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10TH ANNIVERSARY ISSUE

Electronics Today

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February 1987

Canada's Magazine for Electronics & Computing Enthusiasts

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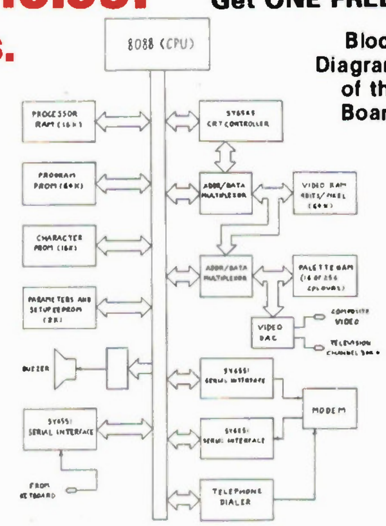
Block Diagram of the Board



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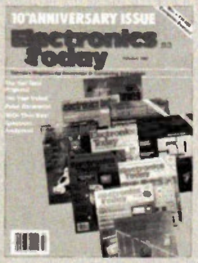

Covers from past Februaries highlight our ten years as Canada's favorite electronics magazine. Design by Dolph Loeb.

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Canada's Magazine for Electronics & Computing Enthusiasts

February 1987 Vol. 11 No. 2

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For Your Information

The Editor's Corner

By Bill Markwick

HELLO, and welcome to our 10th anniversary issue. Electronics Today started in 1977 with offices on Overlea Boulevard in Toronto. I joined in January, 1983, and was made Editor later that year. In late 1985 we moved to our new premises on Don Mills Road, and here we are.

In the past ten years, the invention and success of the microprocessor outdid even the introduction of the transistor to the commercial world of the 1950s, allowing economical desktop computers with the power of a mini. This same invention also negates a lot of the predictions made about the future: no one foresaw the feasibility of the microchip computer, except maybe for science-fiction writers, and they put it into the gee-whiz world of the distant future. In the same way, predictions made now will probably be nullified by the next amazing gadget down the road.

Having said that, I might as well go out on a limb and have some fun with predictions for the next ten years.

A safe one: faster, more powerful chips will proliferate as they come down in price, making something like the 80386 computer available for far less than the $10,000 it is today. No matter how fast they are, though, software writers will produce programs that make you wish you had something better.

There'll be more computers hooked together via networks, perhaps by way of cable or satellite TV. I don't see an awful rush to get into purchasing via TV or computer. The working-at-home idea is a nice one if it suits you, though I find that we're still slaves to paper, and I can't do without the office environment yet. Besides, the work-at-home, shop-at-home mode turns you into a hermit.

In ten years, cars will still be the shiny, dazzling, hi-tech piles of poorly-engineered junk that they are today, and advertising departments will still be proudly crowing over all the technological innovations that are five years out of date on the day they're introduced. You'll be able to buy a car with a satellite/inertial guidance system and total electronic control, but the muffler will still fall off every two years.

There'll be a revival of the aesthetics of cabinetmaking, and a minority of craftsmen will begin to appreciate the advantages of hand-tools for finishing, once the power tools have done the brute-force work.

Soldering transistors into breadboards will become an anachronistic art, rather like weaving your own fabric.

Technology will allow doctors to routinely pull off daily miracles, but they'll still be more concerned with damage control than with health.

The Canadian media will still run stories on Canada's lack of a hi-tech industry, on our lack of entrepreneurial gumption, on the Promise of the Far North.

Comprehensive synthesizers will come down in price and will pervade music to the extent where someone who knows three chords on an acoustic guitar will be like a breath of fresh air.

Canadian beer will improve and TV won't.

Most futurists will have been wrong in their predictions.

Happy Birthday

Here's a letter of congratulations on our 10th anniversary:

"It's hard to believe that it's only the tenth anniversary of Electronics Today. Today, it would be difficult to imagine the electronics scene in Canada without ET; but ten years ago there was no Canadian electronics magazine for the electronics enthusiast. In the days before ET, Canadian hobbyists and electronics buffs were forced to look to popular American magazines for their projects and parts. ET changed all that by providing a Canadian source of information on products and projects available in Canada. ET also provided a reasonably priced magazine for Canadian advertisers, and thus was an essential ingredient in the development of many Canadian companies with products to market to the electronics industry in Canada.

I have had the opportunity to work closely with the people at Moorshead Publications over the past ten years. Without fail, they have been helpful, courteous, reasonable, and operated with the utmost integrity. I would like to offer my personal congratulations and thanks for their help over these ten years to Halvor Moorshead and the entire staff of ET on this special occasion of your tenth anniversary."

Yours Sincerely,
Howard Gladstone

ILP Manufacturing Inc.

IMSAI Update

(From February 1977)

IMSAI have released a new version of their editor-assembler for the 8080. It's yours in the form of paper tape and manual for $40, US price. Biggest part of the update is multiple device driver routines and a larger symbol table space. Also featured is an improved debugger.

PETs Are Here (At Last)

(From June 1978)

While CSA approval is still pending on Commodore PETs, Rick Denda of Marketron is importing them directly from the States and having them approved by Ontario Hydro. As far as we know these are the first PETs to be actually sold in Canada.

A combination of nasty little gremlins in the typesetting machinery and a slip in proofreading lead to some strange looking parts list headings in two January '87 projects.

The "Resistor" heading line of the Mini Tuner (page 52) should read as follows: Resistors (All 1/4W ± 5%); the line should be the same in the parts list for the Micro Tracer Unit on page 20. Our apologies to anyone who was inconvenienced by this.

100 and 1000 Years Ago in Electronics Today

October, 1885: "Can the many readers of Electronics Today really justify to their compatriots the usefulness of the endless hours of diversion provided by coils of wire and battery jars filled with peculiar liquids? While we, the staff, enjoy these pastimes as well, we must answer in the negative. It would appear that the invention of electricity will not prove of use to society, and regretfully must be ranked with other idle fantasies, such as the flying machine or the transmission of animated photographs through the ether.'

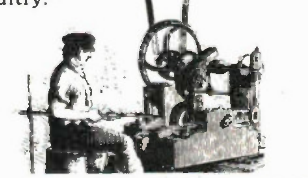
'While the staff of Electronics Today makes every effort to ensure accuracy, things occasionally do go wrong. The printed circuit for last month's Electrical Health Stimulator and Perspiration Suppressor was accidentally omitted and appears in this issue along with apologies for those inconveniencd.'

'Work is progressing in Southern California towards the miniaturizing of relays. The relay, at present an unwieldy coil and frame, can be used as the most basic form of 'memory', since it 'remembers' its electrical state until power is interrupted. Researchers claim that the relay could be made as small as six inches to a side, and dozens of them mounted in a framework no larger than the average living room, giving a 'memory' capability of hundreds of states. At present, we find this concept to be unrealistic; aside from having no conceivable use, it can no doubt be shown that miniaturization to this extent is simply not physically possible.'

October, 985: "Verily, ye Len Fynkler and Companny have prefented a new machine Tool, yclept ye OK-11 Wirewrap Tool from OK Induftries. Cleverly yclad in black ABS Plaftik, ye compact Tool is defigned for ye Production and ye R&D, handling Wire from 22 to 34 AWG. Much Time will be saved over ye previous way of faftening ye Wire with ye blow of an Axe."

"In sooth, ye Goblins do wreke Havok in ye Nyght in our Office; yea, ye Printed Circuit for Ye Electryfyed Broadfword inddeed was omitted from laft Month. It appeareth this Iffue wyth Apologia moft profufe."

"Ye alchemifts do difturb ye Brain and quicken ye Temper: verily, they do infift that ye entyre Drawbrydge could be ufed for a 'Memory' in that it doth 'remember' one of ye two State, forsooth, ye 'up' or 'one', and ye 'down' or 'zero'. Ye Drawbrydges are to be 'miniaturised', God a-willyng, and mounted in ye 'Memory Banks' to keep afresh ye 'Data'. Suche Foolery and wafting of Tyme doth bode ille for ye Induftry."



How It Began

By Halvor Moorshead who started Electronics Today, was Editor from 1980 to 1983, and is currently the Publisher.

IT ALL BEGAN with a phone call from Australia to Britain in September 1975.

In April 1973 I took over as Editor of the British Electronics Today; before that I had been working for a British magazine called Practical Wireless. ETI was a British version of an Australian magazine of the same name that had been very successful in its home market. The magazine had been the inspiration of Collyn Rivers, the best magazine Editor I have ever known.

The British ETI was largely reprints of the Australian magazine, run a couple of months later. At that time we had nine direct competitors and we were right at the bottom. Things went well and by 1975 we were growing very fast and starting to overtake some of the competition. My boss, Arnold Quick, who was of course based in Australia, was the person who made the phone call that started it all. 'Halvor, I don't think there is an electronics magazine in Canada. Is there a market for one?'. I hadn't the faintest idea, I had never even been to North America. My knowledge of Canada was limited to two things: a kid at school who had the strange habit of walking around in bare feet, an eccentricity that made me think that the streets must be very clean and the climate less severe than I had learned in geography, and secondly 'Forest Rangers' which was carried by British TV.

Starting Up

I flew to Toronto in November 1975 to answer my boss's question. Indeed there was no magazine even vaguely like ETI. In Britain, with twice Canada's population, we had several competitors; Australia, with half the population had two and Holland, with the same number of people as Australia, had four. A look at the market showed there was every bit as much interest in electronics here as the rest of the western world.

We decided that we would test the market and began to send over 5,000 of the British edition of the magazine, sporting the addition of a dollar figure to the price, to see if it would sell. It did.

Sales were good and in September 1976 we decided to launch a Canadian edition with its own staff. I started to commute between London and Toronto, spending two weeks in each. This may sound exotic but it was merely exhausting. We had to set up a company, hire the staff and get underway. The differences in publishing tradition between Britain and Canada are enormous and we were faced with all sorts of problems, the worst by far was finding an editor.

During the start period a lot of people were good to us. Gordon and Gotch (who distributed the British magazine during its test) lent me an office for a number of weeks. Heath were incredible; when I went to ask their advice they gave me our first order for advertising without being asked and 50,000 names of their customers to try for subscriptions. The problem of hiring an editor was obviously not going to get solved by the launch of the first issue so we sent over one of the British staff, Les Bell, here for a few months.

Offices were set up in Thorncliffe Park in Toronto with four staff (two of them, Senga Harrison and Sharon Wilson are still with us). The plan was for the magazine to have 50% locally produced editorial with the rest taken from the Australian or British editions who in turn would use the best from the Canadian edition.

The Heath mailing list was very good to us - 7 of the people we mailed took out a subscription even before the first issue and within a couple of issues we had 7,000 subscribers plus healthy newsstand sales supplemented by sales through electronics stores.

In an early issue we ran an ad for an editor and our luck changed - we had some excellent applicants and hired Graham Wideman who saw the magazine through its early stages.

Becoming Canadian

In June 1978 the British company, owned by the Australians and myself, was sold. We had been very successful and had

Continued on page 88

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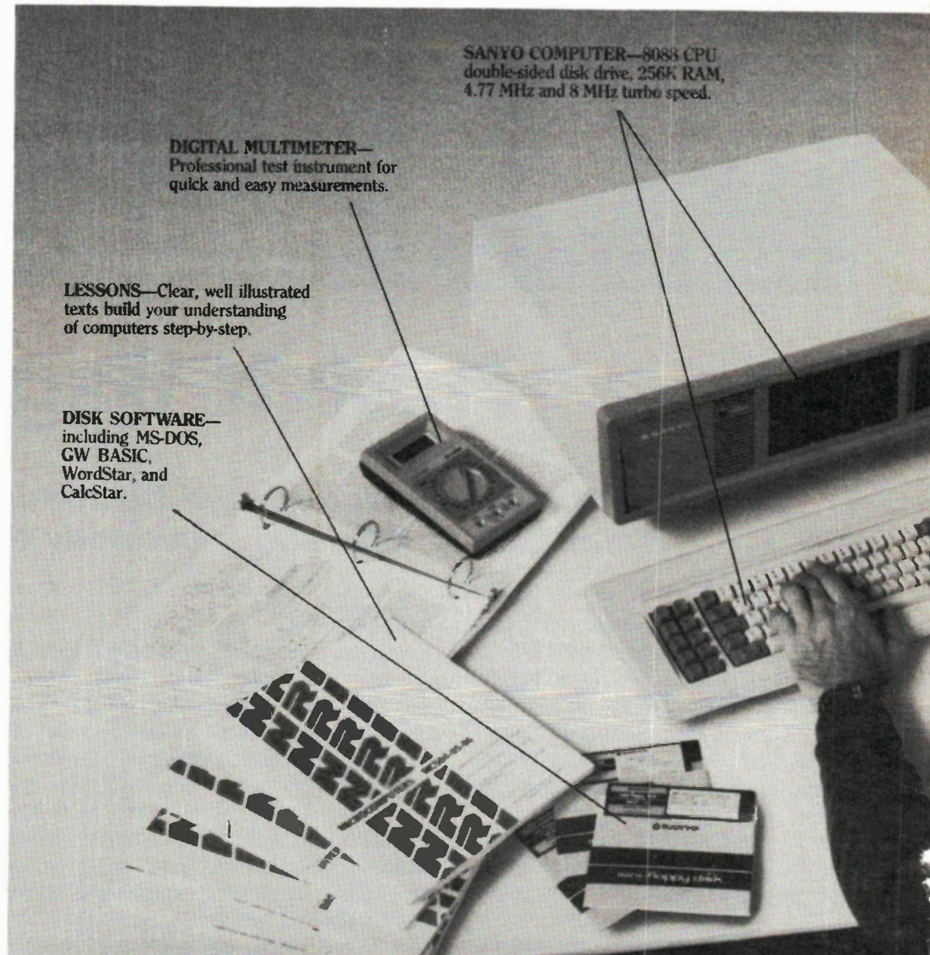

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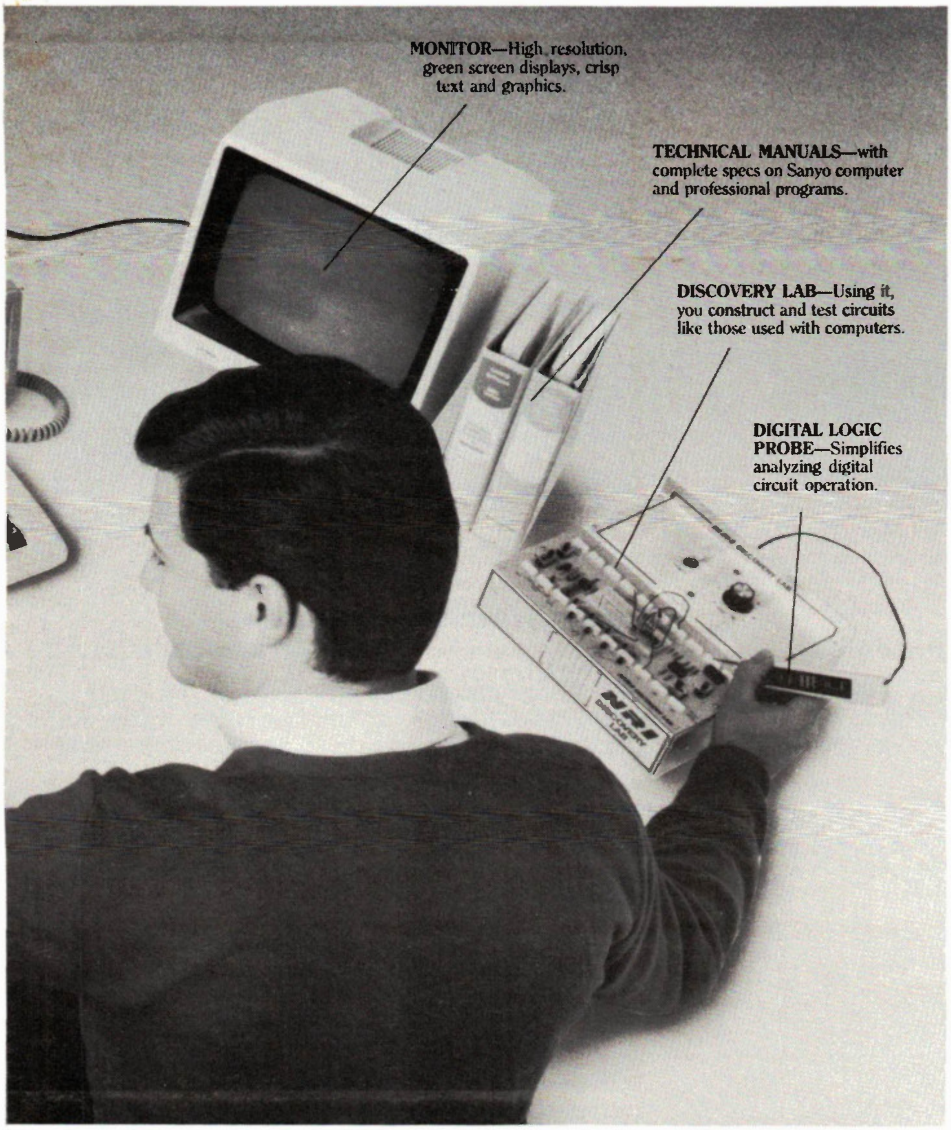

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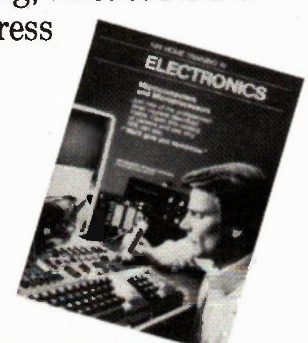

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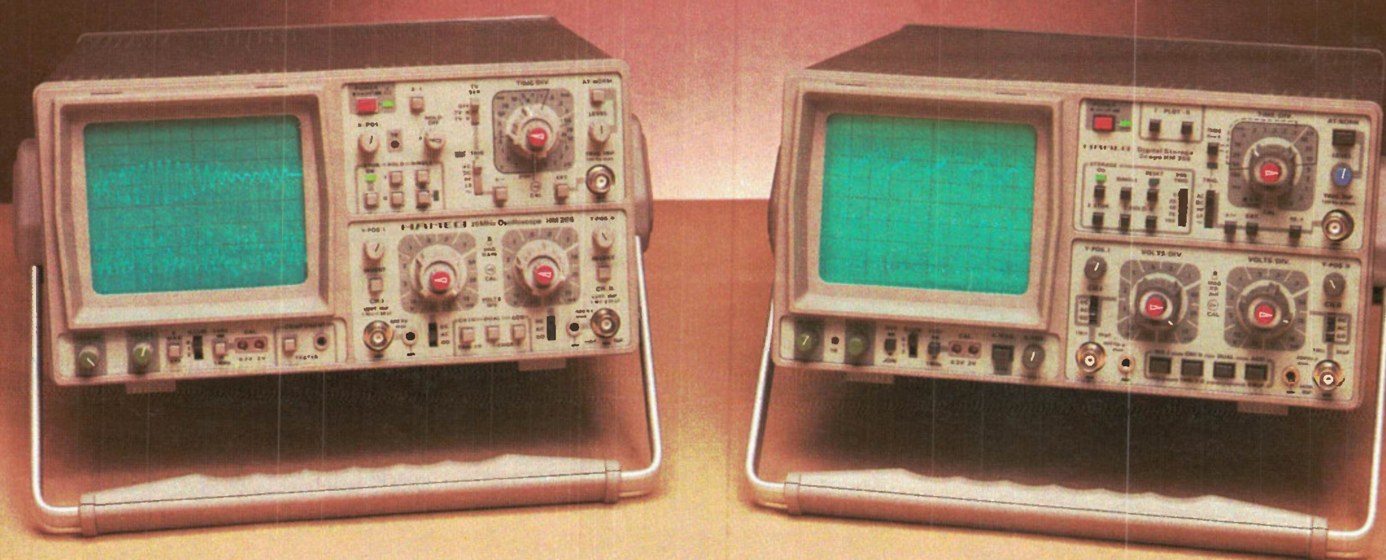

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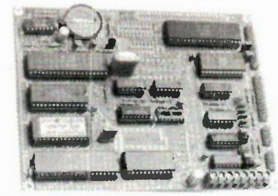

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Circle No. 11 on Reader Service Card

Optically Isolated Switch

Switch on in safety, even in damp conditions.

By T.R. de Vaux Balbirnie

PEOPLE ARE understandably wary of installing 120 VAC switches in damp places for obvious reasons. The optically-isolated system described here overcomes the problem since no electrical connections exist between the switch itself and the power supply. Any light-duty switch may be used, connected with cheap twin wire; some readers might use the circuit simply to avoid the high cost of 120 VAC switches and long pieces of cable. One application is to operate a porch light from a point outside the house; to prevent unauthorized use, a key operated switch could be used.

The Optically-Isolated Switch may be used with lights or other non-inductive appliances up to 300W rating on 120 VAC power. The entire system, apart from the switch and connecting wires, is housed in a wall-mounted plastic case with a socket to connect the remote switch and a flying lead for plugging into a nearby outlet. A 120V on/off switch with a neon indicator and fuse are provided. Internal "AA" size batteries provide power for the switch section of the circuit and these will give long service in normal use. For very long duty periods, it is better to use nickel cadmium-batteries which are kept charged as required. With the light on, the circuit draws a few milliamps from the batteries. When off, consumption is virtually nil.

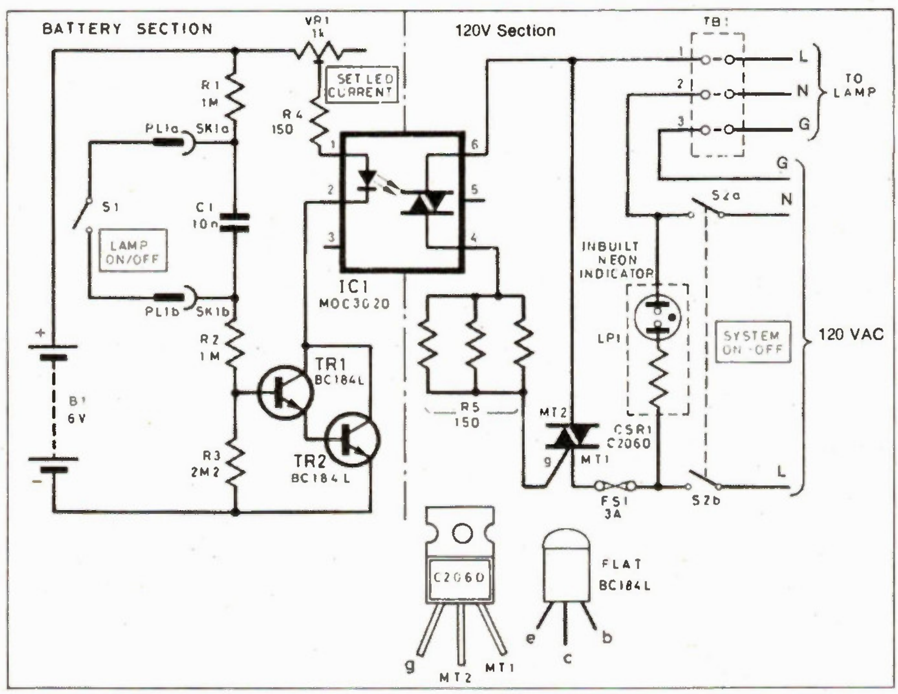

Fig. 1 Complete circuit diagram of the Optically Isolated Switch.

Circuit

The entire circuit for the switch is shown in **Fig. 1**. The dotted line indicates the division between the battery and 120 VAC sections. S1 allows current to flow from the battery, through R1 and R2, to the base of TR1 in the Darlington arrangement, TR1/TR2. Both transistors turn on and allow current to flow in the LED contained in IC1 via pins one and two. Resistor R4 and VR1 limit the operating current. IC1 is a six-pin integrated circuit containing a triac as well as the LED. With the LED on, the triac triggers and operates the 120 VAC power section of the circuit.

The LED often requires much less current to operate the triac than the data specifies so VR1 provides an adjustment to minimize this and conserve the battery. With the triac section of IC1 on, a conducting path is established between pins 4 and 6. Although the internal triac is capable of carrying 120 VAC current, this is not sufficient for a suitable lamp; for this purpose, a separate triac, CSR1, of greater current rating is used. Triggering in achieved through R5, and, with S1 off, the LED no longer maintains the triacs so they both switch off next time the AC cycle falls to zero. Since this never takes place longer than 1/120th of a second, the effect appears to be instantaneous. The reason for the Darlington pair, TR1 and TR2, is to allow a very high input resistance (R1 + R2) giving even greater isolation between the switch and the rest of the circuit.

Fuse FS1 protects the circuit from overload; it may occasionally blow, however, when a lamp fails. For this reason, the fuseholder has been made accessible from the outside of the case. Adjustment to VR1 is made through a hole

Continued on page 82

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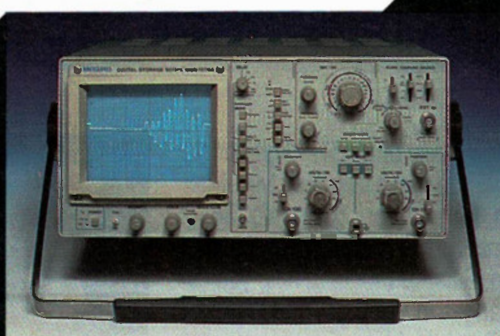

MEGURO MSO-1270A

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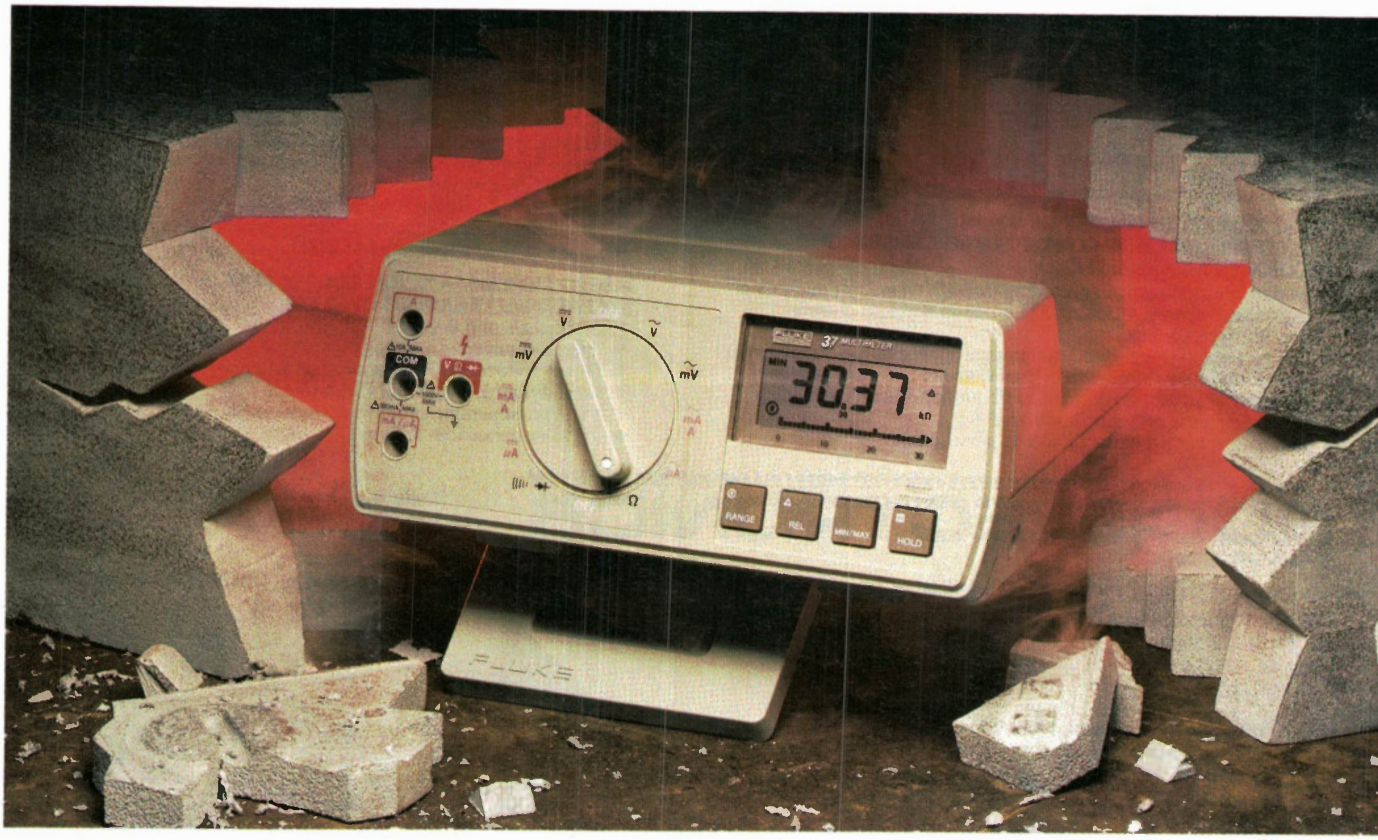
Fluke breaks the old mold.



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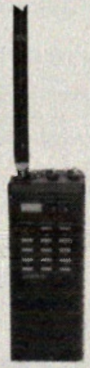

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Murphy's Law

A sample of Murphy's Laws with applications in electronics engineering. Reprinted from our October 1977 issue.

IT HAS LONG been the consideration of the author that the contributions of Edsel Murphy, specifically his general and special laws delineating the behaviour of inanimate objects, have not been fully appreciated. It is deemed that this is, in a large part, due to the inherent simplicity of the law itself.

It is the intent of the author to show, by references drawn from the literature, that the law of Murphy has produced numerous corollaries. It is hoped that by noting these examples, the reader may obtain a greater appreciation of Edsel Murphy, his law, and its ramifications in engineering and science.

As is well known to those versed in the state-of-the-art, Murphy's Law states that "If anything can go wrong, it will". Or, to state it in more exact mathematical form:

1 + 1 ✤ 2

where ✤ is the mathematical symbol for "hardly ever".

Some authorities have held that Murphy's Law was first expounded by H. Cohen when he stated that "If anything can go wrong, it will during demonstration". However, Cohen has made it clear that the broader scope of Murphy's general Law obviously takes precedence.

To show the all-pervasive nature of Murphy's work, the author offers a small sample of the application of the law in electronics engineering.

Engineering

I.1 The more innocuous a design change appears, the further its influence will extend.

I.2 Firmness of delivery dates is inversely proportional to the tightness of the schedule.

I.3 Dimensions will always be expressed in the least usable term. Velocity, for example, will be expressed in furlongs per fortnight.

I.4 An important Instruction Manual or Operating Manual will have been discarded by the Receiving Department.

Mathematics

II.1 Any error that can creep in, will. It will be in the direction that will do the most damage to the calculation.

II.2 All constants are variables.

II.3 In any given computation, the figure that is most obviously correct will be the source of error.

II.4 A decimal will always be misplaced.

Prototyping

III.1 Any wire cut to length will be too short.

III.2 Tolerances will accumulate unidirectionally toward maximum difficulty of assembly.

III.3 Identical units tested under identical conditions will not be identical in the field.

III.4 The availability of a component is inversely proportional to the need for that component.

III.5 If a project requires n components, there will be n-1 units in stock.

III.6 If a particular resistance is needed, that value will not be available. Further, it cannot be developed with any available series of parallel combination.

III.7 A dropped tool will land where it can do the most damage. (Also known as the law of selective gravitation.)

III.8 A device selected at random from a group having 99% reliability, will be a member of the 1% group.

III.9 When one connects a three-phase line, the phase will be wrong.

III.10 A motor will rotate in the wrong direction.

III.11 The probability of a dimension being omitted from a plan or drawing is directly proportional to its importance.

III.12 Interchangeable parts won't.

III.13 Probability of failure of a component, assembly, subsystem or system is inversely proportional to ease of repair or replacement.

III.14 If a prototype functions perfectly, subsequent productions units will malfunction.

III.15 Components that must not and cannot be assembled improperly will be.

III.16 A DC meter will be used on an overly sensitive range and will be wired in backwards.

General

IV.1 After the last of 16 mounting screws has been removed from an access cover, it will be discovered that the wrong access cover has been removed.

IV.2 After an access cover has been secured by 16 hold-down screws, it will be discovered that the gasket has been omitted.

IV.3 After an instrument has been fully assembled, extra components will be found on the bench.

IV.4 In an instrument or device characterized by a number of plus-or-minus errors, the total error will be the sum of all errors adding in the same direction.

IV.5 In any given price estimate, cost of equipment will exceed the estimate by a factor of 3.

IV.6 In specifications, Murphy's Law supercedes Ohm's.

The man who developed one of the most profound concepts of the twentieth century is practically unknown to most engineers. He is a victim of his own law. Destined to a secure place in the engineering hall of fame, something went wrong.

His real contribution lay not merely in the discovery of the law but more in its universality and in its impact. The law itself, though inherently simple, has formed a foundation on which future generations will build.

In fact, the law first came to him in all its simplicity when his bride-to-be informed him that his boss had beaten him to the alter.

This hitherto unpublished photograph Edsel Murphy was taken just after he had heard his ex-fiancees news.

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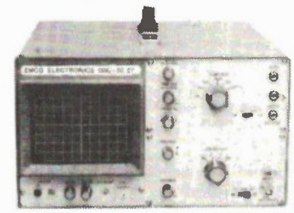

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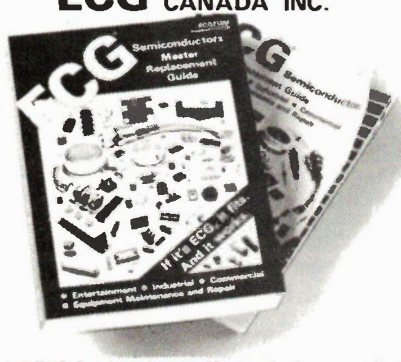

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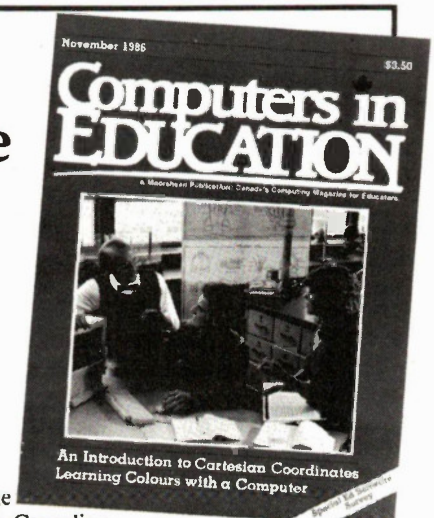

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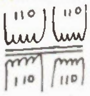

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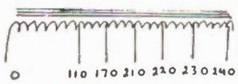

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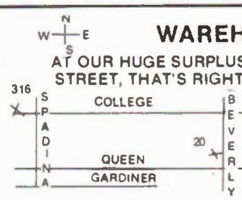

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Index of Electronics Today Articles and Projects from 1977 to 1986. A comprehensive directory of articles and projects from the last ten years of ET.

By ET Staff

Note: Due to the rapid obsolescence of some components in the last ten years, we strongly recommend checking for parts availability before attempting construction of projects from the earlier issues.

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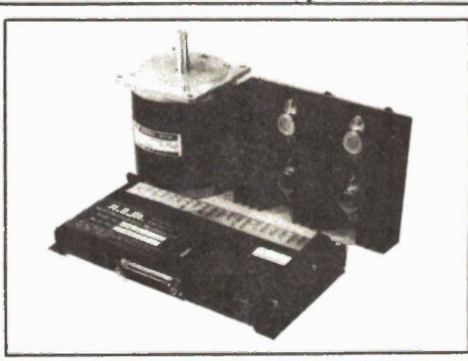

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Designer's Notebook: Capacitors

A review and update of the various types of capacitors.

By Jon Fairall

IT was fashionable during the years of the renaissance to dabble in "natural philosophy" via practical experiments. In 1745 a German cleric with intellectual pretensions did just that. He set up a glass jar and filled it with water, then sealed the top of the jar with a cork through which he had driven a copper stake. To the copper stake he connected an electric machine, a device in which a spinning glass globe was rubbed to create an electrical charge. Nothing seemed to happen, so he stopped the machine and grabbed hold of the glass jar. Instantly, his muscles contracted and the glass jar went flying. E.G. von Kleist had discovered capacitance.

To put the scene into context: electricity was still a mysterious force, but enough work had been done for people to believe that it was manageable, subject to laws that could be uncovered by reason and experiment. One of the questions that plagued experimenters was whether electricity was the kind of thing that could be stored.

The Reverend von Kleist proceeded with the thoroughly reasonable proposition that the way to store to store electricity was probably the way you store most small things: in a bottle. The bottle was glass, a known insulator, and inside was water, a conductor. Of course, when he disconnected the wire he gave himself a bad shock, probably the worst ever experienced up to that time. It "stunned his arms and shoulders", he later wrote.

It so happened that one of the finest minds in Europe, belonging to Professor van Musschenbroek, was working on the problem. He duplicated von Kleist's work, also getting a shock for his pains. Van Musschenbroek was first to publicize it, and so the device was named after the town where he did his experiment. The electric bottle is known to us today as the Leyden jar.

An explanation of the strange effects of the Leyden jar was not long in coming. The glass was an insulator, the water was a conductor, and the hand of the experimenter was also a conductor, especially when wet from pouring the water into the jar. Van Musschenbroek realized that in such a device the effects of electricity were condensed. It was, he said, a "condenser" for electricity. Today we call such a device a capacitor.

Practical capacitors were developed almost as soon as an explanation of the Leyden jar effect. These simply substituted metal foils for the water and the experimenter's hand. Connection to the inner conductor was via a chain threaded through a rubber stopper.

So what was the wonderful new effect that had been discovered?

TABLE 1: COMPARISON OF DIELECTRICS (courtesy Rifa)

Type	Poly-propy-lene	Poly-styrene	Poly-ester	Ceramic NPO	Ceramic Hi-K	Mica	Aluminium oxide	Tantalum oxide
e	2.2	2.4	3.3	450	12000	7	10	28
typical capacitance	10n-100μ	47p-50n	1n-10μ	1p-10n	1n-10μ	1p-100n	100n-1F	10n-1000μ
max V dc	2000	500	600	200	100	500	450	125
dissip-ation factor	0.05	0.02	0.8	0.1	3	0.2	10	10
typical tolerance	5%	1%	10%	10%	80%	1%	30%	5%

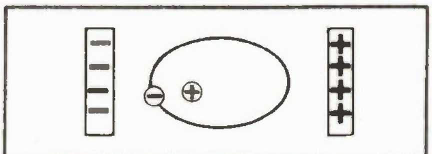

Fig. 1. The elliptical path of an electron around the nucleus of an electric field.

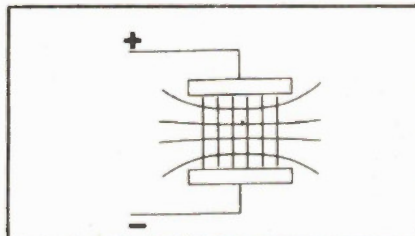

Fig. 2. The field between two conductors. The vertical lines are the equi-potential lines which connect points of equal potential. The horizontal lines are the field lines and represent direction of movement of a free charged particle.

Fields

Capacitance is a measure of the ability to store electric charge. To understand how this works, it's necessary to go back and think about some fundamentals of physics and electricity. Matter is composed of atoms, and all atoms are electrically neutral. However, the constituents of the atoms are not. The nucleus has a positive charge and the electron a negative charge.

One of the fundamentals of electronics is that unlike charges attract and like ones repel. So, if we have a point with a surfeit of electrons, and another point with a lack of them, then all the electrons will flee the negative point and congregate at the positive point. However, this is not the whole story, because how many electrons flow depends on the type of material they are embedded in. Some materials, such as copper and aluminum, encourage electron flow; we call them conductors. Others don't, and we call them insulators or dielectrics.

What's happening? Electron orbits, normally circular, are distorted by the presence of a charge. There is a gradient of force across the electron orbit, so that on the side closest to the origin of force, the disrupting force is stronger than on the side further away. This turns the orbit into an ellipse. The stronger the force, the steeper the gradient and the more elliptical the orbit. When this distorting force becomes too great, the electrons shear off and become negative ions. The amount of force necessary to achieve this depends on the quality of the material. The atoms in conductors are vulnerable, those in dielectrics resistant.

The problem with this account is that it involves what is known as "action at a distance". The electrons are depleted *here* and the atoms react *there*. Exactly the same problem worried Newton when he was working on the theory of gravitation. We can explain things with an abstract mathematical idea called a field. Fields have been involved in gravitation and magnetic theory as well as in electrical theory.

You can give a field some kind of physical reality and delineate it with equipotential lines, That is to say, lines along which the strength of the field is the same. At right anglers to this run field lines which indicate the movement of a free charged particle in this field. As you can see from **Fig. 2**, the rules are that field lines leave and enter their source at right angles; they never cross, and they flow from a positive point to a negative one.

Another way to think about the field: consider what the presence of the field means to the atom across which it is impressed. Each of these has electrons in an orbit of greater or lesser eccentricity. This is a higher energy state than normal, and thus represents a source of energy. It is potential energy, however, since one can't get at it until a conducting path is provided. Then it becomes real energy, showing itself in the deflection of an ammeter. In effect, the energy field is an energy store.

Practical Capacitors

So how do we turn this theory into a practical capacitor? The earliest capacitors consisted of two sheets of parallel metal with an air gap. This is still a preferred method of doing things for variable capacitors. Early in the game, however, it was discovered that other materials make better dielectrics, and for most applications solid materials are used.

There are two main types of capacitors, both conforming to the general pattern of conductor-dielectric-conductor. One is the foil type, in which a strip of dielectric, like mica or ceramic is sandwiched between two strips of conducting foil. Leads are soldered to the foil and the whole assembly heated to seal it against moisture.

A variation on this theme is called "metallization", particularly favored with the plastic dielectrics like polyester and polystyrene. Here the semiconductor material is vaporized in a vacuum container and then deposited onto the dielectric, which is then wound up to form the capacitor. This method has the advantage that it is possible to make the metal layer extremely thin, on the order of microns. Modern techniques allow the dielectric to be of this order of thickness as well, so an extremely compact capacitor results.

Even more compact are the new monolithic capacitors, especially intended for surface mounting. These SMDs (surface mount devices) are made from microslices of ceramic and silver packaged in a cube a few millimetres on a side. It's possible to obtain up to 0.1uF by this method, sufficient to bypass TTL in typical applications.

The other major type of capacitor is the polarized electrolytic. A metal post composed of aluminum or titanium serves as the anode. An extremely thin oxide layer is grown on the outside of the post to serve as the dielectric. The cathode is an electrolyte. Normally an electrolyte is a liquid, but in this case the electrolyte is impregnated in paper or some other porous substance. With this structure it clearly makes a difference which way the current flows through it, and in fact this type of capacitor can only be used when the current flows in a single direction.

Equivalent Circuits

In theory a capacitor is simply a capacitor. In practice, a capacitor, like every other device on a circuit board, has capacitance, inductance and resistance. The only difference is that the capacitance is controlled, and hopefully, the inductance and resistance minimized.

The equivalent circuit of a real capacitor is shown in **Fig. 4**. It shows series inductance, and both series and parallel resistance. The series inductance

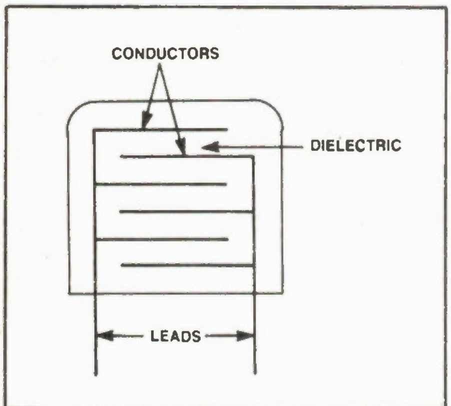

Fig. 3. A typical capacitor.

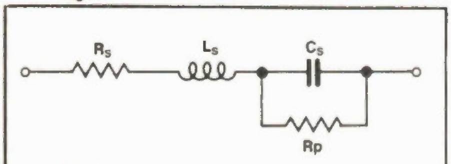

Fig. 4. The equivalent circuit of a capacitor showing inductance and resistance in series with capacitance. The capacitor is also shunted by resistance.

is present in the device leads and indeed, in the body of the component itself. As one would expect, the inductive effects increase with frequency, and so the practical effect on the capacitor as a whole is a decrease in the impedance up to a certain frequency, called the resonant frequency, followed by an increase. This effect is present in all capacitors, but it can be minimized by careful design, and also by careful mounting on a PC board. The rule is: keep the leads short.

Series resistance is a measure of the loss in the capacitor. It is measured as the loss angle or the dissipation factor. These are different ways of approaching essentially the same ting, and they are often used interchangeably, especially in AC theory. Theoretically, in a pure, lossless capacitor, there is a phase difference between current and voltage of 90 degrees. Current leads voltage. In a resistor there is no difference. In a practical component the resultant phase angle is a result of the vector sums of resistance and capacitance. As a result, the loss angle is a good measure of the extent to which power is absorbed in the capacitor, and thus a

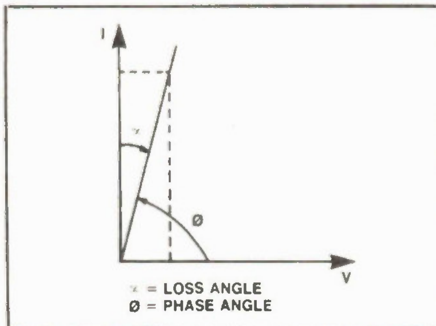

Fig. 5. The loss angle.

measure of the extent of series resistance.

Parallel resistance is more commonly known as insulation resistance, and in fact is a measure of the ability of the dielectric to carry a direct current. As the area of the dielectric and thus the capacitance goes up the insulation resistance goes down.

