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November 1981

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Joystick Interface (PROJECT)

Digital Design Handbook

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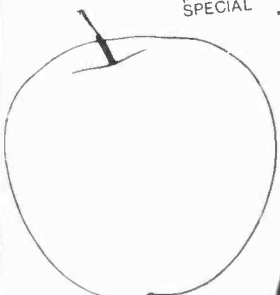

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Digital Design Handbook 10
A veritable plethora of digital circuits, each one completely tested and absolutely guaranteed to wind up flat as a board if you park a truck on it. By Ian Graham.

James Clark Maxwell 27
Maxwell was one of the founding fathers of electronics. Without him, we might never have come upon electronic data processing, and your phone bill would still arrive with the correct charges on it. A great man.

Canada In Space 31
Actually, Canada has done quite a bit way up there, aside from shooting off Aniks to bring King of Kensington re-runs to the Inuits. Roger Allen elaborates.

POKEing the ZX80 37
The Sinclair ZX80 has turned out to be one of the most popular teeny tiny computers around. Here's how to get still more out of this useful little machine.

VIC-20 Review 39
Imagine a full colour computer with four sound generators, a full size keyboard, 9 K BASIC, optional high resolution price tag and a free Rolls Royce, all for $450.00. Now imagine it without the Rolls. Steve Rimmer rattles the keys.

PWM Explained 51
A PWM amplifier is one which produces square waves out, even if you put something else in. Ten years ago, this would have been called total distortion. Advances in technology have given it another name.

Discount Coupons 56
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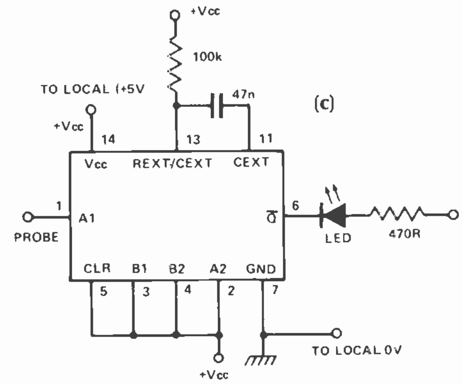

FALLING EDGE / CLOCK DETECTOR PROBE

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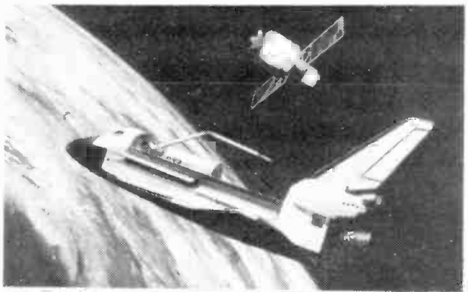

It's been suggested that, whereas the first American astronauts were chimps, we should probably orbit a beaver. Actually, there's been some indication that was tried in the early sixties, but that the little fellow got loose and gnawed down the rocket to build a hydro electric dam. More startling facts about Canada in Space begin on page 31.

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A hand-held game that can be kept with you at all times. Just the thing to idle away the hours in hyper-space waiting to pop out of a time warp in the lesser Magellanic Cloud.

Headlight Delay 24
A simple little accessory for the family chariot, which keeps the headlights on for a while after the engine is switched off, to permit you to find your house keys.

Drum Machine 45
This is a fairly simple drum synthesizer, but it can still produce two channels of adjustable electronic percussion. Build it and become a rock superstar, be adored by millions and live in a palace in Carmel. Bet you never knew it was that simple.

Joysticks 59
With this simple interface, your computer can read the position of an external joystick, providing many relaxing hours of watching the little white dot zoom around the screen until you go blind. What fun!

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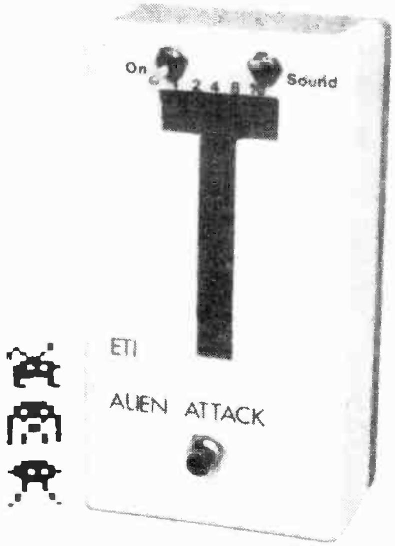

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Resistors are treated similarly: 1.8Mohms is 1M8, 56kohms is the same, 4.7kohms is 4k7, 100ohms is 100R and 5.6ohms is 5R6.

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We're proud to add this to our line. It's similar to our 15 channel LED chaser but with many extra features. There are over 60 selectable modes. A few: Up, Down, Skip, Pulse, Scramble, Single Pulse, Multi Pulse and many more. An optional 120 vac board is available. (Extra)

STROBE LITE KIT $21.95
MODEL EK80SL001
Fantastic for special effects. Variable speed Xenon flash gives you a "STILL MOTION" effect. A real attention getter.

CRYSTAL RADIO KIT $8.95
MODEL EK80CR001
A self powered radio which uses a resonant circuit and detector for AM radio reception. An ideal project for the beginners.

1.5 to 24v POWER
SUPPLY KIT $24.95
MODEL EK80PS024
A variable Power Supply suitable for many digital and linear applications. Delivers an output current of 100ma. from 1.5v to 15v and 500ma. from 16v to 24v.

0.28 VOLT POWER
SUPPLY KIT $39.95
MODEL EK80PS028
A true 0 to 28 volts capable of delivering 1 amp continuous. Full wave rectification, filtering and capacitance multiplication provides a clean dc source for sensitive audio and digital work. An ideal supply for the experimenter.

STEREO AUDIO
MIXER KIT $49.95
MODEL EK80AM001
Inputs 2 phono, 1 aux. Master control. Expandable. Frequency response 20Hz-20kHz; 5v output, 0.01% distortion.

16 CHANNEL LED
CHASER KIT $22.95
MODEL EK80LC016
A very familiar sight seen at discos, department stores, and on neon signs. 16 LED's flash in sequence up-down or alternate. Adaptable to 120 vac. (Extra)

POWER SUPPORT 120 .... $24.95
MODEL EK80PLC120
A 120 volt power board which allows you to connect regular lamps to our LED Chaser Kits. 8 channels are supplied per board with 150 watts per channel. They can be easily interfaced for 16 channels.

5 WATT IC AUDIO
AMPLIFIER KIT $19.95
MODEL EK80A00S
A general purpose 5 watt amplifier with Thermal Overload and Short Circuit Protection.

DOMINION RADIO: The Home of Radio and Electronics Supply

Circle No. 12 on Reader Service Card.

NEWS

Computer Synth

Syntauri Corporation announces that a demonstration record featuring the alphaSyntauri™ all-digital synthesizer is now available. Using Syntauri's new operating system, alphaPlus™, the record demonstrates the sonic versatility of this professional keyboard instrument with selections ranging from the sonorous tones of a pipe organ playing bach to contemporary improvisational jazz to the animated sounds of a tropical rain forest.

Based on the popular Apple II microcomputer, the alphaSyntauri synthesizer is a modular instrument system which uses "soft-wired" technologies (computer programs) rather than hard-wired components to create and control sound. This technology gives musicians the power of an all-digital, accurate instrument that won't become obsolete with advances in music and electronics technologies. Yet, musicians do not need any computer or programming experience to fully use the alphaSyntauri features.

Syntauri provides the operating system software, instrument definitions, sofware utilities, 61-note keyboard, footpedals, and computer interface. Mountain Computer's MusicSystem synthesizers (16 digital oscillators) give the instrument 8-voice stereo polyphony. The entire instrumental system, including the Apple II computer (48k with one disk drive, language card and monitor) sells for under $5000. For those who already have an Apple II, the complete instrument is available for under $2100.

Instruments for the demonstration record were created by many alphaSyntauri users, including New York composer Laurie Spiegel, Los Angeles synthesist Bill Boydstun, and Steve Leonard of the Cretones. Sound effects tracks were created and arranged by Robin J. Jigour and Ilana Wiedhopf of Syntauri.

The alphaSyntauri demonstration record is available from Syntauri Corporation for $2.00 postpaid. The systhesizer system is available worldwide from selected Apple computer and music retailers.

Syntauri Corporation may be reached at 3506 Waverley Street, Palo Alto, CA 94306, telephone (415) 494-1017.

New Multiplexed LCD Drivers

Motorola announces its new MC145000 (Master) LCD Driver and the MC145001 (Slave) LCD Driver. These CMOS devices are designed to drive liquid crystal displays in a multiplexed-by-four configuration. The Master unit generates both frontplane and backplane waveforms, and is capable of independent operation. The Slave unit generates only frontplane waveforms, and is synchronized with the backplanes from the Master unit.

The 24-pin DIP Configuration MC145000 (Master) drives 48 LCD segments and the 18-pin DIP Configuration MC145001 (Slave) provides frontplane drives for 44 LCD segments. Several Slave units may be cascaded from the Master unit to increase the number of LCD segments driven in the system. The devices use data from a microprocessor or other serial data and clock source to drive an LCD segment per bit.

For further information, contact your Motorola sales office or local Motorola distributor.

Writing for Magazines

We're always prepared to consider editorial contributions from readers of ETI: we normally pay for anything we use.

We have prepared a series of notes on writing, not just for ETI, but magazines in general. Copies of these are available on request. Please write to H.W. Moorshead, Editor ETI Magazine at our Toronto address.

VCR Head Cleaning Kit

Now owners of home video machines can perform regular head cleaning maintenance themselves, at a considerable savings over service shop fees. The VCR Head Cleaning Kit is a product designed by Chemtronics Inc., which allows the do-it-yourselfer to obtain professional results. It contains a 1 oz. bottle of Video Renu head cleaning fluid and 10 video sticks; urethane foam swabs specially constructed for safe non-residual cleaning of delicate video heads, as recommened by manufacturers.

Video Renu is formulated to completely dissolve the damaging, abrasive deposits which build up on VCR heads, causing snowy pictures, distortion, and ultimately necessitating costly head replacement.

The VCR Head Cleaning Kit will be available through video recorder and video tape outlets. Anyone having difficulty contacting a dealer stocking the kit may contact us directly at: Paco Electronics Ltd. 20 Steelcase Rd. W, Unit 10, Markham, Ontario, L3R 1B2, Telephone (416) 495-0740.

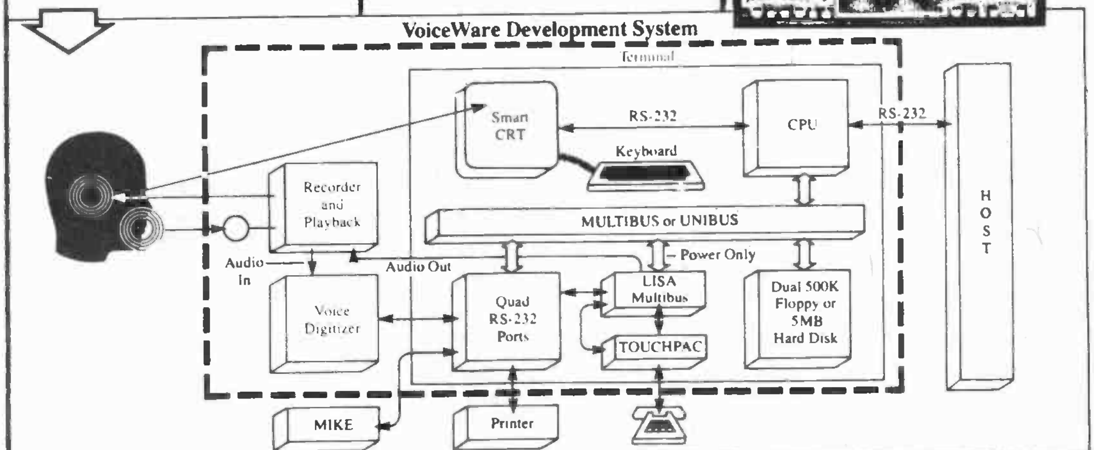
Unlimited Digital Voice

The VoiceWare™ Development System provides digital speech capabilities for almost any computer system. Developed by Centigram Corporation, the VoiceWare System allows users to program digitized voice vocabularies in real time, with storage on disk. The system is easier to use than a word processor, and operators need have no technical or programming knowledge. The resulting speech quality has the tone, cadence, and emphasis of natural voice.

The VoiceWare System enables users to custom-design Voice applications. For example, the system can be used to support applications such as Touch Tone data entry and retrieval, electronic mail, and computer-aided instruction. Because the system generates speech in real time, it is ideal for development of interactive dialog and applications where the speech data changes frequently.

The basic VoiceWare System includes: an intelligent CRT terminal incorporating a CPU with 64k bytes RAM; four RS-232-C serial interface ports with local and self-test; dual 500k byte 5.25 inch floppy disks for voice data storage; a voice digitizer with microphone input; and a Lisa™ voice synthesizer with a speaker output. The Lisa voice synthesizer is supplied in a Multibus format and is housed within the VoiceWare System. Options include: the Mike™ voice recognition system; the Mike application development support software package; a 5 Mbyte winchester disk, Touch Tone inquiry Lisa unit, and custom hardware interfaces.

For more information, contact Len Magmusun at Centigram Corp, 155 Moffett Park Drive, Sunnyvale, California, 94086, telephone (408) 734-3222.



Low-cost colour Alphanumeric Display

A low-cost, eight-colour alphanumeric display terminal for interactive applications was introduced by Data General (Canada) Inc. The new Dasher[R] D280C colour terminal is designed for engineering, scientific, business and industrial uses where colour is important in information discrimination and dramatic highlighting of text is required.

For its low list price of $5,070 ($4,730 for the video display, and $340 for the keyboard), the D280C terminal packs in a number of important features. Two sets of user-definable characters provide 128 symbols in addition to the terminal's 128 upper and lower case ASCII characters. The host computer controlling the D280C terminal can define the shape of the characters in a variety of patterns. The user-definable characters can also be used to construct line and bar charts. The display measures 13-inches diagonally, and has a screen format of 80 columns by 24 rows. A 5 × 9-dot character matrix is used in a 7 × 10-dot cell.

For international use, seven alphanumeric character sets reside inside the terminal. The keyboard is configured in the language ordered by the user; the other six alphabets can also be used under the host computer's control. By means of a shift mechanism, users can easily select the desired alphanumeric character set or user-definable character set. The alphabets and their respective keyboards, are American, British, Danish/Norwegian, French, German, Spanish, and Swedish/Finnish.

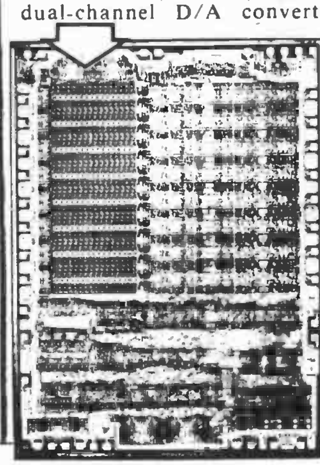
Support for the D280C terminal is provided by Data General Eclipse[R], Nova[R] and microNova[R] computers using standard software. The terminal is fully compatible with the Dasher D100 and D200 displays in single colour mode. Industry-compatible interfaces provide for asynchronous communications and colour video output. With a 20mA current loop, the colour terminal can be connected to a host computer up to 1500 feet away. In addition, the standard EIA RS-232-C interface can be used for remote applications via modems. Users can also select seven transmit and receive speed up to 9600 bps.

For more information contact Sam Donkoh at Data General (Canada) Inc., 2155 Leanne Blvd., Mississauga, Ontario L5K 2K8, telephone (416) 823-7830.

Low Cost Analog I/O Microboards

Six new low cost CMOS 8-bit analog I/O microboards, as low as $99.00 in 100-unit quantity, have been introduced by RCA. The exceptionally low power consumption (as low as 9 mA at 5V) and wide temperature range (-40°C to 85°C) operaton make them suited for use in battery operated remote data acquisition systems and harsh industrial control environments.

These newest additions to the Microboard line include both unipolar and bipolar versions of a combination board containing board containing an A/D converter with 16 single-ended or 8 differential input and two D/A converters, and A/D converter board, and a dual-channel D/A converter



board, all available in both unipolar (0 to 2.5V) or bipolar (±2.5V) versions. All operate from a single +5 volt supply and require no external reference voltages, simplifying system configuration while reducing system cost.

All six new CMOS analog I/O microboards are available for immediate delivery and are priced in 100-unit quantities as follows:

CDP18S644	A/D-D/A (bipolar)	$199
CDP18S647	D/A (bipolar)	$129
CDP18S648	A/D (bipolar)	$129
CDP18S654	A/D-D/A (unipolar)	$159
CDP18S657	D/A (unipolar)	$99
CDP18S658	A/D (unipolar)	$99

Further information may be obtained by writing to RCA Solid State Division, Box 3200, Somerville, NJ 08876.

DIGITAL DESIGN HANDBOOK

The arrival of increasingly complex digital chips brings sophisticated designs within the scope of the hobbyist. It also makes the designer's job more difficult. Tim Orr lays down the ground rules for digital designers.

DIGITAL ELECTRONICS has become enormously sophisticated over the last decade. Just over 10 years ago I made a rhythm generator using discrete components, which occupied over one square foot of board. Within a few years digital ICs became available which reduced the size of the device by about a factor of 10. A few years later an LSI device became available that did it all in one chip. The same is true of a digital clock built in that same period. The device had a 100kHz crystal oscillator, which was divided down by 100,000 to generate seconds, divided and decoded to display the seconds, and again for the minutes, hours and AM/PM. This used between 30 and 40 ICs and required considerable power. Now you can purchase a wide range of sophisticated clock and watch chips that can tell the time (even some that speak the time), handle several time zones, wake you up with a melody of your choice and can run for years on a single hearing aid battery, etc, etc.

This does not mean that digital design is now redundant. It just means that a lot of the hard work can now be done by VLSI chips, supported by a bit of conventional digital hardware. It also means that the problems you will be solving are considerably more complex than those of a decade ago. An important development is the introduction of the microprocessor. This device can be thought of as a programmable logic unit capable of simulating vast digital circuits, which can be relatively easily modified by altering the software, but which is only capable of medium to slow speed operation. If the digital circuit that you are designing is likely to contain about 40 ICs then perhaps a microprocessor design would be a better solution.

Basic Principles

One of the most common series of logic devices is the TTL series. These devices run on a standard +5 V power supply. They consume rather a lot of current and so a complementary range known as LSTTL has been produced (Low-power Schottky TTL). The LS range is generally slower than the TTL devices and now a new faster range called ALS (Advanced Low-power Schottky) is becoming available. There are other types of TTL including Schottky, High speed, Low power, etc, but these are generally only used in professional equipment.

The input to a TTL device is a single or multiple emitter. For the 7410, all the inputs must be high before the output will go low. The maximum current needed to pull an input low is 1.6 mA, but the high input current is 0.04 mA. If a TTL input is left open circuit, it will automatically float high, although for proper operation all unused gates must be tied high and not allowed to float. The output of a TTL device is capable of sinking more current than sourcing it. For the 7410 it is a maximum of 16 mA (low) and 0.4 mA (high). This implies that the 7410 is capable of driving 10 input loads (fan-out of 10). The typical high output voltage is +3V5 and the low is +0V2.

When testing TTL it is important that 'sanitary' logic levels are observed. The signals should always be above +3V and below +0V5. Signals between these may well produce unpredictable results. Short glitches can also generate problems. One source of glitches is a power supply with too high an impedance. As a TTL gate switches, it generates a short current surge on the supply rail which can produce large voltage spikes. This problem can be overcome by using thick ground and V_{CC} tracks and by regularly decoupling the power supply. Use a 10 to 100nF fast ceramic or 470nF tantalum capacitor for decoupling on every four or five packs.

CMOS

TTL can operate at frequencies as high as 50 MHz, but for higher frequencies ECL (Emitter Coupled Logic) devices should be used. These extend the range to as much as 1 GHz. For lower speed applications CMOS devices can be used. Maximum operating speeds of 5 MHz can be obtained. One tremendous advantage of using CMOS is that it consumes only micro-power. For example, the maximum quiescent current for the 4049 device 20 uA. Also, the output voltage swing goes within 10 mV of either supply rail (no load). The inputs are very high impedance, having typical input currents of a mere 10pA. The output stages can usually deliver currents of 0.5mA, giving CMOS an enormous fan-out capability, limited by speed rather than DC drive.

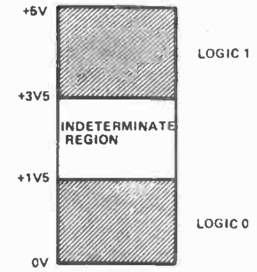


Fig. 1 CMOS operation on a 5V rail.

The B series of CMOS can run on supply rails between 3 and 18 V, making them ideal for battery operation where dropping supply voltage and low current outputs make TTL designs impossible. The CMOS transfer function shows a wide spread from device to device, which results in an indeterminate region of operation of about 60% of the supply voltage. As the input impedance is so high, the input terminals can often act as sample and hold devices. If you bias one to +3V, say, and then

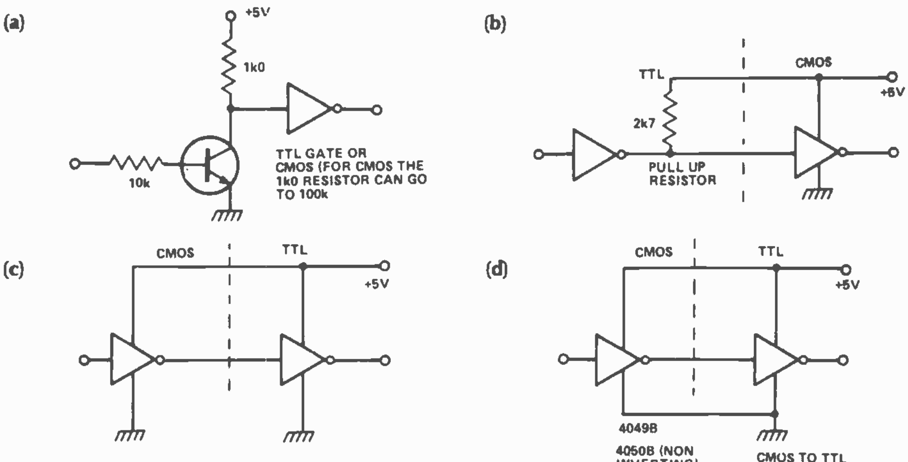


Fig. 2 CMOS/TTL interfacing.

let it float, it may well remain charged at this voltage. Unlike TTL, unused inputs can float anywhere. Some may well float into a region where both output FETs are partly on, thus presenting a load of a few kilohms across the supply rails, destroying the low power condition. Unused inputs should be tied high or low, depending on the desired circuit operation. The CMOS range of devices is different in pinout and part number to TTL devices. However, there does exist a CMOS copy of TTL known as the 74CXX series. Decoupling should be used for CMOS designs, but it is less of a problem than for TTL.

CMOS/TTL Interfacing

Interfacing to either TTL or CMOS can cause problems. To operate TTL a simple pull down transistor (Fig 2a) will suffice. When TTL is driving CMOS it is necessary to put the TTL output high, because the usual +3V5 high signal is just on the intermediate region of operation for the CMOS device (Fig. 2b). CMOS cannot pull down TTL. The typical 1.6 mA pull down is well beyond the output drive capabilities of most CMOS outputs (Fig 2c). The 4049 and the 4050 are buffer/converters, which can drive up to two TTL loads each. When powered from +5V they can even accept CMOS levels up to +18V (Fig. 2d). In doing so they are converting high level CMOS signals to low level TTL drives. Another CMOS converter is the 4041.

Logic Probes

If you don't have an oscilloscope then a simple logic probe can be a useful tool for debugging digital circuits. A

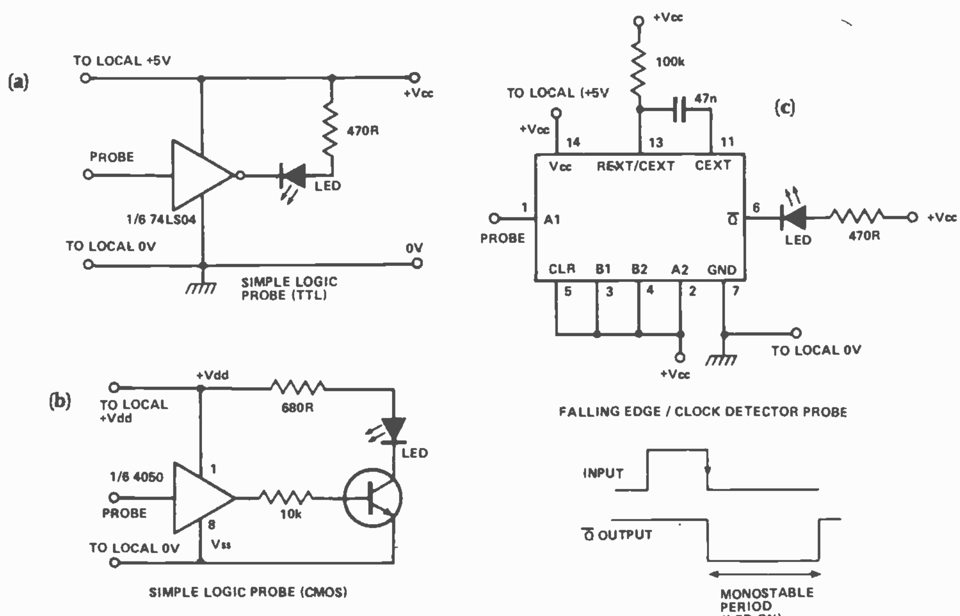


Fig. 3 Three simple logic probes.

simple probe is shown in Fig. 3a. If all six of the inverters are wired up, then the probe can diagnose the logic state of six signals simultaneously, making it very useful for examining data blocks. A logic 1 is represented by the LED being on. Probe B detects the presence of a clock signal. On the falling edge the monostable is fired and the LED turns on. Note that to drive LEDs directly from TTL a pull down circuit must be used. Probe C is for CMOS circuits. Note that the 3 mA drive from the 4050 is not sufficient to light the LED.

A set-reset flip-flop can be implemented using NAND or NOR gates. This device can be used to debounce switch actions or as a single bit memory. Note that positive-going pulses are needed for the NOR version and negative-going pulses for the NAND version.

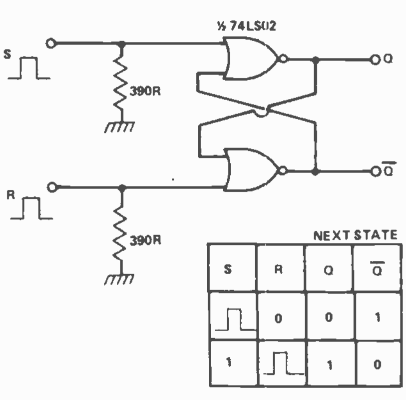


Fig. 4a SR flip-flop using NOR gates.

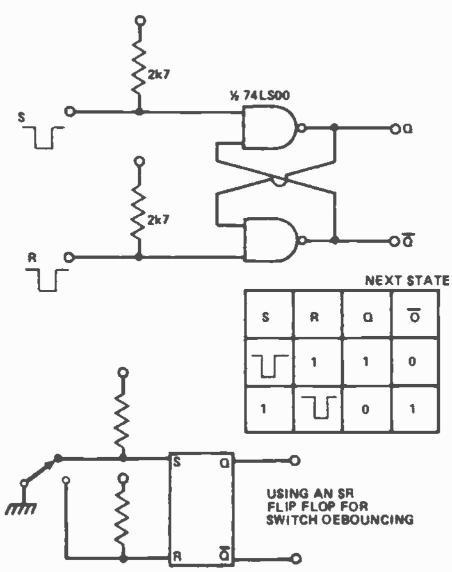


Fig. 4b SR flip-flop using NAND gates.

Switch Debouncing

Contact bounce from a mechanical switch can cause problems in digital circuits. It can be seen as a multiple entry. By filtering the signal and then Schmitting it the bounce can be reduced to a single transition. Note that the TTL device needs a low value resistor to ensure that the logic low is reached.

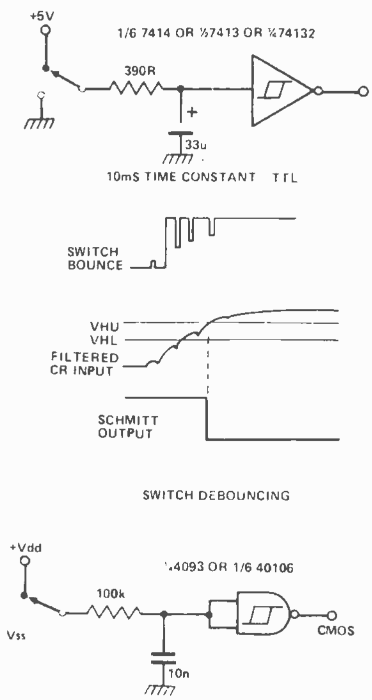


Fig. 5 Switch debouncing.

16 Key Encoder Chip

The 74C922 generates a four bit output code representing the last key pressed. The keyboard can be scanned by an external clock or by its own internal oscillator. All the switches are internally debounced by the IC. The output can drive low power TTL. The device can be used to encode a Hex keyboard or any other switch matrix. For 20 note operation the MM74C923 can be used.

Edge Delay

This circuit is sometimes used to generate a short delay to help prevent a race condition between two signals. A Schmitt trigger gives sharp output waveform. If an ordinary gate is used then the output will have a slower falling edge.

Often a digital signal is very thin (50-100 nS), difficult to see on an oscilloscope and impossible on a logic probe. The monostable action of the pulse stretcher enables the pulse to become visible.

D-Type Flip-Flop

The 4013 is a CMOS dual type flip-flop. Data present at the D input is transferred to the Q output on the positive transition of the clock. The clock waveform should have a rise time of greater than 5 uS. By programming the Set and Reset pins the outputs may be preset to any state. The device may be used as a single bit memory, or by connecting the D input to the Q output a divide by two counter may be built.

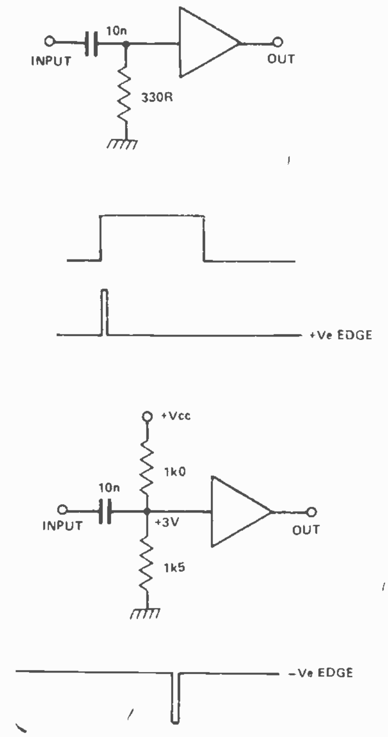


Fig. 7 TTL gates can be used to detect positive and negative edges by using simple CR input networks.

The two halves of a 4013 are used as a two stage binary counter with complementary outputs. The four signals '0', '1', '2' and '3' are known as decoded outputs. These are obtained with two input AND gates. Let's see how decoded output '2' is obtained. Looking at the timing diagram, '2' occurs when Q2 is high and Q1 is low. We can, therefore, generate the waveform by ANDing together Q2 and the inverse of Q1, that is Q1. The timing diagram is the most important tool for designing logic systems. Just by drawing out the timing that you need, it becomes very easy to both understant and implement the system. There is no need to even consider using Karnaugh maps or logic equations.

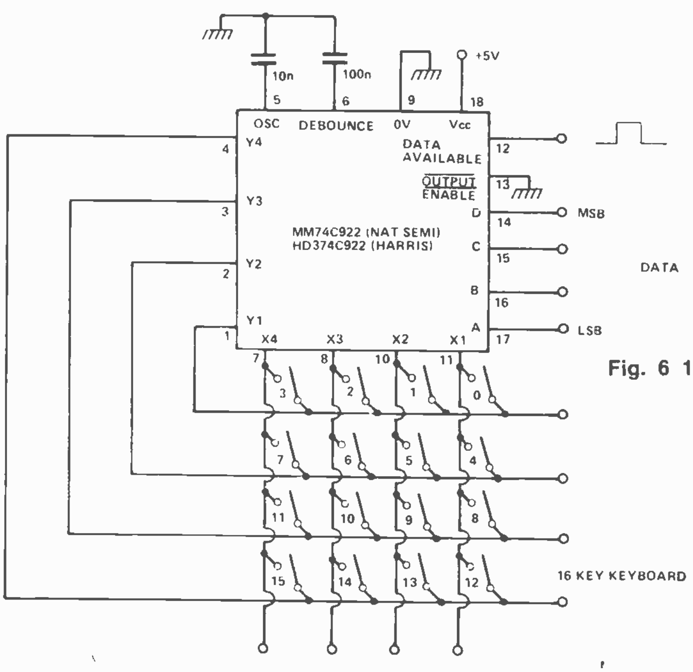
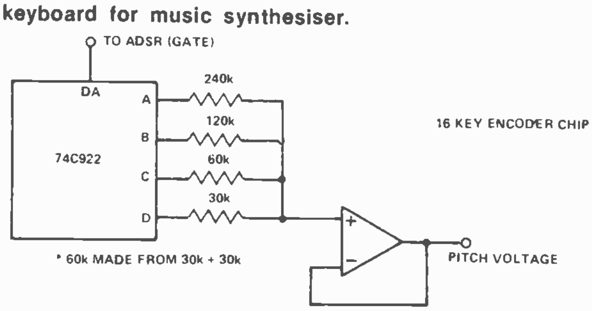


Fig. 6 16 note keyboard for music synthesiser.



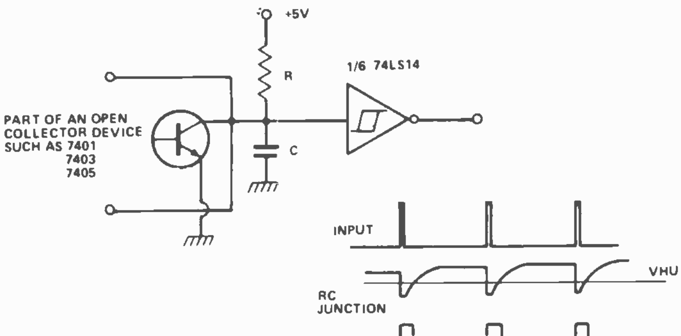


Fig. 8 Pulse stretching.

CLK	D	R	S	Q	Q̄
↑	0	0	0	0	1
↑	1	0	0	1	0
↓	X	0	0	Q	Q̄
X	X	1	0	0	1
X	X	0	1	1	0
X	X	1	1	1	1

CMOS 4013 X = DON'T CARE STATE

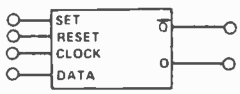


Fig. 9 D-type flip-flop.

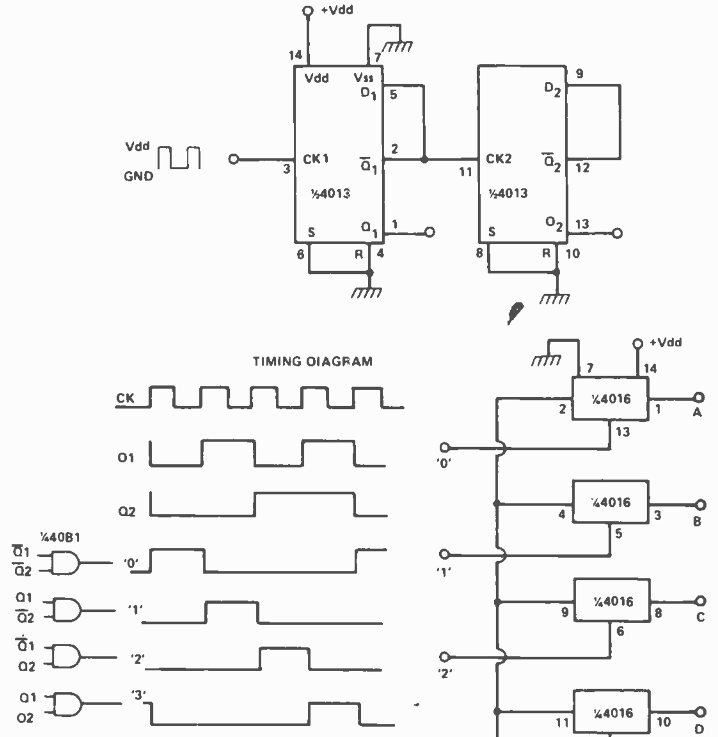


Fig. 10 Divider/decoder/multiplexer.

The last part of the circuit is the multiplexer. This is a digitally selected, analogue single pole four way switch, implemented with the 4016 analogue transmission gate. A logic 1 at the switch control pin turns the switch on, a logic 0 turns it off. Of course, there is a better way of implementing this design. The 4052 is a differential four channel MUX with its own decoding. Thus, the 4081 and the 4016 are replaced with a single 4052. Other multiplexers include the 4051 (eight way MUX) and 4053 (triple two way MUX).

This device is a decade counter with 10 decoded outputs. A high on the reset line clears the counter back to zero. The decoded output is high, all the other outputs are low. The simple transistor circuit enables the counter to drive LEDs.

Counting And Decoding

Another counter/decoder circuit is shown, but this time it uses TTL. The 74LS93 is a four stage binary counter. The four outputs are shown on the timing diagram and three decoded outputs '0', '1', and '11' are shown below them. To obtain these, all four outputs must be decoded. For example, to decode '11' we need to look at the timing diagram. outputs A,B,D are high and C is low. Therefore, a four input AND gate must be driven with A,B,D and C. This could also be determined by studying the truth table. The decoded outputs will probably contain what are known as glitches. These are very thin (100 nS) pulses, which can cause problems in some designs. The outputs of the counter do not all change state at exactly the same time. The outputs further down are later in changing due to the time delays in the system. This counter is known as a ripple counter. When the counter is clocked, the first stage changes state, which, after a short delay, sends a clock pulse to the second stage, which, after another short delay, sends a clock pulse to the next stage, etc. So, the information ripples down the counter causing a skew in the total output. If the outputs is then decoded, it is possible to get a momentary illegal states caused by the time delays. These effects have been overcome in synchronous counters, which use synchronous clocking of all their storage elements. In these devices the skew time is very short.

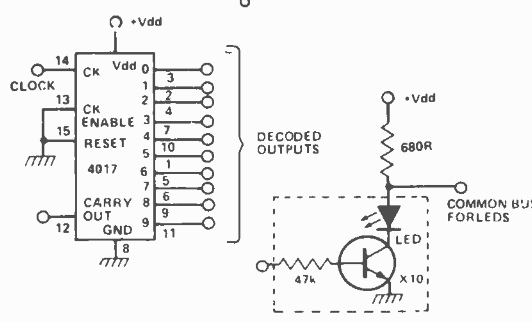
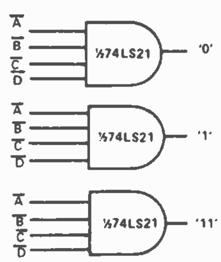


Fig. 11 CMOS counter/decoder.

TRUTH TABLE

COUNT	D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1



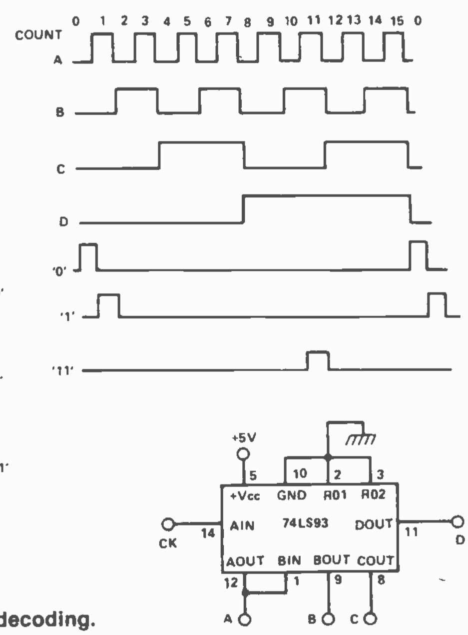


Fig. 12 Counting and decoding.

Schmitt Trigger Oscillator

Using a simple RC timing circuit, a Schmitt trigger can be made to oscillate. The capacitor is exponentially charged and discharged between the hysteresis levels of the Schmitt trigger. If a TTL device is used, then the squarewave output will be asymmetric, mainly due to the relatively large input current of the TTL gate. A simple resistor/diode network will restore the symmetry. The resistor value must be kept low, otherwise the circuit will not be able to pull the input sufficiently low and will not then oscillate. Using a 7413 the maximum frequency obtainable was 50 MHz, which used the stray capacitance of the package as the timing capacitor, C. The same circuit will oscillate using CMOS Schmitts (4903 or 40106). The waveform will be inherently more symmetrical and, of course, the device has a very high input impedance. This will enable the use of timing resistors of up to 10 to 100 M.

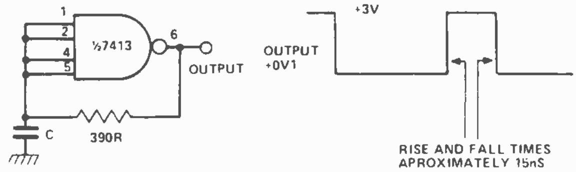
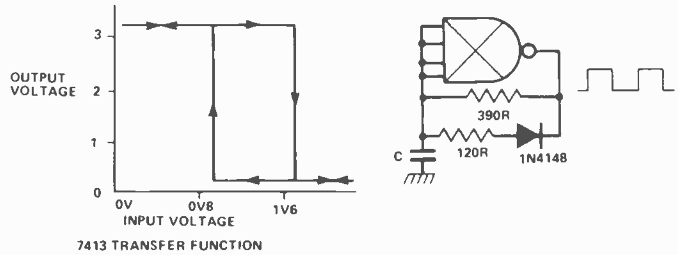


Fig. 13a Schmitt trigger oscillator.

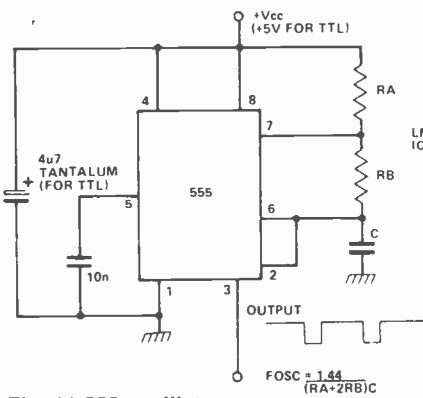


C	OSCILLATION FREQUENCY
0p	50 MHz
1000p	2.2MHz
10n	250kHz
100n	25kHz
1u0	2.5kHz
10u	250Hz

Fig. 13b Modifying the feedback network to give a 1 to 1 output.

555 Oscillator

The 555 chip can be used as an oscillator in digital circuits. The bipolar version of the device can drive several TTL loads, but care should be taken with this device. During the output transition there is a large supply current surge (as much as 350 mA) which can cause problems, such as false triggering. However, if the CMOS is used the current surge is very much smaller and yet the device can still drive TTL loads.



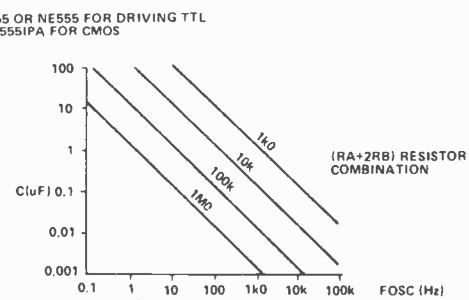


Fig. 14 555 oscillator.

Ring Oscillator

By connecting an odd number of inverting gates in a loop, an oscillator is produced. The oscillation period is the sum of the delay times through all the gates. If outputs are taken from each gate in turn, then phased waveforms are available.

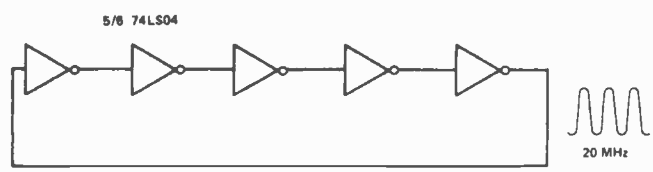


Fig. 15 Ring oscillator.

CMOS Oscillator

This two gate oscillator Fig. 16 is a very common device in logic design. It uses simple AC positive feedback with an RC timing network. It defies all attempts to set up a precise formula defining its oscillation frequency. A close equation is $F_{OSC} = ½ CR$. It should be used where the oscillation frequency is unimportant.

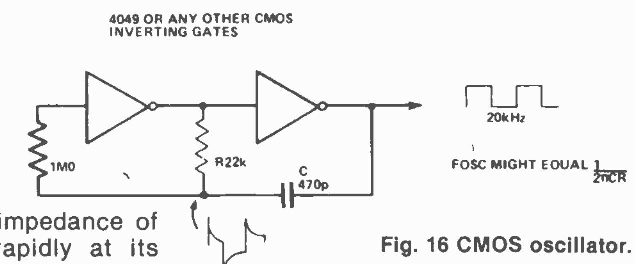


Fig. 16 CMOS oscillator.

Crystal Oscillator

To obtain a stable and precise frequency reference, a crystal oscillator is usually used. The impedance of the crystal changes rapidly at its resonant frequency and so, by using it in the feedback loop of an amplifier, it is possible to stimulate oscillation at the frequency. The trimmer capacitor is used for fine tuning. Crystal oscillators are notorious for not oscillating. The classic CMOS oscillator always includes the resistor R (usually 22k). When I breadboarded it, there was no oscillation unless R was a short circuit! The circuit then oscillated with a wide range of standard TV and computer

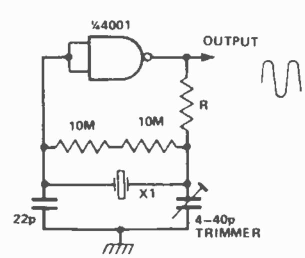


Fig. 17 Crystal oscillator.

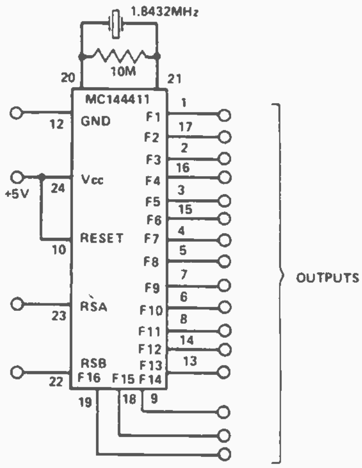
crystals, which included 1.8432, 3.56, 4.0 and 4.125 MHz. One of life's little mysteries!

Bit Rate Generator

When computer terminals and data terminals 'talk' to each other, they do so at standard bit rates. The MC14411 is a bit rate generator IC that produces 14 standard frequencies, with the option of times 8, 16 and 64 rates. If your computer has a serial interface, then it is likely that it has a bit rate generator controlling the data rate.

Voltage Controlled Oscillator

A simple VCO can be constructed using a CMOS Schmitt trigger and a few other parts. The timing capacitor (C) is discharged by current from the current mirror Q1,2. A ramp waveform oscillating between the hysteresis levels of the Schmitt is produced. The oscillator generates a series of short positive-going pulses.



RSA	RSB	RATE
0	0	X1
1	0	X8
0	1	X16
1	1	X64

F1 – 9600Hz
F2 – 7200Hz
F3 – 4800Hz
F4 – 3600Hz
F5 – 2400Hz
F6 – 1800Hz
F7 – 1200Hz
F8 – 600Hz
F9 – 300Hz
F10 – 200Hz
F11 – 150Hz
F12 – 134.5Hz
F13 – 109.9Hz
F14 – 75Hz
F15 – 921.6kHz } NOT CHANGED
F16 – 1.834MHz } BY RATE CODE

Fig. 18 Bit rate generator.

Pseudo-Random Generator

It is possible to generate noise digitally. A random binary sequence has most of the characteristics of a noise source. This random sequence may be produced by taking exclusive OR feedback from selected points in a shift register. the sequence that is produced does, in fact, regularly repeat itsélf, but the repetition rate is relatively slow. The longer the shift register length, the longer the repeat time. Also, by choosing the best feedback points, the sequence length will be maximally long. The chart shows the best feedback points for a selection of shift register lengths. Note that incredibly long sequences may be generated very easily.

A pseudo-random noise generator can be made from two CMOS chips. The output may be filtered to give any desired spectrum. There are also two noise generator chip available, the MM5837 and the S2688. The uses of pseudo-random generators include constant noise spectrums for audio testing, noise sources for music synthesisers and random number generators for lottery nuts!

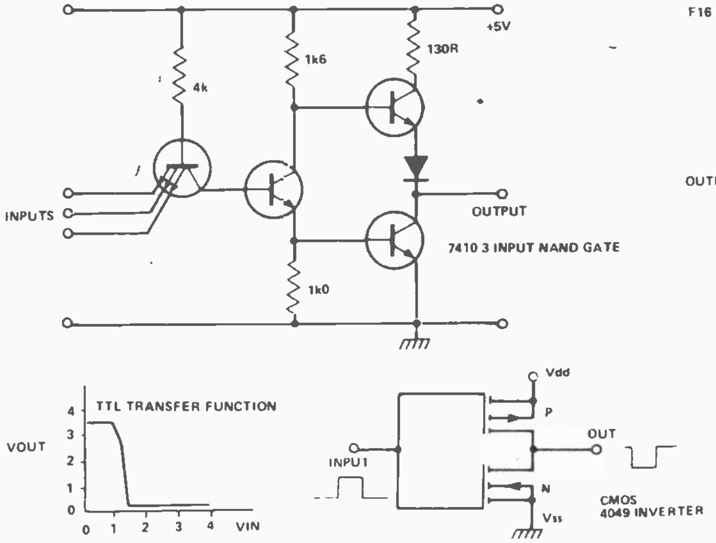


Fig. 19a Going back to basic principles.

