128K and tamecard) for $275.00.

DIGITAL MULTI-METER

AMAZINE QUALITY AT LOW COST

$69.96

EXTRA FEATURE

● Diode test circuit ● Lo voltage ohms, 0.5v ● Lo battery indicator ● Auto-Zero ● Auto polarity ● Overload protection, all ranges ● ABS case (will not crack) ● One hand push buttons.

ASCII KEYBOARDS

Our ASCII keyboards are by ALPS, a famous Japanese switchmaker and feature high quality debounced switches. Full upper and lower case capability. Direct plug in compatible with all 6502 boards and 'SURF' board. Available in numeric and std style.

(a) Standard KB $89.00
(b) Numeric KB $99.00

MAIL ORDERS

We accept Personal Cheques, Postal Money Orders, Certified Cheques, Travelers Cheques, Visa, American Express, Mastercard, Bank Draft. We ship C.O.D. only by CANPAR and Truck. We do not use Canada Post C.O.D. We will send your goods via CANPAR or Canada Post unless you say otherwise. You will be charged a min $3.00 for delivery and handling or more if your goods are heavier than the $3.00 weight or if you specify another delivery service that charges more. All Ont res + 7% sales tax. We sell wholesale to any retail store or other reseller with a sales tax exemption #. as long as a realistic quantity is bought. We ship within a week if in stock and we will cancel any backorders over 4 weeks unless otherwise instructed. 20% Restocking Charge.

Circle No. 15 on Reader Service Card.