Compromise

Given all this, what are the limits that constrain capacitor design? As always when dealing with nature, there are com-

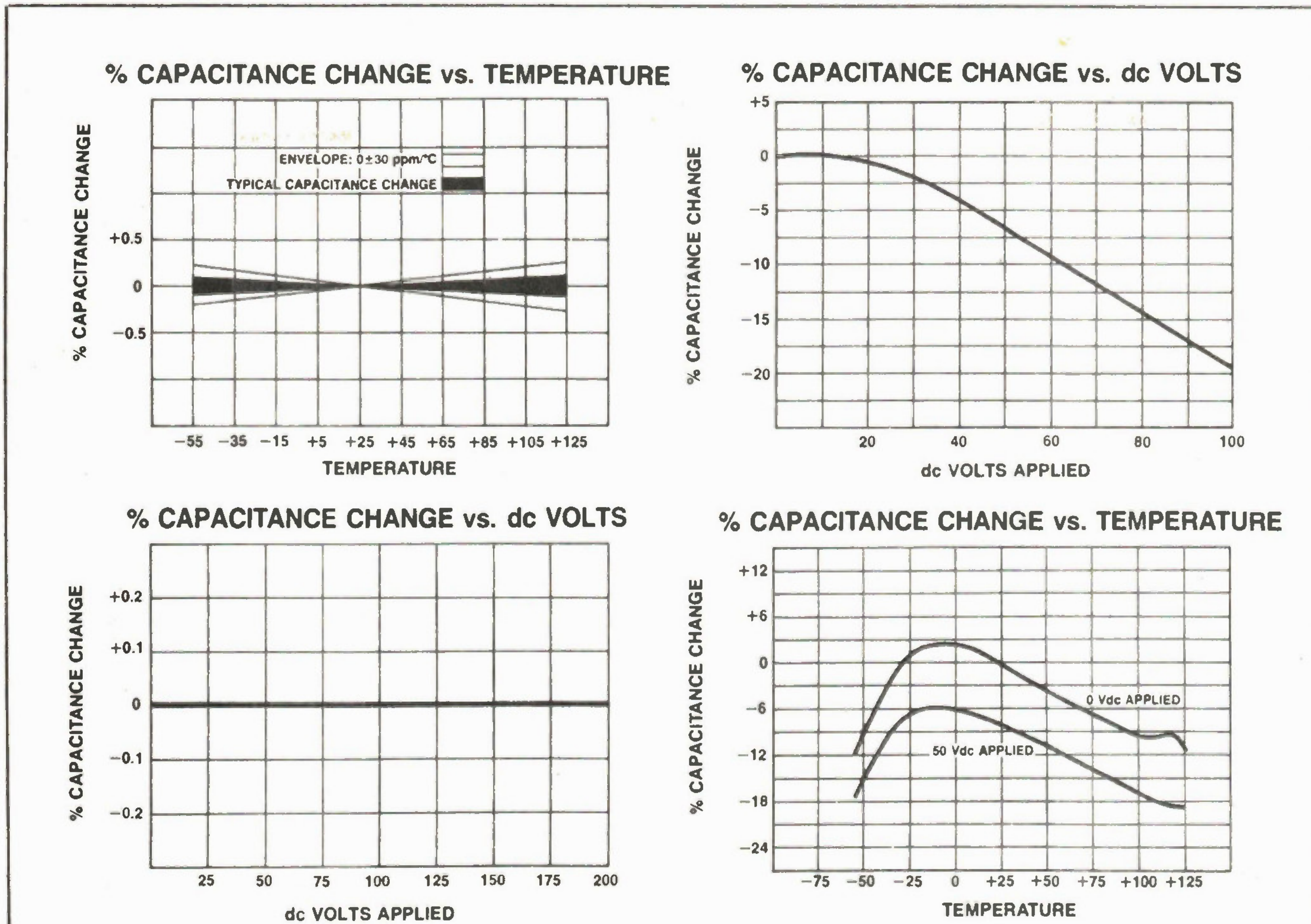

Fig. 6. Comparison of two ceramic dielectrics..

promises to be made.

Capacitance in any capacitor is proportional to eA/d, where *e* is the dielectric constant, *A* is the conductor area and *d* is the distance between conductors. Since the maker usually wants to get as much capacitance into as small an area as possible, he can do any of three things: increase A or e, or decrease d.

Increasing e has been a preoccupation of scientists since 1745. However, as we will see, high values of e often have nasty side effects. Modern trends have included research into plastics that has seen products like polystyrene and polypropylene join standards like polyester. Research is also going on into the creation of new types of ceramics.

The problem is that large dielectric constants are associated with some undesirable electrical properties. Perhaps the most notable in a practical sense is that most dielectrics are unstable. They tend to be sensitive to temperature, frequency and voltage, and any or all of them can cause the capacitance to change quite dramatically.

The most dramatic example of this can be seen in ceramic capacitors. Ceramic is not, as often imagined, a single type of dielectric. In fact ceramic capacitors are made by mixing up a brew of "powders"; a little of this, a little of that. Graphs of capacitance versus temperature and DC volts are shown in **Fig. 6** for two types of dielectric, NPO and BX. With an NPO dielectric, a capacitor about a millimetre cubed can have between 1 and 150pF of capacitance, An equivalent sized BX capacitor will range between 100pF and 5.6nF.

The state of the dielectric also changes with frequency. Most significantly, the dissipation factor increases dramatically with frequency in any given dielectric, and as usual, it's the ones with the higher dielectric constant that are hardest hit. Tantalum, for instance, has much worse high frequency response than either ceramic or plastic film capacitors. Ceramic or plastic can be used to decouple high frequency transients from integrated circuits; tantalum is essentially useful in this application.

Another factor is the question of aging. There are many applications where there is a requirement for capacitors to last 30, 40 or even 50 years without significant changes in capacitance. Expensive equipment in telephone exchanges would be a prime example. Front runners for this application are polystyrene and polypropylene, with dielectric constants around three.

Designers have a number of tricks up their sleeves to increase the value of A. Perhaps the earliest, and still the commonest, is to roll the dielectric up like a

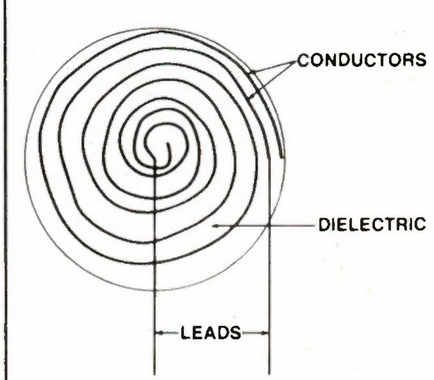

Fig. 7. Structure of a typical thin dielectric metallized capacitor.

Swiss cheese (**Fig. 7**). A rather more subtle measure is to increase the microscopic corrugations in the surface of the conductor, thus effectively increasing A without increasing the bulk of the whole assembly. Etched aluminum surfaces do just this, resulting in substantial increases in A. Perhaps the most spectacular example is NEC's Supercap, which uses a layer of activated carbon that is so rough it has an area of 10 million square cm for every gram of carbon. Going down this route has resulted in a farad of capacitance in a coin-sized package.

Manufacturers have made some remarkable achievements in pursuit of super thin film dielectrics. In 1951 DuPont in the US announced Mylar, the first of the plastic films suitable for miniature capacitors. It is still in use today as "Mylar C" and available down to 1.5um. Films of these dimensions are used by Wima in Germany to produce ultraminiature capacitors with lead spacing only 2.5mm apart. Paper layers in metallized capacitors have been produced that are only 10um thick. Rifa is now manufacturing polypropylene dielectrics as thin as 4um. Research is currently underway that will allow large scale manufacturing of 1um sheets.

There are many problems with relying on super thin dielectrics. Some idea of the scale: 20 layers of Mylar film one on top of the other would be thinner than a human hair. For a start there are mechanical problems that come from handling material that thin. It tears easily and is susceptible to heat. However, these problems can be overcome (at a price). What cannot be overcome is the voltage sensitivity of such capacitors. All things being equal, the thinner the dielectric the less voltage you can put across it. ■

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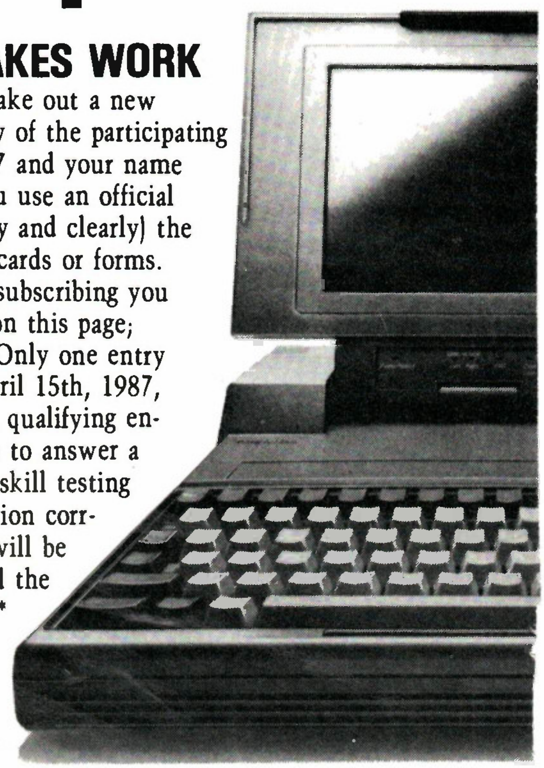

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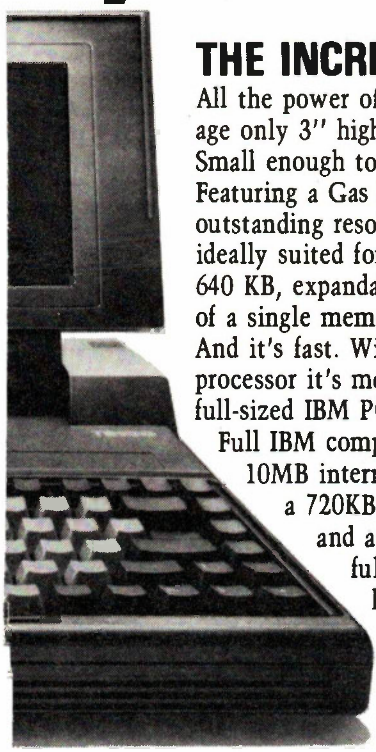

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Ten Articles we wish we'd never seen.

By Bill Markwick and Ed Zapletal

(Publisher: "Hmmm. I don't remember seeing any of these in ET."
Editor (opening another litre of Conners Ale): "Would I lie to you?")

1. The Cockpit of the Future. The freelance writer professed to be an expert on aviation and asked if he could submit his story on the Cockpit of the Future.

This turned out to be a kitchen counter and a mouse.

"Well," he said, "it works pretty good on my MicroSoft Flight Simulator."

2. The Sex-Detecting Doorbell. The doorbell featured an infrared thermal sensor mounted on the outside at knee level and worked on the theory that women would register "female" because they'd be wearing skirts, releasing more radiation to the sensor.

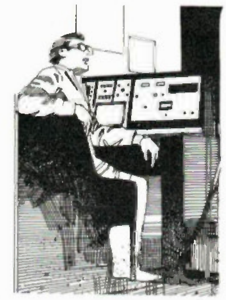
The inventor suffered serious injury when he threw open the door and embraced a visiting Scotsman.

3. Electronics in Alien Spacecraft. The author claimed to have been taken aboard a number of flying saucers and found the electronics modules to consist mainly of racks of 12AX7s and 6CA7s, powered by a particle converter which changed blueberry yogurt into electrons.

4. Build Your Own Time Machine. The author arrived with his prototype for a demonstration. The machine began to switch on and off like a skipping record, forever cycling the author 15 minutes into the past. In fact, for five years now he's been in the reception area trying to get an appointment to see an editor.

5. Electronic Cigarette Lighter. Since smokers at parties are now forced to go out in the yard or down in the basement, this lighter module includes a handwarmer, a storage space for butts, a Tic-Tac-Toe game for something to do, and a readout showing the amount of time deducted from the smoker's life by each cigarette.

6. The Compufib Telephone Answering Machine. Using a limited amount of voice recognition, the machine listens patiently to the caller and then triggers on keywords, playing back a number of prerecorded excuses: "The database must have a glitch in it", "I sent it to the mailroom yesterday", or "It's held up in another processing section". Persistent callers are sent down the winding path, their call repeatedly transferred to other departments until they go away.



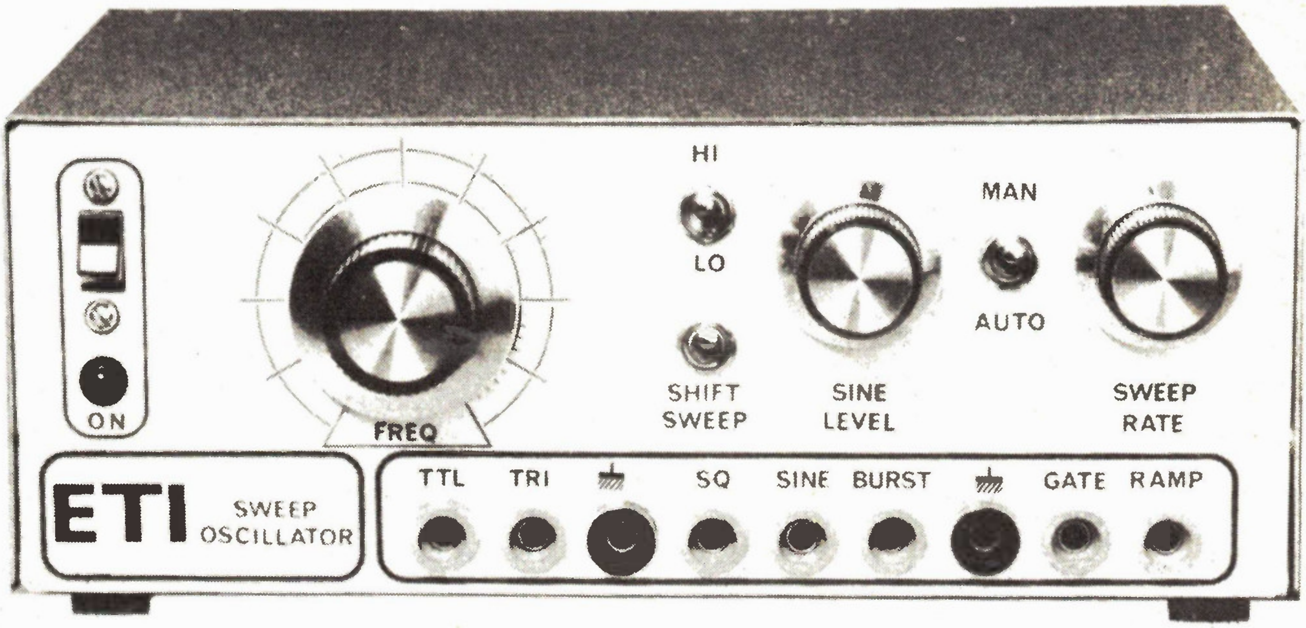
7. Build a Urinalysis Machine. Now anytime you see an employee doing stupid, incompetent, blundering things, you can give them a low-cost test. Unfortunately, in most companies, this will mean most of the employees will be busy giving specimens.

8. Build a Power Tool Destroyer. Sick and tired of building crooked bookcases and ratty-looking teapot stands? Like some more space in your basement? The Power Tool Destroyer combines the best of hydraulic rams and acetylene cutting torches to reduce your saws and drills to a neat, compact pile readily saleable to the scrap dealer.

9. 500 Uses For A Dead ZX-81. And we thought they were only good for doorstops. Splitting wedges, wheel blocks, gerbil cage cleaning shovels, the list goes on and on.

10. Kitchen Compactor Project. Every Christmas, somebody gives you another appliance for the kitchen until the place is overflowing with drink stirrers and dough blenders and carrot teasers. Use the Kitchen Compactor to crush them all into a small, convenient footstool. ■

Audio Sweep Oscillator



An invaluable addition to the test bench.

By Tim Orr and P. Wielk

SWEEP OSCILLATORS are generally considered to be a rather fancy piece of equipment and usually attract a fancy price. Units similar to the one described here sell for around $200 to $300. It produces square and rectangular wave forms from a voltage controllable oscillator, which can be internally swept by the machines own ramp generator (which is itself controllable), or it can be connected to an external control voltage source. Thus various frequency modulations can be performed, the most useful one being a wide range logarithmic sweep for resolving the frequency response of various networks and filters. To do this, a swept sinusoidal waveform must be synthesized. The triangle waveform is bent by passing it through a diode function generator until it closely resembles a sine wave.

Another waveform provided by the function generator is a tone burst output. This gates the sinewave signal on and off and thus generates a burst of sine waves followed by a period of silence. Tone bursts are very useful for analyzing the dynamic responses (as opposed to steady state responses) of networks such as filters, compressors, expanders, and loudspeakers etc. The last waveform provided is a square wave suitable for driving TTL circuits. This output uses a current sinking transistor so that up to about 30 TTL unit loads can be driven by it.

Selecting ICs

The function generator needs fast op amps to buffer the signals to the external world. These op amps should also remain stable when connected to various reactive loads. Several devices were tried, namely: the 741S, a fast version of the 741; the 748, an uncompensated version of the 741; the CA3130 and CA3140, both of which are fast CMOS devices. Also the LM318, a fast (50v/uS) slew rate op amp made by National; and the NE531v, another fast device from Signetics. Not all of these proved successful, particularly when driving reactive loads. Also, some of them require external frequency compensation and so the PCB was designed to accept various capacitors. You can use any of the op amps, but I feel that the best results will be obtained by using the suggested devices. In fact, you can use a regular 741 , but this will result in degraded waveforms. **Fig. 4** shows the suggested ICs.

Using The Machine

Generally try to keep the load impedances presented to the machine as high as possible. The current driving capabilities of all the outputs are limited, particularly at high frequencies, and so you may find that outputs become degraded as the frequency increases.

If you want to investigate the frequency response of a filter design to get a non-flickering display, you may have to use a fast sweep rate, say 20 times a second. This could result in a 'time-smeared' display due to the ringing time of the filter. The display will be a cross between the filter's dynamic and steady state response. To overcome this problem, there are two possible solutions: use a slow sweep speed (if you have a storage scope this will be OK), or, frequency scale the filter up in frequency, so that say, a 100 Hz bandpass filter becomes a 1 KHz filter. You can then increase the sweep speed by a factor of times 10. However, this is generally only possible when you are designing a filter and when you know that there is a sufficient bandwidth margin still available.

Construction

Even though this is electronically a complex project, construction is reasonably straightforward. Main points to note are as follows: first insert and solder all the wire links, followed by the trimpots. The link near RV1 is insulated. It's a good idea to use terminal pins for all the off-board leads; it saves trouble if you have to move a wire. Next, the resistors, capacitors, and diodes can be fitted, and C3 only needs to be fitted if you can't get C2 on the board. Q7 needs its base lead bent to fit underneath the board. The only IC that really needs a socket is IC15, but sockets can save hours if used for all ICs.

All off-board connections should be soldered before inserting IC15 anyway. Shielded wire should be used for connection to the controls, but only the socket end should be grounded otherwise nasty hum loops can develop. The external voltage control socket was mounted on the rear panel. The transformer specified has twin windings which are used in parallel. IC1 does not need any heat sink as very little of its capacity is used. Last, but by no means least, R16 and R34 are both mounted off the main board.

Setting Up and Alignment

Having built and tested the unit, it now only remains for you to align the six trimpots.

RV1 - frequency bias

Set switch SW2 to manual and switch SW4 to the high frequency range. By turn-

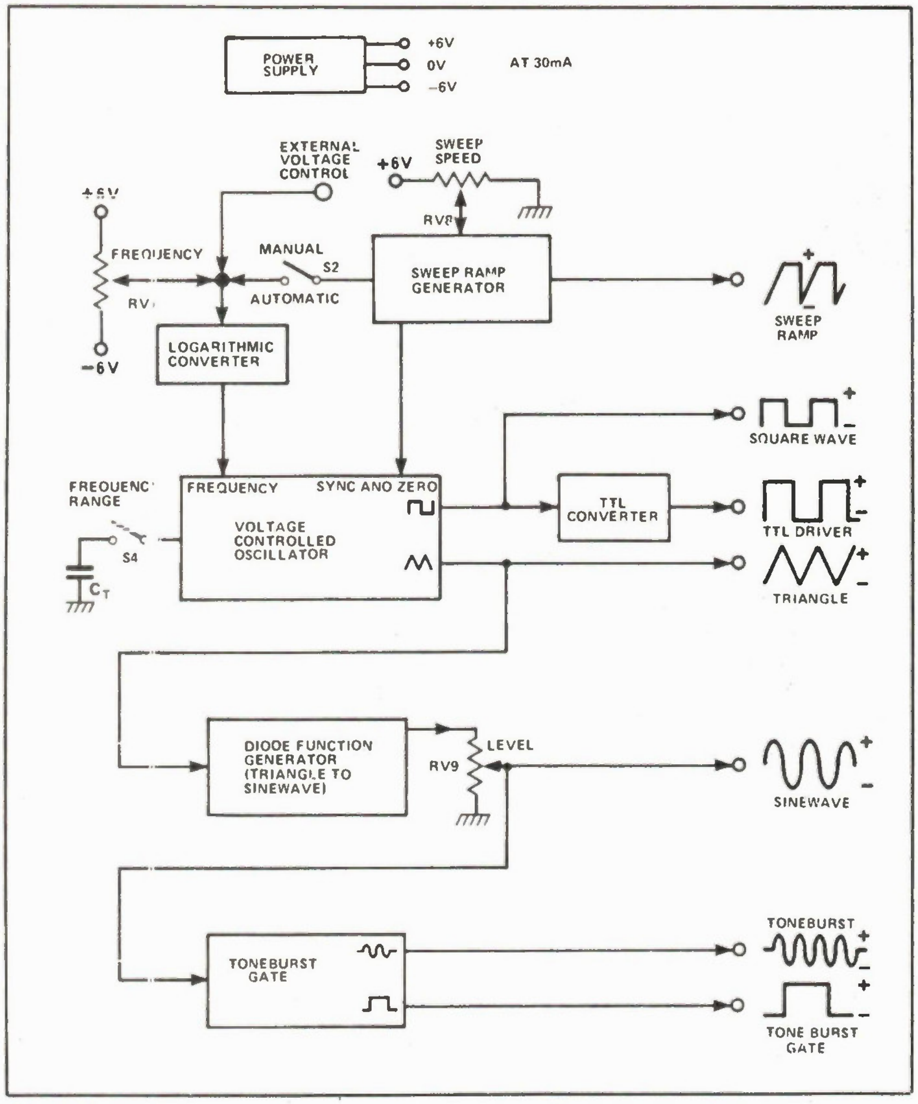


Fig. 1 General system organization of the Sweep Oscillator.

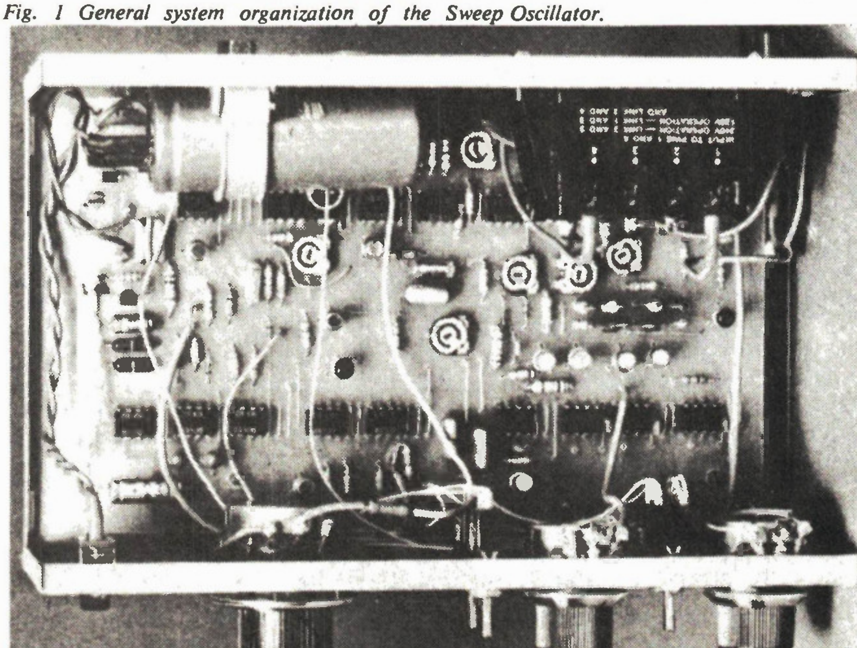


Fig. 2 Internal view of the completed unit.

ing the frequency control knob, the output of the unit should range from approximately 20Hz to 20KHz. However, the transistors in the transistor array IC3 are only matched to within ± 5mV and this can shift the generator's operating range. So to counteract this mismatch, adjust RV1 until manual operating range is as near to 20Hz to 20KHz as possible.

RV2 - triangle time symmetry
The time symmetry of the triangle wave form may not be exactly 1:1, and if this is the case, then the sinewave will have a large THD. The root cause of any time asymmetry is IC5 which is a CA3080. If the time symmetry varies significantly when the frequency is changed, then IC5 will have to be changed until a suitable output is obtained. To align RV2, set the operating frequency to 1KHz, look at the triangle waveform and rotate RV2 until the best symmetry is obtained. This preset should be readjusted later when the THD alignment is being performed. Move the frequency throughout its range and check that the symmetry is well maintained.

RV3,4,5,& 6 - THD minimization
As it was not practical to use low tolerance components and matched diodes in this design, it is necessary to perform several alignments to produce the possible sine wave. The way in which you align this generator depends on the equipment at you disposal. Here are three methods.

First, by ear. Your hearing apparatus is surprisingly acute to matters of frequency and harmonic structure. For instance, if you listen to the square wave output on a good pair of headphones (preferably high impedance), then you can adjust the time symmetry (RV2) by ear with far more accuracy than you can with a direct visual display on an oscilloscope.

As RV2 is adjusted, and the symmetry changes, there comes a point where all the even harmonics disappear, which can be distinctly heard. You can also try to align RV3, 4, 5, and 6 by listening to the sinewave output at a frequency of say 400Hz. As you adjust each pot you should be able to minimize the harmonics and generally converge upon settings that give the purest tone.

Secondly, by using an oscilloscope, look at the sine wave (set to 1kHz and adjust RV6 so that the waveform, whatever it looks like, is vertically symmetrical. RV6 merely compensates for any loss of DC offset that has occurred in the production of the triangle. Presets RV3, 4, and 5 can now be used to adjust the breakpoint slopes. By careful adjustment of them it is possible to converge upon a waveform that looks very nearly sinusoidal.

Thirdly, by using a distortion meter

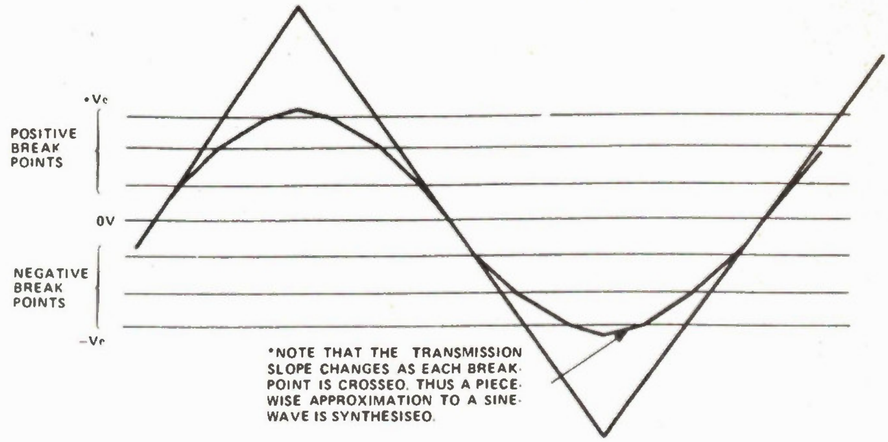


Fig. 3 Technique used to synthesize sine wave for triangle wave form.

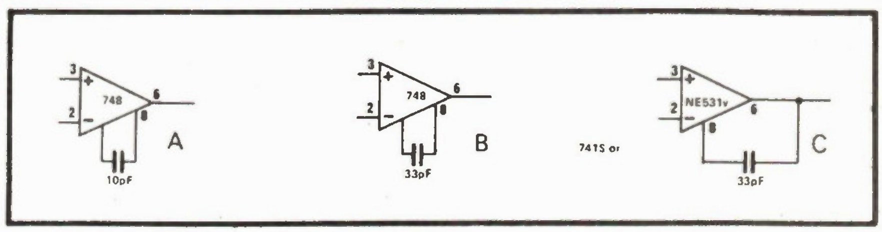


Fig. 4 Suggested ICs for IC11, 12, 13, and 16 with correct equalization capacitors. IC11 is C, IC12 is A, and IC13 and 16 are B.

(tuneable notch filter), the sinewave is connected to this device and the fundamental is notched out leaving only the harmonics, which you can see and measure. The procedure is to set the frequency to 1kHz and adjust the distortion meter so that the sinewave fundamental has been removed. Look at the residue with an oscilloscope and/or millivoltmeter and adjust RV3, 4, and 5 until this residue is at a minimum.

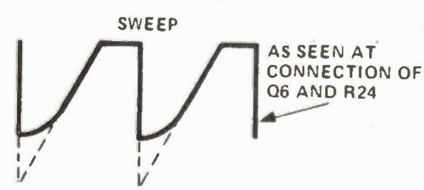
If you don't happen to own a distortion meter you can construct a notch filter at about 1kHz and notch out the fundamental by altering the function generator's frequency.

Problems Likely To Be Encountered

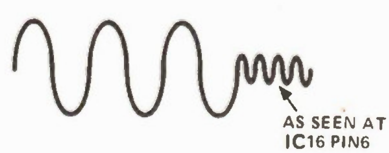
The power supply can be a problem source; the 12 volt regulator can be responsible for many deviations from the predicted performance, due to the ± 5% spread in output voltage. This could cause the sweep range to be larger or smaller, or it can effect the distortion of the sine wave. The following is a list of common problems and solutions:

Reduced frequency range. If the manual or swept frequency range is less than expected then increase R12 from 1k to 1k1. This will approximately provide an increase of one octave. If the range is too large, then reduce R12 to 910 ohms.

Clipped triangle. This could be caused by a lower power supply rail or a large Vp in Q3. Either change Q3 for a low Vp FET or reduce R17 to 470 ohms. Similarly, if the sweep output waveform (output 19) is bent on its negative end, change Q6 for a low Vp device or reduce R24 to 4k7.



Tone burst does not shut off. This is because Q12 will not switch off. Change Q12 for a low Vp device.



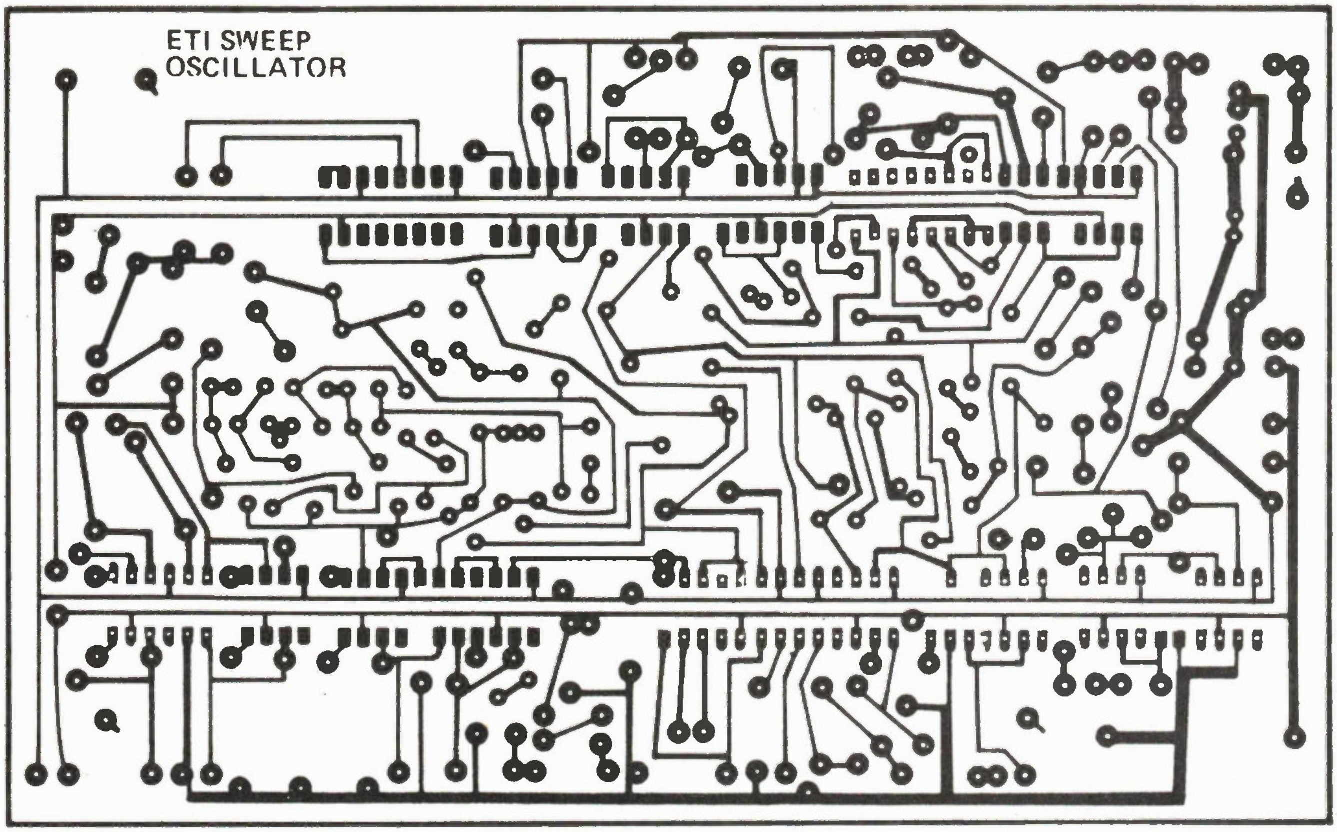
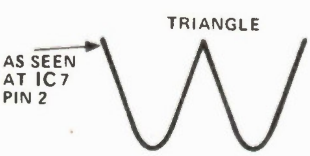


Fig. 5 Full size PCB pattern for the PCB.

Sine wave has a high THD. If the THD cannot be trimmed to about 1% then it is likely that the diode function generator has the wrong gain. If the sinewave looks more like a triangle (a), then increase R42 to 20k. If it has flattened ends (b), then decrease R42 to 16k. Note, very small changes in R42 have a large effect on the THD figure.



This project was originally published in our September 1977 issue.

SINE WAVE (Variable 0-4V)	**THD<1.5%**
TONE BURST (Variable 0-4V)	**16Hz on 48Hz off**
TRIANGLE (3V5 Fixed)	**Summetry ±2%** (better than)
SQUAREWAVE (3V5 Fixed)	**Markspace 1:1 ±2%** (better than)
TTL (5V, pulldown to zero)	**Markspace 1:1 ±2%** (better than)
TONEBURST GATE	**12V Fixed**
X SWEEP RAMP	**1V9 Fixed**
CONTROL INPUT	**+1V/Octave +3V3/Decade**
SWEEP RANGE (Logarithmic)	**1000:1**
RAMP RANGE (30Hz to 0.06Hz)	**500:1**
HIGH RANGE	**20Hz to 20kHz**
LOW RANGE	**0.2Hz to 200Hz**
(Manual or Automatic Sweep)	

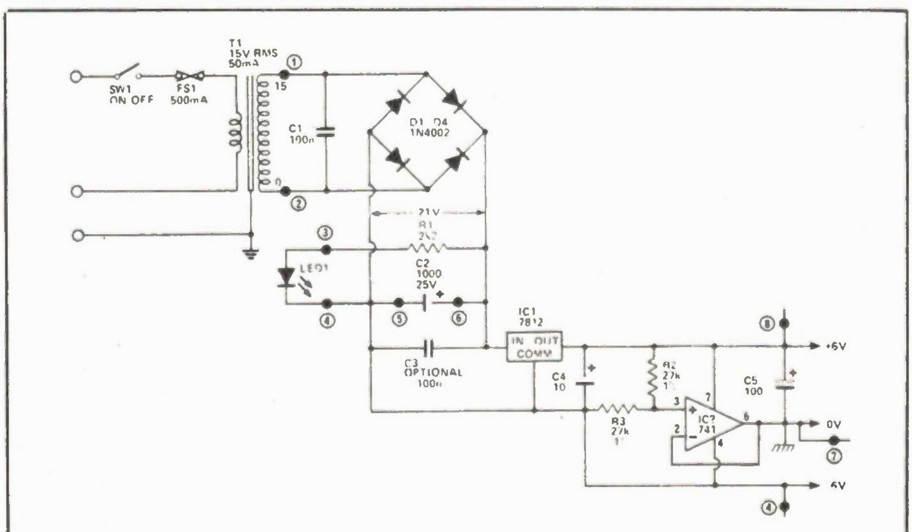


Fig. 6 Power supply circuit diagram.

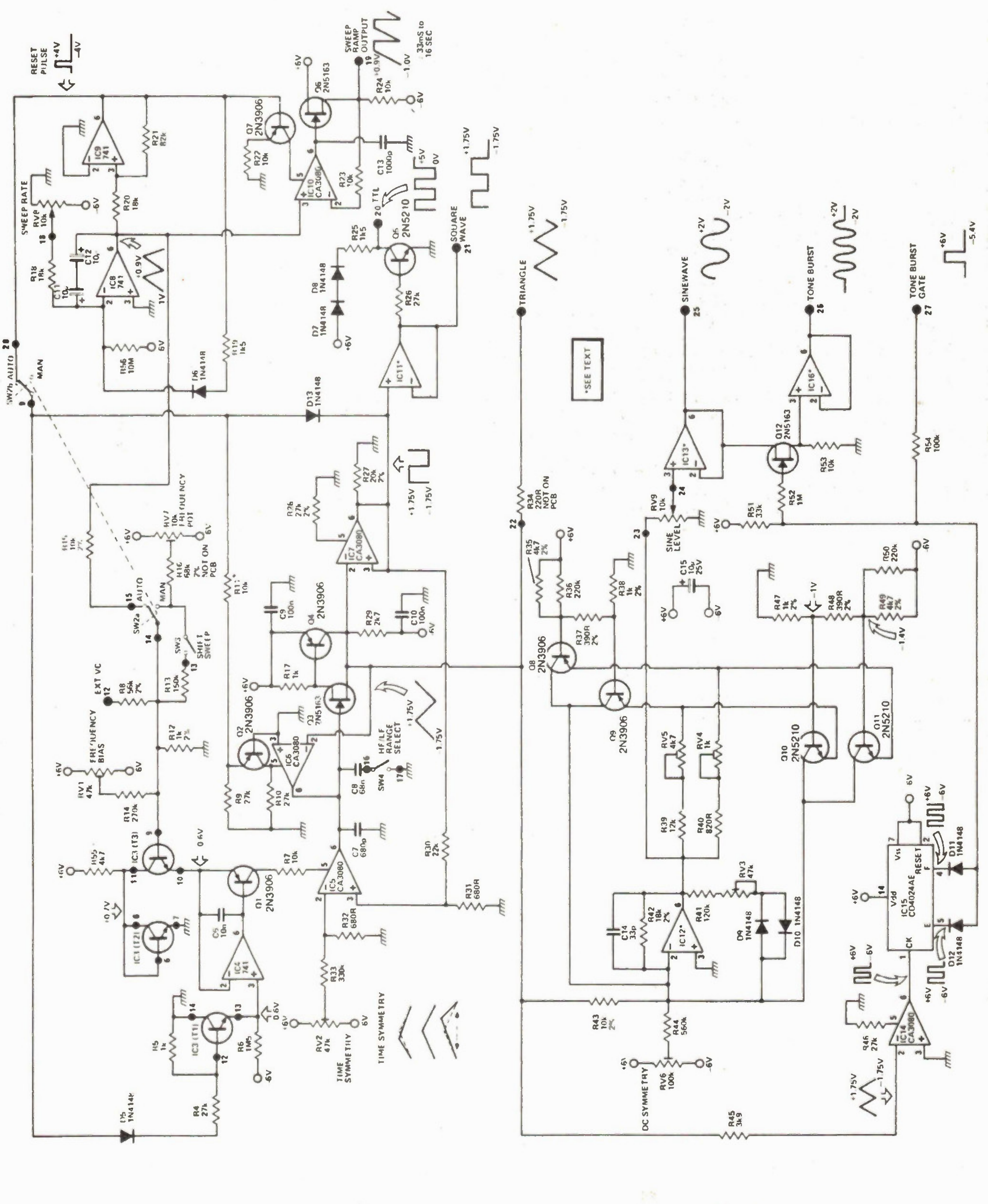


Fig. 7 Main circuit diagram of the Sweep Oscillator. See figure 4 for details of IC11, 12, 13, and 16.

How It Works

The general system diagram is shown in Fig 1. The heart of the generator is the voltage controlled oscillator shown in more detail in Fig 3 and in the circuit diagram, fig 7. This is the well known triangle square wave oscillator made from an integrator and a schmitt trigger. A control current, (this determines the oscillating frequency), is fed into a current steering device IC5. When a positive voltage is applied to the non-inverting terminal, this control current comes out of IC5 and charges up the timing capacitors C7 and C8. When C8 is switched so that it is in parallel with C7, this selects the low frequency range of operation, (0.2Hz-200Hz). If the applied voltage is negative, then a current equal to the control current is 'sunk' into IC5 and the timing capacitors are discharged. Thus IC5 can either charge or discharge the capacitors, this being determined by the steering voltage.

The speed at which the capacitors charge or discharge is determined by the magnitude of the control current. If this current is constant then the capacitor voltage will increase or decrease linearly. The voltage on the timing capacitor is buffered by a high impedance buffer, Q3,Q4. The FETQ3, has such a high impedance that it hardly takes any current from the timing capacitor, so that it does not affect the charging or discharging operation. Q4 is arranged to drive Q3 at constant current, and the pair, (Q3, Q4), form a high input impedance voltage follower, with a DC shift caused by the FET characteristics. In fact it would be advisable to use low pinch off voltage FET's throughout so as to minimise the effects of these offset voltages.

The way in which oscillation occurs is as follows. Control current is injected into IC5 and the voltage on the timing capacitor rises. This voltage is buffered and presented to the schmitt trigger IC7. When this voltage reaches the upper hysteresis level, the schmitt flips over to its low state and thus the steering voltage becomes reversed. The timing capacitor voltage then ramps down until the lower hysteresis level is reached and then the schmitt flips back to its original state. Thus the timing capacitor voltage ramps up and down between these two hysteresis levels, the speed at which this occurs being determined by the control current. Switching in another capacitor C8, will reduce the ramp rate and hence the frequency of operation. This circuit produces triangles and square waves with a 1 to 1 time symmetry and symmetry about OV.

IC6 and Q2 are used to 'zero' the triangle output for the start of sweep. IC6 adjusts the voltage on the timing capacitor so that the triangle output is at OV. It does this only when Q2 supplies it with current.

The triangle output has a 220ohm resistor connected in series to prevent any damage caused by possible short circuits. The square wave output is buffered by A11 which has a fast slew rate. Q5 is the TTL driver stage. When switched on, it will pull down almost any load to a voltage near to OV. If a faster pull up is required the 1K5 resistor can be reduced.

Next the logarithmic converter. This device converts the sum of all the control voltages into a current, (the control current), to which it is logarithmically related. That means that for every 1V increase of external control voltage the control current and hence the operating frequency will double. This logarithmic relationship is very useful for audio work, because when using a swept output, (displayed on an oscilloscope), the X axis is in octaves and decades rather than being linear. The circuit that does the conversion is known as an exponentiator and works in the following manner (see IC3, (T1,2,3.) IC4 and Q1).

IC3 is a CA3046 which is a transistor array providing us with a set of well matched devices at a low cost. Transistor IC3, (T1), has a current of 3.5mA passing through it and this produces a reference voltage of about −600mV at its emitter. IC4 and Q1 adjust themselves so that the emitter of IC3 (T3), is also held at this reference voltage. There are three control voltages, from the frequency pot wiper, the external control voltage terminal and the internal sweep ramp. These are resistively summed together and presented to the base of IC3, (T3). This transistor converts the control voltage into a current which flows out through the emitter, completely through Q1 and then to IC5. This is the control current. The voltage at the base of IC3, (T3) is logarithmically related to its emitter current. A voltage increase of about 18mV will double this current. However, this process is very sensitive to temperature changes which would result in drift in the function generators operating frequency, and so the arrangement of IC3 (T1) and IC3 (T3) has been used to provide temperature compensation. Also to keep self-heating effects to a minimum, IC3 (T2) is used to clamp the collector voltage of IC3 (T3) to +0.7v and thus reduce the power dissipated in the transistor array.

The next section to be discussed is the internal sweep ramp generator, (IC8,9,10,Q6,Q7). IC8, 9 form another triangle/square wave oscillator, having a controllable rise time and a fast reset time. IC8 is the integrator, IC9 the schmitt trigger. The output of IC8 ramps up at a rate largely determined by the sweep rate pot setting. When the upper hysteresis level is reached, IC9 output goes high, D6 becomes forward biased and the integrator ramps down very rapidly, reaches the lower hysteresis level, the schmitt trigger flips over and the process repeats itself. The ramp output is then used to drive the base of IC3 (T3), eventually sweeping the oscillator over a frequency range of 1000:1. This is approximately 10 octaves which requires a change in Vbe IC3 (T3) of about 180mV.

The ramp waveform can be used to drive the X axis on an oscilloscope but it needs some slight modifications to make it suitable. It needs to have a very fast reset of the order of a few microseconds to make the fly back invisible. This is achieved with the track and hold circuit Q6, 7, IC10. During the sweep the output of this circuit follows the input. However, during the reset period, IC10 is 'held' by virtue of the fact that no current is supplied to it. When the reset period is over, current returns to IC10 but its input has the 'start' ramp waveform presented to it, but its output has the stored value of the 'finish' ramp waveform. The output jumps as fast as it can, (within a few microseconds) to the input voltage and proceeds to track it. The process repeats itself. The reset voltage is used (in the sweep mode only), to perform three other tasks. One, it sets the schmitt trigger IC7 into a high state so that it always starts a new sweep with the same phase, (via the D13 route). This stops jitter on the display.

Two, the reset is used to activate the zeroing switch mechanisms Q2 and IC6. Three, the control current is reduced during reset, due to the connection of D5. This helps the zeroing process. When switch SW2 (this is a double pole switch) is in the automatic position, both the sweep wave form and the reset pulse are routed to their respective sections of the circuit, and a logarithmically swept output is generated. The manual frequency control knob has no effect on the process, except when switch SW3 (the shift sweep), is closed.

This enables the sweep to be manually displaced up or down the frequency axis by a factor of about 5 times. That is if the sweep were between 20Hz to 20kHz it could be shifted up to 100Hz to 100kHz or down to 4Hz to 4kHz, thus enabling the useful range of the generator to be greatly extended. When switch SW2 is in the manual position, the sweep and reset signals are disconnected and so the generators output frequency is entirely determined by the manual control knob plus any external control voltages and of course the position of the range switch SW4.

Next the diode function generator IC12, Q8, 9, 10, 11 and D9, 10. This circuit converts the triangle waveform into one that approximates a sinewave, see fig. 3. It is called a diode function generator, although four of these supposed diodes are transistors, Q8,9,10,11. The triangle is applied to an op-amp with several feedback routes, the purpose of which are to change the gain of the section, depending upon the instantaneous signal level. As the triangle waveform (which is symetrical about OV) goes positive, the output of IC12 goes negative. When it exceeds −0.6V, diode D9 begins to turn on and in doing so, the overall feedback resistance is reduced and so therefore the transmission slope is also reduced. This is known as the first break point. Transistors Q10,11 have their bases biased to voltages of −1.0v and 1.4v respectively. These transistors will provide further feed back routes when the output of IC12 exceeds 1.6v and 2.0v, and this extra feedback will decrease even more the transmission slope. Thus, the triangle waveform is gradually bent to resemble a sinewave in the negative excursion of IC12.

However there is also a complementary set of feedback routes for positive excursions via D10,Q9 and Q8 and so a complete sinewave is synthesised. This process is far from perfect and the best THD figure that can be obtained by careful adjustment of RV3, 4, 5, 6 is about 1.0% at 1kHz. This compares with a figure of about 0.2 to 0.5% THD for moderately expensive commercial function generators. These lower figures can only be obtained by having a precision regulated power supply, good tolerance resistors (0.5%) and a more elaborate set of MATCHED diodes. Also, some high quality equipment will be needed to make the final adjustments to the sinewave.