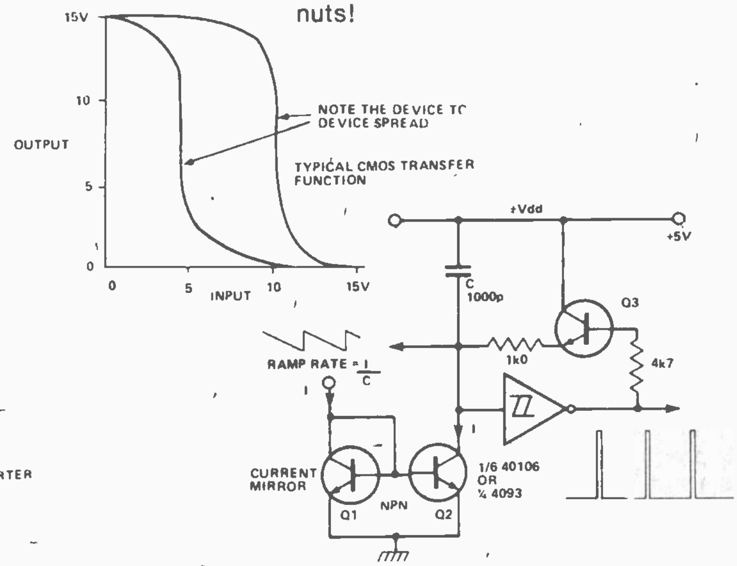


Fig. 19b Constructing a VCO.

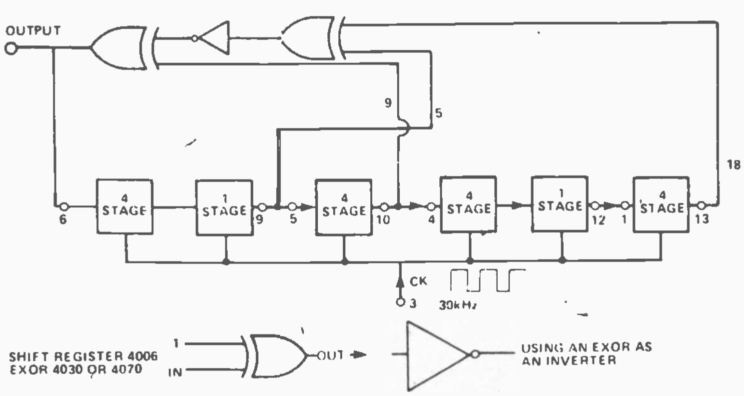


Fig. 20a Pseudo-random noise generator using CMOS.

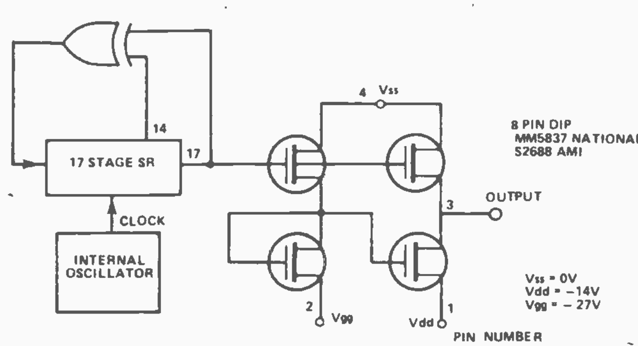


Fig. 20b Using a special function chip.

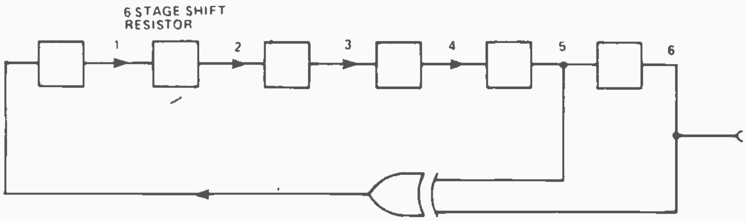


Fig. 20c Pseudo-random noise generator.

(n) SHIFT REGISTER LENGTH	(2^n-1) SEQUENCE LENGTH	FEEDBACK POINTS
2	3	1,2
3	7	2,3
4	15	3,4
5	31	3,5
6	63	5,6
7	127	6,7
9	512	5,9
10	1,023	7,10
15	32,767	14,15
17	131,071	14,17
18	262,143	11,18
31	2,147,483,647	28,31
33	8,589,934,591	20,33

Fig. 20d Feedback points for various shift register lengths.

Memories

Memory circuits are becoming cheaper. Static RAMs (Random Access Memories) are the easiest memories to design into systems. Dynamic RAMs are, in fact, less expensive and more dense than static ones but they need extra support circuitry. The information they contain is very volatile and every piece of the memory must be refreshed every few milliseconds. A static RAM has no need to refresh its memory.

Memory is organised into 'handy' sizes. The 2101 has four data inputs and four outputs plus an eight bit address input. The 2102 has only one data input and one data output, but it has a 10 bit address input. The 2114 has four data terminals and a 10 bit address input. Note that the data terminals for the 2114 act as both inputs and outputs. The write cycle for the 2114 is as follows. Set up the memory address and take WE low. Set up the data and take CS low. The RAM has now been written into. Take CS and WE high. The RAM is now in its read mode (that is, it is outputing data) but it is disabled. To read data, set up the address, leave WE high and take CS low. The relevant data will pear at the data I/O pins. The 2114 is a a convenient size for microprocessor memories. By using two of them, eight bit words can be stored. When the power is removed from a RAM all the information stored is lost. Some systems employ low power CMOS RAMs with a back-up battery. When the power is removed the battery keeps the RAMs powered up. CMOS RAMs are at present very much more expensive than the common 1K and 4K devices

ROM (Read Only Memory) can be used to store data so that it is non-volatile. The data is preprogrammed into the device and can only thereafter be read. It is not possible to subsequently write into a ROM. Many ROMs are externally programmable but by far the most popular is the EPROM (Erasable Programmable Read Only Memory). This device stores its information in small charge wells. It is electrically programmable and, if the contents should need to be altered, it is possible to erase the device by exposing it to hard ultraviolent radiation. It can then be reprogrammed. The 2716 is at present an industry standard, being 2K long and eight bits wide. Microprocessor software is often stored in 2716 arrays.

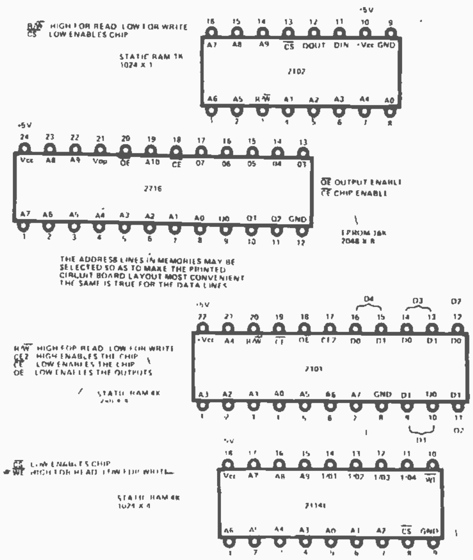
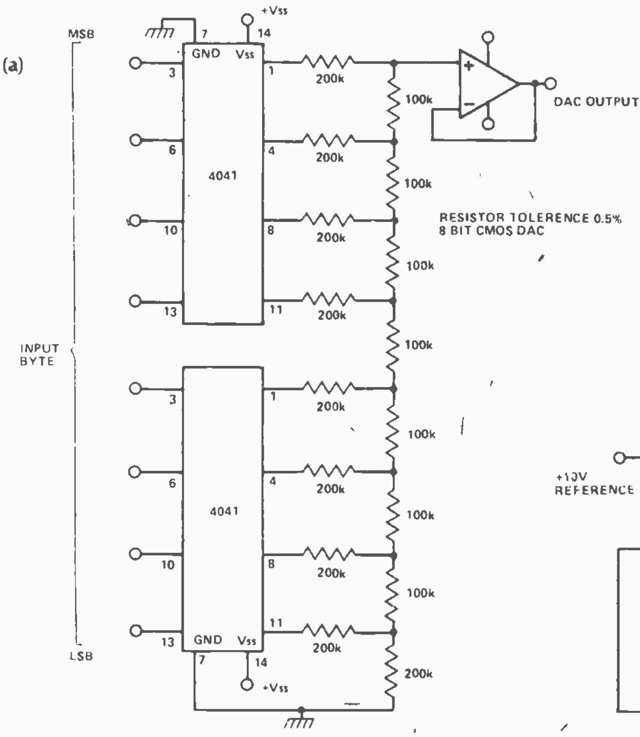


Fig. 21 Typical memory configurations.



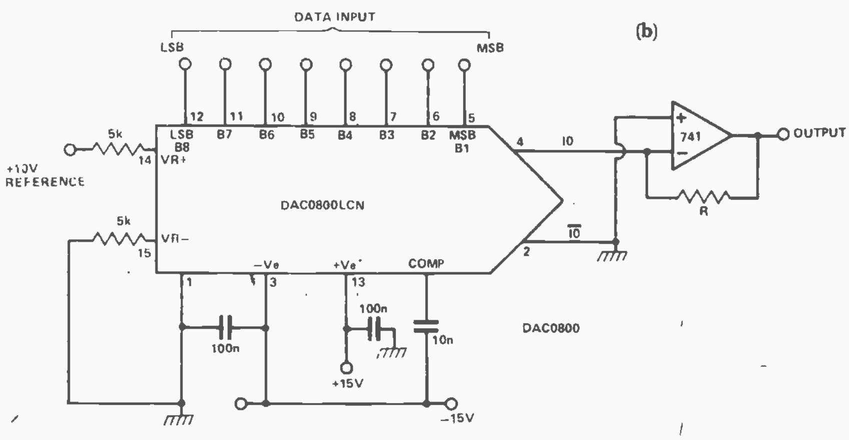
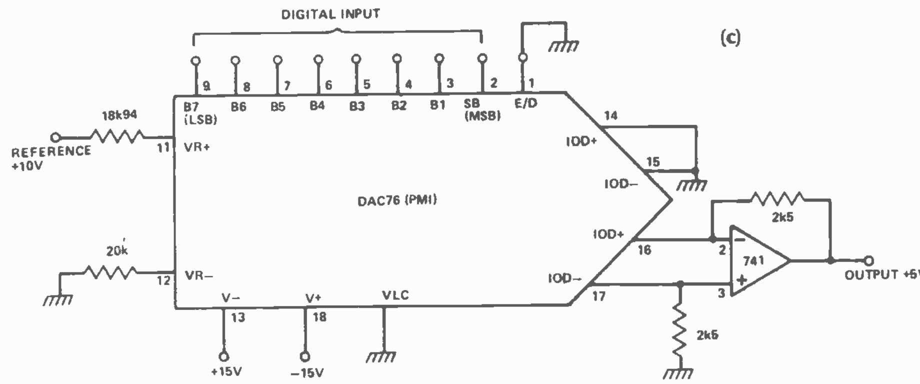
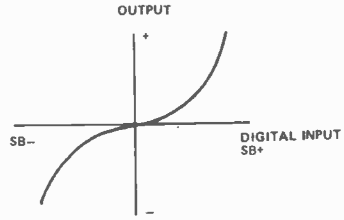


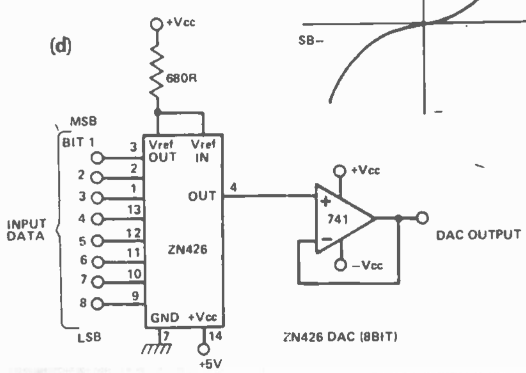
Fig. 22 Digital to analogue converters: (a) eight bit CMOS DAC (b) DAC 0800 (c) eight bit companding DAC (d) ZN426 DAC (eight bit) (e) eight bit DAC + latch (Ferranti).

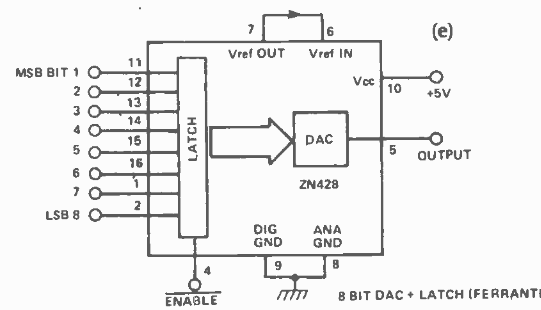
DACs

Once it is possible to interface analogue signals with digital hardware, a wide range of interesting products can be made. To input analogue information into a digital system an analogue-to-digital converter (ADC) is needed. A digital-to-analogue converter (DAC) is used to convert digital signals back into analogue.



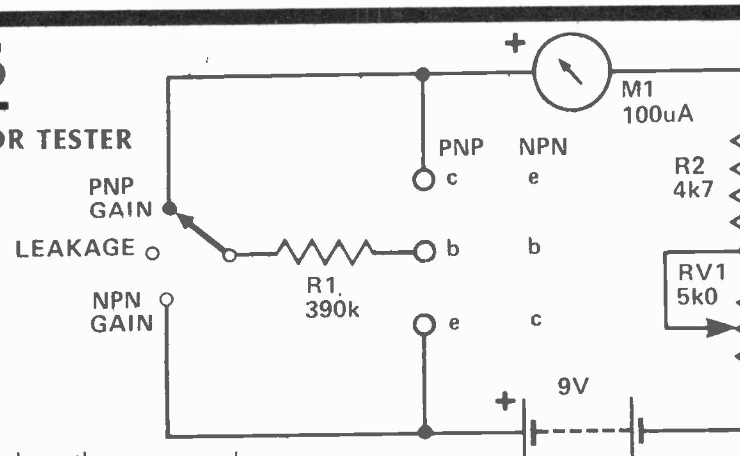






DESIGNER CIRCUITS

TRANSISTOR TESTER



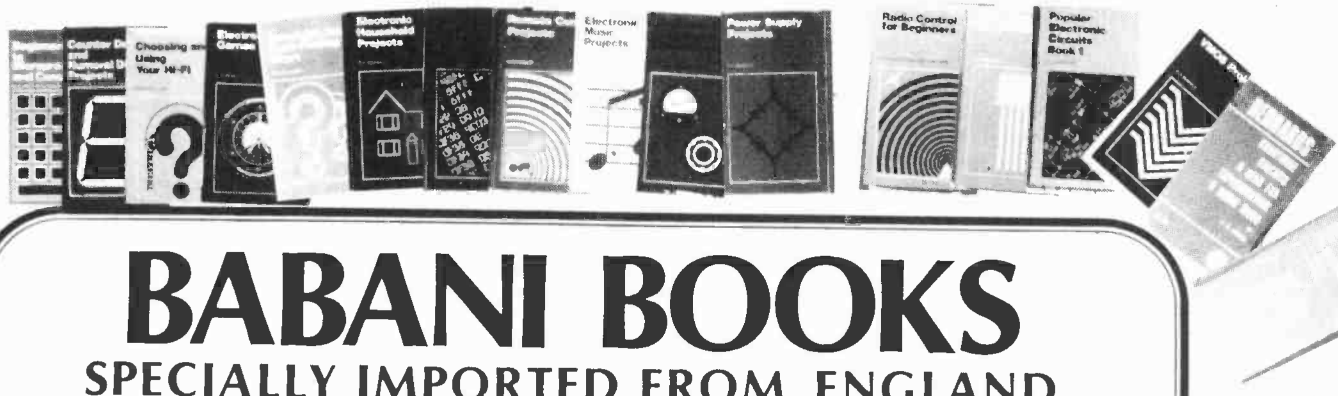
The cheapest way of building up a stock of transistors is to purchase "bargin bags" from component stores. The main drawback is that you have no idea what characteristics the devices will have, if indeed they have any characteristics at all! Usually between 10% and 30% of the devices will be useless, the remainder will be out of tolerance and not suitable for commercial use — but perfect for use by the experimenter.

With the aid of this transistor tester you will be able to sort transistors for gain and leakage characteristics, these being the most important for the majority of applications.

Transistor leakage is the current passing between the collector and emitter when no base bias is applied. Gain of a transistor is the ratio of base current to collector current. To avoid complex switching only one socket is used for the testing of devices — NPN and PNP types are inserted in opposite ways to test them. By comparing the meter deflectons caused by good quality transistors and surplus types, an evaluation of the characteristics of any paiticular device can be made — high gain, low gain, high leakage, low leakage, etc. Germanium transistors (such as 2SBxxx) will register much higher leakage than more modern silicon types (2N3904 etc.). If no reading is given for either gain or leakage the transistor is open circuit internally and useless. R2 and RV1 are included to protect the meter movement if the device under test is short circuited internally — again a useless device.

As well as acting as a transistor tester, the unit can be used to check diodes and measure resistance. Diodes inserted between the collector and emitter points will register little or no current one way round, the other way round they should cause high current to be registered. To measure resistance, connect the emitter and collector sockets together and adjust RV1 to give full scale deflection on the meter. Then the meter scale can be marked to coincide with the readings from a selection of known resistor values, connected across the emitter and collector terminals.

Another use for the circuit is for checking 9V batteries: short the emitter to collector-terminal and plug battery in to replace the normal one: No deflection or not full scale deflection, means that the battery is on its last legs. Electrolytic capacitors, when connected across the emitter and collector terminals (making sure positive is to the PNP emitter socket) will produce a 'kick' of the pointer — falling as the capacitor charges up. With practice, an estimate of actual capacitance can be made — no 'kick' means the component is open-circuit, no fall back means the component is short circuited.



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This book is divided into three parts: Part I, understanding audio IC's. Part II, Pre-amplifiers, Mixers and Tone Controls. Part III Power Amplifiers and Supplies. Includes practical constructional details of pure IC and Hybrid IC and Transistor designs from about 250mW to 100W output.

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F.G.RAYER, T.Eng.(CEI),Assoc.IERE
Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of application 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.

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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.

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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.

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.

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This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. The chapter on amplitude modulated (a.m.) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, while the chapter on frequency modulation (f.m.) receivers will appeal to those who desire high fidelity reception.

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.

BP48: ELECTRONIC PROJECTS FOR BEGINNERS $5.90
F.G. RAYER, T.Eng (CEI), Assoc.IERE
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Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering and, thus, avoid the need for a soldering iron.

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

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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.

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E.F. SCOTT, M.Sc., C.Eng.
As indicated by the title, this book is intended as an introduction to the basic theory and concepts of binary arithmetic, microprocessor operation and machine language programming.

There are occasions in the text where some background information might be helpful and a Glossary is included at the end of the book.

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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.

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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.

BP69: ELECTRONIC GAMES $7.55
AUTHOR: R.A. PENFOLD
In this book Mr. R. A. Penfold has designed and developed a number of interesting electronic game projects using modern integrated circuits. The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits.

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AUTHOR: CHAS. E. MILLER
Across the top of the chart will be found four rectangles containing brief descriptions of these faults vis — sound weak but undistorted, set dead, sound low or distorted and background noises. One then selects the most appropriate of these and following the arrows, carries out the suggested checks in sequence until the fault is cleared.

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Some of the most useful and popular electronic construction projects are those that can be used in or around the home. The circuits range from such things as '2 Tone Door Buzzer', Intercom, through Smoke or Gas Detectors to Baby and Freezer Alarms.

BP72: A MICROPROCESSOR PRIMER $7.70
AUTHOR: E.A. PARR, B.Sc., C.Eng., M.I.E.E.
A newcomer to electronics tends to be overwhelmed when first confronted with articles or books on microprocessors. In an attempt to give a painless approach to computing, this small book will start by designing a simple computer and because of it simplicity and logical structure, the language is hopefully easy to learn and understand. In this way, such ideas as Relative Addressing, Index Registers etc. will be developed and it is hoped that these will be seen as logical progressions rather than arbitrary things to be accepted but not understood.

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The reader is given constructional details of how to build a simple model train controller: controller with simulated inertia and a high power controller. A signal system and lighting for model trains is discussed as is the suppression of RF interference from model railways. The construction of an electronic steam whistle and a model train chuffer is also covered.

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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.

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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.

BP24: 50 PROJECTS USING IC741 $4.25
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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, "must" for everyone whatever their interest in electronics.

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An invaluable book for all calculator users whatever their age or occupation, or whether they have the simplest or most sophisticated of calculators. Presents formulae, data, methods of calculation, conversion factors, etc., with the calculator user especially in mind, often illustrated with simple examples. Includes the way to calculate using only a simple four function calculator Trigonometric Functions (Sin, Cos, Tan), Hyperbolic Functions (Sinh, Cosh, Tanh) Logarithms, Square Roots and Powers.

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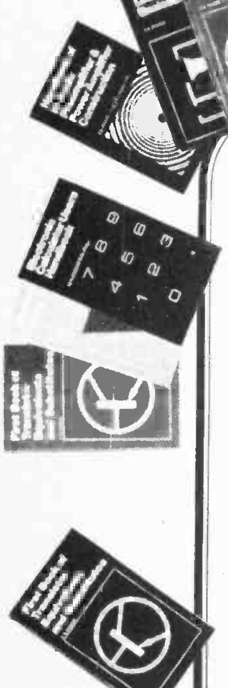

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Although modern bipolar power transistor give excellent results in a wide range of applications, they are not without their drawbacks or limitations. This book will primarily be concerned with VMOS power FETs although power MOSFETs will be dealt with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

BP84: DIGITAL IC PROJECTS $8.10
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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.

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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.

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AUTHOR: S. DALY
This book is based on the authors own experience in learning BASIC and in helping others, mostly beginners, to program and understand the language.

Also included are a program library containing various programs, that the author has actually written and run, these are for biorhythms, plotting a graph of Y against X, standard deviation, regression, generating a musical note sequence and a card game.

The book is complemented by a number of appendices which include test questions and answers on each chapter and a glossary.

BP87: SIMPLE L.E.D. CIRCUITS $5.90
AUTHOR: 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.

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.

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.

BP90: AUDIO PROJECTS $8.10
AUTHOR: 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.

Babani Books are now available from Arkon, CESCO, Dominion Radio and General Electronics.

BP49: POPULAR ELECTRONIC PROJECTS $6.25
R.A. PENFOLD
Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to interest most electronics constructors. The projects selected cover a very wide range and are divided into four basic types: Radio Projects, Audio Projects, Household Projects and Test Equipment.

BP 50: 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.

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.

No. 215: Shortwave Circuits & Gear For Experimenters & Radio Hams $3.70
Covers constructional details of a number of projects for the shortwave enthusiast and radio "Ham". Included are: an add-in crystal filter, adding an "S" meter in your receiver; crystal locked H.F. Receiver; AM tuner using phase locked loop; converter for 2MHz, 40 to 800 MHz RF amplifier, Aerials for the 52, 144MHz bands, Solid State Crystal Frequency Calibrator, etc.

ELEMENTS OF ELECTRONICS — An on-going series
AUTHOR: F.A. WILSON, C.G.I.A., C.Eng.

BP62:	BOOK 1. The Simple Electronic Circuit and Components	$8.95
BP63:	BOOK 2. Alternating Current Theory	$8.95
BP64:	BOOK 3. Semiconductor Technology	8.95
BP77:	BOOK 4. Microprocessing Systems And Circuits	$12.30
BP89:	BOOK 5. Communication	$12.30

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

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

Each book is a complete treatise of a particular branch of the subject and, therefore, can be used on its own with one proviso, that the later books do not duplicate material from their predecessors, thus a working knowledge of the subjects covered by the earlier books is assumed.

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

BOOK 2: This book continues with alternating current theory without which there can be no comprehension of speech, music, radio, television or even the electricity mains.

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

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

BOOK 5: A book covering the whole communicatic scene.

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 buy also Infra-red, visible light and Ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

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 Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser Units, Tremelo Generator etc.

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.

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.

BP78: PRACTICAL COMPUTER EXPERIMENTS $7.30
E.A. PARR, B.Sc., C.Eng., M.I.E.E.
Curiously most published material on the microprocessor tends to be of two sorts, the first treats the microprocessor as a black box and deals at length with programming and using the "beast". The second type of book deals with the social impact. None of these books deal with the background to the chip, and this is a shame as the basic ideas are both interesting and simple.

This book aims to fill in the background to the microprocessor by constructing typical computer circuits in discrete logic and it is hoped that this will form a useful introduction to devices such as adders, memories etc as well as a general source book of logic circuits.

BP79: RADIO CONTROL FOR BEGINNERS $7.30
F.G RAYER, T.Eng.(CEI),Assoc.IERE.
The aim of this book is to act as an introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions that are allowable for such things as frequency and power of transmission. This is followed by a "block" explanation of how control-device and transmitter operate and receiver and actuator(s) produce motion in a model.

Details are then given of actual solid state transmitting equipment which the reader can build. Plain and loaded aerials are then discussed and so is the field-strength meter to help with proper setting up.

The radio receiving equipment is then dealt with which includes a simple receiver and also a crystal controlled superhet. The book ends with the electromechanical means of obtaining movement of the controls of the model.

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Whether you're looking for a career, or you are a service technician, computer repair is an opportunity you should be looking at. The author covers all aspects of digital and computer electronics as well as the mathematical and logical concepts involved.

Beginner's Guide To Computer Programming
TAB No.574 $16.45
Computer programming is an increasingly attractive field to the individual, however many people still overlook it as a career. The material in this book has been developed in a logical sequence, from the basic steps to machine language.

Microprocessor/Microprogramming Handbook
TAB No.785 $14.45
A comprehensive guide to microprocessor hardware and programming. Techniques discussed include subroutines, handling interrupts and program loops.

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The Power Supply Handbook
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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.

Build Your Own Working Robot
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Beginners Guide To Microprocessors
TAB No.995 $10.45
If you aren't sure exactly what a microprocessor is, then this is the book for you. The book takes the beginner from the basic theories and history of these essential devices, right up to some real world hardware applications.

A Beginner's Guide to Computers and Microprocessors — With Projects.
TAB No.1015 $13.45
Here's a plain English introduction to the world of .rocomputers — it's capabilities, parts and functions and how you can use one. Numerous projects demonstrate operating principles and lead to the construction of an actual working computer capable of performing many useful functions.

The BASIC Cookbook.
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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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PASCAL
TAB No.1205 $16.45
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Tower's International Op-Amp Linear IC Selector
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A practical guide on how to build a robot capable of learning how to adapt to a changing enviroment. The creature developed in the book, Rodney, is fully self programming, can develop theories to deal with situations and apply those theories in future circumstances.

Microprocessor Interfacing Handbook: A/D & D/A
TAB No.1271 $14.45
A useful handbook for computerists interested in using their machines in linear applications. Topics discussed include voltage references, op-amps for data conversion, analogue switching and multiplexing and more.

The GIANT Handbook of Electronic Circuits
TAB No.1300 $24.45
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.

ALIEN ATTACK

Hand-held games are becoming just as popular as the arcade versions (we can play in the comfort of our own office!) so we just had to publish our own version.

ONCE UPON A TIME you could only blast the hordes of little green aliens by taking a trip to your nearest pub or amusement arcade. But it wasn't long before you could indulge your violent tendencies in the privacy of your own home with TV game versions. Nowadays it's possible to avoid withdrawal symptoms wherever you may be by purchasing a hand-held version — the invaders are even turning up in calculators. Now ETI presents a simple-to-build hand-held game that, while lacking the refinements of commercial machines (such as custom-designed little 'alien' LEDs), is still a lot of fun to play with and offers a full range of sound effects.

The 'field of battle' and the score display both take the form of a line of LEDs. When the game is switched on, 'aliens' begin to drop towards you, their passage being shown by the LEDs in the display lighting one after another. When the tenth and final LED is lit, you have to fire your laser at the alien by pushing the 'fire' button. If you're successful, the score display is increased by one and another alien launches his attack. For simplicity and low cost, a simple binary counter is used to register the score.

The catch is that as you destroy the aliens, the speed at which they fall increases quite rapidly. The game has a built-in time limit of about 25-30 s, and the object is to achieve the highest score before the game ends. Your reactions have to be pretty accurate because firing the laser when the ninth LED is lit will zero your score.

Four voltage-controlled oscillators are provided, giving the familiar tromp-tromp-tromp, laser fire, falling bomb and explosion noises. An on-off switch is provided for the sound so that battery life may be extended, if desired. The unit consumes approximately 15 mA with sound or 5 mA without.

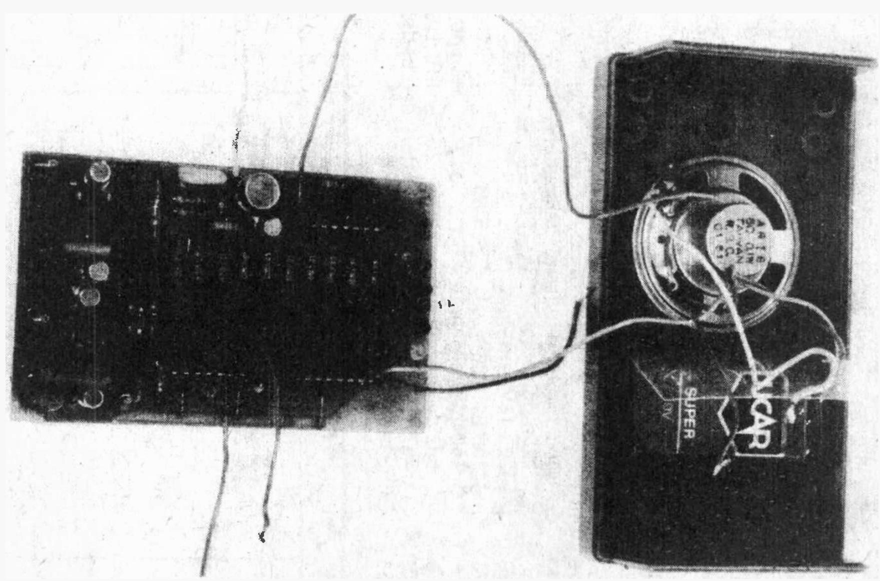
Construction

The circuit is built on a single PCB but for reasons of space this is fairly cramped and several components are mounted vertically. Tantalum capacitors are also used instead of ordinary electrolytics because of their small size. Solder all the components in place as shown on the overlay, using a soldering iron with a fine bit and lots of 'due care and attention'; the PCB tracks are very fine. Take the usual precautions when handling the CMOS ICs.

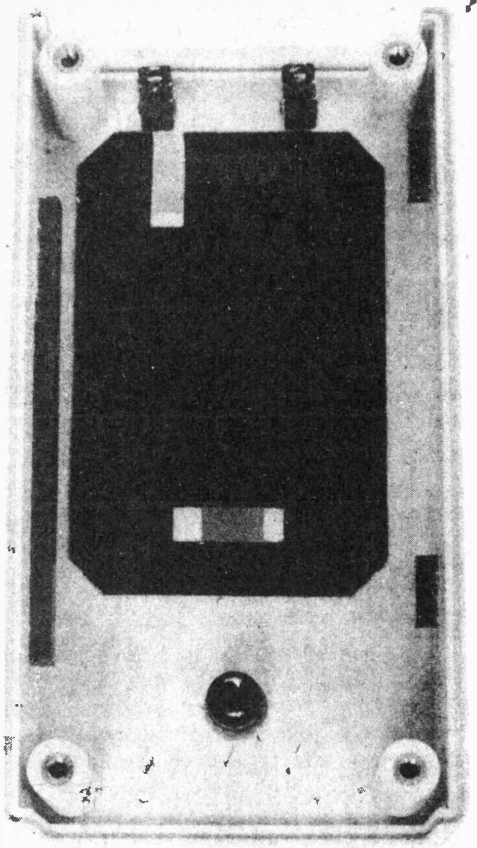
Note that R29 and C13 are not located on the PCB but are soldered onto the loudspeaker lead — the photographs should make this clear.

A T-shaped hole is cut in the top of the case to reveal the LEDs and a piece of red plastic can be stuck over the aperture to improve the viewing contrast. Of course, you'll have to cut holes in it above the green LEDs or they'll disappear! The three switches are also mounted on the top of the case; the loudspeaker is fixed to the bottom after drilling a few holes to let the sound out. Thin plastic strips are glued to the sides of the case to support the PCB the correct distance from the cutout. Now the interwiring can be completed and the case screwed together.

This completes the construction of the project; now you can be the envy of your fellow commuters and annoy total strangers in your efforts to beat your last score.



The completed board, wired up to lower half of the case. The remaining wires go the switches on the front panel.



This photograph shows the red filter and plastic mounting strips glued into the top of the case.

PARTS LIST

Resistors (all ¼W, 5%)

R1	4M7
R2-11,18	2k2
R12,24,26, 27,28	100k
R13,15,20,23	1M0
R14,16	22k
R17,21	470k
R19	10k
R22	330k
R25	180k
R29	150R

Capacitors

C1,13	10u 16V tantalum
C2	220n polyester
C3	22u 16V tantalum
C4	15n polyester
C5	1u0 16V tantalum
C6	8n2 polycarbonate
C7,9,10	4u7 16V tantalum
C8	33n polyester
C11	10n polyester
C12	47n polyester

Semiconductors

IC1	4017B
IC2	4081B
IC3,4	4011B
IC5	4024B
Q1-4	2N3904
D1-9	1N4148
LED1-9, 11-14	0.125" red LED
LED10,15	0.125" green LED

Miscellaneous

PB1	single pole push-to-make
SW1,2	SPST ultraminiature toggle
LS1	8R, 1½" diameter
9V battery and battery clip, case.	

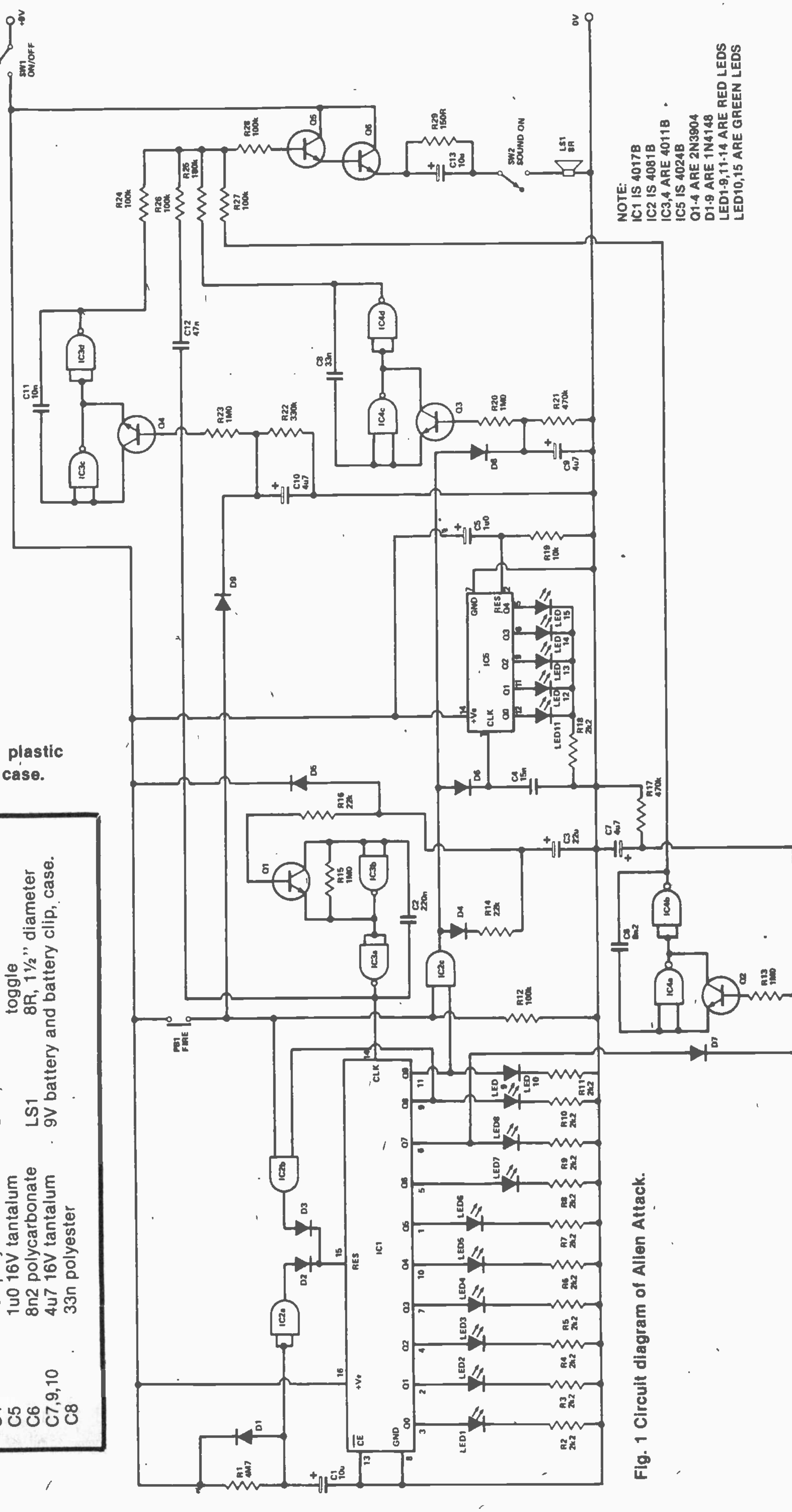
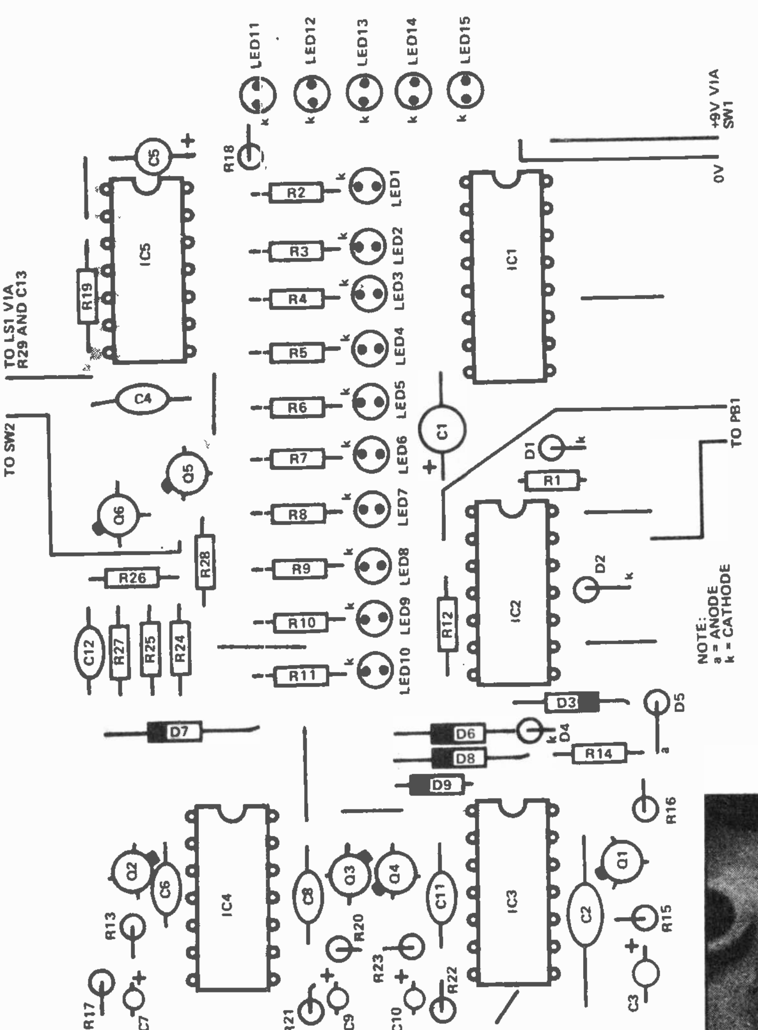


Fig. 1 Circuit diagram of Alien Attack.



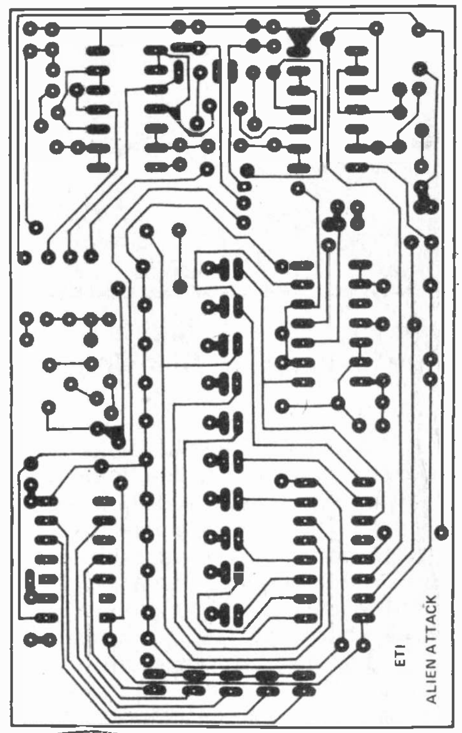
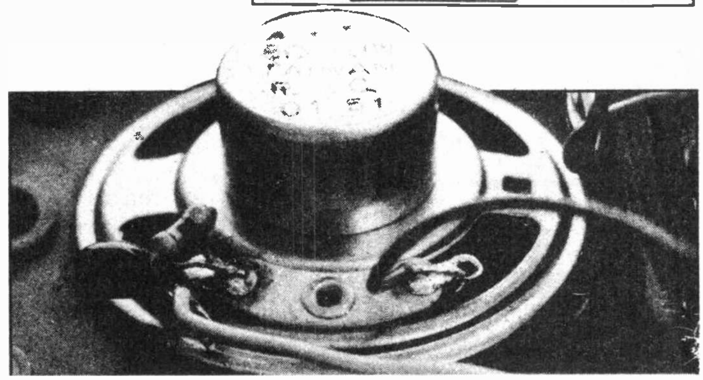


Fig. 2 Component overlay.



Here you can see R29 and C13 soldered to the loudspeaker.

HOW IT WORKS

The circuit falls into four basic sections — the decade counter IC1, which lights LEDs 1 to 10 in turn; the binary counter IC5, which provides the scoring for the game; four voltage-controlled oscillators (VCOs) which provide the sound effects; and the mixer-amplifier, which drives a small loudspeaker.

The VCOs use the common CMOS oscillator circuit, but with a difference. Instead of using a fixed resistor with a capacitor to determine the frequency, a transistor replaces the resistor and functions as a variable resistor.

Taking the VCO formed by IC4a and IC4b as an example, it can be seen that with no connection to the base of Q2, the collector-emitter resistance will be very high, preventing C6 from charging and thus disabling the oscillator. However, if a voltage is applied to Q2's base the collector-emitter resistance will fall in proportion to the applied voltage. Thus the time taken for C6 to charge will be proportional to this voltage, and so will the frequency of operation of the oscillator.

If a capacitor and resistor are connected from the base of the transistor to ground, then fully charging the capacitor will give the highest oscillator frequency. As the capacitor discharges via the resistor, the frequency will fall until the circuit again stops oscillating.

In the case of the IC3a-IC3b VCO, the lowest frequency is determined by R15.

When the circuit is switched on, C5 provides a power-on reset pulse to IC5, thus extinguishing LEDs 11 to 15. C1 will also start to charge via R1 and when the voltage on C1 eventually reaches the threshold of gate IC2a counter IC1 will be held reset, thus ending the game. With the values shown, this should take approximately 25 s.

The IC3a-IC3b VCO will clock IC1, lighting LEDs 1 to 10 in turn. When LED8 lights a pulse will be fed to the VCO formed by IC4a and IC4b, giving a falling frequency.

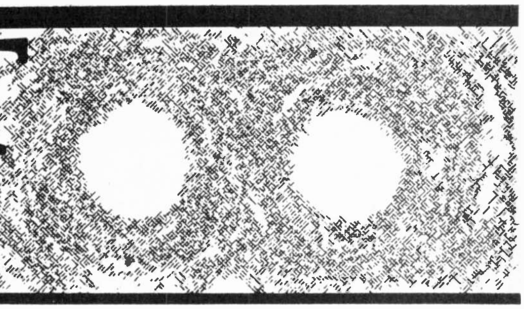
If the 'fire' button (PB1) is pressed, then the IC3c-IC3d VCO will be enabled. Pressing PB1 when LED10 is lit will result in IC2c enabling the VCO formed by IC4c and IC4d, and also charging C3 by an amount determined by R14. Thus the VCO driving IC1 will increase in frequency. IC5 will also be clocked, adding one to the score. C4 debounces the clock input.

If PB1 is pressed when LED9 is lit, a reset pulse is sent to IC1 by IC2b, thus preventing cheating.

The four oscillator outputs are mixed by R24-27 and C12. Q5 and Q6 act as an amplifier, driving an 8R speaker, through the filter formed by R29 and C13. This filter prevents excessive DC from reaching the speaker, as would happen if one of the VCO outputs stayed high.

Because IC2a has no hysteresis applied to the input, as the voltage on C1 reaches the gate's threshold the output will oscillate, which results in the aliens making several abortive attacks. D1 and D5 ensure that capacitors C1 and C3 are discharged at the end of each game when the circuit is switched off. This ensures that the game length and starting speed of the aliens are the same for each game.

HEADLIGHT DELAY



Use your car headlights to give post-parking illumination with this simple unit.

THIS SIMPLE LITTLE UNIT lets you use your car head lights to illuminate your pathway for a pre-set period of about 50 seconds after you have parked the vehicle. At the end of this period the unit turns the lights off automatically.

The unit thus enables you to avoid walking into trash cans or tripping over junk that may be obstructing your private driveway, and helps you avoid stepping into various nasties that may be laying on the public sidewalk. The unit is easy to install in the vehicle.

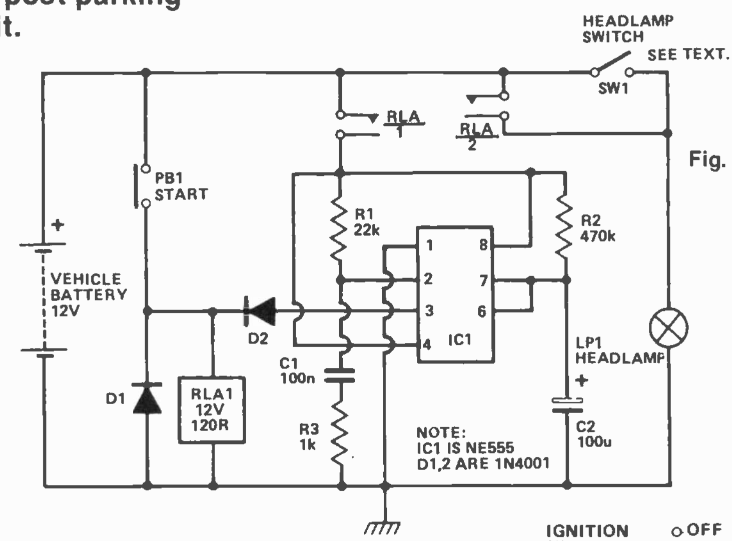
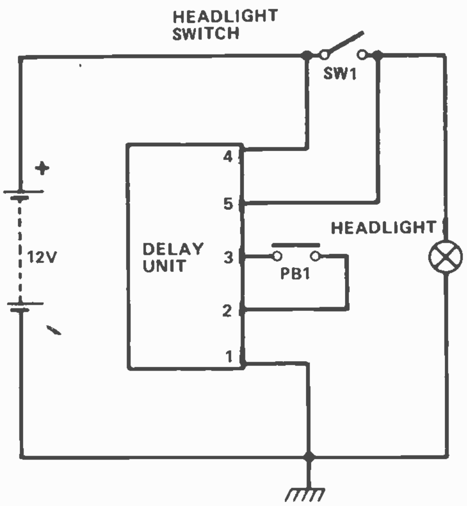


Fig. 1 Circuit diagram of the unit.



The alternative connection is shown in Fig 2b. Here, the headlight switch is wired in series with the vehicle's ignition switch, so that the headlights only operate when the ignition is turned on. If your vehicle uses this type of connection, take connection 4 of the 5 way terminal block to the live side of the ignition switch, and take connection 5 to the headlamp side of SW1.

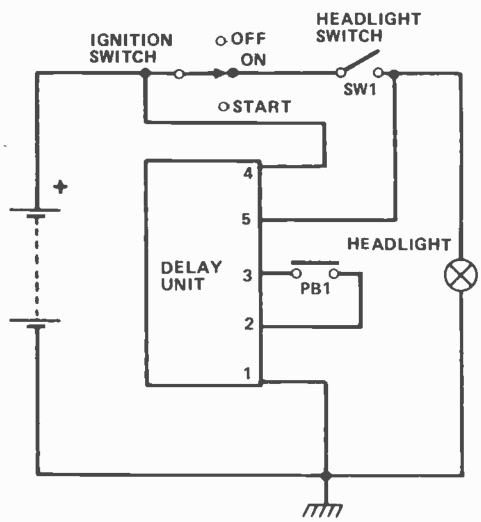


Fig. 2a (Left): Connection of the delay unit to a car system where the headlights are independent of the ignition switch.
Fig. 2b (Right): Connection to all other systems!

Construction and Use

Construction of the unit should present no problems at all. The relay can be any 12V type with a coil resistance of 120 ohms or greater, and with two or more sets of N.O. contacts that are rated at 3 amps or greater.

When it comes to installing the unit, note that two methods of correction to the vehicle are possible. On some vehicles the headlight switch is connected directly to the battery so that the headlights operate even when the ignition is turned off (see Fig. 2a). In this case take connection 4 of the 5 way terminal block directly to the live side of headlamp switch SW1, and connection 5 to the headlamp side of SW1.