The sinewave from IC12 is passed through a manual level control and is buffered by the voltage follower IC13 to the output terminal. The sinewave also goes to the **toneburst section.** IC14, 15, 16 and Q12 FET Q12 is used as an analogue switch between the sinewave and the voltage follower/buffer IC16. This switch is turned on for 16 cycles of the sine wave and off for 48 cycles. The switching occurs synchronously as the waveform passes through OV. The control for the FET switch is generated by IC14 and 15. IC14 is used as a voltage comparator which determines whether the triangle waveform is positive or negative. It generates a square wave of + and −6V state as the triangle waveform passes through OV. This square wave is used to clock a seven stage CMOS counter, IC15. The divide by 32 and 64 outputs are AND'd together to generate the voltage control for the FET switch. This voltage is high (FET switch on) for 16 cycles and low (FET switch off) for 48 cycles and is used as an output (toneburst gate) to trigger, say, an oscilloscope.

The last piece of circuitry to be described is the power supply, IC1, 2. This delivers + and −6V at about 30mA. The transformer delivers 15V RMS which produces about 21V of unregulated supply. A 12VRMS transformer would be rather low and you might experience problems of the supply dropping out.

Parts List

Resistors (all 1/4W, 5% unless noted)

R1	2k2
R2,3	27k 1%
R4,9,10,26,46	27k
R5,17	1k
R6	1M5
R7,11,22,23,24,53	10k
R8	56k 2%
R12,38,47	1k 2%
R13	150k
R14	270k
R15,43	10k 2%
R16	68k 2%
R18,20	18k
R19,25	1k5
R21	82k
R27	20k 2%
R28	27k 2%
R29	2k7
R30	22k
R31,32	680R
R33	330k
R34	220R
R35,49	4k7 2%
R36,50	220k
R37,48	390R 2%
R39	12k
R40	820R
R41	120k
R42	18k 2%
R44	560k
R45	3k9
R51	33k
R52	1M
R54	100k
R55	4k7
R56	10M

Semiconductors

Q1,2,4,7,8,9	2N3906 or 2N5086
Q3,6,12	2N5163 or 2N3819 (N type FET)
Q5,10,11	2N5210
D1-4	1N4002
D5-13	1N4148
LED1	0.2"
IC1	7812
IC2,4,8,9	741
IC3	CA3046 or CA3146
IC5,6,7,10,14	CA3080
IC11,12,13,16	see text
IC15	CD4024AE

Miscellaneous

500mA fuse and holder; shielded wire; stranded wire; PCB; line cord; (8) red sockets; (2) black sockets; knobs; case; etc.

Potentiometers

RV1,2,3	47k Horiz. min. trim
RV4	1k Horiz. min. trim
RV5	4k7 Horiz. min. trim
RV6	100k Horiz. min. trim
RV7	10k lin. carbon pot.
RV8,9	10k lin. carbon pot.

Capacitors

C1,3,9,10	100n polyester
C2	1000u 25V elect.
C4,11,12,15	10u 25V tantalum elect.
C5	100u 25V elect.
C6	10n polyester
C7	680p polystyrene
C8	68n polyester
C13	1n polystyrene
C14	33p ceramic

Switches

SW1	off-on rocker 3A, 120V
SW2	DPDT toggle
SW3,4	SPST toggle

Transformer

T1	120V - 30V c.t. 0.5A

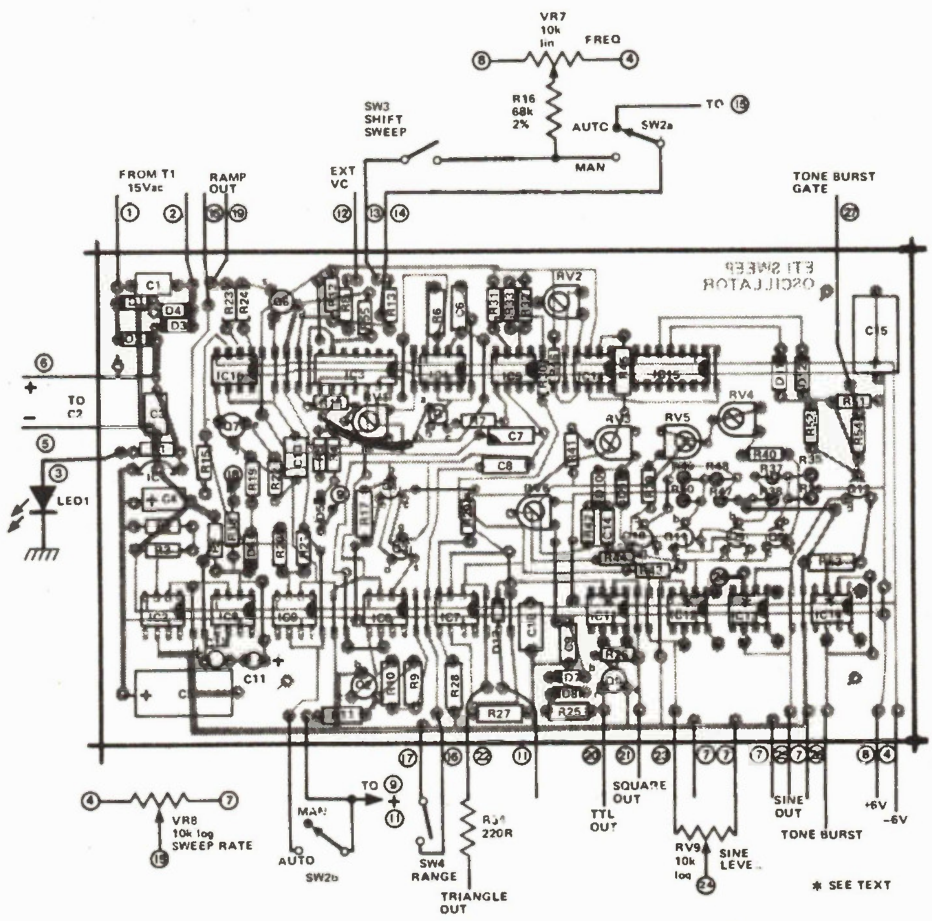
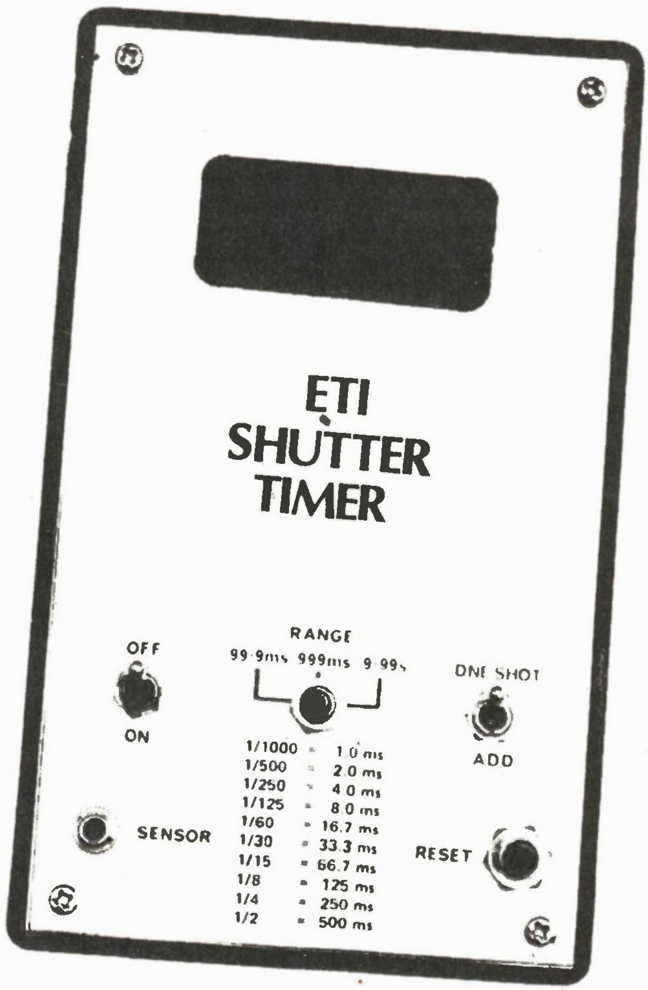


Fig. 8 Overlay and interconnection pattern.

Shutter Speed Timer

A project from the amateur photographer on ET's project team to enable accurate checking of the camera's mechanical bits.



THE NUCLEUS of good photography is correct exposure. This is a combination of shutter speed and lens aperture as determined by an exposure meter. if either speed or aperture is not as indicated on the camera, the results will be less than perfect.

While the lens aperture is a simple mechanical operation and unlikely to be in error, the same cannot be said about the shutter with its springs and things. Not only may the speed not be exactly as indicated on the dial, it may (probably) change as the camera gets older. Therefore it is desirable that a simple method of determining the actual speed should be available.

This project describes the design and construction of a unit which is capable of measuring times from 1/10000 sec. to 10 sec. This allows the actual speed to be measured and then used to calculate the correct aperture when taking those important photos.

SPECIFICATIONS

Timing range	0.1ms to 9.99 sec.
Sensor	Photo transistor
Display	3 digit LED
Power supply	9 volt batteries 65 — 16mA LEDs on 20mA LEDs off
Battery life	6 hours — normal 20 hrs — alkaline

It is suitable for checking cameras with a hinged or removable back so that the sensor can be placed in the film plane. For cameras where the film fits into a slot this cannot be used.

Construction

Commence construction with the PCB adding, initially, the nine wire links required. Next, add the resistors and capacitors in the appropriate locations as shown in the component overlay. Note that capacitor C5 is polarized and must be inserted the correct way around.

The transistors and the displays can now be soldered in place taking care with orientation of the transistors.

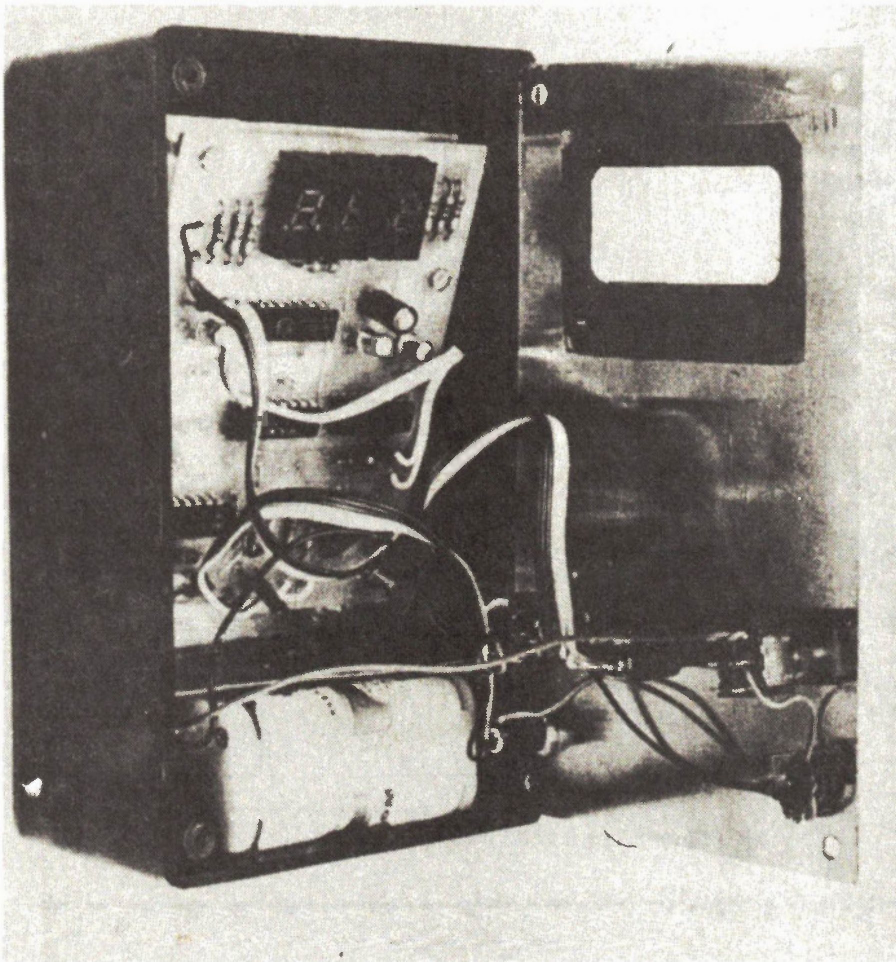
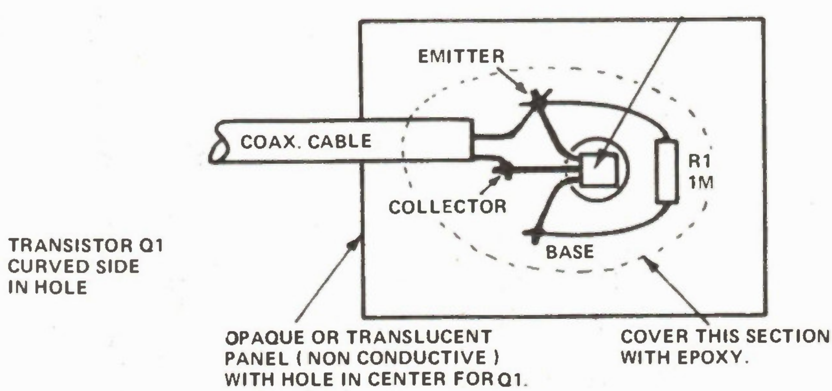


Fig. 3. Connection of the transistor on the sensor plate.



The ICs are the last components to be installed and these must be in the correct location and orientation. When soldering the ICs, solder the corner pins (power supplies), pins 7 and 14 or 8 and 16, first as this allows the internal protection diodes to work while you solder the other pins.

The front panel can now be drilled and cut. A piece of polarized plastic helps as a display window. The switches, pushbutton and phone jack can now be fitted and connected to the PCB as shown in the overlay. The only point which could cause problems here is that the phone jack connections sometimes vary, and you should check yours before connection.

The PCB can now be mounted onto the support bracket with 6mm spacers and the bracket into the box with two screws. When positioned correctly, the display will be visible through the window and the battery holders will be held in position at the other end.

Sensitive

The sensor plate which contains Q1 and R1 can now be made. We used a piece of PCB material, although any non-conductive material which is opaque or translucent may be used. Start by cutting the plate to size and drilling a 6mm hole in the center. The phototransistor, Q1, should be mounted with the curved surface (which is the active side) into the hole and R1 soldered to the leads. The whole assembly should then be glued onto the plate with quick-dry epoxy. Ensure that all conductive parts are covered with epoxy to prevent touching when in use.

Calibration

The unit can be calibrated accurately enough with a stopwatch which has a second hand. Set the camera up as detailed in the operational notes and using single-shot mode, open the lens for five seconds. By adjusting RV1 get the reading close to 5s.

Now use a longer time, say 20s, noting that the first digit will be missing, (i.e. a reading of 8.52 represents 18.52s while 2.31 would be 22.31s) and finally adjust RV1.

To aid setting up, a pushbutton can be substituted for the phototransistor but the "add" position should be used and the timer manually reset as contact bounce

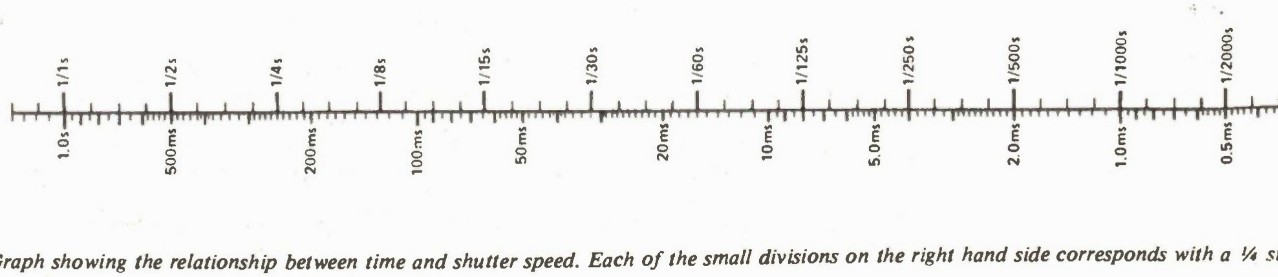
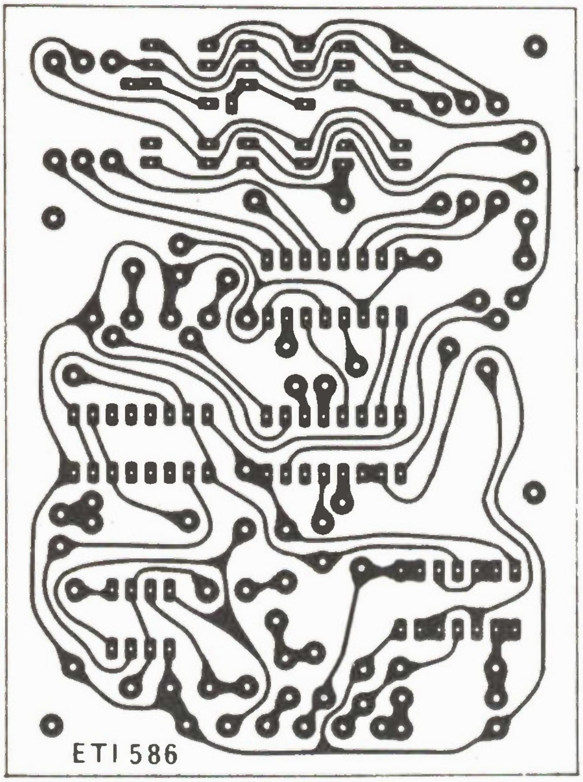


Fig. 4. Graph showing the relationship between time and shutter speed. Each of the small divisions on the right hand side corresponds with a ¼ stop.



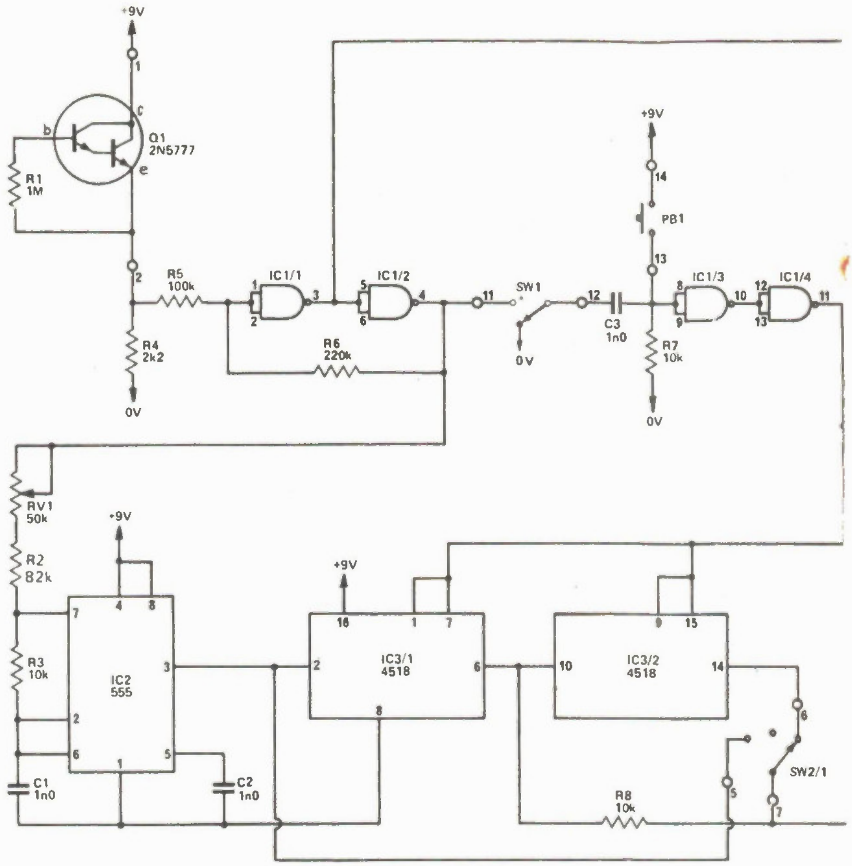


Fig. 1 Circuit diagram of the timer.

can cause the display to reset on release of the button.

Operation

While the camera can be hand-held, it is recommended that a tripod be used. Mount the camera on the tripod pointing at a light of 100 to 500 Watt, about 2 to 3 feet away. Open the back of the camera and position the sensor plate so that the light is focused on the sensor. Initially, have the lens wide open; if enough light is hitting the sensor, the display will be blanked. Stop the lens down until the display comes on then go back one stop.

This sets the sensitivity and by selecting the appropriate range, the shutter speed can be checked. ■

This project was originally published in our September 1978 issue.

HOW IT WORKS

To measure the time the shutter is open we use a phototransistor, Q1, positioned in the film plane in the camera. When the shutter is operated and if the camera is focusing a bright light on to the transistor, the voltage across R4 will rise to about 7 V for the duration of the shutter being open. The transistor used is a Darlington type and is normally too slow for measuring times shorter than 1 ms. The addition of R1 increases the speed at the expense of sensitivity – hence the need for a bright light.

The output across R4 is squared up by the Schmitt trigger formed by IC1/1,2. The output of this controls the input to the 10 kHz oscillator IC2. This is an ordinary 555 oscillator where the frequency is set by C1, R2, R3 and RV1. The output of IC2 is divided by 10 in IC3/1 and again by 10 in IC3/2. We use the enable inputs of IC3 as they give clocking on the negative edges, which is what we need. We now have three outputs of 10 kHz, 1 kHz and 100 Hz. One of these outputs is selected by SW2/1 which is a centre off toggle switch. When it is in the off position, 1 kHz is selected via R8, while in the other positions the 1 kHz signal is swamped by the low output impedance of the other dividers.

Whichever frequency is selected clocks IC4 which is a 3 decade counter-latch-multiplexer. We are not using the latch in this application. This IC simply counts the number of pulses it receives and with the help of IC5 (7 segment decoder-driver) and Q2 – Q4 displays the result on the LED displays. During the counting period the display is blanked to prevent ripple on the supply rail upsetting the 555 timer. The ripple would occur as the current changes with different digits displayed. The decimal point is controlled by SW2/2.

Two modes, single-shot and add, are provided. In the single-shot mode when light hits Q1 operating the Schmitt trigger the monostable formed by IC1/3 gives a pulse about 50 µs long which resets the main counter IC4 and the /10 dividers, IC3. Pins 1 and 9 on IC3 which have to be low to allow clocking are taken high during the reset pulse only because it made the PCB easier and does not affect the operation. In the 'add' mode the reset pulse does not occur and unless the reset button is pressed the second and successive counts will simply add on to the previous count. This allows say ten tests to be made and the total divided by ten to find the average.

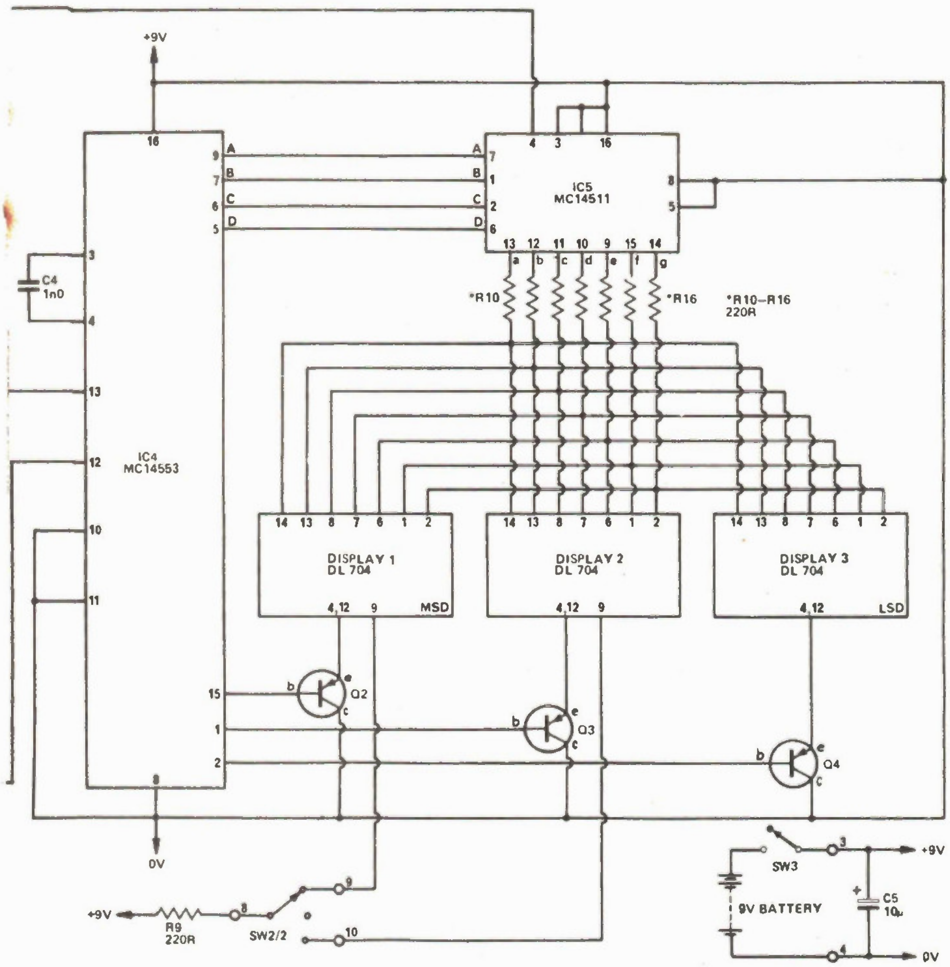
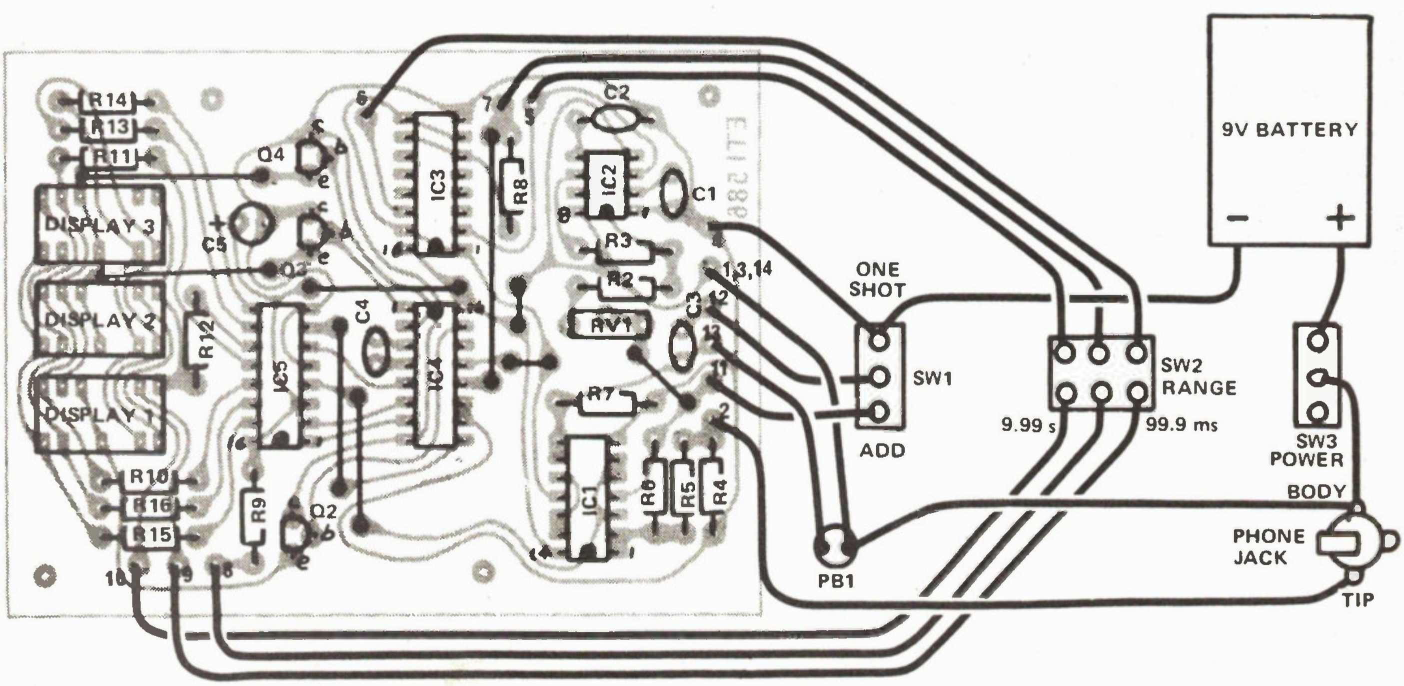


Fig. 2. Component overlay and wiring diagram.



PARTS LIST

Resistors (all 1/2W, 5%)

R1	1M
R2	82k
R3	10k
R4	2k2
R5	100k
R6	220k
R7,8	10k
R9-16	220R
RV1	50k

Capacitors

C1-4	1n0 polyester
C5	10u, 16V elect.

Semiconductors

IC1	4011
IC2	555
IC3	4518
IC4	14553
IC5	4511
Display 1-3	DL704
Q1	2N5777
Q2-4	2N3905

Switches

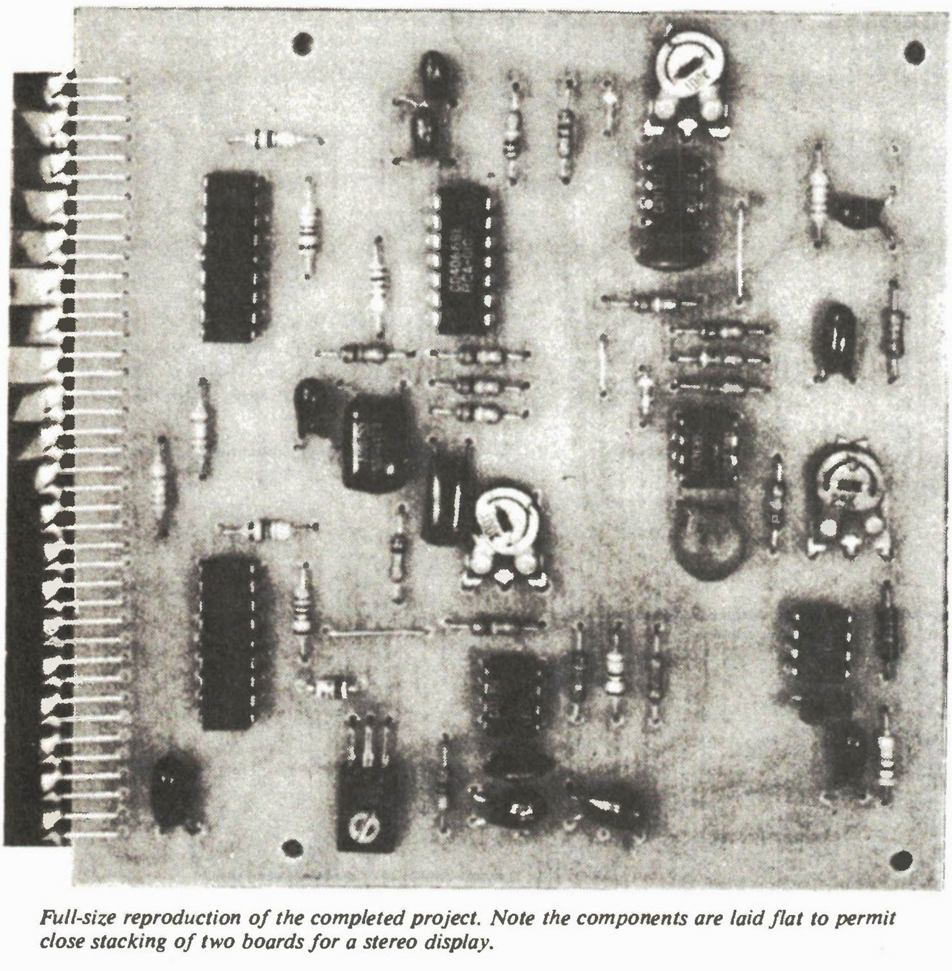
SW1,3	SPDT toggle
SW2	DPDT toggle, center off

Miscellaneous

PCB; case to suit; pushbutton; phone jack and plug; battery holder; battery clip; support bracket; spacers; nuts and bolts; wire etc.

LED Level Meter

The LED level meter described here, is ideal for any application requiring a wide dynamic range level display. Naturally, two are required for stereo applications.



Full-size reproduction of the completed project. Note the components are laid flat to permit close stacking of two boards for a stereo display.

THE ETI LED LEVEL meter overcomes a number of the drawbacks inherent in mechanical VU meters by replacing the meter movement with a row of light emitting diodes driven by a pair of dB LED display drivers. Twenty LEDs are used, with 3 dB between each LED, so the total dynamic range displayed is 60 dB. The circuit monitors both the true peak and the average signal level and displays both simultaneously. The difference between the peak and the average voltages of a sinewave is around 3 dB, so with a sinewave applied consecutive LEDs will light. With music applied however, the difference between the two LEDs will be substantially greater, depending on the transient nature of the signal applied.

Fig. 2 shows a complete circuit diagram for the LED level display. The input is fed first to a prescaling amplifier formed by an LM301 op-amp, IC1, and the associated passive components. This stage has adjustable gain, set by the preset RV1 that allows the 0 dB point to be set to the desired reference voltage. This will be covered in greater depth later, in the setting up procedure. The output of the prescaling stage is connected to the input of a full wave rectifier formed by IC2 and its associated components. The output of the full wave rectifier is fed to an averaging filter formed by R9 and C6, and to a peak follower formed by IC3 and associated components. The peak follower has a rapid attack/slow decay characteristic so that it responds quickly to any transients but decays slowly so the transient can be seen easily on the display. The outputs from the peak follower and the averaging filter are connected to the inputs of two CMOS analogue switches.

The outputs of these switches are connected together and go to the input of the LED display. Two more CMOS switches are used to form a square wave oscillator. This oscillator has out of phase outputs used to drive the signal-carrying analogue switches alternately off and on at a relatively high frequency. When the switch connected to the output of the averaging filter is on, the average signal voltage is connected to the input of the LED display. This switch is subsequently turned off by the oscillator and the other analogue switch turned on, connecting the output of the peak follower to the LED display. So, only one of the two LEDs is on at any instant, but the rapid switching speed between them and the persistence of vision make them both appear to be on.

Input signals to the LED display portion of the circuit are fed simultaneously to the LM3915 driving the upper 30 dB display and via a voltage amplifier to the lower 30 dB display.

The resistors R26 and R27 set the

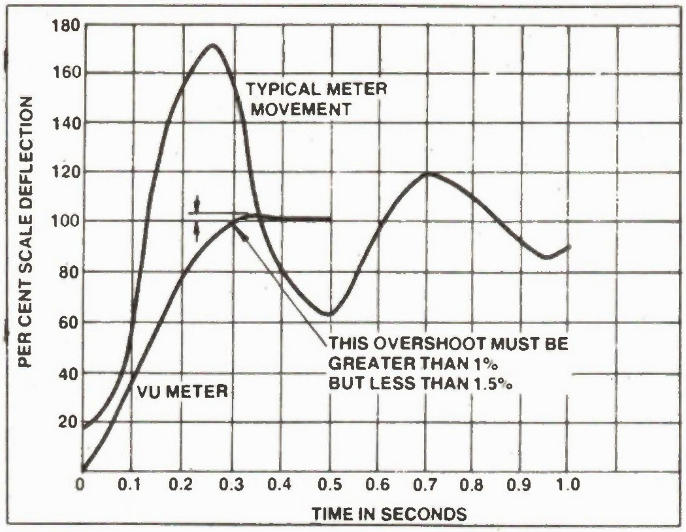


Fig. 1. 'Ballistics' of a VU meter compared to conventional moving-coil meter.

reference voltage of IC7 at 3.1 V and 30 dB below this voltage is

$$\frac{-30}{20} = \log\frac{x}{3.1}, \text{ or } 98\text{ mV}.$$

Now, the top LED driven by IC6 must correspond to this voltage, so the required gain around IC5 is 5.34/98 mV or 54.6. The values of the resistors R19 and R18 set this gain at (180+33+3.9)/3.9 or around 56 which is a good enough approximation, amounting to an error of less than 0.5 dB.

Internally, the LM3915 consists of a string of comparators; each one compares the input signal to a reference voltage it derives from a ten-way protential divider (see Figure 3). The accuracy of the LM3915 is determined by these internal resistors and is therefore very good. To ensure the display is accurate over the entire 60 dB range it is only necessary to ensure that the changeover from one LM3915 to the other is accurate. Resistors

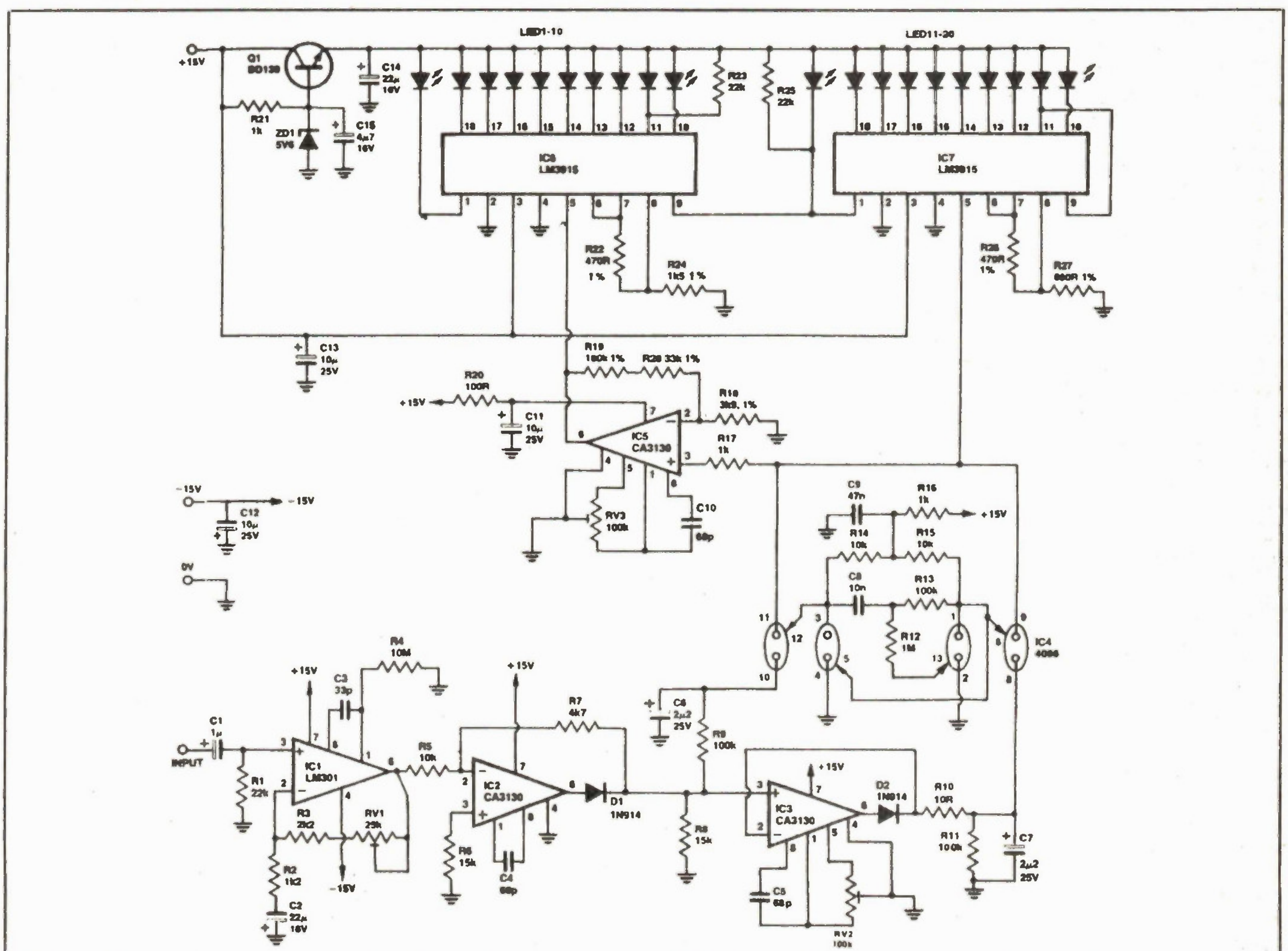


Fig. 2 Circuit diagram of the LED Level meter.

R18, R19, R22, R24, R26, and R27 have been specified as 1% tolerance types for this reason.

Transistor Q1 forms a simple voltage regulator delivering 5V to the LEDs. This decreases the power dissipation in the LM3915s. The current consumption from the positive rail is around 100 mA while the negative rail needs only several milliamps. If the display is to be used from an existing power supply in a preamplifier for example, care should be taken to ensure that the relatively high positive rail current does not upset the preamplifier performance.

Construction

Start construction by mounting the LEDs. This is by far the most difficult part of the project. The LEDs must be inserted evenly and with equal heights, and this is not easy. Furthermore, the LEDs must be inserted the right way around. The longer of the leads represents the anode of the LED. Check the orientation of each LED against the overlay, before soldering.

Now all the other components can be mounted. The order of mounting is not really important although it is good general practice to solder the passive components first (resistors and capacitors). And then solder the ICs and transistors. The presets are mounted against the circuit board and this is best done by bending their leads at right angles first, and then soldering. Similarly, many of the larger capacitors may have to be folded against the board. Be careful with the orientation of all polarised components, such as transistor Q1 and the electrolytic and tantalum capacitors. Tantalum capacitators are very intolerant of reverse biasing.

Setting Up Proceedure

Once all the components have been mounted on the pc board and checked, the unit can be switched on. Ensure that the power supply you are using has sufficient current capability for the positive rail and that it is correctly connected to the supply points on the circit board. If the input is touched with a finger two LEDs should light and move up the display. If all is well the dc offsets can now be adjusted. The preset RV2 adjusts the dc offset of the peak follower. This will be adjusted to equal the dc level of the average filter, i.e. that from the output of the full wave rectifier. The overall dc offset can be nulled by RV3.

First connect the input of the LED level meter to ground on the board. This ensures that no signal voltage will be present when the adjustments are made. Now turn both RV2 and RV3 fully clockwise; both LEDs should run off the bottom of

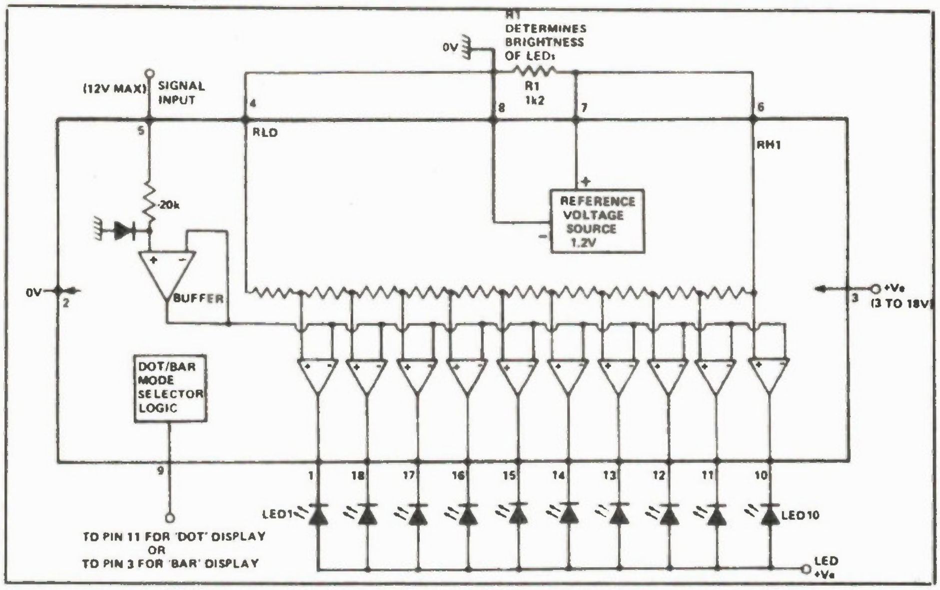
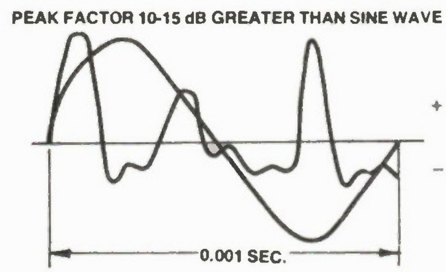


Fig. 3 Internal block diagram of the LM3915.



A typical 'music' signal may have a completely different peak-to-average ratio compared to a sinewave, and the peaks are often not symmetrical in amplitude about the zero axis. The duration of peaks may be as short as 50 microseconds.

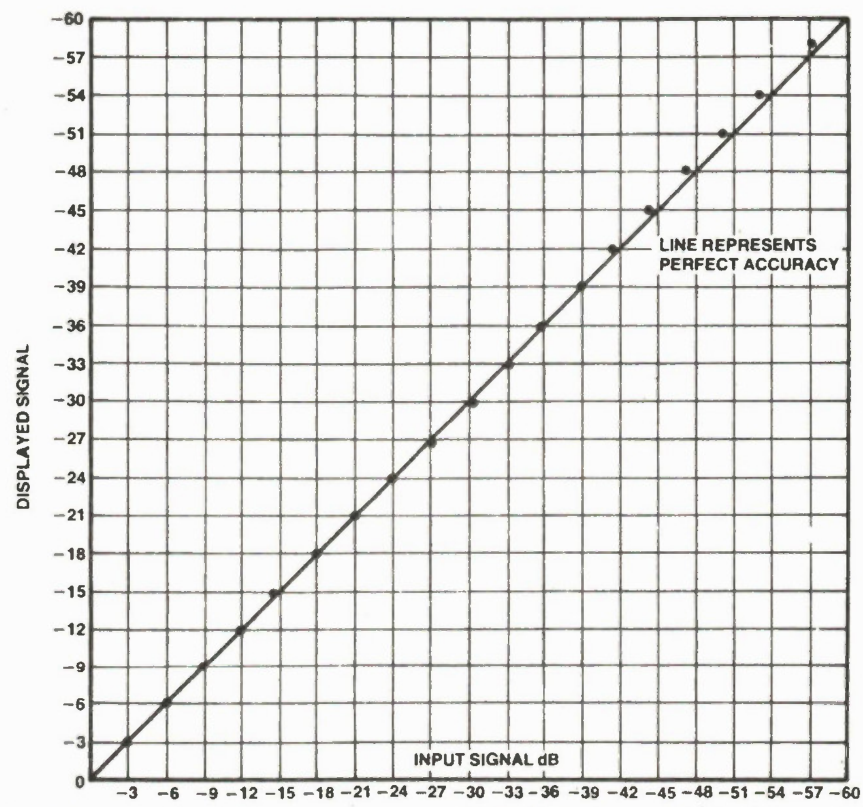
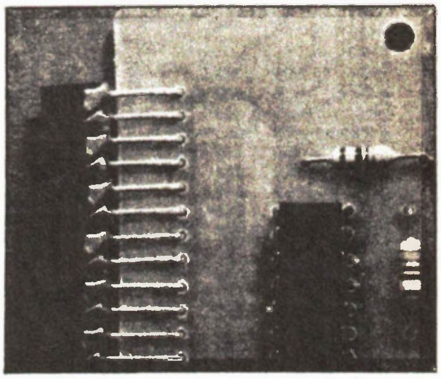


Fig. 4 Accuracy of the ETI LED level meter display (dots) compared to 'perfect accuracy' (line).

the display. Turn RV3 slowly counterclockwise until the second LED from the bottom has just turned on. If RV2 is now turned counterclockwise also, a second LED will light on the display. This is the peak level LED. Adjust RV2 to superimpose this LED onto the second bottom LED. Now adjust RV3, turning it clockwise again until the LED has just run off the bottom of the display.

The final stage in the setting up procedure is to align the meter for the appropriate 0 dB level. Preset RV1 varies the gain of the prescaling amplifier stage formed by IC1. Adjustment of this preset will vary the input voltage required to light the top LED between 260 mV and 2.5 V. If your application requries 0 dB to be a higher voltage than 2.2 V, use a potential divider at the input to decrease the input signal voltage. If more gain is required increasing the value of the preset from 25k to 100k will decrease the necessary input voltage to around 70 mV, which should be sufficient for most applications.

This project was originally published in our May 1982 issue.



Close-up of the pc board showing orientation of the LEDs. IC7 at lower right.

HOW IT WORKS

The input stage consists of a variable gain amplifier formed by IC1 and its associated components. This is a conventional IC amplifier circuit in which the gain is determined by the values of the components RV1, R3 and R2. Specifically:

$$A_V = \frac{R2 + R3 + RV1}{R2}$$

So the bigger the value set on RV1, the greater the gain. Capacitor C2 has the effect of decreasing this gain for very low frequencies, or dc, decreasing the dc offset on the output.

The second stage is the full wave rectifier or 'absolute value generator'. As mentioned in the text, most fully wave rectifiers requrie more than a single op-amp, so this stage will be of use in any application requiring a full wave rectifier with minimum component count. For negative-going signals the stage functions as an inverting amplifier with a gain of 0.5. This is determined by the values of R5 and R7. when the input signal goes positive the output is driven hard against its negative supply voltage, which in this case is 0 V. So the output stage is turned off, and has a relatively high output impedance. In this state the resistors R5, R7 and R8 form a potential divider and connect the input signal to the output directly. Again, the output voltage is one half of the input voltage. In order for this circuit to work, the output stage in the op-amp must be CMOS so that the output can go completely to 0V and have an output impedance high enough not to short out the signal voltage from the potential divider. This is the reason the CA3130 is used. Furthermore, this is a relatively fast device which ensures that the full wave rectifier will have a frequency response that covers the entire audio spectrum. The one disadvantage of the circuit is that it requires a high load impedance since the output signal for positive-going input signals is obtained from the potential divider and not from the op-amp itself. In this application the load is around 100k (R9) which causes negligible error.

The output of the full wave rectifier is fed simultaneously to an average filter formed by R9 and C6, and to the peak hold circuit formed by IC3 and its associated components. The peak hold circuit is really nothing more than a 'precision diode' that charges a capacitor to the peak voltage. The precision diode is formed by including a conventional signal diode in the feedback loop of a fast op-amp. If an input signal is applied which is less than the forward voltage drop of the diode, the stage is effectively in open loop gain (around 320,000 for the CA3130). The output voltage will rise very quickly, turning the diode on. Since the output of the diode is connected to the inverting input of the op-amp, the stage functions with unity gain once the diode has been turned on. Capacitor C5 ensures stability of the stage while preset RV2 allows adjustment of dc offsets due to this stage. The output of the peak hold circuit charges capacitor C7 through resistor R10. The combination of R10 and C7 defines the attack rate of the peak detector.

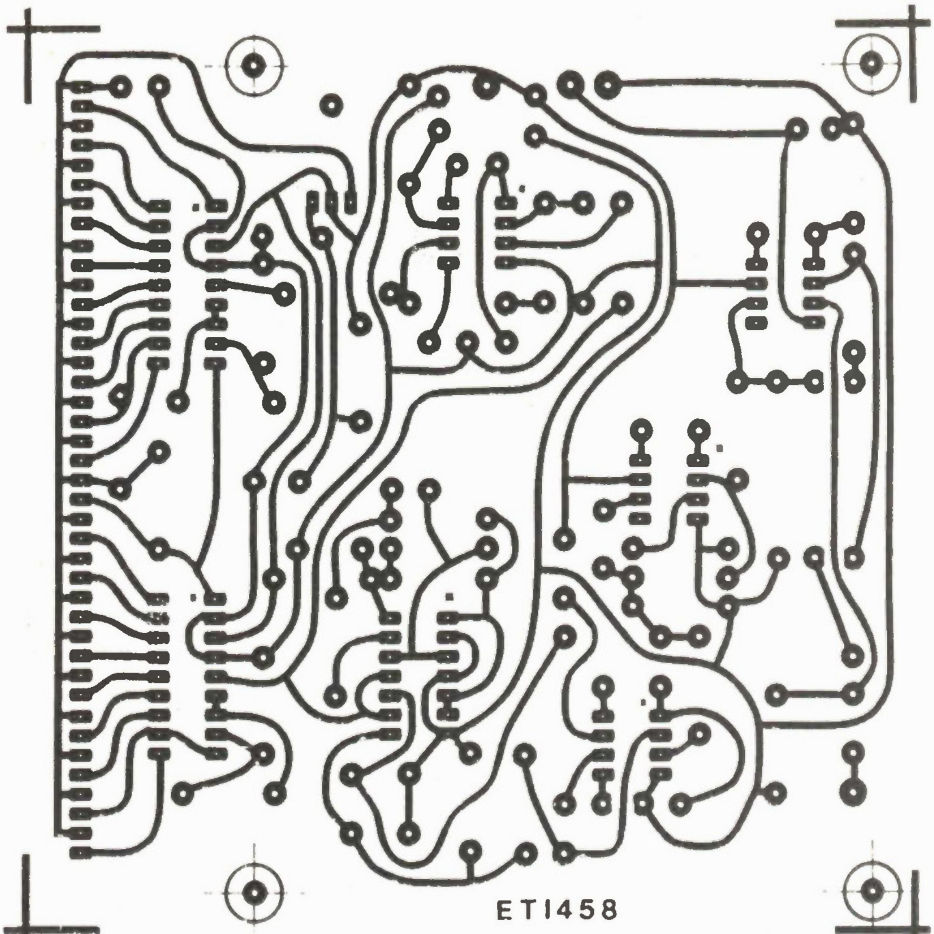
As shown, the value of R10 is 10 ohms and this is small in comparison to the output impedance of the CA3130, but is included in case some applications requrie the peak detector to have a slower attack rate. With the values shown, the LED level meter will display single 50 uS pulses accurately and this is entirely adequate for any audio application.

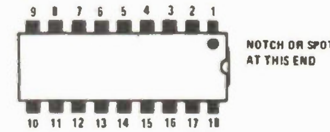
Resistor R11 discharges the capacitor and its value of 100k dictates a decay rate of around one second. This gives the level meter its rapid attack, slow decay characteristic and enables even short transients to be spotted.

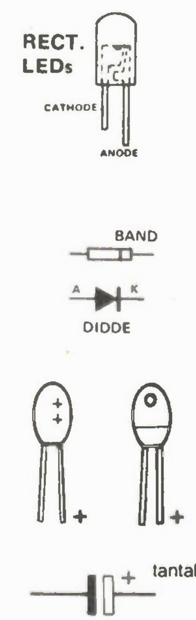
As explained in the text, both the average and the peak levels of the signal are displayed simultaneously. This is accomplished by multiplexing the outputs of the peak and average detectors. This is done by switching between the output of these two circuits at a relatively high frequency (say a few hundred Hertz). In the circuit, this is done with CMOS transmission gates. The 4066 was chosen mainly because its on resistance is a little lower than the older 4016 and this enables the remaining two gates in the package to be used as the driving oscillator. The oscillator is formed by resistors R12 to R15 and capacitor C8, with the associated two transmission gates. The frequency of the oscillator is determined by the values of R13 and C8 at around 150 Hz.

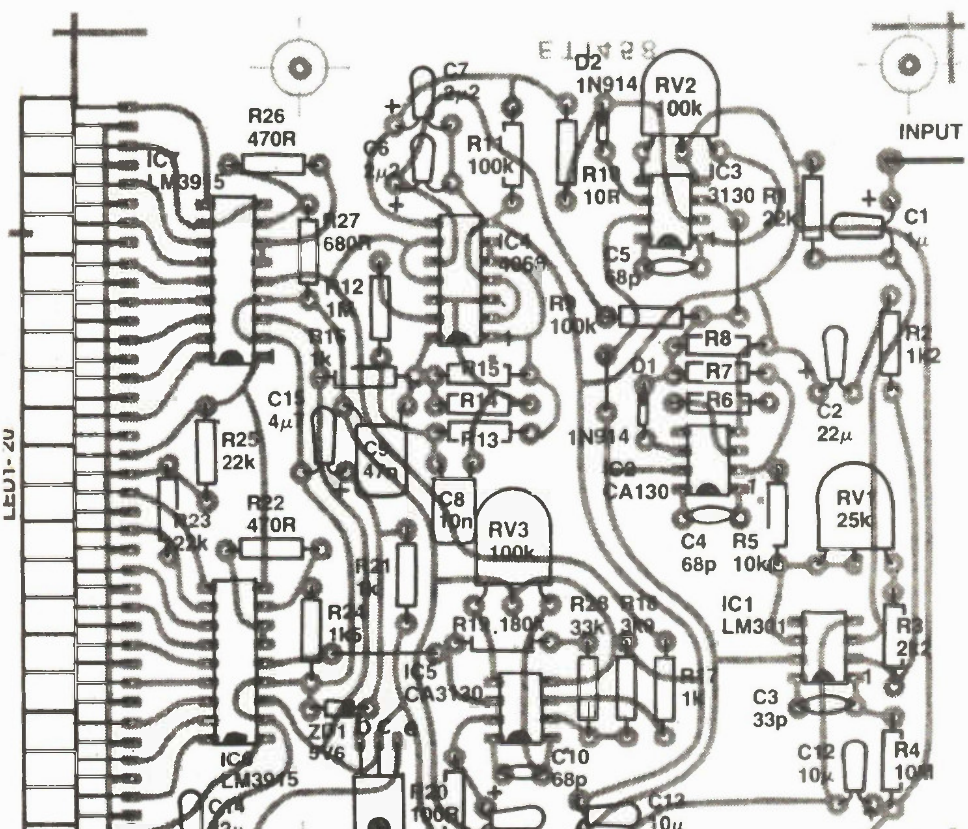
IC5 functions as an amplifier stage as discussed in the text. Once again dc offset adjustment is provided, this time by RV3. Capacitor C10 provides the necessary compensation to ensure stability. Details of the two LED drivers and the amplifier formed by IC5 are in the main text.

The transistor Q1 and the associated components R21, C15 and ZD1 form a simple 5V regulator to power the LM3915s. Capacitor C16 is essential for stability of the LED drivers and must be mounted close to the LEDs.









Parts List

Resistors (all ½ W, 5% unless marked otherwise

R1,23,25	22k
R2	1k2
R3	2k2
R4	10M
R5,14,15	10k
R6,8	15k
R7	4k7
R9,11,13	100k
R10	10R
R12	1M
R16,17,21	1k
R18	3k9 1%
R19	180k 1%
R20	100R
R22,26	470R 1%
R24	1k5 1%
R27	680R 1%
R28	33k 1%
RV1	25k min trimpot
RV2, RV3	100k min trimpot

Capacitors

C1	1u/6V tant.
C2,14	22u/16V tant.
C3	33p ceramic
C4,5,10	68p ceramic
C6,7	2u2/25V tant.
C8	10n greencap
C9	47n greencap
C11,12,13	10u/25 V tant.
C15	4u7/16V tant.

Semiconductors

IC1	LM301, 8-pin DIL
IC2,3,5	CA3130, 8-pin DIL
IC4	4066
IC6,IC7	LM3915
D1,D2	1N914 or sim
ZD1	5V6 zener diode
Q1	TIP29C
LED1-20	Siemens LD80-2 or sim.

Miscellaneous

pc board; one bolt and nut. ■

Loudspeaker Protector

By David Tilbrook

Providing up to 1500 watts of DC and over-power protection, this unit requires no power supply and has no discernible effect on sound quality.

YOU'VE JUST unpacked and connected that shiny new 400 watt amplifier you've always wanted, and you lower the tonearm expectantly. There's a short detonation, and smoke silently curls from the speaker grille cloth. Nobody had pointed out to you that those bargain basement speakers could only handle 15 watts.

Never, you say? You always check such things? Murphy's Law lies in wait: power amps fail occasionally, and a shorted output transistor can connect the power supply directly to the speaker coil, applying a steady 30 to 50 volts DC, usually enough to char the coil or rip the mountings apart.

A solution to this is the ETI Signal Powered Loudspeaker Protector. It is applicable to almost all speakers, and can fit inside the cabinet itself. Since the unit is powered by the audio signal, there are no batteries to fuss with, and unlike a fuse, it automatically resets when the overload is removed. It can also tell the difference between applied DC and low-frequency signals, and can be adjusted to cut out at a desired level without tripping on loud but harmless transients.

The self-powering feature is not only convenient, but adds no audible distortion to the signal, even with low-wattage amplifiers having rather high output impedances.

This is done in this case by placing a fullwave rectifier across the speaker lines and charging a 1000uF capacitor through a 47 ohm resistor. The worst possible load presented to the speaker line is therefore 47 ohms and this is only while charging the capacitor and for signal voltages in excess of 12V. This ensures that the unit has no discernible effect on audio quality but makes possible a truly "set and forget" loudspeaker protector that can be mounted inside the loudspeaker enclosure if desired.

The protector tests for both DC and over-power, which can be adjusted by a preset on the board to suit a particular loudspeaker or application. The circuit also uses a new filter design with an almost "brick wall" response enabling it to be connected to very large power amps. This is discussed in more detail in the "How It Works" section.

The maximum power that can be applied to the unit is determined by the type of regulator transistor (Q1) used. We have specified a TIP31C for this device which has a 100V collector-to-emitter breakdown voltage. Since the emitter is at 12V, the maximum voltage that can be applied to the unit is 112V. This is equivalent to an amp capable of supplying approximately 784 watts into an 8 ohm load or 1568 watts into a 4 ohm load. If the amplifier to be used is capable of powers greater than these the regulator transistor should be substituted for a device with a higher Vceo rating. The relay pulls around 40 mA when operated, so power dissipation in the regulator transistor will be around 4 watts when dropping 100 volts. Although this is not a particularly high dissipation it is high enough to lie outside the Safe Operating Area of many high voltage transistors, so be careful when choosing an alternate regulator transistor.

Construction

Construction is straightforward since all of the components are mounted on the PC board. The usual precautions should be taken to ensure that all polarized components have been mounted with the correct orientation. The IC used is a CMOS type and is therefore static sensitive. Solder this last and preferably using a grounded soldering iron. It is a wise precaution to discharge yourself before handling the device by first touching a grounded metal appliance.

It is wise to space the 2.5W resistor, R2, off the PC board slightly. In the case of a high-powered loudspeaker going faulty with DC, this component will get quite hot and spacing improves ventilation around the component and prevents the possibility of charring the PC board. If you can't obtain a 2.5W type, then a 5W type may be substituted.

Before mounting the unit, check operation by connecting around 20 VDC across the speaker input terminals on the PC board. The relay should cut in after about one tenth of a second. If the protector passes this test connect the speaker wiring. If the preset is turned fully down (turn it counterclockwise when viewing the board with the components on top and the relay to the right) the relay will cut in when the power exceeds around 20 watts for an extended period. The protector allows transients to the full supply rail to pass but will prevent a continuous 20W from being applied to the loudspeaker. To increase this, turn the preset clockwise until the desired response is achieved. ■

PARTS LIST

Parts List (all 1/2W, 5% unless noted)

R1	47R
R2	2k2, 2 1/2W
R3,9	47k
R4,5	100k
R6,7,10	470k
R8	220k
R11	2M2
R12	10M
RV1	20k mini. trimpot

Capacitors

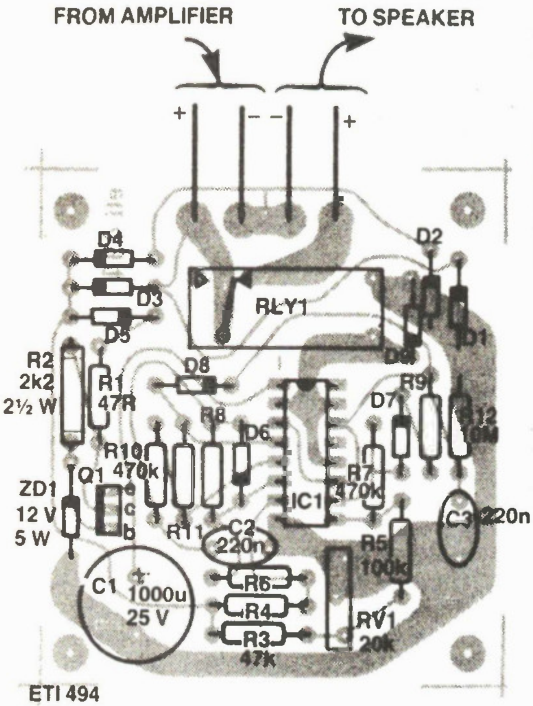
C1	1000u 25V elect.
C2,3	220n

Semiconductors

D1-5	1N4001
D6-9	1N914, or 1N4148
IC1	4050 Hex buffer
Q1	TIP31C
ZD1	12V, 5W zener

Miscellaneous

PC board; RL1 - 12V SPDT 10A or similar PC mount type.



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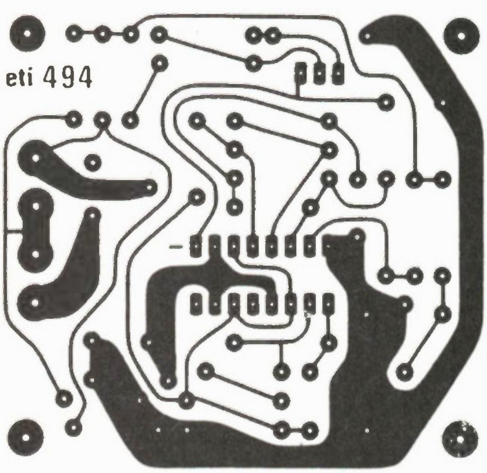
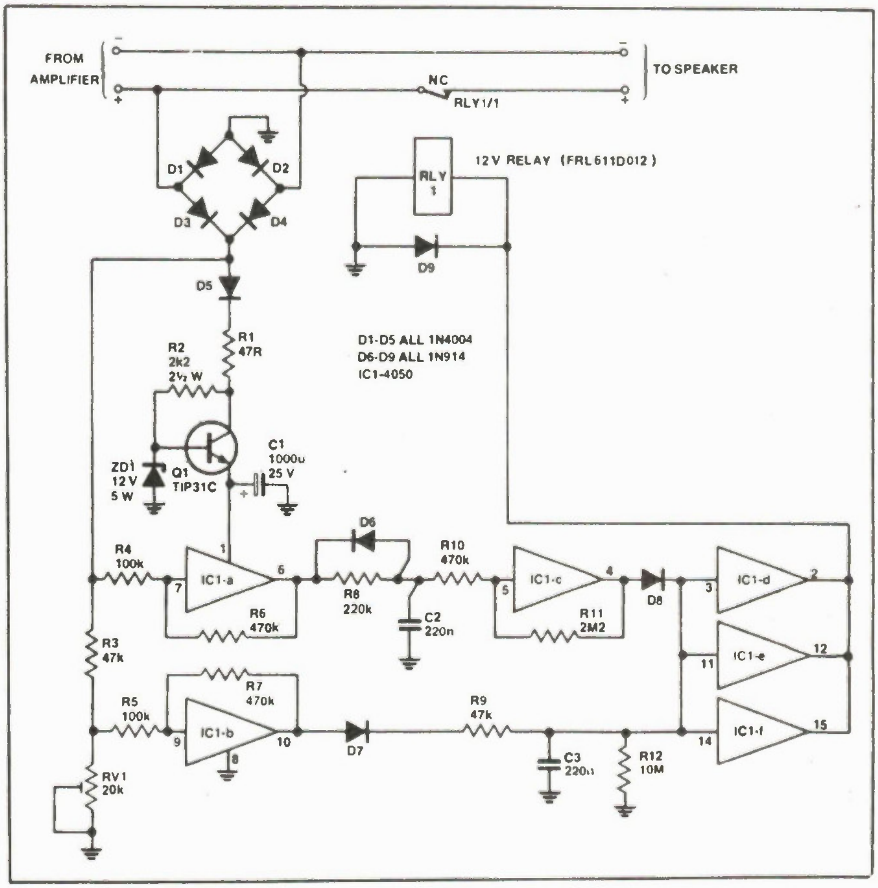


HOW IT WORKS

The signal from the power amp is rectified by the fullwave rectifier formed by D1-D4. The output of this is fed through a 12V regulator circuit formed by Q1 and its associated resistors and zener diode, and charges the electrolytic capacitor, C1. The output of the rectifier is also fed to the input of the dc sense and over-power detection circuitry.

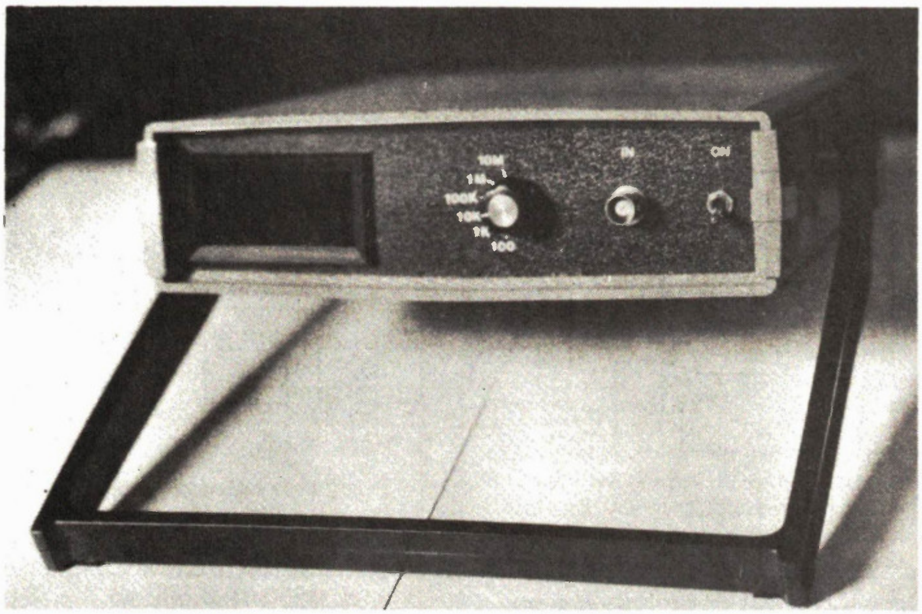
IC1 gates a and c form the dc filter. Resistors R4 and R6 form a Schmitt trigger with a small deadband. When the signal goes above the trigger voltage the output of the trigger swings hard to the positive supply rail of the IC, charging C2 through the 220k resistor, R8. Resistors R10 and R11 with gate c form a second Schmitt trigger monitoring the voltage across C2. If the voltage across C2 reaches the trigger voltage of this second Schmitt, gates d, e and f are activated, pulling in the relay contacts and disconnecting the loudspeaker. It takes about 100 ms to charge C2 through R8, and on normal audio content the output of gate 'a' will be driven low before this occurs, discharging C2 rapidly through D6. Only signals which do not have a zero crossing for longer than 100 ms will trigger the protector.

The over-power protector consists simply of a voltage divider feeding a third Schmitt trigger. Whenever the signal voltage exceeds the trigger voltage the output of gate 'b' is driven high and C3 starts to charge. If this condition persists for long enough the output gates are turned on and the relay pulls in. Note that both the dc and over-power sense circuits charge C3 when activated. The circuits are decoupled from this capacitor by diodes so that, once charged, C3 can only be discharged by the parallel resistor R12 (the effect of the input impedance of the gates is negligible). Since it takes about one second to discharge this capacitor, the relay will hold in for this time. The protector therefore reconnects the loudspeaker approximately one second after the fault condition has been removed.



This project was originally published in our April 1983 issue. ■

Frequency Counter



For those who need frequencies counted, ET presents a simple, easy-to-build digital frequency counter.

Design by Dave Bedrosian

A FREQUENCY COUNTER is a very useful piece of test equipment as it can be used for troubleshooting both analog and digital circuitry. The design shown in this article uses readily available TTL and CMOS ICs for measuring frequencies from below 10 Hz up to 10 MHz.

This counter differs from others in several important areas:

The gating times are generated by a crystal controlled clock which is very accurate and will not drift significantly with time as opposed to the more commonly used monostable multivibrator.

When measuring low frequencies (below 10 KHz), the input signal is multiplied by up to 100, thereby reducing the reading time to one second or less.

This frequency counter automatically updates its display about three times every second (approximately once per second on the 100 Hz range), and a latch is used to provide a flicker-free display of the input frequency.

A block diagram of the frequency counter is shown in figure 1. The input signal, after being conditioned by the input circuit, is "anded" with the gating pulse and the resulting signal is fed to the counter, which counts the number of high to low transitions at its input. This count is then latched and displayed on the four seven-segment displays. If, for example, the gating pulse is set at one second and the input frequency is 2259 Hz, the counter will 'see' 2259 high to low transitions in the one second gating period and thus 2259 will be displayed. Refer to the "How it Works" section for a more detailed description of the frequency counter.

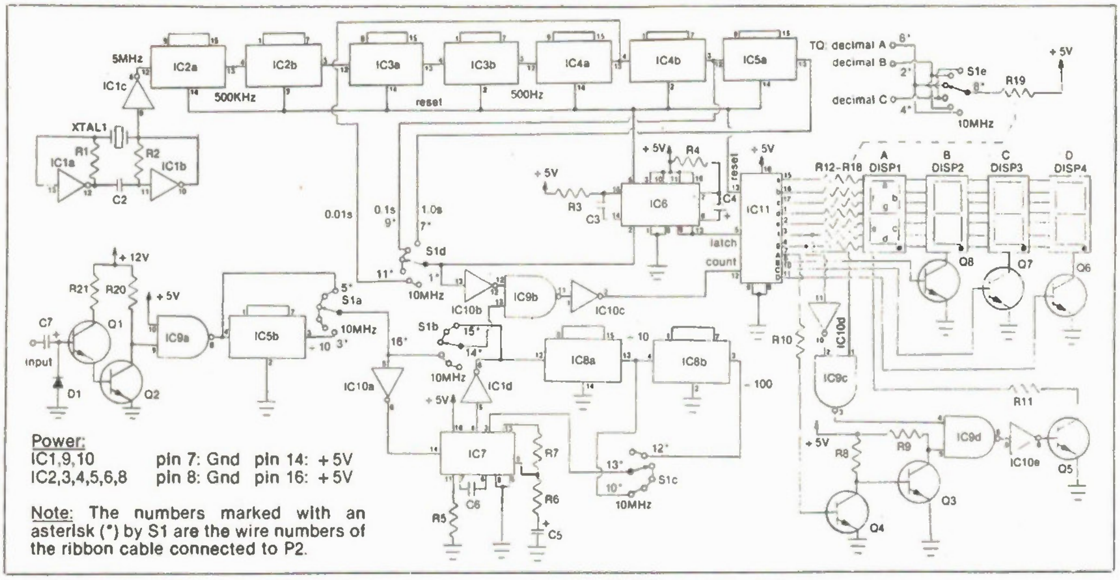
Construction

The printed circuit boards shown in this article are recommended to speed construction and reduce the possibility of wiring errors; however, wire-wrapping techniques could be used if desired. The following construction details apply when the suggested Hammond case is used with the printed circuit boards.

Start by assembling the large board. First solder in the jumpers; there are 24 of them. Use a short piece of insulation to insulate J1 from the crystal leads. Next, solder in the IC sockets and the power supply parts. Be sure to attach heatsinks to both the bridge rectifier and the regulator before soldering them in place. Neither silicone nor mica insulators are required for either heatsink. The remaining parts can now be soldered in place. Pay attention to the orientation of the tantalum capacitors, transistors and diode.

Before inserting the ICs, temporarily apply power to the board and check the power supply. The input to the regulator should be 9V or greater (depending on the transformer used) and the outut of the regulator should be 5V, within half a volt. Check each IC socket separately for +5V and ground (excluding the two 16 pin header sockets and the DIP resistor socket). Pin 7, 8, or 9 should be ground and pin 14, 16, or 18 should be +5V for 14, 16, and 18 pin sockets respectively. If there is a problem, check that all of the jumpers are installed correctly. With ground and +5V at each IC socket, power should be removed and the ICs inserted; note the proper orientation of each one. The DIP resistor obviously can go in either way; if, however, it is not available eight 33 ohm resistors bent for 0.4 inch insertion can be used instead.

With the main board completed, the



Schematic diagram for the frequency counter.

display board can be assembled next. Solder in the ten jumpers and the two IC sockets, then insert the four displays using the parts overlay and figure 2. The decimal point of each display should be on the bottom half of the display board. Next a six inch sixteen pin header cable should be made as indicated in figure 3 and connected to both boards as shown on the parts overlay.

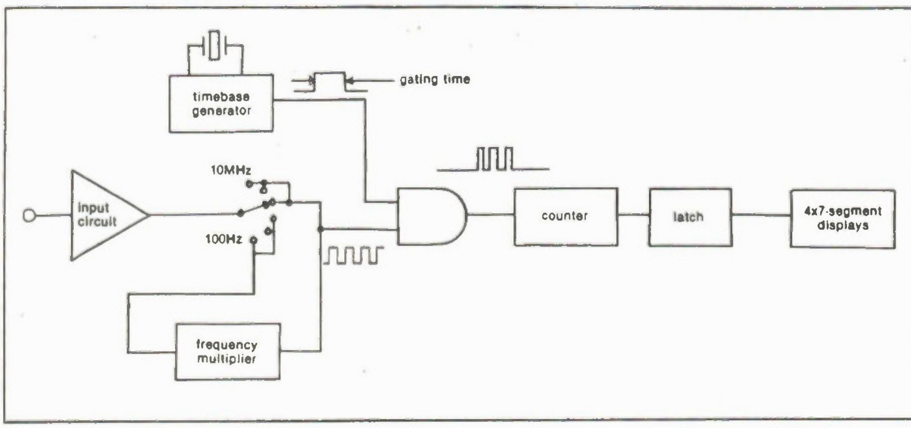
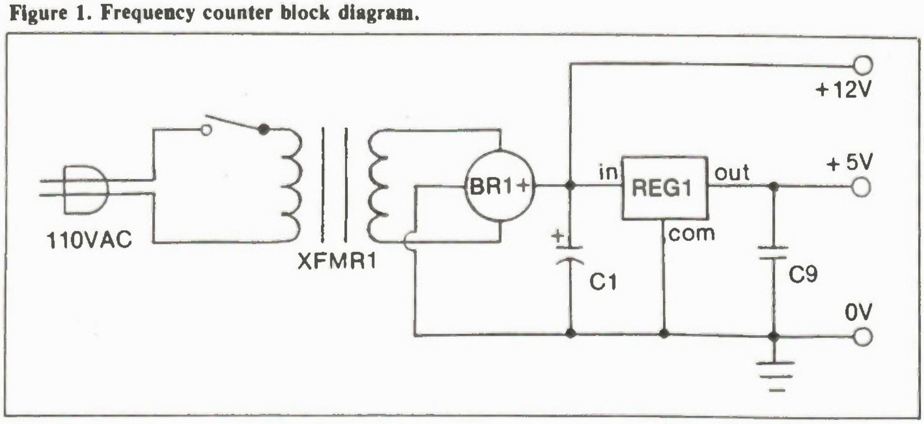


Figure 1. Frequency counter block diagram.

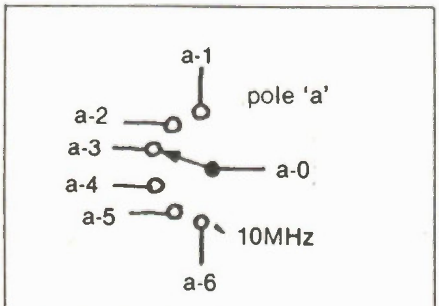
Table 1

Wire Number	Switch Location
1	d-0
2	e-2, e-5
3	a-6
4	e-1, e-4
5	a-1,a-2,a-3,a-4,a-5
6	e-3, e-6
7	d-1
8	e-0
9	d-2, d-3, d-4
10	c-3, c-4, c-5, c-6
11	d-5, d-6
12	c-1, c-2
13	c-0
14	b-0
15	b-1, b-2, b-3
16	a-0, b-4, b-5, b-6

Table 1. Wiring table for switch 1.



Power supply schematic for the frequency counter.



Having completed both printed circuit boards, the rotary switch can be wired. Initially it should be tested with an ohmmeter to verify that each position of each pole is operational; this may save considerable time if troubleshooting is required later. Use table 1 to connect an eleven inch piece of ribbon cable to the switch.

At this point in construction the unit can be fully tested. With the rotary switch and the display board connected properly, apply power to the main board. If all is well the display will read '000' or '001' and the leftmost digit will be extinguished. If there is a problem, refer to the troubleshooting section, otherwise continue testing. Apply about a 2V peak to

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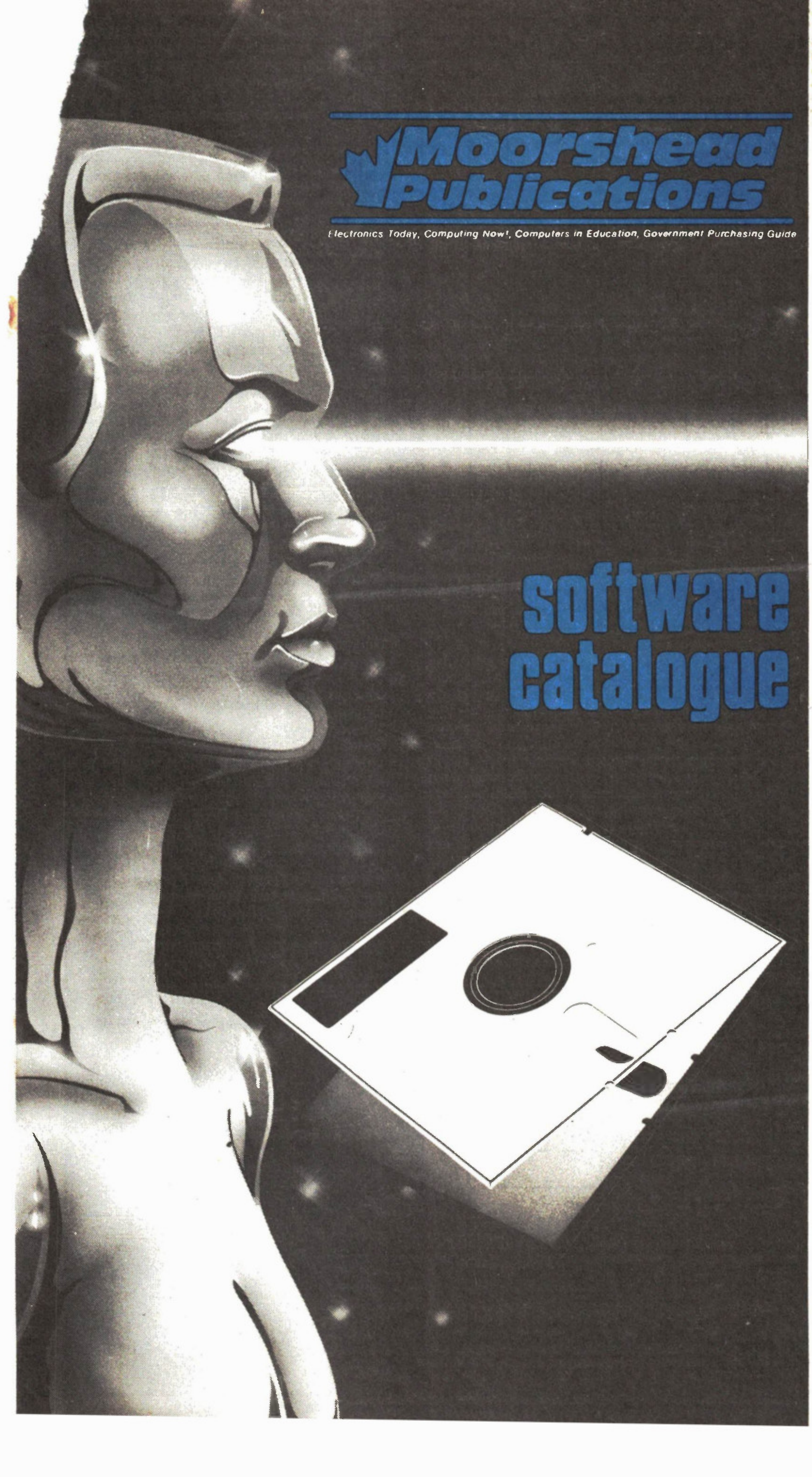

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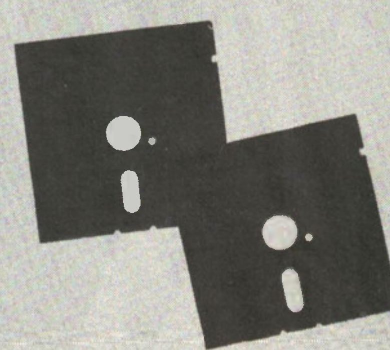

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ARTIFICIAL ART This is one of the most useless programs anyone's ever written, but you'll probably spend a lot of time running it. It generates an ever changing graphic image on your PC - with accompanying sound. While it may seem a bit pedestrian, it's a gas to watch. Requires a colour graphics adapter.

AsEasy This is a public domain spreadsheet package, very similar in its abilities to the more popular functions of Lotus 1-2-3. Unlike Lotus, it doesn't cost anything and it isn't copy protected.

ASYNC This is an assembler file which creates a device driver to make the PC's serial ports behave as they should, with interrupt driven buffered inputs and outputs. This is a programmer's delight. Requires MASM to use.

ChessII This is one of the best chess programs yet devised for the PC. Aside from being small and fast, it lets you physically pick up the pieces and move them rather than entering board co-ordinates. Plays an evil game, too.

HAUNT This is a haunted house adventure game. You wander around looking for the mysterious pumpkin man while picking up things, encountering ghosts and, if you're not careful, getting busted for shoplifting. Very nicely executed, and it doesn't require any graphics facilities.

LPTX The most flexible printer redirection program imaginable, this thing lets you set up virtual printers, that is, disk files to capture the output of things that think they're printing. Includes both executable and source files.

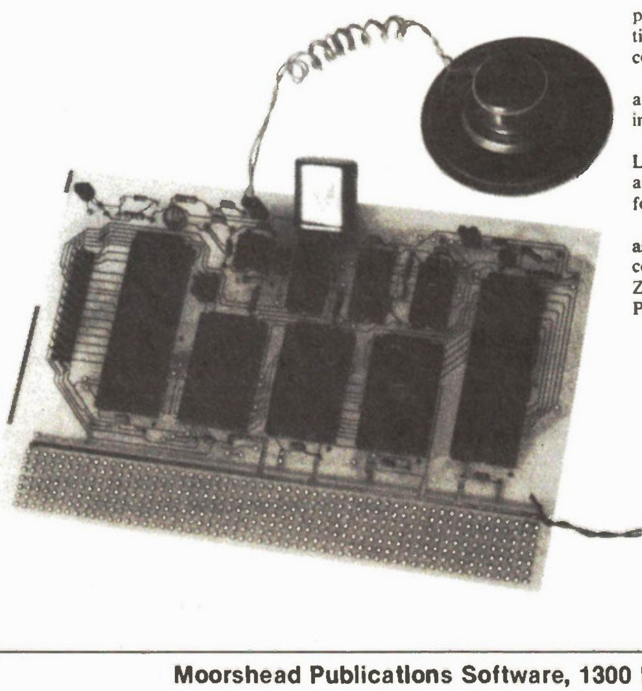
PITFALL This is a supremely clever ASCII game. Aside from being an absolutely superb game in itself, it's a clever use of the PC's screen. You get to pilot a spaceship down a winding, rather nasty pit. More fun than being beamedginto a supernova.

RAMDISK Once you've installed a normal RAM disk, it's there for the duration. This one allows you to change the size of the disk on the fly, or blow it away all together, without having to reboot anything.

ZAPDRAW This is the C source code for the Graphics in C article from the January 1986 edition of Computing Now!. It creates a general purpose high speed PC graphics library, suitable for use on both the colour card and the Hercules board. Requires Lattice C or something similar.

Only $19.95

The Learning Computer



Computers can do a lot more than play video games and run spreadsheets. Specialized dedicated microprocessor boards are at the hearts of the latest generation of television sets, appliances, cars and sophisticated industrial controls.

The design of these boards is a large undertaking and, as such, few programmers ever get a chance to learn the art of writing dedicated system firmware first hand. However, with the increasing use of microprocessors in all sorts of high technology, there is a growing need for people to write "ROMmable" code.

The Sloth board is a small dedicated microprocessor board which has been designed to be a general purpose small control board of the sort found in industry. It's not a trainer... it can be made to do the sorts of tasks that similar custom boards are doing in the real world. However, carefully documented and thought out, the Sloth is the ideal board for learning about this powerful aspect of programming.

The Sloth is based on the popular Z-80 microprocessor. It's programmed with inexpensive... and reusable... 2716 EPROMs. It has two kilobytes of RAM, three counter timers and twenty-four lines of I/O. It also has a speaker driver, and the Sloth package comes with an auxillary six digit LED display board.

The board can be populated with easy to find parts. It can be programmed to be anything from a frequency counter to a video tape recorder timer to whatever one's imagination runs to.

The Sloth package available from us includes a bare Sloth main board and a bare LED display board, a parts list and overlay, a large easy to read schematic and a series of article reprints which document the board in great detail. This includes a source listing for a sample program to illustrate how the various devices on the board are accessed.

In addition to the Sloth itself, you'll need a system to develop Z-80 or 8080 assembler code and subsequently to burn it into EPROMs. We recommend an Apple compatible system running CP/M with a Multiflex PROM burner or an IBM PC running Z80MU and a PC compatible EPROM programmer. Z80MU, a CP/M emulator for the PC, is available separately from our almost free software service for $19.95.

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Volume 19

BOTH If you print out a lot of documents, manuscripts, program listings or other manifestations of hard copy, you'll have noticed that the backs of the pages usually look a bit bare. This program can slash your paper bill by allowing you to print long files on both sides of the sheets

DIAGS Written by the author of Z80MU, this collection of tools will be nirvana for the experienced PC programmer. It does things like generate an annotated list of all the interrupt vectors in your PC, let you meddle with the 6845 registers, test most of the ins and outs of your system and so on. It's a brilliant bit of work.

GRCP Graphic cut and paste is a memory resident tool that allows you to scoop things from a PC high resolution graphic screen and pop them into other applications. Shades of the Macintosh.

LOCKERUP This tiny microbe of code sleeps in your system until you have to leave your PC for a while. Then it enables you to irrevocably lock up your keyboard until you come back to restart it. It's perfect for offices where there are more fingers than hands to contain them.

MEGAPEDE Just when you thought that it was safe to play ASCII games again... This one is a sophisticated variation of the classic "snake" programs and it plays with the speed of a boa constrictor. Don't count on winning for a while.

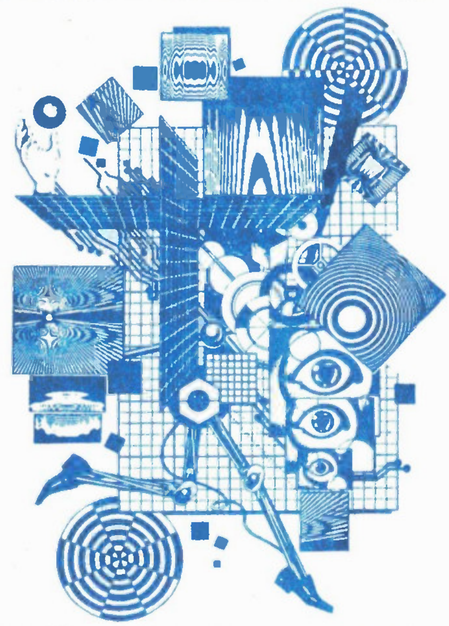
MURPHY Sort of an iconoclast in a can, this program will print a random selection of several hundred of murphy's laws, corollaries and commentaries thereon each time it's run. If you put it in your AUTOEXEC file it will say something clever each time you start your computer. Slaughters more sacred cows than McDonalds ever will.

QUEBERT This fast PC implementation of the classic arcade game is every bit as exciting as the real thing but lacks a coin slot. Jump down the mountain, avoid the snake and try not to get clobbered with fresh fruit. Sounds like real life...

SAT This is a powerful, menu driven satellite data downlink terminal, as discussed in the December 1986 edition of Computing Now!.

SCAV This is a great program for people who buy economical floppy disks and just about everyone else who can't afford a clean room for their PCs. It cruises through one's disks locking out bad sectors and restores previously 'fried' disks to usefulness. The ASM source code is included, as well as a COM file.

SimCGA If you own a Hercules card you'll have encountered the intense frustration of not being able to use programs written to employ the graphics of a standard colour card. This utility does an astoundingly good job of making the Herc card behave like a colour graphics adapter for quite a lot of software.



STUFFIT Stuffit is a disk management utility which stuffs files into the inner tracks of a floppy disk, allowing the outer tracks to be used for work space. This improves the disk access times and the reliability of mostly full disks considerably.

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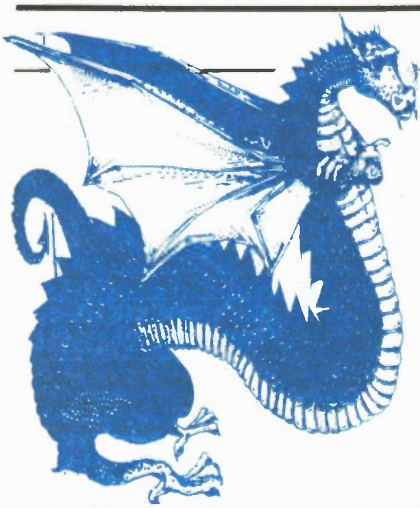
Volume 18



Bradford Fancy printing programs, like Printrix and Fancy Font, are slick but expensive. This public domain version does much of what they do, but it does it for free. Requires an Epson or Gemini dot matrix printer.

ZOARRE This is another dungeon game, but terrifically well done and very intricate. It displays a picture of the room you're in, zaps you with various monsters and generally tries its very best to kill you. If you liked Castle you'll freak over this one.

DIVERTFN This is a tiny program which doubles the effective screen printing speed of most programs which print through DOS.

DONKEY KONG This is a pretty snappy public domain implementation of the classic arcade game. Getting squashed by oil drums is more fun than anything. Requires a colour card.

MASTERKEY The Norton utilities are extremely handy, but they're also expensive. This public domain disk manipulation program offers much the same power for nothing. It offers track and sector editing, unerasing files, and all the general low level fiddling that the expensive programs do.

POPCALC This is a clever bit of resident code that implements a moderately sophisticated calculator which pops up whenever you hit "ALT-C". It's fast, harder to lose than a real calculator and takes up a minimum of system overhead.

PRINTER This is the PRINTER.BAS program from the December 1986 edition of Computing Now!. It reprograms the high end characters of an Epson FX-80 (or compatible) printer to make them print IBM PC screen block graphics.

QUICKEY This little program speeds up the keyboard action.

Card This is the draw poker machine program from the December 1986 edition of Computing Now!. It's included here both as an executable COM file and as source code in C.

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Volume 17

ARC512 This is the latest version of the de facto standard PC file compression and archiving utility. It will create, maintain and crack unpack ARC files, providing a convenient way to reduce the size of files and to merge pots of little files into a single larger one. See the November 1986 edition of Computing Now! for more about this.

ATC ATC stands for "Air Traffic Controller". In this colourful simulation of the rigors of managing the planes at a busy airport may, among other things, renew your interest in train travel.

Draw Poker This is a really slick little poker machine simulation. The graphics are good, the play is fast and the machine doesn't always win. It's a shame it won't spew silver dollars out of your disk drives.