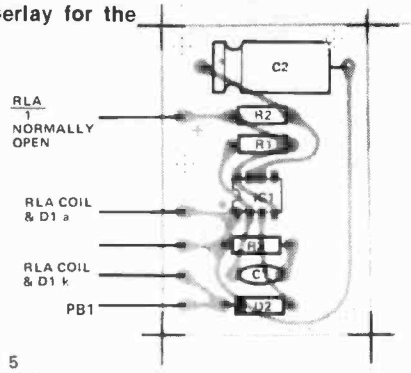
HOW IT WORKS

The unit is designed around a type-555 timer i.e., with a relay output. The relay has two sets of normally-open contacts. Normally, START switch PB1 and the relay contacts are open. so zero power is fed to the timer circuit and (assuming that HEADLIGHT switch SW1 is open) the headlights are off. Circuit action is initiated by briefly closing push-button switch PB1.

When PB1 is momentarily closed power is fed directly to the relay coil, and the relay turns on. As the relay turns on contacts RLA/2 close and apply power to the headlights and contacts RLA/1 close and apply power to the timer circuit, but pin 2 of the IC is briefly tied to ground via C1 and R3 at this moment, so a negative trigger pulse is immediately fed to pin 2 of the IC and a timing cycle is initiated. Consequently, pin 3 of the IC switches high at the moment that the relay contacts close, and thus locks the relay on irrespective of the subsequent state of switch PB1.

The 555 is wired as a one-shot timer or monostable with a timing period of about 50 seconds (determined by R2 and C2). Thus, the relay and headlights are held on for the duration of this 50 second timing period. At the end of the timing period pin 3 of the IC switches to the low state, so the relay turns off and contacts RLA/1 and RLA/2 open, removing power from the timing circuit and the headlights. The operating sequence is then complete.

Fig. 3 Component overlay for the delay unit.



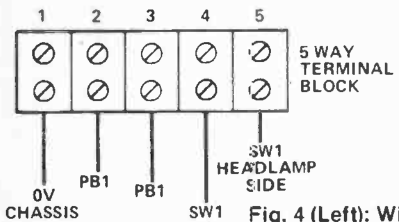


Fig. 4 (Left): Wiring of the delay unit to a 5 terminal connection block.

Fig. 5 Full size foil pattern of the headlight delay PCB.

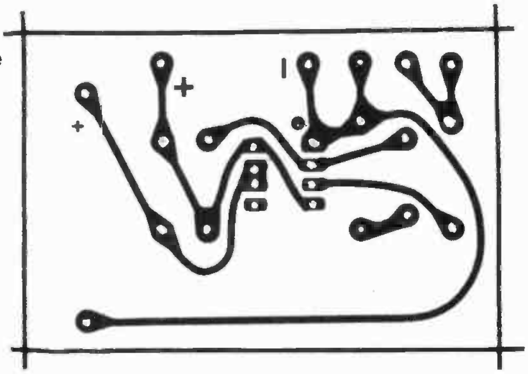
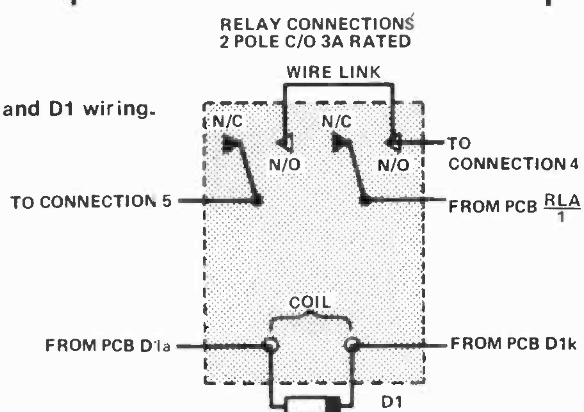


Fig. 6
The relay and D1 wiring.



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RESISTORS

R1	22k
R2	470k
R3	1k

CAPACITORS

C1	100n polyester
C2	100u elect.

SEMICONDUCTORS

IC1	NE555
D1,2	1N4001

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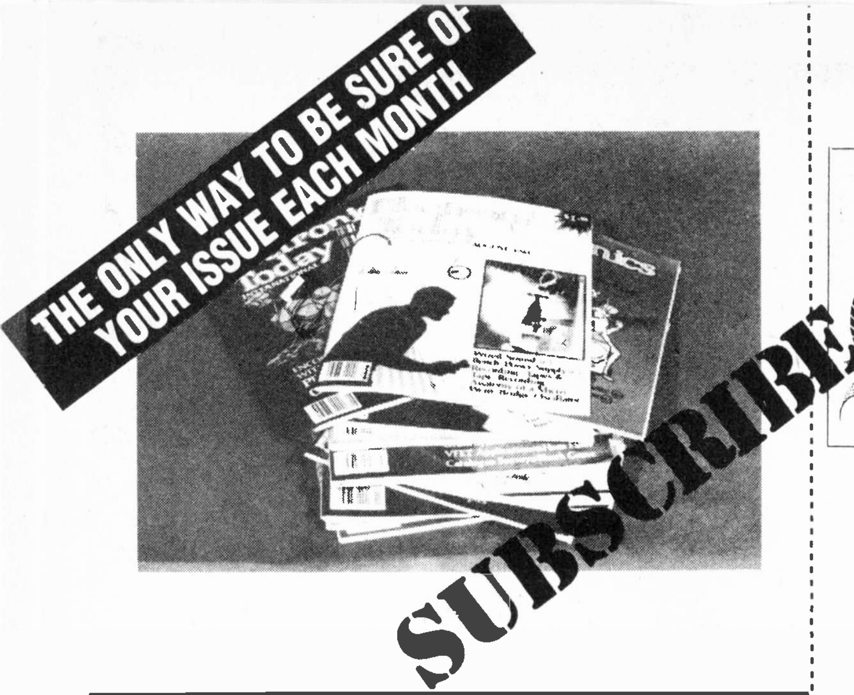

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As it once was

You may have noticed some definite trends in our society, especially in terms of money. The old guy who sells papers on the corner doesn't get upset if you ask him to change a hundred. The meat section of your supermarket has a sign that reads 'If you have to ask you can't afford it'. Recently the gas pumps began being recalibrated in increments of ten dollars. However, through all this heavy inflationary nastiness, ETI has still remained a good value for your ever shrinking buck. Since our inception four years ago the average issue has actually gotten thicker, with more and better projects and features. Compare this to the price of a box of eggs, and realize a copy of ETI will probably last longer, and doesn't leave you with a pile of messy shells. Yes, if this country was put together as well as ETI . . . well, think how easy it would be to find parts.

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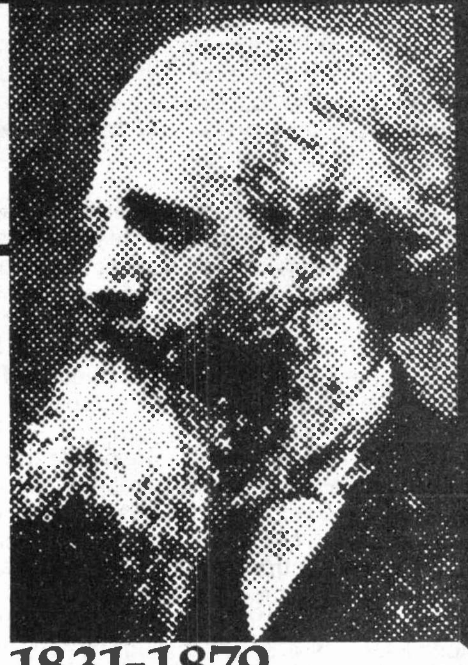
BIOGRAPHY

JAMES CLARK MAXWELL



1831-1879

James Clark Maxwell was an academic of great brilliance who, in one single act of genius, directed the efforts of engineers to a complete new world — the world of radio waves.

MAXWELL WAS BORN in 1831, and had a brilliant school career, followed by an equally brilliant university course at Edinburgh. By the age of 19 he had already had two papers published by the Royal Society, which led him directly to Cambridge, first to Peterhouse and then to Trinity. He graduated in mathematics in 1854, and achieved such distinction in theoretical physics that he was appointed Professor of Physics at Marishal College, Aberdeen, in 1856, aged 25.

His main interest at that time was the kinetic theory of gases: the idea that gases consist of molecules which are continually in motion, and which are, on average, large distances apart compared with their own diameters. Nowadays, anyone who does routine physics at school learns simple kinetic theory, but the theory which Maxwell produced was as far beyond simple kinetic theory as a home computer is beyond a one-transistor amplifier.

All very academic, you might say, and nothing to do with electronics? Well, as it happens, the way that molecules in a gas behave is often very similar to the behaviour of electrons inside a conductor, so that the mathematical methods which Maxwell devised have been very useful to later researchers. They did Maxwell's career quite a lot of good too. In 1860 he was appointed as Professor of Physics at Kings College, London, where he remained until late in his life, when he became the first Cavendish Professor of Physics at Cambridge.

What was the work which justified these plum academic appointments? Most of them would take too long to explain, but one is of such outstanding importance that we have to take a stab at it, even at the risk of missing out bits in order to simplify what it's all about. That one was the theory of electromagnetic radiation, Maxwell's masterpiece.

In the 1860s, electrical theory was doing quite nicely, thank you. Ohm and Kirchoff had established the laws which are as familiar today as they were then and which are the fundamentals of electrical circuit theory. Thanks to the practical work of Faraday and the theory of Biot and Savart, electricity and magnetism were recognised as being two aspects of the same thing. For some time also, electrostatics had also been recognised as being part of electricity, but the place of electrostatics in relation to electricity (that is, electrical current flow) was not sufficiently recognised. It's easy for us now to see that electrostatics is the study of electrons at rest, and current electricity is the study of moving electrons. It wasn't quite so easy in the 1860s because the electron hadn't been discovered: it was only dimly suspected.

Maxwell was not impressed by this apparent progress, because he sensed something missing. Even now, over a hundred years later, it's not easy to describe what was missing without using the natural language of physics, which is mathematics. The mathematics that's needed is a bit above our standard, though, and we'll have to make do with second best — a bit like describing music with colours.

Another Kind Of Current

Maxwell, so like Faraday before him, was fascinated with 'lines of force'. Let's refresh our memories on this topic. Take a bar magnet, place a sheet of glass over it, and sprinkle iron filings on top. Now tap the plate, and the filings take up the pattern which we call the lines of force. These lines are just a contour map of the strength and direction of the magnetic field around the magnet — or are they? Maxwell, like many theoretical physicists before him, saw these lines as being something much more significant — a visible indication of invisible strains in the material around the magnet. Each line of force around a magnet is just one kind of line of force. An electrostatically charged object can also reveal lines of force — electrostatic 'lines' — which behave quite differently from the magnetic ones.

In the midst of all the work which was going on with regard to electric current in conductors, Maxwell took quite a different view. To him, a conductor was simply where an electrostatic line of force ended or started, and around which a magnetic line of force was coiled. Maxwell's interest was drawn to the space around the conductor, the space which supported these invisible lines of force. By one deduction, he predicted an effect which was not confirmed for twenty years but which has totally altered the world. That deduction was displacement current.

Distinguishing Lines Of Force

In the 1860s three effects were well known. One was that an electric field in a conductor (produced by a voltage applied between the ends of the conductor) caused a *current*.

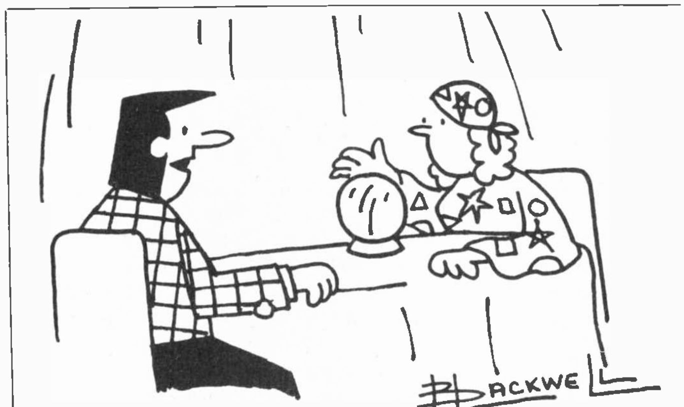
That little lot was the work of Georg Simeon Ohm. They knew also that a current flowing through a conductor caused a magnetic field: this had been the work of Oersted. Finally, as a result of Faraday's painstaking work, they knew that a changing magnetic field would create a voltage. All these three effects can be described in equations, which Maxwell wrote down and studied, as many must have done before. Maxwell saw something missing, a fourth equation which was needed to complete the set. His genius was not only to see that something was missing but also to predict what it must be. His deduction was that a changing electrostatic field should behave like a current, but a current which should be able to exist in space without conductors. Maxwell called this a 'displacement' current, and he saw this as a normal part of any alternating current circuit which included capacitors.

Maxwell laid his displacement current equation alongside the others, and saw a familiar pattern. Merged together, these four separate equations formed a single equation, an equation well known to physicists as that of a wave. What it boiled down to was that changing electrostatic and magnetic fields could cause a wave motion. More remarkably, the equations enabled the speed of this theoretical wave to be calculated, and the calculated value was identical to the measured speed of light.

Maxwell published the details of his remarkable theory at once. His conclusions were completely revolutionary. Light, he maintained, was an electromagnetic wave, and not a completely separate effect. More important, there must be a complete family of such electromagnetic waves, all capable of travelling through empty space at the same speed of three hundred million metres per second, all capable of carrying energy from one place to another through empty space. These waves, he predicted, would differ only in having different frequencies and wavelengths.

Maxwell's work was politely ignored. It was regarded as an interesting piece of academic research, but without practical applications. Don't feel too superior, because the same is said about nearly every great scientific discovery — as much now as it ever was. Remember that light seemed unaffected by electric or magnetic fields — though Faraday had shown that the plane of polarisation of light could be rotated by the effect of a magnetic field on a crystal. Remember also that there was no evidence for any of these other electromagnetic waves at the time. The evidence was to come later when Heinrich Hertz discovered radio waves, measured their speed, and showed that these were indeed the waves which Maxwell had predicted. By that time though, Maxwell's career had come to an end with his death in 1879.

One little side-line is worth noting, and it also illustrates a very practical side to Maxwell. In the middle of his work on electromagnetic waves, Maxwell produced the first colour photograph. He had seen that a colour photograph could be produced by projecting three images, one in each primary colour, so that they superimposed. This was in 1864, and it was some ninety years before family photograph albums were being decorated with colour photographs as a matter of routine. With that, and the prediction of radio waves, how much more ahead of his time could he be?



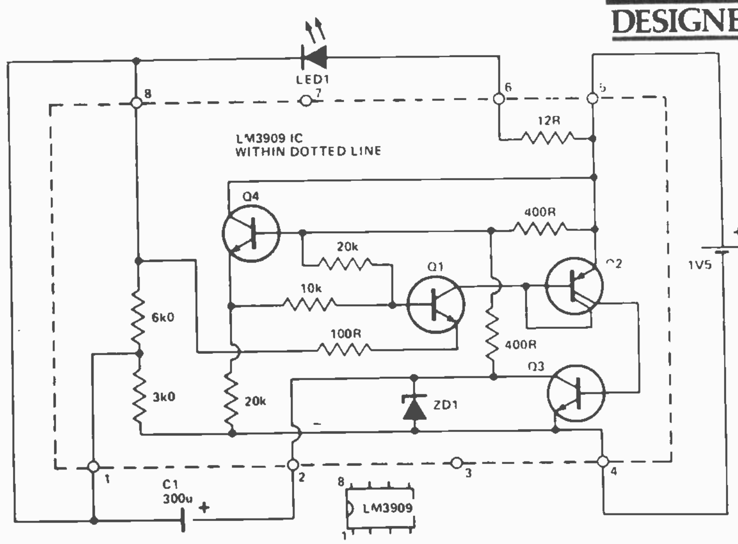
"Can't you see anything else in the future besides electronics?"

DESIGNER CIRCUITS

LOW-POWER FLASHING LIGHT

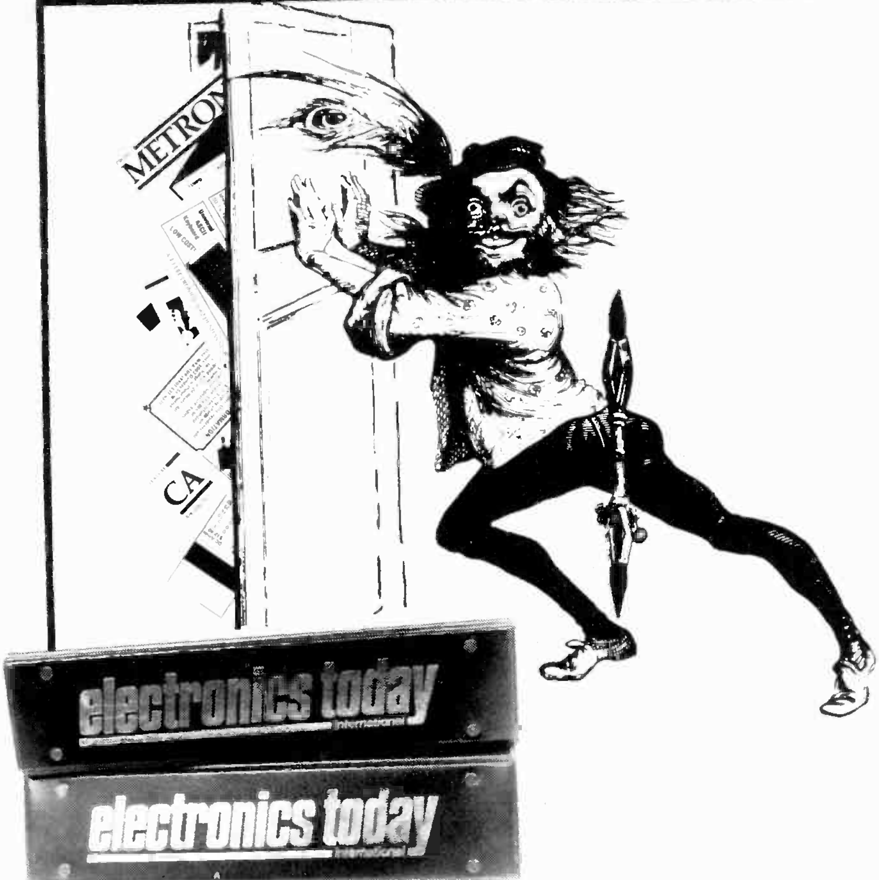
Most integrated circuits, in fact most electronic circuits, are designed to operate with power supplies in the range 4V5 to 40V. It is quite rare to find battery-operated equipment fitted with indicator lamps, due to the unacceptable current drain. Even light emitting diodes (LEDs), which use up very little current (usually 10 to 20mA), are not used all that often. At very low voltages (below 2V) an LED will not even illuminate!

National Semiconductor have produced an integrated circuit to be used specifically for flashing an LED, even operating at voltages as low as 1V1, with an average current consumption orders of magnitude below that of an LED on its own.



The circuit achieves it's very low current consumption in two ways. Firstly the LED is only illuminated 1 % of the time, and only transistor Q4 is turned on for the rest of the time drawing a current of only 50uA while on. The 300u capacitor determines the flash rate by charging up via the two 400R resistors and the 3k0 resistor. Q1 and Q2 are turned off until the voltage at the positive end of C1 reaches about 1V0. The exact voltage is determined by the junction voltage drop of Q1 and Q4 plus the voltage divider across Q4's base and emitter.

When the voltage at pin 1 is 1V0 more negative than the positive supply (pin 5), Q1 starts to turn on. This in turn switches on Q2 and Q3. The circuit then supplies a high current pulse to the LED. Q3 is a medium-power transistor that can handle 100mA of current, and rapidly brings pin 2 to a voltage close to zero volts. As the capacitor has a charge it makes terminal 1 (the negative end of the capacitor) go below supply zero. At this point in the cycle the cathode of the LED is at a higher potential than supply positive, and the current that flows through the LED is limited by the 12R resistor between pins 5 and 6. The cycle then repeats itself.



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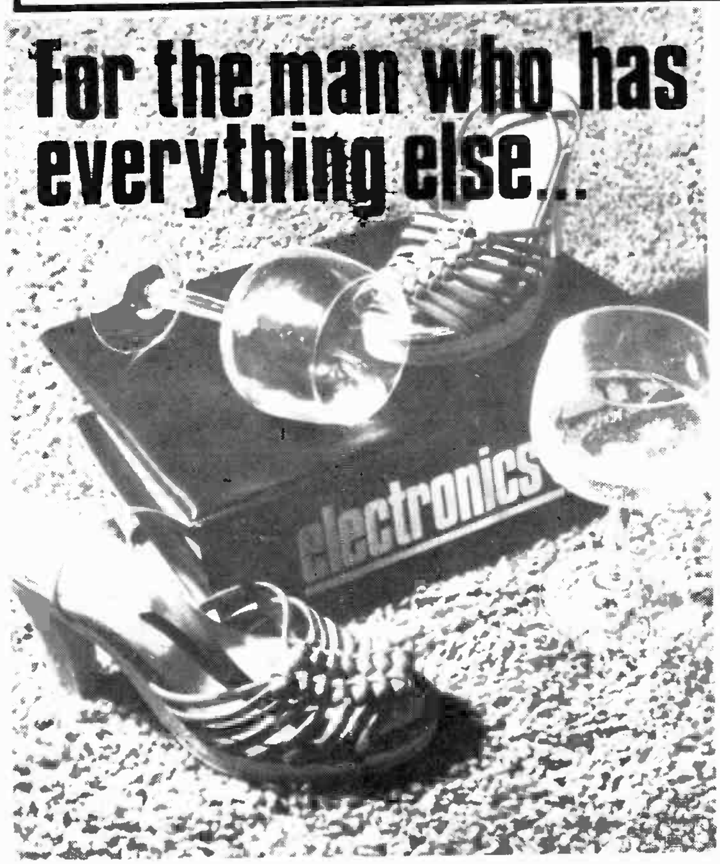

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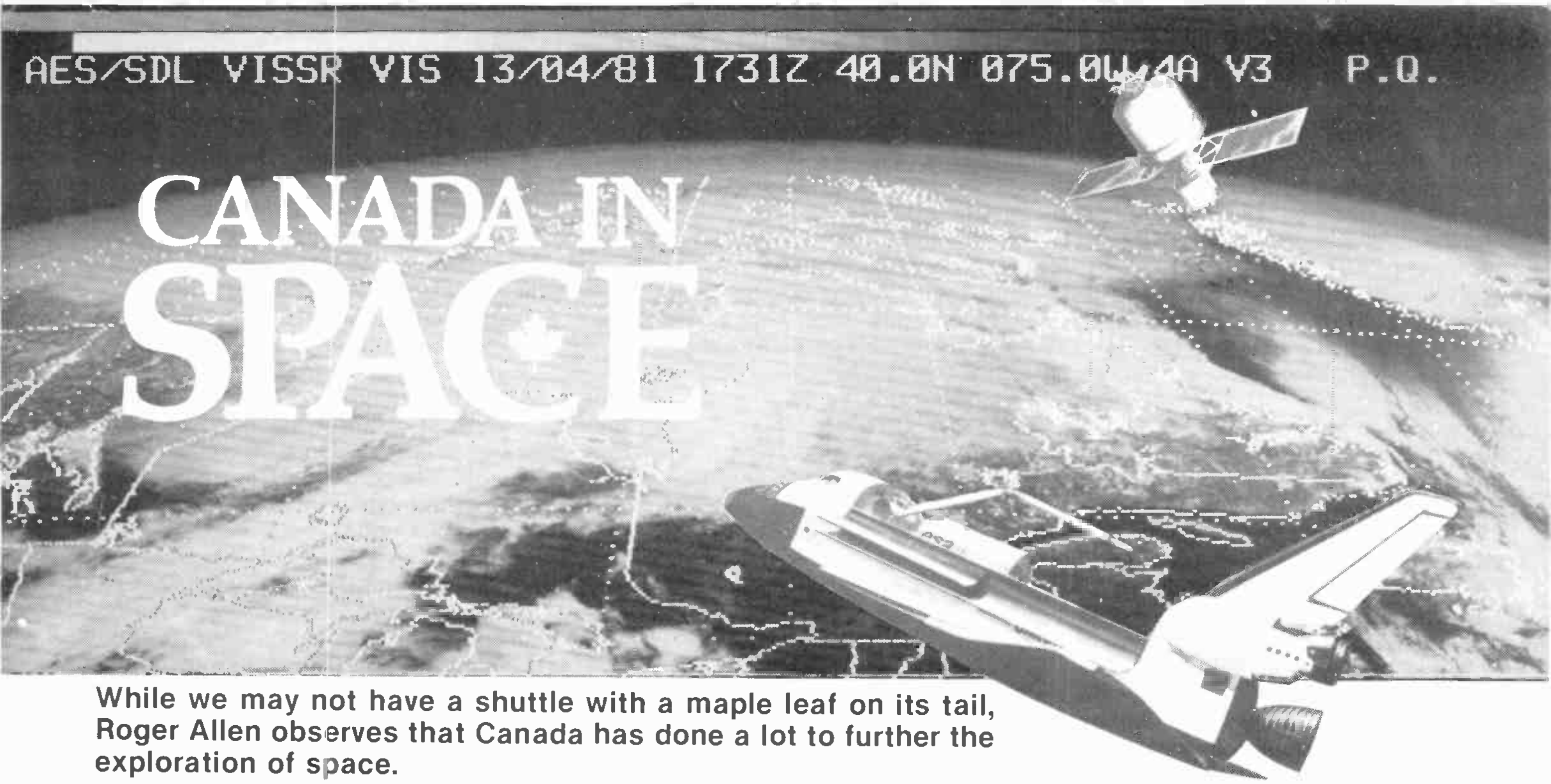


CANADA IN SPACE

While we may not have a shuttle with a maple leaf on its tail, Roger Allen observes that Canada has done a lot to further the exploration of space.

IT IS A reality of the Canadian experience, though regretably little noted by the popularizers of our history, that Canada has always been at the forefront in pushing back natural frontiers — whether the grossly physical as in our westward colonization, the depths of the sea as in the work of Dr. Tuzo Wilson and plate tectonics, the depths of the mind by Dr. Wilder Penfield, the microscopic world by the electron microscope developed at the University of Toronto, and in space.

No doubt our relatively spartan population has precluded our attaining any continual Niagara of exploits in any given field, but none the less Canada has always played a creditable role in extending the frontiers of knowledge and ability, a role which belies Canada's customary self denigaration.

Canada's first efforts in studying space began during WW I with the study of near space, particularly the ionosphere and its effect on radio wave reflection by signals generated at ground based stations. A product of this research ultimately led to it becoming technologically feasible to construct the Canadian Broadcasting System (CBC), and hence in later decades via the CBC an extension and generation of Canadian culture and political unity.

Eyeing the Ionosphere

Starting in the late 1920's, long term broad based studies of the aurora borealis and other auroral atmospheric radiative processes were undertaken by the University of Saskatchewan in Saskatoon, later including work by the Canadian Atmospheric Environment Service (AES), the University of Calgary and the Canadian Armament and Research and Development Establishment (CARDE). Initially involving isonosondes to probe the upper atmosphere, this system of ground based stations was expanded and updated during WW II by the Defense Research Telecommunications Establishment (DRTE), and while the investigative process has been largely assumed by the research instruments of balloon and rocket probes, modern isonosondes are still operating at three Canadian locations.

Balloons carrying instrument packages to study the weather were first used by the Meteorological Service after WW I, and more recently high altitude balloons launched by the Defense Research Board (DRB) and the Universities of Saskatchewan and Montreal have been used on a regular basis to study X- and cosmic rays. With the gradual decline in CARDE, balloon flown instrument package based research was assumed by the National Research Council (NRC) and AES resulting in 1976 with the development and deployment of a self contained mobile balloon launching facility, currently based in Gimli, Manitoba and used to fly both Canadian and US payloads.

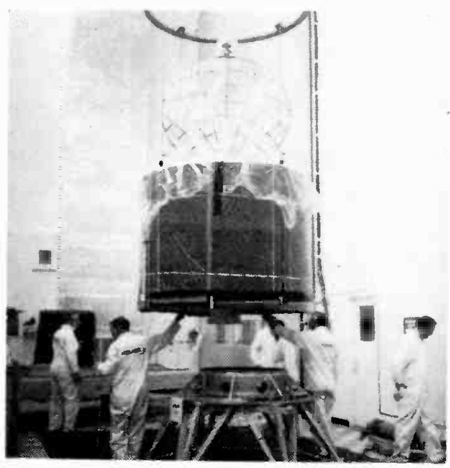


Fig. 1. TELESAT-A prior to launch.
(Photo courtesy NASA)

Canada first became involved in the development of rockets in the early 1950's. Funded by CARDE this development was based on the work of the German war scientists and initially limited its studies to supporting military missile programs. Within a couple of years CARDE became interested in developing a rocket capable of sounding the upper atmosphere. To fulfill this specification, CARDE developed the Black Brant rocket — CARDE being responsible for the the propellant and filling while Bristol Aerospace of Winnipeg produced the casing.

The Black Brant soon showed itself to be a widely useable workhorse for atmospheric and near space studies. Utilizing a solid propellant it comes in three sizes — 5, 10, and 17 feet. The 5' model is used for flying small meteorological instrument packages to 80 km heights, while the 10 and 17 foot models can push packages up to 250-300 km. by joining the two rocket motors forming a two stage rocket, payloads of up to 100 lbs can be flown to heights reaching 900 km. Widely used by Canadian researchers, the Black Brant has been sold around the world for scientific purposes.

To utilize the Black Brant to its fullest, in 1954 the Canadian Army constructed a rocket firing facility at Fort Churchill, Manitoba. extensively used during International Geophysical Year (1957-58) when over 200 rockets were fired. The Churchill base was used by both Canadian and US scientists on a fairly regular basis until 1961 when the facility was closed due to fire damage. It was reopened in 1962 in a rebuilt and expanded state. In 1965 the NRC and NASA agreed to share the cost of the facility, but in 1966 responsibility was solely invested in the NRC due to the preponderance of Canadian firings. Surprisingly, range maintenance and general operation management remained in the hands of a public contractor, Pan American Airways, a situation which continued until 1978 when it was decided to close Fort Churchill on a year round basis and restrict its use to an expeditionary basis. This was due to a decline in the number of rocket launches due to improved and cheaper data being obtained from international research satellites. Other temporary rocket launch sites were built at East Quoddy, NS and Eskimo Point on the western shore of Hudson's Bay for the 1971 and 1972 solar eclipses, and at Red Lake, Ontario for the 1979 eclipse.

Instrument payloads for these flights were primarily the responsibility of the Space Research Facilities branch of the NRC, while those components unique to the experiment remained in the hands of the individual research groups, which today primarily means university science departments.

The moderately high cost of firing rocket borne instrument packages combined with the far cheaper but less accurate trajectories obtained by balloon borne instrumentation left a gap in those Canadian experiments requiring repeated probes along the same trajectory. This gap was filled in 1961 by the construction of a 16' gun, later extend in length to 119' by attaching two US naval gun barrels, making it the largest gun in the world.

Located on the island of Barbadoes, and code named MARTLET, the gun is capable of firing an instrument package weighing 200 lbs to a height of 150 km. Its advantage over rocket or balloon borne instrument packages is that it can be fired at hourly intervals, each firing following the same trajectory, and doesn't cost very much. Its major disadvantage is due to the force of acceleration — necessitating instrument packages

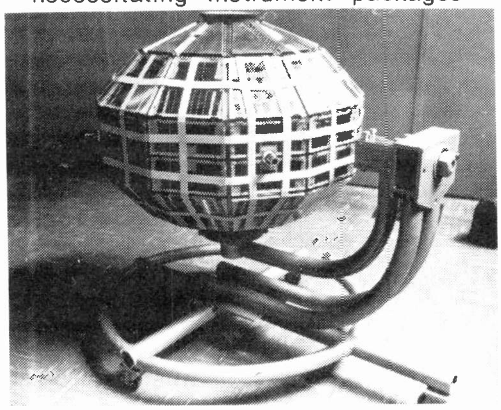


Fig. 2. Alouette, an ionispheric sounding satellite.
(Photo courtesy NASA)

capable of withstanding forces of 25,000 gravities. The facility has not been used for some years, but in its heyday MARTLET produced voluminous data dealing with atmospheric spectroscopy and high altitude wind movements.

Satellite Successes

With the launching of Sputnik in 1957 the true advent of near space utilization for peaceful and military defensive purposes began. Despite the possibility, proven on paper but never demonstrated in practise, of using clusters of Black Brants to launch satellites, Canada has remained dependent on the US and USSR to provide launch capabilities for Canadian space hardware. Needless to say, military, political and economic considerations have precluded, at least to date, the Canadian utilization of Soviet rockets which in turn has meant that Canadian space programs have become totally intertwined with US launch capabilities and scheduling. While possibly appearing to be somewhat of an affront to Canadian pride to be dependent on foreign launch capabilities and scheduling it has in fact been beneficial to Canadian space endeavours for it passed the enormous costs of launch systems R and D, such as the Space Transportation System (Shuttle), directly onto the shoulders of the American tax payer. This in turn has permitted the Canadian space community of engineers, scientists, support staff, administrators and taxpayers to concentrate on those areas of space utilization which are most pertinent and useful to Canada: the explication of Canada's preeminent characteristic — its geography.

Canada's first direct involvement in space satellites began in 1959 with the agreement between NASA and the DRB for a topside-sounder system to investigate the ionosphere. The program was particularly important for the future use of satellites for the ionosphere with its charged ions is the major natural stumbling block in radio and microwave communication from ground to ground stations

Fig. 3. A satellite downlink in Northern Canada.

and for surface to satellite comunication of virtually all types. While a great deal had been learned by the use of isonosondes, exploration of the ionosphere from the top down remained largely unknown but was vital if any large scale civilian satellite communication system was to be constructed.

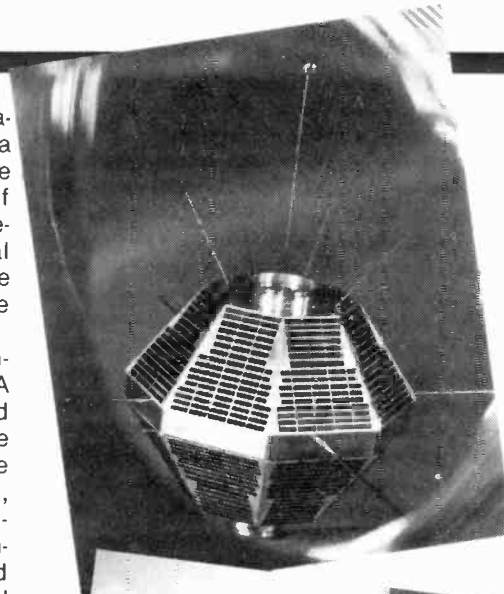
Called ALOUETTE I and launched without cost to Canada by NASA in 1962, the satellite proved beyond doubt Canadian abilities in space technology. In addition to the ionosphere radar experiment, ALOUETTE I carried three other experiments to study very low frequency radio waves, cosmic noise and energetic particles, all areas that had to be explored before communication satellites would be designed to operate effectively. Designed to operate for two years, it lasted ten, setting a number of 'records' in the process: longest lived satellite to date, satellite that produced the largest number of scientific papers, and so on.

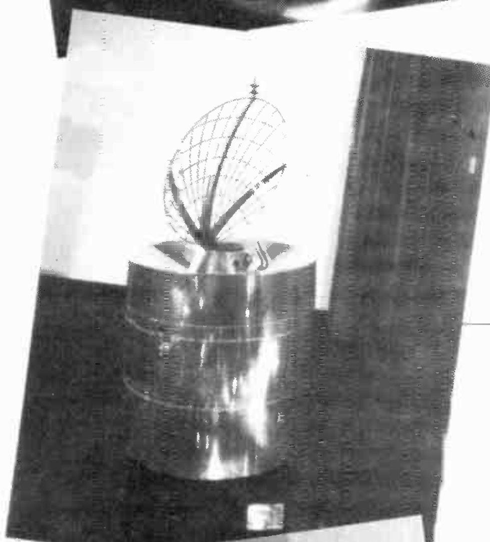
Compounding and expanding the data received by Canada's first satellite came ALOUETTE II launched in 1965. With considerably more output than its predecessor sister, ALOUETTE II continued the four experiments of ALOUETTE I with a fifth called a Langmuir probe which studied electron densities and their temperatures. Designed to last two years, ALOUETTE II continued to broadcast for only four months less than the decade of transmission achieved by its sister.

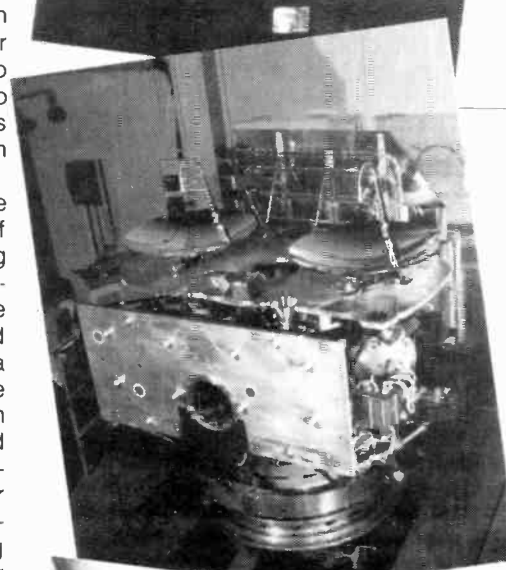
One of the more notable technological achievements of ALOUETTE II was its attitude sensing ability. In all previous satellites launched by any nation, the ability of the satellite to broadcast to a ground based station was dependent on a correct trajectory determined by the navigational ability of the launch vehicle with some help from onboard sensors. The onboard sensors consisted of a single axis magnetometer and thermistors. ALOUETTE II advanced the art of satellite positioning by using a three-axis magnetometer and a solar aspect sensor as well as thermistors. This permitted vastly improved positioning of the satellite ana has been widely copied by many nations. A second then unique technical ability of ALOUETTE II was its use of Canadian designed nickel-cadmium batteries to power the satellite during those periods its solar cells were in darkness. These batteries have proven themselves to be arguably superior to any other battery used by any nation's satellites to date.

With the success of ALOUETTE I, Canada, the US and the United Kingdom agreed to develop a long term research project to continue studying the ionosphere. Named the International Satellites for Ionospheric Studies (ISIS), the program employed the launching of two satellites in 1969 and 1971 whose onboard experimentation eventually included devices provided by seven countries other than the three original signatory nations, with all participating nations having access to all data generated by the satellite. As well as several experimental devices, Canada designed, developed and largely constructed the satellites.

By the late 1960's, the Canadian government recognized that the major reality in Canadian space utilization was government involvement and funding, a reality that precluded industrial development free of excessive civil service red tape. The government recognized that Canadian industry, such as Spar Aerospace in Toronto, had reached an internal technological and managerial capability whereby they could stand on their own and compete in the international marketplace without constantly deferring to government approval. Henceforth, Canadian industry played a larger role in determining the structure and capability of Canadian satellites, providing a solid foundation for a viable and increasingly intensive space industry by the early 1980's. This did not mean that Canadian governmental support of the industry was removed or phased out, but rather that whenever there was a choice between constructing a satellite under government auspices or by private industry that private industry was to be given the work. If the choice was between private industry in Canada and private industry in the US, the difference being higher Canadian costs, then the government would subsidize







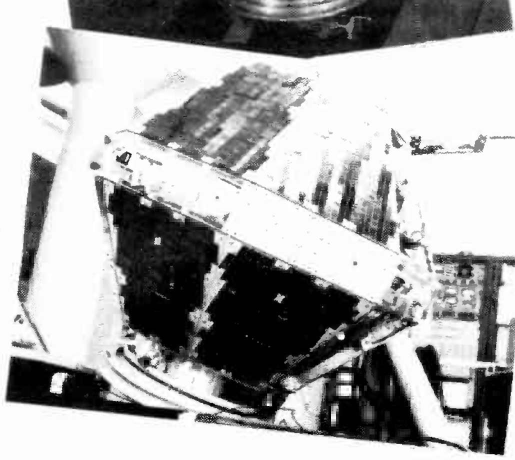


Fig. 4. ISIS I, launched in 1969.
(Photo courtesy DOC)

Fig. 5. ANIK-A, our first communications satellite.
(Photo courtest DOC)

Fig. 6. HERMES, launched in 1976.
(Photo courtesy DOC)

Fig. 7. ISIS-A prior to launch.
(Photo courtesy NASA)

the difference providing work for Canadian industry. The only drawback created by this policy, according to industry sources, is that the launching of several satellites has been somewhat delayed past their scheduled dates due to industrial construction delays.

The Communications Connection

The next major development in Canadian space technology marked the beginning of what will no doubt prove to be the longest continuing technological development in Canada's history. For long after roads have disappeared as a means of communication, communication satellites will remain.

Canadian involvement in communication satellites indirectly began in 1964 when Canada joined ten other nations in creating an international communications system employing satellite technology, named INTELSAT. Utilizing American built satellites stationed over the Indian, Pacific and Atlantic oceans, INTELSAT now involves 101 member nations utilizing 163 ground stations in 88 countries. Canada's three ground stations: at Lake Cowichan on Vancouver Island to handle trans-Pacific communications; Mill Village, NS for trans-Atlantic hookups and one in the Laurentians north on Montreal are managed by Teleglobe Canada, a Crown corporation. The dramatic use of the INTELSAT system was shown during the 1976 Olympic Games when Teleglobe provided two television channels to transmit 800 hours of simultaneous programming from Montreal to Africa, Asia, Europe and both the Americas. This made the Montreal Olympics the most widely viewed event in history, and did much to enhance Canada's international prestige.

According to the weather satellite this rain will last another two days.

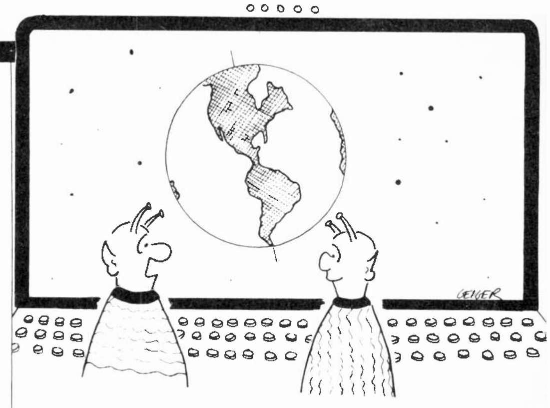
Continuing its policy of extending Canadian involvement in space while fostering Canadian non-government involvement, Parliament in 1969 created an organization known as Telesat. A successful hybrid commercial venture legally lying between being a Crown corporation and a government agency, Telesat's ownership is shared by the Federal government and Canadian communications carriers. This was a means by which industry could become more directly involved in satellite communications, but still permit the government to require Telesat to construct a satellite grid which would cover all of Canada, including the sparsely populated and therefore commercially non-profitable northern regions.

Of the nine Telesat satellites (NASA coded A to H) scheduled to be launched between the commencement of the program and 1985, four are in operation have been launched in 1972, 1973, 1975 and 1978. Named ANIK after the Inuit word 'brother', the ANIK satellites I, II and III (known as the A series) provide twelve high capacity microwave channels operating on the 6/4 Gigahertz (GHz) frequency, each channel capable of relaying one colour television program or 960 multiplexed voice signals. While ANIK IV (B series) provides 18 channels, 6 on the 14/12 GHz band and 12 on the 6/4 GHz band. The 6/4 GHz represents that the uplink is on 6 GHz while the downlink is on the 4 GHz band. The advantage of the 14/12 GHz band is that the links are not susceptible to radio interference from ground based broadcasting stations. Four more ANIK satellites (C series) are scheduled to be launched between 1982 and 1984, and are similar in construction to ANIK IV.

Down To Earth Links

One of the great difficulties in using satellites for civilian communication is the necessity of using expensive tracking ground stations to follow the orbiting satellites. The cost for a non-tracking dish is considerably less, but requires a geostationary satellite, a considerable technical difficulty when Telesat was created.

Using Canadian developed technology, specifically compressed hydrazine gas, and the positional ability learned from the ALOUETTE and ISIS program, the ANIK satellites are geostationary and therefore permit the ground stations to consist of relatively cheap non-tracking microwave dishes. In fact, of the 100



I think they're watching us . . .

prime ground stations owned by or leased from Telesat, only three are trackable — two at Allan Park north of Toronto and one at Lake Cowichan. This is not only because these stations are used as command transmission stations during launches and general housekeeping manouvers (along with a US station on the island of Guam) but because they provide the end points for the high density Vancouver/Toronto high quality telephone, television and radio links.

While the ANIK series provide commercial communication, ANIK B is something of a hybrid satellite providing both commercial communication services as well as acting as a science platform. Of the 17 experiments being performed by ANIK B possibly the most important and far ranging involves direct broadcast to homes and small communities using 100 small microwave dishes provided by the Federal government. So successful has this system been that it has provoked legal (unlicensed ground stations), legislative (who owns signals from space), artistic (copyright) and cultural (Eskimos watching 'Mork and Mindy') difficulties — for Canada appears to have been caught flat-footed in its inability to deal with this first step toward home to home direct satellite communication. Yet so successful has the Telesat system been that both its satellite and ground technology has been copied by the US Western Union WESTAR, the Indonesian PALAPA and the Brazilian domestic satellite communication systems.

The ninth and by far the most powerful of Canada's satellites was launched in 1976 and operated until 1979. Originally called the Communication Technology Satellite, it was renamed HERMES after the Greek messenger god shortly after it was launched. It was a joint effort with a difference, for it was virtually a solely Canadian effort with NASA on-

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ly providing a very high powered (200 watt) transmitting tube and the launch vehicle. Some minor onboard components were provided by the European Space Agency. The purpose of the satellite was to test the then new 14/12 GHz frequency bands (later used on the ANIK B) and to develop advanced component and subsystems capacity in Canadian industry, both for home use and for export.

Using the satellite on alternate days, Canada and the US commenced their experiments two months after launch. In Canada, 30 organizations conducted 15 technical and 22 social experiments. The technical experiments consisted primarily of direct broadcasts to small receivers in individual homes and schools, while the social experiments primarily dealt with non-customary satellite usage. For instance in the realm of tele-medicine, two way voice and visual contact was used by a neurosurgeon in London, Ontario to diagnose a patient in Moose Factory, 1,124 km away as not having a suspected brain tumer; while patients in a St. John's, Nfld, hospital were able to visit home' to remote settlements in Labrador thereby helping to alleviate the emotional familial aspect of hospital incarceration. In the realm of tel-education, Carleton University in Ottawa and Stanford University in California shared graduate level engineering classes on a daily basis over a period of six months, providing academic credits to students at both ends of the link.

While the major single elements in Canadian space ventures have generally also been the 'glamour' projects — Canadian space involvement has included large scale though less colourful programs. It was the first country to receive pictures from the US LANDSAT satellite (much to the chagrin of the Americans). LANDSAT is a surveillance satellite which provides photographic data useful in monitoring agricultural, forest and resource industries. Many of its components and ground base technology were developed in Canada. Canada is fully involved in the next generation satellite LANDSAT D, expected to be launched in 1983. A companion development, SEASAT, provides images of the earth under conditions of cloud, fog and darkness and is to be included in Canada's SURSAT (Surveillance Satellite) which will be used to monitor ice coverage and drift, and for detecting and pinpointing (by monitoring bow-wave configurations) human activity in coastal and ocean areas. Spar Industries of Toronto have developed and built the Remote Manipulator System (RMS), better known as the space arm. Attached to the US Shuttle, it will be able to pick up and deploy satellites and equipment while in orbit. The first of four such arms was paid for by the Canadian government, the next three are to be bought by NASA. The Federal Government funds the David Florida Laboratory, a spacecraft test and integration facility. Built in 1972 to meet the needs of the HERMES program, it was expanded in 1981 and is expected to be able to handle virtually all forseeable Canadian satellite requirements into the 1980's.

By 1981, therefore, Canada had developed the world's second largest domestic space industry, employing some 2500 people in high technology jobs. 1979 sales totalled $140 million of which 43% was for the export market. For purposes of comparison, 1975 sales totaled $11 million of which 11% was in exports (1961-1979 grand total: $650 million). This does not include the government/private sector element of Telesat, which in 1980 generated sales of $58 million.

Onwards and Upwards

It is these figures that the greatest truism of space utilization is to be found — for these figures would be zero if the Canadian government had not invested some $600 million between 1961-1979. It is this reality — no government interest = no space program — that has been both the boon and bane of Canada's space effort. For within the Federal government there are three major and several minor departments involved in the space program — the Department of Communication involved in basic research, communications and industrial development; the National Research Board involved in scientific rocket and balloon experiments, the RMS and the co-operative space program with NASA; and the Canada Centre for Remote Sensing involved in LANDSAT, SEASAT and SURSAT. It was this confusion of responsibilities and funding sources which prompted industry to lobby the government to create a single unitary authority, modelled on NASA. While the government has been unprepared to go that far, in July of 1980 it assigned the Ministry of State for Science and Technology the responsibility of the leadership role with respect to space policy and development. With this 'sort of' amalgamation of government responsibilities came the possibility of overcoming the second major industrial difficulty — the hit or miss government funding programs. What industry felt was necessary involved an extended program of funding over several years. This was met in 1980 by the government announcing a four year $195 million research, development and procurement program extending to 1984. In 1981 a further $65 million was allocated as an addition for the last three years of the plan. The plan basically involves extension of remote sensing capabilities (LANDSAT D, SEASAT, SURSAT), continued application testing of current technology, development of a search and rescue satellite with other nations, environmental pollutant monitoring and the development of advanced solid-state devices such as the Gallium Arsenide Field Effect Transistor. It is with upfront support such as this, combined with the continued communications satellites owned by Telesat, that will permit the Canadian space industry to generate some $280 million in annual sales with about 66% for export by 1985, and hence maintain Canada's forefront position in the exploration and utilization of space — the final frontier. ETI

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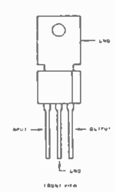
TL075	2.75	Quad Low-noise BIFET Op Amp
TL081	.60	JFet-input Op Amp
TL084	2.00	Quad JFet-input Op Amp
SN76477	2.45	Sound Generator

If you don't see the linear IC you need, please call us at (416) 921-5295. Even if we don't stock the device you need, our staff can usually recommend a good source.

Fixed Voltage Regulators

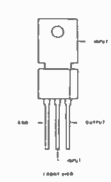
78MXX

Plastic Package



79MXX

TO 202 Power Package (P)



How to order Voltage Regulators:

Part Number = 7nyxxwww

n = 8 for a Positive Regulator
  = 9 for a Negative Regulator

y = L for 100 milliamps
  = M for 500 milliamps
  = nonexistent for 1 Amp
  = H for 5 Amps*
  = P for 10 Amps*
*5 and 12 Volt types only

xx = 05 for 6 Volts
  = 06 for 6 Volts
  = 62 for 6.2 Volts
  = 08 for 8 Volts
  = 85 for 8.5 Volts
  = 10 for 10 Volts
  = 12 for 12 Volts
  = 15 for 15 Volts
  = 18 for 18 Volts
  = 24 for 24 Volts

www = AHC for TO-5 case (L and M versions)
  = AWC for TO-92 case (L version)
  = UC for TO-220 case (M and 1 Amp versions)
  = KC for TO-3 case (1 amp, H, and P versions)

Example: 79M10UC

= -10 Volts, 500 mA, TO-220 Case

PRICES (partial)

78LxxAWC series 65¢ each
79LxxAWC series 99¢ each
78MxxUC series $1.19 each
79MxxUC series $1.69 each
78xxUC series $1.39 each
79xxUC series $1.89 each
78HxxKC series $7.95 each

Please phone or write for price information on other regulators

Adjustable Voltage Regulators

78MGU1C	1.65	500 mA, +5 to +30 Volts, 4-lead TO-220 Case
79MGU1C	1.90	500 mA, -30 to -2.2 Volts, 4-lead TO-220 Case
78GU1C	1.75	1 Amp, +5 to +30 Volts, 4-lead TO-220 Case
79GU1C	2.00	1 Amp, -30 to -2.2 Volts, 4-lead TO-220 Case
78GKC	2.65	1 Amp, +5 to +30 Volts, 4- lead TO-3 Case
79GKC	3.10	1 Amp, -30 to -2.2 Volts, 4-lead TO-3 Case
78HGKC	9.00	5 Amp, +5 to +24 Volts, 4-lead TO-3 Case
79HGKC	12.00	5 Amp, -24 to -2.2 Volts, 4-lead TO-3 Case

Other Voltage Regulators are listed in numerical order under Linear Section.

SOLDERTAIL SOCKETS

1¢ a pin
BURNDY & CAMBION
TI SOLDERTAIL
AVAILABLE at 2¢ a pin

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8 PIN . . . .$ .40
14 PIN 61
16 PIN 68
18 PIN 70
20 PIN 99
22 PIN 1.05
24 PIN 1.07
28 PIN 1.20
40 PIN 1.85

Send for our separate package of information on kits.

TTL Digital Logic

Suffix (nnn)	74nnn price	74LSnnn price	74Snnn price	Device Description
00	.29	.22	.46	Quad 2-input NAND
01	.29	.22	n.a	Quad 2-input NAND (oc)
02	.29	.27	.47	Quad 2-input NOR
03	.29	.29	.49	Quad 2-input NAND (oc)
04	.29	.27	.70	Hex Inverter
05	.30	.29	.62	Hex Inverter (oc)
06	.47	n.a	n.a	Hex Inverter/Buffer (oc,hv)
07	.46	n.a	n.a	Hex Buffer (oc,hv)
08	.30	.22	.61	Quad 2-input AND
09	.30	.30	.27	Quad 2-input AND (oc)
10	.30	.25	.62	Triple 3-input NAND
11	n.a	.30	.62	Triple 3-input AND
12	.49	.30	n.a	Triple 3-input NAND (oc)
13	.50	.32	n.a	Dual 4-input NAND (st)
14	.54	.50	n.a	Hex Inverter (st)
15	n.a	n.a	.62	Triple 3-input AND (oc)
16	.46	n.a	n.a	Hex Inverter/Buffer (oc,hv)
17	.46	n.a	n.a	Hex Buffer (oc,hv)
20	.38	.23	.61	Dual 4-input NAND
21	n.a	.23	n.a	Dual 4-input AND
22	.48	n.a	n.a	Dual 4-input NAND (oc)
23	.47	n.a	n.a	Expandable Dual 4-input NOR with strobe
25	.41	n.a	n.a	Dual 4-input NOR with strobe
26	.55	.50	n.a	Quad 2-input NAND Buffer (hv)
27	.42	.37	n.a	Triple 3-input NOR
28	.54	n.a	n.a	Quad 2-input NOR Buffer
30	.29	.23	.47	8-input NAND
32	.49	.29	.82	Quad 2-input OR
33	.50	n.a	n.a	Quad 2-input NOR Buffer (oc)
37	.45	.35	1.17	Quad 2-input NAND Buffer
38	.47	.35	1.17	Quad 2-input NAND Buffer (oc)
39	n.a	n.a	n.a	Quad 2-input NAND Buffer (oc,hv)
40	.29	n.a	.50	Dual 4-input NAND Buffer
42	.57	.56	n.a	BCD-to-Decimal Decoder
43	n.a	n.a	n.a	Excess-3-to-Decimal Decoder
44	n.a	n.a	n.a	Gray-to-Decimal Decoder
45	1.08	n.a	n.a	BCD-to-Decimal Decoder (oc)
46	1.08	n.a	n.a	BCD-to-7 segment Decoder (oc,hv)
47	.85	.88	n.a	BCD-to-7 segment Decoder (oc)
48	n.a	1.20	n.a	BCD-to-7 segment Decoder
49	n.a	n.a	n.a	BCD-to-7 segment Decoder (oc)
50	.28	n.a	n.a	Expandable Dual 2-wide, 2-input AND-OR-Invert gate
51	.37	.27	.46	Dual 2-wide, 2-input AND-OR-Invert
53	.37	n.a	n.a	Expandable 4-wide, 2-input AND-OR-Invert gate
54	.37	.27	n.a	4-wide, 2-input AND-OR-Invert
55	n.a	.30	n.a	2-wide, 4-input AND-OR-Invert
60	n.a	n.a	n.a	Dual 4-input Expander
70	n.a	n.a	n.a	JK positive ET F/F
72	.45	n.a	n.a	JK Master-Slave F/F
73	.46	.42	n.a	Dual JK Master-Slave F/F
74	.46	.40	.73	Dual type D positive ET F/F
75	.50	.45	n.a	4-bit bistable Latch
76	.49	.47	n.a	Dual JK Master-Slave F/F
77	n.a	n.a	n.a	Quad D-type Latch
78	n.a	.37	n.a	Dual JK F/F with Preset
80	n.a	n.a	n.a	Gated Full Adder
81	n.a	n.a	n.a	16-bit RAM
82	n.a	n.a	n.a	2-bit Full Adder
83	.61	.89	n.a	4-bit Binary Full Adder
84	1.75	n.a	n.a	16-bit RAM with Input Gating
85	.85	1.05	2.59	4-bit Magnitude Comparator
86	.50	.49	.95	Quad 2-input XOR
89	n.a	n.a	n.a	64-bit RAM
90	.41	.49	n.a	BCD Decade Counter
91	.54	1.10	n.a	8-bit Shift Register
92	.47	.59	n.a	Divide-by-12 Counter
93	.48	.59	n.a	Divide-by-16 Counter
94	.87	n.a	n.a	4-bit Shift Register
95	.70	.59	n.a	4-bit Left/Right Shift Reg.
96	.76	.74	n.a	5-bit Shift Register
97	2.40	n.a	n.a	Synchronous Modulo-64 Bit Rate Multiplier
100	1.75	n.a	n.a	Dual 4-bit Latch
104	.82	n.a	n.a	Gated JK Master-Slave F/F
105	n.a	n.a	n.a	Gated JK Master-Slave F/F
107	.55	.45	n.a	Dual JK F/F with Clear
109	.55	.47	n.a	Dual JK positive ET F/F with Preset and Clear
110	.58	n.a	n.a	JK Master-Slave F/F with Data Lockout
111	.74	n.a	n.a	Dual JK Master-Slave F/F with Data Lockout
112	n.a	.47	.93	Dual JK Negative ET F/F with Preset and Clear
113	n.a	n.a	n.a	Dual JK ET F/F with Preset
114	n.a	n.a	1.67	Dual Negative ET F/F with Preset, Common Clear & Clock
116	1.55	n.a	n.a	Dual 4-bit Latch with Clear
120	1.60	n.a	n.a	Dual Pulse Synchronizer/Driver
121	.60	n.a	n.a	Monostable Multivibrator
122	.67	.60	n.a	Retriggerable Monostable Multivibrator with Clear
123	.47	.75	n.a	Dual Retriggerable Monostable Multivibrator with Clear
124	n.a	n.a	3.29	Dual Voltage-Controlled Osc.
125	.61	.55	n.a	Quad 3-S Buffer
126	.61	.55	n.a	Quad 3-S Buffer
128	.90	n.a	n.a	50-Ohm Line Driver
132	.58	.51	1.59	Quad 2-input NAND (st)
133	n.a	1.25	.64	13-input NAND
134	n.a	n.a	.70	12-input NAND (3-S)
135	n.a	n.a	1.68	Quad XOR/XNOR
136	.65	.55	n.a	Quad 2-input XOR
138	n.a	.73	1.24	3-to-8 Line Decoder
139	n.a	.61	1.24	Dual 2-to-4 Line Decoder
140	n.a	n.a	.96	Dual 4-input NAND with 50 Ohm Line Driver Output
141	1.07	n.a	n.a	BCD-to-Decimal Decoder (Nixie)
142	3.75	n.a	n.a	Decade Counter/Decoder (Nixie)
143	4.45	n.a	n.a	4-bit Counter/Latch/7-segment Decoder
144	4.45	n.a	n.a	4-bit Counter/Latch/7-segment Decoder
145	.85	1.40	n.a	BCD-to-Decimal Decoder (oc)
147	1.60	2.55	n.a	BCD Priority Encoder
148	1.15	1.70	n.a	Octal Priority Encoder
150	1.62	n.a	n.a	1-of-16 Data Selector
151	.55	.54	1.29	1-of-8 Data Selector
152	n.a	n.a	n.a	1-of-8 Data Selector
153	.45	.45	1.24	Dual 1-of-4 Data Selector
154	1.65	2.25	n.a	4-to-16 line Decoder
155	.57	.85	n.a	Dual 2-to-4 line Decoder
156	n.a	.93	n.a	Dual 2-to-4 line Decoder (oc)
157	.60	.60	1.23	Quad 2-input Multiplexer
158	n.a	.60	1.23	Quad 2-input Inverting Multiplexer
159	1.97	n.a	n.a	4-to-16 line Decoder (oc)
160	.60	.90	n.a	Synchronous Presettable BCD Counter, Synchronous Reset
161	.80	.75	3.70	Synchronous Presettable Binary Counter, Synchronous Reset
162	.80	.93	4.79	Synchronous Presettable BCD Counter, Asynchronous Reset
163	.82	.74	4.59	Synchronous Presettable Binary Counter, Asynchronous Reset
164	.82	.74	n.a	Serial-in, Parallel-out Shift Register
165	.82	1.05	n.a	8-bit Parallel-to-Serial Converter
166	.85	1.99	n.a	8-bit Shift Register
167	n.a	n.a	n.a	Synchronous Decade Rate Multiplier
168	n.a	n.a	5.75	Synchronous Up/Down BCD Counter
169	n.a	n.a	5.80	Synchronous Up/Down Binary Counter
170	2.50	1.99	n.a	4-by-4 Register File (oc)
172	6.40	n.a	n.a	16-bit Multi-Port Reg. File (3-S)
173	1.00	.75	n.a	4-bit D-type Register (3-S)
174	.75	.50	1.25	Hex type D F/F
175	.75	.50	1.25	Quad type D F/F
176	.97	n.a	n.a	Presettable Decade Counter
177	n.a	n.a	n.a	Presettable Binary Counter
178	1.40	n.a	n.a	4-bit Shift Register
179	1.40	n.a	n.a	4-bit Shift Register
180	.95	n.a	n.a	4-bit Parity Generator/Checker
181	n.a	2.55	5.15	4-bit ALU
182	.60	n.a	2.20	Lokahead Carry Generator
183	n.a	n.a	n.a	Dual High-Speed Adder
184	3.00	n.a	n.a	BCD-to-Binary Converter
185	3.00	n.a	n.a	Binary-to-BCD Converter
186	n.a	n.a	n.a	64-by-8 PROM 50 nS (oc)
188	n.a	n.a	3.24	32-by-8 PROM (oc)
189	n.a	5.75	5.81	64-bit RAM (3-S)
190	.85	.94	n.a	Up/Down Decade Counter
191	.85	.92	n.a	Up/Down Binary Counter
192	.82	.82	n.a	Up/Down Decade Counter
193	.82	.82	2.18	Up/Down Binary Counter
194	.60	n.a	2.18	4-bit Bidirectional Shift Reg.
195	.99	1.13	n.a	Universal 4-bit Shift Reg.
196	.92	1.13	n.a	Presettable Decade Counter
197	1.80	n.a	n.a	Presettable Binary Counter
198	1.79	n.a	n.a	8-bit Left/Right Shift Reg.
199	n.a	n.a	7.60	8-bit Parallel I/O Shift Reg.
201	n.a	n.a	n.a	256-by-1 RAM (3-S)
207	n.a	n.a	n.a	256-by-4 RAM Common I/O (3-S)
208	n.a	n.a	n.a	256-by-4 RAM Separate I/O (3-S)
214	n.a	n.a	n.a	1K-by-1 RAM (3-S)
215	.88	1.15	n.a	1K-by-1 RAM Power-Down (3-S)
221	n.a	n.a	6.49	Dual Monostable Multivibrator
225	n.a	n.a	2.55	16-by-5 Asynchronous FIFO
226	n.a	1.10	3.82	(8226) 4-bit Bus Transceiver
240	n.a	1.10	3.82	Octal Inverting Bus/Line Driver
242	n.a	1.10	n.a	Quad Inverting Bus Transceiver
243	n.a	1.10	n.a	Quad True-Data Bus Transceiver
244	n.a	1.10	3.82	Octal Bus Driver
245	n.a	2.10	n.a	Octal Bus Transceiver
246	1.75	n.a	n.a	BCD-to-7 segment Decoder (oc,hv)
247	1.61	.99	n.a	BCD-to-7 segment Decoder (oc,hv)
248	n.a	1.40	n.a	BCD-to-7 segment Decoder
249	n.a	1.25	n.a	BCD-to-7 segment Decoder (oc)
251	.99	.70	1.54	1-of-8 Data Selector with True and Inverted Outputs (3-S)
253	n.a	.70	2.55	Dual 1-of-4 Data Selector (3-S)
257	n.a	.72	1.40	Quad 1-of-2 Data Selector (3-S)

abbreviations: (oc)=open-collector; (hv)=high-voltage outputs; (st)=Schmitt-trigger inputs; (3-S)=tri-state outputs; n.a=device or price not available at time of publication: call for up-to-date information.

TTL Continued

Suffix (nnn)	74nnn price	74LSnnn price	74Snnn price	Device Description
258	n.a	.72	1.40	Quad 2-input Multiplexer (3-S)
259	2.45	1.65	n.a	8-bit Addressable Latch
260	n.a	1.15	1.25	Dual 5-input NOR
261	n.a	n.a	n.a	2-by-4-bit Binary Multiplier
265	n.a	n.a	n.a	Quad Complimentary Output Element
266	n.a	.45	n.a	Quad 2-input X-NOR (oc)
273	2.50	1.20	n.a	Octal type D F/F with Clear
274	n.a	n.a	20.59	4-by-4 Binary Multiplier (3-S)
275	n.a	5.14	20.59	7-bit Slice Wallace Tree (3-S)
276	1.25	n.a	n.a	Quad JK F/F
278	2.99	n.a	n.a	4-bit Cascadable Priority Reg.
279	.75	.62	n.a	Quad Set/Reset Latch
280	n.a	1.95	2.59	9-bit Parity Generator/Checker
281	n.a	n.a	n.a	4-bit Parallel Binary Accumulator
283	1.25	.99	3.85	4-bit Binary Full Adder Fast Carry
284	n.a	n.a	n.a	4-by-4 bit Parallel Binary Multiplier
285	n.a	n.a	n.a	4-by-4 bit Parallel Binary Multiplier
287	n.a	n.a	n.a	256-by-4 PROM (3-S)
288	n.a	n.a	3.25	32-by-8 PROM (3-S)
289	n.a	n.a	n.a	16-by-4 RAM 12 nS (oc)
290	n.a	.94	n.a	BCD Decade COunter
293	.90	.45	n.a	Modulo-16 Binary Counter
295	n.a	n.a	n.a	4-bit Left/Right Shift Reg. (3-S)
298	1.05	1.15	n.a	Quad 2-Port Register
299	n.a	3.25	7.59	8-bit Universal Shift/Storage Reg.
301	n.a	n.a	n.a	256-bit RAM 13 nS (oc)
314	n.a	n.a	n.a	1K-by-1 RAM (oc)
315	n.a	n.a	n.a	1K-by-1 RAM Power Down (oc)
322	n.a	6.40	n.a	8-bit Universal Shift/Storage Register
323	n.a	6.40	n.a	8-bit Universal Shift/Storage Register (3-S)
324	n.a	3.20	n.a	VCO with 2-phase Outputs
325	n.a	n.a	n.a	VCO with 2-phase Outputs
326	n.a	n.a	n.a	VCO with 2-phase outputs
327	n.a	n.a	n.a	VCO with single-phase Output
330	n.a	n.a	n.a	12-in, 6-out, 50-term FPLA
331	n.a	n.a	n.a	12-in, 6-out, 50-term FPLA
347	n.a	n.a	n.a	BCD-to-7 segment Decoder (oc,hv)
348	n.a	3.44	n.a	Octal Priority Encoder (3-S)
351	2.85	n.a	n.a	Dual Data Selector (3-S)
352	n.a	1.75	n.a	Dual Inverting 4-input Multiplexer
353	n.a	2.15	n.a	Dual Inverting 4-input Multiplexer (3-S)
362	n.a	12.90	n.a	(TMS9904) 4-Phase Clock Generator
365	.73	.67	n.a	Hex True Data Bus Driver
366	.85	.67	n.a	Hex Inverting Bus Driver
367	.75	.67	n.a	Hex True Data Bus Driver
368	.75	.67	n.a	Hex Inverting Bus Driver
373	n.a	1.60	3.85	Octal Transparent Latch (3-S)
374	n.a	1.60	3.85	Octal Type D F/F (3-S)
375	n.a	.82	n.a	4-bit Bistable Latch
376	n.a	n.a	n.a	Quad JK F/F Common Clear and Clock
377	n.a	1.60	n.a	Octal Type D F/F Common Enable and Clock
378	n.a	1.27	n.a	Hex type D F/F Common Enable and Clock
379	n.a	1.40	n.a	Quad type D F/F Common Enable and Clock
381	n.a	n.a	7.72	4-bit ALU/Function Generator
385	n.a	n.a	n.a	4-bit Adder/Subtracter
386	n.a	n.a	n.a	Quad 2-input XOR
387	n.a	n.a	n.a	256-by-4 PROM (oc)
390	1.25	1.25	n.a	Dual Decade Counter
393	1.65	1.25	n.a	Dual 4-bit Binary Counter
395	n.a	1.54	n.a	4-bit Cascadable Shift Reg. (3-S)
396	n.a	n.a	n.a	8-bit Storage Register
398	n.a	n.a	n.a	Quad type D F/F with Latch
399	n.a	n.a	n.a	Quad 2-input Multiplexer with Storage
412	n.a	n.a	3.85	(8212) Multimode Buffered Latch
424	n.a	n.a	n.a	8080A Clock Driver
428	n.a	n.a	n.a	(8228) System Controller and Bus Driver for 8080A
445	n.a	n.a	n.a	BCD-to-7 segment Decoder (hv)
447	n.a	1.12	n.a	BCD-to-7 segment Decoder (oc,hv)
470	n.a	n.a	n.a	256-by-8 PROM (oc)
471	n.a	n.a	8.35	256-by-8 PROM (3-S)
472	n.a	n.a	12.50	512-by-8 PROM 55 nS (3-S)
473	n.a	n.a	n.a	512-by-8 PROM 55 nS (oc)
474	n.a	n.a	12.50	512-by-8 PROM (3-S)
629	n.a	n.a	n.a	Supersedes 74LS124

9000 Series

9368	2.89	Hex Decoder/Driver Com. Cathode
9370	11.95	Hex Decoder/Driver Com. Anode
9602	1.49	Dual Retriggerable Oneshot

abbreviations: (oc)=open-collector; (hv)=high-voltage outputs; (st)=Schmitt-trigger inputs; (3-S)=tri-state outputs; n.a=device or price not available at time of publication: call for up-to-date information.

CMOS Digital Logic

part	price	description
4000	.40	Dual 3-input NOR plus Inverter
4001	.36	Quad 2-input NOR
4002	.36	Dual 4-input NOR
4006	1.38	18-stage Static Shift Register
4007	.45	Dual Complimentary pairs plus Inverters
4008	1.27	4-bit Full Adder
4009	.78	Hex Inverting Buffer/Converter
4010	.83	Hex True Data Buffer/Converter
4011	.43	Quad 2-input NAND
4012	.40	Dual 4-input NAND
4013	.57	Dual type D ET F/F
4014	1.13	8-bit Static Shift Register
4015	1.13	Dual 4-bit Static Shift Reg.
4016	.70	Quad Bilateral Switch
4017	1.28	Decimal-decoded Decade Counter
4018	1.09	Presettable divide-by-n Counter
4019	1.18	Quad 1-of-2 Data Selector
4020	1.42	14-stage Ripple Counter
4021	1.21	8-bit Static Shift Register
4022	1.41	Divide-by-8 Counter/Divider
4023	.38	Triple 3-input NAND
4024	.98	7-stage Binary Counter
4025	.38	Triple 3-input NOR
4026	2.32	Decade Counter/Divider
4027	.71	Dual JK F/F
4028	1.18	BCD-to-Decimal Decoder
4029	1.27	Presettable Up/Down Binary/Decade Counter
4030	.95	Quad XOR
4033	1.55	Decade Counter/Divider
4034	3.65	8-bit Universal Bus Register
4035	1.88	4-stage Parallel-in/Parallel-out Shift Register
4040	1.40	12-stage Binary Ripple Counter
4041	1.58	Quad True/Complimemt Buffer
4042	1.13	Quad type D latch
4043	1.45	Quad NOR S/R latch (3-S)
4044	1.25	Quad NAND S/R latch (3-S)
4046	1.48	Phase-Locked Loop
4047	1.34	Monostable/Astable Multivibrator
4049	.60	Hex Inverting Buffer/Converter
4050	.70	Hex True Data Buffer/Converter
4051	1.37	8-channel Analog Mux/Demux
4052	1.39	Dual 4-channel Analog Mux/Demux
4060	1.39	14-stage Binary Counter/Oscillator
4053	1.83	Triple 2-channel Analog Mux/Demux
4066	.96	Quad Bilateral Switch
4067	4.95	16-channel Analog Mux/Demux
4068	.47	8-input NAND
4069	.41	Hex Inverter
4070	.43	Quad 2-input XOR
4071	.42	Quad 2-input OR
4072	.35	Dual 4-input OR
4073	.81	Triple 3-input AND
4075	.43	Triple 3-input OR
4076	1.33	4-bit type D Register
4077	.63	Quad X-NOR
4078	.47	8-input NOR
4081	.37	Quad 2-input AND
4082	.34	Dual 4-input AND
4085	.92	Dual 2-wide 2-input AND/OR/Invert gate
4086	1.30	Expandable 4-wide 2-input AND/OR/Invert
4093	.74	Quad 2-input NAND (st)
4104	3.29	Quad Level Converter (3-S)
4502	2.00	Strobed Hex Inverter/Buffer
4507	1.35	Quad XOR
4508	3.25	Dual 4-bit Latch (3-S)
4510	1.32	BCD Up/Down Counter
4511	1.37	BCD-to-7 segment Latch/Decoder
4512	1.34	8-channel Data Selector (3-S)
4514	3.07	1-of-16 Data Selector
4515	3.38	1-of-16 Data Selector
4516	1.67	Binary Up/Down Counter
4518	1.69	Dual BCD Up Counter
4519	.84	Quad 1-of-2 Data Selector
4520	1.24	Dual Binary Up Counter
4522	1.57	BCD divide-by-n Counter
4526	1.80	4-bit Binary Divide-by-n Counter
4527	1.63	BCD Rate Multiplier
4528	1.45	Dual Retriggerable/Resettable Monostable Multivibrator
4531	1.91	12-bit Parity Generator/Checker
4532	1.80	8-bit Priority Encoder
4539	1.32	Dual 4-channel Mux
4543	2.06	BCD-to-7 segment Latch/Decoder/Driver for LCD Displays
4553	3.91	3-digit BCD Counter
4555	1.23	Dual 2-to-4 line Decoder
4556	1.01	Dual 2-to-4 line Decoder
4581	3.82	4-bit ALU
4582	1.43	Lookahead Carry Generator
4584	.85	Hex Schmitt Trigger
4702	11.59	Programmable Baud Rate Gen.
4703	15.10	FIFO Buffer
4704	*	Data Path Switch
4705	*	Arithmetic Logic Register Stack
4706	*	16-by-4 Program Stack
4707	*	Data Access Register
4710	1.10	Register-Oriented 16-by-4 RAM (3-S)
4720	10.55	256-bit RAM (3-S)
4721	*	256-by-4 RAM
4723	2.35	Dual 4-bit Addressable Latch
4724	2.45	8-bit Addressable Latch
4725	5.85	16-by-4 RAM (3-S)
4727	1.65	7-Stage Counter
4731	15.85	Quad 64-bit Static Shift Reg.
40014	1.49	(47C14) Hex Schmitt Trigger
40020	.59	(74C20) Dual 4-input NAND
40074	.91	(74C74) Dual type D F/F
40076	.47	(74C76) Dual JK F/F
40085	2.40	(74C85) 4-bit Magnitude Comparator
40097	1.13	(74C97) Hex True Data Buffer (3-S)
40098	1.13	(74C98) Hex Inverting Buffer (3-S)
40107	.39	(74C107) Dual JK F/F
40151	1.39	(74C151) 8-bit Data Selector
40160	1.59	(74C160) Asynchronous Decade Resettable Counter
40161	2.21	(74C161) Asynchronous Binary Resettable Counter
40162	1.59	(74C162) Synchronous Decade Resettable Counter
40163	1.59	(74C163) Synchronous Binary Resettable Counter
40174	1.48	(74C174) Hex type D F/F
40175	1.46	(74C175) Quad type D F/F
40192	2.25	(74C192) Synchronous Up/Down Decade Counter
40193	2.25	(74C193) Synchronous Up/Down 4-bit Binary Counter
40194	1.75	(74C194) 4-bit Universal Left/Right Shift Reg.
40195	1.75	(74C195) 4-bit Shift Reg.

* price unavailable or subject to fluctuation at press time. Call for up-to-date info.

Rectifier Diodes

Device	price	PIV (volts)	$I_{(max)}$ (amps)
1N4001	.05	50	1
1N4002	.06	100	1
1N4003	.065	200	1
1N4004	.07	400	1
1N4005	.075	600	1
1N4006	.08	800	1
1N4007	.09	1000	1
1N5400	.15	50	3
1N5401	.17	100	3
1N5402	.19	200	3
1N5403	.20	300	3
1N5404	.21	400	3
1N5405	.26	500	3
1N5406	.29	600	3
1N5408	.38	1000	3
MR750/P600A	.81	50	6
MR751/P600B	.85	100	6
MR752/P600D	.89	200	6
MR754/P600G	.95	400	6
MR756/P600J	1.35	600	6
MR758/P600K	1.58	800	6
MR760/P600M	2.10	1000	6

Bridge Rectifiers

Catalog number

BR-iii/vvv

vvv = Peak Inverse Voltage
= 50 for 50 Volts (lower price)
= 200 for 200 Volts (higher price

ii = max. forward current
= 01 for 1 Amp (.30/.40)
= 04 for 4 Amp (.90/1.00)
= 10 for 10 Amp (1.65/1.85)
= 25 for 25 Amp (1.95/2.25)
= 35 for 35 Amp (600V=3.50)

Example: BR-04/50 = 4 Amp, 50 Volts

This ordering sytem is for "generic" rectifiers. Please contact Exceltronix for price and availability of specific manufacturers, case style etc.

Signal Diodes

1N34A	.10	60 PIV, 5 mA Ge signal
1N914	.05	100 PIV, 4 nS Si switching
1N4148	.05	100 PIV, 4 nS Si switching

SCRs and Triacs

2N5061	.20	SCR	800mA	60V	I_{gt}=200µA
2N5062	.25	SCR	800mA	100V	I_{gt}=200µA
2N5063	.30	SCR	800mA	150V	I_{gt}=200µA
2N5064	.35	SCR	800mA	200V	I_{gt}=200µA
TIC106B	.45	SCR	5 Amp	200V	
TIC106D	.50	SCR	5 Amp	400V	
TIC116B	1.20	SCR	8 Amp	200V	
TIC116D	1.29	SCR	8 Amp	400V	
TIC126B	1.55	SCR	12 Amp	200V	
TIC126D	1.65	SCR	12 Amp	400V	
TIC206B	1.05	Triac	3 Amp	200V	
TIC206D	1.20	Triac	3 Amp	400V	
TIC216B	1.29	Triac	6 Amp	200V	
TIC216D	1.39	Triac	6 Amp	400V	
TIC236B	1.55	Triac	12 Amp	200V	
TIC236D	1.75	Triac	12 Amp	400V	
TIC263B	2.75	Triac	25 Amp	200V	
TIC263D	2.90	Triac	25 Amp	400V	

Transistors

device	price	pol.	mat'l	BV_{ceo}	I_{cmax}	f_t or P_{diss}	h_{FE}	case
2N697	.38	NPN	Si	60V	1A	100MHz	120 max.	TO-5
2N706	.24	NPN	Si	25V	200mA	400MHz	60 max.	TO-18
2N720	.50	NPN	Si	120V	1A	50MHz	100 typ.	TO-18
2N760	.18	NPN	Si	45V	100mA	50MHz	100 typ.	TO-18
2N915	.36	NPN	Si	50V	n.a.	250MHz	250 max.	TO-18
2N918	.44	NPN	Si	15V	50mA	500MHz	40 max.	TO-72
2N930	.30	NPN	Si	45V	30mA	30MHz	600 max.	TO-18
2N964	.23	PNP	Ge	7V	300mA	300MHz	20 typ.	TO-18
2N1040	.50	PNP	Ge	50V	3A	20W	200 max.	TO-5
2N1303	.50	PNP	Ge	25V	300mA	3MHz	50 typ.	TO-5
2N1304	.86	NPN	Ge	25V	300mA	5MHz	70 typ.	TO-5
2N1379	.18	PNP	Ge	25V	200mA	n.a.	200 typ.	TO-5
2N1893	.51	NPN	Si	120V	500mA	50MHz	35 max.	TO-5
2N2102	.51	NPN	Si	65V	1A	60MHz	120 max.	TO-5
2N2219A	.43	NPN	Si	40V	800mA	250MHz	300 max.	TO-5
2N2221A	.45	NPN	Si	40V	800mA	250MHz	120 max.	TO-18
2N2222A	.33	NPN	Si	40V	800mA	300MHz	300 max.	TO-18
2N2239	.39	NPN	Si	40V	1A	n.a.	30 min.	TO-37
2N2270	.57	NPN	Si	45V	1A	100MHz	200 max.	TO-5
2N2369A	.26	NPN	Si	15V	200mA	500MHz	120 max.	TO-18
2N2428	.15	PNP	Ge	12V	100mA	1.2MHz	130 max.	TO-1
2N2432A	.26	NPN	Si	45V	100mA	20MHz	50 min.	TO-18
2N2483	.17	NPN	Si	60V	50mA	60MHz	120 max.	TO-18
2N2484	.29	NPN	Si	60V	50mA	60MHz	500 max.	TO-18
2N2614	.35	PNP	Ge	40V	50mA	4MHz	110 typ.	TO-1
2N2641	.85	2×NPN	Si	45V	30mA	30MHz	300 max.	TO-99
2N2646	.73	UJT	Si	30V	2A	n.a.	η=0.75 max.	TO-18
2N2647	.65	UJT	Si	30V	2A	n.a.	η=0.82 max.	TO-18
2N2904	.32	PNP	Si	40V	600mA	200MHz	120 max.	TO-5
2N2905	.44	PNP	Si	40V	600mA	200MHz	300 max.	TO-5
2N2906	.23	PNP	Si	40V	600mA	200MHz	120 max.	TO-18
2N2907A	.34	PNP	Si	40V	600mA	200MHz	300 max.	TO-18
2N2920	.50	2×NPN	Si	60V	30mA	60MHz	600 max.	TO-99
2N2983	.50	NPN	Si	60V	700mA	60MHz	250 max.	TO-5
2N3014	.20	NPN	Si	20V	200mA	350MHz	120 max.	TO-52
2N3019	.51	NPN	Si	80V	1A	100MHz	300 max.	TO-5
2N3053	.40	NPN	Si	40V	700mA	100MHz	250 max.	TO-5
2N3054	1.15	NPN	Si	55V	4A	25W	100 max.	TO-66
2N3055	.95	NPN	Si	60V	15A	115W	70 max.	TO-3
2N3117	.60	NPN	Si	60V	50mA	60MHz	900 max.	TO-18
2N3227	.22	NPN	Si	20V	500mA	500MHz	300 max.	TO-18
2N3250	.18	PNP	Si	40V	200mA	250MHz	150 max.	TO-18
2N3391A	.19	NPN	Si	25V	100mA	90MHz	375 typ.	TO-98
2N3394	.19	NPN	Si	25V	100mA	80MHz	82 typ.	TO-98
2N3415	.21	NPN	Si	25V	500mA	n.a.	360 typ.	TO-98
2N3440	.92	NPN	Si	250V	1A	10W	80 typ.	TO-5
2N3442	1.77	NPN	Si	140V	10A	115W	38 typ.	TO-3
2N3565	.19	NPN	Si	25V	50mA	40MHz	300 typ.	TO-106
2N3566	.26	NPN	Si	30V	50mA	40MHz	300 typ.	TO-105
2N3567	.20	NPN	Si	40V	500mA	60MHz	70 typ.	TO-105
2N3568	.24	NPN	Si	60V	500mA	60MHz	70 typ.	TO-105
2N3569	.26	NPN	Si	40V	500mA	60MHz	175 typ.	TO-105
2N3638A	.26	PNP	Si	25V	500mA	150MHz	130 typ.	TO-105
2N3641	.20	NPN	Si	30V	500mA	150MHz	70 typ.	TO-105
2N3642	.20	NPN	Si	45V	500mA	150MHz	70 typ.	TO-105
2N3643	.26	NPN	Si	30V	500mA	250MHz	140 typ.	TO-105
2N3644	.26	PNP	Si	45V	500mA	200MHz	140 typ.	TO-105
2N3645	.20	PNP	Si	60V	500mA	200MHz	140 typ.	TO-105
2N3703	.19	PNP	Si	30V	200mA	100MHz	75 typ.	TO-92
2N3704	.19	NPN	Si	30V	800mA	100MHz	300 max.	TO-92
2N3705	.14	NPN	Si	30V	800mA	100MHz	150 max.	TO-92
2N3725	.60	NPN	Si	50V	1A	250MHz	150 max.	TO-5
2N3773	3.85	NPN	Si	140V	30A	150W	30 typ.	TO-3
2N3819	.39	N-JFet	Si	25V	10mA	n.a.	y_{fs}= 6500µΩ^{-1}	TO-92
2N3820	.36	P-JFet	Si	20V	10mA	n.a.	y_{fs}= 5000µΩ^{-1}	TO-92
2N3904	.13	NPN	Si	40V	200mA	300MHz	160 typ.	TO-92
2N3905	.13	PNP	Si	40V	200mA	200MHz	100 typ.	TO-92
2N3906	.13	PNP	Si	40V	200mA	250MHz	160 typ.	TO-92
2N3947	.25	NPN	Si	40V	200mA	300MHz	160 typ.	TO-18

device	price	pol.	mat'l	BV_{ceo}	I_{cmax}	f_t or P_{diss}	h_{FE}	case
2N4036	.85	PNP	Si	65V	1A	7W	76 typ.	TO-5
2N4037	.76	PNP	Si	40V	1A	60MHz	110 typ.	TO-5
2N4062	.23	PNP	Si	30V	30mA	n.a.	170 typ.	TO-92
2N4112	2.50	NPN	Si	60V	5A	30W	140 typ.	TO-3
2N4123	.12	NPN	Si	30V	200mA	250MHz	150 max.	TO-92
2N4124	.12	NPN	Si	25V	200mA	300MHz	360 max.	TO-92
2N4125	.12	PNP	Si	30V	200mA	200MHz	150 max.	TO-92
2N4126	.12	PNP	Si	25V	200mA	250MHz	360 max.	TO-92
2N4208	.33	PNP	Si	12V	50mA	700MHz	60 typ.	TO-18
2N4222	.99	N-JFet	Si	30V	15mA	n.a.	y_{fs} = 6mΩ^{-1}	TO-72
2N4248	.23	PNP	Si	40V	100mA	40MHz	1000 max.	TO-106
2N4250	.18	PNP	Si	40V	100mA	50MHz	800 max.	TO-106
2N4339	.50	N-JFet	Si	50V	15mA	n.a.	y_{fs} = 800µΩ^{-1}	TO-18
2N4400	.13	NPN	Si	40V	600mA	200MHz	150 max.	TO-92
2N4401	.16	NPN	Si	40V	600mA	250MHz	300 max.	TO-92
2N4402	.13	PNP	Si	40V	600mA	150MHz	150 max.	TO-92
2N4403	.13	PNP	Si	40V	600mA	200MHz	300 max.	TO-92
2N4416	.74	N-JFet	Si	30V	10mA	n.a.	y_{fs} = 4mΩ^{-1}	TO-72
2N4853	.30	UJT	Si	30V	50mA	n.a.	η=0.85 max.	TO-18
2N4856	.39	N-JFet	Si	40V	50mA	n.a.	R_{ds}=25Ω	TO-18
2N4871	.67	UJT	Si	35V	1.5A	n.a.	η=0.85 max.	TO-92
2N4891	.62	UJT	Si	30V	1A	n.a.	η=0.82 max.	TO-92
2N4901	1.30	PNP	Si	40V	5A	80W	20 min.	TO-3
2N4904	1.35	PNP	Si	40V	5A	80W	40 min.	TO-3
2N4916	.30	PNP	Si	30V	100mA	400MHz	150 typ.	TO-106
2N5086	.18	PNP	Si	50V	50mA	40MHz	500 max.	TO-92
2N5087	.18	PNP	Si	50V	50mA	40MHz	800 max.	TO-92
2N5088	.18	NPN	Si	30V	50mA	50MHz	900 max.	TO-92
2N5089	.18	NPN	Si	25V	50mA	50MHz	1200 max.	TO-92
2N5128	.16	NPN	Si	12V	100mA	100MHz	75 typ.	TO-105
2N5129	.12	NPN	Si	12V	100mA	150MHz	75 typ.	TO-105
2N5135	.12	NPN	Si	25V	100mA	40MHz	400 typ.	TO-105
2N5136	.12	NPN	Si	20V	100mA	40MHz	100 typ.	TO-105
2N5142	.14	PNP	Si	20V	500mA	100MHz	50 typ.	TO-105
2N5143	.16	PNP	Si	20V	500mA	100MHz	50 typ.	TO-106
2N5172	.13	NPN	Si	25V	100mA	120MHz	500 max.	TO-92
2N5195	.50	PNP	Si	80V	4A	40W	80 max.	77-03
2N5210	.19	NPN	Si	50V	50mA	30MHz	600 max.	TO-92
2N5232A	.17	NPN	Si	50V	100mA	n.a.	375 typ.	TO-98
2N5245	.47	N-JFet	Si	30V	50mA	n.a.	y_{fs}= 8mΩ^{-1}	TO-92
2N5307	.20	NPN§	Si	40V	200mA	60MHz	2000 min.	TO-92
2N5356	.45	PNP	Si	25V	300mA	250MHz	375 typ.	TO-98
2N5369	.26	NPN	Si	30V	500mA	250MHz	175 typ.	TO-92
2N5400	.24	PNP	Si	120V	600mA	100MHz	180 max.	TO-92
2N5401	.28	PNP	Si	150V	600mA	100MHz	240 max.	TO-92
2N5415	1.29	PNP	Si	200V	1A	15MHz	68 typ.	TO-5
2N5447	.24	PNP	Si	25V	200mA	500MHz	300 max.	TO-92
2N5457	.75	N-JFet	Si	25V	10mA	n.a.	y = 5000µΩ^{-1}	TO-92
2N5458	.75	N-JFet	Si	25V	10mA	n.a.	y = 5500µΩ^{-1}	TO-92
2N5459	.75	N-JFet	Si	25V	10ma	n.a.	y = 6000µΩ^{-1}	TO-92
2N5485	.35	N-JFet	Si	25V	30mA	n.a.	y = 7000µΩ^{-1}	TO-92
2N5525	.40	NPN§	Si	40V	220mA	200MHz	5000 min.	TO-92
2N5550	.22	NPN	Si	140V	600mA	100MHz	250 max.	TO-92
2N5770	.20	NPN	Si	12V	50mA	900MHz	40 min.	TO-92
2N5771	.22	PNP	Si	15V	50mA	850MHz	35 min.	TO-92
2N5772	.22	NPN	Si	15V	300mA	350MHz	30 min.	TO-92
2N5881	2.15	NPN	Si	60V	15A	160W	20 min.	TO-3
2N5962	.45	NPN	Si	45V	50mA	100MHz	450 min.	TO-92
2N6027	.34	PUT	Si	40V	150mA	n.a.	n.a.	TO-92
2N6028	.34	PUT	Si	40V	150V	n.a.	n.a.	TO-92
2N6059	3.95	NPN§	Si	100V	12A	150W	18000 max.	TO-3
2N6657	7.25	N-VFet	Si	60V	2A	25W	R_{ds}=3Ω	TO-3
2N6658	9.40	N-VFet	Si	90V	2A	25W	R_{ds}=4Ω	TO-3
MJ802	4.50	NPN	Si	90V	30A	200W	100 max.	TO-3
MJ2955	1.75	PNP	Si	60V	15A	150W	70 max.	TO-3
MJ3701	.50	PNP	Si	40V	1A	25W	100 max.	TO-66
MJ4502	4.75	PNP	Si	90V	30A	200W	100 max.	TO-3
MJE340	3.85	NPN	Si	300V	500mA	20W	240 max.	77-03
MJE520	3.25	NPN	Si	30V	3A	25W	25 min.	77-03
MJE702	2.65	PNP§	Si	80V	4A	40W	750 min.	77-03
MJE802	2.25	NPN§	Si	80V	4A	40W	750 min.	77-03

Transistors Cont.

device	price	pol.	mat'l	BV_{ceo}	$I_{c max}$	f_t or P_{diss}	h_{FE}	case
MJE1093	3.65	PNP§	Si	80V	5A	70W	750 min.	90-05
MJE1102	2.95	NPN§	Si	80V	5A	70W	750 min.	90-05
MJE1103	2.95	NPN§	Si	80V	5A	70W	750 min.	90-05
MPF102	.50	N-JFet	Si	25V	10mA	n.a.	y_{fs}= 7500$\mu\Omega^{-1}$	TO-92
MPF105	.50	N-JFet	Si	25V	16mA	n.a.	y_{fs}= 2000$\mu\Omega^{-1}$	TO-92
MPS5172	.17	NPN	Si	25V	100mA	120MHz	500 max.	TO-92
MPS6514	.30	NPN	Si	25V	100mA	390MHz	300 max.	TO-92
MPS6515	.45	NPN	Si	25V	100mA	390MHz	500 max.	TO-92
MPS6516	.35	PNP	Si	40V	100mA	270MHz	100 max.	TO-92
MPS6519	.45	PNP	Si	25V	100mA	420MHz	500 max.	TO-92
MPSA05	.30	NPN	Si	60V	500mA	100MHz	50 min.	TO-92
MPSA06	.21	NPN	Si	60V	500mA	100MHz	50 min.	TO-92
MPSA09	.20	NPN	Si	50V	50mA	80MHz	600 max.	TO-92
MPSA13	.21	NPN§	Si	30V	500mA	125MHz	10000 min.	TO-92
MPSA14	.26	NPN§	Si	30V	500mA	125MHz	20000 min.	TO-92
MPSA18	.22	NPN	Si	45V	200mA	100MHz	1500 max.	TO-92
MPSA20	.25	NPN	Si	40V	100mA	125MHz	400 typ.	TO-92
MPSA42	.25	NPN	Si	300V	500mA	50MHz	40 min.	TO-92
MPSA43	.25	NPN	Si	200V	500mA	50MHz	50 min.	TO-92
MPSA55	.21	PNP	Si	80V	500mA	100MHz	50 min.	TO-92
MPSA56	.20	PNP	Si	80V	500mA	100MHz	50 min.	TO-92
MPSA65	.20	PNP§	Si	30V	300mA	175MHz	20000 min.	TO-92
MPSA70	.17	PNP	Si	40V	100mA	125MHz	400 typ.	TO-92
MPSA92	.28	PNP	Si	300V	500mA	50MHz	25 min.	TO-92
MPSU05	1.00	NPN	Si	60V	2A	150MHz	125 max.	152-02
MPSU06	1.25	NPN	Si	80V	2A	150MHz	125 max.	152-02
MPSU10	1.50	NPN	Si	300V	500mA	60MHz	25 min.	152-02
MPSU55	1.00	PNP	Si	60V	2A	100MHz	160 typ.	152-02
MPSU56	1.25	PNP	Si	80V	2A	100MHz	160 typ.	152-02
MPSU60	1.50	PNP	Si	300V	500mA	60MHz	25 min.	152-02
PN2222A	.20	Electrically identical to 2N2222A						TO-92
TIP29B	.59	NPN	Si	80V	1A	30W	40 min.	TO-220
TIP29C	.61	NPN	Si	100V	1A	30W	40 min.	TO-220
TIP30A	.58	PNP	Si	60V	1A	30W	40 min.	TO-220
TIP30B	.60	PNP	Si	80V	1A	30W	40 min.	TO-220
TIP30C	.61	PNP	Si	100V	1A	30W	40 min.	TO-220
TIP31A	.65	NPN	Si	60V	3A	40W	25 min.	TO-220
TIP31B	.67	NPN	Si	80V	3A	40W	25 min.	TO-220
TIP31C	.71	NPN	Si	100V	3A	40W	25 min.	TO-220
TIP32	.70	PNP	Si	40V	3A	40W	25 min.	TO-220
TIP32B	.71	PNP	Si	80V	3A	40W	25 min.	TO-220
TIP32C	.77	PNP	Si	100V	3A	40W	25 min.	TO-220
TIP33C	1.29	NPN	Si	100V	10A	80W	100 max.	CP-3
TIP34B	1.45	PNP	Si	80V	10A	80W	100 max.	CP-3
TIP34C	1.57	PNP	Si	100V	10A	80W	100 max.	CP-3
TIP35A	2.10	NPN	Si	60V	25A	125W	50 max.	CP-3
TIP35B	2.65	NPN	Si	80V	25A	125W	50 max.	CP-3
TIP35C	2.96	NPN	Si	100V	25A	125W	50 max.	CP-3
TIP36C	3.05	PNP	Si	100V	25A	125W	50 max.	CP-3
TIP41A	.85	NPN	Si	60V	6A	65W	75 max.	TO-220
TIP41B	.91	NPN	Si	80V	6A	65W	75 max.	TO-220
TIP41C	.95	NPN	Si	100V	6A	65W	75 max.	TO-220
TIP42C	.98	PNP	Si	100V	6A	65W	75 max.	TO-220
TIP47	.75	NPN	Si	250V	1A	40W	25 min.	TO-220
TIP48	.86	NPN	Si	300V	1A	40W	25 min.	TO-220
TIP49	.91	NPN	Si	350V	1A	40W	25 min.	TO-220
TIP50	1.03	NPN	Si	400V	1A	40W	25 min.	TO-220
TIP110	.90	NPN§	Si	60V	2A	50W	500 min.	TO-220
TIP111	.95	NPN§	Si	80V	2A	50W	500 min.	TO-220
TIP115	.91	PNP§	Si	60V	2A	50W	500 min.	TO-220
TIP120	.86	NPN§	Si	60V	5A	65W	1000 min.	TO-220
TIP121	.99	NPN§	Si	80V	5A	65W	1000 min.	TO-220
TIP122	1.07	NPN§	Si	100V	5A	65W	1000 min.	TO-220
TIP125	.98	PNP§	Si	60V	5A	65W	1000 min.	TO-220
TIP127	1.19	PNP§	Si	100V	5A	65W	1000 min.	TO-220
TIP140	2.22	NPN§	Si	60V	10A	125W	500 min.	CP-3
TIP141	2.46	NPN§	Si	80V	10A	125W	500 min.	CP-3
TIP142	2.93	NPN§	Si	100V	10A	125W	500 min.	CP-3
TIP146	2.80	PNP	Si	80V	10A	125W	500 min.	CP-3
TIP2955	1.17	PNP	Si	60V	15A	90W	15 min.	CP-3
TIP3055	.98	NPN	Si	60V	15A	90W	15 min.	CP-3
TIS43	.66	UJT	Si	30V	50mA	n.a.	η=0.82 max.	TO-92
TIS58	.37	N-JFet	Si	25V	10mA	n.a.	y_{fs}= 4000$\mu\Omega^{-1}$	TO-92
TIS59	.37	N-JFet	Si	25V	10mA	n.a.	y_{fs}= 4800$\mu\Omega^{-1}$	TO-92
TIS62	.29	NPN	Si	12V	30mA	500MHz	30 min.	TO-92
TIS73	.53	N-JFet	Si	30V	50mA	n.a.	R_{ds}≈25Ω	TO-92
TIS74	.42	N-JFet	Si	30V	50mA	n.a.	R_{ds}=40Ω	TO-92
TIS75	.42	N-JFet	Si	30V	50mA	n.a.	R_{ds}=60Ω	TO-92
TIS84	.34	NPN	Si	30V	50mA	100MHz	45 typ.	TO-92
TIS86	.43	NPN	Si	30V	50mA	500MHz	200 max.	TO-92
TIS87	.48	NPN	Si	45V	50mA	500MHa	150 max.	TO-92

ABBREVIATIONS:
η = Intrinsic Standoff Ratio
y_{fs}= Small-signal Common-source Forward Transfer Admittance
R_{ds}= Small-signal Drain-source On-state Resistance
§ = Darlington-type Transistor
Ω^{-1}= Reciprocal Ohms or Mhos

DIPPED TANTALUM CAPACITOR

CAPAC	WV	UNIT	CAPAC	WV	UNIT	CAPAC	WV	UNIT
.15	50	.35	3.3	16	.35	15	16	.42
.22	35	.30	3.3	20	.37	15	25	.50
.22	50	.35	3.3	25	.39	22	3	.36
.33	35	.30	3.3	50	.45	22	6.3	.38
.33	50	.36	4.7	50	.51	22	16	.45
.47	50	.38	6.8	6.3	.58	22	25	1.04
.68	35	.35	6.8	10	.79	33	3	.38
.68	50	.39	6.8	16	1.38	33	10	.45
1.0	35	.35	6.8	50	2.63	47	3	.40
1.0	50	.39	10	3	.35	47	6.3	.45
1.5	20	.33	10	16	.14	47	16	1.20
1.5	50	.42	10	20	.45	68	6.3	.45
2.2	20	.35	10	25	.47	68	10	1.04
2.2	25	.37	10	35	.50	100	3	.57
			15	10	.38	100	6.3	1.04
						100	10	1.38
						150	6.3	1.38
						220	6.3	1.73

Infra-red Devices

TIL32	.50	Infrared-emitting LED
TIL78	.40	Infrared phototransistor, complimentary to TIL32
TIL138	2.25	IR source/sensor array for transmissive sensing
TIL139	2.25	IR source/sensor array for reflective sensing

Opto-Isolators

ILCT6/MCT6	1.65	Dual Phototransistor Opto-isolator,30V,8-pin DIP
4N26	.70	Single Phototransistor Opto-isolator,30V,6-pin DIP
4N27	.70	Single Phototransistor Opto-isolator,30V,6-pin DIP
4N30	.85	Single Photodarlington Opto-isolator,30V,6-pin DIP
4N33	.85	Single Photodarlington Opto-isolator,30V,6-pin DIP

7 Segment Displays

TIL312	1.75	0.3" ht, com. anode, 0.3" lead spacing, left/right dec
TIL313	1.75	0.3" ht, com. cathode, 0.3" lead spacing, right decimal
FND500	1.85	0.5" ht, com. cathode, 0.6" lead spacing, right decimal
FND507	1.85	0.5" ht, com. anode, 0.6" lead spacing, right decimal
DL704	1.75	0.3" ht, com. cathode, 0.3" lead spacing, right decimal
DL707	1.75	0.3" ht, com. anode, 0.3" lead spacing, left decimal

This is only a partial listing of the 7-segment displays we carry. Many other types including half-digits are available. Please contact Exceltronix about your specific requirements.