HercBIOS This set of routines will allow you to display text on a Hercules card when it's in one of its graphics modes - just as you can with a colour card. It will intercept the 10H interrupt vector so that anything that normally tries to print to the colour card will also work for the Hercules card.

HotDos If you've ever found yourself wanting to run a second program without quitting your first application, then HotDos was made for you! Hit its control key combination from within most popular programs and it will give you a DOS prompt to run any other program at. When you're done, type EXIT and you'll be back in your first application.

KBD This is a very tiny keyboard buffer extender. It's a useful few bytes to have around, and extremely tiny.

LinkFour A simulation of "Connect Four", this is a deceptively simple game. It's easy to understand, but requires practice if you want to win. The graphics and sound effects are particularly good.

MONEY Yet another Canadian mortgage program, this easy-to-use program is surprisingly most colourful. It will also calculate charts for a variety of financial situations.

PCWindow This is a resident utility which lets you call up a number of useful "windows". These include an elaborate event timer, a note pad, an ASCII code chart and so on. It's well done, fast, and fairly small.

PD This program redirects the output of one's system from the printer port to a disk file. It lets you to use things that normally insist on having a printer on line even if you don't own one, or don't want hard copy.

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Volume 16

ARCDIR The archive file compression system is the most efficient way to store large files in a small space. However, it's weird and complicated. This simple ARC directory utility was featured in the November 1986 edition of Computing Now!. Aside from being useful, it includes both a COM file and the source code so you can see how it works. Requires a C compiler if you want to meddle with it.

BRICKS The "Little Brick Out" game is one of the classic programs for microcomputers. This splendid version will get you turned onto simple games all over again.

DX This is a small DX-7 voice librarian, as found in the Book of Computer Music. It includes both a COM file and the assembler source code.

MOREROOM If you have a hard drive system you may have noticed that it's extremely inefficient with small files. Here's a collection of tricks to get substantially more space on your disk.

E88 While huge word processors like WordStar and PC-Write can be used as text editors, they're hardly very good at the task and they gobble a lot of disk space. If you're trying to manage a C compiler or an assembler on a pair of floppies you've probably encountered this. E88 is a tiny - but powerful - text editor.

EXPERT Commercial Expert Systems software is still in its technological infancy. If you're interested in learning about expert systems and how they relate to your computing needs, you should try this simple program.

FULLDOS A DOS enhancement program that makes the DOS user interface behave in a rather more friendly manner. It creates a command stack and lets you re-execute previous commands.

K9 This is yet another resident keyboard enhancer - with a difference. Aside from expanding the keyboard buffer, installing a screen timeout and so on, it makes a number of the alternate keys 'hot', giving you dozens of unique functions.

InstantMENU This is the code for the Instant Menus article which appeared in the November 1986 Computing Now!. With it, you can create elaborate batch file menus with absolutely no tricky programming. The menus can be easily altered with a text editor or word processor. Source code is included.

PALERT We've all occasionally run out of disk space while inside an application and discover that we've been dumped back to DOS unexpectedly. This is a serious drag if you've left a few hours of work behind you trashed in memory. This program warns you of an impending full disk.

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Volume 15

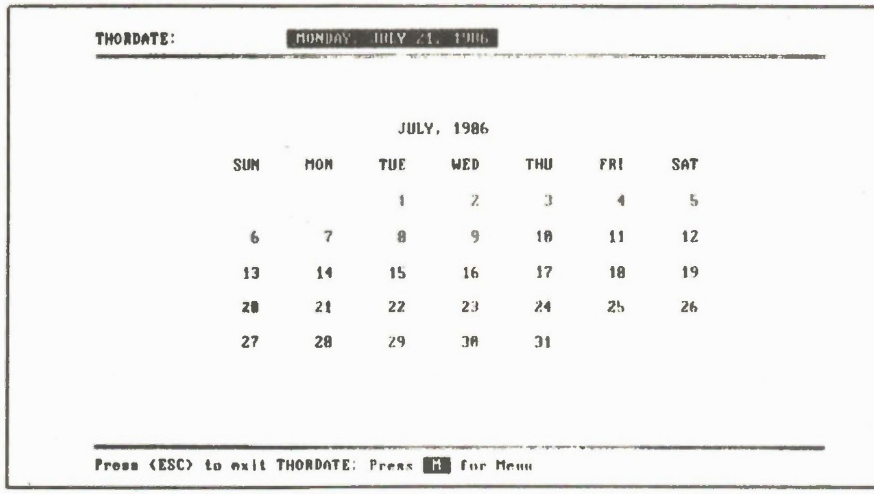
There is a lot of good stuff on this disk... but most important, there are two dynamite games herein. We could get into the graphics package, the CP/M emulator, the fractal program in C... however, it's the games that do it. Plan to lose at least a weekend over this one.

Altamira is one of the nicest public domain paint box programs available for the PC. Unlike most of the so called graphics packages available for the PC, this one isn't restricted to doing bar charts and graphs. It does first rate pictures. Requires a colour card.

Fractal is the source code for the fractal generator in C that we looked at in the August 86 edition of Computing Now!. It's useful even if you don't like fractals, as it illustrates the use of high resolution graphics in C. Requires a C compiler and a colour card.

NEMON is a really weird game. You get stuck in the catacombs of king Nemon with nothing more than your wits and a flashlight. You have to find some keys, some treasures and, hopefully, a way around a host of arcade game nasties.

Thor used to be the god of thunder. Now he appears to be the world's most sophisticated desk calendar program. He'll remind you of appointments, keep track of your agenda and do things that would usually require a host of low tech objects, like pencils and note pads.



Round 42 is a wholly bizzarre variation on the theme of space invaders. No longer the dusty arcade game that it once was, this thing breaths new and rather ichorous life into the ceaseless battle between you and the phospore aliens. This is one of the best computer games in creation. Requires a colour graphic card.

V20 is a CP/M emulator for users of the NEC V20 chip. Replace your existing 8088 with a V20, score this little program and most CP/M software will run on your system as if someone had stolen half the bits out of your PC. Regular MS-DOS isn't affected. Requires a V20.

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Volume 14

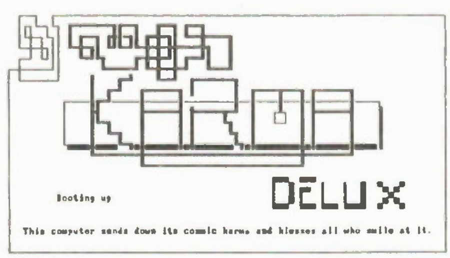
Cut and Paste is a memory resident program that allows you to grab text from the screen of any application and paste it into any other application that accepts characters for input. You could, for example, copy part of a Lotus spreadsheet and paste it into a WordStar document.

INT13 will help you unravel the copy protection schemes of your software so you can make archive copies - just in case the cat takes a fancy to your masters. It prints a log of direct disk accesses and where they're called from so you can check out the code that's going after specific tracks, the heart of most protection systems. Includes the assembler source code.

PMAP tells you what's living in the memory of your system - and where. It will help you to find the resident utilities you have loaded and, more important, is great for sorting out peculiar interactions between multiple resident programs.

SoftTouch is a keyboard macro program not unlike ProKey. It allows you to store up to twenty five thousand key strokes, has a built in screen blanker and great wandering herds of other features.

Sub Chase is a first rate graphics arcade game. One sails across the clear blue sea - or green sea, depending on what sort of monitor you have - heaving depth charges off the stern to blow up subs. It's extremely well done and it has a panic button to clear the screen should the boss walk in. Requires a colour graphics card.



TheDraw is an ANSI screen editor. It allows you to create and edit full colour screens of text and graphics which can subsequently be typed to make them appear - in full colour - or integrated into programs. Requires DOS two or better, ANSI.SYS and is more fun with a colour monitor.

Trek is the best Star Trek game anyone has yet devised for the PC. The graphics are stunning, the complexity is intense and the action scoots along at warp nine as soon as the program gets going. Requires a colour card.

Crossword is a utility which translates text files from one application to another. It supports several popular word processors, including WordStar, WordStar 2000, Multimate, XYwrite, SideKick and standard ASCII. It saves ages worth of reformatting and does some useful things besides.

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Volume 12

CV is a small utility for changing the volume name on disks. Since most of us never bother to specify volume names when formatting disks, this six hundred byte program provides a second chance.

Breakout Box is an assembly language program that hides in memory and shows you what your serial ports are doing. It's a valuable trouble-shooting utility for pin pointing serial printer and modem problems.

Icon Maker allows you to generate sophisticated bit-mapped images. Its' easy to use and extremely colourful, producing data that can be incorporated into other programs.

Shell is another DOS menu program. This one is very fast, free of 'snow', and provides easy access to virtually all DOS features.

Striker is an experience. It's a brilliantly written helicopter game in the style of Choplifter, complete with professional high resolution graphics and running spies. This is one of the best public domain games we've ever encountered.

Ramset is a RAM expansion program from the July 1986 edition of Computing Now!. It allows you exceed the PC's 640K memory limit. Ramset also lets you bypass the PC's time-consuming memory check.

Trap is the high-resolution Gemini patch program from the May edition of Computing Now!. It makes the Gemini 10x suitable for use with Personal Composer, but is easily modified to fix most bit-mapped printing problems. MASM and Link are required to assemble the program.

Almost Free PC Software Volume 12

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Volume 11

Pac Girl is, predictably, a variation on the almost mythical Pacman game. This one moves fast, and plays much like the arcade version.

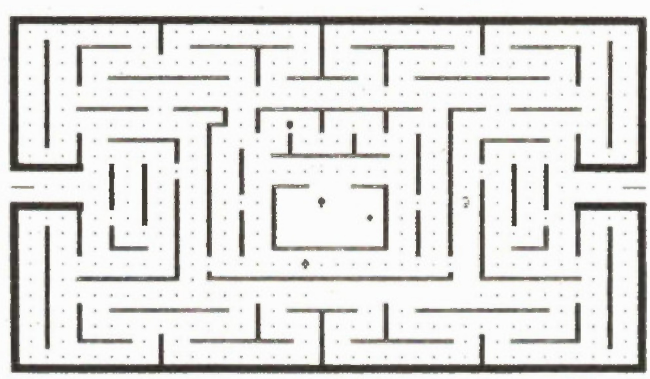
Menu lets you create a menu-driven tree-strctured environment that is friendlier and more manageable than is DOS. It's ideal creating interactive systems for non-technichal users.

Z80MU is one of the most brilliant pieces of software we've ever encountered - free or not. It actually emulates a Z80-based computer running CP/M on the PC with no additional hardware - you don't even need a V20. It will run almost all CP/M software, including old favourites like WordStar and dBase. However, Z80MU also includes features lacking in both C/PM and MS-DOS operating systems.

SERIO is the assembler file from the July edition of Computing Now! that implements an interupt-driven terminal in higher level languages such as C. It's also suitable for use with compiled BASIC. Both MASM and Link are requred to use SERIO.

Breakdown is a peculiar program which takes meaningful text, analyzes it and generates meaningless, but profound-sounding prose from it. If you've been wondering if your co-workers *really* read your office memos and reports, try filtering your prose through this program. The effects will be astounding.

GRABIT is the screen grab program from the July 1986 edition of Computing Now!. It will make a useable text file from the contents of ones screen at the touch of a key. MASM are Link are required.



XMODEM is a C language implementation of the XMODEM file transfer protocol, from the July 1986 edition of Computing Now!. It can be integrated into other programs to allow easy access to telecommunications facilities. This code requires SERIO (see above) and version three Lattice C.

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Almost Free PC Software

Volume 10

Monopoly is the first working implementation of the classic board game that we've come across - and we've had several that bombed pretty colourfully. This one is great, though, with fast and occasionally sarcastic play, a graphic board display and pretty good sound effects.

D20 is the latest version of Steve's sorted directory program. This one uses DOS two calls and handles subdirectories.

Edit is a lightning fast full screen editor, ideal for editing program source files, dBASE stuff or other ASCII phenomena.

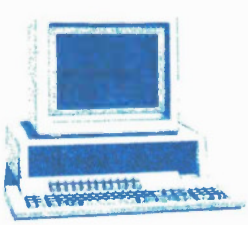
Banner takes mere text and prints it sideways on your printer - in gargantuan block letters that can be read from miles away if you have a good set of binoculars. It's not the sort of thing that you'd want to publish a book with, but sign makers will love it.

Mortgage is another utility to help you understand just what you've gotten yourself into. Its one of the nicest mortgage programs we've seen so far - lifelong debt and ruination has never been so well formatted.

Quick speeds up your PC quite a bit. It hooks into the video and makes it run a great deal faster, eliminating at least some of the glacial slowness that makes an IBM what it is.

Speech is a rather remarkable little germ of code. It talks through the PC's internal squeaker speaker. The voice isn't exactly human, but it's understandable on most machines. This is an interesting bit of work, one that can be accessed from within other programs to create talking applications.

PC-AR is an accounts receivable package for the PC. While not the equal of some of the commercial software that handles this function, it will take care of the records for a small or medium sized business quite well.



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Volume 9

Small C If you've ever wanted to try writing programs in the C language, this compiler will fascinate you. It's a restricted implementation of C, producing code which is compatible with Microsoft's MASM and LINK programs -you'll need these to get it going.

Map is an interesting little utility which will check how DOS is situated in the memory of your computer and tell you a number of things about it. It's a useful programming tool, especially helpful if you're debugging software which interacts directly with DOS.

Note is the source file for the memory resident note pad which appeared in the March 1986 edition of Computing Now! It requires MASM and LINK to use. It will create a resident memo page that you can call up from within any application.

Pango is one of the wildest games we've come across for the PC. While its premise is a bit improbable, it's fast and *weird* - hours of fun.

PC-Spell is a spelling checker written in BASIC. Despite its pedestrian sounding origins, it's fast, accurate and easy to use. It can be listed if you want to see how it works, and comes with a large dictionary file and a utility to assist you in customizing it.

Peacock is a memory resident program which allows you to change the colours of your screen with alternate function keys. It's useful, for example, if you run software which insists on using eye-straining screen colours.

Recover is a utility which assists you in getting data back from damaged files. It lets you look at your files one sector at a time in order to put the pieces back together.

Tally is a program which accurately counts the number of characters, words and lines in a file -all within your lifetime.

Xeno edits the tracks and sectors of your disks in a user friendly format - or, at least, one that doesn't lunge for your throat every time you boot it. You can use it to explore DOS, fix trashed disks, unerase files and do all the other low level magic that sector editors are renowned for.

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Volume 8

Load-Us allows users of the popular Lotus 1-2-3 and Symphony programs to run them on a hard drive. This preboot program does not "crack" Lotus's copy protection scheme, but it does help legitimate users overcome the inconvenience of keeping a "key" disk in a floppy drive while running Lotus or Symphony on a hard drive.

DDCal is a very clever perpetual calendar and desk diary. It keeps track of your appointments and performs several other functions that you probably thought could only be done on the backs of match books.

PC-Key Draw is a remarkable public domain paintbox program which compares favorably with many commercial applications. It'll handle multiple screen images, business graphics and superb computer art - all in full colour. It's worth the cost of this disk all by itself.

CPU is a tiny program which tells you the effective speed of your system.

Xray is a remarkable co-resident utility which monitors what a program is doing while it's busy doing it. It allows you to interrupt the execution of your code and have a look inside.

Game - well, there are no words for this program, or, at least, none that are printable. This game is a bit rude - depending on just how weird your mind is, it can get pretty bizarre. This program does use some suggestive language, and we recommend that young or sensitive users not boot it.

Tune is a very small music generator which makes noises from within batch files. It's useful to see where things are in a complex process.

Chasm, or cheap assembler, is just the thing if you want to get into assembly language programming but don't want to spring for the Microsoft macro assembler package. It's reasonably fast, not too huge - it'll run in as little as sixty-four kilobytes - and, above all, it's cheap.

Getdir is a resident directory utility. It allows you to see what files are on your disks, even if you're in the middle of doing something else.

CopyPC, not to be confused with the commercial Copy II PC, is a quick disk backup utility.

Lookit is a full screen browsing program which lets you scroll forward and backwards through text files - sort of like a tiny word processor with no editing features.

Syslock is a security device for hard disk users. By running this utility on your XT or compatible, access to your computer will only be granted to users with a valid password.

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Volume 7

ACKJACK is a BASIC implementation of s popular card game. It's both interesting to ay and enlightening to dismantle. It can, of urse, be easily listed so you can see how it orks.

DSCR is a screen editor which can be used ith virtually any programming language from ssembler to dBase III. The program lets you paint' PC screens with block graphics and saves them as .DAT files which can be easily adapted to work in most languages. An example screen is included.

FK allows you to make the function keys of your PC do more useful things under DOS. They can be redefined to execute commonly used commands and command sequences.

FXMASTER is a printer program for the popular Epson FX Series and compatible printers. It uses a full screen menu to enable you to easily change printer settings and modes.

INDEX allows you to generate indexes from WordStar documents... or text files from any other text editor. It's an invaluable writer's tool.

KEYCLICK is a memory co-resident program which will make your keys click. Small and easily included in an AUTOEXEC file, KEYCLICK solves many problems associated with clone keyboards.

PCBW is a small utility which makes colour screen displays show up in monochrome video. Great for users with colour graphics cards and monochrome monitors.

PINBALL is a pinball simulation that is easily worth the cost of this disk all by itself. The game plays much like a real pinball machine... but its hard to tilt.

QUICKGRAF is a powerful business graphics package which generates complex bar, line and scatter charts in medium and high resolution. An Epson with GrafTrax or compatible printer is necessary to produce hardcopy.

SERPENT is a variation on the classic snake game. Written in BASIC, this one is weird, but very fast.

SHOWCLK is yet another clock program... its the smallest one yet, and it beeps to chime the hour.

VTREE is a graphic TREE program that shows you how the subdirectories are set up on your disk... in a fashion more easily understood than the MS-DOS TREE utility.

WORLD is a remarkable program which incorporates a world map. It allows you to zoom in on specific areas of the globe, locate major cities and perform a number of useful calculation. It also has a feature for tracking hurricanes... tracked any good hurricanes lately?

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Volume 6

3-DEMON is one of the most interesting variations on Pac-Man in the known universe. Instead of simply looking at a map of a maze, this program shows you a three dimensional view of it. You wander through endless corridors, munching food pellets or granola bars... your choice... and avoiding the deadly ghosts.

DU was one of the most powerful CP/M-based disk utilities ever created. This version for the PC captures much of its power and flexibility. It allows you to see what the tracks and sectors on your disks look like, recover erased or damaged files, and meddle with the system tracks.

General Ledger This is a complete general ledger accounting program. Written in BASIC, the program possesses most of the features found in commercial packages. An enormous documentation file is also included.

PC-CHESS is a slick chess program which makes good use of the PC's colour graphics abilities and boasts a running chess clock.

RAMDISK is the assembler source code for a memory disk program. If you've always wanted to know how these things work, or have a secret desire to write your own variation of this useful utility, here's your chance.

VFILER is a file management utility which lets you view files in a directory and allows you to COPY, TYPE and even run programs... in short, it does almost everything DOS does but it's user-friendly.

QMODEM is unquestionably the best telecommunications package in existence. The most recent version of it is replete with windowing, multiple protocols, definable function keys. And the code is unspeakably well debugged.

ARC is a sophisticated file archiving program which stores several files in single library files. As an added bonus, ARC applies one of four data compression techniques to each file in order to optimize disk space.

ZAPLOAD is a utility for programers to handle Intel standard HEX files. Very fast and well documented.

SOPWITH Using superb graphics, SOPWITH lets you pilot a World War I biplane on dangerous bombing missions.

JSB Another BASIC music program for your collection. This one plays a soothing sonata.

ALSO: Star, Surface, Op.

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Volume 5

AREACODE is a useful tool if you use the telephone a lot. Give it an area code and it will match it with the city in which the code is used.

D in another sorted directory program. This one emulates the CP/M style D, which is arguably more useful for most applications.

FRACTALS An amazing implementation of the Mandlebrot Microscope, which generates unearthly images on your screen.

HIDE is a set of utilities which let you create, enter and remove invisible DOS directories. This allows you to set up a hard drive system with secure areas which can only be used by people who know about them.

LAR is a library utility that allows you to concatenate several small files into a library to save on disk overhead. Individual files can be extracted as they are needed.

MAIL1 is a mailing label utility written in BASIC.

MORERAM This is an assembler program. You need MASM and LINK to make it work. It lets you alter the memory setting on the PC's motherboard to enable it to use more than 640K RAM. It will even let you set the switch settings to 64K to speed up disk boots and then change the RAM setting after bootup.

MORTGAGE generates amortization charts.

MXSET lets you control the parameters of Epson printers form the DOS command line. It's a lot easier than LPRINTing characters from BASIC every time you want to change print modes.

NUSQ unsqueezes files that have been previously compressed to save space. Should be of primary interest to bulletin board users.

PARCHK is an assembler program which requires MASM and LINK to work. It installs a trap for parity errors in your computer. A vital aid to help locate suspect RAM chips.

VDEL is a Delete with Verify program. You could type VDEL *.BAK and it would show them name of every .BAK file in the current directory and ask you if you want it deleted.

WHEREIS finds files in a complex hard disk system.

ZAXXONPC This is an incredible implementation of one of the most popular micro games ever created.

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Volume 4

BUGS is an off the wall ASCII game in which a player uses the cursor pad keys to move a 'nuclear fly swatter' around the screen blowing up a long crawling bug.

CLOCK is a useful tutorial in writing character oriented device drivers for the PC. In addition, the program is an improved replacement CLOCK.SYS file which works with many real time clocks. The ASM file is included.

DEFRAG is a utility that lets you "defragment" your disks to make your applications run faster. The utility reorganizes a disk, connecting up the fragments of files created by DOS.

DOSEDIT is one of the most useful DOS utilities available. it enhances the command line facility of MS-DOS by creating a command stack. Instead of merely being able to recall a command with the F3 key, DOSEDIT lets you use the cursor arrow keys to scroll through a whole stack of previously entered commands, re-executing the ones you need.

DUmp is a utility program designed to produce Hex dumps of object files. Useful in its own right, the program also serves as a good example of how to use DOS disk service calls. The ASM file is also included.

FREE is a tiny file which tells you how much space is left on a disk... without having to view an entire directory listing. Its especially handy for hard disk systems.

LABEL changes the labels on disk drive volumes. It's a simple utility, but useful if you use volume labels to keep track of your disks.

LIST is an improved version of the DOS TYPE command which shows you the contents of a file page by page.

MEMBRAIN is the most sophisticated RAM disk program we've seen yet. It lets users install variable sized disks and provides control over several other parameters.

SPACE INVADERS A fast variation of this popular arcade game. the graphics are superb.

SPEED is a simple program which changes some of the PC's floppy disk parameters and effectively speeds up disk accesses for some applications.

WIZARDS is an adventure game in the classic style, except that it ranks as one of the most sarcastic programs in creation. The program is vast... you can wander about its darkened corridors for hours.

ALSO: Backscroll, Bigcal, Crypto, Kbfix, Monoclok, Move, Newbell, Nuxq, Parchk, and Sp.

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Volume 3

FIXWS is a simple utility which modifies WordStar files so that they can be used by programs which work with ordinary ASCII files.

WRT DOS 2.0 allows for each file to have a 'read only' flag, but it lacks a way of manipulating them. This pair of utilities allows you to set and unset this flag, protecting important files from accidental erasure.

BROWSE is a timesaving program which provides a useful alternative to the DOS 'TYPE' command. BROWSE allows you to easily scroll up and down through text files, saving you the effort of running your word processor just to get a quick look at a text file.

CAT If the DIR display is too dull for your taste, CAT may be just what you need. It will tell you everything you could possibly want to know about the files on your disks.

CGCLOCK is a simple little program which displays the running time in the upper right hand corner of your screen. In addition, the program has lots of display options and works with the colour graphics card.

CURSOR A tiny twenty-four byte program which displays a large cursor on your monitor.

CMP This program does a very elaborate comparison of two files and reports their differences. It can for example, spot corrupted files and may prove useful when dealing with files created by redirection.

JUMPJOE A bit like "Miner 2049'er", this game is certain to damage your mind. You get to be the janitor of a space station and must deal with berserk robots and other weirdness. It's a hoot!

CASTLE Wander through a deserted castle collecting treasures... but mind you don't get killed by the nasties. A solution is included should frustration set in.

78INT This is a small BASIC program to calculate interest using the rule of seventy-eight.

MOON is one of the nicest lunar lander games we've come across. This version uses high resolution graphics and startling sound effects to hurl you to your doom in style.

PERTCHT is a BASIC program which prints PERT charts. It should interest anyone involved in project management and scheduling.

DATNOIDS is one of the strangest games ever put on a disk. In fact, mere words don't serve to describe it: you'll have to try it for yourself.

NUK-NY This is one of the nastiest bits of software we've ever seen. It produces a full color high resolution simulation of a nuclear attack on New York City.

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Volume 2

SWEEP is a disk utility which virtually replaces the DOS Copy command. It lets you COPY, REN, TYPE and DEL files quickly and easily from a simple menu.

Worldmap is a sophisticated graphics program which draws a very detailed map of the world. It can display its wares on your monitor, or send them out to a dot-matrix printer.

ANITRA plays Anitra's Dance by Edvard Grieg. A beautiful addition to your computer music collection.

RAMDISK is one of the most useful utilities you'll ever plug into your PC. Once installed, it creates a virtual drive in memory on your PC. Files can be copied to the RAM-disk and accessed in less time than real drives take to turn on their LEDs.

Alien plays a bizarre adventure game and will lead you into some of the most exotic spots in the universe. It comes with a massive data file for an adventure that you won't get tired of 'til the dragons come home for the evening.

ASMGEN is one of the best text disassemblers we've come across. It takes any executable COM or EXE file and produces an assembler listing. It's surprisingly good at distinguishing between code and embedded data or text.

Jukebox represents yet another PC music system. This one comes with a host of songs to play and some really electric graphics.

FOS is a well designed personal finance manager which will do much to help you tame your cheque books.

STRUCT will appeal to the rabid programmer in everyone. It enables MASM to be used to assemble a higher level language. Included also is a test file to illustrate the syntax.

PRTSC replaces the internal PC screen dump code with something more suited to reality. It allows one to hit the PrtSc* key and then select the print quality from a menu. It supports a number of popular printers.

BREAKOUT plays a PC version of the popular game. It will accept input from either a joystick or the keyboard. The graphics are good and the action is adjustable from a beginner's level right up to 'fast and nasty'.

UTIL is a collection system utilities which can be accessed from a single menu. Among its many talents are a sorted directory, keyboard redefinition and the facility for scrolling up and down through a text file.

Only $19.95

Volume 1

PC-Write An earlier, compact version of this well-known word processor - perfect for program editing. PC-Write comes extremely close to equalling the power of commercial word processors costing several hundred dollars. With full screen editing, sophisticated cursor movement, PC-Write also boasts features such as user-definable help screens and a 'printer ruler file' which can be customized to work with virtually any printer.

SOLFE is a small BASIC program that plays baroque music. While it has little practical use, it's a lot of fun. It's also a fabulous tutorial on how to use BASICA's sound statements.

PC-TALK Telecommunications packages for the IBM PC are typically intricate, powerful and huge. This one is no exception. It has menus for everything and allows full control of all parameters. It does file transfers in both ASCII dump and MODEM7/XMODEM protocols. And, it comes with a large documentation file.

SD This sorted directory produces displays which are a lot more readable that those spewed out by typing DIR.

FORTH This is a small FORTH, written in Microsoft BASIC. A good tool for teaching the ideas and concepts of this esoteric, but useful language.

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

MAGDALEN This is another BASIC music program. We couldn't decide which of the two we liked better, so we wound up putting both of them on the disk.

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

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

UNWS WordStar has an unusual propensity for setting the high order bits on some of the characters in the files it creates. Here's a utility to strip the bits and 'un-WordStar' the text. The assembler source code is also provided.

HOST2 This program includes BASIC source and documentation files to allow users with SmartModems to access their PC's remotely.

Only $19.95

Moorshead Publications Software, 1300 Don Mills, North York (Toronto), Ont. M3B 3M8

MA.BAS The Micro Accountant is a complete, working accounting and check register program, with a 25K documentation file.

PCWNDW22 A "Sidekick"-like co-resident window utility. Pop-up window functions include ASCII table, stopwatch, alarm, printer setup utility and notepad. The entire program takes up less than 30K of space on your disk.

PSHIFT A time saving and convenient 'memory partition' utility. Lets you define up to nine memory areas. Load programs such as dBase II and WordStar into separate partitions and 'flip' between them instantly with simple keystrokes.

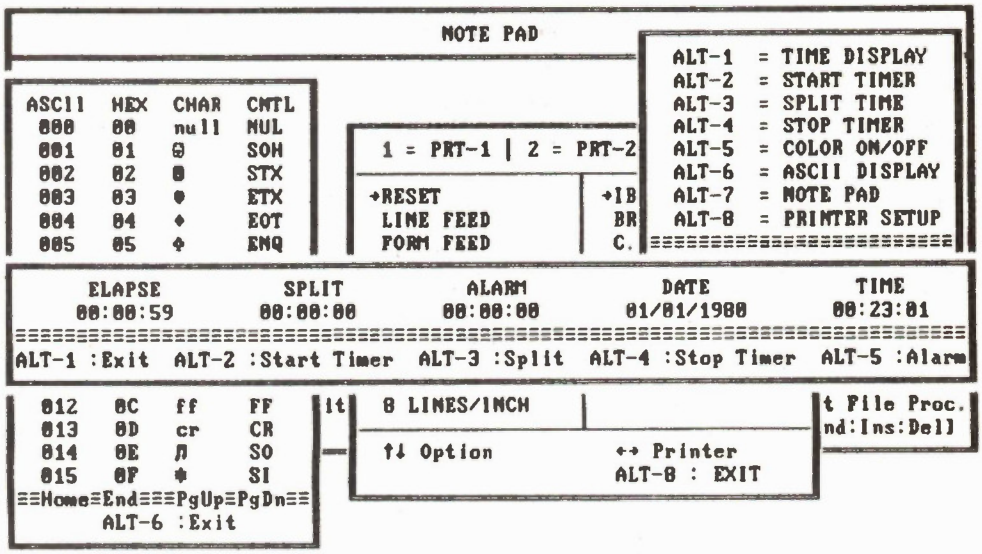
PC-TOUCH.BAS Increase typing speed and accuracy with this easy-to-use typing tutor. Also provides accuracy and speed statistics.

PCYEARBK.EXE Appointments and reminder program to help you keep track of your time.

TASKPLAN.BAS Project management software which lets you track up to 50 tasks over 50 time periods (days, weeks or months).

NOCOLOR A handy little utility for users with monochrome monitors and colour software.

MAXIT A simple but subtle game for two human opponents, or one player and the computer. Hours of fun!



PERTCHT A sophisticated project management tool using the Program Evaluation Review Technique (PERT).

PLUS More utilities to help organize maintain and copy your files, including a "monitor saving" program which blanks out your screen when it is not in use.

Only $19.95

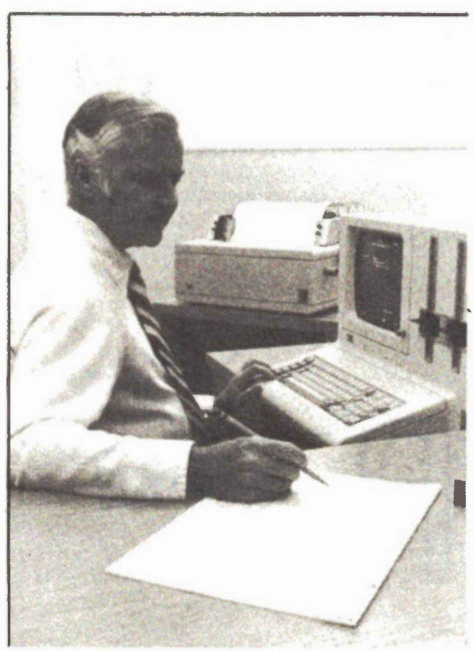
Stockboy Inventory

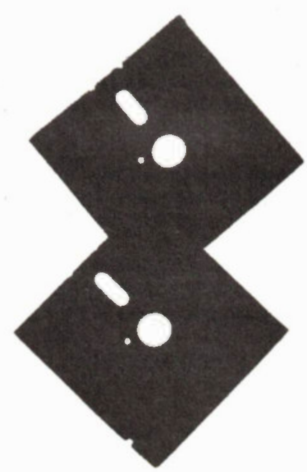
Stockboy is a good, powerful, flexible bargain-priced inventory package which will handle inventory for most small businesses needs. We use *Stockboy* for our own inventory control and it has stood the test of time.

Stockboy can:

- Maintain an inventory database with current, maximum and minimum stock reporting when an item needs re-ordering.
- Be a point of sale terminal, adjusting the stock data base on line.
- Produce individual packing lists.
- Generate a customer list to be used in mass mailings.
- Run on any CP/M or MS-DOS based computer, including Apple II systems with a Softcard.

Stockboy is written in Microsoft BASIC and is designed to be easily altered to suit your needs. It can be compiled using BASCOM if desired and is designed to be used by non-technical operators. Available for MS-DOS/PC-DOS and many CP/M systems.





Only $29.95

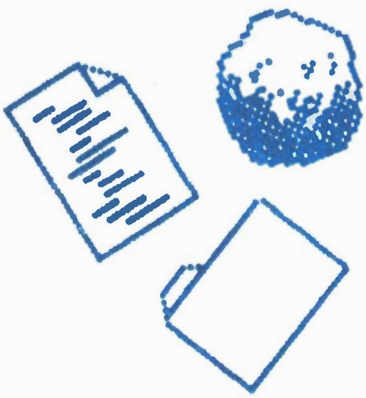
Almost Free Macintosh Software

Volume 1

ASTEROIDS This is a splendid implementation of one of the most popular arcade games of all time. The graphics and sound effects are amazing.

RED RYDER Telecommunication on the Mac has never been this easy. RED RYDER includes XMODEM and Kermit protocols and many other features.

MacCLONE Many users have found the Mac's disk copy routine to be less than perfect. This is a vast improvement. It even defeats a number of copy protection schemes.



BINHEX is a utility for RED RYDER which converts applications files to binary files and back again to allow them to be transferred over phones lines.

LIFE is one of the classic computer programs, and this version is exceedingly well done.

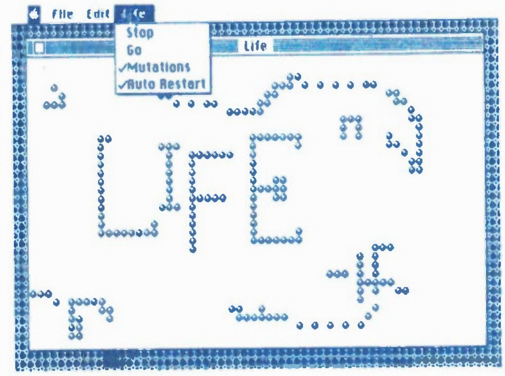
VIEW PAINT Ever wanted to look at a MacPaint drawing without getting into MacPAint. This utility lets you sneak peeks at your drawing files without fussing about.

RESOURCE EDITOR Macintosh icons and other resource items just cry out to be personalized. This little tool will help you make your Mac look its best for you.

SCREEN MAKER Moving text from MacWrite to MacPaint can be a bit disappointing... something gets lost in the clipboard. This utility helps your words make the trip unscathed.

FONT EDITOR For those longing to make their own fonts... and for those who just want to adjust the ones they have... this editor lets you shuffle fat bits to your heart's content.

MENU EDITOR A handy utility for editing the words in Macintosh application menus.



Only $24.95

Volume 2

FONT LIBRARIAN A splendid alternative to the Macintosh system font mover, this utility makes it easy to create custom collections of Macintosh fonts.

WIZARD'S FIRE This is a lively game which comes with still more lively games tucked away in the desk accessories. Get the magic rays before they get you!

SWITCHER Multitasking on a Mac? Why not. SWITCHER lets you run up to four applications concurrently on a 512K 'Fat Mac'.

RAMSTART Creates a RAM disk of any size on a fat MAc, and effectively increases the speed of most applications several times over.

MADONNA A MacPAint picture of the popular pop star.

MOCK CHART A desk accessory to handle the creation and printing of small business charts.

DAM A *D*esk *A*ccessory *M*anager for setting up the Apple menu on your Macintosh the way *you* want it.

MOCK TERMINAL A desk accessory for telecommunication functions from *within* another application.

HP CALC Add a simulated Hewlett-Packard calculator to your Mac.

REdit A slick resource editor. See the December 1985 issue of Computing Now! for an in depth look at this esoteric art form.

ORION This one is worth the price of the disk all by itself. It simulates a star ship cruising around the galaxy at the speed of light. Stars fly past like white lines on the highway ... with or without star names fluttering like celestial flags. The heavens are accurately mapped and the star ship handles like any other warp drive star Chevy.

Only $24.95

Moorshead Publications Software, 1300 Don Mills, North York (Toronto), Ont. M3B 3M8

Volume 3

Icon Collector is a peculiar program that allows you to locate icons in applications and capture them to disk for use in other programs.

Billiard Parlor is worth the cost of this disk all by itself. It's an excellent simulation of a billiard table. It will play most of the usual variations of pool and billiards, and simulates the movement of the balls with unspeakable realism.

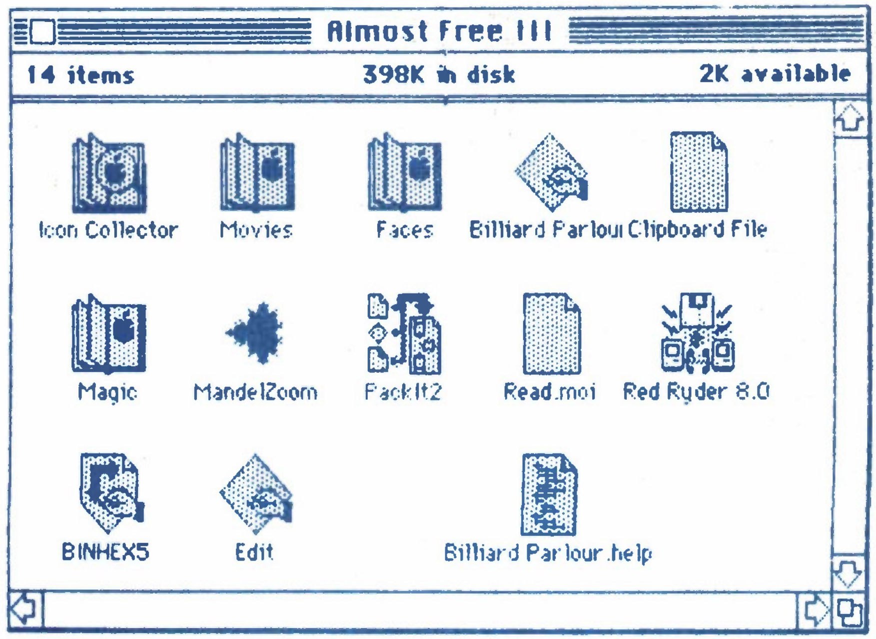
MandelZoom is the nicest Macintosh fractal generator we've come across. It's surprisingly fast, considering the nature of the Mac's floating point library.

Red Ryder This is the latest version of this popular communications program. It runs perfectly, giving you a sophisticated terminal with download facilities, macros and dozens of other features.

PackIt2 - not to be confused with PackIt - will compress and uncompress P2T libraries which have been downloaded from bulletin boards. An essential utility for telecommunications.

BINHEX5 is a file manipulation utility which allows Mac files to be sent over a modem.

Edit is the most sophisticated text editor available for the Mac. Operating similar to MacWrite, it allows you to edit documents in multiple windows. Ideal for program editing, Edit produces clean text files which can be compiled.



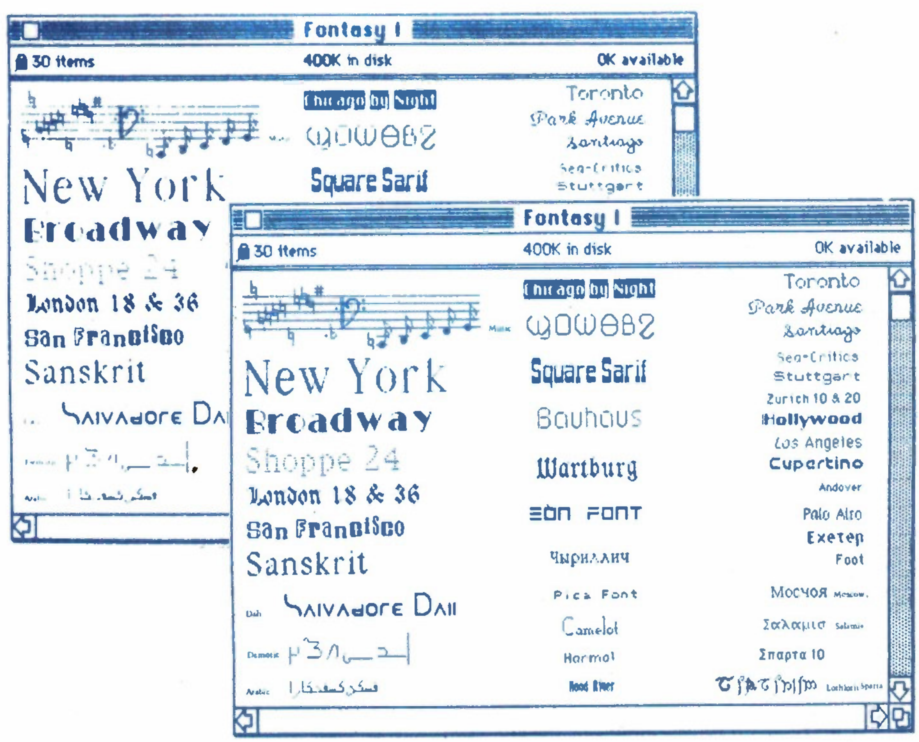
Only $24.95

Volume 4

One of the most interesting aspects of the Macintosh is its ability to use software-based character sets. While there are a number of commercial font packages for the Mac, we feel that this collection of public domain fonts ranks among the best. This disk is filled - to the last byte -with thirty-eight unique fonts. We've selected a variety of body copy and display typefaces, spanning traditional and avant garde designs, along with a number of special purpose sets.

Bid fairwell to the placid exterior of Chicago, the mild amusement of Geneva, the unadventurous disposition of Athens and plug your Mac into this typesetter's pipe dream.

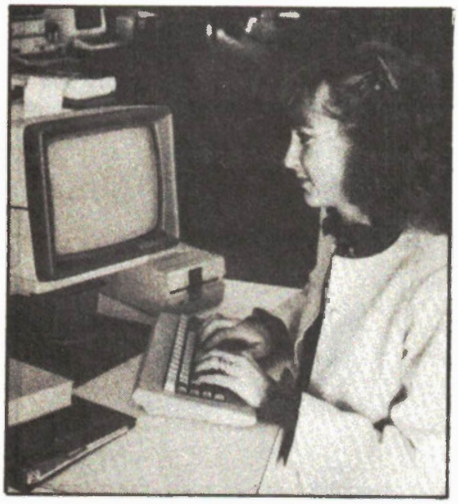
A powerful font librarian is also included to assist in adding the fonts you want to your system.



Only $24.95

Almost Free Software (CP/M)

Volume 1



MODEM 7 Allows you to communicate with any CP/M-based system to download and upload files. Complete details for this program first appeared in the November 1983 issue of Computing Now!

PACMAN You really can play PACMAN without graphics... and it works pretty fast.

FORTH An up-to-date version of FIG FORTH, complete with its own internal DOS.

DUU The ultimate disk utility, DUU lets you recover accidentally erased files, fix corrupted files, and modify the system.

D A sorted directory program that tells you how big your files are and how much space is left on the disk.

USQ/SQ Lets you compress and un-compress files. You can pack about 40 more data on a disk with this system.

FINANCE A fairly sophisticated financial package written in Microsoft BASIC.

BADLIM Ever had to throw out a disk with a single bad sector? BADLIM isolates bad sectors and allocates them to an invisible file, making the rest of the disk useable.

DISK Allows you to COPY, MOVE, DELETE and VIEW files with a simple command structure.

QUEST Similar to "Dungeons and Dragons", QUEST provides hours of glorious adventure.

STOCKS A complete stock management program written in BASIC.

SEE Also known as TYPE17, this utility will TYPE any file, compressed or not, allowing you read documents which are stored in a compressed form.

Only $19.95

Call or write for available formats.

Volume 2

BISHOW is the ultimate file typer. This version will type squeezed or un-squeezed files and allow you to type files which have been archived with utilities such as LU (see below). BISHOW even lets you scroll up and down through typed files.

LU is a library utility which stores multiple files under a single file name in order to save disk space. Files can be removed from the library as they are needed.

MORTGAGE is a fancy mortgage amortization program which produces a variety of useful tables.

NBASIC Large, commercial BASIC's are powerful, but expensive. This one however is free, and every bit as flexible as many commercial packages. It's also compatible with North Star BASIC.

Z80ASM is a complete assembler package which uses true Zilog Z80 mnemonics. It has a rich vocabulary of pseudo-ops, permitting you to use features of your Z80-based machine which are unavailable with ASM or MAC.

VFILE Easily the ultimate disk utility, VFILE gives you a full screen view of the files on your disk and allows you to do mass COPY and DELETE operations using a two-dimensional cursor. It has lots of 'extras', a built-in help file and it's fast.

ROMAN Though some say it's silly, this novel little program is a fun way to convert ROMAN numerals into decimal numbers.

CATCHUM If you like the fast pace and incredible realism of Pacman, you'll go quietly insane over CATCHUM... which plays basically the same game using ASCII characters. Watch little "C"'s gobble periods, while you try to avoid the delay "A"'s.

DEBUG The DDT debugger is good, but this utility adds many new facilities, including symbolic debugging. It's almost like being able to step, trace and disassemble through a source listing.

DU87 This version overcomes several limitations of the older DUU program and adds some new features. It will adapt to any system and can search, map and dump disk sectors or files. Its invaluable in recovering damaged files too.

ELIZA Written in MBASIC, this classic program is a microcomputer analyst. With a little imagination you will be able to believe you are conversing with a real psychiatrist.

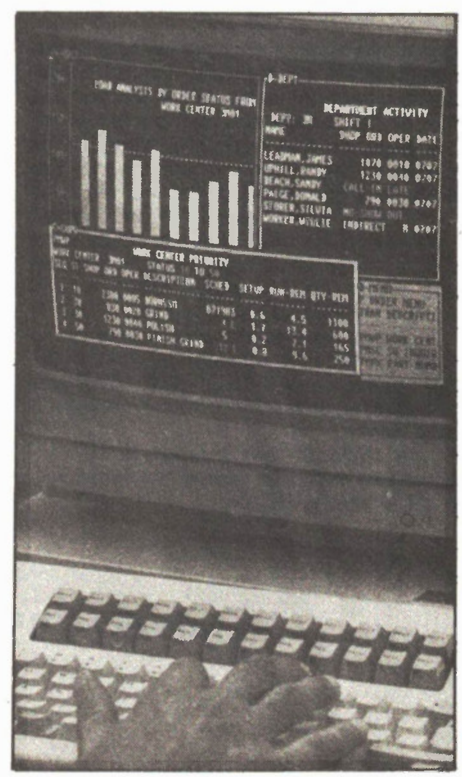
LADDER Fast, bizarre and probably a major cause of eye strain. This program plays like Donkey Kong with ASCII characters.

QUIKKEY Programmable function keys let you hit one key to issue a multi-character command. This tiny utility lets you define as many "macros" as you want, with seldom used control codes. Keys can be redefined at any time... even from within another program.

RESOURCE While a debugger will enable you to disassemble small bits of code easily enough, only a true text based disassembler can take a .COM file and make source out of it again. This is one of the best ones available.

Only $19.95

Call or write for available formats.



Only $19.95 each or $39.95 for all 3!

Call or write for available formats.

Volume 3

OIL An interesting simulation of the working of the oil industry. It can be approached either as a game or as a fairly sophisticated model.

CHESS This program really does play a mean game of chess. It has an on-screen display of the board, a choice of colours and selectable levels of play.

A Teacher for the Apple

Specifically developed for the educational market, this disk introduces both teachers and students to the Apple II series and compatible systems.

It is designed to show you how to make the computer work for *you*.

After introducing you to the computer, it goes on to explain the BASIC programming language. With step-by-step instructions it shows you the ins-and-outs of Apple programming and explains the workings of DOS and high resolution graphics.

Designed for new computer users, just turn on the computer, slide in disk, and enter the world of Apple programming.

Requires Applesoft BASIC, 48K RAM and one disk drive.

Only $19.95

Almost Free Electronics Design.

Contains BASIC utilities for attenuators, highpass and lowpass filters, series and parallel resistors, slew rate prediction, resonant circuits, power transformer selection, audio transformer selection, RMS-average-peak conversions for full and half-wave, transistor selection, and more. Also contains a program for determining the parameters of strobe light circuits; it determines power ratings, time constants, capacitor size, resistor sizes, operating voltages, dissipation and other necessary calculations. Written by Bill Markwick, the editor of Electronics Today, the utilities are not copy-protected and are easily modified to suit the user's requirements.

Available for MS/PC DOS with GWBASIC or Apple II systems with Applesoft BASIC.

Only $19.95

Steve's Wunderdisk

Over the years many first rate program listings have graced the pages of Computing Now!. And we have many which have never been published. We've collected the best of these and put them on one disk. Included are programs like STAR, for setting up a Gemini 10 printer, the Last WordStar Unhook, CPMAP and the CP/M HOST program, complete with several unreleased support programs.

The Wunderdisk is an excellent collection of tricky CP/M routines. It's deal for anyone who wants to make their CP/M system sing! And the programs on the disk are well documented... most of them have been explored and explained in the pages of Computing Now!

Only $19.95

MDM730 for Apple CP/M

First featured in the July 1984 issue of Computing Now!, MDM730 is one of the most powerful MODEM7 programs available. Our version incorporates features not available in the public domain. MDM730 is an efficient, easy-to-use software tool for anyone interested in telecommunications, bulletin boards and downloading software. Consider these features:

- Terminal program which works at any baud rate.
- Ten programmable macro function keys.
- A Phone number library for 36 numbers.
- Christensen software transfer protocol.
- User selectable toggles for linefeeds, ON-XOFF, etc.
- Extensive help menus.
- Baud rate selection on the fly.
- ASCII dump and capture.
- Status menu.

In addition, we've added dialing support for the Apple version. While the standard MDM730 can not dial unless it's hooked to a Hayes Smartmodem, we've added patches to allow it to do pin twenty-five pulse dialing and to dial through the Hayes Micromodem II and the SSM card. The Computing Now MDM730 will also:

- Select a number form the library and dial it.
- Dial manually entered numbers.
- Log you on to a remote system if it's free.
- Optionally autodial if the remote system is busy.
- Keep track of the number of re-dial attempts.

The Computing Now! MDM730 package is available for:

- The Hayes Micromodem II card.
- The SSM 300 Baud modem card.
- The PDA 232C serial card with external modem.

The PDA 232C package includes versions supporting both the Smartmodem and a dumb modem with pin twenty-five control, such as the Novation AutoCat.

Each package also includes utilities for updating the phone number library and redefining the function key macro strings, as well as an extensive help file.

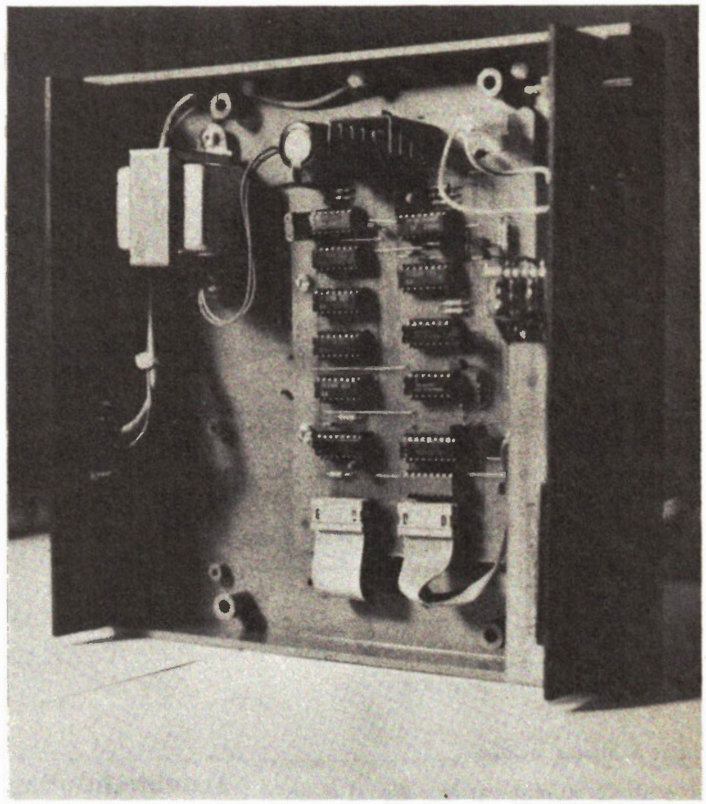
The source code for this program is over one hundred and fifty kilobytes long and can not be hacked on a standard Apple system. We patched it on a larger machine and downloaded it. We're confident you won't find MDM730 with these features anywhere else.

Only $19.95

Available for Apple II series and compatibles with CP/M

Problem	Area of Problem	Possible Cause of the Problem
all four digits extinguished	display driver circuitry	- DISP1-DISP4 properly oriented - ribbon cable connected properly - DIP resistor in place - IC11 properly inserted - Q6,Q7,Q8 properly inserted
leftmost digit always extinguished	first-digit blanking circuitry	- Q3,Q4,Q5 correctly in place - R8-R11 proper values - proper insertion of IC9,IC10
decimal point not on	decimal point switching circuitry	- proper connection of ribbon cable - wiring of switch 1, pole 'e' - R19 (DIP resistor) okay
display on, but unit won't count on any range	input circuit or clock circuit or reset circuit	- input BNC connector - input circuitry (Q1,Q2) - wiring of switch 1 poles 'a', 'b' and 'd' - R3,C3,R4,C4 proper values - IC6 inserted correctly - operaton of the clock and clock divider circuitry (IC1-IC5) - proper insertion of IC9-IC11
operational on all but the lower three ranges	input frequency multiplier	- switch 1, pole 'c' - all parts associated with IC7 and IC8
operational on all but the 10 MHz range	input frequency divider	- switch 1, pole 'a' - proper wiring of IC5b

Table 2. Troubleshooting guide.



peak signal to the input for each of the six ranges; in each case the display should read out the correct frequency. For frequencies above approximately 200 KHz, a TTL equivalent signal should be applied to J17, bypassing the input circuit since it only responds to signals below this frequency. With a signal applied to J17, the frequency counter should read signals up to 9.999 MHz. Also check that the leftmost digit is extinguished when it is zero, and that the decimal point moves according to the rotary switch position. If all ranges work properly, continue construction by mounting all parts inside the cabinet.

The front and back panels which come with the cabinet are over three inches high and should both be cut down to the two inch mark and appropriate holes drilled. The display board and bezel can be mounted to the front panel followed by the rotary switch, BNC connector and the power switch. The back panel only has the power connection. The main board is mounted inside the cabinet with the input molex connector adjacent to the BNC connector. Mount the transformer and wire the power switch followed by the BNC and power connectors. Finally, plug the two 16 pin headers into the appropriate sockets.

The frequency counter is now complete and should be tested again. If input signals greater than 200 KHz are frequently going to be measured, the input circuit should be redesigned to respond to signals up to 10 MHz. Alternatively, a switch could be used to take the input circuit out of the signal path in which case the input signal would have to be TTL compatible.

Use

The frequency counter is very easy to use. An appropriate signal is applied to the input BNC connector, and the corresponding frequency is read off the display. If the recommended input circuit is used, the input signal should be less than 200 KHz with an amplitude greater than two volts peak to peak. When taking a reading, the highest range should be selected first and lower ranges selected until the left display is lit; this avoids misreading the counter when there is an overflow. The lower three ranges of the counter may take a few

Figure 2. The display board.

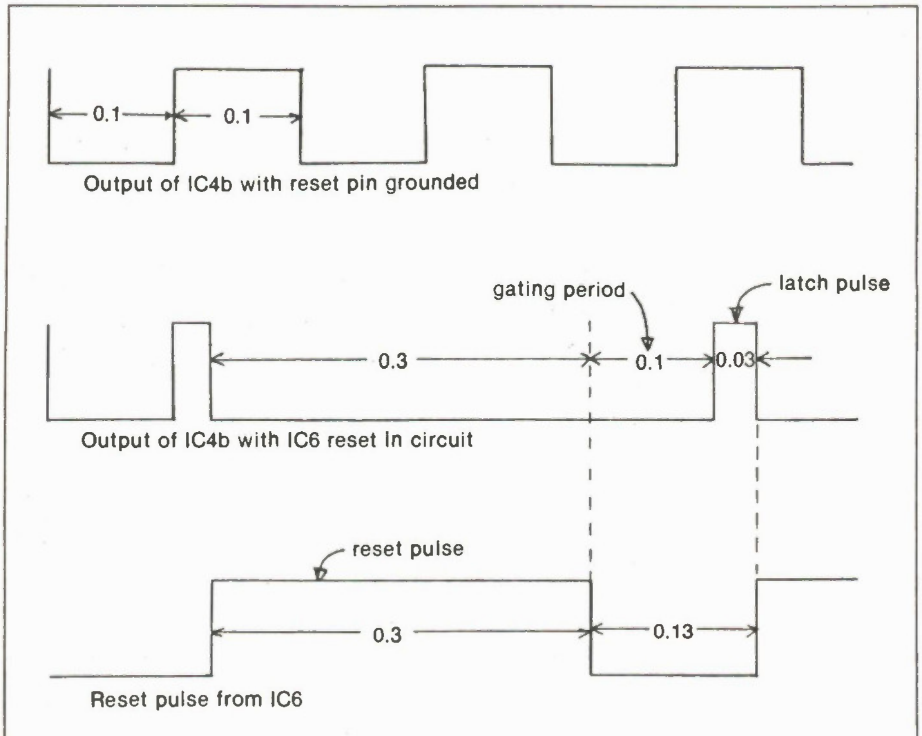


Figure 3. Timing diagrams.

seconds to stabilize after a signal is applied while the phase-locked loop locks onto the input signal. On all but the 100 Hz range, the display is updated about once every 300 ms; the 100 Hz range, having a gating time of one second, is updated once every 1.3 s or so.

Troubleshooting

If the frequency counter does not function properly, first check the power supply for +5V. Both circuit boards should be inspected for solder bridges and all IC leads should be checked for proper insertion. If the problem(s) still persist, use table 2 as a guide in troubleshooting the unit.

This project was originally published in our March 1984 issue.

PARTS LIST

Resistors (all ¼W 5% unless otherwise specified)

R1,2	270R
R3,8,9,20	4k7
R4	390k
R5	18k
R6	47k
R7	10k
R10	1k
R11	10R
R12-19	33R DIP resistor (Bourns 4116R-001-330 or equiv.) *
R21	4M7

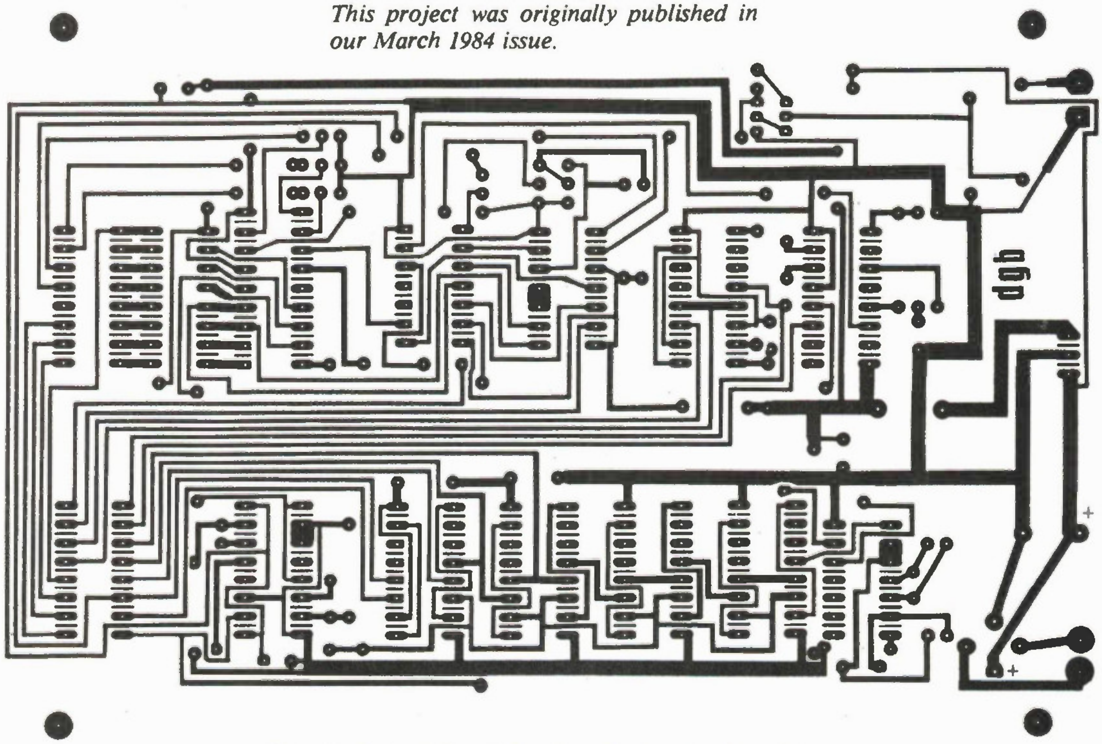
XTAL1 5,000 MHz crystal — Displays IEE 2678R or FND500 XFRMR1 10 to 12 V 500 mA — Bezel IEE 24036R — Cabinet Hammond 9H CH BU. The bezel, displays, and 16 pin connectors are available from the source listed in the parts list.

Capacitors

C1	2200*u* 25 V electrolytic
C2	10n ceramic
C3,8,9,10,11	100n ceramic
C4	1*u* tantalum
C5	4*u*7 tantalum
C6	50p silver mica
C7	2*u*2 tantalum

Semiconductors

Q1-Q8	2N3904 or equiv.
D1	1N4148 or equiv.
BR1	1.5A, 200 V bridge rectifier with heatsink (W02M or equiv.)
REG1	5V, 1A regulator with heatsink (LM7805)
IC1,10	74LS04
IC2,3,4,5,8	74LS390
IC6	74LS221
IC7	MC14046B
IC9	74LS132
IC11	74C926 (National)



The printed circuit layouts for the main board and display.

HOW IT WORKS

The frequency counter can best be understood if it is broken down into five separate sections: the power supply, the input circuit, the frequency multiplier, the clock generator and divider, and the counter/display driver.

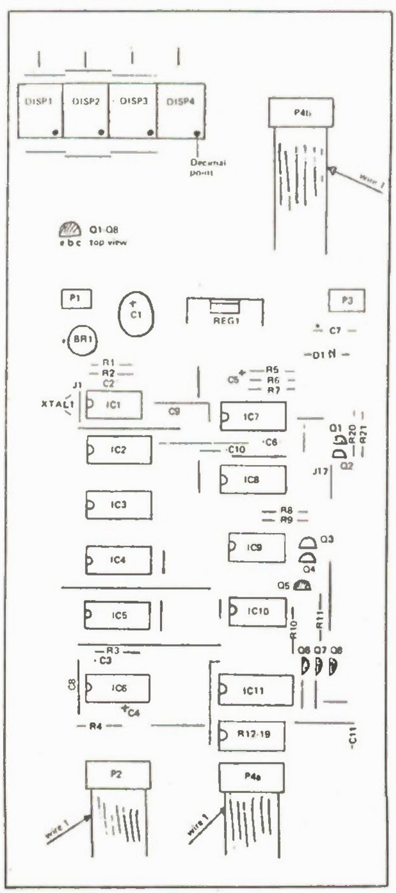
Power Supply
The secondary voltage from the transformer is full wave rectified by BR1 and filtered by C1; it is then fed to the regulator where it is regulated down to 5 VDC. The output of the regulator is used to drive all of the ICs and the unregulated 12 VDC (or so) is used in the input circuitry. C9 improves the stability of the regulator.

Input Circuit
Input signals are fed to the main board via the BNC connector on the front panel. C7 removes any DC component from the input signal, and D1 clips off the negative half of the signal. Q1 and Q2 amplify the input to a square wave which is fed to the input of IC9a; the output is connected to both a decade divider (IC5b) and switch 1 pole 'a'. While on the 10 MHz range the divided signal from pin 3 of IC5 is used; on all other ranges the direct output from IC9a is used. The output from S1a feeds both switch 1 pole 'b' and the frequency multiplier.

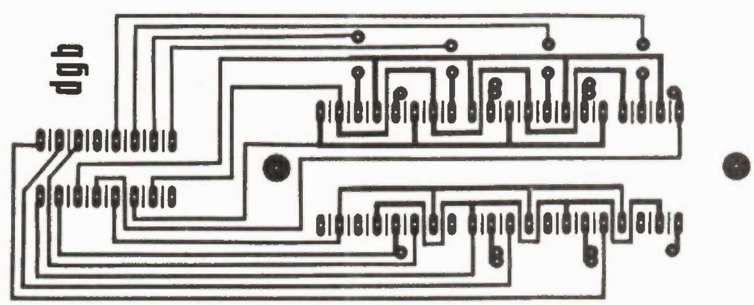
Frequency Multiplier
An MC14046B phase-locked loop (PLL) is configured to multiply the input frequency by 10 on the 10 KHz range and by 100 on the 100 Hz and the 1 KHz range. The signal from S1a is buffered and inverted by IC10a and is fed to the input of the PLL (pin 14). This input signal is compared to the output of the decade dividers IC8a and b, and a comparison signal is generated at pin 13; this signal is filtered by C5, R6, and R7 and drives the voltage controlled oscillator input (pin 9). The VCO output at pin 4 is buffered and inverted by IC1d and drives both the decade dividers and the input of IC9b. The VCO adjusts its frequency until the input signal and the comparison signal from the decade dividers are equal. At this point the PLL is locked, and the output frequency is either 10 or 100 times the frequency at pin 14, depending on the position of the rotary switch.

Clock Generator and Divider
IC1a, b, c, and the crystal are configured to oscillate at a frequency of 5 MHz. The 74LS390 decade dividers reduce this frequency to produce the required gating times of 0.01s, 0.1s, and 1.0s. Switch 1 pole 'd' selects which of the gating times will be used; the following explanation assumes a gating time of 0.1s. At the end of the 0.1s, the output of IC4b will swing from low to high, triggering one half of IC6 (a dual one-shot timer). This one-shot generates a 'high' pulse approximately 300us wide (determined by the time constant of R3 and C3) at pin 13. This pulse transfers the output of the counter into a latch and triggers the second one-shot. A 300ms pulse is produced at pin 5, resetting both the decade dividers and the counter, but not the contents of the latch. With the decade dividers reset, another gating pulse is generated and the contents of the latch are updated. The gating pulses from S1d are inverted and 'anded' with the conditioned input signal to produce the 'count' signal. A timing diagram showing the clock signals is given in figure 4.

Counter/Display Driver
The 74C926 is a complete counter, latch, and display driver. The count, latch, and reset signals are connected to IC11 and the appropriate display signals are generated. R12–R18 limit the current to the displays and Q6, Q7, and Q8 drive the common cathode of DISP4, DISP3, and DISP2 respectively. DISP1 is blanked when it is zero, and therefore requires some extra circuitry. Note that DISP1 is zero when segment 'f' is on and segment 'g' is off. Q3, Q4, IC10d and e, and IC9c and d decode this condition and blank the display. Switch 1 pole 'e' selects the proper decimal point to light.



Parts overlay for the frequency counter.



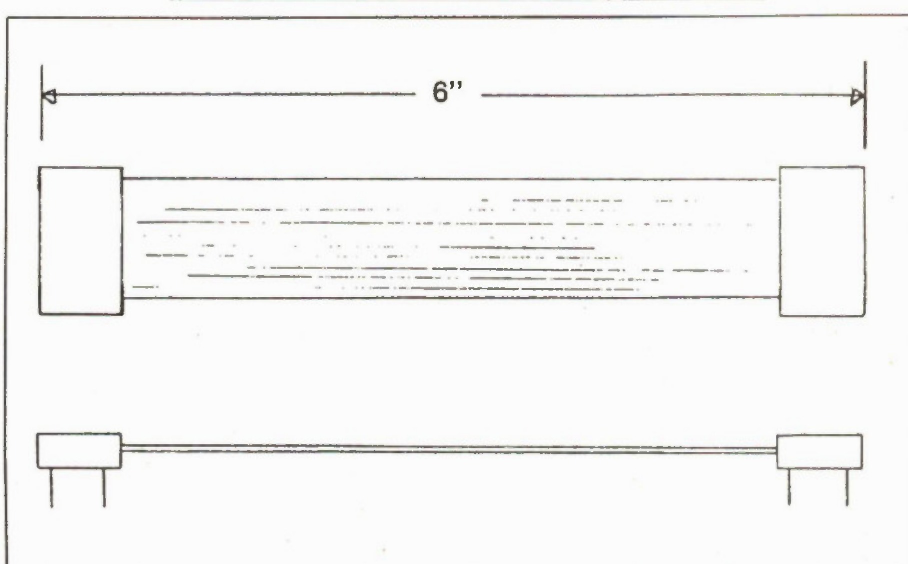
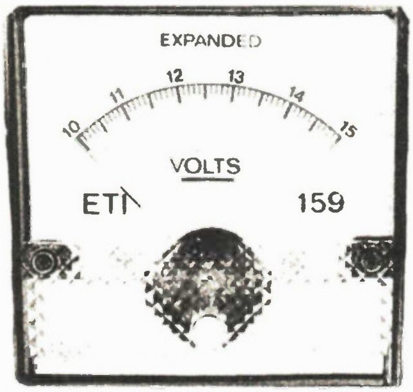


Figure 4. Header cable diagram.

Expanded Scale Voltmeter Covering The 10-15 V Range

A simple, low-cost instrument that can be built into power supplies or used as a portable or fixed 'battery condition' monitoring meter.



COMMON STORAGE batteries to power nominal 12 V DC electrical systems have a terminal voltage that ranges from a little over 10 volts when discharged to around 15 volts when fully charged, the operating voltage being somewhere in the range 11.5 V to 13.8 V. Lead-acid batteries, for example, may have a terminal voltage under rated discharge that commences at around 14.2 V and drops to about 11.8 V. A 12 V (nominal) nickel-cadmium battery may typically have a terminal voltage under rated discharge that starts at 13 volts, dropping to 11 volts when discharged.

Equipment designed to operate from a nominal 12 V DC supply may only deliver its specified performance at a supply voltage of 13.8 V — mobile CB and amateur transceivers being a case in point. Other DC operated equipment may perform properly at 12.5 V but 'complain' when the supply reaches 14.5 V.

To monitor the state of charge/discharge of a battery, a battery-operated system or the output of power supplies, chargers, etc., a voltmeter which can be easily read to 100 mV over the range of interest, i.e., 10 to 15 volts, is an invaluable asset. This project does just that.

This instrument, being of the true analogue type, is intended for exacting measurement and is better characterized as a test instrument.

The Circuit

An LM723 variable voltage regulator IC is employed to set an accurate 'offset' voltage of 5 V, and the meter (M1) plus the trimpot RV2 and R3 make up a 5 V meter, with the trimpot allowing calibration. The negative terminal of the meter is connected to the output of the 723 so that it is always held at 5 V 'above' the circuit negative line. The positive end of the meter goes to a zener which will not conduct until more than 5 V appears between the circuit +ve and -ve lines. Thus the meter will not have forward current flowing through it until the voltage between the circuit +ve and -ve rails is greater than 10 V, and will read full scale when it reaches 15 V (after RV2 is set correctly).

The meter scale limits may be adjusted by setting the output of the 723 higher or lower (adjusted by RV1) and setting RV2 so that the meter has an increased or decreased full-scale deflection range.

A variety of meter makes and sizes may be used.

Construction

Mechanical construction of this project has been arranged so that the pc board can be accommodated on the rear of any of the commonly available moving coil meter movements. We chose a meter with a 55 mm wide scale (overall panel width, 82 mm). A meter movement with a large scale is an advantage as it is considerably easier, and more accurate, to read than meters with a smaller scale. It also pays to buy a 2% fsd accuracy meter for best accuracy.

Having chosen your meter, drill out the pc board to suit the meter terminal spacing first. The components may then be assembled to the board in any particular order that suites you. Watch the orientation of the 723, ZD1, the FET and particularly D1. The latter is an 'idiot diode'. That is, if you have a lapse of concentration or forethought and connect your project backwards across a battery, the fuse will blow and not the project. Fuses are generally found to be cheaper than this project!

Seat all the components right down on the pc board as the board may be positioned on the rear of the meter with the

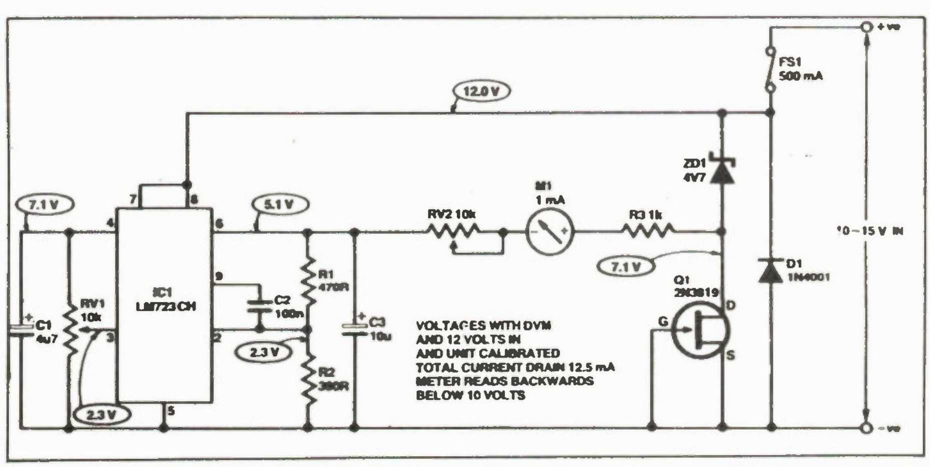
HOW IT WORKS

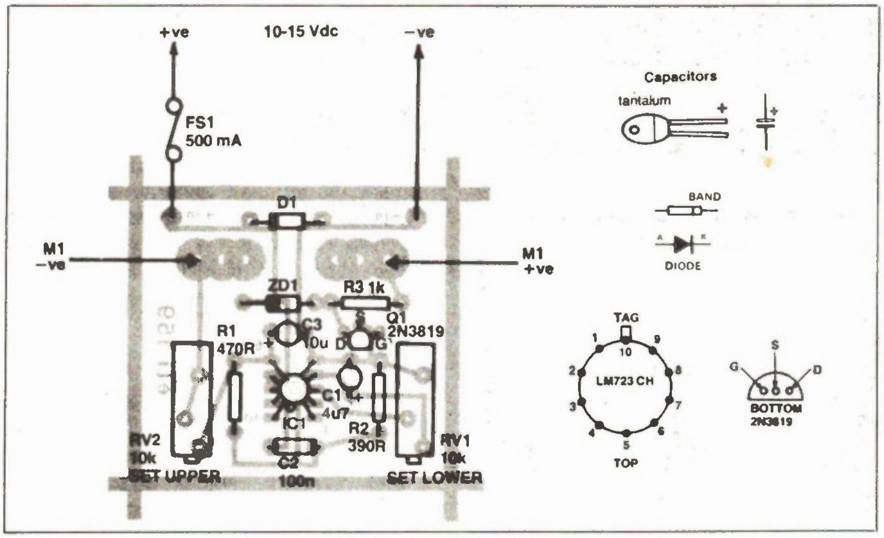
The meter, M1, is a 1 mA meter with series resistance — made up of R3 and RV2 — so that it becomes a 0-5 V voltmeter. The negative end of the meter is maintained at 5 V above the circuit negative line by the output of IC1, a 723 adjustable regulator. The positive end of the meter is connected to the circuit positive line via ZD1, a 4V7 zener diode. Thus, no 'forward' current will flow in the meter until the voltage between the circuit negative line and the circuit positive line is greater than 5 + 4.7 = 9.7 volts.

Bias current for the zener is provided by a FET, Q1, connected as a constant current source so that the zener current is accurately maintained over the range of circuit input voltage. This ensures the zener voltage remains essentially constant so that meter reading accuracy is maintained.

The trimpot RV1 sets the output voltage of the 723. This determines the lower scale voltage. Trimpot RV2 sets the meter scale range. More resistance increases the scale range, less resistance decreases it.

Diode D1 protects the circuit against damage from reverse connection.





components facing the meter The size of C2 may give you a little trouble. We used a 'Monobloc' type capacitor — as commonly used on computer pc boards as bypasses. Alternatively, a 100n tantalum capacitor (+ve to pin 2 of IC1) may be used. The actual value or type of capacitor is not all that critical.

We have used multiturn trimpots for RV1 and RV2 as they make the setting up a whole lot easier.

PARTS LIST

Resistors (All ½W 1% or 2% metal film)

R1	470R
R2	390R
R3	1k
RV1,RV2	10k cermet multiturn horizontal trimpot

Capacitors

C1	4u7/10 V tant.
C2	100n ceramic
C3	10u/10 V tant.

Semiconductors

IC1	LM723CH
ZD1	4V7, 400 mW or 1W zener
Q1	2N3819
D1	1N4002 or similar

Miscellaneous

M1	1 mA meter (see text)
FS1	500 mA fuse and in-line fuse holder

pc board; meterscale to suit meter.

Battery Condition and Terminal Voltage

The 12 V battery, in its many forms, is a pretty well universal source of mobile or portable electric power. There are lead-acid wet cell types, lead-acid gel electrolyte (sealed) types, sealed and vented nickel cadmium types, and so on. They are to be found in cars, trucks, tractors, portable lighting plants, receivers, transceivers, aircraft, electric fences and microwave relay stations — to name but a few areas.

No matter what the application, the occasion arises when you need to reliably determine the battery's condition — its state of charge, or discharge. With wet cell lead-acid types, the specific gravity of the electrolyte is one reliable indicator. However, it gets a bit confusing as the recommended electrolyte can have a different SG depending on the intended use. For example, a low duty lead-acid battery intended for lighting applications may have a recommended electrolyte SG of 1.210, while a heavy-duty truck or tractor battery may have a recommended electrolyte SG of 1.275. Car batteries generally have a recommended SG of 1.260. That's all very well for common wet cell batteries, but measuring the electrolyte SG of sealed lead-acid or nickel-cadmium batteries is out of the question.

With NiCads, the electrolyte doesn't change during charge or discharge.

Fortunately, the terminal voltage is a good indicator of the state of charge or discharge. In general, the terminal voltage of a battery will be at a defined minimum when discharged (generally between 10 and 11 volts), and rise to a defined maximum when fully charged (generally around 15 volts). Under load, the terminal voltage will vary between these limits, depending on the battery's condition.

Hence a voltmeter having a scale 'spread' to read between these two extremes is a very good and useful indicator of battery condition. It's a lot less messy and more convenient than wielding a hydrometer to measure specific gravity of the electrolyte!

The charge and discharge characteristics of typical lead-acid and sealed NiCad batteries are given in the accompanying figures.

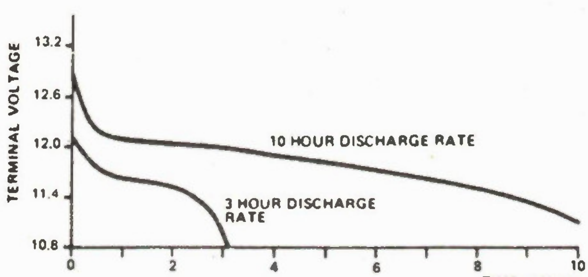


Fig 1. Typical discharge characteristics of a 12 V (nominal lead-acid battery.

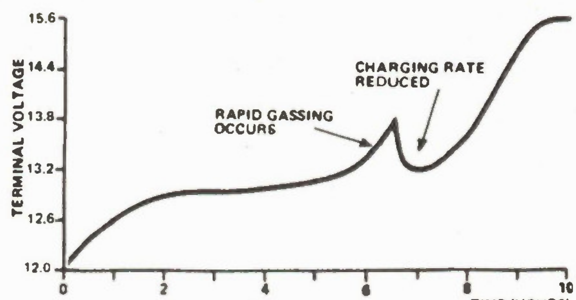


Fig. 2. Charging characteristics of a 12 V (nom.) lead-acid battery. The 'kind' in the curve near 6 hrs is explained in the text.

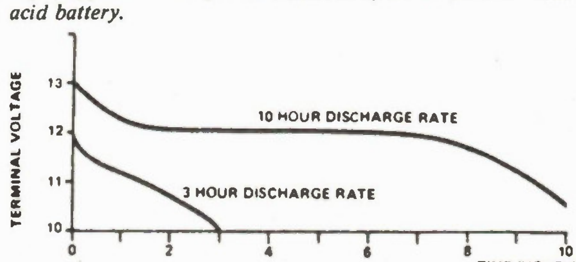


Fig. 3. Typical discharge characteristics of a 12 V (nom.) nickel-cadmium battery (usually consisting of 10 cells in series).

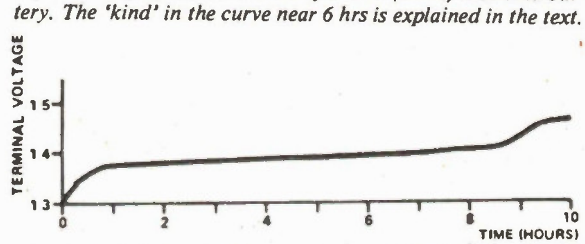


Fig. 4. Typical charging characteristics of a 12 V NiCad battery (10 cells) charged with a constant current at one-tenth rated capacity (0.1C).

Continued on page 80

60W NDFL Amp

Here is a practical amplifier design, presented as a module, with very low distortion.

Design by Edward M. Cherry.

THIS AMPLIFIER will perhaps be of most interest to home constructors who want to rebuild an existing system and upgrade its performance without the expense of new major components. The power output transistors employed are the well-known types MJ802 and MJ4502 which have been around for several years and have proved their reliability. Indeed, the whole design is mature and home constructors should have no difficulty in making it work.

Grounding

In any amplifier where the basic distortion has been reduced to a few parts per million, several distortion mechanisms not ordinarily considered may become significant. One such mechanism is associated with currents circulating in the ground leads and power-supply wiring.

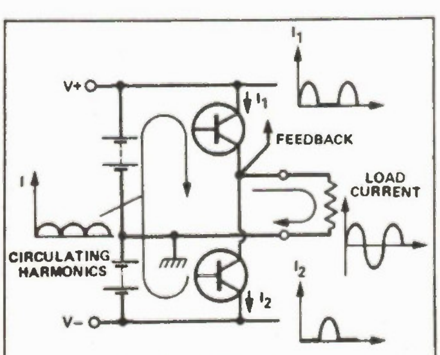


Figure 1 Circulating even-harmonic current in a Class-B output stage.

Figure 1 explains the origin of this distortion. The current in each power transistor of a class B stage is a half-wave rectified version of the output. The two currents, drawn alternatively from the positive and negative supplies, are equivalent to a circulating full-wave rectified current and this is basically an even-harmonic distortion of the signal output. If there is any mutual inductance between the power-supply wiring (including the grounds) and the signal wiring (also including the grounds), then an even-harmonic distortion is induced in the amplifier and feedback is powerless to correct it.

The circuit board has been laid out so as to minimise this effect. The areas enclosed by some tracks are critical, and home constructors making their own PCBs are cautioned to follow the layout exactly, using the accompanying foil pattern.

Note that the circuit uses three distinct ground symbols.

a)  is the *quiet ground* track on the circuit board (one per channel).

b)  is the *noisy ground* track on the circuit board (one per channel).

c)  is the metal chassis ground (there are six connections to the chassis in total).

Each channel is connected to chassis ground at two points. The input socket is connected to the chassis (rather than insulated from it), the input lead from socket to circuit board is shielded, and the quiet ground track is connected to chassis ground at the input socket via the screen. Similarly, the ground output terminal is screwed into the chassis, the leads from the circuit board to the output terminals are a twisted pair and the noisy ground track is connected to chassis ground at the output terminals via the ground output lead. The remaining two connections to chassis are in the power supply (Fig. 5).

Note that a 10 ohm resistor, R31, links the quiet and noisy ground tracks. This resistor is short circuited at low frequencies by the input shielding and neutral output wiring to chassis ground. However, the resistor takes over at high frequencies where wiring inductance become significant.

The 15uH filter inductors in the supply rails are also for suppressing circulating currents (R6 and R7 represent the winding resistances of L1 and L2).

This amplifier employs only two nested differentiating feedback loops and its distortion is not down to the ultimate limit. The benefit of including the filter inductors is therefore marginal. The author is not blessed with 'golden ears' and cannot hear the effect of removing the filters, although the difference is clearly measurable. The filters should certainly be included in amplifiers that use three or more NDFLs. As the inductors must be home-made, and therefore cost nothing but time, and as they do make a measurable (if small) improvement, most home constructors will probably wish to include them. Winding data is given in Table 1.

The precise values of inductance and resistance are not important — ±50% is good enough — but do not use the 1.25 mm wire from L3 as something like 0.1 ohm series resistance is essential. For a similar reason, do not parallel the 470uF bypass capacitors C9 and C10 with high-frequency types. Brass or steel mounting screws are perfectly satisfactory for the filter inductors, as linearity is not important.

Critical Components

The majority of the components in this amplifier are not critical. Almost any small-signal diodes will do, such as the 1N914 and 1N4148. Q1 and Q2 should be high-gain, low-noise types — BC109 and BC549 are among the cheapest available. The others could be almost any small signal types: BC107 and BC547 are readily available NPN types, the BC177 and BC557 are suitable PNPs. The driver and output transistors should be the types shown: TIP29C and TIP30C for the drivers, MJ802 and MJ4502 for the power transistors. The biasing transistor, Q11, could be any NPN in a TO-126 pack that can be mounted on the heatsink: the TIP29C is a readily available type that would suit.

Unless the contrary is indicated on the Parts List, resistors can be standard ½ W types and the capacitors can be the lowest available working voltage. A few components, however, do require special mention. A feedback amplifier cannot be more linear than its feedback network, so the various components that constitute the feedback network should have small voltage coefficients.

Specifically:

a) The overall feedback resisitors R11 and R12 should be high-stability types, such as metal oxide or metal film;

b) C4,C6 and C8 should be NPO ceramics, not high-K types (NPO means negative-positive zero, a low-K capacitor with a very low temperature coefficient; metallised plate ceramics, for example. Silvered mica capacitors are also suitable);

c) C5 and C14 should be polycarbonate, polystyrene or polypropylene types, but not polyester (eg. mylar types);

d) C3 should be an ordinary cheap aluminum electrolytic, definitely not one of the relatively expensive resin-dipped tantalum types (this is not a misprint!)

The 6u8 H inductor (L3) needs to be home-made. Winding data is given in Table 1. The bobbin should be mounted on the circuit board with a nylon screw; brass or steel must not be used, because of non-linear eddy current losses.

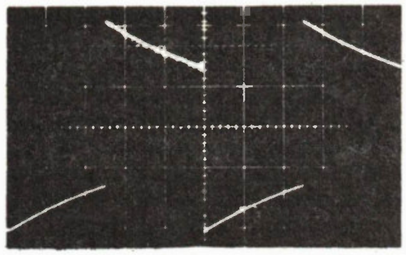


Figure 3a Square wave response of the amp without group-delay compensation.

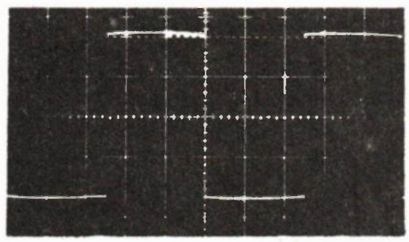


Figure 3b Square wave response of the amp with group-delay compensation — note the improvement over Fig. 3a.

Construction

Assembly of the PCB is quite straightforward. It is probably best to commence by soldering all the resistors in place. Note that R32 could be either a 2 W type (not common) or two 1 W resistors (15R and 18R) in parallel. Note that the emitter ballast resistors of Q16 and Q17 (R29 and R30) should have very low inductance and if you have trouble with high frequency instability, these resistors are likely to be the culprit. The best solution may be several carbon resistors in parallel. Mount R29 and R30 a few millimeters above the board.

Assemble the diodes next, making sure you get them all the right way round. Install the links next. Follow with the capacitors. Note that C5 and C14 must be polycarbonate types and C4,6 and 8 must be NPO ceramics. None of the other ceramic capacitors should be hi-K types, as mentioned earlier. When mounting C9 and C11, see that there is three or four millimetres between the capacitor body and the adjacent 5 W resistors (R29 and R30)

The transistors may be mounted now. See that each is oriented correctly. Wind L3 next and mount it on the board. Details are given in Table 1. It is not necessary to strictly follow the former dimensions given, but the inductance needs to be close to 6u8 H and wound from 1.25 mm wire at least, for low resistance.

Assembly of the components mounted to the heatsink comes next. The heatsinks in the original were a standard type sold by many companies. Each heatsink has a thermal resistance to ambient of about 1 °C/W, and other types could, of

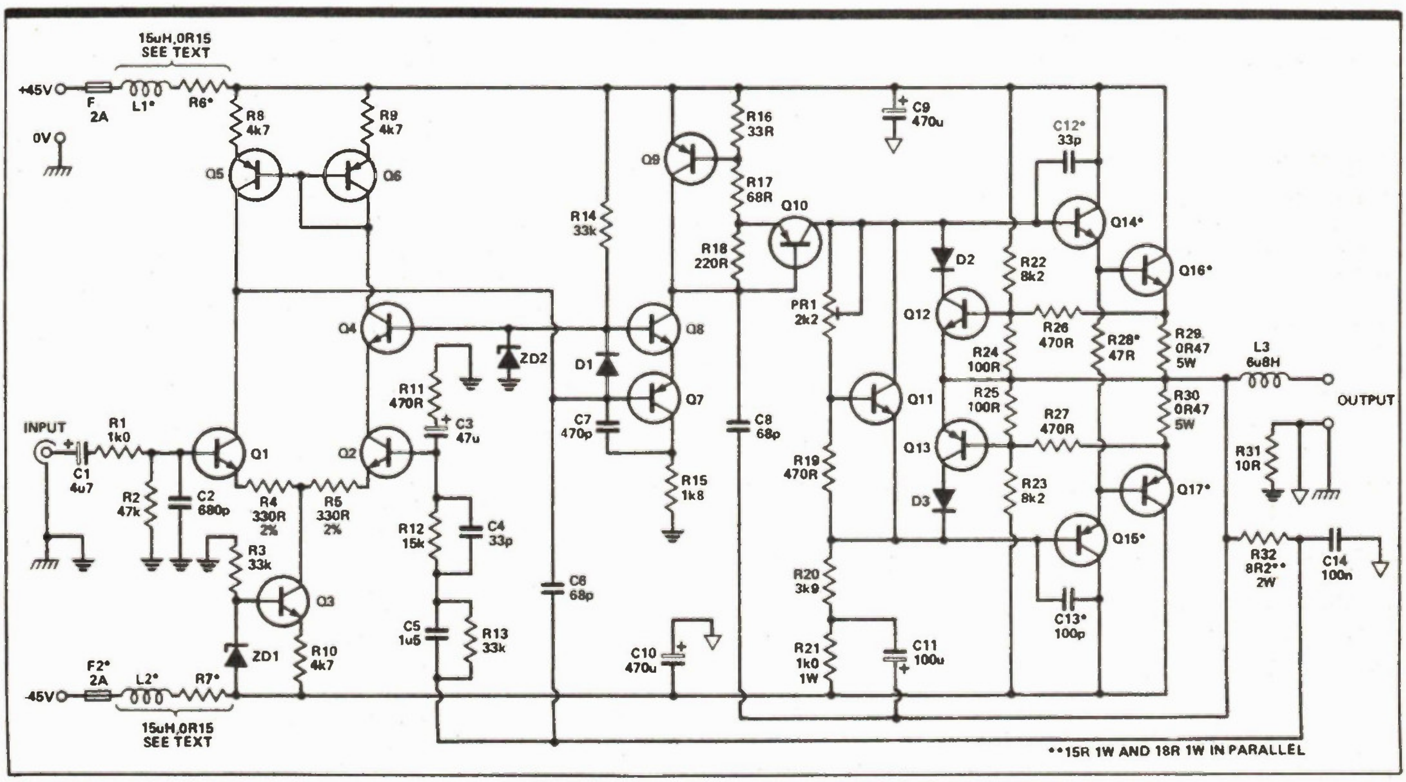


Figure 2 Circuit diagram of the 60W power amp. Components marked with a single asterisk are not mounted on the PCB.

course, be substituted. The specified thermal resistance permits continuous operation at full power: smaller heatsinks (up to 2°C/W) could be substituted if the amplifier is to be used only for domestic sound reproduction. Use one heatsink per channel.

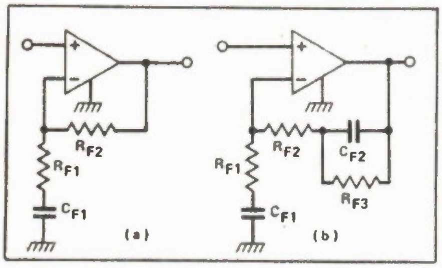


Figure 4 Circuit for compensating low frequency group delay: (a) basic uncompensated circuit; (b) compensated circuit.

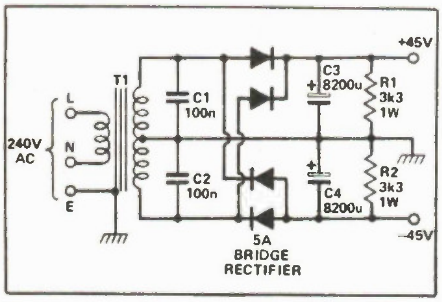


Figure 5 Suggested PSU for the amplifier.

TABLE 1

Formers
If a suitable type is not at hand, these may be turned from 25 mm diameter polystyrene rod to give 12 mm internal bobbin diameter with 7.5 mm winding space between cheeks.

Wire & Winding L1,2
Take two 1680 mm lengths of 0.75 mm diameter enamelled copper wire and wind onto each former leaving 20 mm or so lead length at start and finish.

Wire & winding L3
Take a 1190 mm length of 1.25 mm diameter enamelled copper wire and wind it onto the former. Leave 20 mm or so lead length at start and finish.