Fixed Resistors

¼W and ½W ±5% carbon-film resistors are available in values from 1.0Ω to 10MΩ, in multiples of the following

1.0 1.1 1.2 1.3 1.5 1.6 1.8 2.0 2.2 2.4 2.7 3.0
3.3 3.6 3.9 4.3 4.7 5.1 5.6 6.2 6.8 7.5 8.2 9.1

¼ Watt: 3¢ each for 1 to 99; 2¢ each for 100 and up.
* mail order only: 4¢ each for 1 to 10.

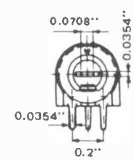
½ Watt: 6¢ each for 1 to 99; 4¢ each for 100 and up.
* mail order only: 8¢ each for 1 to 10.

Trimmer Potentiometers

Part Numbers: Vertical	Part Numbers: Horizontal	Resistance Ohms	Min. Res. Ends	I Max. Slide* (mA)
MINIATURE 086 SERIES 0.1 WATT				
086BC 100R	086BD 100R	100	10	10
086BC 220R	086BD 220R	220	10	7
086BC 470R	086BD 470R	470	10	4.5
086BC 1K	086BD 1K	1K	20	3.2
086BC 2K2	086BD 2K2	2.2K	40	2.2
086BC 4K7	086BD 4K7	4.7K	100	1.4
086BC 10K	086BD 10K	10K	200	1.0
086BC 22K	086BD 22K	22K	400	.7
086BC 47K	086BD 47K	47K	1000	.5
086BC 100K	086BD 100K	100K	2000	.32
086BC 220K	086BD 220K	220K	4000	.22
086BC 470K	086BD 470K	470K	10K	.22
086BC 1M	086BD 1M	1M	20K	.22


086BC

VERTICAL MOUNTING



Zener Diodes ½W & 1W, 5%

V_Z, volts	0.5W type	1.0W type	V_Z, volts	0.5W type	1.0W type
2.4	1N5221B		18	1N5248B	1N4746A
2.5	1N5222B		19	1N5249B	
2.7	1N5223B		20	1N5250B	1N4747A
2.8	1N5224B		22	1N5251B	1N4748A
3.0	1N5225B		24	1N5252B	1N4749A
3.3	1N5226B	1N4728A	25	1N5253B	
3.6	1N5227B	1N4729A	27	1N5254B	1N4750A
3.9	1N5228B	1N4730A	28	1N5255B	
4.3	1N5229B	1N4731A	30	1N5256B	1N4751A
4.7	1N5230B	1N4732A	33	1N5257B	1N4752A
5.1	1N5231B	1N4733A	36	1N5258B	1N4753A
5.6	1N5232B	1N4734A	39	1N5259B	1N4754A
6.0	1N5233B		43	1N5260B	1N4755A
6.2	1N5234B	1N4735A	47	1N5261B	1N4756A
6.8	1N5235B	1N4736A	51	1N5262B	1N4757A
7.5	1N5236B	1N4737A	56	1N5263B	1N4758A
8.2	1N5237B	1N4738A	60	1N5264B	
8.7	1N5238B		62	1N5265B	1N4759A
9.1	1N5239B	1N4739A	68	1N5266B	1N4760A
10	1N5240B	1N4740A	75	1N5267B	1N4761A
11	1N5241B	1N4741A	82	1N5268B	1N4762A
12	1N5242B	1N4742A	87	1N5269B	
13	1N5243B	1N4743A	91	1N5270B	1N4763A
14	1N5244B		100	1N5271B	1N4764A
15	1N5245B	1N4744A	110	1N5272B	
16	1N5246B	1N4745A	120	1N5273B	
17	1N5247B				

V_Z specifications guaranteed to ±5%.

1N5200B series 20¢ each: 1N4700A series 25¢

YOU CAN'T BEAT THE BEST!

SD SYSTEMS

A SUBSIDIARY OF THE MICHIGAN GENERAL CORPORATION

VERSAFLOPPY II Disk Controller

— Controls 4 independent drives— 8" single sided/double density, 8" double sided/single density, and 5¼" single sided/single density maybe used in any combination.— Control firmware PROM available. **$498**

SBC200 Single-Board Computer

— Z80A CPU runs at 4 MHz.— 8K EPROM and 1K RAM— Serial and parallel I/O ports— 4-channel counter-timer using Z80-CTC— Programmable baud rate generator for serial port— No "front panel" required.. **$445**

EXPANDORAM II Memory Board

— Uses 4116 or 4164 RAM chips for up to 256K on one S-100 board— Bank-select feature allows up to 8 boards on the same bus— Operates with Z80 CPUs at up to 4 MHz— Hidden refresh— Address-locatable **$319**

VDB 8024 Video Board

— 80 characters by 24 lines— 7 by 10 matrix— Upper/lower case, special, and user-programmable characters— Full cursor control— On-board Z80-CPU and 2K RAM— Keyboard power and interface— Many special features..... **$539**

MPB100 CPU Board

— S-100 compatible Z80 microprocessor board— 2 or 4 MHz operation— Automatic power-on-jump to start of any 4K block in memory— Socket for 2K EPROM— Optional wait states— Can be used with many S-100 computers....................... **$348**

PROM 100 EPROM Programmer

— Programs 2708, 2716, 2732, and 2516 EPROMs— 25V programming pulse generated on-board— Automatic verification of programming and erasure— Zero insertion force socket— Control software in Z80 code.. **$279**

MPC4 4-Channel Serial I/O Board

— Four serial I/O ports— Two Z80-DARTs and a Z80-CPU— Real-time clock— Programmable baud rates for all ports— 1K RAM on board— 2K control EPROM— FIFO buffers on all ports— Expandable RAM.. **$685**

EXPANDOPROM EPROM Board

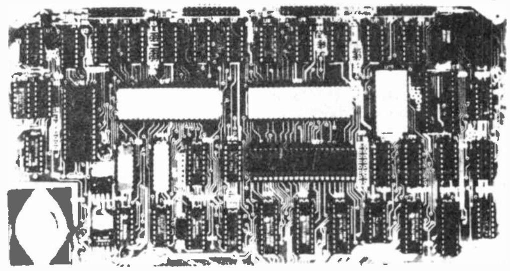
— 16 sockets, DIP switch selectable, for 2708 or 2716EPROMs (1 to 32K)— Compatible with S.D. Systems, Imsai, Altair,SOL-20 or Cromemco Z80 CPU cards— Also compatible with 8080A and 8085-based systems........................... **$197**

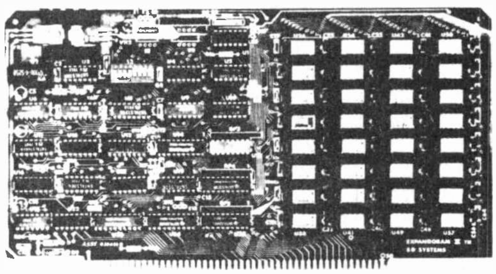
Z80 Starter Kit

— Complete microcomputer on a board— Hex keyboard and display— PROM programmer— Kansas City standard cassette interface— Provision for two S-100 card slots— Wire-wrap area— Monitor ROM provides memory/port examine and change, CPU register examine and change, break-points— Z80-CTC and Z80-PIO allow parallel I/O and vectored interrupts— 1K on-board RAM expandable to 2K.. **$485**

MPC-4

Multi-port Communicator with Four Serial Ports





EXPANDORAM II

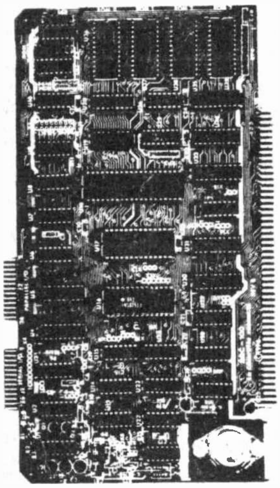
The Random Access Memory

S.D. COMPLETE SYSTEMS

Starting at under $2000.00

Complete systems are available from Exceltronix. These systems consist of a SBC-200 CPU board, and EXPANDORAM II RAM board, a VERSAFLOPPY II floppy disk controller board, and a VDB-8024 video display board, a card cage with room for 2 more cards and a 8" double-sided double-density disk drive. Call us for more details and the current price of this remarkable system.

Consult us for your requirements



SBC 200 Single Board Computer

Discounts available on purchases of two or more Bus.

SYSTEM SOFTWARE

Description	Price
CP/M Disk operating system, SS, V1.4	$112.50
CP/M Disk operating system, DS, V1.4	$225.00
CP/M Disk operating system V2.2 8" single sided single density for VDB-8024 Video Display Board	$283.50
Versafloppy control software (BIOS)	$ 50.40
Versafloppy diagnostic software (VDIAG)	$ 50.40
Versafloppy diagnostic software (VDIAG2) for use with SBC-100	$112.50
SD Monitor for SBC-100 with RS-232 terminals	$ 28.80
SD Monitor for SBC-100 with VDB-8024	$ 28.80
SD Monitor PROM for SBC-200 with RS-232	$112.50
Disk control software (DBIOS) 5" minidiskette for RS-232 console	$112.50
Disk control software (DBIOS) 5" minidiskette for VDB-8024 Video Display Board	$112.50
Disk control software (DBIOS) 8" diskette for RS-232 console	$112.50
Disk control software (DBIOS) 8" diskettes for VDB-8024 Video Display Board	$112.50
Disk control and diagnostic software for Versafloppy II (DBIOS & VDIAG3)	$112.50
Z-80 global package	$112.50
SDOS disk operating system, 5" single density for RS-232 console	$225.00
SDOS disk operating system, 5" single density for VDB-8024 Video Display Board	$225.00
SDOS disk operating system, 8" single density for RS-232 console	$225.00
SDOS disk operating system, 8" single density for VDB-8024 Video Display Board	$225.00
SDOS disk operating system, 8" double density for VDB-8024 Video Display Board	$225.00
SDOS disk operating system, 8" single density for VDB-8024 Video Display Board, with C-Basic II (for SD-100)	$337.50
SDOS disk operating system, 8" double density for VDB-8024 Video Display Board, with C-Basic II (for SD-200)	$337.50
COSMOS multiuser disk operating system, 8" double density	$396.00
PROM-100 software on disk	$ 45.00
PROM-100 software in PROM	$112.50
Z80 starter kit experimental workbook	$ 28.80

We maintain a professional service staff.

Exceltronix Components & Computing Inc.

Multiflex

Multiflex Z80A Computer

This two-board, Z80A-based S-100 microcomputer is one of the most versatile, useful, and easily expandable systems money can buy. Furthermore, its low price sets it apart from all competition. No other microcomputer offers as many features as the Multiflex Z80A, at anywhere near its price.

The Z80A system is designed to be useful immediately as a training and evaluation tool, to introduce users to the Z80A (4 MHz) microprocessor. Its Monitor program, together with system resources like the built-in EPROM programmer, may be used to develop resident software for virtually any application. The system has been designed' around the industry-standard S-100 bus structure, making the addition of accessories not only possible, but quire simple and straightforward. Moreover, the user is not restricted to using Multiflex products to expand his system: He may select S-100 products from literally hundreds of manufacturers across North America.

This system should not be confused with other "evaluation kit" products. Most of these are expensive devices with few hardware features, and require the purchase of a separate "expansion board" or "bus extender" before any accessories may be added to develop a complete system. The Multiflex Z80A, with four S-100 card slots, already has enough expansion capability for most applications. Filling these slots with the included CPU board, a 64K memory board, a video display board and a disk controller, for example, will produce a system equal to some of the best on the market, at about half the cost.

Features of the Multiflex Z80A Computer:

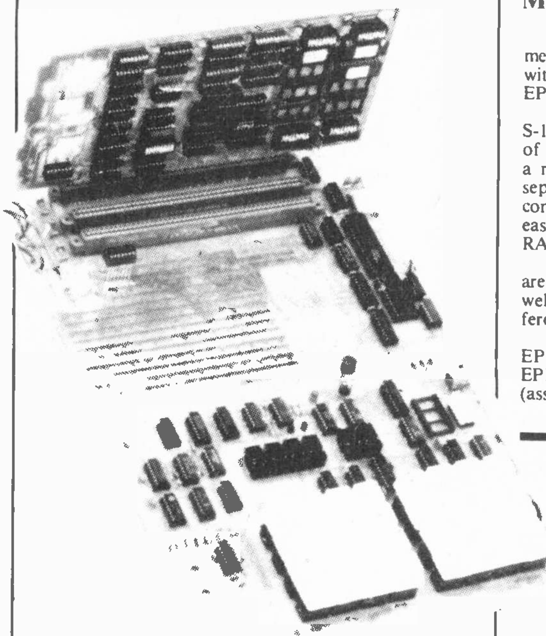
- 4 MHz, Z80A-CPU
- 2 banks of 2K bytes RAM. The address range of each bank may be defined by hardware jumpers.
- space for up to 16K of EPROM, using 2708 or 2716 devices, with jumpers to define the address range
- resident 4K Monitor software to facilitate machine-language program development, execution and debugging, and to control all I/O hardware in the system.
- hex keypad, 14 monitor function keys, 2 unassigned keys
- hex address and data display
- 2000 baud audio cassette interface
- built-in EPROM programmer for 2708 or 2716 devices
- 24-line parallel I/O interface based on the 8255 PPI chip
- optional RS-232C interface, already wired on the PC board
- 40-chip wire-wrap area for customizing
- four S-100 slots
- basic system requries only +5 Volts at 1.3 Amps
- provision for on-board voltage regulators, for operation from standard S-100 supplies

Multiflex Z80Z Computer Kit with 1K RAM $375.00
Multiflex Z80A Computer Kit with 4K RAM $400.00
RS-232 Interface Option $25.00
5 Volt 3 amp Power Supply $49.95
Multiflex Z80A Computer Assembled $475.00

Multiflex Dynamic Memory

Based on the new 8202 dynamic memory controller chip from Intel, this S-100 board features onboard refresh and bank-select. The board may be populated with 16K, 32K, 48K or 64K RAM (4116 200 nS devices), and up to 8 full boards may be used on the same bus. If desired, the internal refresh may be disabled to allow the use of the refresh signal from a Z80 or Z80A Microprocessor

Memory Kit (without RAM ICs) $325.00
Memory Kit (with 64K RAMS) .... $349.00 special



Multiflex EPROM Simulator

This S-100 board features two 8255 PPI chips for up to 48 bits of parallel I/O, two 8251 PCI chips configured as fully handshaked RS-232C serial interfaces, and an 8253 3-channel real-time clock. Two channels of the 8253 3-channel real-time clock. Two channels of the 8253 are used as programmable baud rate generators for the serial ports, and the third channel is available to the host computer.

I/O Board (kit) $140.00
I/O Board (assembled) $195.00

Multiflex Video Board I

This S-100 board makes the resources of a number of LSI chips available to a host computer. It is fundamentally a colour video board, but with wiring for numerous I/O resources. The video section, based on the Motorola 6847, has all the features of that chip: Eleven different program-selectable modes allow 16-line by 32-character text display (with inverse video); two semigraphics modes with eight colours (64 × 32 or 32 × 64 pixels); and eight full-graphics modes with two sets of four colours (64 × 64 and 256 × 192 pixels) and two sets of one colour (246 by 192 pixels).

If desired, a 3-channel real-time clock (8253) may be installed, one channel of which is used as a programmable baud rate generator for an 8251 PCI chip configured as a fully handshaked RS-232C serial interface. Two 8255 PPI chips may also be added, to allow up to 48-bit parallel I/O functions.

All devices on the board may generate interrupts for the host processor for control over memory access, etc. The advanced interrupt control circuitry generates vector addresses for all interrupts.

This board is compatible with the proposed IEEE standard for S-100 computers, and is controlled through a block of I/O ports. The dispiayed video data is memory-mapped. A parallel ASCII keyboard interface is provided, as well as up to 6K of static RAM. A complete colour RF modulator is included on-board to allow the use of a conventional colour television set as a monitor.

Complete Kit with all functions $275.00
Assembled board with all functions $350.00

Please contact Exceltronix for price structure of kit and assembled versions with partial functions.

Multiflex I/O Board

This new product is invaluable in the development of dedicated microprocessor systems. It works with a host computer to totally simulate a 2716 or 2732 EPROM in real time.

The board itself plugs into any IEEE-compatible S-100 computer system, to which it appears as a block of RAM. A 24-pin DIP plug attached to the board by a ribbon cable, plugs into an EPROM socket in a separate system and acts just like a real EPROM. The contents of this simulated EPROM may be changed as easily as the host computer can modify a block of RAM.

The block size and location of the on-board RAM are selectable by DIP switches. All S-100 signals, as well as those to the DIP plug connector, are fully buffered.

EPROM Emulator board (kit) $295.00
EPROM Emulator borad (assembled) $380.00
(Available in Dec. 81)

CHECK OUT THE INDEPENDENT REVIEW OF THE MULTIFLEX IN ETI's JULY 1981 ISSUE.

KEEP UP WITH THE NEW MULTIFLEX DEVELOPMENTS FOLLOW OUR ETI ADS.

Multiflex Industrial Timer

This stand-alone computer combines the functions of an electronic stopwatch (actually six of them, implemented in software) with I/O hardware to allow event detection and control of external equipment under precise timing. All aspects of its operation are user-programmable, but no knowledge of conventional computer programming is required.

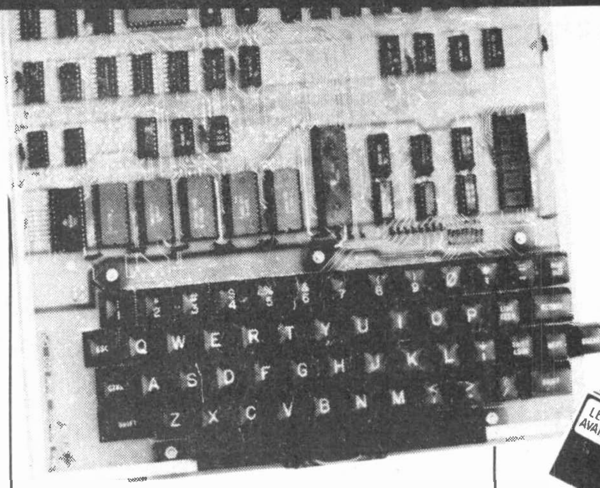
The unit contains six independent real-time clocks, each with a resolution of 1/100 sec. An 8-digit LED display allows the time value of any of the clocks to be displayed, either in 24-hour mode or 12-hour mode with AM/PM indication. A serial time-code output allows the use of external or remotely-located displays. Five of the clocks can time to a maximum of 24 hours, and the sixth has complete calendar capability for timing up to one full year.

A keyboard on the Timer allows the user to program its operation. The five 24-hour clocks may be started, stopped, or cleared for simple "stopwatch" functions, or preset to any starting time. Each clock may be programmed to count either forwards or backwards, and may be assigned a limit. The clocks can initiate various outputs to external devices upon reaching their assigned limits, and these actions are totally programmable by the user. One special feature of the Timer is that when a backward-counting clock reaches its limit, it will automatically switch to upward counting for "overtime" indication.

Six pulse inputs are provided, which may be programmed to start, stop, or clear any combination of the clocks. These inputs can also be software-associated with the various outputs, allowing each of the clocks to start, stop, or clear others. In this way, complex and/or iterative timing routines can be programmed.

Programmable Timer (assembled with case) $350.00
(Power supply extra)

YOU CAN'T BEAT THE BEST!



OSI Superboard

Superboard 2:

Big system features at a low price. Full ASCII keyboard, 8K BASIC in ROM plus 4K of RAM with room for an additional 4K on board. The built in cassette interface allows storing programs on tape as well as utilizing a large variety of commercial software. Character sets included contain upper and lower case letters plus plus graphics and games characters, and can be displayed on a monitor or a TV set with an RF modulator. A 5 volt, 3A power supply is required.

Superboard 2 with 4K RAM $449.00
Superboard 2 with 8K RAM $475.00
Custom Case for Superboard $73.00
Power Supply (+5V, 3A) $49.95
RF Modulator Kit $14.00
Plastic Enclosure $28.95

OSI Challenger

Challenger 1P Series 2:

All the features of the Superboard plus a fully shielded high impact case, an internal power supply, 8K of RAM on board, expandable to 32 K, video format programmable for 24 x 24, 12 x 48, 32 x 32 and 16 x 24 characters. A DAC facilitates sound and music synthesis, and a 300 BAUD RS232 interface will drive printers and modems.

Challenger 1P with 8K RAM $699.00

Challenger 1P-MF Series 2:

Everything in the Challenger 1P as well as a 5¼ inch disk drive for 90K of mass storage, with option to add a second, and a real time clock. A powerful disk operating system is available.

Challenger 1P-MF with
32K RAM $1850.00

C4P Series 2:

The C4P has all the features of the C1P plus full colour video, mudular bus structure and keypad and joystick interfaces.

C4P with 8K RAM .... **Please contact**
C4P with 16K RAM ....**us for best**
C4P with 32K RAM .... **pricing.**

C4P-MF Series 2:

Includes a 90K disk system, 24K of RAM, expandable to 48K and a home security interface and 16 bit I/O capability.

C4P-MF with 24K RAM ...... **Please contact us**
C4P-MF with 48K RAM ....**for best pricing.**

610-8K:

8K RAM expansion for Superboard 2 or C1P. A further 16K can be added. Board also contains a dual disk controller. Requires 5V ' 4.5A.

610-8K ..... **Please contact us for best pricing.**

630:

I/O and video expansion board for C1P and C1P-MF systems. Allows full-colour video display (RGB and NTSC composite outputs), interfaces for joysticks, dual remote keypads, AC control, security system, 16-bit parallel I/O.

630 .... **Please contact us for best pricing.**

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GAMES

GALAXIA- Bloodthirsty aliens, engaged in a dogfight to the death. Written in machine code, this is a lightning fast game in the realm of 'Alien Invaders'. $12.50 tape, $16.50 disk.
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ORBITAL WAR- Take the helm of the Enterprise and defend Earth from swarms of deadly monsters. Fast paced graphics. $11.25 tape.
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ALIEN INVADERS- Another classic game. Save Earth from being devoured by waves of monsters from Mars. Blow it and the human race is intergallactic Fritos. $8.75 tape.
ALIEN II- ALIEN ATTACK in machine code: faster than a greased phaser. Selectable speeds. $13.75 tape, $16.75 disk.
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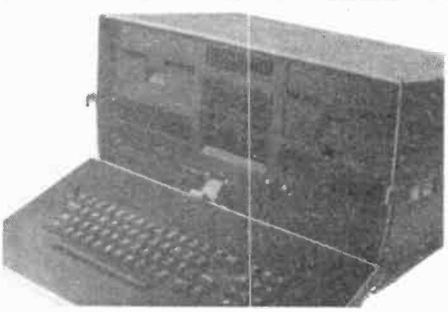

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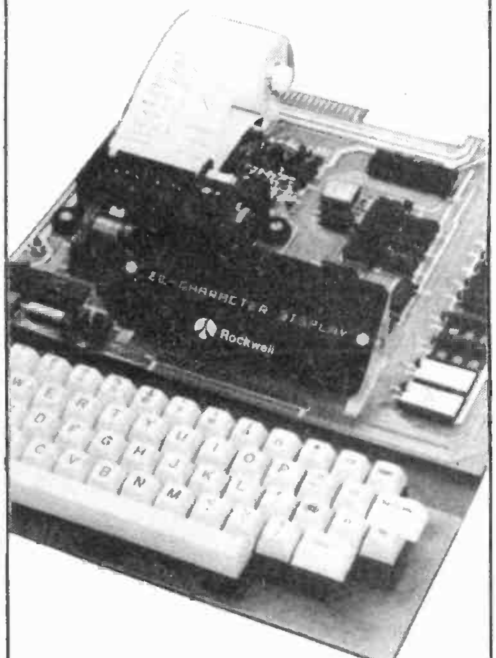
AIM-65



Rockwell AIM-65 Computer

The AIM-65 is a one board 6502 system, with a typewriter type keyboard, 20 character LED display and a 20 column thermal printer. There's room for 20K of ROM or EPROM, with a monitor in 8K, and 1K of RAM, expandable on board to 4K. As well, there's a dual cassette interface, two 8 bit I/O ports, and a serial teletype port. The Microflex 65 support products can be interfaced via an expansion connector. Extensive documentation is provided.

AIM-65 with 1K RAM	$650.00
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— Fully assembled and tested 6502-based microcomputer
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6809
SINGLE BOARD COMPUTER

This is a suberb state-of-the-art single board computer based on the 6809 microprocessor. Its standard features are: 1 serial port for a RS-232 terminal; 1 serial port for either a modem or a printer; a complete machine language monitor; a Kansas City Standard cassette interface; 2 parallel ports; a 4-digit ASCII display; up to 48K of dynamic RAM on-board; room for 8K more of EPROM (using 2532 EPROM's); and a fully-buffered bus connector. There is also an option for a full-screen editor/assembler which accepts the standard 6809 menomics and conventions. This computer is available in either kit form or assembled

$495.00 (with 4K Monitor)....... $595.00 assembled

Additional 8K of assembler available in PROM **$160.00**

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SSM Boards

CB1A 8080 CPU Board

The CPU board to grow with; a functional small computer with just a video or I/O board, but capable of almost unlimited expansion. Check the specs.
Specifications: Processor Type: 8080A Speed: 2 MHz On board EPROM: 2048 x 8 bits of 2708 capacity, (not included), dip switch addressing at any 2K boundary, only one wait state added. On board RAM: 1024 x 8 bits of 2114 capacity, dip switch addressing at any 1K boundary, no wait states added. On-board input ports: 8 bit data ports, 1 bit status port, 0 to 31 (decimal) port address, dip switch addressing. Vector jump: jump on power-on and/or reset to any 2K boundary, selectable disable. Number of IC's: 40 (less EPROMS) Power: +8V @ .95A, +16V @ 50ma, -16V @ 25ma, all less EPROMS.

Bareboard.......... $62.00, Kit.......... $219.00

CB2 Z-80 CPU Board

As powerful as the CB1A, but utilizing the newer Z-80 microprocessor, allowing operation to 4 MHz.
Spectifications: Processor Type: Z-80 Speed: 2 MHz, 4MHz, mixed. On board EPROM: 2048/4096 x 8 bits of 2716/2732 (not included), dip switch addressing to any 2K/4K boundary, dip switch disable, only one wait state added. On board RAM: 2048 x 8 bits of HM6116 (not included), dip switch addressing in 2K blocks, dip switch disable, only one wait state added. Addressing: 8 lines controlled by port FE. Vector jump: Power on/reset jump on first EPROM instruction. Special features: Run/stop and single step switches, jumper selected MWRITE, jumpers for new IEEE S-100 signals, one wait per M1 or PSYNC, all lines buffered. Number of IC's: 51 (less EPROMS). Power: +8V @ .75A.

.... $285.00

VB1B Memory Mapped Video Board

Full 1024 character display, software control and reverse video make this a powerful video board
Specifications: Display: 16 lines of 32 or 64 characters plus 128 by 48 matrix graphics, upper and lower case plus Greek, normal and reverse video. Monitor: Modified TV or commercial monitor, 16,200 Hz horizontal, 75 ohm video out plus seperate sync and video. On-board memory: 1024 bytes of 2102AL-2 (250 nS), dip switch addressing in 1K increments. Buffering: All lines. Number of IC's: 42. Software: Drivers for cursor control and X-Y graphics. Power: +8V @ 1.4A, +16V @ 30ma, -16V @ 15ma.

.... Bareboard $49.00

VB2 I/O Mapped Video Board

A complete video terminal, with keyboard input capacity and video output, plus circuitry to produce an audible tone.
Specifications: Display: 64 characters in 16 lines, normal or reverse video, underline cursor, full interlace, North American standard TV sweep, adjustable horizontal margin and character size and vertical position. Interface: composite video out, external sync inputs for slave control, parralel keyboard input, full duplex, dip switch selection of port address. Number of ICs: 45. Power: +8V @ 1.1A, -16V @ 79ma.

Bareboard.......... $52.00 Kit.......... $230.00

MT1 15 Slot Motherboard

Provisions for 100 termination resistors, available with or without connectors.
Specifications: Connector spacing: .25 inch across pin, .125 inch between pin. PC Board: 11 5/8 inches by 11 inches, .09 inches thick.

.... $75.00

VB3 80 Character Video Board

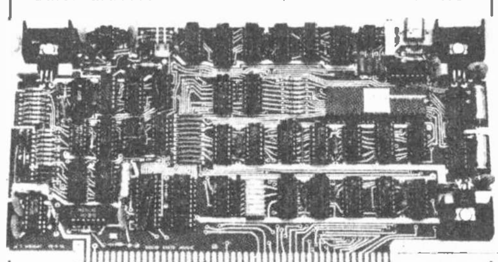
This high density memeory mapped display can produce up to 48 lines of 80 characters, making it ideal for high density graphics or word processors.
Specifications: Display: Up to 48 lines of 80 characters, graphics to 160 x 192 matrix, upper and lower case, up to 256 user defined symbols (optional EPROM), reverse video, 1 grey level, blinking characters, underline, strike through, blank out. Timing: Software controlled margins, size and position, U.S. and European timing, full and non interlace, 16 MHz dot rate. Interface: composite video plus seperated sync outputs, memory mapped input, keyboard port with status, dip switch port addressing, all lines buffered. On board RAM: 4096 Bytes (8192 optional) of 2114L, switch addressing in 8K increments, on board bank select of RAM. Software: CP/M compatible driver, terminal simulator. Power: +8V @ 2A, +16V @ 50ma, -16V @ 20ma.

(80 x 24).......... $595.00 (80 x 48).......... $795.00

IO2 Parrallel I/O Board

A low cost I/O board with one input and one output port to interface with a keyboard or printer, plus a prototyping area. Schematics are provided for a serial interface, small ROM board or two extra parralel ports.
Specifications: Ports: One each eight bit input and output. Addressing: dip switch selection of 256 addresses. Prototyping area 1 x 40 pin dip, 2 x 24 pin dip, 9 x 16 pin dip, 1 x 14 pin dip, 1 regulator space. Number of ICs: 9. Power: +8V @ 300ma.

Bareboard.......... $53.00, Kit.......... $89.00



IO4 2 Parralel & 2 Serial I/O Board

6 ports in all, optically isolated RS232 current loops for the serial interfaces with BAUD rates from 55 to 9600.
Specifications: Ports: 2 Serial ports with status, 2 each parallel input and output, serial interface via optically isolated 20/60 ma current loops, EIA receivers and drivers, 55 to 9600 BAUD, 134.5 BAUD to run Selectrics, UART presets by dip switch for stop bits, word length and parity, + 5V, +12V and -12V available at port, parallel parts have 8212 latches, +5V and -12V available at port. Addressing: dip switch addressing of any serial port to any four port boundary, parallel to two port boundary. Prototyping area: 2 x 16 pin dips: Number of ICs: 37. Power: +8V @ .95A, +16V @ 50ma, -16V @ 80ma.

Bareboard.......... 55.00, Kit.......... $275.00

SB1 Music Synthesizer Board

User can define pitch, tempo, timbre, envelope and volume level of a waveform. Comes complete with software, which will drive up to eight boards for complex harmonies.
Specifications: Addressing: Memory mapped onto any 256 bytes from 8000 hex. Sound parameters: Pitch 15Hz to 25KHz with ½% maximum error, volume range 16 linear steps, waveform definition 32 bytes long x 256 levels high, envelope deffinition 16 bytes long by 16 bytes high, .05 to 4 seconds duration. Software: MUS-X1 interperter with 9 octave control, can run eight cards, double whole note to 1/64 note, capacity for triplets, repeats, ties, 40 to 200 beats per minutes in 2/2 to 8/8 time, available on paper tape in Intel Hex or on disc. Interface: All lines buffered. Number of ICs: 45. Power: +8V @ 1.1A, +16V @ 20ma, -16V @ 20ma.

Bareboard.......... $67, Kit.......... $295.00

MB7 Low Power 16K Static RAM Board

Extremely low power and operation to 3 MHz make this an ideal board for any 8080 or 8085 system.
Specifications: Memory: 16384 bytes of uPD410 RAM. Addressing: Dip switched to any 16K block at any 4K boundary, phantom disable, protect/unprotect, all lines buffered. Speed: 3MHz. Number of ICs: 52. Power: +8V @ .55A, +16V @ 80ma, -16V @ 25ma.

.... $60.00

PB1 2708/2716 Programmer & 4K/8K EPROM board

Textool sockets for the two programmers, on board power supply generation plus 4 EPROM sockets make this a highly useful dual function board. LED indicator for programming mode and switch to disable programming voltage.
Specifications: Memory: 4096/0192 bytes of 2708/2716 EPROM. Addressing: Dip switched to any 4K boundary for programmer, any 4K/8K boundary above 8000 hex for on board EPROMS, unused sockets do not enable data bus drive, all lines buffered. Wait states: 0 to 4 clock cycles. Number of ICs: 22 (less EPROMs). Software: Programming and verification. Power: +8V @ 500ma, +16V @ 300ma, -16V @ 10ma.

Kit.. $219.00

MB8A 1K/16K EPROM Board

16 x 1K of EPROMS, which can be mapped over existing RAM and ROM, and only enabled when needed. Enough space to hold a large BASIC.
Specifications: Memory: 16384 bytes of 2708. Addressing: dip switch selection to any 16K boundary, RAM/ROM overlay capacity, disable in 1K increments, all lines buffered. Wait sates: 0 to 8 clock cycles. Number of ICs: 15 (less EPROMs). Power: +8V @ 160ma, +16V @ 10ma, all less EPROMs.

Bareboard.......... $53.00, Kit.......... $145.00

OB1 Vector Jump & Prototyping Board

Vector jump for an 8080 or Z80 system without a front panel. Activated by power on or reset, to any memory location. Plus a prototyping area
Specifications: Vector jump: Dip switched to any location from 0 to 65536, on systems with or without phantom disable. Prototype areas: 3 x 24/28 pin dips, 10 x 16 pin dips, 2 regulator spaces. Number of ICs: 7. Power: +8V @ 150ma.

.... $49.50

T-1 Active Terminator Board

Reduces noise, crosstalk and ringing. Provides active load of +2.75 volts with an impedance of 275 ohms, on a 2.5 x 10 inch board.

.... $39.00

XB1 Extender Board

Essential for troubleshooting; with optional edge connector, is same size as standard S-100 card.

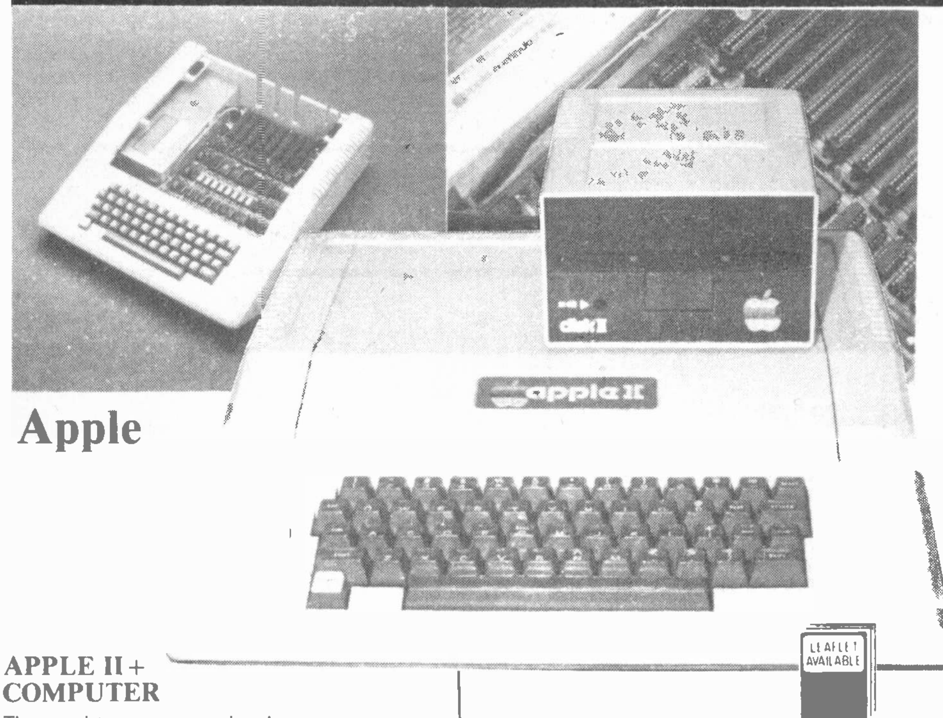
.... $25.00

SB1 Music Synthesizer Disk Software

8 inch floppy disk containing source and object listing of MUS-X1, SB1 test program and 18 encoded music pieces. MUS-X1 is a high level real time interperter which reads scores and runs up to eight SB1 boards. Score is in standard ASCII. MUS-X1 starts at 100 hex to support CP/M, video display (VB1B) at CC00 hex, SB1 boards at D000 hex.

.... $40.00

YOU CAN'T BEAT THE BEST!



Apple

APPLE II+ COMPUTER

The complete computer package!

This very popular system is based on a 1 MHz 6502 microprocessor. Three display modes are available to the user: 40 × 24 of text (which can be removed if desired). All text is in 5 × 7 suppercase format. All the display modes are software selectable. Comes with 48K of RAM memory and Applesoft II, Apple's floating point BASIC interpreter in ROM. Also, standard are semi full screen editing, tracing functions, direct memory access commands, a dissambler and mini-assembler, and a typewriter style keyboard with N-key rollover and cassette interface. Standard accessories include an AC power cord, video cable for compisite video and complete reference manuals.

SPECIAL $1795.00

DISK II

The Disk II floppy disk system is a powerful mas storage system for the Apple II computer. Its fast access time (600 ms. over 35 tracks) and large storage capabilities (116K bytes/diskette) make it a very easy system to use. The DOS allows you to load and save files by name (up to 35 car./name), program chaining, random or sequential file access and individual file write protection. The system comes complete with interface card which will handle 1 or 2 drives, and the disk operating system. The Apple II will accept up to 14 drives with a total capacity of almost 1.6 Mbytes of information.

SPECIAL 795.00

SUP'R'MOD

This is a RF modulator, colour or black-and-white comatable, for use with the Apple II computer and any standard TV. This high performance unit comes complete with coaxial cable and antenna transformer.

.... $48.00

HAYES MICROMODEM II

With the Hayes direct-connect Micromodem II, your Apple II can communicate by phone with the outside world. This, the world's largest selling direct modem for the Apple II, comes complete with everything you need to communicate with other computers at either 110 or 300 baud. Included are a module which plugs directly into any modular telephone jack (no phone needed!), and disk programs that will dial the phone numbers you want, and even send messages while you're out. Put the outside world in your Apple with the Microcomdem II.

Please contact us for best pricing.

Apple Software

VISICALC

(Available in Dec. 81)

Visicalc is the world's most useful, most important programs yet developed in the world of personal computing. Visicalc is a electronic spreadsheet of up to 63 columns by 254 rows. To use the system, you first set up the column and rows names, just as you would with a piece of paper and a pencil. Then you can put data where you want to put data, or make a calculation where you want a calaculation made, all you have to do is type in the formula. Visicalc instantly performs the calculations and displays the results in the indicated locations. And if you chang any of the data, the worksheet instantly displays the new result. And when you're finished you can get a hard copy of the sheet on your printer.

Other titles include:

- -CCA Data Manangment System
- Desk Top Plan
- Bridge Partner
- Checker King
- Gammon Gambler
- Microchess 2.0
- Apple PILOT
- Apple PLOT
- Apple POST

INTEGER BASIC ROM BOARD

Please contact us for best pricing.

This board, for owners of the Apple II+ computer, allows you to add the fast execution speed and the wide software base of Apple's Integer BASIC language. This language does in no way interfere with the operation of the Applesoft language already in your computer.

MICROSOFT Z-80 SOFTCARD

This interface allows you to put a Z-80 "under the hood" of your Apple. Why, you ask would you want to do this? The reason is most of the major languages and a lot of software is written for the CP/M operating system, which is written for either Z-80 or 8080-based systems. The Softcard allows you to do this, and it comes with an Apple-compatible version of CP/M. It also supports all Apple periphials, so you can use it just about any system configuration. Minimum system requirements are 48K of RAM and 1 disk drive.

Please contact us for best pricing.

Check Out Our Great Prices On Printers And Modems (P14, 15)

APPLE SERIAL INTERFACE CARD

The Serial Interface Card allows an Apple computer to exchange data with other computers, printers, and accessories in serial format. It is intended for applications that use data rates other than those handled by the Communications Interface Card (see below), or that involve serial printers that don't require "handshaking." This card provides an industry-standard RS-232 interface to your computer, and is easily controlled from BASIC or Pascal using simple commands. Its baud rate is selectable from 75 to 19K, and offers easy set-up though switch selectable preset conditions

Please contact us for best pricing.

APPLE COMMINCATIONS INTERFACTCARD

This card allows you to connect your Apple to modems, CRT terminals, and other devices employing a bi-directional, serial (RS-232), 110 or 300 baud interface. The card's built-in intelligence lets you control these devices easily from BASIC or Pascal. This card also lets you use your Apple II as an intellegent terminal.

Please contact us for best pricing.

APPLE PRINTER INTERFACE CARD

This Printer Interface Card gives you the capability to generate reports, listings, labels, and letters with your Apple II computer. A special version of this card is available for use specifically with the Centronics 779 printer. (NOTE: The Centronics Interface Card does not support the Centronics 730 series of printers.) Both card support 40-255 characters/line, with a speed of up to 5000 char./sec. (3700 lpm at 80 char./line). The built in intelligence allows simple control from either BASIC or Pascal, with no need to write or load extra assembly language programs.

Please contact us for best pricing.

MULTIFLEX APPLE II BOARDS

FLOPPY CONTROLLER BOARD

(Available in Dec. 81)

This board allows you to interface disk drives to your Apple II× computer. It comes with all the software to use an Shugart SA400 disk drive and simply plugs into one of the expansion slots in the back of the computer. The board, complete with one SA400 disk drive is $599.00. You can't afford not to get one at this price!

SERIAL INTERFACE CARD

(Available in Dec. 81)

This card performs all the functions of the Apple serial interface card and the Apple communications card put together. It also comes with all the software needed for using the board in just about any serial port application.

PARALLEL INTERFACE CARD

(Available in Dec. 81)

With this card, any parallel input printer can be used with your Apple II, including the Centronics 779 and 730 series of printers. This enables you to get a hard copy of any project you are working on, be programming or word processing of graphics or whatever.

Exceltronix Components & Computing Inc.

Atari

ATARI 400 Personal Computer

-6502 microcomputer running at
-1.8 MHz
-connects to any TV
-comes with 8K of RAM; which is expandable to 16K
-BASIC programming language standard
-display is 24 lines of 40 characters or up to 390 × 192 for high resolution graphics
-3 text modes
-16 colours with 8 intensities
-4 independant sound shannels
-1 serial I/C port and connectors for connection of up to 4 joysticks, etc.
-power transformer supplied
-semi-full-screen editing

.... $790.00

ATARI 800 Personal Computer

-all the features of the 400 computer plus:
-supplied with 16K RAM instead of 8K
-expandable to 48K instead of 16K
-keyboard features full stroke key instead of touch-panel key (standard on the 400)

.... $1495.00

Periphials available:
410 PROGRAM RECORDER
810 SINGLE DISK DRIVE UNIT
815 DUAL DISK DRIVE UNIT
820 PRINTER
822 THERMAL PRINTER
825 LETTER QUALITY PRINTER
850 INTERFACE MODULE
830 ACOUSTIC MODEM

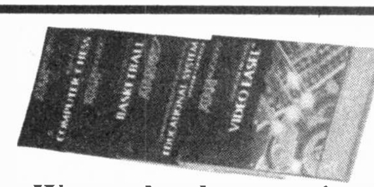
ATARI SOFTWARE
Much soft ware is available for the ATARI computer on disk, cassette of ROM cartridge. Some of the more popular titles include:
-ASTEROIDS -STAR RAIDERS -SUPER BREAKOUT -COMPUTER CHESS -SPACE INVADERS -VISICALC

We also stock a good selection of
MONITORS
B&W, 12", Starting at $70.00

Colour RGB
MONITORS
$350.00 up

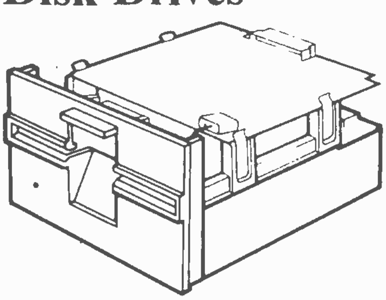
Keyboards
ASCII
Starting at $39.00

wide range of
Power Supplies
including switching supplies



We stock a large variety of software for Apple and Atari.

Disk Drives



Floppy Disk Drives by Shugart

SA400: — Single sided, single or double density 5¼" floppy drive — Soft or hard sectored
.... FEATURE **$390**

SA450: — All the features of the SA400 (above) except double sided
.... **$580**

SA801R: — Single sided, single or double density 8" floppy drive — Hard or soft-sectored — Designed for side-by side mounting of two drives in a standard 19-inch rack
.... **$685**

SA850R: —All the features of the SA801R (above) but double sided
.... **$950**

SPECIAL
$650.00

CDC 9406: — Double sided, single or double density 8" floppy drive — hard or soft-sectored
.... **$650**

Winchester Hard-Disk Drives
— Century Data Systems' Marksman M20
— 20 Megabyte capacity
$700 and up. Call or visit us for details.

CDC DISKETTES

Single Sided Single Density 8"	$ 7.89
Single Sided Double Density 8"	9.75
Dual Sided Single Density 8"	9.75
Dual Sided Dual Density 8"	10.95
MINIDISKETS 5¼" - BULK	7.50

MAXELL MINIFLOPPY DISKS

MH1 Single Sided 16 Sector Holes 5¼	8.40
MD1 Single Sided 5¼"	8.50
MD2 Double Sided Double Density	8.50

NOTE
15% OFF IF YOU BUY 10 OR MORE

Acoustic MODEMS

Low-Cost Modems From Novation

The "Cat" Acoustic Modem
— The world's largest selling acoustic modem. Allows any computer with an RS-232C interface to communicate over ordinary telephone lines with NO special wiring. Two-way communication is possible with any other Bell 103-compatible modem, at speeds from zero to 300 baud. Switch-selectable Originate/Answer/Test modes and Full/Half duplex operation.
.... **$289**

The "D-Cat" Direct-connection Modem
— All the features of the "Cat" (above) but designed for direct connection to telephone lines via a modular jack. No special telephone wiring is required.
.... **$289**

The "Auto-Cat" Automatic-Answer Modem
— All the features of the "D-Cat" (above) plus automatic-answer feature. Auto-Cat will automatically answer a telephone line to allow communications with an unattended computer system.
.... **$349**

Send for our separate package of information on kits.