Three small components are mounted on the heatsink adjacent to the transistors to keep certain leads short: R28, C12 and C13. Construction is very much simplified if a 4-way terminal strip is installed under one of the collector mounting bolts of Q16 and a 5-way strip under one of Q17's mounting bolts. Figure 8 shows details.

The collector and emitter leads from each power transistor to the circuit board should be twisted. The base leads to Q14 and Q15 could be twisted in with the corresponding collector and emitter leads (although this is not necessary) and the base lead of Q11 can be kept separate. Note that all transistors must be insulated from the heatsink. Note also that the TIP30C specified for Q10 needs its leads dressed to fit the board.

Quiescent current in the power transistors should be set to 40-60 mA by PR1. *Be warned* that this quiescent current is almost zero until PR1 is about three-quarters of its maximum resistance, after which the current increases very rapidly; be sure that PR1 is set to *minimum resistance* when the amplifier is turned on for the first time.

A convenient way to check the quiescent current is by means of the voltage drop across R29 and R30; this should be 40-60 mV (total) for zero signal input to the amplifier.

This project was originally published in our August 1983 issue.

HARMONIC ANALYSIS AT 6 kHz

Harmonic	Rated output 21V9 60 W	-20 dB 2V19 600 mW
2nd	115 ppm	40 ppm
3rd	100	25
4th	32	15
5th	40	9

Harmonics higher than the 3rd are ultrasonic and hence inaudible.

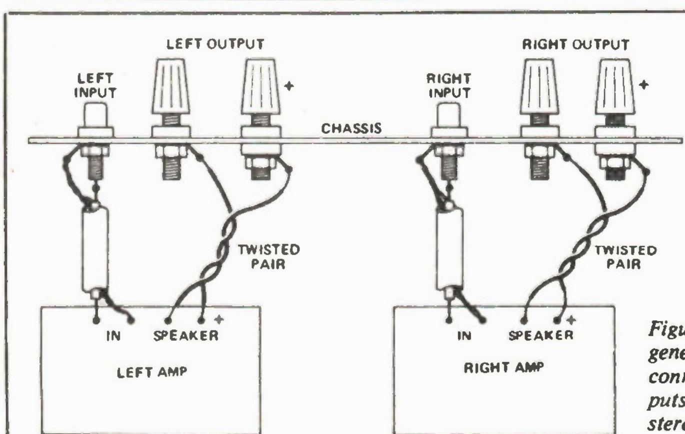


Figure 6 Showing the general technique for connecting inputs, outputs and grounds to a stereo pair of modules.

PARTS LIST

Resistors

(all ½W, 5% except where stated)

R1	1k0
R2	47k
R3,13,14	33k
R4,5	330R 2%
R6,7	see text
R8-10	4k7
R11	470R metal oxide or metal film
R12	15k metal oxide or metal film
R15	1k8
R16	33R
R17	68R
R18	220R
R19,26,27	470R
R20	3k9
R21	1k0, 1W
R22,23	8k2
R24,25	100R
R28	47R
R29,30	0R47, 5 W
R31	10R
R32	8R2, 2 W or 15R//18R, each 1 W

Potentiometer

PR1	2k2 miniature vertical preset

Capacitors

C1	4u7 axial electrolytic
C2	680pF ceramic
C3	47uF axial electrolytic
C4	33pF 100 V NPO ceramic
C5	1u5 polycarbonate
C6,8	68pF 100 V NPO ceramic
C7	470pF ceramic
C9,10	470uF 63 V axial electrolytic
C11	100uF 63 V axial electrolytic
C12,13	33pF 100 V ceramic
C14	100nF 100 V polycarbonate

Inductors

L1,2	15uH (see text and Table 1)
L3	6u8 H (see TAble 1)

Semiconductors

Q1,2	BC109, BC549 etc.
Q3,4,8,12	BC107, BC547 etc.
Q5-7,9,13	BC177, BC557 etc.
Q11,14	TIP29C
Q10,15	TIP30C
Q16	MJ802
Q17	MJ4502
D1-3	1N4148, 1N914, etc.
ZD1,2	15 V 400 mW zener

Miscellaneous

F1,2	2 A standard fuse

PCB; one 4-way and one 5-way terminal strip; heatsink to suit (see text); PCB stakes; bobbins for inductors; wire, etc.

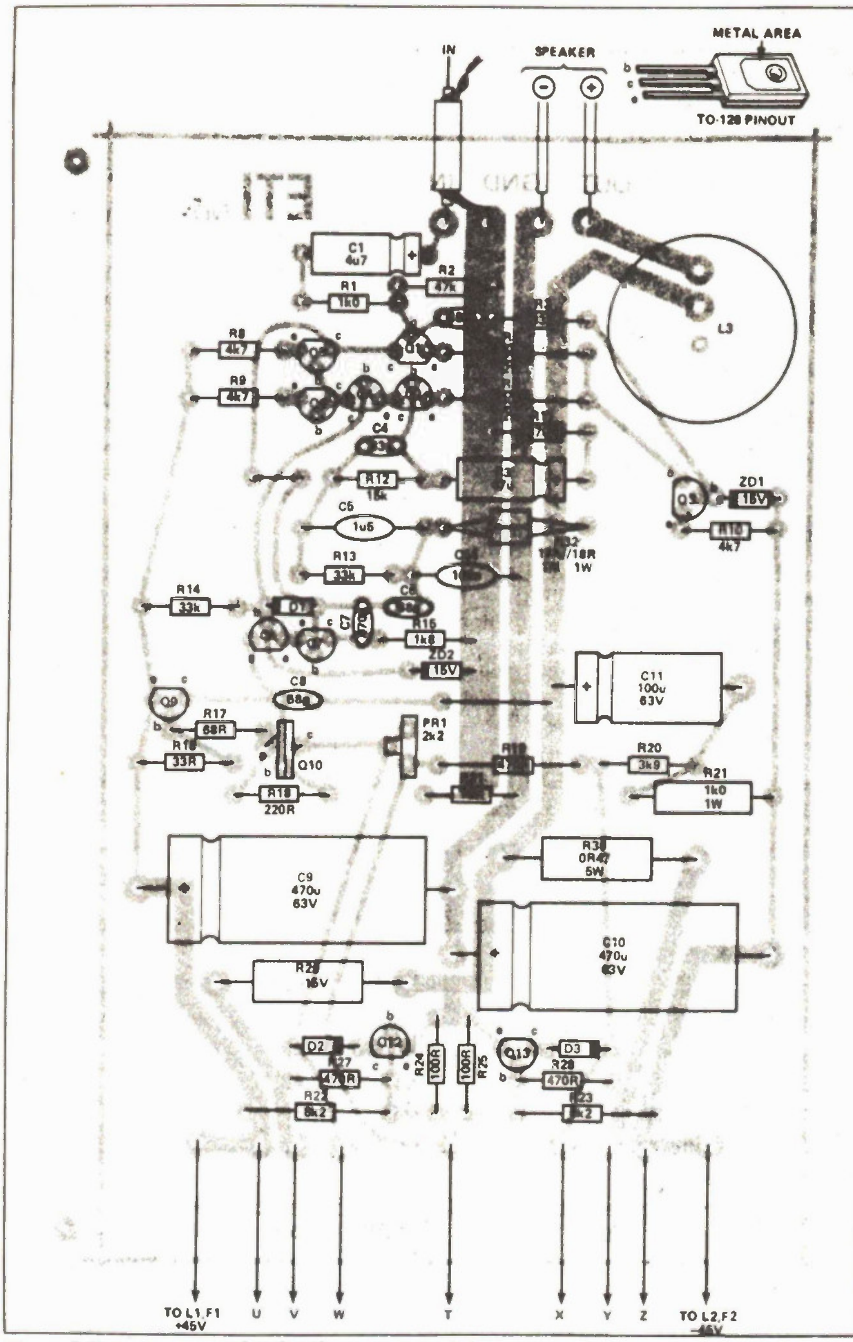


Figure 7 Component overlay for the power amplifier.

HOW IT WORKS

Figure 2 is the complete circuit of one channel of the amplifier; equations referred to in the explanation refer to last month's feature. The circuit is clearly based on Fig. 10 (in the theory article), with major parameters

$$1/B = 32.9$$
$$r_x = 800 \text{ nS}$$

The value of B is set by the overall feedback resistors R11 and R12 (470R and 15k — see Equation 1). r_x *is set by:*

a) *R4 and R5 (33R) plus C6 and C8 (68p) in conjunction with the chosen value of B* (see Equation 13);

b) R15 and C7 (1k8 and 470p — see Equation 14);

c) R32 and C14 (8R2 nd 100n) plus the 8 ohm nominal load and L3 (6u8 H);

d) R12 and C4 (15k and 33p) via the other constants in Equation 15.

The first stage requires little comment. Q1 and Q2 operate at 1.5 mA each, Q3 is a current source, Q4 is a common-base stage to equalise the quiescent voltages on Q1 and Q2; Q5 and Q6 constitute a current mirror. R1 and C2 form a 200 kHz low-pass filter against RF interference.

The current amplifier operates at 3 mA, set by R18, and it incorporates a catching diode (D1) to accelerate recovery from overdrive. The pre-driver, Q10, operates at 8 mA; Q9 protects the stage against damagingly large currents under fault conditions. Driver quiescent current is 25 mA, set by R28.

Transistors Q12 and Q13 provide short-term protection for the power transistors. Short-circuit current is limited to about 4 A, and peak signal current is limited to 7 A. Long-term protection is provided by 2 A fuses in each supply rail; these should be 'ordinary' types, rather than delay or quick-blow. In the unlikely event of transistor failure, these fuses limit the loudspeaker current to 2 A, corresponding to 32 W into 8 ohms.

The common alternative of a single fuse in the loudspeaker lead is less satisfactory: it provides less protection for the amplifier; it provides less protection for the loudspeaker as the fuse must be rated to carry the full signal current, and it introduces distortion on large-amplitude, low-frequency signals.

Low Frequency Compensation

A feature of Fig. 2 not discussed so far is a low-frequency compensating circuit, R13 and C5.

Amplifiers of the basic circuit topology of Fig. 2 (theory article) have a group delay which is different for different signal frequencies. Some frequencies take longer or shorter times than others to pass through the amplifier. High-frequency group delay in NDFL amplifiers can be corrected, as described last month, by a small capacitor in the feedback network (See Equation 15). Errors in low-frequency group delay, in both Figures 2 and 10 (theory article) are associated with the input coupling capacitor and the capacitor in series with R_{F1}. Low-frequency square-wave inputs are reproduced with a 'tilt' as in Fig. 3a.

One approach to this problem is to use a truly direct-coupled amplifier, with no capacitors in series with the signal path; commercial audio power amplifiers of this type appeared in the 1970s. Unfortunately, such amplifiers are prone to drift. A significant DC voltage may appear at the output even when there is no input. Although it is possible to reduce drift in a power amplifier to an acceptable level, it is not possible with today's technology to build a system that is truly direct-coupled from pick-up input, through the RIAA network and the power amplifier.

In the last few years a generation of amplifiers has appeared which include some form of servo amplifier to correct the drift. All circuits known to the author reintroduce the problem of group delay, albeit in a lesser form.

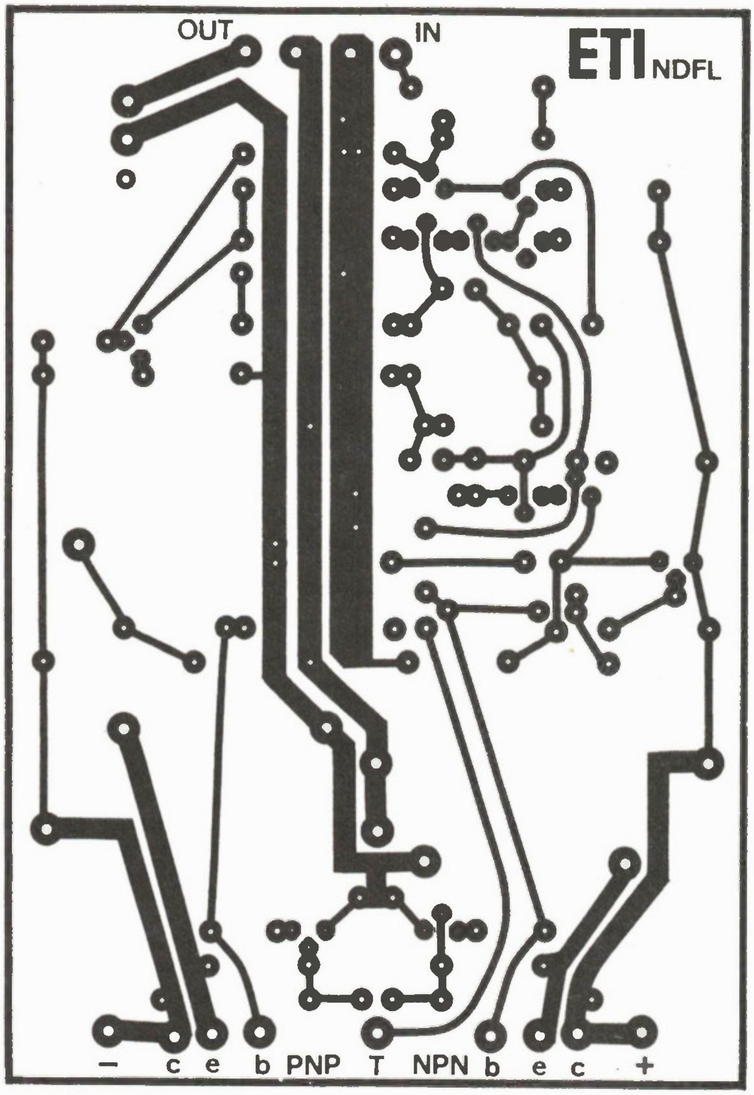
The approach adopted in the design is to retain the coupling capacitors and thereby eliminate drift, but include a group-delay correcting circuit. Figure 4 shows the outline. Group delay is optimally compensated if:

$$R_{F3} = 2R_{RF2,} \quad (16)$$

$$R_{F2}C_{F2} = R_{F1}C_{F1} \quad (17)$$

Figure 3b shows the improvement in square-wave response.

Low-frequency group-delay compensation could well be included in audio power amplifiers and pre-amplifiers other than NDFL types.



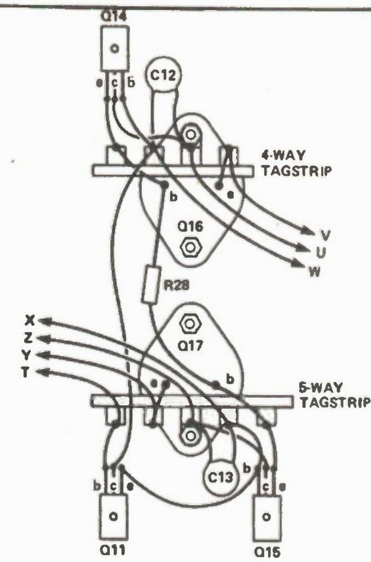


Figure 8 Wiring diagram for the components mounted on the heatsink.

HARMONIC ANALYSIS AT 1kHz

Harmonic	Rated output 21V9 60 W	-20 dB 2V19 600 mW
2nd	19 ppm	5 ppm
3rd	14	3.5
4th	2.5	2.5
5th	3.0	1.5
6th	1	1
7th	1.8	1.8
8th	1	1
9th	1.0	1
10th	1.8	1

Notice how the harmonics drop away at small signal amplitude. In this regard a class-B NDFL amplifier is more like a conventional class-A amplifier than a class-B amplifier.

1 ppm = 0.0001%

Direct Injection Box

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

By Andrew Armstrong

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

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

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

Well Balanced Design

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

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

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

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

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

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

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

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

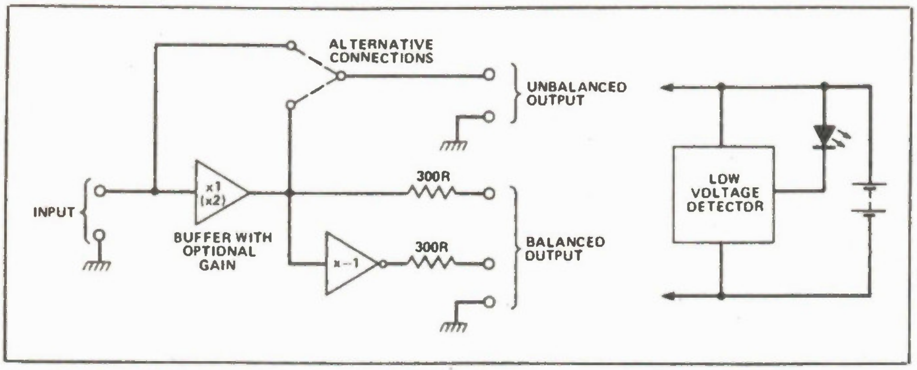


Fig. 1 The block diagram of the direct injection box.

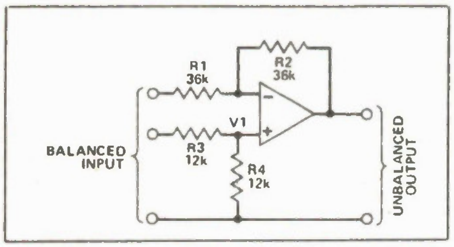


Fig. 2 A standard differential input arrangement.

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

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

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

Power Consumption

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

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

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

Low Battery Alarm

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

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

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

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

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

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

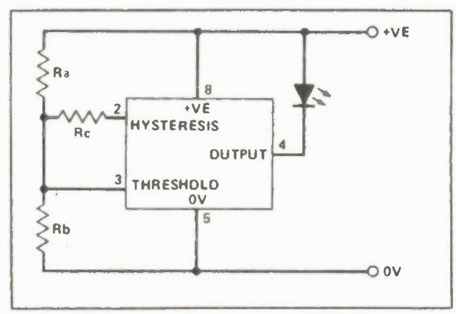


Fig. 4 The low voltage warning circuit using the 8211 micro power sensor.

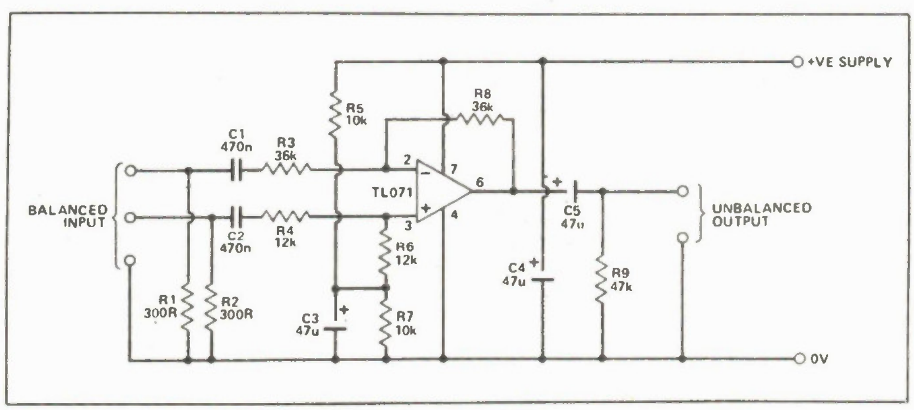


Fig. 3 A practical circuit for a differential input stage.

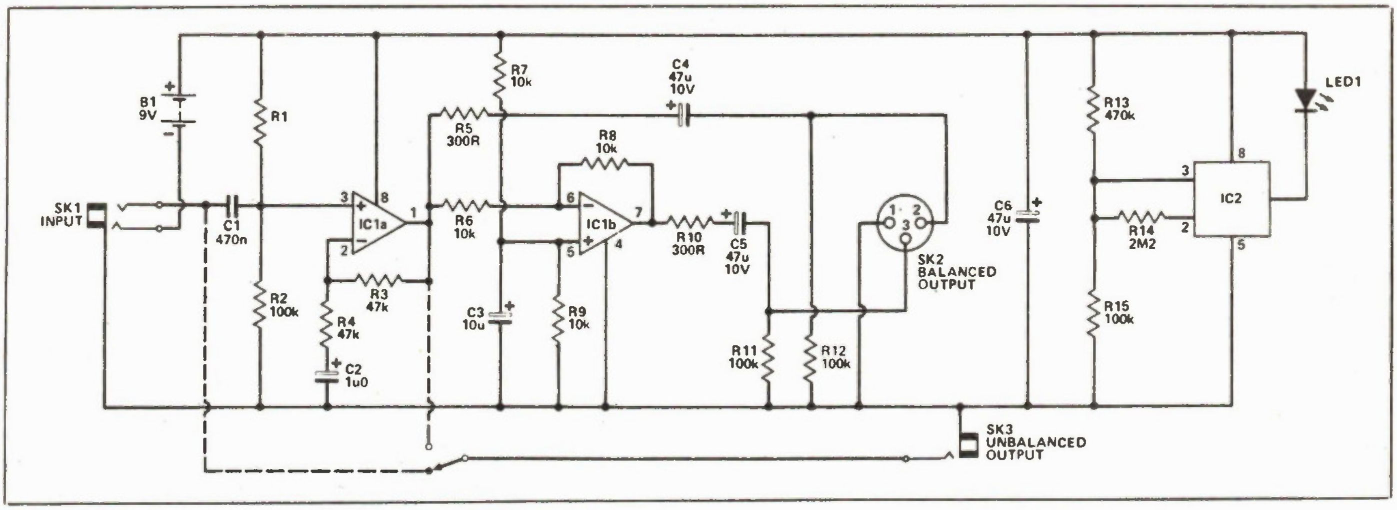


Fig. 5 Complete circuit diagram of the direct injection box.

Construction

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

Testing

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

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

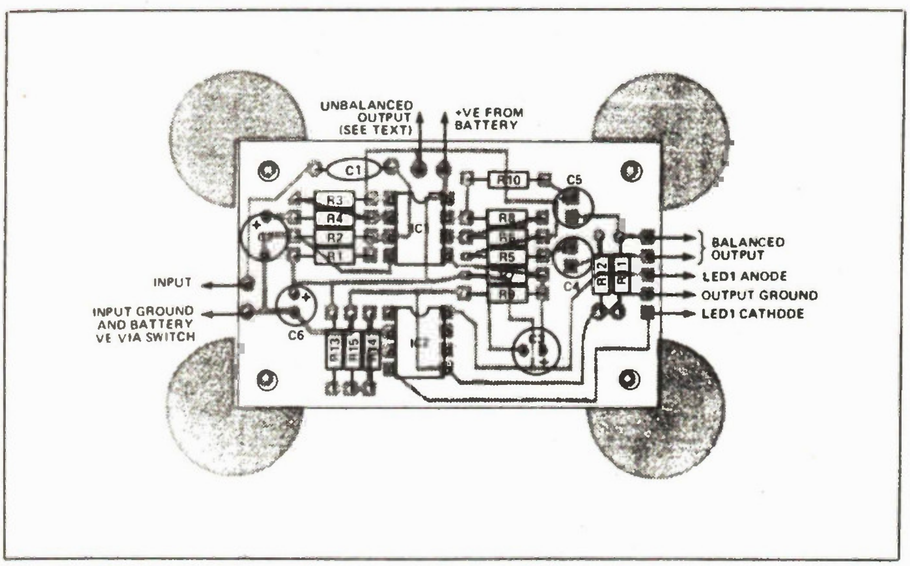


Fig. 6 The component overlay for DI box.

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

Parts List

Resitors
(¼ W 5% unless otherwise stated)
R1,2,11,12,15 .... 100k
R3 .... 47k
R4 .... 47k (see text)
R5,10 .... 300R 1%
R6, 8 .... 10k 1%
R7,9 .... 10k
R13 .... 470k
R14 .... 2M2 (see text)

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

Semiconductors
IC1 .... NE5532 dual op-amp
IC2 .... ICL8211 micropower sensor

Miscellaneous
SK1 .... ¼" stereo jack socket
SK2 .... XLR 3-pole chassis plug (XLR-3-32 or equivalent)
SK3 .... ¼" mono jack socket
PCB: die cast box, approx 110 x 60 x 30mm; panel-mounting bush for LED1; battery connector; nuts and bolts to mount SK2 and the PCB.

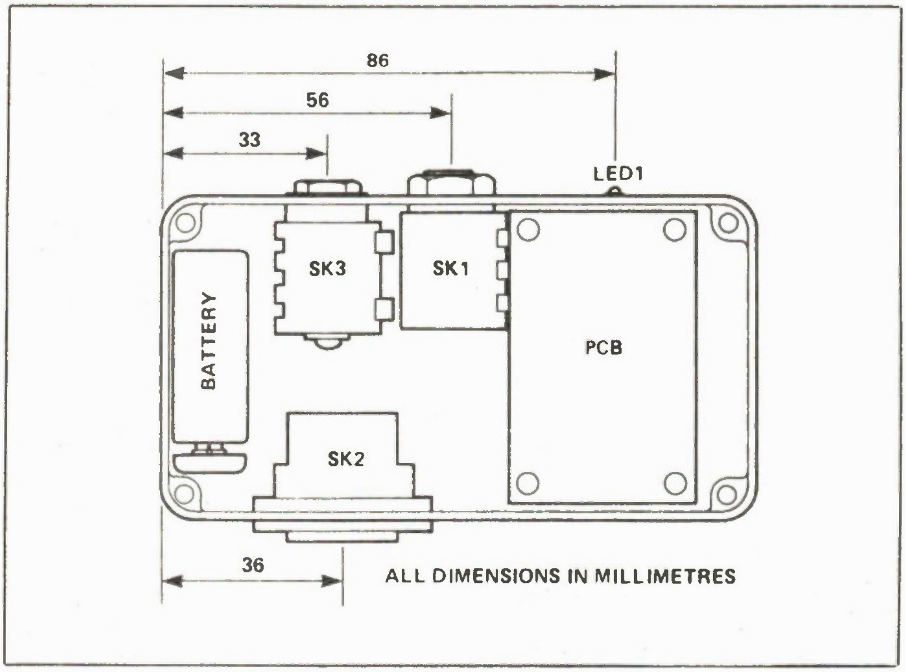
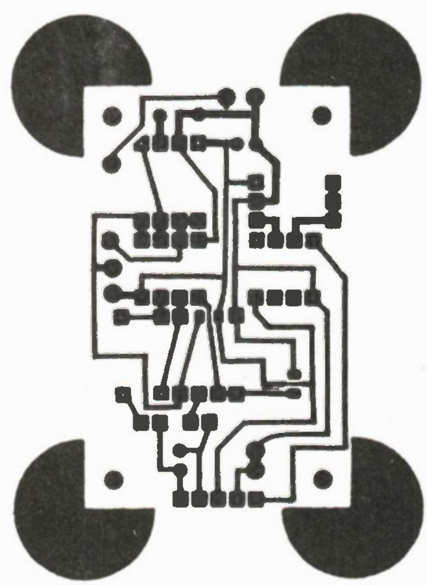


Fig. 7 Layout of the major components within the case.

How it Works

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

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



PCB for the DI box.

This project was originally published in our November 1985 issue.

■

The Digger

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

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

Use

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

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

The Circuit

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

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

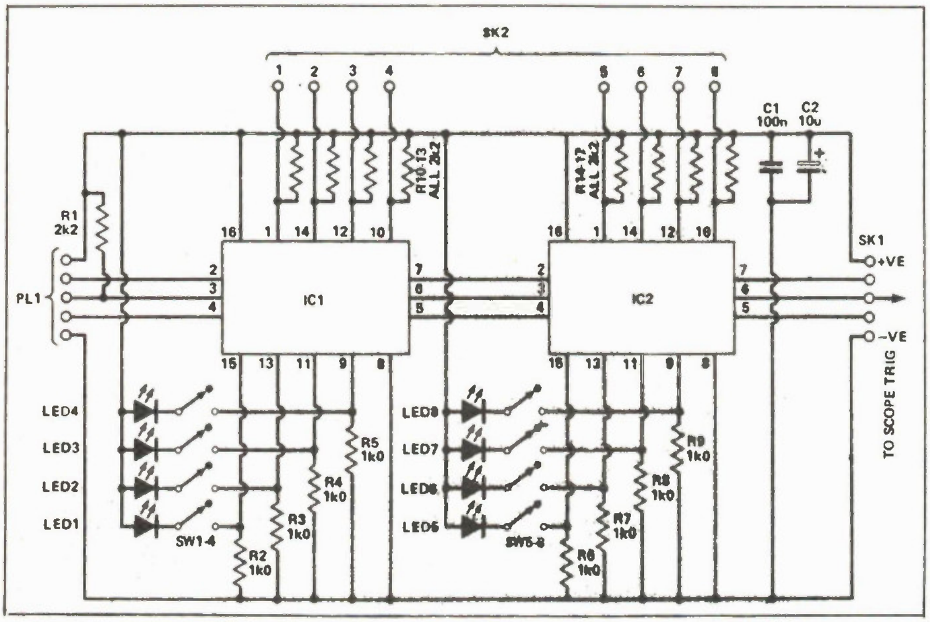
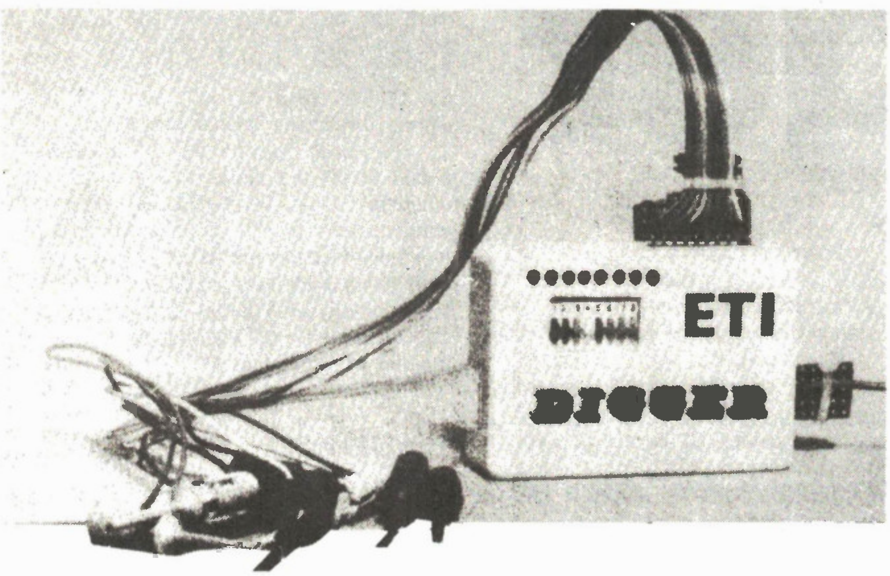
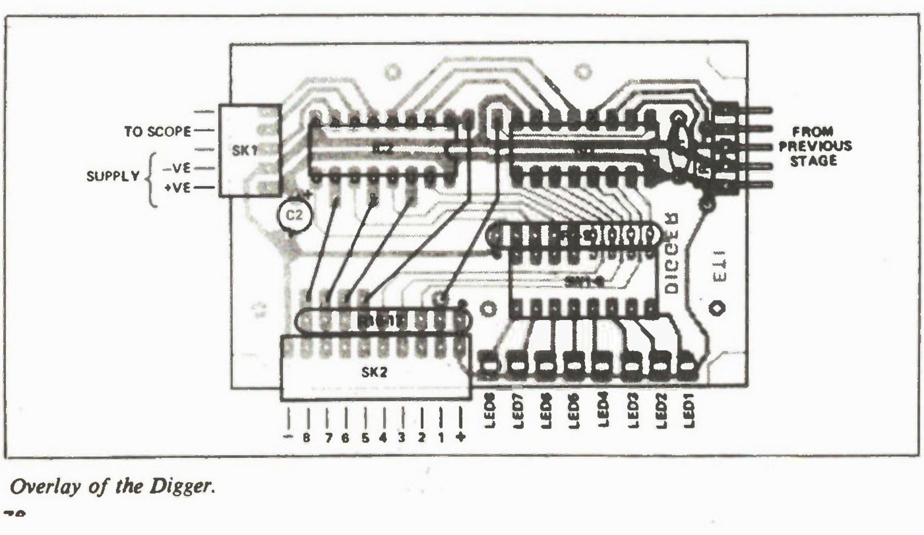


Fig. 1. Circuit diagram, PL1 and SK1 are used when two or more units are cascaded, SK2 is the 8-bit input.





Overlay of the Digger.

Construction

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

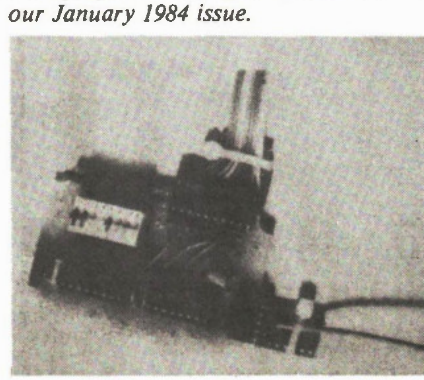
It will be necessary to use a 16 pin wirewrap type socket for the DIP switch so that it can be positioned through a hole in the box. The LED leads will probably be long enough without extension. We would also recommend using ordinary sockets for IC1 and 2.

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

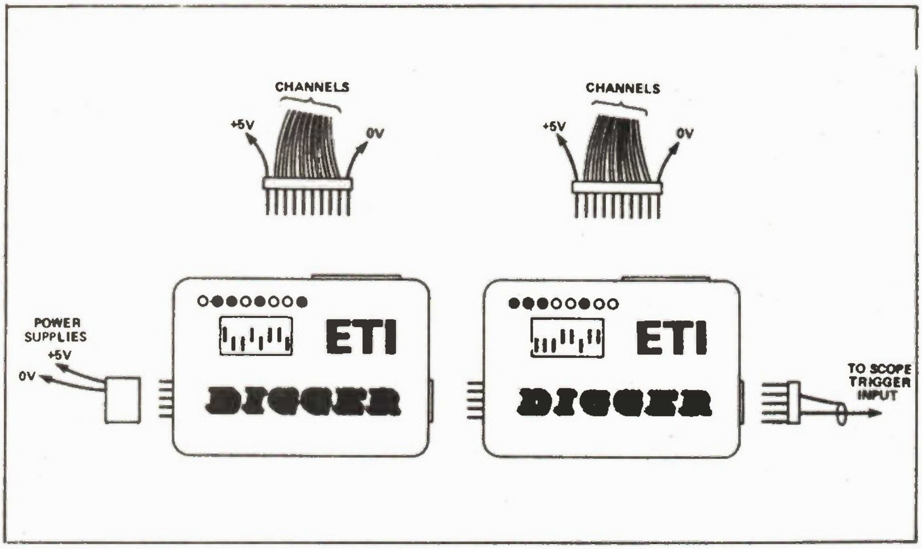
The PCB can now be bolted to the lid and the box put together. Connections to the outside world are made via the plugs and sockets. If you use right-angled plug parts, then a small piece of Veroboard soldered to them makes a solid connector. The socket should be a socket housing with crimp terminals.

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

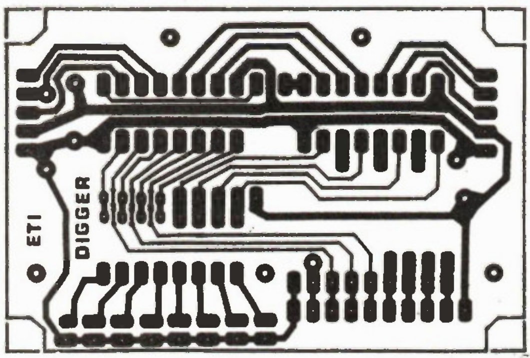
This project was originally published in our January 1984 issue.



The Digger itself, less case.



Two or more Diggers can be cascaded.



HOW IT WORKS

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

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

PARTS LIST

RESISTORS (¼ W 5% carbon film unless stated)

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

CAPACITORS

C1	100nF ceramic
C2	10uF 16 V electrolytic

SEMICONDUCTORS

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

MISCELLANEOUS

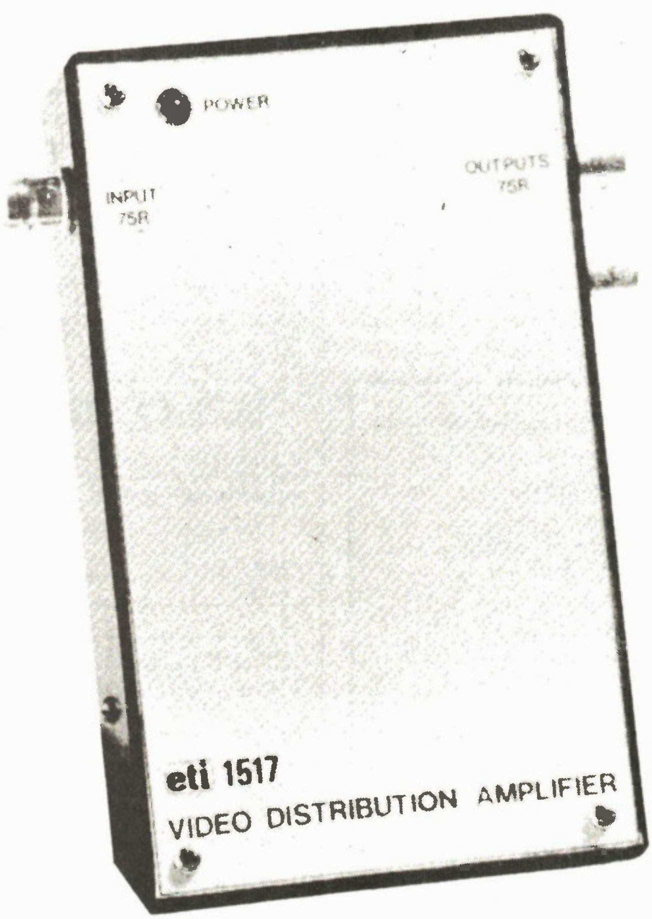
SW1-8	8 pole SPST DIP switch

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

Video Distribution Amplifier

This simple, low-cost project will allow you to drive up to five video monitors from one source, such as a video cassette recorder or a computer.

by John Power



Design

The requirements of a video distribution amplifier are quite straightforward. The unit must be able to take a single input and to drive the required number of outputs while retaining video fidelity. The bandwidth at full output level must be at least 5 MHz, or more, so as to retain video fidelity. The input and output impedances must be matched to standard 75 ohms widely used in video work and adding or subtracting units to or from the outputs should not affect any other device connected to an output. In essence, that's what this project does.

The heart of the unit is a transistor array IC — a CA3086. The transistors inside this package have been connected as a differential amplifier, the output of which drives a power output stage. Feedback provides a gain of one (i.e., unity) and ensures a wide bandwidth. Regulated ± 5 V supplies are used so that the whole amplifier can be direct-coupled, yet main tain the output on at DC ground potential. In practice, the 'DC offset' at the output is on the order of 100 mV or so (it could be positive or negative).

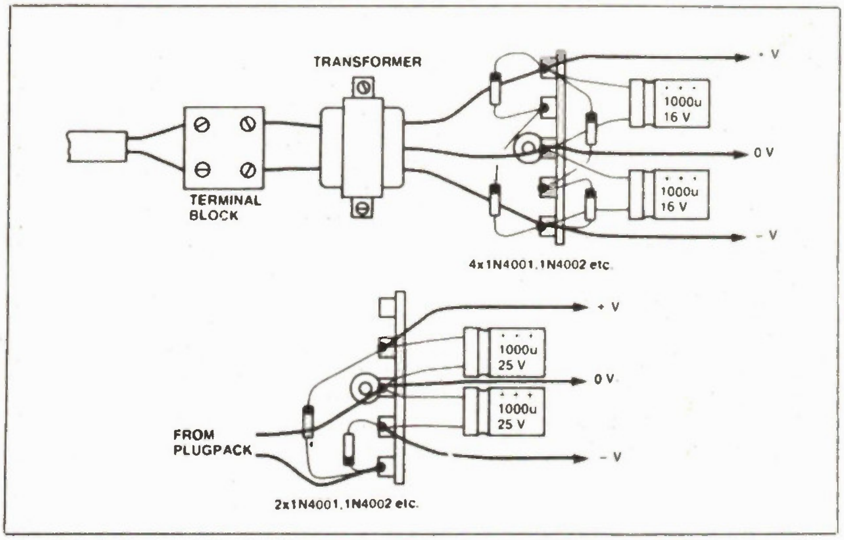
Construction

The video amplifier fits into a 50 x 95 x 158 mm project box along with its own power supply. This has the advantage of convenience, though it is possible to run the circuit off a 12 volt AC adaptor, which would make the whole a little cheaper if you already have the adaptor. These are also safer for the constructor who is unfamiliar with mains wiring, though more expensive in the first place. Anyway, details are given for both situations.

Select the connectors you intend to use. Some video systems use RCA sockets and cables rather than the more robust BNC type. You may not require the full five outputs which the unit is capable of driving. Thus you may elect to economize and fit only two BNC sockets. (BNC sockets, if good ones, are not cheap). Or, you may fit two BNC's and an RCA type, in case. Note that solder lugs are needed for grounding.

Having selected the connectors, you must decide on the power supply. Included are the full power transformer, rectifier, filter and so on, all of the components for which cam to about half the cost of an adaptor. I recommend this approach as cost effective as well as convenient. (You cannot easily lose the parts you bolt in, like you can lose an adaptor.)

Next, drill the box to allow the entry of the power cable or the mounting of an adaptor connector as appropriate. Also, mounting holes for the connectors, the LED, printed circuit board and power



Power supplies. Wiring details for the two types of power supplies suggested.

transformer, if applicable, will be needed.

Once the drilling is finished, fit the components to the pc board after checking that all holes are correctly drilled and that all the tracks are OK. Be sure to get the IC's and the tantalum capacitors and transistors the correct way around. Attach short lengths of hookup wire to the pc board input, output and power connections. These can be trimmed and soldered to their respective destinations once the board is bolted in place.

Next fit the transformer, power cable and connectors in their respective positions in the box. Clamp the power cable carefully and connect it to the terminal block, along with the transformer wires.

Now wire up the tagstrip, following the diagram carefully. Solder onto it the transformer secondary wires and the wires leading to the pc board. Mount the tagstrip and the pc board. Run a ground

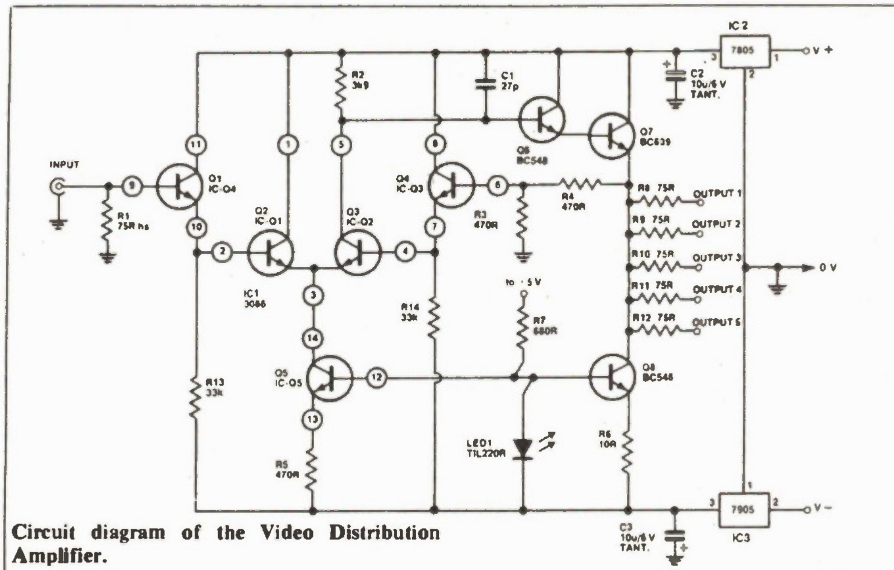
HOW IT WORKS

The unit is basically a dc-coupled feedback amplifier. It comprises a differential input stage, a buffer stage, and a power output stage which together form a small but fast and powerful operational amplifier. This is suitably configured to give an overall gain to 75 ohm matched loads of precisely one, and a bandwidth of better than five megahertz — the requirement for a video distribution amplifier.

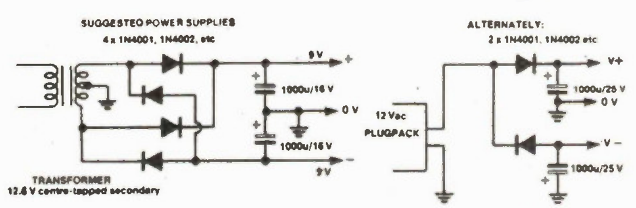
The differential input stage is created from a CA3086 IC (IC1) which counts five discrete transistors. Four (Q1 to Q4) are used to provide a Darlington long-tailed pair, with the fifth transistor (Q5) acting as the current source for the stage. The use of this IC, rather than having five discrete transistors guarantees good thermal matching for low offset and good matching of the transistors for predictable balance and gain.

The open loop bandwidth of the circuit is defined by the capacitor C1 in conjunction with the 3k9 load resistor, R2, and other minor effects.

Transistor Q6 is a common collector circuit which buffers the differential pair output and provides a negative dc shift of about 0.6 volts. Q7 and Q8 form the output stage. Q8 is a current source setting the output quiescent current to about 100 mA which is required (worst case) to drive five parallel output lines of 75 Ohms each. Q7 is a common collector stage which drives the output. Q8 also uses the LED as a voltage reference.



Circuit diagram of the Video Distribution Amplifier.



Resistors R3 and R4 form the feedback ratio defining resistors. High stability metal film types have been specified here. In practice, they define the gain of the whole amplifier and hence should be precise enough to ensure that the standard video levels are maintained. However, their value is not critical, only that they should be equal. it would be possible to use a pair of selected resistors of any value from 330 to 560 Ohms.

The input termination resistor and the output termination resistors are also specified as metal film types. This is in order to minimize mismatches with the cables used to connect to other video systems. It would be possible to use 47 or 51 Ohm metal film resistors if your system is 50 Ohm. In this case, the output stage could handle only four parallel loads.

The amplifier runs off + and -5 volts, provided by two three-terminal regulators. These are prevented from oscillating by the two tantalum capacitors, C2 and C3, which also provide supply rail bypassing over a wide bandwidth.

Specifications of the Video Distribution Amplifier

Number of outputs	up to five
Peak output	2 V peak-to-peak
Power bandwidth	8 MHz (-3 dB @ 1 Vp-p output)
Small signal bandwidth	26MHz (-3dB @ 200 mVp-p output)
Input impedance	75 ohms
Output impedance	75 Ohms (any port)

lead to each of the connector ground lugs, as shown in the wiring diagram, and then the 0 V point to the pc board. Finally, connect the input and output leads and the LED wires.

Test

To test it, apply power and check that the rectifier outputs are correct. If you're using the 12 VCT transformer, you should measure around 9 V across each of the 1000*u* filter capacitors. If you're using the adaptor supply, you should get around 16-17 V across the 1000*u* filter capacitors. If they're okay, check the outputs of the two regulators. These should each be 5 V. The LED should be lit.

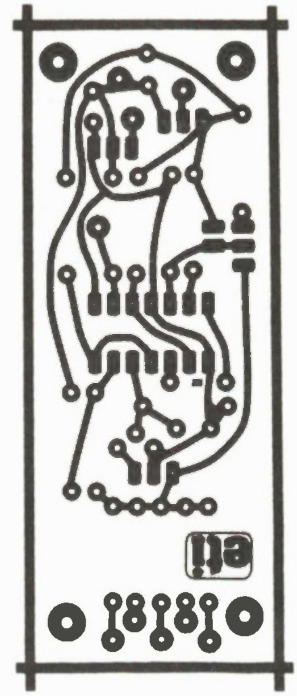
If there are any faults to this stage, switch off and sort them out before continuing. A wiring error is the usual culprit.