YOU CAN'T BEAT THE BEST!

Printers

CENTRONICS MODEL 739 PRINTER

The new Centronics Model 739 dot matrix printer sets new high standards for print quality, convenience and flexibility for the office of the 80s. This versatile printer provides standard print for normal applications and, under software control, will generate superior quality, proportional spaced, high desity matrix characters for letter writing. The Model 739 generates characters in an Nx9 dot matrix in the proportional spacing mode and a 7 × 8 dot matrix when printing a fixed 80 or 132 column line for business applications. It is capable of handling single sheets, roll paper and fan fold paper. Its rugged design allows you to print under the most demanding conditions. exciting additional features include a nine wire printhead that prints a true lower-case, descending characters, underlines, and high resolution graphics. This quiet Model 739 is ideal for office installations. The Model 739's intelligent and functional design permits the operator to justify right margins, roll paper forward and backwards . . . manually or under software control . . . and in half-line steps in order to perform sub and superscripts for equations, general text printing, and mathematical applications.

. . . . $1,175.00

CENTRONICS MODEL 737 PRINTER

The model 737 printer is the first small business printer to offer correspondence quality printing. The 18 × 9 dot matrix provides high-quality characters with true decenders as well as underlining. Proportional spacing, serif typeface, and the ability to justify right margins as well as print subscripts and superscripts give superior print appearance and make the 737 ideal for text processing applications. Standard data processing spacing of 10 and 16.7 characters per inch is also resident in the 737. Three-way paper handling permits letterhead, roll paper or fanfold to be used.

737-1 . . . . $1,250.00
737-3 . . . . $1,340.00

Centronics 730-series Printers

Features include:
— Three-way paper handling system for forms, rolls, or fanfold paper — Software-selectable number of characters per line (80 or 132) — Printing at 100 characters per second — Upper/lower case, 96-character set — 7 by 7 dot matrix printing

Model 730-1 with Parallel interface and 1-line buffer $950

Model 730-3 with serial interface and 256-character buffer $985

Lear Siegler ADM-3A "Dumb Terminal"

— 12-inch diagonal video display
— 80 characters by 24 lines, 5 by 7 dot matrix
— 64 displayable characters (upper case plus punctuation and control)
— Typewriter-style keyboard with control characters and cursor control keys
— Switch selectable RS-232 or 20 mA current-loop interface
— Switch-selectable baud rates from 75 to 19200 baud
— Extension RS-232 interface for "daisy-chain" connections
— User-definable data transmission characteristics

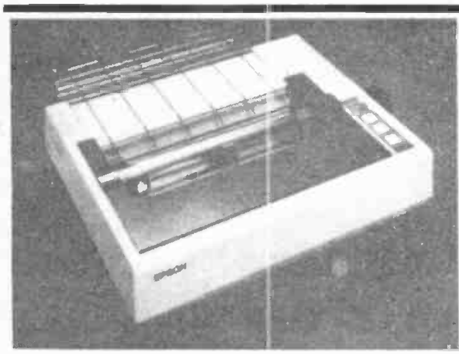
$1250

ADM-3A with lower case (96 displayable characters) **$1295**

Hazeltine model 1420 Terminal

— Typewriter-style keyboard plus 15-key numeric keypad
— 80 characters per line by 24 lines
— 5 by 7 dot matrix, 96 displayable characters including lower case
— Accepts all 128 ASCII codes
— RS-232 interface has 8 selectable baud rates up to 9600 baud
— User-defined display attributes include blink, half-intensity and non-display

$1395



EPSON MX-80 PRINTER

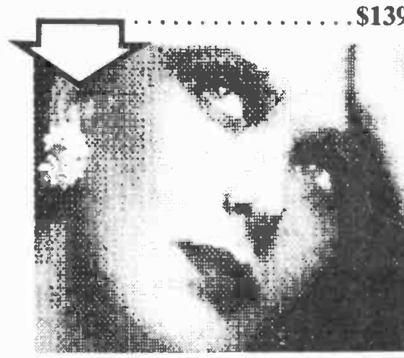
The EPSON MX-80 Dot Matrix Printer is a highly versatile, general purpose and computer-grade printer featuring 80 CPS bi-directional printing with logical seeking capability and 9 × 9 dot-matrix character formation. The MX-80 accepts the ASCII 96 codes for special characters/symbols. It also accepts codes for 64 graphic symbols.

Characters can be printed in any desired size — enlarged, condensed, emphasized, normal, etc. The one-chip microprocessor is engaged in performing all functions of the Printerand the two built-in stepper motors of the MX-80 control the carriage and paper feeding functions respectively. Therefore, versatile software controls, suchas horizontal and vertical tabs, and form feed are at your disposal. In addition, interface options are available to permit handshaking with most personal computers.

. . . . $819.00

The Epson MX-100 68/116/136/233-Column Dot Matrix Printer.

. . . . $1390.00



EPSON Accessories

Apple II Interface	$85.00
Apple Cable	$39.00
TRS 80 Interface	$72.95
TRS 80 Cable	$39.50
PET Interface	$108.00
PET Cable	$39.50
Serial Interface (RS 232-C)	$99.00
MX-80 Printhead	$49.00
TX-80 Ribbon	$4.50
MX-80 Ribbon Cassette	$15.75

ALL PRICES ARE IN CANADIAN FUNDS, 9% FEDERAL SALES TAX INCLUDED

Exceltronix Components & Computing Inc.

Test Equipment

LEADER LBO-515B OSCILLOSCOPE

The LBO-515B is a compact, extremely versatile oscilloscope for both lab and field use. Its 30 MHz bandwidth and 5mV sensitivity make it suitable for a broad range of applications in design, testing and servicing of both digital and analog circuits and equipment. A 4-inch internal graticule PDA CRT provides sharp, bright displays even at the highest sweep rates. The dual time base with calibrated delay time permits accurate observation and time interval measurements of complex waveforms.

....$2,275.00

LEADER LBO-308S 'SCOPE

LBO-308S is battery operable dual trace oscilloscope with a bandwidth of DC-20MHz and sensitivity of 2 mV/DIV. With the adoption of 95mm rectangular C.R.T., internal graticule in highly spot brilliancy and clearness is to be obtained. Engineered for service in the field of television, V.T.R., computer with wide bandwidth LBO-308S is portable, easy and convenient of operation for use in schools or the hobbiest shop.

................................$1,394.00

HIOKI TEST EQUIPMENT

3207 DIGITAL POCKET HI TESTER

This is a full autoranging 3½ LCD digit digital multimeter in a case that is only 12.5mm thick. It features autopolarity, unit symbol, automatic or manual ranging, overrange alarm, a maximum input voltage of 1000VDC and 750VAC, and a low power ohms tester for in-circuit testing.

................................$199.95

3209 DIGITAL HI TESTER

This is a high-quality bench-style digital multitester. The following functions are available: capacitance (0.001nF-20uF), continuity (with audio alert), low power ohms (for in-circuit testing), diode checking, and the standard functions (AC volts, DC volts, DC amps, etc.). Also standard is a BCD output is either digit-serial or bit-parallel, which can be used with a digital printer for data processing.

................................$595.00

3208 CALCU HI TESTER

This is a pocket digital multimeter with a full function electronic calculator built right in. The multimeter has all the features of the 3027 multimeter (see above), and the calculator is an 8-digit calculator with scientific functions available.

................................$361.45

Multiflex Low Cost Logic State Analyser

You've just completed a microprocessor system, and it doesn't work. What next? You can use a scope to check for clock signals and the like, but if everything appears to be in order you can't go any further without more sophisticated equipment. In these situations, professionals use Logic State Analyzers costing thousands of dollars to locate the problems. The Multiflex Logic State Analyzer has all the essential features of such expensive equipment, at a tenth of the price. This is a high-quality piece of test equipment, suitable for industrial or scientific use, but it is affordable by the hobbyist. It is simple to understand and operate.

The Logic Analyzer allows you to monitor 16 points in a digital system (ie: data bus, address, or control lines) which carry continually changing signals. Then you can select a bit pattern you expect will appear at those points, which will trigger the analyzer to record the next 1023 bit patters so that they can be examined, step by step. For software development the Analyzer is invaluable, especially for dedicated systems. If you design a microprocessor system for a specific function, and you have no monitor, assembler, or similar software, the best and often the only way to test and debug the system is with a Logic Analyzer. It will let you look closely at the data flow as a program is executing, or monitor the address lines to make sure the instructions are being executed in the proper sequence. You can also examine the various control lines such as memory read and write, DMA, interrupts, or enable and disable signals. You can of course monitor any combination of these signals, such as the data bus and half of the address bus, or half of each plus four control lines, etc.

A special feature of the Multiflex Logix Analyzer is that any number of units can be interconnected for dealing with larger input words. With two Analyzers, you monitor the address and data buses of an 8-bit microcomputer, and have 8 spare inputs for control lines, i/o signals, or signals from external devices.

Technical Specifications

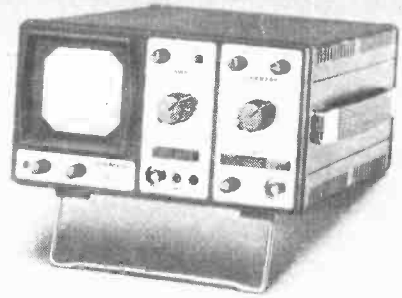
- 16 bit input word; 16 bit combination trigger selection
- any number of units may be interconnected for larger input words
- 1 K words storage
- 5 MHz, 6.6 MHz, and special 10 MHz versions available
- 16 LED binary readout plus 4 hex digits
- 3 hex digit entry number display
- forward and back stepping at low and high speed
- switch selectable logic polarity and clocking edge

LSA-1K Logic Analyzer kit without case $295.00

LSA-1KC Logic Analyzer kit with case $350.00

LSA-1 Logic Analyzer (assembled, with case) $465.00

Hameg Oscilloscopes



— The specials continue on German-made Hameg scopes:

HM307 $495.00

Specification

Vertical Deflection (Y)

Bandwidth DC to 10MHz (-3dB)
DC to 15MHz (-6dB)
Risetime approx. 35ns
Overshoot max. 1%
Deflection coefficients 12 calibr. steps
5mV/cm to 20V/cm in 1-2-5 sequence
accuracy better than ±5%
Input impedance 1MΩ//25pF
Input coupling DC AC GD
Input voltage max. 500V (DC + peak AC)

HM512 $1795.00

Specification

Vertical Deflection (Y)

Bandwidth of both channels
DC 50 MHz (-3dB) DC 65 MHz (-6dB)
Risetime 7 ns (approx.)
Overshoot 1% (maximum)
Deflection Coefficients 12 calibr. steps
5mV/cm 20 V/cm (1-2-5 sequence)
with variable gain control uncalibr. to 50 V/cm
accuracy better than ±3% (in cal. position)
Input Impedance 1 Megohm 25 pF
Input Coupling DC AC GND
Max. Input Voltage 500 V (DC + peak AC)
Polarity normal or inverted on channel I
Overscanning indicated by 2 LED's
Delay Line allows viewing of leading edge

Operating Modes

Channel I, channels I and II
alternate or chopped (approx. 1MHz)
Addition channel I + II
Difference with channel I inverted
X-Y Operation (ratio 1 : 1 input via ch. II)

HM312 $769.00

Specification

Vertical Deflection (Y)

Bandwidth of both channels
DC-20 MHz (-3dB) DC-28 MHz (-6dB)
Risetime 17.5 ns (approx.)
Overshoot 1% (maximum)
Deflection coefficients 12 calibr. steps
5 mV/cm 20 V/cm (1-2-5 sequence)
accuracy better than ±3%
Input impedance 1 Megohm 25 pF
Input coupling DC AC-GND
Max. input voltage 500 V (DC + peak AC)
Operating modes
Channel I, channel II, channel I and II
alternate or chopped (approx. 120 kHz)
X-Y operation (ratio 1 : 1 (X input via ch. II)

Timebase

Time coefficients 18 calibrated steps
0.5 µs/cm 0.2 s/cm (1-2-5 sequence)
with magnifier x5 to 100 ns/cm
with variable control uncalibr. to 40 ns/cm
accuracy better than ±3% (in cal. position)
Ramp output 5 V (approx.)

HM412 $1149.00

Specification

Vertical Deflection (Y)

Bandwidth: of both channels
DC 20 MHz (-3dB) DC-28 MHz (-6dB)
Risetime 17.5 ns (approx.)
Overshoot 1% (maximum)
Deflection coefficients: 12 calibr. steps
5 mV/cm-20 V/cm (1-2-5 sequence)
variable gain control uncalibr. to 2 mV/cm
accuracy better than ±3% (in cal. position)
Input Impedance: 1 Megohm // 25 pF
Input coupling DC-AC-GND
Max. input voltage 500 V (DC + peak AC)
Polarity normal or inverted on channel I
Overscanning indicated by 2 LED's
Operating modes
Channel I, channel II and II
alternate or chopped (approx. 1 MHz)
Addition channel I + II
Difference with channel I inverted
X-Y operation (ratio 1 : 1 input via ch. II)

Mail Orders

SEND A CERTIFIED CHEQUE OR MONEY ORDER (DO NOT SEND CASH). MINIMUM ORDER IS $10 PLUS $3 FOR SHIPPING. ONTARIO RESIDENTS MUST ADD 7% PROVINCIAL SALES TAX. VISA AND MASTERCARD ACCEPTED: SEND CARD NO., SIGNATURE, EXPIRY DATE AND NAME OF BANK.

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Price Policy

REMEMBER THAT AT EXCELTRONIX, ALL PRICES ARE NEGOTIABLE FOR QUANTITY PURCHASES. IF YOU CANNOT AFFORD LARGE QUANTITIES ON YOUR OWN, HOW ABOUT STARTING A CO-OP.

 Prices are subject to fluctuation. For quantity pricing or industrial purchases please contact us.

POKEING ON THE ZX80

Here are some useful tips for owners of this popular little low-cost micro, showing how to make screen POKEs by M.E. Bryant.

OF THE DESIGN compromises which allowed Sinclair to produce a high-level language microcomputer selling for under $300 here, perhaps the most noticeable is the lack of a memory-mapped display with separate video control, resulting in the now infamous screen-flicker on data entry and the absence of any display during computations.

The absence of a memory-mapped display can be a nuisance, especially for the writer of games programs, as one of the most interesting things one is able to do is to PEEK at individual screen locations and to POKE characters directly on to the screen. Animated graphics, of course, depend on this facility, but they are definitely out with the ZX80 because the screen would remain blank while the action was being computed. On the other hand, using POKE to put characters on to the screen is feasible and is potentially a useful feature.

Filing a display

With a memory-mapped display there is no problem because the display file is contained within a fixed amount of RAM. The screen can be considered to consist of a matrix of locations (number of lines by number of characters per line) with the memory address of each one fixed and known. To make a character appear at any desired point on the screen it is simply a matter of POKEing the code for that character at the relevant location address.

On the ZX80 things are rather different. The display-file uses a variable amount of RAM depending on the quantity of data to be displayed. The addresses of the various locations on the screen also vary according to the length of the program. In addition, the location addresses change during the running of a program whenever data is input for the first time or variables are assigned.

The computer, of course, knows where the display-file is in the RAM at any time and the address of the start of the display-file is recorded as a two-byte record at address 16396. By PEEKing at that address we can locate the display-file and then calculate the addresses where we need to POKE to get characters on to the screen.

Character by character

The first character in the display-file is a "newline" character, so that if we call the address of the start of the display-file W then the first visible character location (top left) is at W + 1. Each line consists of up to 32 visible characters with a new line character at column 33. By adding the appropriate multiple of 33 plus the column number to W we can get the address of any character location on the screen. If we call the row number A and the column number B then the address formula is
W + (A – 1)*33 + B.

Of course the display-file has to exist before we can start PEEKing and POKEing at it. If we wish to POKE on to a blank screen then it is first necessary to create a display-file full of spaces. Unfortunately a succession of PRINT statements will not achieve this and although a FOR ... NEXT loop PRINTing individual spaces will, it is very cumbersome. Luckily PRINT ,,,, creates a line full of spaces so a short loop can be used to produce the required number of screen lines. Obviously characters can be used as well as spaces to create a display-file. Up to 23 lines can be printed in this way.

Having ensured that we have a display-file we can now take a PEEK at its starting address. The following subroutine achieves this and it is used in all subsequent listings:-

```
500  LET P = PEEK(16397)
510  IF P>127 THEN LET P = R-256
520  LET W = PEEK(16396) + P*256
530  RETURN
```

It should now be obvious how we can use this address to POKE a character on to the screen. The following program establishes a blank display-file, inputs a row and column number, POKEs character code 148 (inverse asterisk) at the relevant address and then inputs another "grid reference". When the program is run, inverse asterisks appear at your bidding anywhere on the screen:-

```
 10  LET P = 0
 20  LET W = 0
 30  FOR A = 1 TO 22
 40  PRINT ,,,,
 50  NEXT A
 60  INPUT A
 70  INPUT B
 80  IF A>22 OR B>32 THEN GOTO 60
 90  LET Y = (A-1)*33 - B
100  GOSUB 500
110  POKE W + Y, 148
120  GOTO 60
500  LET P = PEEK(16397)
510  IF P>127 THEN LET P = P-256
520  LET W = PEEK(16396) + P*256
530  RETURN
```

The following two alterations to the listing extend this simple program:-Specify character to be POKEd:-

```
 84  INPUT C
110  POKE W + Y,C
```

(C is relevant character code)

POKE character taken from the keyboard:-

```
 84  INPUT C$
 86  LET X = CODE(C$)
 88  IF X>191 THEN GOTO 84
110  POKE W + Y,X
```

It will be noticed that the programs above assign variable P and W before the first PEEK. This is because, as mentioned before, any variable assignment or initial input will alter the location of the display file. If you write any screen-POKE programmes and find that the characters are displaced it will almost certainly be because a variable in either PEEK or POKE has not been previously assigned. A similar case is where an initial input or an assignment is made after a previous PEEK or POKE, when it will be necessary to take another PEEK at W before POKEing again.

Careful POKEs

Another thing worth remembering is that POKEing can be a hazardous occupation if you happen to POKE in the wrong place or even if you POKE an inappropriate character code in the right place. Care should therefore be taken when writing programs to ensure that characters are not POKEd outside the boundaries of the display-file. Usually such characters

Continued on page 70

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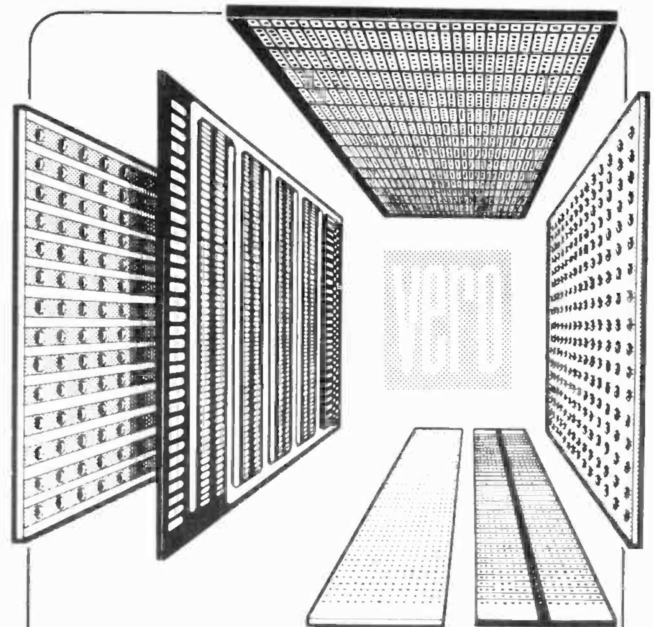

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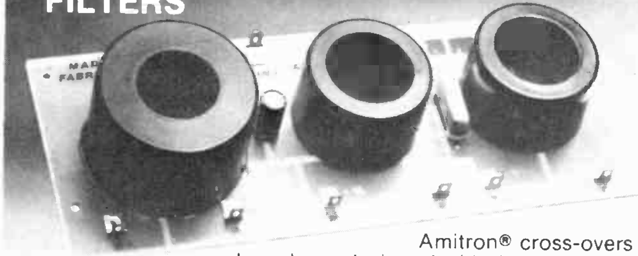

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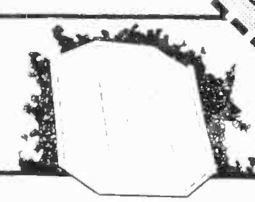

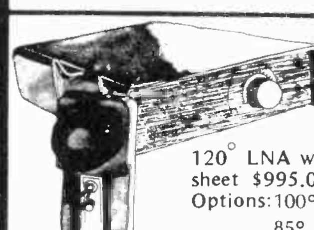

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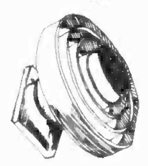

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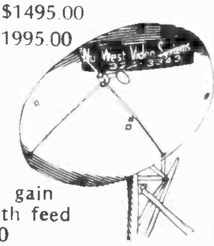

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VIC·20
COMPUTER REVIEW

The VIC-20 is a complete video games arcade, with a full blown micro-computer in the bargain.

IF YOU CONSIDER the amount of money spent each year on the vital necessities of life, such as Space Invaders games, Asterock games and the all important Roadrace with adjustable levels of difficulty games, and add that to the time it takes to drive to and from the saloon where the games are kept, plus the price of eighteen to twenty beers at $1.45 a throw to break the tension whilest waiting for the aliens to fire upon your helpless spacecraft. . . it doesn't take too much rationalization to figure out that you need a home computer. If you consider that a computer, at, say, $500.00, would pay for itself in just 2000 games, the way is clear. It's time to break out the cheque book and put an ad in the paper to sell the Edsel.

For considerably less than a fully restored, mint condition Edsel would go for these days, you can buy a fairly fabulous home computer, the VIC-20, from the boys at Commodore Bussiness Machines. Actually, at $450.00 for the basic VIC, it's less than the tag on a rusty '67 Chevy with optional engine. While you can't actually drive a VIC, you can write a program that will do a brilliant simulation.

The VIC is, in a sense, an outgrowth of the PET. However, it is particularly suited for game playing, as well as the more serious happenings that can be done on a small computer. It has features oozing out of every opening in the case, including a variety of input/output ports, sixteen colours for the screen, four voices of sound (three programmable tones plus noise), programmable characters, full upper and lower case characters plus PET graphics plus a few other characters because they were there, and provisions for all sorts of expansion, peripherals and high technology do-dads. It has been extremely difficult to pry our sample away from the rest of the herd here to write this review.

The $450.00 (Canadian) price includes the VIC, a VHF modulator, cables, and 'a Friendly Computer Guide', the VIC-20 manual. Even this is really well done, equal in most respects to even the documentation for the Apple.

The VIC does not come with a tape recorder, which is $120.00 extra if you buy it from Commodore. Actually, all but the very cheapest of cassette machines will work, and there's no hassle interfacing them. (The mating connector for the board is a standard six position dual readout .156 inch edge connector, such as Edac 308-012-400-202, and the pinout is given in the VIC manual.)

The VIC itself is 16 x 8 x 3 inches in the totality of its volume, or very little larger than the size of its keyboard. Without expansion, there's 3583 bytes of useable RAM. On to the internals.

Graphics

The VIC can generate sixteen colours. These can be seen as screen (background), character (foreground) and border colours. The colours can be set by POKEing locations in memory. Some basic colour manipulation can be done from the keyboard, as well.

The VIC has a character set of graphics, just like the one on the PET. Unlike the PET, it is accessible from the keyboard directly, instead of by POKing an internal register. Thus, each key can produce the character on its top, plus two other ones, which are printed on its face. A bit tricky to get the hang of, but emminently useful in the end. The keyboard can also be set to type in lower case, with shifted uppers, just as in a regular typewriter. This is a drag when entering BASIC programming, which is all in upper case, so there's also a mode that allows the unshifted characters all to be upper. These various permutations are not as complex as they seem

The thing that seperates the VIC's graphics from the PET's is the fact that the characters are programmable. With most computers, including the PET, the dot patterns for the characters are called directly from a ROM. This means that they are, for practical purposes, pretty well inalterable, unless you change the ROM. With the VIC, however, the contents of the ROM get dumped into RAM upon power up, and are thence read from there. These locations can be POKEd, and, hence, changed. Therefore, each ASCII value can be assigned a corresponding dot pattern of any desired shape. The dots that comprise an 'a', for example, could be changed to form a specialized math symbol, part of a space ship, or any shape needed for complex graphics, and, thereafter, any time an 'a' was typed, that symbol would show up. The VIC is fairly loaded with specialized graphics characters as it stands, so there are plenty of places to store reprogrammed characters, even leaving the alpha and numerical ones alone.

The screen memory consists of 506 contiguous locations, which can be PEEKed and POKEed, just like regular memory. Thus, fairly rapid animation is possible. The CBM V2 BASIC in the VIC seems to be unusually fast, even on things like PRINT statements, which generally take quite a while, by computer standards.

The VIC uses the same sort of screen editing capabilities as the PET. To modify a line of programming on the screen, you just cursor up to it, and change it. As soon as the carriage return is struck, it is entered into BASIC memory. The lines are twenty two characters long, with up to four lines being allowed for each line number.

Ports

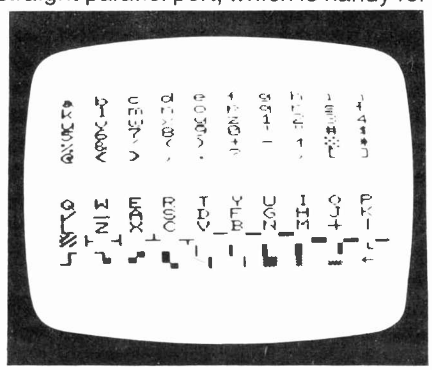
The I/O if the VIC is handled by a single gorrilla IC, the 6560 Vidio Interface Chip. . . hence the machine's name. It's quite the device; hopefully, in a couple of months we'll be having a closer look at the chip itself.

There are several connections to get in and out of the VIC. The simplest is something that looks like a mini RS-232 thing on the side. It is predominately a game interface, accessing A/D converters, and inputs for a light pen. It can thus handle joysticks and paddles without any interfacing hardware at all.

There is a memory expansion port, which permits both additional RAM, plus firmware to be added to the bus. Both will be available shortly. The firmware looks to be quite interesting. 'ROM-packs' will be available with games, utilities and implements to upgrade BASIC. The most impressive one I saw was a high resolution graphics pack, which added DRAW and PAINT commands, plus CIRCLE, ELLIPSE and ARC functions, permitting some really dazzling pictures.

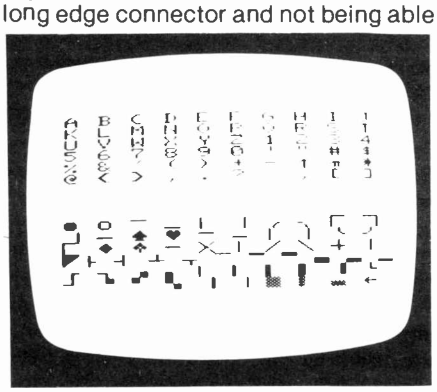
There's a serial interface port, which will drive things like discs and printers. On the PET, this was buried in the user's port; this makes it a bit more accessable.

The user's port on the VIC is a straight parallel port, which is handy for



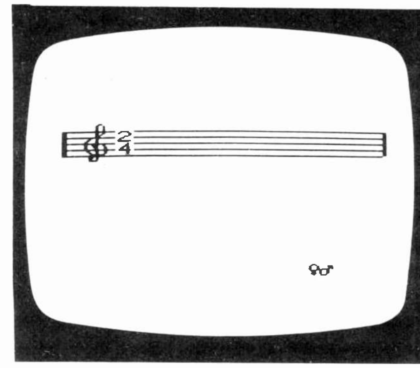
having the machine talk to other, un-memory mapped devices.

If you're really into hanging peripherals on your machine, you will never have enough I/O lines. However, the appointment of the VIC seems to be a fairly good compromise between having the whole rear of the machine one long edge connector and not being able



to get at the internal workings all. The fancy ports, like the ADCs, offer a whole bunch of potentials that are usually a fair bit of hassle to implement.

The VIC can provide up to four simultanious sounds, which can be accessed through the video output jack, or, more easily, fed into the modulator and heard through the TV set's speaker. These are three organ type tones, in three registers, plus noise of variable spectral content. The three tone ranges, dubbed alto, tenor and soprano, cover about six octaves, overlapping quite a bit. There are 127 steps of pitch control.



Each tone can be enabled and disabled separately. There are also 127 steps for the filter on the noise. The four sound sources are fed through a single attenuator, which can be programmed for sixteen steps of volume.

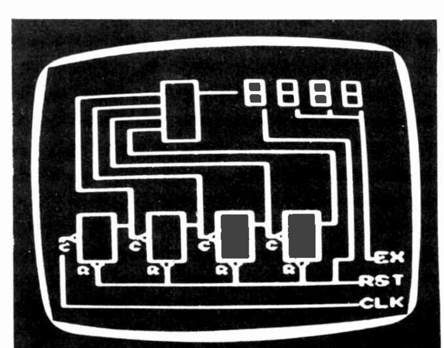
The control on the tone pitches isn't bad; you can set them to between a quarter and an eighth of a semi-tone of actual piano notes, which is certainly good enough to play recognizable music. To get any better, additional 'trimming' registers would be needed for fine tuning, which would greatly add to the complexity of the sounds. As it is, you could hook a keyboard up to the VIC and make a first rate practice organ. The BASIC is fast enough to actually implement envelopes for the sounds.

The VIC manual lists several pages of routines to produce an array of sounds for games and what have you. They range from birds chirping to laser beams and several aspects of UFOs. We tried a few, and they are amazingly good for such a simple synthesizer.

The Manual

A computer is only as good as its documentation. If you don't believe this, try programming a microprocessor board with the information contained in the data sheets for the chip. Thus it is that something needs be said about the VIC's little spiral bound book.

As an experiment, we gave the machine and book to Cindy, the girl who sets the type here, to see what she could make of it, on the basis that, prior to that moment, Cindy had never done anything



more with a computer than play blackjack on one. By the time lunch time came, and hunger overtook her, she was about a third of the way through the book, and could deal with most of the primary functions of BASIC. The book provides an excellent introduction to the machine, and is ideal for someone who's never used a computer before.

If you do know how to deal with a BASIC machine, the features peculiar to the VIC are outlined, in condenced form, in the appendixes at the back of the book, which saves having to wade through pages of introductory material. The only thing lacking is a page 0 memory map; being able to fool around with this is one of the things that makes PETs so magic. Presumably this can be pried out of Commodore if desired.

The Future

The additions presently in the works for the VIC are pretty nice looking. By the time you read this, a few should actually be available, with the rest on the way.

The 'Super Expander Cartridge' snags the memory expansion port, adding 3K more RAM, the high resolution graphics and some additional functions for the keyboard. The 'Programming Aid Cartridge' adds some extra BASIC commands, similar to the 'Programmer's Toolkit' ROMs for the PET, a machine language monitor, and other additional keyboard functions. There's a six slot bus extender with a built in IEEE-488 interface, which lets one use multiple ROM cartridges, and other peripheral flotsam simultaniously.

The IEEE-488 interface can also be had all by itself.

Commodore is planning a 5¼ inch floppy disc, and a printer, both of which are expected shortly, both under $500.00 each. The printer will be able to reproduce any character that can be put up on the screen.

The user port contains an RS-232 interface, which will hook up to a modem, permitting the VIC to talk to other data systems.

There will, of course, be joysticks and paddles available to plug into the game port. There will also be game software in ROM, which is neat, because it boots automatically upon power up.

The Last Word

We're all very impressed with the VIC. To date, it's the best home computer we've seen, and by far the best machine available for under $500.00. It strikes a really fine balance between economy and flexibility, and should be a valuable tool for both the complete novice, the experianced user, and the occasional girl who does typesetting.

Now, if there was only some way to dislodge her from it, so as to get back to playing 'Breakout'.

Shortly after writing this review, we decided that we needed yet another computer here, and bought the VIC we'd had for this article.

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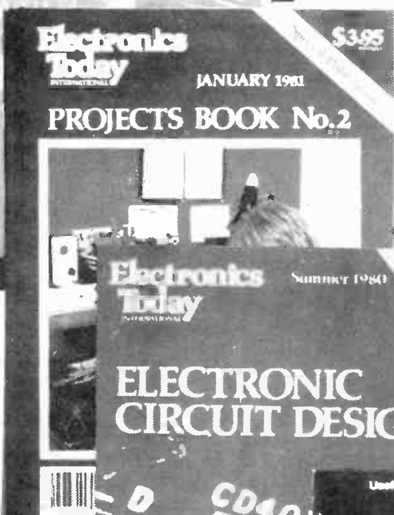

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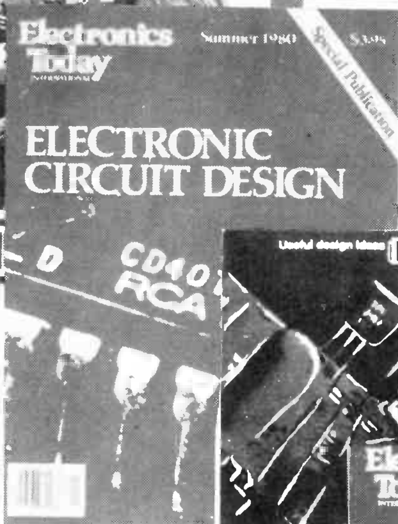

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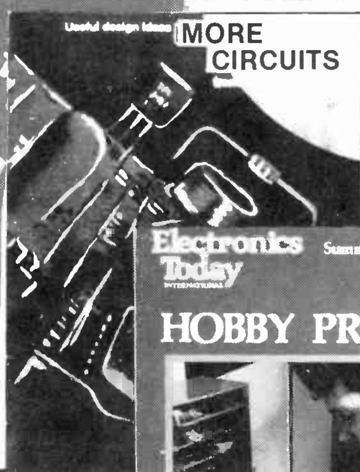

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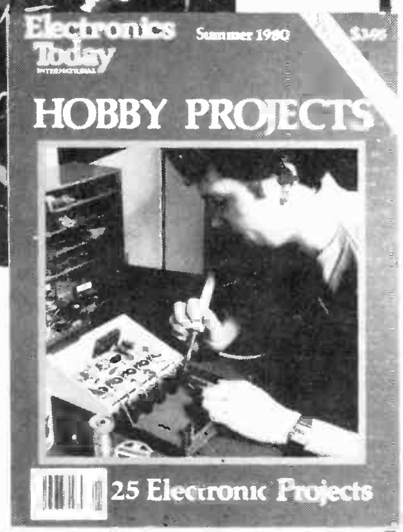

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Play it, Sam

The instrument can either be played manually, automatcally, or by a combination of the two methods. In the manual mode, each channel can be played using a small speaker, connected to the channel input: the speaker acts as a 'drum head' transducer and triggers a percussion sound when the cone is tapped with a finger or stick.

The instrument can be played automatically using the built-in eight-step double sequencer. Each channel of the sequencer is used to control one of the channels of the percussion instrument, and can be programmed with a DIP package of eight SPST switches to generate ant one of a variety of rhythms. The sequencer can be used in the fully automatic mode, in which it continuously cycles through the eight-step sequence, or can be used in a triggered, or manual initiate, mode in which it runs through a single eight-step sequence each time that an external switch is momentarily closed. The manual initiate facility enables the internally-generated rhythm to be manually synchronised to an external beat (with a foot switch, etc), or to be introduced into the music only in those parts where it is required.

The manual and automatic playing methods operate in the OR mode. In other words, manually-initiated percussion sounds can be played at the same time as the automatically initiated sounds. A particularly attractive way of using the instrument is to play it mainly in the manual mode, but to occasionally bring in a few bars of automatic sequencing with a foot switch, using the manual initiate facility. The unit thus acts as a highly versatile musical instrument.

Construction

The circuitry is built up on two PCBs, a single large board being used to hold all of the components (except the pots and switches) of the main double percussion instrument, and a smaller board being used for the components of the sequencer circuit. The unit uses a good deal of interwiring between the PCB and the total of eleven control pots, etc., so some care is required in the construction.

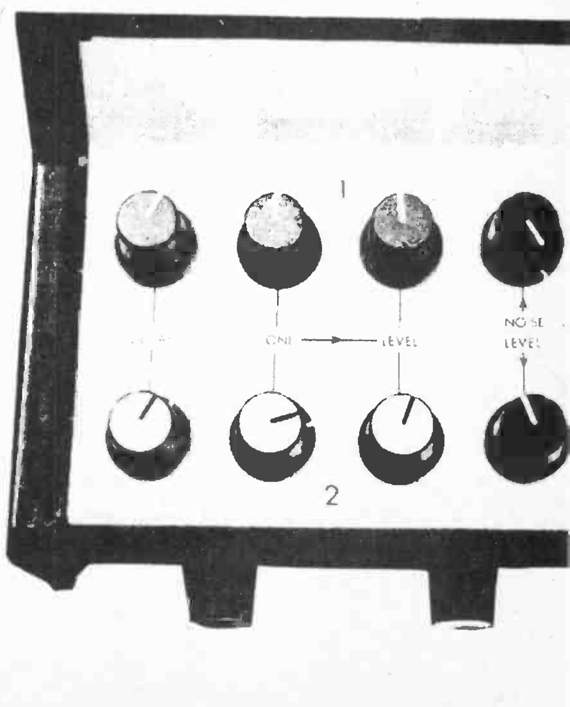
Start the construction by building up the main PCB, taking the usual care over the component polarities. Use Veropins to facilitate the connections from the PCB to the ten control pots.

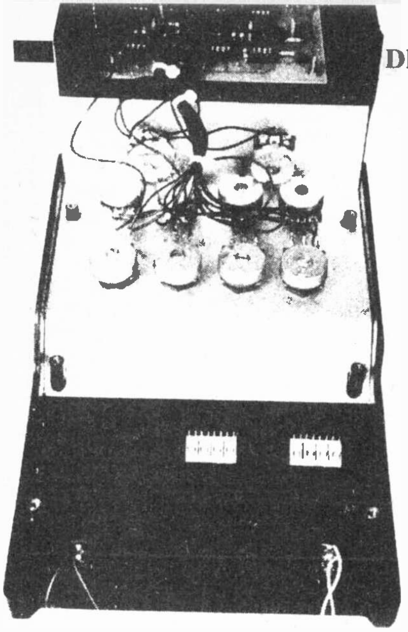
When construction of the main PCB is complete, give it a functional check by temporarily connecting the ten pots to the unit, wire a couple of small speakers (impedance not important) to the two input terminals, connect the unit to a 12 V supply and take the output to an external power amplifier. Check that plain drum sounds can be manually generated on channel 1, and all types of percussion sounds from channel 2. Note on channel 2 that Q5 is used as a white noise source (for generating cymbal sounds, etc), and may have to be selected on test to produce an adequate noise level.

Proceed next with the construction of the sequencer circuit on the smaller PCB. Note that the two sets of DIP switches MUST be mounted in sockets, and that capacitor C2 is mounted on the underside of the PCB.

You can now proceed with the assembly of the two boards and all other components in the case. To complete the construction, fit all the remaining switches and sockets into place and complete the interwiring. We recommend that you use jack sockets to connect the two 'drum head' speakers to the unit, configured so that the input pins short out if the speakers are removed.

When using the completed unit, note that, if the 'drum head' speakers are not used, they must be replaced by short circuits, to eliminate the possibility of circuit instability.





The DIP switches are epoxied to the top of the case as shown here. The sequencer board can then be secured by plugging the DIP sockets onto the exposed pins.

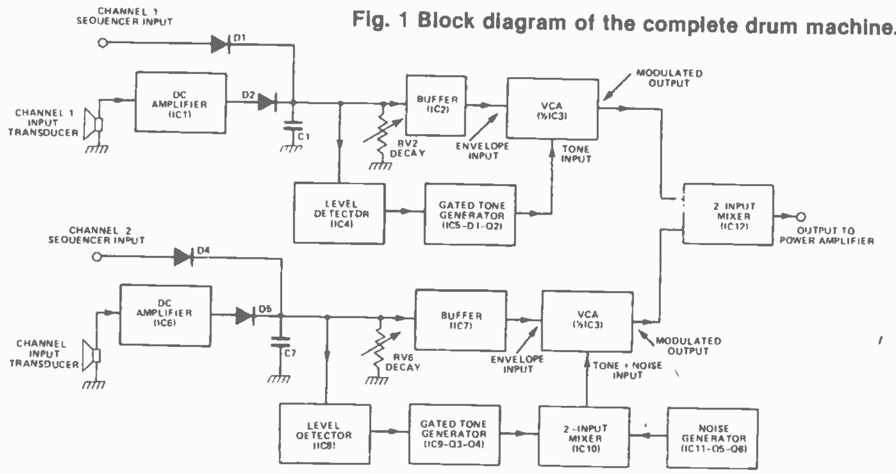
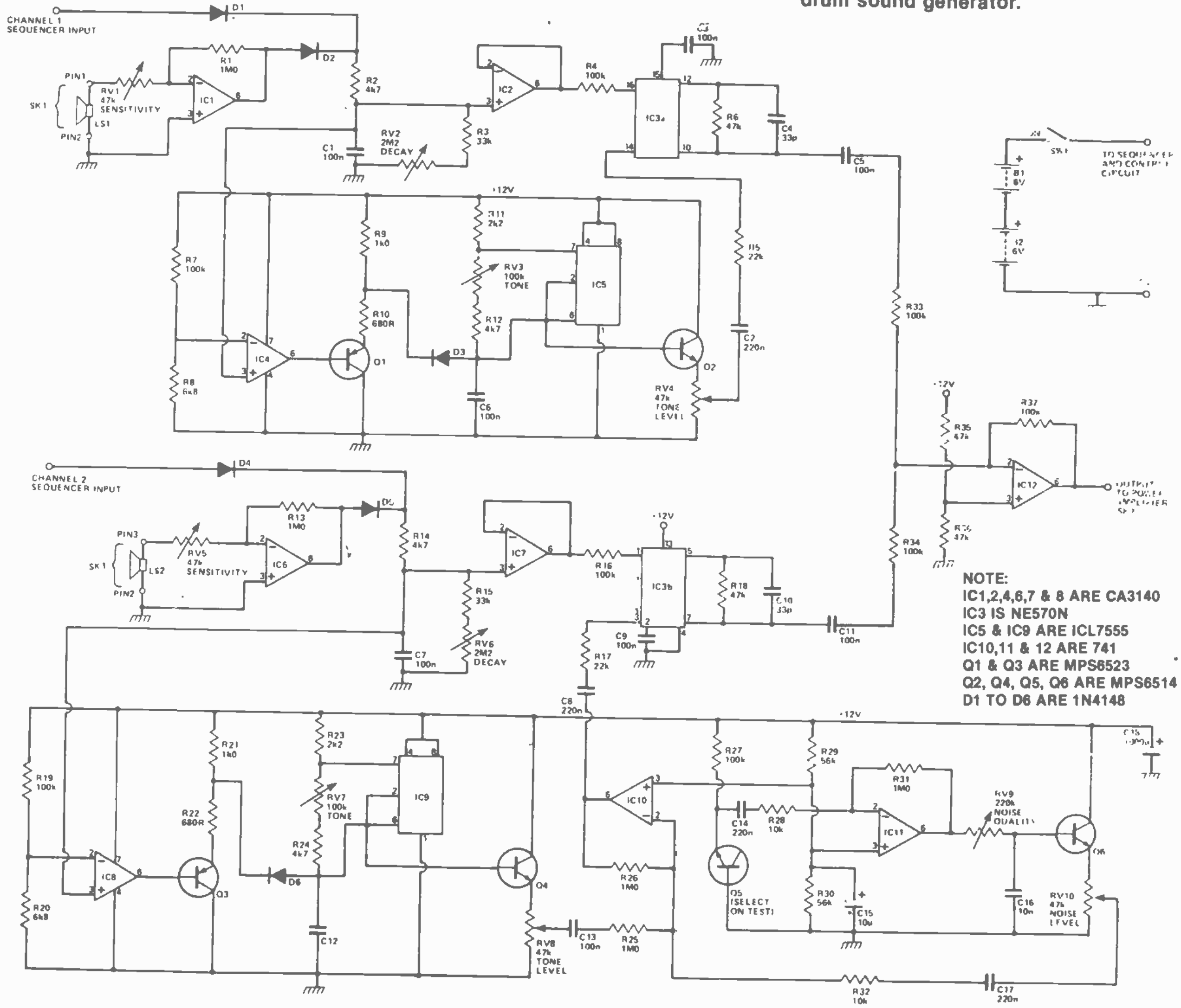


Fig. 1 Block diagram of the complete drum machine.

Fig. 2 Circuit diagram of both channels of the drum sound generator.



NOTE:
IC1,2,4,6,7 & 8 ARE CA3140
IC3 IS NE570N
IC5 & IC9 ARE ICL7555
IC10,11 & 12 ARE 741
Q1 & Q3 ARE MPS6523
Q2, Q4, Q5, Q6 ARE MPS6514
D1 TO D6 ARE 1N4148

HOW IT WORKS

The basic instrument contains two essentially similar channels (see block diagram), each comprising a voltage-controlled amplifier (VCA), a gated tone generator and an envelope generator. The envelope generator produces the characteristic fast-attacks/slow-decay modulation waveform of a percussion instrument and can be activated by either an external transducer (a speaker) or the pulse input of an automatic sequencer unit.

The outputs of the two channels are added in a two-input mixer and are made available at a phono socket, where they can be fed to a power amplifier. The channel 1 circuitry produces modulated tone signals only, and can be used to generate a range of simple drum sounds. The channel 2 circuitry incorporates a noise generator and a two-input mixer as well as a tone-generator, and can be used to repreduce all of the sounds of channel 1 plus snare drums, cymbals, etc.

The two channels of the instrument are basically similar, so let's start off with a detailed description of channel 1. When used in the manual mode the instrument is played using an external transducer such as a speaker (LS1), which is connected to the input of high-gain DC amplifier IC1. Each time that the transducer is tapped, the output of IC1 jumps abruptly positive and rapidly charges C1 via D2-R2: C1 then discharges exponentially via R3-RV2, to produce the characteristic fast-attack/slow decay modulation waveform of a percussion instrument. The waveform is then fed to one half of dual VCA IC3 via unity-gain buffer IC2, where it is used to control the gain of the VCA.

Note that the C1 modulation generator can be activated by either the transducer or by a pulse signal fed to C1 via D1-R1 from the independent sequencer circuit (auto mode). The C1 voltage is monitored by comparator IC4, which gates on astable IC5 whenever the C1 voltage exceeds a few hundred millivolts. The astable generates a symmetrical ramp waveform, which is buffered by Q1 and fed to the 'tone' input of VCA via level control RV4. The tone of the astable can be varied over the range 83 Hz to 1.4 kHz with RV3.

Thus, each time the channel is activated (by the transducer or by a sequencer) a modulation waveform is fed to one input of the VCA and a tone signal is fed to the other, to produce a modulated tone signal at output pin 10 of IC3. The signal is fed to one input of two-input mixer IC12. A wide variety of drum sounds can be simulated by suitable adjustment of RV2, RV3 and RV4.

Channel 2 is similar to channel 1, except that the output of the tone generator (from RV8) is fed to the VCA via a two-input mixer designed around IC10. The other input to this mixer is derived from a noise generator designed around Q5-IC11 and Q6. Here, the reverse-biased base-emitter junction of Q5 is used as a noise source and the noise signal is then amplified by IC11, filtered by RV9-C16 and made available via level control RV10.

The instrument is powered from a 12V supply, derived from eight 1V5 cells. This supply is also used to power the Auto-Manual Eight-Step Sequencer unit.

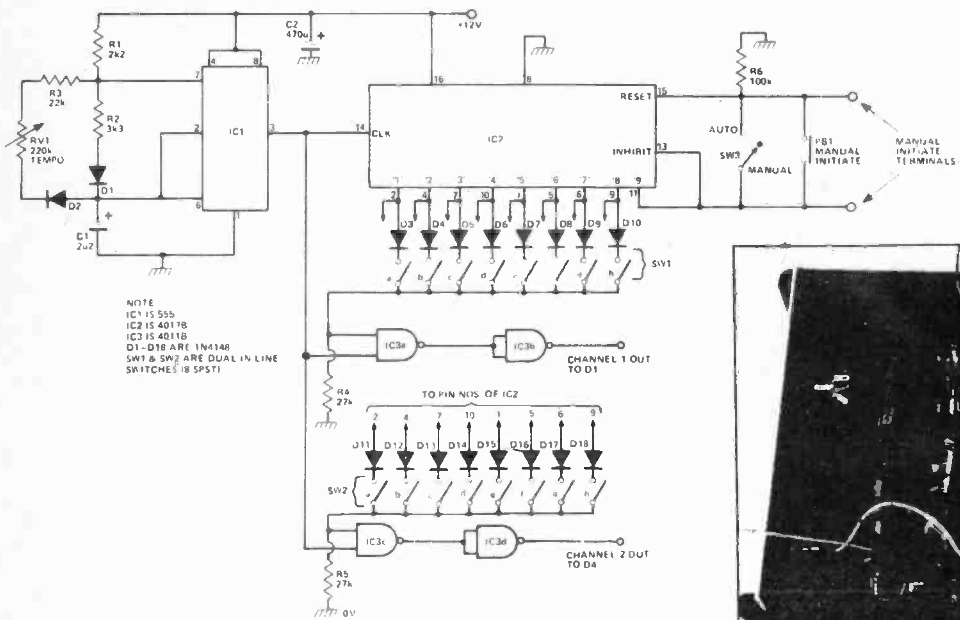
The sequencer unit has two output channels, each of which produces a single or repeating sequence of up to eight 5 mS output pulses: the sequencing period can be varied over a wide range by a clock (or 'tempo') generator, and individual pulses can be programmed in or out on each channel with a dual-in-line package of eight SPST switches. The unit is designed to automatically sequence the double percussion instrument,

The unit comprises a clock generator (IC1), a 4017 counter (IC2) and two sets of switch-programmable clock/decoder coincidence detectors (IC1 and D3 to D18). The clock generator is designed around a 555 astable and generates a series of 5mS pulses, with the inter-pulse period variable over a wide range by RV1. The pulses are used to clock IC2.

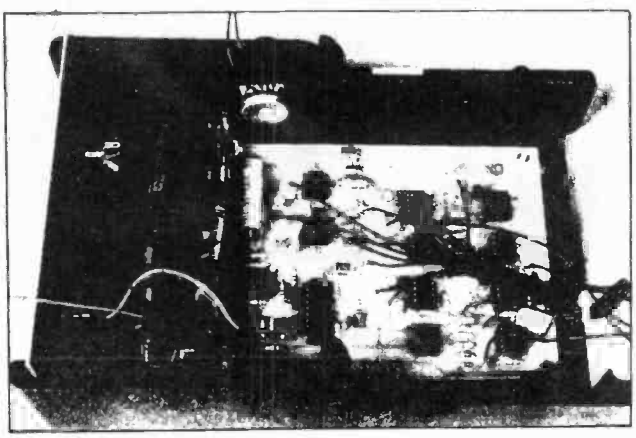
IC2 is a 4017 counter with ten decoded outputs. These output sequentially go high on the arrival of each new clock pulse, with only one output being high at any moment in time. On each channel the decoded 4017 outputs that are required are fed to one side of a two-input AND gate (IC3a-IC3b or IC3c-IC3d) via a bank of diodes and switches, while the 5mS clock pulse is fed to the other side of the AND gate. The programmed sequence of 5 mS pulses are thus generated at the output of each AND gate.

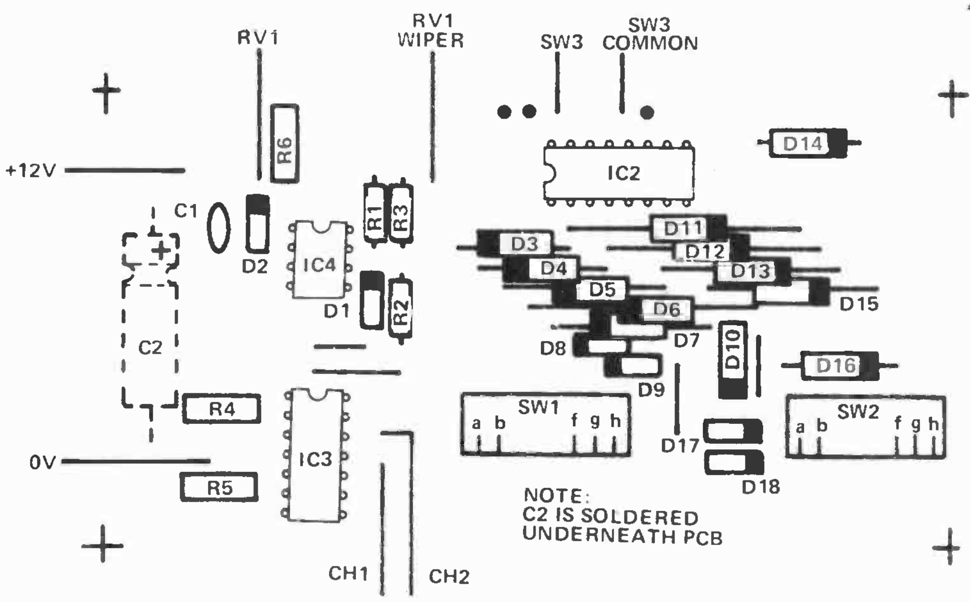
When the unit is operated in the manual mode, the 4017 sequences automatically for the first eight clock pulses and then stops as its '9' output goes high and activates the inhibit pin: the single automatic sequence can be re-initiated by momentarily closing PB1 and thus resetting the 4017 to see a double clock pulse as the '9' output goes momentarily high, thereby causing the '0' output to go high as the IC resets but then causing the '1' output to go high almost immediately. The net effect of all this is that that the sequence repeats continuously when SW3 is set to the auto mode.

Fig. 3 Circuit diagram of the eight step sequencer unit.



Below: the sound generator board and batteries are mounted in the lower half of the case. RV1 (tempo control) can be seen mounted on the side — all other pots are situated on the front panel.





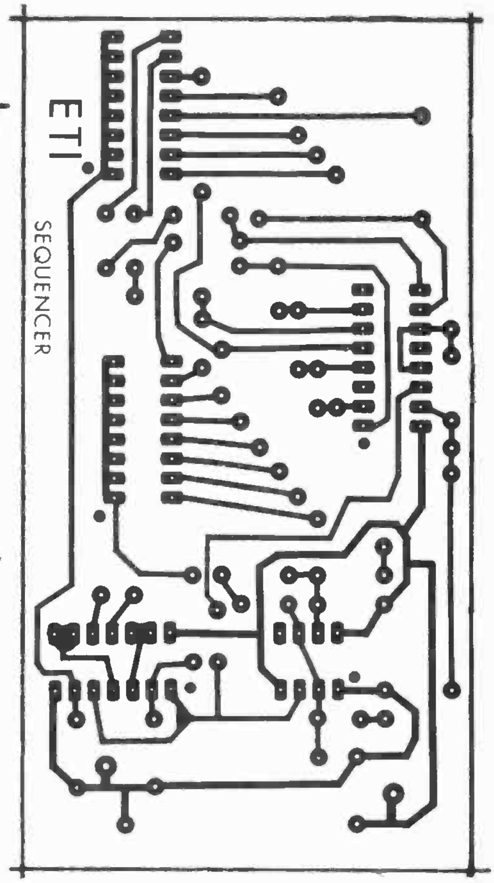
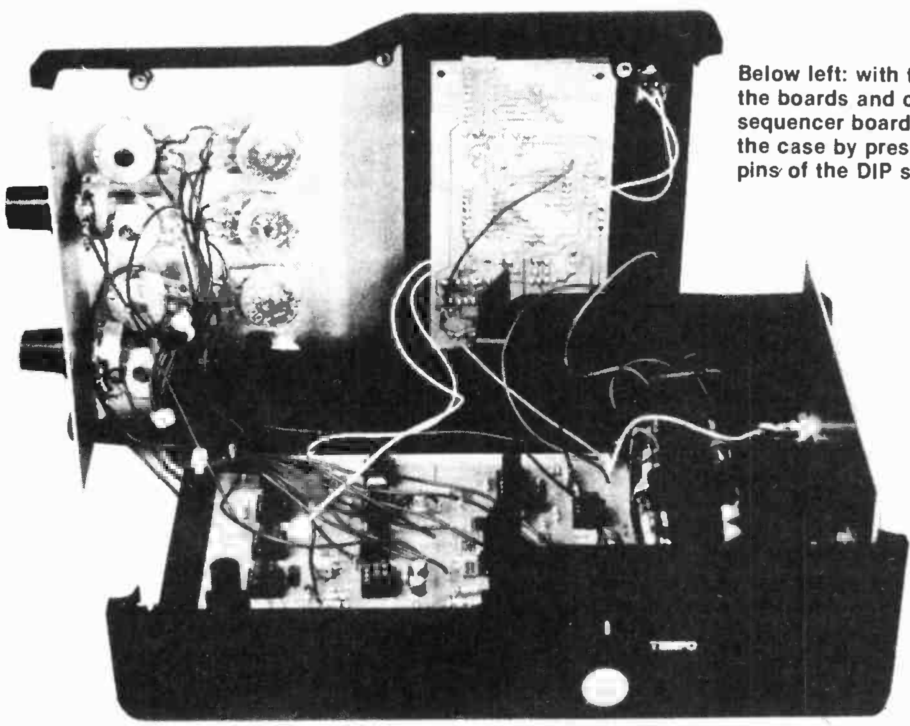
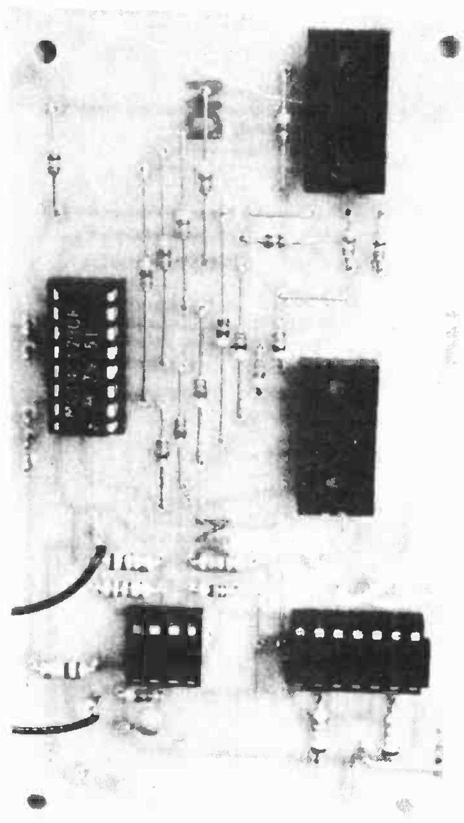


Fig. 4 component overlay for the sequencer board. Note that C2 is soldered underneath the PCB, and an insulated link should be soldered between IC2 pin 8 and the 0 V rail.

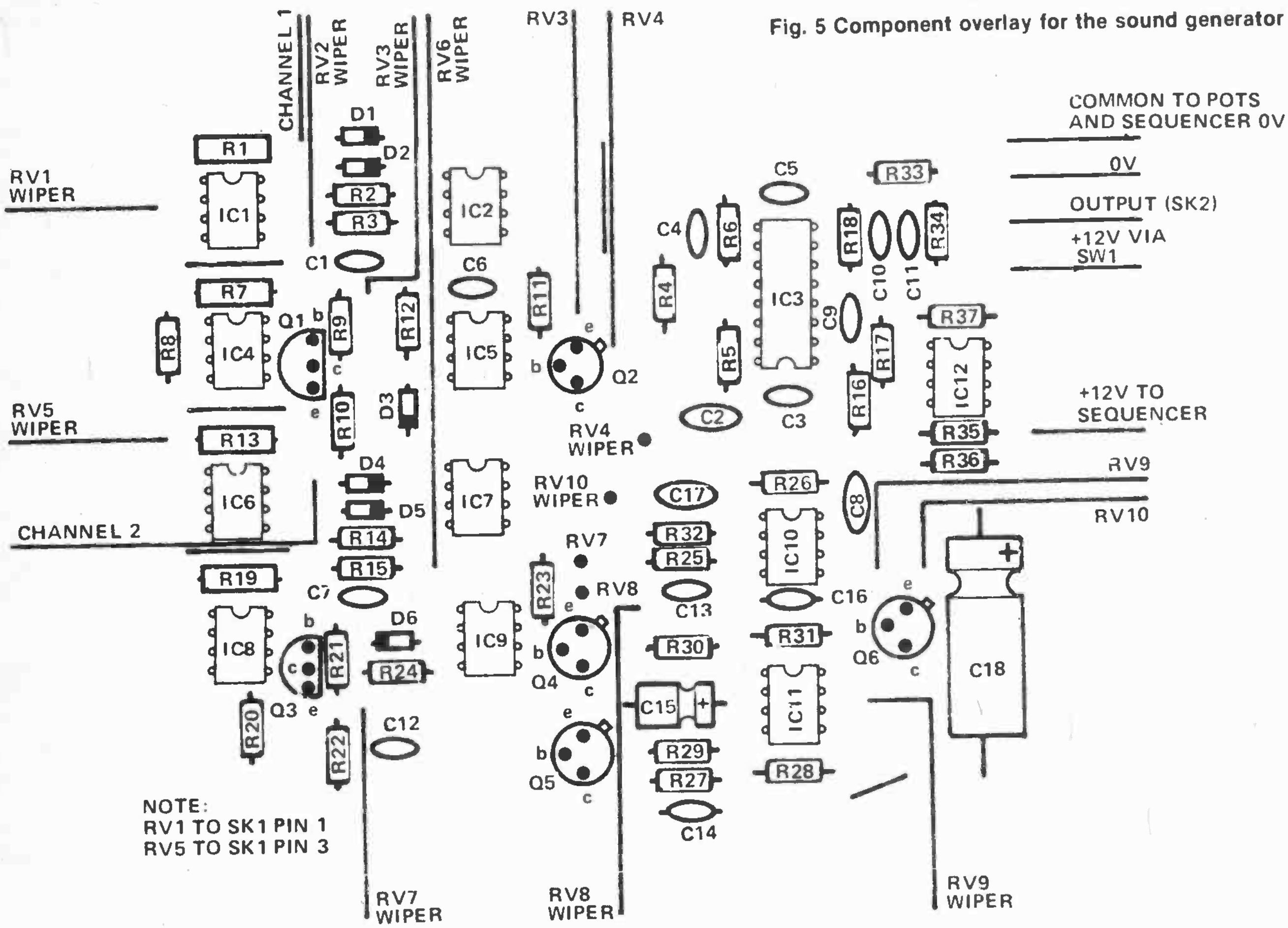


Below left: with the case open you can see how the boards and controls are interwired. The sequencer board (below) is secured to the top of the case by pressing the empty sockets onto the pins of the DIP switches.

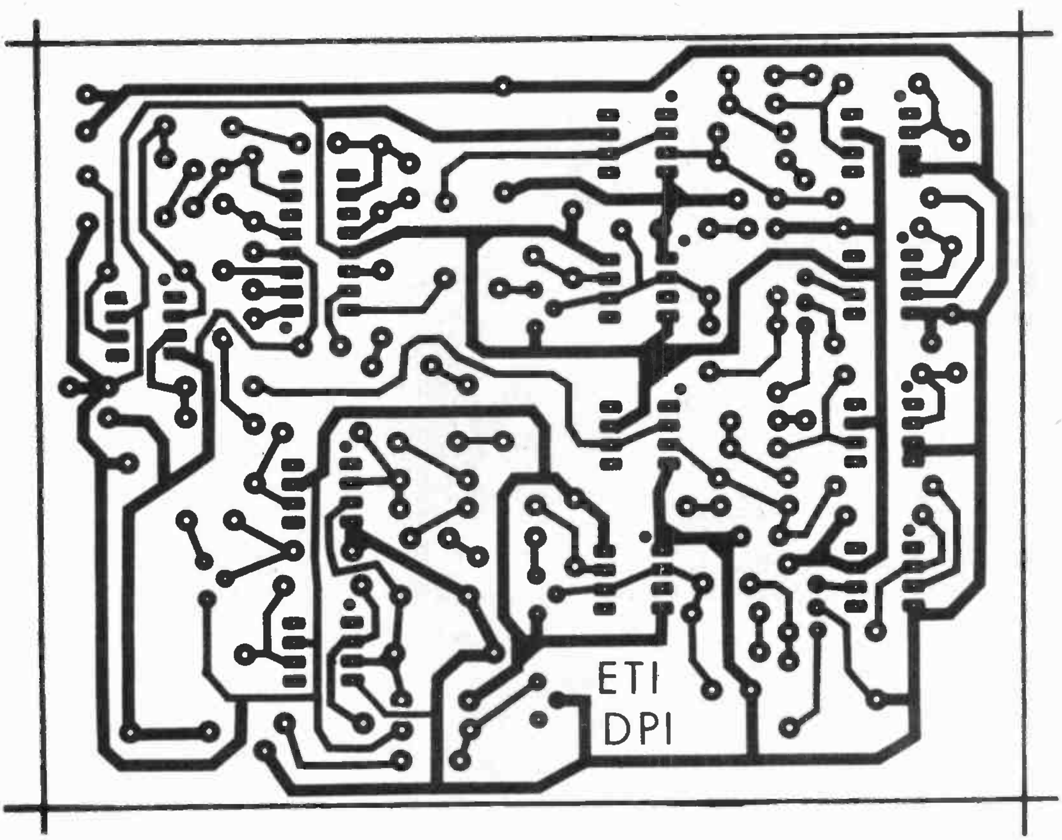


PROBLEMS? NEED PCBs? Before you write to us, please refer to 'Component Notations' and 'PCB Suppliers' in the Table Of Contents. If you still have problems, please address your letters to 'ETI Query', care of this magazine. A stamped, self addressed envelope will ensure fastest reply. Sorry, we cannot answer queries by telephone.

Fig. 5 Component overlay for the sound generator board.



PCB foil pattern



PARTS LIST

CONTROL CIRCUIT

Resistors (all ¼W, 5%)

R1,13,25,26,31	1M0
R2,12,14,24	4k7
R3,15	33k
R4,7,16,19,27,33,34,37	100k
R5,17	22k
R6,18,35,36	47k
R8,20	6k8
R9,21	1k0
R10,22	680R
R11,23	2k2
R28,32	10k
R29,30	56k

Capacitors

C1,3,5,6,7,9,11,12,13	100n ceramic
C2,8,14,17	220n polycarbonate
C4,10	33p ceramic
C15	10u 25V axial electrolytic
C16	10n ceramic
C18	1000u 16V axial electrolytic

Potentiometers

RV1,3,4,8,10	47k linear
RV2,6	2M2 linear
RV3,7	100k linear
RV9	220k linear

Semiconductors

IC1,2,4,6,7,8	CA3140
IC3	NE570N
IC5,9	7555
IC10,11,12	741
Q1,3	MPS6523
Q2,4,5,6	MPS6514

Miscellaneous

SW1	SPST miniature toggle
SK1	3 pin DIN socket and plug
SK2	phono socket
LS1,2	50mm loudspeaker

10 knobs, caps and nut covers
Case
2 four section battery holders.

SEQUENCER

Resistors (all ¼W, 5%)

R1	2k2
R2	3k3
R3	22k
R4,5	27k
R6	100k

Potentiometers

RV1	220k linear

Capacitors

C1	2u2 35V tantalum
C2	470u 25V axial electrolytic

Semiconductos

IC1	555
IC2	4017B
IC3	4011B
D1-D18	1N4148

Miscellaneous

SW1,2	8-SPST dual-in-line lateral switches
SW3	SPST miniature toggle
PB1	momentary push button

1 off collet knob, cap and nut cover.

PULLING THE PLUG

SO, YOU'VE FINALLY gotten 'round to building that fallout shelter you've always been planning. Got it all stocked with food, warm clothing, hundred gallon drums of beer, all the amenities. The wife and rug-rats know how to use the surplus Geiger counters, and there's a Russian phrase book by the door, just in case. However, have you given any thought to what you're going to do with yourself after the big bang?

Consider the options. Most of the pinball arcades will probably be closed. The Post Office will no doubt be on strike for mutation pay, so you won't be getting your copies of ETI. Sitting around your hovel regluing parts of your body can get to be a real drag after a while, and Monopoly looses its charm when all the houses and hotels have been attacked by genetically deformed plastic viruses.

The answer, of course, is to watch TV. If you think about it, there's no reason why a simple atomic holocaust should keep you from screening the new fall shows, find out who shot J.R. this time, watching the home team skating around the ice-9, and all the other pleasures of the tube. However, TV viewing may not be too easy after the blast. Most consumer-type sets aren't designed to withstand the Roentgen levels common even twenty five miles from ground zero. Standard electro-lytic capacitors may dry out when exposed to the intense heat, and the fragile picture tube surely will not take the vibration. Furthermore, the glow from the radioactive fallout may wash out the picture. This is especially a drag when watching the news, as there'll be so much colour after the bombs drop. Mostly green.

Fortunately, Paranoia Developement Corporation of San Banana, California has recently come up with a ruggedly engineered survivalist TV, as shown in figure 1. Capable of withstanding stresses far in excess of even really drugged out human beings, this little set will keep on working even if the nearest unatomized viewer is on Proxima Centauri. It features three inches of lead sheilding all 'round a tough ABS plastic case that's waterproof and resistant to chewing by hungry neighbours. The picture tube is of the same type as is used in space. Colour lock controls permit one button adjustments which will reproduce perfect fleshtones, even if the subjects didn't have them to begin with. The set contains its own internal air conditioning plant, dehumidifier and environmental computer with complete programming to insure the survival of the set in all conditions. It is also armed with two .44 caliber automatic turret gunners to protect itself.

The set weighs seventy five pounds, three ounces, and is fully portable using the handle provided. It is also available in a console model, with patented 'Works in a Vault' circuitry. For more information contact Paranoia Developement Corporation, Foxhole Number 3, San Banana, California 90261.

PWM EXPLAINED

Pulse Width Modulation is a phrase you'll be hearing more and more. This important control technique looks set to revolutionise digital electronics.

LET US delve into the realms of digital control. The particular technique involved is pulse width modulation. This technique is likely to become more and more common in audio amplification and power supplies, especially now that high speed switching devices are becoming widely available.

To understand the principle, look at the simple circuit of Fig. 1d. Here a transistor, used in the common emitter mode, has a square wave of equal mark space ratio as an input. The transistor is in saturation or cut off for equal periods, so the average voltage at the collector, as measured with a multimeter will be half the supply voltage (Fig 1a). If the mark to space ratio is increased as in Fig. 1b then the average voltage will rise. Conversly if the mark to space ratio is decreased (Fig. 1c) then the output voltage will fall. Taken to extremes the transistor would be either in saturation or cut off for the whole time and the output voltage would either be zero or supply voltage.

Well, you say, so what? The simple answer is that, unlike an analogue design, a current can be delivered to a load with hardly any power loss or dissipation in the driving device. For instance, look back to the circuit of Fig. 1 and assume that we have a supply voltage of 9 V and a collector resistance Rc of 100R. To maintain a voltage of 4.5V across this resistor there must be a current flow of 45 mA. The power dissipated in the transistor and the resistor is found by multiplying the voltage drop by the current flowing. In this case $4.5\text{V} \times 4.5 \times 10^{-2}\text{A} = 0.2025$ W. In the switching circuit a 1:1 mark space ratio square wave would be used to set the required voltage across the resistor. Ideally the voltage drop across the transistor would be zero when it was in saturation, and the current through Rc is then 9 V ÷ I, i.e. 0V x 90 mA, zero! When the transistor is cut off the full supply voltage would appear across it and the power dissipation would again be equal to V x I, 9 V x 0 mA, again zero! In reality there will always be a small saturation voltage across the transistor of a few hundred millivolts, and even when the transistor is cut off there will still be a small leakage current flowing, although this will only be in the order of a few microamps.

Although transistors are imperfect devices, you can see that the square wave circuit is many times more efficient than an analogue one.

Square Waves

Before the idea can be used practically, a means must be found of generating a square wave with an easily adjustable mark space ratio. A simple method of doing this is to feed a triangle wave of known amplitude into one input of a comparator, and a control voltage into the other. For those unfamiliar with comparators, a quick description is probably in order. A comparator has two inputs, an inverting and a non-inverting, like an op amp. It also has a high voltage gain but unlike an op amp is operated without negative feedback. It functions as a switch – the output is at zero potential when the non-inverting input is more negative than the inverting while the output is fully positive when the non-inverting input is more positive than the inverting one. Because the gain of the comparator is very high a voltage difference of a few millivolts at the inputs will be sufficient to ensure switching. Comparators, as the name implies, are used for detecting and comparing voltage levels. If one input is fed with a triangle wave and the other with a variable voltage level the output consists of a square wave whose mark space ratio depends upon the voltage at the input. Figure 2 should make this clear.

Practicalities

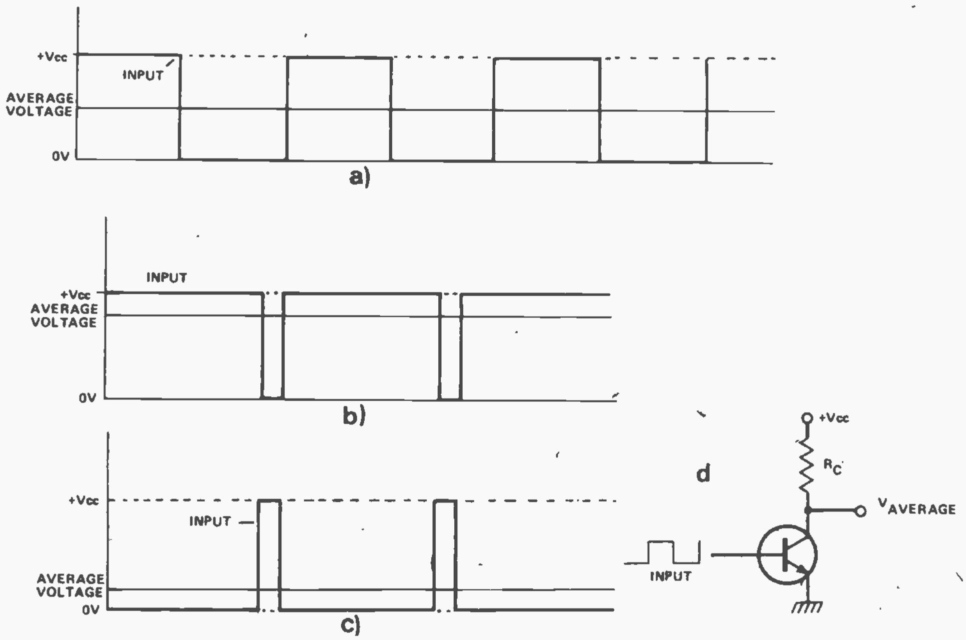
The practical application is shown in Fig. 3, a pulse width modulator that will deliver in excess of one amp to a load (such as a motor or lamp) that can be simply adjusted by a control voltage.

The circuit is an excellent power saving device with an efficiency of 90% and is ideally suited to battery operated equipment.

To keep the circuit simple while providing maximum flexibility, a low cost quad op amp is used as the active device. The type chosen, the LM324, contains four op amps that are similar to the good old 741 but with the advantage that the output can go down to ground even when operated from a single supply voltage.

IC1a is used as an astable multivibrator that produces a 1:1 mark space spuare wave at its output. These are input to an integrator, which converts the square wave into a linear triangle wave suitable for the pulse width modulator, IC1c. IC1c is used as a comparator with the triangle wave at one input and the control voltage at the other. The resulting square waves at the output of IC1c are used to drive the output transistor, a TIP41A which is used in the common emitter mode.

Fig. 1. (a) 1:1 mark-space ratio. (b). Increasing the mark-space ratio increases the average voltage. (c) Reducing the mark-space ratio reduces the average Voltage. (d) Using an NPN transistor to demonstrate the principle of Pulse Width Modulation.



Having outlined the circuit we can consider its operation in more detail.

How It Works

The non-inverting input of IC1a is connected to the junction of R1, R2 and R3. IC1a is being used as a comparator and its output must either be high or low.

When power is first applied C1 is discharged. Thus the voltage at the inverting input is held lower than that of the non-inverting input, and the output of the op amp is at supply voltage. C1 starts to charge up via R4 and when the voltage at the inverting input exceeds that at non-inverting input the output of the op amp goes down to 0 V. Now C1 discharges through R4 and the op amp's output stage.

The non-inverting output is held at a potential that depends on the values of R1, 2 and 3. When the output is high R1 and R3 are effectively in parallel while when the output is low R2 and R3 are in parallel. Since R3 is connected from the output to the non-inverting input a positive feedback loop is obtained. In practice this ensures that the output of the op amp changes from high to low state and vice versa very rapidly. If all three are made equal in value then the potential at the non-inverting input will oscillate between 1/3rd and 2/3rds of the supply voltage.

The frequency at which the circuit runs is determined by the values of R4 and C1 and can be calculated from the formula

$$f = \frac{1}{1{\cdot}4R4C1}$$

To operate small motors and lamps from the pulse width modulator the actual frequency employed is not critical. The lower limit for reliable operation seems to be 100Hz. At the upper end this particular circuit is limited by the rate at which the output of the op amp can change. This is known as the slew rate and you will find it quoted on op amp data sheets. For the LM324 the slew rate is 0.5 V/microsecond. Another measure of this same effect is the full power bandwidth, also quoted in data sheets. For the 324 this is 6kHz. Within these limits the values of R4 and C1 can be whatever happens to be at hand. In the prototype an operating frequency of 1kHz was chosen. A 10n capacitor was available for C1 and so the equation was rearranged thus

$$R4 = \frac{1}{1{\cdot}4fC1} = 1 \div (1{\cdot}4x10^3x10^{-8})$$

68k is the nearest value.

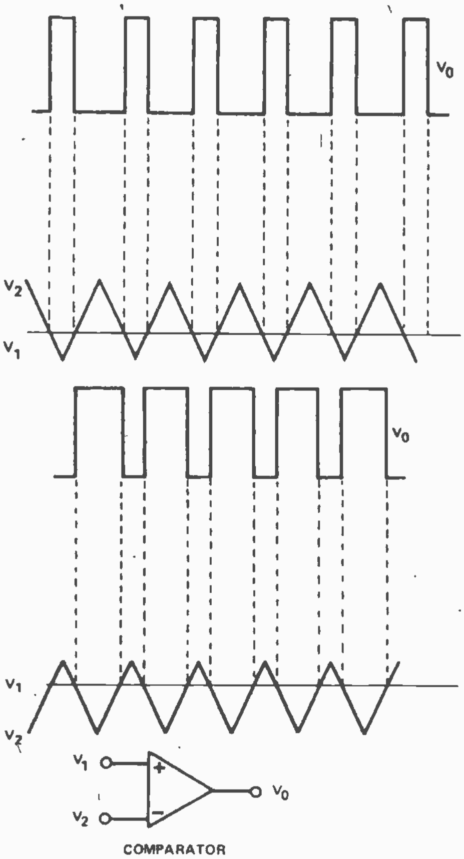


Fig. 2. Using a comparator to produce square wave from a triangle wave and a variable DC level.

Our square wave must now be converted into a triangle wave by a circuit known as an integrator. The output of this circuit is directly proportional to the integral of the input. The integral of a square wave is a linear triangle wave. A positive voltage level at the integrator's input produces a negative ramp at the output. If a negative voltage level is input, a positive-going ramp comes out. Since our square wave consists of alternate high and low levels the triangle wave at the output will resemble that shown as V_2 in Fig. 2. To calculate the values that we require for R5 and C2 we use the following formula,

$$V_0 = \frac{Vcc}{4RCf}$$

Again a large range of values can be employed and by simply rearranging the equation one can easily calculate the required values. An example of the procedure follows. To get a large adjustment range a fairly large signal swing is required. Assuming that the circuit will be employed over a range of supply voltages it is necessary to ensure that an undistorted and unclipped signal is available. For this reason a peak-to-peak voltage of 7 V was chosen and the required component values were calculated as follows. Choose an arbitrary value for C2 say 100n. The value of R5 can be calculated by rearranging the above equation thus:

$$R = \frac{Vcc}{4V_0Cf}$$

$$= \frac{9}{4x7x10^{-7}x10^3} = 3{\cdot}2x10^5$$

The nearest value is 330k.

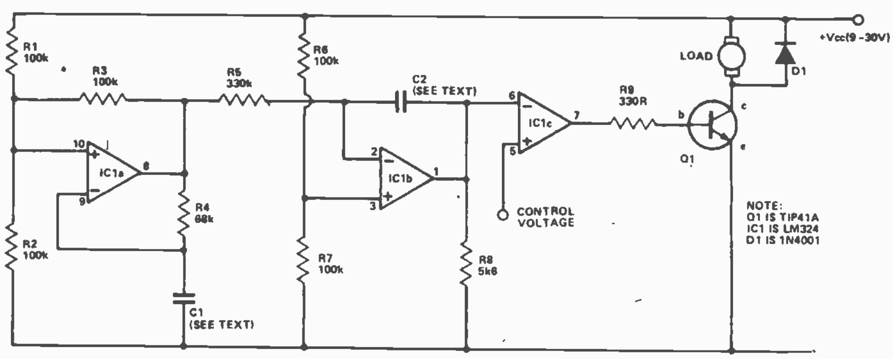
Note that 9 V was taken for the supply voltage. This calculation does not need to be repeated for other voltages as the amplitude of the triangle wave will be in direct proportion to the supply voltage used.

The last part of the circuit is built around IC1c. This is the pulse width modulator proper and its function has already been described. The output square wave drives the power transistor, a TIP41A. Base current is limited by R9.

D1 is included to protect Q1. When a current is fed into an inductive load, for instance, a motor winding, energy is stored in the magnetic field that builds up around the wire. When the supply is interrupted the field collapses and as it does so the magnetic flux produces a large reverse polarity voltage spike.

This spike can have sufficient amplitude to destroy the driving transistor. The diode will short any such spikes to the positive rail thus protecting the transistor. If you glance through any projects in ETI where tran-

Fig. 3. (Below) A practical circuit using Pulse Width Modulation to control a motor.



sistors are used to drive relays, for example, you will notice this feature has been included.

Layout

A simple Veroboard layout for the circuit is given in Fig. 4. The TIP41A does not require a heatsink. As it stands the circuit has many applications. A typical application would be a model train speed controller.

Audio Applications

PWM amps are not new. Sinclair marketed a 10 W version in the sixties. What has precipitated the recent interest is the advent of digital recording techniques, and the increasing avail-

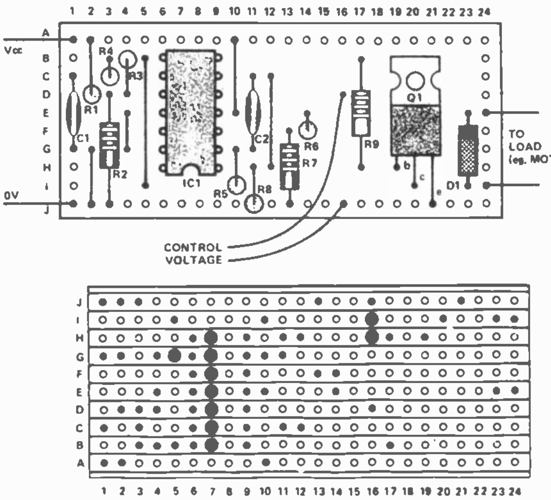


Fig. 4. Veroboard layout for the circuit in Figure 3.

ability of fast switching transistors, especially the VFET.

To recap, a pulse width modulator is basically a square wave oscillator whose output markspace ratio can be altered by an external voltage. If this voltage is an audio signal and the output frequency is sufficiently high, the average output voltage of the oscillator will be the audio signal. The obvious question is how high does the frequency have to be to encode the full aduio band from 20 Hz to 20 kHz? Surprisingly, thanks to the work of Nyquist, the answer is only 40 kHz. Nyquist showed that a signal, in the form of modulation on a carrier wave, could be fully recovered as long as the carrier was at least twice the maximum frequency of the modulating signal.

Given that information it should be possible to produce a PWM amp with a beefy output stage running at well over 40 kHz that can deliver a signal to a normal loudspeaker. Such a digital amplifier has lots of advantages in terms of performance. If a push-pull output stage is employed, the power devices dissipate very little heat since they are either in saturation or in cut-off.

As long as the signal is linearly transferred into digital form no audio distortion can occur. Similarly, there is no crossover distortion or noise added to the signal. What has prevented all audio amplifiers from being built this way is the problem caused by the electromagnetic radiation at carrier frequency from the speaker leads. A second problem has been the shortage of devices.

When Sinclair marketed his PWM amp in the sixties, silicon transistors and logic ICs were expensive novelties. Nowadays there is a proliferation of ICs and transistors capable of being employed in such circuits.

The problem of carrier radiation is a vexed one. Most domestic appliances produce RF radiation, as can be confirmed by anyone whose hi-fi equipment is upset by switching 'thumps'. The simplest way over this problem is to place a low-pass filter between the amp's output and the load. Using screened lead with the screen connected to ground is another precaution. With the amp described here RF radiation is not a real problem as long as the filter is incorporated.

The last circuit employed a comparator to produce PWM. This time the same result is obtained by using the audio signal to alter the switching thresholds of a Schmitt trigger. This trigger is a device that has two switching thresholds, let's call them t1 and t2 (Fig. 5). When the input voltage is less than t1 the output is low. As soon as the voltage exceeds t1 it goes high.

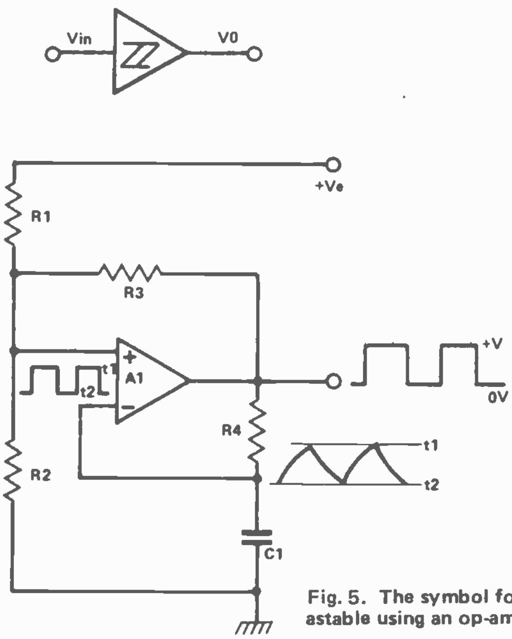


Fig. 5. The symbol for a Schmitt trigger is shown above. Below is an astable using an op-amp operating in a Schmitt trigger action.

Low Down Volts

If the voltage is now reduced, nothing happens until it falls below t2. At this point the output goes low again. (Note that the two threshold voltages t1 and t2 are not equal.) This characteristic is known as hysteresis. The ZZ indicates a Schmitt device or function and these triggers are usually employed in digital circuits to convert slowly rising and falling waveforms to pulse trains suitable for logic systems. A Schmitt trigger can be made from an op-amp or comparator. Figure 5 also shows an astable similar to one employed last month but this time it is built around an op-amp.

On switch-on, capacitor C1 is discharged, holding the inverting input of A1 low relative to the non-inverting input. Since this is so, the output will be high. Now, if we make R1, R2 and R3 equal in value, then the non-inverting input will be held at 2/3 Vcc, because R3 is effectively in parallel with R1. In consequence, C1 will rapidly charge through R4 until the voltage at the inverting input exceeds 2/3 Vcc. At this point A1's output will start going negative. Positive feedback through R3 makes the output's transition from high to low extremely rapid.

A second stable voltage will now be found at the non-inverting input, equal to 1/3 Vcc. This time, R3 is effectively in parallel with R2. Capacitor C1 will now discharge via R4 and A1's output stage until the voltage on the inverting input falls below 1/3 Vcc. The output again goes high and the cycle repeats itself indefinitely.

Because of the influence of R3, A1 acts as a Schmitt trigger, t1 and t2 being 2/3 Vcc and 1/3 Vcc.

Figure 6 shows how this simple circuit can be modified to encode an audio signal into PWM. The audio is simply imposed upon the non-inverting input, thus altering the threshold switching voltages. Resistor R5 prevents interaction between the audio signal and carrier as does R6. Capacitor C2 isolates DC voltages from the astable. Unfortunately, C1 charges exponentially via R4 so somewhat less hysteresis is applied by making R3 much larger than either R1 or R2. This has the effect of making the switching thresholds very close together and linearising the triangular waveform across C1 resulting from it being charged through R4.

To produce a good square wave at high frequencies an LF351 op-amp is used. This is JFET device which features a high slewing rate, that is 13V/uS.

The full circuit of the digital amplifier is shown in **Figure 7**. Here, the op-amp drives a pair of transistors in a push-pull output stage. These transistors, a 2N2297 and a 2N4037, are rated at 1 A collector current. As you can see they are connected, without base bias, as emitter-followers. When the output of the op-amp is high, Q2 is in saturation and provides current to the load via the low-pass filter L1, C5 and

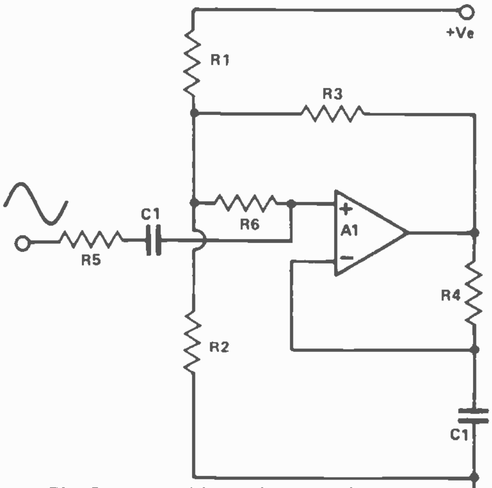


Fig. 6. An astable used to encode an audio signal applied at its input into PWM.

the output coupling capacitor C6. Incidentally, in class B amps the latter component is often of a lower value. This is a pity since the lower – 3 dB point is defined by the size of this capacitor.

As you will remember, the impedance Z of a capacitor is given by:

$$Z = \frac{1}{2\pi FC}$$

where C is in farads and Z is in ohms.

Negative Feedback

The astable has a unity gain and so, to improve the sensitivity, an audio pre-amplifier stage has been added. This is built around Q1 which is used in the commmon-emitter mode. Negative feedback, however, is applied from the collector via R3. A collector current of 1 mA has been chosen to allow adequate drive. Resistor R7, therefore, drops 1 V while C3 decouples line ripple to ground. For linear drive the collector is operated at 17 V/2 8 V. The value of R4, therefore, is given by 8 $V/10^{-3}$ A=8k, the nearest value being 8k2.

An MPSA16 is used for Q1 and this has a gain of 200 minimum at 1 mA. Base current IB is therefore equal to:

$$\frac{10^{-3}\,A}{2\times10^{2}} = 5uA$$

The base will be 0.65 V above ground and, taking 10 x IB through R2 and R3, the value of R3 is given by:

$$\frac{0.65}{5\times10^{-5}} = 1.3\times10^{4}R,$$

12k being the nearest value.

Similarly, the value of R2 will be equal to the collector voltage minus the base voltage divided by 50uA, given by:

$$R2 = \frac{8 - 0.65}{5\times10^{-5}A}$$

$$= 147k,$$

150k being the nearest value.

Virtual Ground

Using a transistor in this way, with feedback from collector to base forms a 'virtual ground amplifier'. This is because the feedback reduces the input impedance. The gain of the stage is set by the ratio of R3 to R1. For a gain of 10, sensitivity 900 mB, a value of 15k was chosen. Capacitor C1 simply isolates the input from DC from previous stages. A suitable Veroboard layout is shown in **Fig. 8.** In the circuit shown in **Fig. 7.** we have a classic high-pass filter formed by the speaker impedance Z and C. The lower – 3dB point can be calculated by rearranging the equation for f1 given by:

$$\frac{1}{2\pi CZ}$$

substituting:

$$f1 = \frac{1}{2\times3.14\times2.2\times10^{-3}\times8} = 9.05\ Hz$$

The minimum gain of the output transistors Q2 and Q3 is 30 at 1 A. In practice this is the absolute minimum likely to be encountered. The op-amp output can source or sink 25 mA. It follows that the worst-case minimum current that can be fed into the speaker is:

$$\pm25\,mA\times30 = 750\,mA.$$

Since the speaker impedance is 8R, the peak voltage under these conditions is equal to 1R; that is, 750 mA x 8R = 6 V, or 12 V peak-to-peak. Since the power output is given by V^2/R, one could be forgiven for thinking that the output power would be (12 x 12)/8 = 18W. Unfortunately, you would be wrong!

The output power is the RMS voltage divided by the load. Assuming our output is a sinewave of 12 V peak-to-peak, the RMS value is found by dividing Vpk-pk by 2.8.

The output power (minimum) is therefore given by:

$$\left(\frac{12}{2.8}\right)^2/8R = 2.29W\ RMS.$$

Because of the small voltage drop that occurs across a saturated transistor, the output will be slightly less than this, namely 2 W.

Going back to our astable, the operating frequency has been set at 300 kHz. This gives a full power bandwidth of 10 Hz to 150 kHz.

Build It Yourself

The construction is quite straightforward and requires little comment ex-

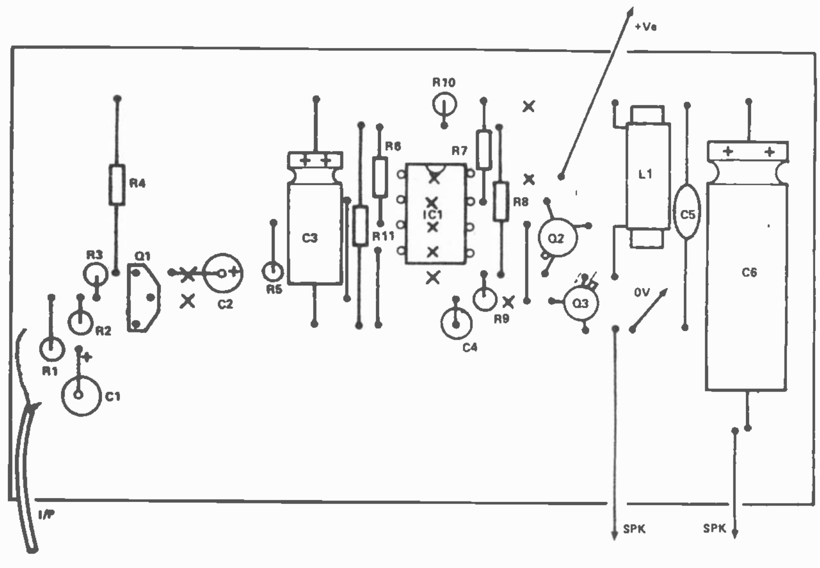


Fig. 8. The veroboard layout of the PWM amp. The small crosses (x) indicate breaks in the copper track underneath the board.

Continued on page 70

Electronics Today INTERNATIONAL

NEXT MONTH

At the time of going to press, the articles mentioned are in an advanced stage of preparation. However, circumstances may result in changes to the final contents of the magazine.

December 1981

Early Radio in Canada

Harken back to the days before the haunted aquarium offered evenings spent with Mork from Ork, back when radio was king and guys who walked around with radios on their shoulders left five inch deep footprints in the asphalt.

Op Amp Checker

If you design circuits wherein parts failures are usually catastrophic, you probably won't need this little project, as the smoke is often a sufficient clue as to the location of the defective device. However, for the less violent experimenter, here's a way to find out which of those little black bugs haven't been sprayed with electronic Raid.

Speaker Design

The mysteries of speaker design are manifold, leading some speaker designers to produce enclosures that resemble interplanetary probes, Rorschach tests and infectious bacteria. Next month, we'll look at the basics of design, culminating in a speaker construction project the issue after.

Into Linear ICs

Our recent 'Into Electronics' feature may have gone to that great parts box in the sky, but its memory lives on. Beginning next month, beware of . . . Son of Into Electronics. In 70mm and stereophonic sound.

Universal Counter

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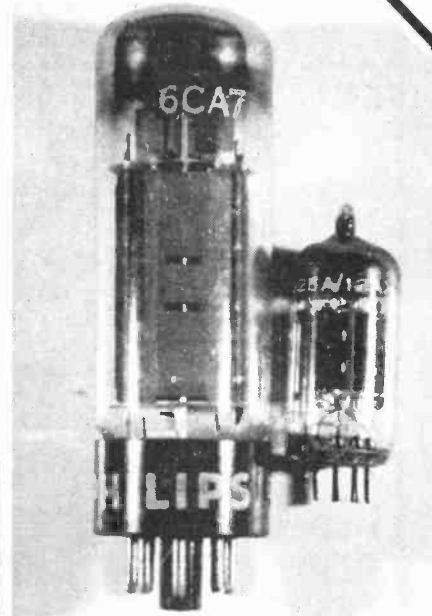
Band Pass and Beyond

Band pass filters are usually found in circuits someone else designed. However, they aren't as tricky as all that, and they're fabulously useful for effects, signal processing and making people think your cheap tape recorder has Dolby. The secrets revealed.



Tubes

A tube is very much like a transistor, except that it's much easier to find if it rolls off the bench, because it leaves a trail of broken glass. If you have never known anything but solid state, learn the rudiments of tubes, next issue.

Musical Doorbell

Ah, yes, the London Philharmonic playing the Ode to Joy; it must be the side door. We also have Jumpin' Jack Flash wired as an alarm on the icebox. Freak out travelling salesmen, next issue.

4 Input Mixer

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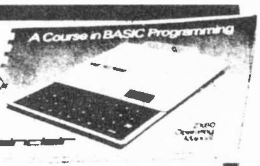

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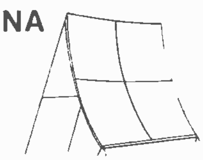

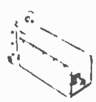

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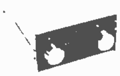

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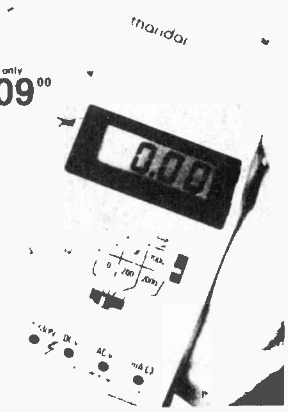

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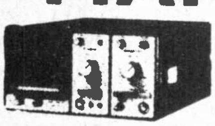

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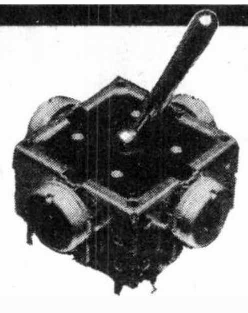
JOYSTICK CONTROL



Video games have never been more popular, but many require the use of joystick controls. This A-to-D converter, submitted by I. Forster will provide such controls for any microcomputer using a 6502, and as many other applications.

THIS ARTICLE describes a system for analogue-to-digital (A-to-D) conversion, originally intended to provide cheap and simple joystick controls for a Commodore PET computer. The system should work on any computer having a USER port, although the software necessary will probably be different to that used by the PET. The software is in 6502 machine code and can be merged with a BASIC program or used as a machine code subroutine.

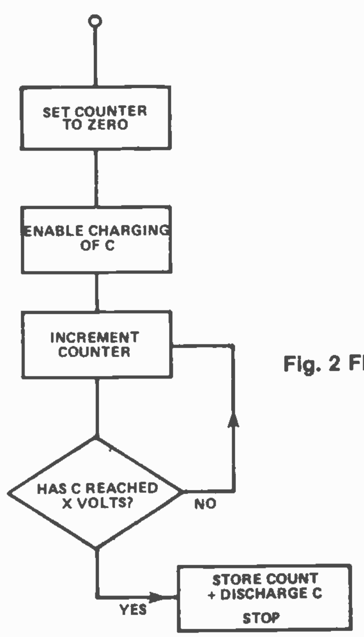
Apart from joystick controls there are a number of other possibilities inherent in the principle. A few of these are described, although no practical results have been obtained with these circuits yet. The field is open for the experimenter!

There are a number of improvements possible, such as using both the X and Y registers in the 6502 as counters, giving 64K resolution on an input. Hardware improvements are also very definitely possible, although beyond a certain point it would probably be much cheaper to build a dedicated device.

Joystick Controls

The circuit for use with a joystick unit is shown in Fig. 1. Two of these are necessary, one for the X axis, one for the Y. The flow diagram for operation is shown in Fig. 2. X volts is the transfer voltage of one gate in the 4081BE. This is not very predictable and better results could be obtained using a Schmitt trigger of some kind, such as the op-amp circuit shown in Fig. 3 or a CMOS Schmitt gate. If C1 is increased, keeping the charging resistor constant, the time taken to reach X volts becomes larger. If C1 is made too large the counter (in this case the X register of the 6502) will overflow and count round.

The sofware is disassembled Hex machine code, as shown below. It could be entered via the PET TIM monitor or as a data statement in a BASIC program. From BASIC it is called by SYS 826 and the values of the two conversions are stored in 1022(X) and 1023(Y); they can be retrieved by a PEEK instruction.



LOC'N	CODE	INSTRUCTION
033A	78	SEI
033B	A9 55	LDA •55
033D	8D 43 E8	STA E843
0340	A9 00	LDA •00
0342	8D 4F E8	STA E84F
0345	A9 01	LDA •01
0347	8D 4F E8	STA E84F
034A	A2 00	LDX •00
034C	E8	INX
034D	AD4F E8	LDA E84F
0350	C9 A3	CMP •A3
0352	D0 F8	BNE 034C
0354	A9 00	LDA •00
0356	8D 4F E8	STA E84F
0359	8E FE 03	STX 03FE
035C	E8	INX
035D	E0 FF	CPX •FF
035F	D0 FB	BNE 035C
0361	A9 55	LDA •55
0363	8D 43 E8	STA E843
0366	A9 00	LDA •00
0368	8D 4F E8	STA E84F
036B	A9 04	LDA •04
036D	8D 4F E8	STA E84F
0370	A2 00	LDX •00
0372	E8	INX
0373	AD4F E8	LDA E84F
0376	C9 AC	CMP •AC
0378	D0 F8	BNE 0372
037A	A9 00	LDA •00
037C	8D 4F E8	STA E84F
037F	8E FF 03	STX 03FF
0382	E8	INX
0383	E0 FF	CPX •FF
0385	D0 FB	BNE 0382
0387	58	CLI
0388	60	RTS

Fig. 2 Flow diagram for the ADC.

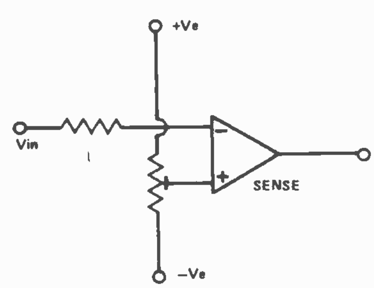
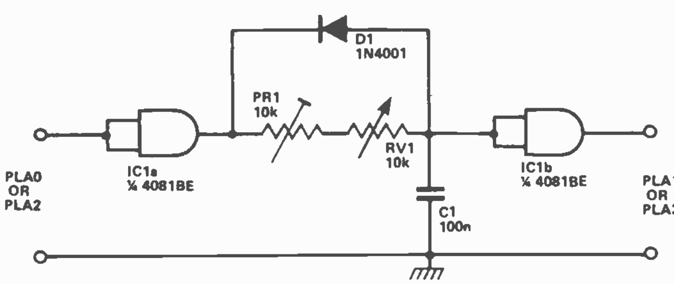


Fig. 3 Using an op-amp as the sensing device allows the transfer voltage to be chosen to suit.

Fig. 1 Simple joystick version of the analogue-to-digital converter.



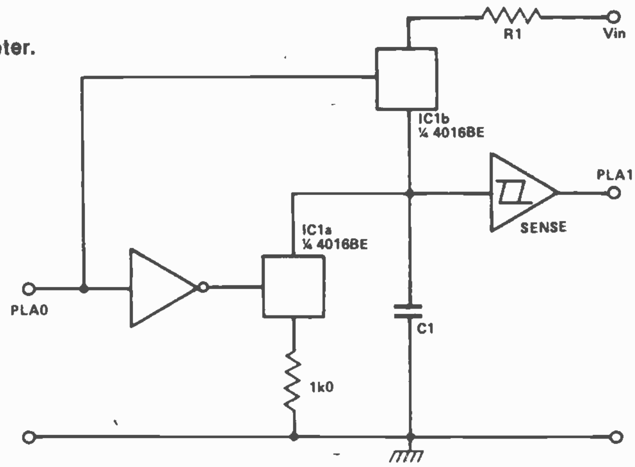


Fig. 4 Experimental voltmeter.

Simple Sums

The calculations involved are simple and are shown below: Fig. 1 refers.

Let X be the transfer voltage of IC1b — ie the voltage at which IC1b's output switches high. Then the time taken to get to X volts can be derived thus:-

$Q = C1 \times V$

where Q is charge
V is voltage

Also $Q = I \times t$
where I is current
t is time

so $t = C1 \times V/I$

Since V = X(transfer voltage)

$t = C1 \times X/I$

But $I = V_{DD}/R$

where R depends on the setting of PR1 and RV1

So $t = C1 \times S \times R/V_{DD}$

$C1, X, V_{DD}$ are constant and so t is proportional to R.

Time And Again

Two other circuits are shown in Fig. 4 and Fig. 5 which use the principle of measuring the time taken to charge a capacitor. In both cases the symbol labelled 'sense' is a Schmitt trigger of some kind. The voltage across the analogue gates of the 4016BE should be less than the power supply to the chip. However, a simple op amp prescaler theoretically allows voltages up to the breakdown voltage of the resistors used to be measured. All the levels returned to the PET must be 5 V logic, so the 4016, inverter and sense output should all be 5 V logic. IC1b in Fig. 4 could be removed, although this complicates calculations because the capacitor will not start charging from 0 V.

The circuit of Fig. 5 is designed as a frequency meter with a range of 0-100 kHz. The 741 produces a square wave of the same frequency as the input. MM1 is a positive-edge-triggered monostable with a period of 10 uS; its output is fed via a diode, analogue gate and resistor to charge the capacitor. The leakage of the capacitor could be very significant so care must be used in selecting the values of R and C as well as component types.

Current can be measured by using a virtual ground type circuit for an op-amp. With a 741 only about 10 mA can be measured since it can only sink a maximum of 20 mA. A resistive divider network or a power op amp could improve this.

Conclusion

The circuits described are fairly crude but could offer useable results to the amateur electronics experimenter. Expense is a major factor in most circuits, and most of these could be built for a few dollars. Of course, you need a computer! Beware of locking your machine into endless loops — this is harmless to the computer but very wearing on your nerves. If not already provided, setting up a way of using the NMI (nonmaskable interrupt) on your processor might be advisable. Good luck!

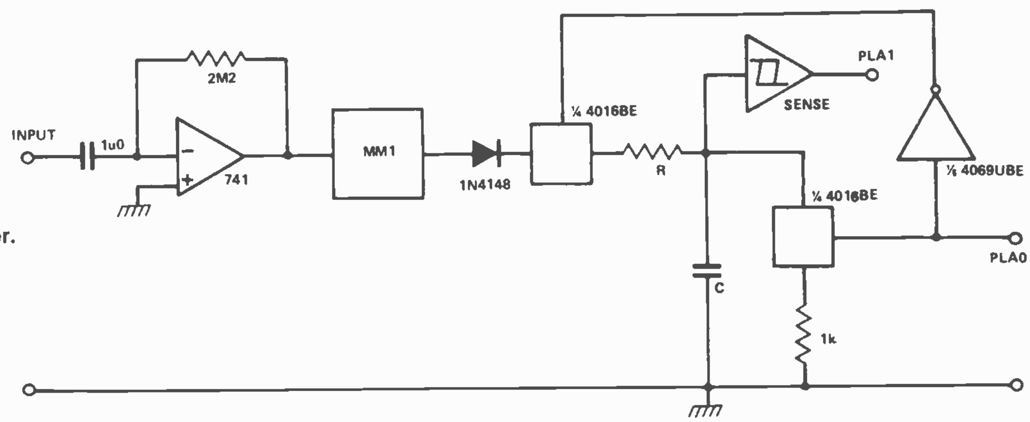


Fig. 5 Experimental frequency meter.

AUDIO TODAY

Wally Parsons

This month Wally Parsons takes a look at mixing different audio components.

LAST MONTH WE CONSIDERED the question of component compatibility primarily from the standpoint of speaker/power amplifier interface. One of the great frustrations for audiophiles is the reluctance of many manufacturers to provide the kind of information which is useful in examining this interface, despite what would appear to be a plethora of data. Salesmen and many followers of the subjective school of audio evaluation don't know and don't want to know. Heaven forbid that the mind should be cluttered up with facts, and time wasted with such nonsense as logic and reason. Indeed, one popular British speaker is notable for its poor midrange response, the result of operating the woofer in the cone breakup region, an equalizing crossover which produces an impedance curve which makes a roller coaster look like a level crossing, and more reactance than a television Bible thumper. Its admirers claim it reveals the faults of any power amplifier to which it is connected. I'll bet you thought only Woody Allen could make that kind of statement with a straight face.

In fact, that whole subject deserves more attention then it has generally received, and I intend to look at it in greater detail in these pages at a later date. But for now we shall content ourselves with examining the question of compatibility among other components of the audio chain.

Universality?

First of all, virtually all consumer audio components are more or less compatible with each other. This is inevitable; after all, manufacturer A may *prefer* that you buy his preamp as well as his power amp, but if you already own preamp B or are determined to buy it, he'll still be happy to sell you his amplifier.

Even so, differences from one product to another can result in less than optimum performance when several units are used in combination.

Consider, for example, a preamp intended to drive a power amplifier. Generally speaking, power amplfiers are designed with a sensitivity such that full output can be attained with about 1.0 V. The general range tends to go down to about 500 mV up to 2.5 V, although extremes such as 150 mV and 3.5 V have been reported.

Happily, preamps generally are rated at around 1.0 V output at rated distortion. Several units deliver as little as 500 mV, while others are rated as high as 2.5V, 5.0V and even 10V, while a tube unit might be capable of putting out as much as 30V.

Suppose we have a power amplifier capable of 250 W output with an input of 1 V. This means that 1 V input will result in 45 V output for a gain of 33 dB. This is similar in magnitude to the gain of a phone preamp, so a claimed S/N ratio of 100 dB is certainly quite impressive.

But how about preamp noise?

In most preamps we can reasonably expect to find the volume control in front of an early stage, but after phono preamplification. Suppose our preamp is rated at 10 V output. Now, one virtue of such a preamp lies in the 20 dB of headroom available. In fact, the power amplifier will clip 20 dB before the preamp. This is certainly a desireable state of affairs, because if the preamp clips first, serious distortion will occur before the power amp reaches maximum output, and at the edge of power amp clipping we will have a distorted reproduction of a distorted signal, with a final distortion greater than the sum of the two.

In other words, arrgh!

Unfortunately for dedicated souls, not enough manufacturers rate preamp S/N ratio in a way which is unequivocal from this standpoint. However, since most manufacturers use the best figure which can be legitimately claimed, it is generally safe to take it as so many dB below maximum output. If our hypothetical preamp was rated at 10 V out and S/N 100 dB, then the noise voltage at the output would be .1 mV. But this is only 80 dB below 1 V, and with a noisless power amp, 80 dB below 250 W. Most of the time the power demands would be less than 2.5 W, but the noise level will remain the same, so now it has been reduced to 60 dB.

By reducing the gain of the power amp, either by its basic design, or with an input level control, we can realize a S/N ratio more closely approaching the capabilities of the equipment, but at the expense of preamp headroom.

The Preamp End

Good engineering practice dictates that we should allow at least 20 dB of headroom at each point in the chain to avoid clipping on signal peaks. Thus, it would be a good idea to retain that 10 V capability at the preamp/power amp interface. This will certainly come in handy if tone controls are used for anything other than correction of real deficiencies of programme, and you will always be aware that you have a high power amplifier.

I do think it's a wonderful invention Harold, but I simply don't think the world is ready for electric bagpipes.

The signal sensitivity for rated output ranges from about 100 mV to 2.5 V for most preamps, but this may or may not be measured at the input switching point. Consequently, most of the noise may or may not be generated after the volume control. If it is, then the aforementioned considerations regarding noise will hold. However, if any amplification occurs between the switching and the volume control, only a small proportion of the total noise will be generated after the volume control, thus preserving more of our original S/N ratio. Clearly, such a preamp would be a better match for our power amplifier.

Nothing For Nothing
What happens if this preamp's sensitivity is in the order of 100 mV for 10 V output? Since most programme sources are likely to deliver signals in excess of this figure, the volume control will always be operating somewhere within the first quarter turn. Obviously, we should have level sets at each of the inputs, so that, with the main volume control at about mid-point, no noticeable noise is generated, and listening volume can be controlled without being touchy.

But let's take another look at our power amp before leaving the subject this month. Suppose that, instead of 250 W, our amplifier is rated at 25 W. Maximum output has been reduced by 10 dB, but if the gain is still 33 dB, the sensitivity has not changed. For an output of 0.3 V, 0.3V input will also result in our gig amp delivering 14 V. The actual loudness will be the same. It's just that one will run out of steam before the other.

No Simple Answers
Is should be apparent that no easy rules can be laid down as to matching even these two components for compatibility. But all too often we see people looking at specifications without a full understanding of their implications, and without realizing that if you lock yourself into one component, you have dictated the requirements of each other component.

In other words, the best components aren't much good if they don't like each other.

Bang & Olufsen strikes again
A trip through your favourite audio store (or even you not-so-favourite store) can be a pretty boring experience for the jaded audiophile tired of me-too copy-cat engineering and design variations on a theme of knobs, buttons, chrome and plastic. You must admit, though, much of the gear available today certainly attracts attention.

Traditionally, B & O was attracted attention by being inconspicuous. Now, this is not easy to do when your styling and operating facilities are totally different from everyone else's. But there is a certain elegant logic to it. After all, stereo equipment is intended to reproduce sound, presumably music, and the perfect system would be totally unseen.

The Beosystem 8000 comes pretty close. In fact, B & O has made hi-tech so low key that they don't even capitalize the word "Beosystem" in their press release.

This is an almost totally automated system consisting of reciever, cassette recorder, turntable and loudspeakers, which can be directly controlled from anywhere in the listening room by means of a wireless remote control module. I say "almost totally automated", because it will not decide what record you want, or which radio station you want to listen to. In fact, it won't even take your chosen record or tape off the shelf and out of its sleeve for you, let alone read your mind and do what you want. But short of that, it will do just about anything you might desire.

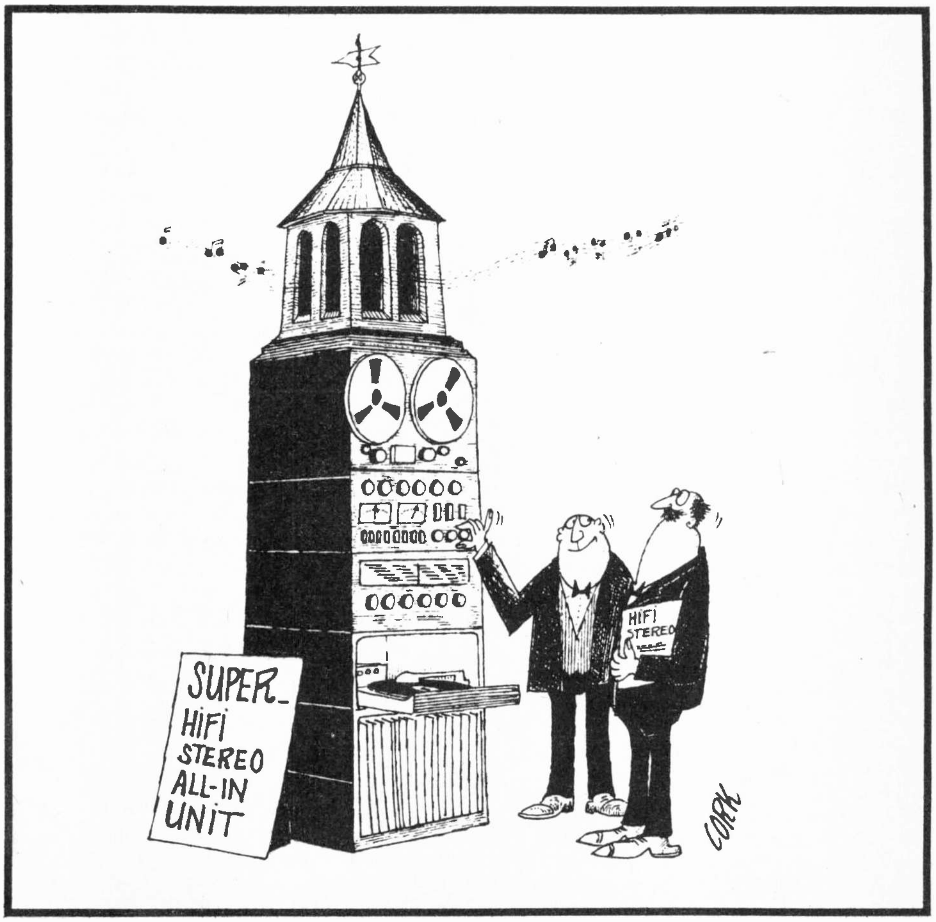
In fact, if it breaks down it will even test itself and tell you what's wrong.

I was planning on touching on some of the high points of this equipment, but there simply isn't room to do it justice, so I will deal with each component in forthcoming issues. In addition, I have been promised by Fran Dym, a delightful lady who is a true dyed-in-the-wool audio enthusiast, all kinds of detailed information on the technology, which will form the basis of some future Audio Today columns.

But I should mention the HX professional tape bias system. This is an advanced bias system capable of delivering performance with ordinary ferric oxide tape which rivals that of metal particle.

Stay tuned.

And for impatient souls, contact BSR (Canada) Ltd, P.O. Box 7003, Stn B, Rexdale Ontario M9V 4B3. Or if the postal workers go on strike in support of U.S. Air Traffic Controllers (any old excuse, right?) phone (416) 675-2425.



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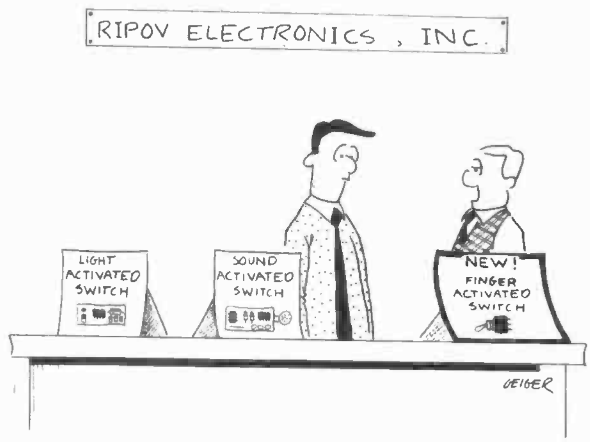
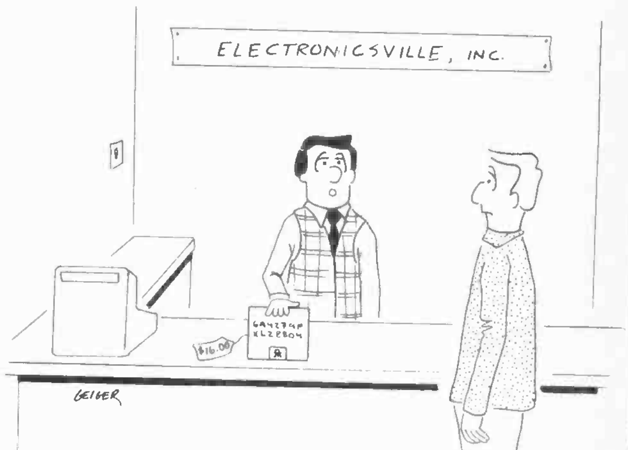
The Fun of Electronics



Never underestimate the gullibility of the public — these have been selling like hotcakes!

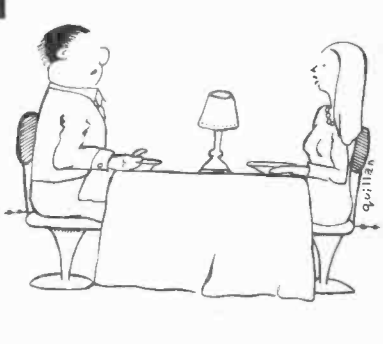
Last week the 'electronics genius' built his own smoke detector, but he had it wired wrong and it darn near burnt the house down!

By the way, don't play with the wire-wrap gun . . . it's been acting up lately.

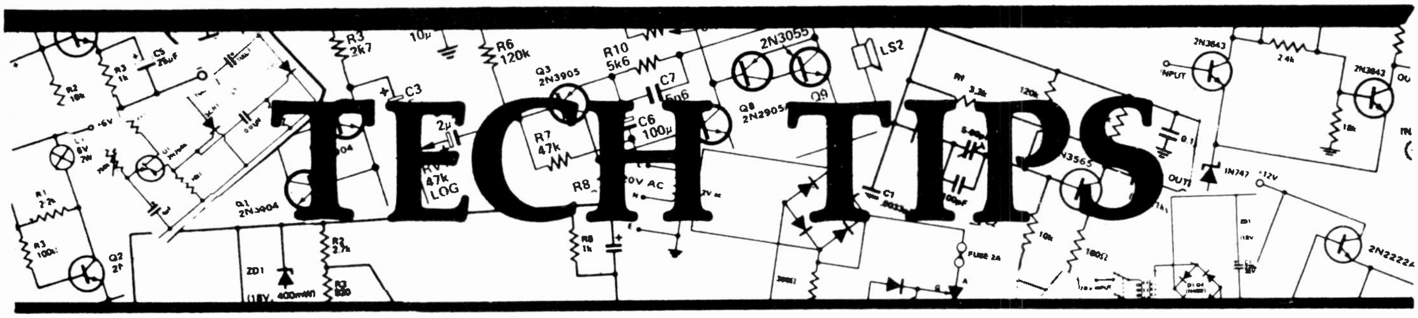


The actual transistor is only worth about a dollar — it costs them fifteen dollars to print the part number on it.

According to the computer, we can't afford to buy groceries this week, but we can purchase a larger computer.



No dear, eating alphabet soup is not word processing.

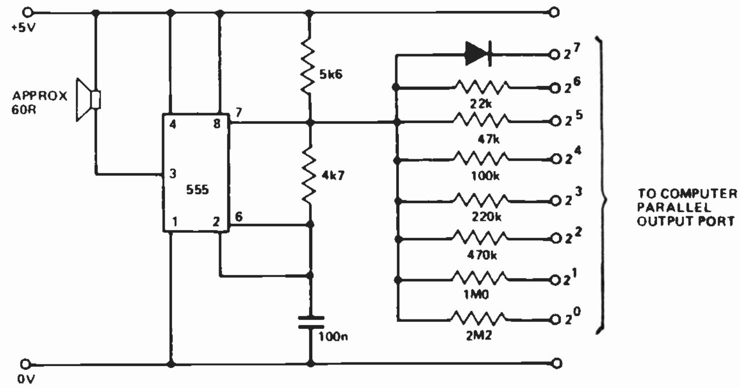


Cheap micro music box

The circuit may be connected to the output port of any micro to generate musical notes over a range of about 1½ octaves. On/off control is provided by the most significant bit and the resistors provide seven-bit resolution. alternative on/off control methods can be used to give eight-bit resolution, e.g: by using the handshake lines, if available.

If the diode is replaced by a resistor, say 10k, it will be found that below a certain output value the voltage at pin 7 is insufficient to charge the capacitor. Thus the sound can be switched off.

The resolution is sufficient to enable values to be found corresponding to tones and semitones throughout the frequency range. Current consumption depends largely on the loudspeaker impedance and is generally low enough for power to be taken directly from the computer.



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VLF ramp generator

G. Malloy

It is always satisfying to exploit the otherwise unwanted property of a device — the reverse bias current of a leaky germanium dide, in this circuit.

The reverse saturation current is typically a few microamps for the 1N34 and is relatively constant over 2-10V. This constant current is used to linearly charge the capacitor in the relaxation oscillator built around the 741.

When the diode becomes forward biased the capacitor is rapidly discharged by the limited output current of the op-amp. Frequencies below 0.01 Hz are possible, though measures may have to be taken to improve the linearity of the ramp.

PR1 allows some degree of dc offset of the ramp, and the source follower (Q1) reduces the loading on the capacitor, whick tends to degrade the ramp's linearity. for the same reason tantalum or RBLL electros (i.e: low leakage) types should be used for large values of C1. Linearity can be further improved by the use of a FET input op-amp such as the 3140.

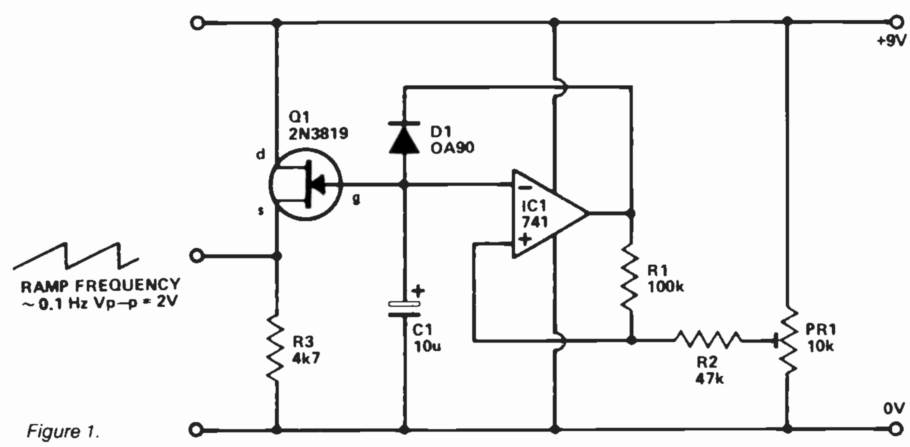


Figure 1.

The frequency can be made variable by using the FET constant current generator shown in Figure 2, which should replace the diode, D1. With RV1 at 100k the current will be about 30 uA and roughly inversely proportional to RV1. This constant current generator needs a voltage of about 3 V to function well. This may require an increased power supply. However, the resulting linearity is excellent, especially with the suggested FET input op-amp.

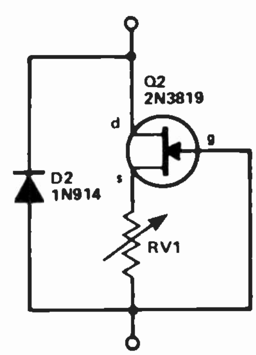
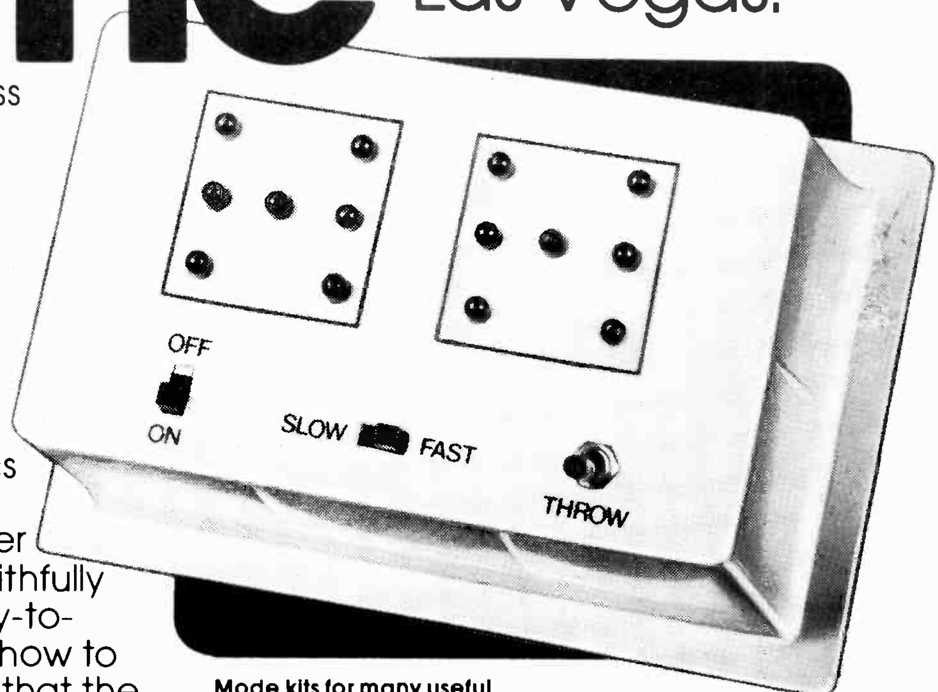


Figure 2.

Clever, easy-to-make, inexpensive Mode kits

dice game

Produces more random numbers than Las Vegas!



True randomness is hard to achieve in any kind of mathematics. But Mode Dice Game can keep the numbers more unpredictable and 'honest' than old-fashioned real dice, once they are even slightly worn.

Friends who are unfamiliar with the powers of electronics will be most impressed with your Mode Dice Game's never failing ability to reproduce faithfully the patterns of dice. The easy-to-follow Mode plans show you how to program your Dice Game so that the dots light up invariably in true dice configurations.

Like most Mode kits (see list), Dice Game comes complete with detailed plans, all parts except battery, and the container converts to case. If you enjoy putting electronics together, here is your chance to harness mathematics and make something new and different of every dice-throwing game from Monopoly to Craps.

Mode kits for many useful and entertaining purposes.

1. Automatic Headlight Reminder
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Circle no. 7 on Reader Service Card.

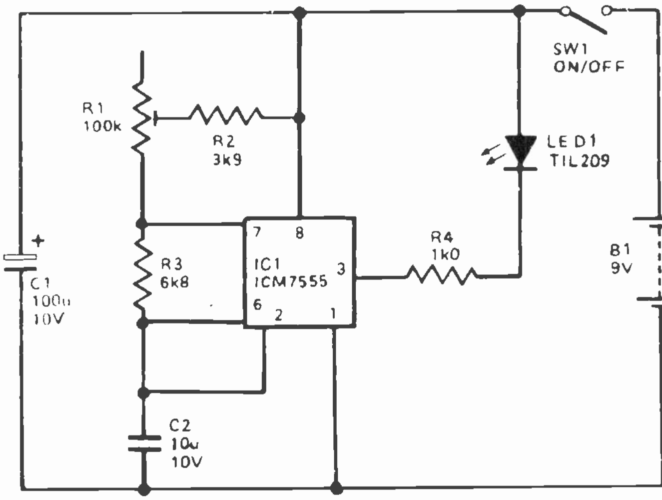
Simple photographic timer

Although this timing device may seem to be rather unsophisticated, it is a handy little gadget for timing darkroom exposures, or time exposures made on a camera with the shutter set to the 'B' position. The unit simply flashes a LED indicator briefly at one-second intervals. If, for example, one wishes to make a ten-second time exposure, then the shutter is opened during any convenient flash produced by the unit, and then closed after a further ten flashes have been produced. Adequate accuracy for normal requirements can be obtained in this way.

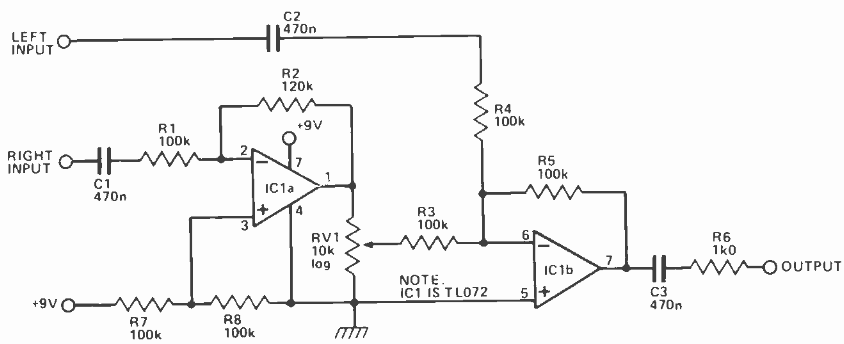
The circuit is based on the CMOS version of the well known 555 timer device. The CMOS version has the advantage of having a current consumption which is only about one hundredth of that taken by the conventinal version, and this is obviously beneficial in a battery-powered piece of equipment such as this one. The average current consumption of the unit is actually less than 1 mA, giving an extremely long battery life.

The CMOS version of the 555 operates in the same basic manner as the ordinary version, with timing capacitor C2 first charging up to ⅔ V+ by way of the timing resistors R1, R2, R3. The device is then triggered into the discharge mode, resulting in C2 being discharged through R4 to a potential of ⅓ V+, whereupon the ciruit reverts to its original state with C2 charging up once again. Continuous oscillation thus results. The frequency of operation is adjusted to 1 Hz by adjusting R1, and in practice this is adjusted by trial and error to obtain (say) 60 flashes in a one-minute period. Longer calibration periods can be used if better accuracy is required.

The output of IC1 assumes the high state while C2 is charging, and the low state while it is discharging. As C2 charges via R1, R2 and R3, but only discharges through R4, the discharge time is therefore much shorter than the charge time. By connecting LED indicator D1 and its current limiting resistor R4 between the output of the IC1 and the positive supply, the required brief flashes are thus obtained.



Vocal Canceller
S.P. GILES



If you want to lower the level of the vocal on a record, then this circuit does the trick very easily. It very often happens that during the mixing of the multichannel recording to give a stereo image, the vocal is positioned in the middle with the other instruments on the left and right. If we therefore invert the right channel and mix it with the left, any signals which were originally equal on both channels will cancel out (or at worst become very much reduced in level).

In the circuit shown here the right channel is inverted by IC1a and given a small gain. The output is attenuated by RV1 and mixed with the left channel by IC1b. To set up the circuit, listen to the output and adjust RV1 for best cancellation.

The circuit works very well with Led Zeppelin II.

Parametric equaliser

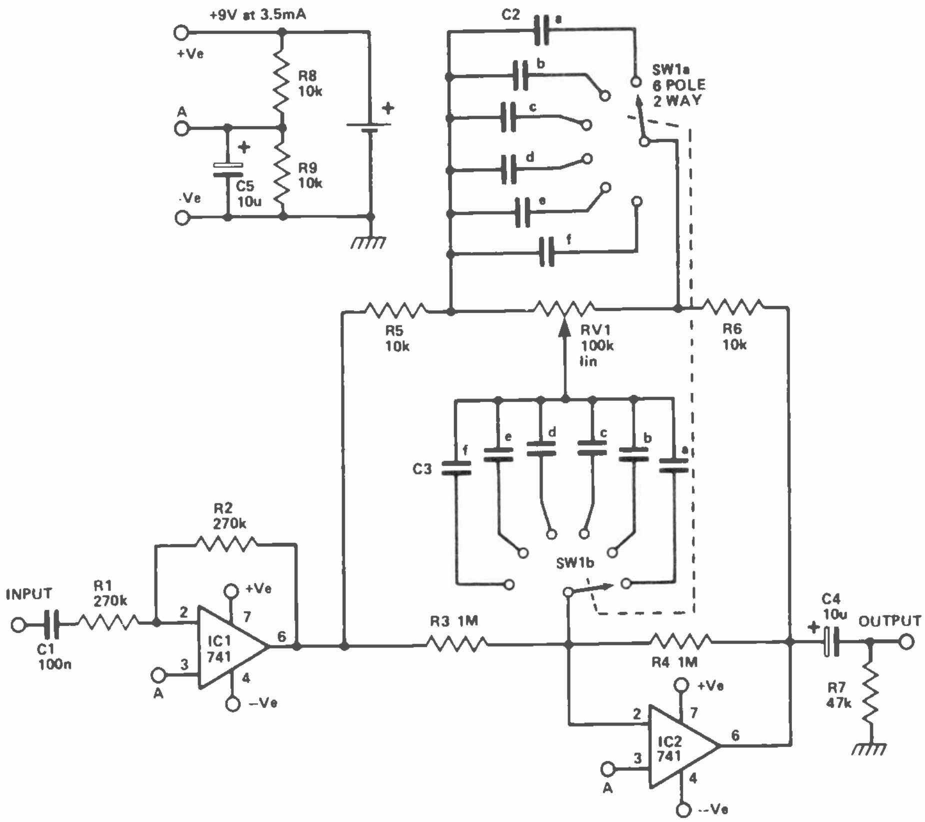
C.E. READ

This parametric equaliser offers six bands of tone control separated by an octave in frequency, each frequency band being selected by the six-position rotary switch.

Potentiometer RV1 permits the selected frequency band to be boosted or cut by 12 dB. The filter is particularly deal for use with a guitar to modify and enhance the tonal qualities of the instrument. For example, the 500 Hz setting with cut gives a hollow funky sound, while the 500 Hz setting with boost gives an overdriven tube amplifier the raunchy sound favoured by many rock guitarists, but without the unpleasant, muddy, harsh sound resulting from boosting the entire audio frequency spectrum.

Capacitor values for the filter frequencies are given in the accompanying table.

	FREQ (Hz)	C2 (pF)	C3 (pF)
a	125	47000	4700
b	250	22000	2200
c	500	12000	1200
d	1k	5600	560
e	2k	2700	270
f	4k	1500	150



PWM EXPLAINED

Continued from page 54

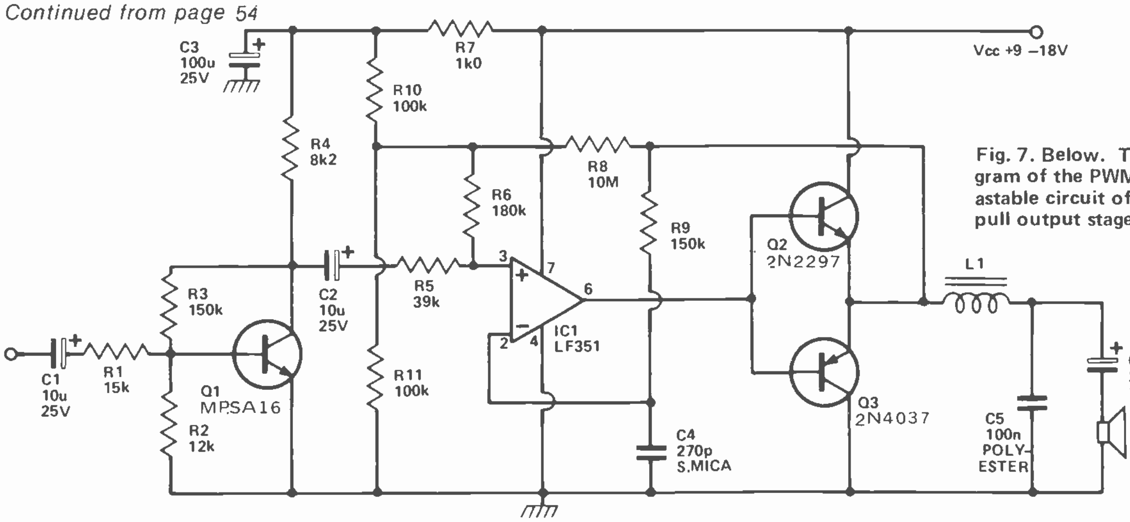


Fig. 7. Below. The complete circuit diagram of the PWM amp combining the astable astable circuit of figure 6 with a push-pull out pull output stage.

cept that it is necessary to ensure that all the semiconductors are correctly orientated and the breaks in the veroboard tracks are not forgotten.

Although the circuit will operate from 9 V, batteries are not really suitable and any line PSU offering an output voltage in the range indicated is better.

L1 consists of 60 turns of 0.56mm enamelled copper wire, pile-wound on a 1 in length of 3/8 in diameter ferrite rod.

When construction is completed, no adjustments need to be made to the circuit. All that is required is an input signal and a speaker. ●

POKEING THE ZX80

Continued from page 37

seem to disappear without trace but sometimes they can find their way into your program, invariably with unpleasant consequences. Some bad POKEs can cause havoc with the video control. The codes for all statements, tokens and operators should *definitely* be avoided (i.e: codes greater than 191).

A more subtle problem is that any extensive use of screen space is very expensive in terms of memory. A 23-line "blank" screen will occupy 760 bytes of RAM, which does not leave much for the program if you are using the basic model ZX80 with 1K of memory. You therefore need to think hard about the balance of memory requirement when writing screen-POKE programs if you have no memory expansion.

Having grasped the principles involved in defining and locating the display-file it is relatively simple to manipulate it. Existing characters on the screen can be replaced by POKEing an alternative code at the same address. If this is the code for a space (0) then the character already on the screen disappears. By PEEKing at the address you plan to POKE to you can see what character already occupies that location, thus opening up the possibility of a conditional response. All the relevant character codes are identified in the ZX80 handbook. ETI

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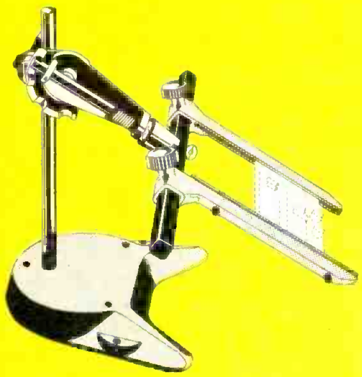

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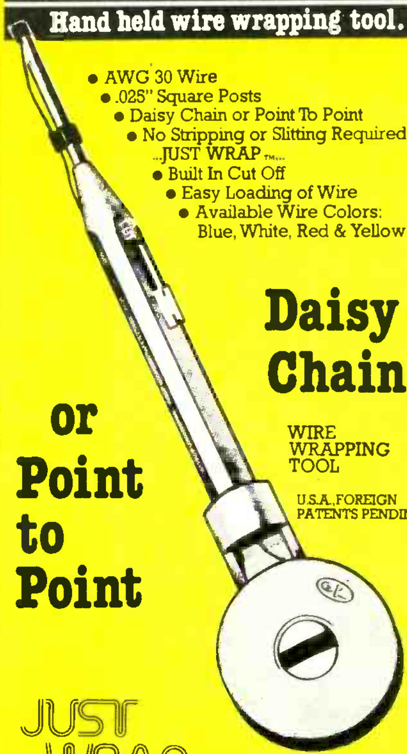

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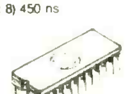

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XR13600	Dual Operational Transconductance Amp	2.49
XR2200	Hammer Drive	1.81

OPTOELECTRONICS

VLED'S

LED 209 T 1 3mm Red	.13
LED 211 T 1 3mm Green	.40
LED 212 T-1 3mm Yellow	.40
LED 220 T 1 3/4 5mm Red	.13
LED 222 T-1 3/4 5mm Green	.24
LED 224 T 1 3/4 5mm Yellow	.23

DISPLAYS

FND 357 375 Common Cathode	1.59
FND 500 500 Common Cathode	1.25
FND 507 500 Common Anode	1.25
DL1416 4 digit 16 segment alphanumeric display 16" ht.	32.25

ISOLATORS

ILD74 Dual Opto Isolator 1500V	1.69
ILQ74 Quad Opto Isolator 1500V	4.45
ILCT6 Dual Opto Isolator 1500V	1.67
MCT2 Opto Coupler 1500V	.84
TIL111 Opto Coupler 1500 V	.74
4N26 Opto Isolator 2500V	.85
4N33 Opto Isolator 1500V	1.07

SCR'S and TRIAC'S

C106D	.49	SCR	5 amp	400V	TO 220
TIC44	.45	SCR	0.6 amp	30V	TO 92
TIC47	.70	SCR	0.6 amp	200V	TO-92
TIC116B	1.38	SCR	8 amp	200V	TO-220
TIC116D	1.38	SCR	8 amp	400V	TO-220
TIC126B	1.54	SCR	12 amp	200V	TO 220
TIC126D	1.54	SCR	12 amp	400V	TO-220
TIC216B	1.46	Triac	6 amp	200V	TO-220
TIC216D	1.29	Triac	6 amp	400V	TO 220
TIC226D	1.23	Triac	8 amp	400V	TO 220
TIC236D	1.89	Triac	12 amp	400V	TO-220
TIC246D	1.89	Triac	16 amp	400V	TO-220

Bi-Fet OP AMPS

TL061CP	.84	Low Power
TL062CP	1.35	Dual Low Power
TL064CN	2.30	Quad Low Power
TL071CP	.65	Low Noise
TL072CP	1.21	Dual Low Noise
TL074CN	2.14	Quad Low Noise
TL081CP	.52	J-Fet Input
TL082CP	1.05	Dual J Fet Input
TL084CN	1.93	Quad J Fet Input
TL495CN	6.44	Switch Volt Reg 25mA

TRANSISTORS

TIP29A	.40	TIP121	.70	2N2905A	.46	2N4125	.11
TIP29B	.44	TIP122	.74	2N2907A	.28	2N4126	.11
TIP29C	.48	TIP125	.74	2N3053	.40	2N4401	.13
TIP30A	.46	TIP126	.89	2N3055	.87	2N4402	.13
TIP30B	.49	TIP127	.83	2N3440	.85	2N4403	.13
TIP30C	.51	TIP140	1.62	2N3771	1.77	2N4410	.23
TIP31A	.48	TIP141	1.86	2N3772	1.77	2N5087	.16
TIP31B	.49	TIP142	2.21	2N3773	2.94	2N5088	.16
TIP31C	.52	TIP145	1.99	2N6133	1.35	2N5172	.16
TIP32A	.48	TIP146	2.12	2N6489	1.49	2N5220	.23
TIP32B	.53	TIP147	2.51	2N6545	4.75	2N5221	.23
TIP32C	.57	TIP2955	.90	2N3439	1.01	2N5223	.23
TIP41A	.64	TIP3055	.81	2N6059	6.13	2N5226	.23
TIP41B	.70	FT3055	.77	2N6055	1.99	2N5227	.23
TIP41C	.75			2N6079	3.08	2N5401	.19
TIP42A	.70	2N404A	2.25	2N3702	.14	2N5500	.12
TIP42B	.73	2N697	.42	2N3704	.14	2N5551	.14
TIP42C	.80	2N706	.34	2N3706	.14	2N5570	.20
TIP110	.64	2N1613	.42	2N3710	.14	2N5771	.21
TIP111	.67	2N1711	.42	2N3904	.10	2N5772	.21
TIP112	.73	2N1893	.45	2N3906	.10	PN2222A	.15
TIP115	.70	2N2222A	.28	2N3907	.13	PN2369A	.16
TIP116	.70	2N2369A	.29	2N4123	.11	PN2907A	.15
TIP117	.76	2N2484	.28	2N4124	.11	PN3565	.15
TIP120	.63						

CMOS

CD4001BE	.26	CD4040BE	.81	CD4108BE	2.00
CD4002BE	.23	CD4041BE	.91	CD4510BE	.71
CD4006BE	.74	CD4042BE	.67	CD4511BE	.76
CD4007BE	.29	CD4043BE	.76	CD4512BE	.84
CD4008BE	.77	CD4044BE	.65	CD4514BE	2.16
CD4009BE	.46	CD4046BE	.99	CD4515BE	1.85
CD4010BE	.49	CD4047BE	.91	CD4516BE	.88
CD4011BE	.26	CD4049BE	.42	CD4519BE	.60
CD4012BE	.23	CD4050BE	.42	CD4520BE	.76
CD4013BE	.23	CD4051BE	1.07	CD4522BE	.96
CD4014BE	.39	CD4052BE	1.03	CD4526BE	1.23
CD4015BE	.68	CD4053BE	.99	CD4527BE	1.94
CD4016BE	.70	CD4060BE	1.07	CD4528BE	.88
CD4017BE	.37	CD4066BE	.68	CD4531BE	.73
CD4018BE	.65	CD4068BE	.31	CD4532BE	.91
CD4019BE	.59	CD4069BE	.29	CD4539BE	.85
CD4020BE	.84	CD4070BE	.36	CD4543BE	1.38
CD4021BE	.68	CD4071BE	.32	CD4553BE	3.73
CD4022BE	.99	CD4072BE	.24	CD4555BE	.68
CD4023BE	.26	CD4073BE	.34	CD4556BE	.71
CD4024BE	.57	CD4075BE	.34	CD4581BE	2.00
CD4025BE	.26	CD4076BE	.76	CD4582BE	.70
CD4026BE	1.52	CD4078BE	.34	CD4584BE	.49
CD4027BE	.51	CD4081BE	.29	CD4585BE	.91
CD4028BE	.67	CD4082BE	.24	CD4702BE	13.49
CD4029BE	.87	CD4085BE	.60	40097PC	.92
CD4030BE	.46	CD4086BE	.76	40098PC	1.07
CD4033BE	2.17	CD4093BE	.65	40161PC	1.54
CD4034BE	2.33	CD4099BE	1.34	40174PC	1.52
CD4035BE	.84	CD4104BE	3.09	40175PC	1.15

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