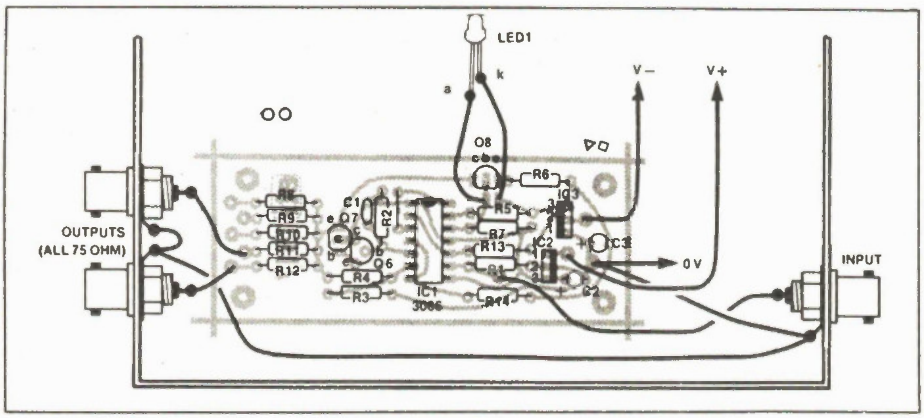
If all's well, connect it up and try it out.

PARTS LIST

Resistors (all ¼ W, 5% unless noted)	
R1, R8-12	75R, 1%
R2	3k9
R3, R4	470R, 1%
R5	470R
R7	680R
R13, R14	33k
Capacitors	
C1	27p
C2,C3	10u/6 V tant.
Semiconductors	
IC1	CA3086, LM3086
IC2	LM7805, LM340/T5
IC3	LM7905, LM345/T5.0
Q6,Q7,Q8	2N5818
LED1	TIL220R red LED

Miscellaneous
pc board; box (50x90x150 mm); required number of BNC sockets; AC adaptor (12 V(or power supply components to suit — see text; wire, nuts, bolts, etc.





Overlay and wiring diagram. Showing how the pc board is assembled and wired up.

This project was originally published in our October 1984 issue. ■

Continued from page 65

Expanded Scale Voltmeter

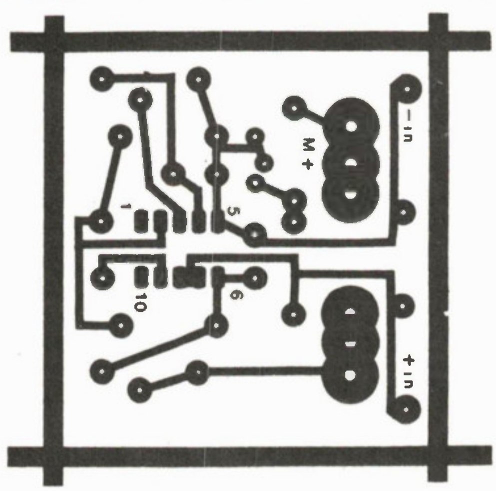
Note that the fuse (to protect the project) is inserted in an in-line holder in the external connecting leads.

Calibration

For this you will need a variable power supply covering 10 to 15 volts and a digital multimeter (borrow one for the occasion).

First set the 10 V point. Connect the digital multimeter across the power supply output and adjust the power supply to obtain 10.00 volts. Set the mechanical zero on the meter movement to zero the meter's pointer. Connect the unit to the power supply output and adjust RV1 to zero the meter needle.

Next, set the power supply to obtain 15.00 V. Now adjust RV2 so that the meter needle sits on 15 V (full scale). Check the meter reading with the power supply output set at various voltages across the range. We were able to obtain readings across the full scale within ± half a scale reading (± 50 mV). With a 2% meter, the worst error may be about ± one scale division.



When set up, our unit drew 12.5 mA maximum current drain, which is probably typical, but current drain may be around 20 mA or so maximum. Note that, when the input voltage is below 10 V, the meter needle will move in the reverse direction.

This project was originally published in our December 1983 issue. ■

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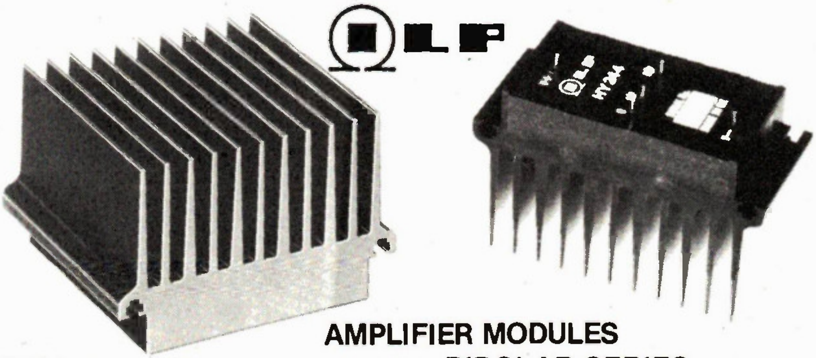

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Harmonic Distortion (@1 Khz) : 0.005% *Intermodulation Distortion (60 Hz/7 Khz 4:1 ratio)* : 0.006% *Slew rate:* 20v/µs. *Rise time:* 3 µs. *S/N ratio:* 100 db *Frequency response:* (-3db): 15Hz -100 KHz. *Input sensitivity:* 500 mV rms. *Input Impedance:* 100K Ω *Damping factor* (@ 100 Hz): >400

ILP Model	Output Power RMS Watts	Load Impedance Ohms	Supply Voltage (DC V)	Size (in mm)	$
MOS128	60	4-8Ω	± 45	120x78x40	139.80
MOS248	120	4-8Ω	± 55	120x78x40	180.59
MOS364	180	4Ω	± 55	120x78x100	268.01

RACK MOUNT CABINETS

Professional 19" x 5 1/4" cabinets for the ultimate in appearance and flexibility in assembling ILP amplifiers. Modules mount on pre-cut side panels. Transformers and power supplies mount internally. Supplied with quality hardware and instructions. **$99.95 each**

ILP MODEL	FOR USE WITH THESE MODULES
A1905	2 x HY244 OR HY248
B1905	2 x MOS248
C1905	2 x HY364, HY368 OR MOS364 plus power supplies

BIPOLAR SERIES

These ILP modular hybrid amplifiers have been designed to provide the utmost in high fidelity performance. They are encapsulated to a built-in heatsink. They have internal safeguards to ensure full protection and make them both mechanically and electrically rugged. Connections are made simply and quickly by only five soldered terminations.

The HY30 and HY60 are extremely small-sized amplifiers that are widely used for compact equipment, including portable amplifiers, guitar amplifiers, and public address systems. The HY6060 is a compact stereo unit.

The other units in the series share similar height and length, however the higher power units have greater physical depth. Models are available to provide 4 or 8 ohm output, and power of 60, 120 and 180 watts RMS.

Model HY30, HY60, HY6060. *Harmonic Distortion* (@ 1 KHz) : 0.015% *Intermodulation distortion* (60 Hz/7 KHz 4:1 ratio): 0.006%

Model HY124, HY128, HY244, HY248, HY364, HY368. *Harmonic Distortion:* 0.01%. *Intermodulation Distortion:* 0.006%

All models *Protection:* Full load line. *Slew rate: 15v/µs. Rise time:* 5 µs. *S/N ratio:* 100 db. *Frequency response:* (-3db) 15Hz - 50 KHz. *Input sensitivity:* 500 mV rms. *Input impedance:* 100K ohms. *Damping factor* (@100 Hz): >400.

ILP Model	Output Power RMS Watts	Load Impedance Ohms	Supply Voltage (DC V)	Size (in mm)	$
HY30	15	4-8Ω	± 18	76x68x40	40.73
HY60	30	4-8Ω	± 25	76x68x40	40.73
HY6060	30 + 30	4-8Ω	± 25	120x78x40	87.35
HY124	60	4Ω	± 35	120x78x40	69.87
HY128	60	8Ω	± 35	120x78x40	69.87
HY244	120	4Ω	± 45	120x78x50	93.18
HY248	120	8Ω	± 45	120x78x50	93.18
HY364	180	4Ω	± 55	120x78x100	139.80
HY368	180	8Ω	± 55	120x78x100	139.80

APPLICATIONS HANDBOOK

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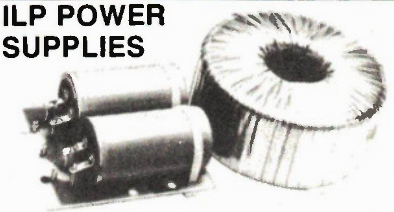
ILP POWER SUPPLIES



ILP Power Supply units consist of an ILP toroidal transformer and matching circuit board with power supply components. These are designed to give the proper voltage and current for ILP audio amplifier modules. Transformers may be purchased separately.

ILP Model	For use with	Price
PSU410	1 OR 2 HY60 - 1 HY6060 - 1 HY124	67.57
4A027	TRANSFORMER FROM PSU410	48.08
PSU420	1 HY128	76.36
4A040	TRANSFORMER FROM PSU420	48.08
PSU430	1 MOS128	80.76
4A041	TRANSFORMER FROM PSU430	48.08
PSU510	2 HY128 - 1 HY244	82.96
5A020	TRANSFORMER FROM PSU510	60.63
PSU520	2 HY124	82.96
5A027	TRANSFORMER FROM PSU520	60.63
PSU530	2 MOS128	87.36
5A035	TRANSFORMER FROM PSU530	60.63
PSU540	1 HY248	87.36
5A019	TRANSFORMER FROM PSU540	60.63
PSU550	1 MOS248	96.15
5A035	TRANSFORMER FROM PSU550	60.63
PSU710	2 HY244	106.05
7A047	TRANSFORMER FROM PSU710	76.22
PSU720	2 HY248	110.44
7A047	TRANSFORMER FROM PSU720	76.22
PSU730	1 HY364	110.44
7A017	TRANSFORMER FROM PSU730	76.42
PSU740	1 HY368	119.25
7A017	TRANSFORMER FROM PSU740	76.22
PSU750	2 MOS248	119.25
7A036	TRANSFORMER FROM PSU750	76.22
PSU760	2 HY364 (includes 2 pcbs)	199.95
8A017/S	THANSFORMER FROM PSU760	105.34
PSU770	2 HY368 (includes 2 pcbs)	199.95
8A026/S	TRANSFORMER FROM PSU770	105.34
PSU780	2 MOS364 (includes 2 pcbs)	210.94
9A036/S	TRANSFORMER FROM PSU780	131.54

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Compact modules — not much larger than a matchbox — that provide the best audio reproduction possible. All ILP modules are fully compatible so you can combine modules to create systems as required. Fully short-proof. All connections made via edge connector (supplied). Complete circuitry is encapsulated and simply plugs into the connector. Require ± 15 VDC @ 20 ma (HY67 requires 80 mA).

HY6 Mono Preamp Provides input for mic, phono (magnetic cartridge) tuner, tape, auxiliary with volume, bass, treble controls. **$34.91**

HY66 Stereo Preamp Similar to HY6 with two stereo channels **$64.04**

HY78 Stereo Preamp Similar to HY66 minus tone controls. Inputs for phono, tuner, auxiliary, plus tape monitor **$58.22**

HY67 Stereo Headphone Amplifier Will drive stereo headphones in the 4 ohm- 2K ohm range. **$64.04**

HY73 Guitar Preamp Provides for two guitars (bass + lead) and mic with separate volume/bass/treble and mixing **$64.04**

HY83 Guitar Preamplifier State of the art unit with bass/mid/treble controls, separate channels for "clean", overdrive, reverb with master control **$79.95**

HY76 Stereo Matrix Switch Provides two channels each switching one of four signals into one. **$75.77**

HY77 Stereo VU Meter Driver Programmable gain/ LED overload driver. **$46.56**

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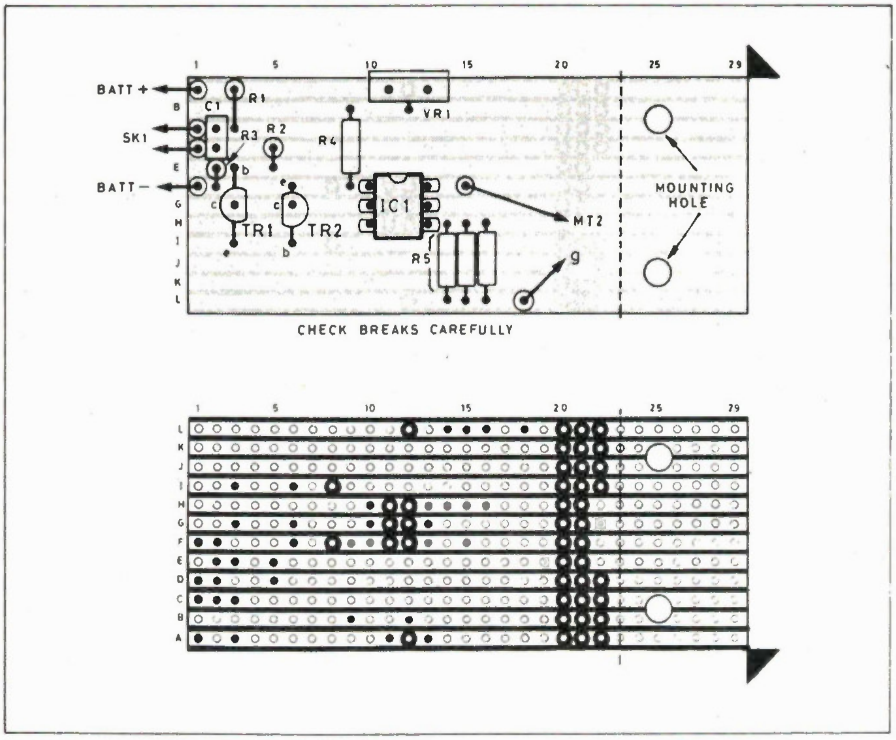


Fig. 2 Veroboard layout and construction.

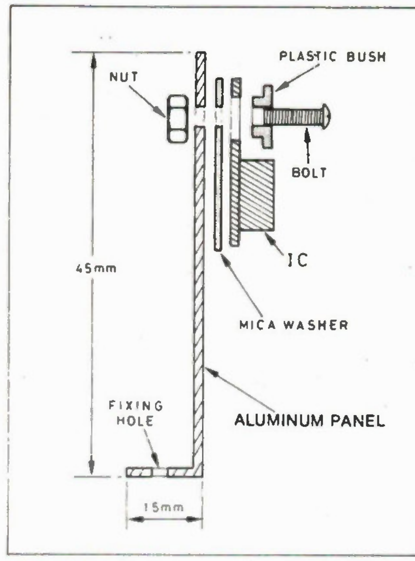


Fig. 3 Details for mounting the triac.

drilled in the case lid so all testing and operation is carried out with the case closed - an important safety point.

Construction

Refer to **Fig. 2** and build the circuit up on a piece of 0.1 inch stripboard, 12 strips by 29 holes in size. Make the breaks as indicated: *Safety depends on the copper strips being completely broken.* Drill the two holes use for mounting the triac panel, and mount the IC socket. Follow with all the on-board components.

Resistor R5 requires an adequate power rating and either three 470 ohm resistors as specified connected in parallel. Alternatively, a single 150 ohm, 2W component will suffice.

Solder light-duty stranded connecting wires to strips C and D. Extend the battery connector leads as necessary and connect these to strips A and F. **Fig. 3** shows details for making the triac panel from a thin sheet of 32 x 60mm aluminum. Attach the triac using a single screw and a mounting kit. This prevents the panel

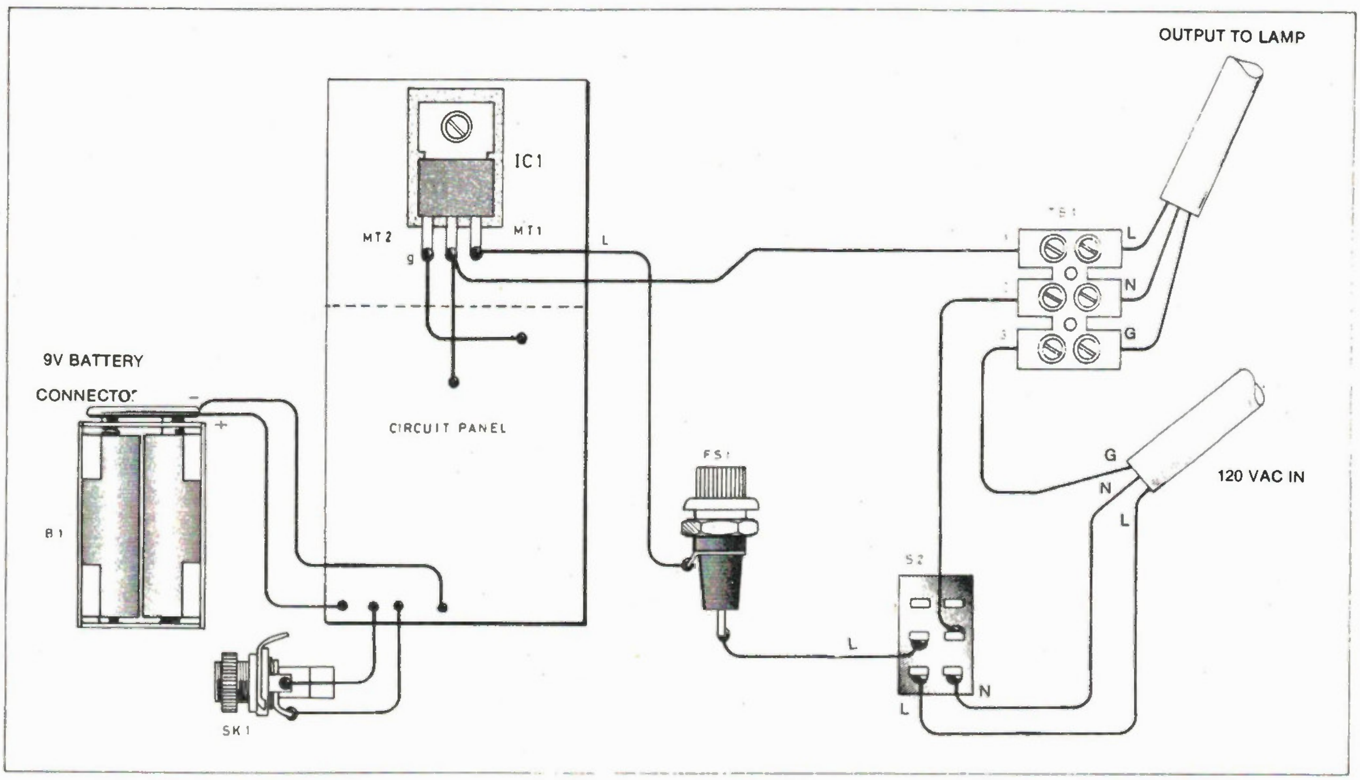


Fig. 4 Interwiring of the Veroboard and other components.

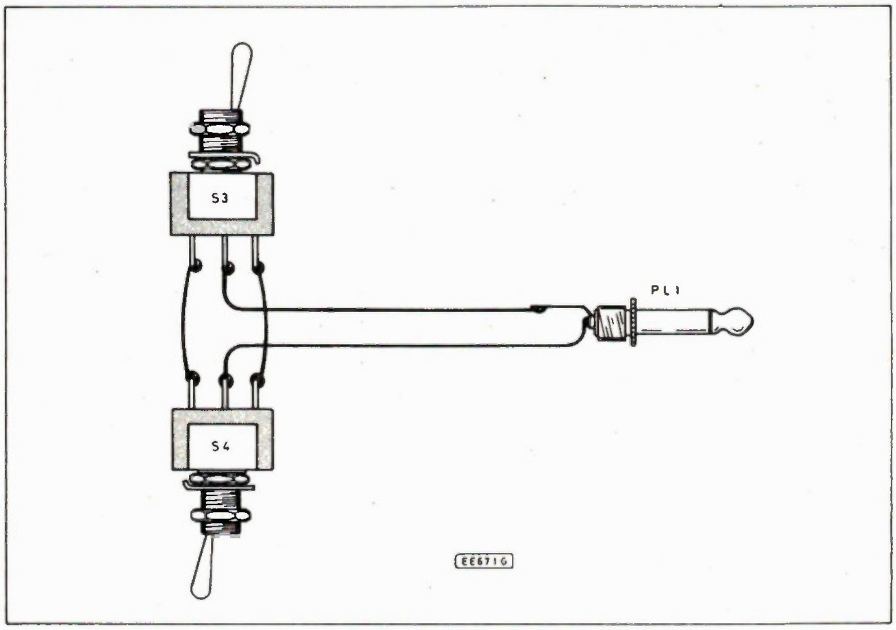


Fig. 5. Details for using two switches to switch the lamp with one and off with the other.

Parts List

Resistors (All 1/4W, except where noted)
R1,2 .... 1M
R3 .... 2M2
R4 .... 150R
R5 ..... 150R, 2W or (3) 470R, 1/2W wired in parallel.

Potentiometers
VR1 .... 1k mini. preset vert. mounting

Capacitor
C1 .... 10n ceramic

Semiconductors
IC1 ...... MOC3020 optically isolated triac
CSR1 .... 3A triac
TR1,2 .... 2N5210 or BC184L NPN silicon

Miscellaneous
S1 .... small single-pole
S2 ...... DPST 120VAC rocker switch with neon ind.
SK1 .... Suitable jack socket
B1 .... (4) "AA" size batteries
FS1 .... 3A fuse and 20mm panel-mounting fuseholder
TB1 .... 3A terminal block

Battery holder for above with 9V connector; 6-pin DIL socket; TO66 mounting kit for CSR1; thin sheet aluminum for triac panel 32 x 60mm; case 150 x 80 x 50mm; fixings; connecting wire; cable clamps etc.

from becoming "live". Attach the triac panel to the circuit board using the previously drilled holes. Make the gate and MT2 connection using wire rated for 120 VAC purposes.

Refer to **Fig. 4** and complete the internal wiring using 3A 120 VAC-rated wire for S2, FS1, and TB1 connections. Leave the sliding contact of VR1 fully clockwise. Fit the 120VAC with strain relief clamps, place a 3A fuse in the fuseholder, and connect the batteries. If possible, fit used batteries for testing and adjustment purposes since this will ensure correct operation as the new ones age. Cut two pieces of thick cardboard to secure the battery holder as shown in the photograph.

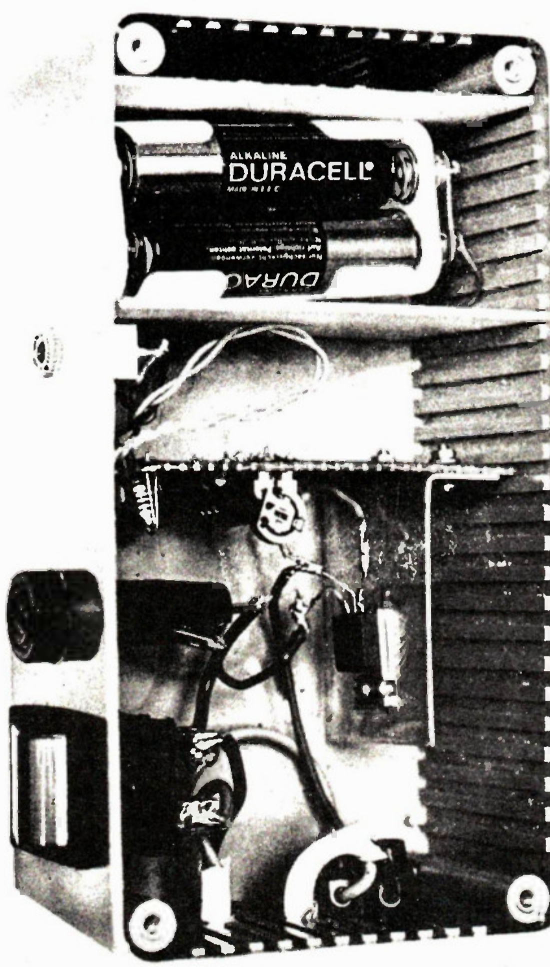
Installation and Adjustment

Due to exposed high voltage connections, all operation must be carried out with the lid of the case on. *Shut down the main power whenever a battery change is necessary.* Secure the main unit to the wall in a dry place. Connect S1 with light-duty twin wire, plug the unit into the 120VAC circuit, and test the system. The lamp may flash briefly as S2 is switched on; this will not effect the unit at all. Adjust VR1 anti-clockwise to give minimum LED current for reliable operation. If it works with the sliding contact fully anti-clockwise, all the better.

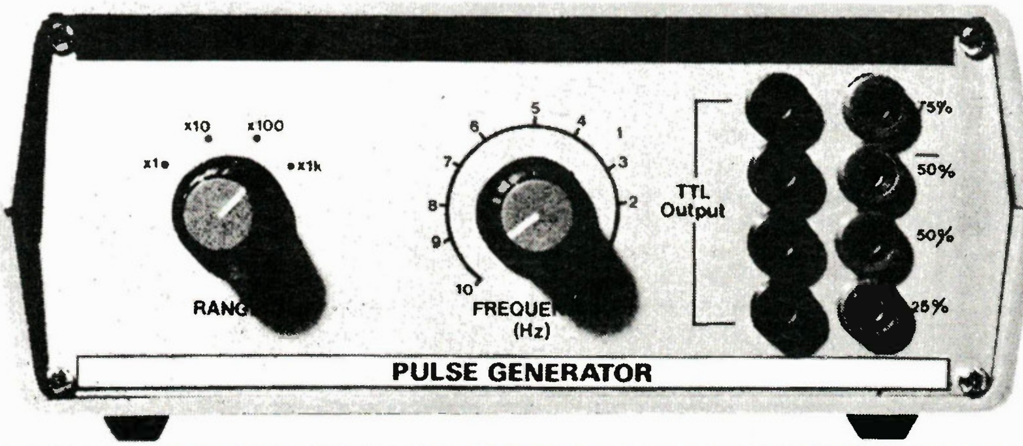
Switches situated outdoors should be protected from moisture to prevent corrosion and early failure. Also, any water entering and bridging the contacts will short circuit them and actuate the light. If the lamp flickers or operates at reduced brightness this is a sign to replace the batteries.

Two-Way Switch

A circuit to enable the light to be operated from two switches is shown in **Fig. 5**. Both switches are single-pole two-way types. ■



Digital Pulse Generator



A pulse generator designed specifically for testing digital circuits

By Michael Tooley and David Whitfield

TESTING DIGITAL circuits is quite different in a number of important aspects from the testing of analog circuits. However, much of the same test equipment can still be used, although in many cases it is more convenient if an appropriate digital instrument is available. In other cases, there are additional needs which call for test equipment which caters specifically to the needs of digital troubleshooting.

The unit described here is a digital pulse generator. It produces digital signals in four switched frequency ranges giving an overall coverage of 1 Hz to 10 KHz. At any given frequency, four independent outputs are available with duty cycles of 25%, 50%, $\overline{50}$%, and 75% respectively. This allows a number of signals of known phase relationship to be used for testing a digital circuit. All of the outputs are at TTL levels, and the unit operates from a single +5V supply.

Circuit Description

A block diagram for the digital pulse generator is shown in **Fig. 1**, with the corresponding circuit diagram in **Fig.** 2. IC1 is a monolithic timer arranged in an oscillator configuration. This oscillator is set to run at four times the output frequency. The output from this oscillator has alternating "high" (near +5 volts) and "low" (near 0 volts) periods. The durations of these periods (TH and TL) are determined by the following equations:

$$T_H = 0{\cdot}693 \times (VR1 + R1 + R2) \times C$$
$$T_L = 0{\cdot}693 \times R2 \times C$$

The values are: time in microseconds, resistance in ohms, and capacitance in uF. The capacitance, C, is the value of the capacitor currently selected by S1. From this it can be seen that the "low" period of the waveform will always be less than the "high" period; often very much less. For any given range, the "low" period is fixed, and it is the "high" period which varies as the setting of VR1 is altered. With the components selected, the frequency of the oscillator varies over a range of approximately 10:1 as VR1 is adjusted. The oscillator provides decade frequency ranges, with slight overlaps between the ends of adjacent ranges.

Divider

The oscillator output is applied to the clock input of a D-type flip-flop, IC2b, which is configured as a divide-by-two circuit. The output from IC2b si a square wave signal at half of the oscillator frequency. The output is then fed to a second divide-by-two circuit which uses a second flip-flop, IC2a, to produce a square wave at a quarter of the oscillator frequency. The D-type flip-flops each have two output signals which are logical inverses of each other. Thus, while the Q output is "high", the $\overline{Q}$ output is "low", and vice versa. The 50% and $\overline{50}$% outputs are therefore taken directly from the outputs of IC2a. The 25% and 75% output signals are then derived by gating the 50% signal and the signal at twice the output frequency. Two NOR gates, IC3a and IC3b, are used for this purpose; the result is illustrated in the overall timing diagram for the unit in **Fig. 3**.

The power supply for the pulse generator is a single +5V rail. This should ideally be kept within 250mV of its nominal level. Protection against reverse polarity is given by D1, which will behave as a short-circuit under such conditions. C6 provides LF decoupling. If a suitable stabilized power supply is not available, a higher voltage supply may be used in conjunction with an integrated circuit fixed regulator.

Construction

The layout for the Veroboard is shown in **Fig. 4**. However, before soldering any components in place, four mounting holes of suitable diameter must be drilled in preparation for mounting into the case.

The order of assembly is not critical but a left to right approach is recommended. You may also wish to use DIL sockets for

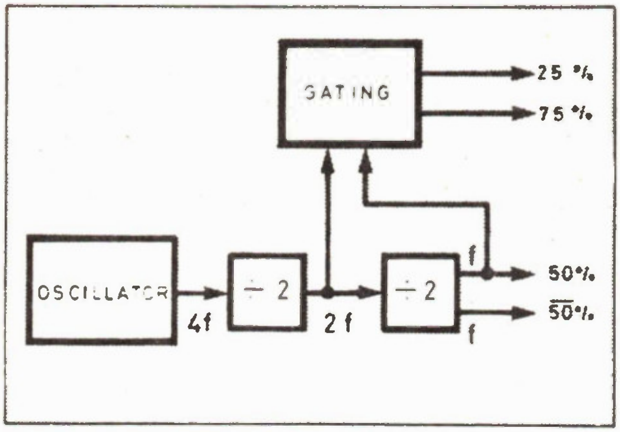


Fig. 1 Block diagram of the Digital Pulse Generator.

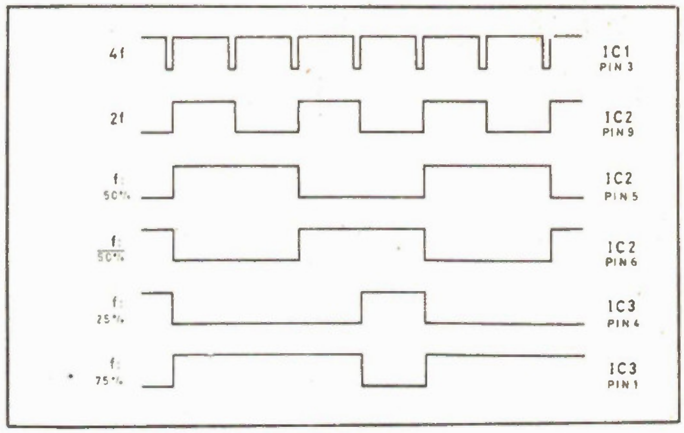


Fig. 3 Overall timing diagram for the Pulse Generator.

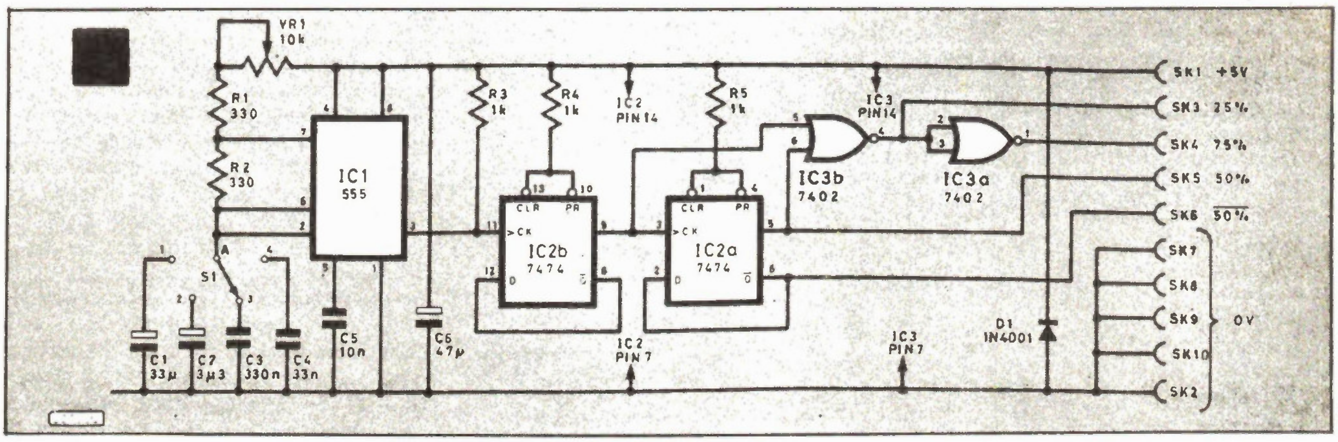


Fig. 2 Complete circuit diagram for the DPG.

the ICs, but these are not essential. Take the usual care in orienting the polarized components (ICs, electrolytic capacitor, and the diode). The wire links are best made using lengths of tinned copper wire; 22AWG or similar is quite suitable. Also, use terminal pins for all the off-board connections that will be made; this will simplify the later installation of the interconnection wiring.

Carefully inspect the board for all connections and wire links, as well as solder bridges etc. Once everything looks satisfactory, you're set for testing.

Testing

The first step is to measure the supply current drawn by the unit. This should typically be in the range of 30 to 40mA for a +5V supply with no loads connected to the outputs. The higher current figure is to be expected when VR1 is set to the maximum frequency end of its range, and the lower figure when it's set to the minimum frequency. Any significant deviation from these figures should be investigated before proceeding. If the supply current is significantly higher it's possible that the supply has been connected with the wrong

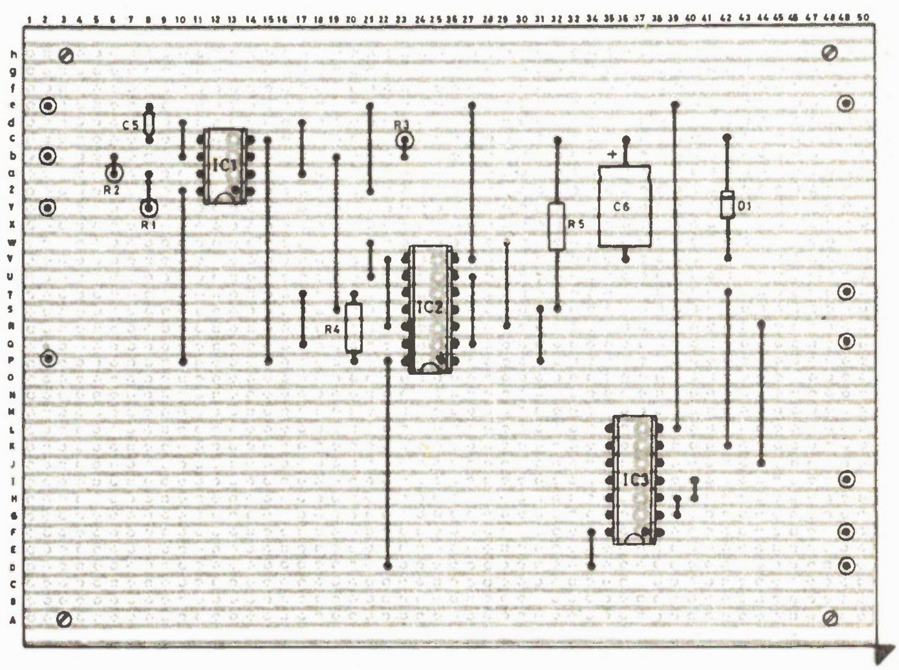


Fig. 4 Veroboard layout and details of breaks to be made in the underside copper strips. Breaks are required in the following locations: F37, G37, H37, I37, J37, K37, L37; P25, Q25, R25, S25, T25, U25, V25, Z13, a13, b13, and c13 (total of 18 cuts).

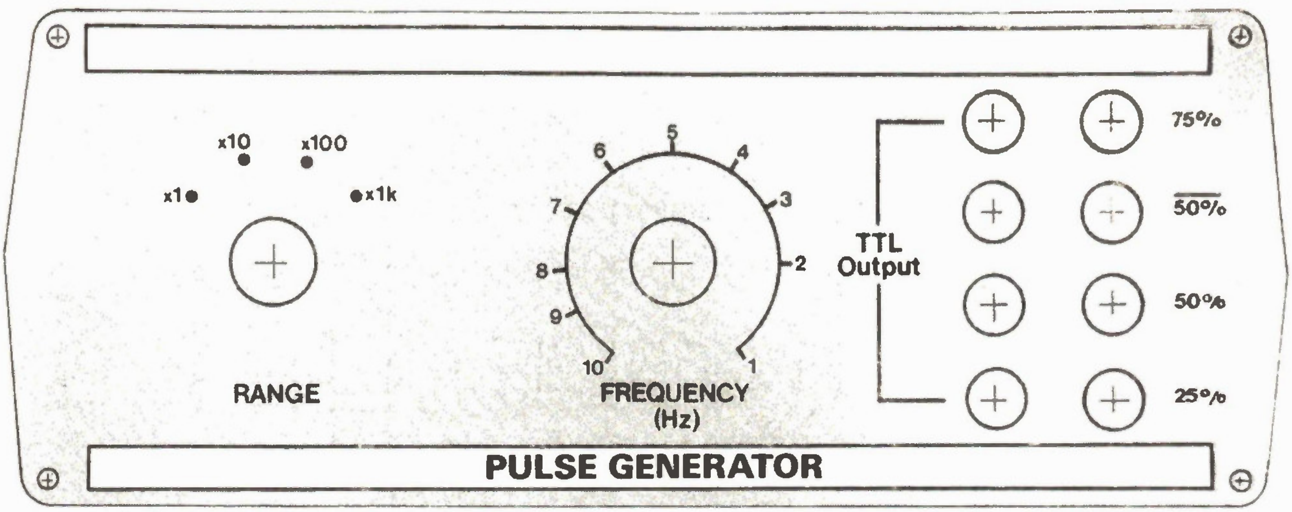


Fig. 5 Full-size front panel layout. The final calibration may vary slightly to that shown.

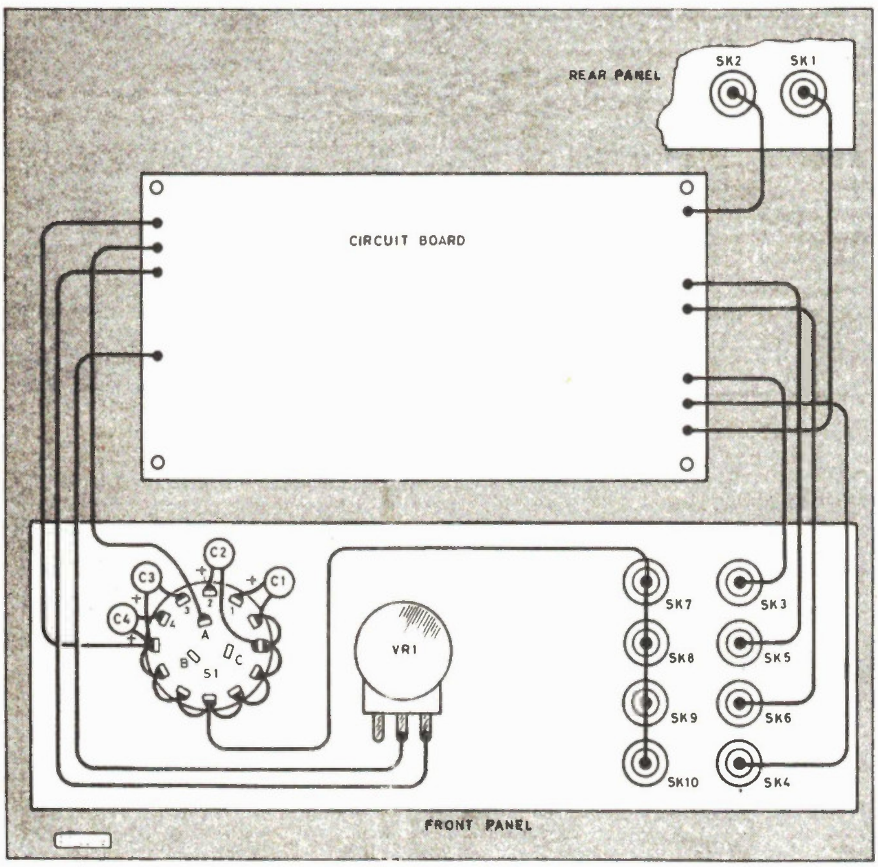


Fig. 6 Assembly and interwiring details.

polarity, and that D1 is conducting.

Next, set the instrument to the lowest frequency range and adjust VR1 to give the lowest frequency. A multimeter connected to SK3, SK5, SK6, and SK4 in turn should indicate a 1 Hz output signal, but with different duty cycles. If an oscilloscope is available, the output waveforms may be checked against the timing diagram shown in Fig. 3. Alternatively, four LEDs can be connected in a forward biased configuration (one for each output) directly between the outputs and 0V; the cathode of each diode should be connected to 0V. At the lowest frequency, the timing relationships will then be visible for all four outputs at the same time. Constructors should note that this technique is only suitable for standard 74 series TTL. In addition, it should be noted that although the logic states indicated by the diodes (i.e. "on" = "high") are correct, the levels themselves will not be correct TTL levels while the diodes remain connected. The LEDs cannot, therefore, be left permanently connected in this fashion. If permanent indicators are required, the outputs to the diodes will need to be buffered by additional gates. If a frequency counter is available, the unit may finally be checked on all four ranges. Any frequency errors between ranges are likely to be due to component tolerances, particularly of C1 to C4.

In use, the unit is capable of driving up to ten standard TTL loads from each output. This in practice means that up to 800uA may be sourced in the "high" output state, while up to 16mA may be sunk in the "low" state. A "low" output here is any level below +0.8V, while a "high" output is any level above +2.4V (typically it's +3.4V). ■

Parts List

Resistors

R1, R2 .... 330R 0.25W, 2%
R3,R4,R5 . . 1k 0.25W, 10% all carbon film

Potentiometer

VR1 .... 10k logarithmic

Capacitors

C1 .... 33uF 16V tant. elect.
C2 .... 3.3uF 16V tant. elect.
C3 .... 330nF polyester (10% or better)
C4 .... 33nF polyester (10% or better)
C5 .... 10nF polyester or ceramic
C6 .... 47uF 16V elect.

Semiconductors

D1 .... 1N4001
IC1 .... 555 (8-pin)
IC2 7474
IC3 7402

Miscellaneous

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SK1,3,4,5,6 .... 4mm red socket
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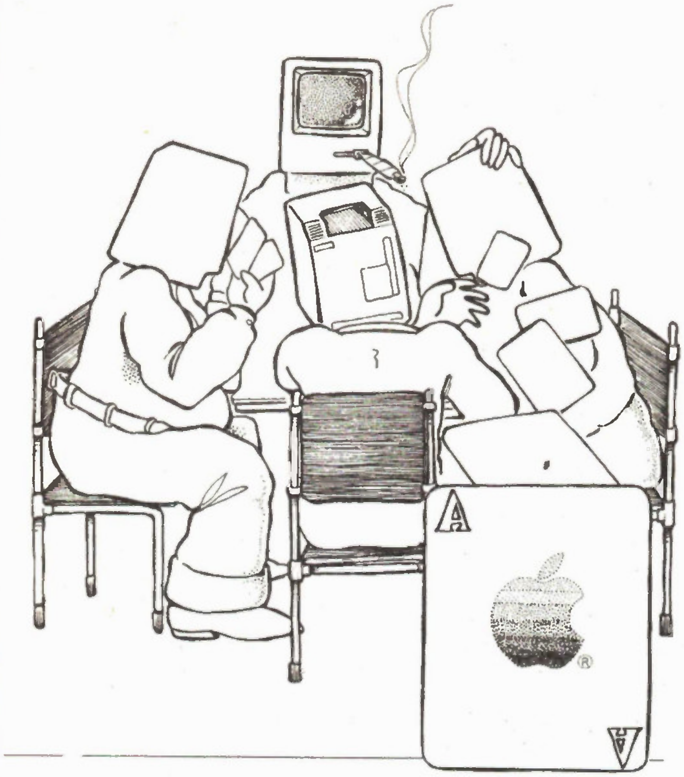

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Review of Colour Printers

We didn't find a pot 'o gold at the end of the rainbow, but we did discover four colour printers in need of review.

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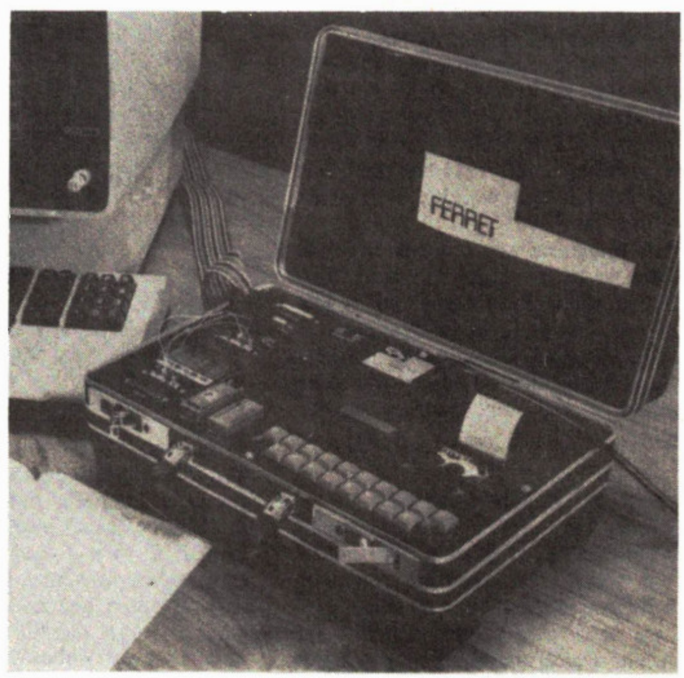

Computer Troubleshooting

Troubleshooting computers doesn't have to mean stabbing in the dark with a logic probe or scope. Sophisticated, easy-to-use test equipment abounds, and we look at some of the models available.

Reliability

How and why does equipment of any kind fail? Can it be predicted and something done about it? What exactly is MTBF? Answers next month.

Build a Bulk Eraser

Take 300 pounds of pink rubber... No, but seriously, next month author Harold Wright describes the construction of an eraser for restoring audio tapes to blank purity.

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Continued from page 7

climbed from being the smallest in the market to become number one and a big corporation with a matching cheque book made us an 'offer we couldn't refuse'. As part of the sale agreement, I took over ownership of the Canadian company but was also put in the extraordinary position by that same agreement of having to run the British company for at least one and a half years, without being allowed to take any interest in the Canadian company. On the day that this agreement expired (February 1980) I quit and the next day emigrated here with my family; I am now a Canadian citizen. Since that time the company has been 100% Canadian and we now have only ancestral links to the other editions of Electronics Today in Australia and the UK.

People and Magazines

Many of the people who have worked on Electronics Today are still around in other capacities. Steve Rimmer joined us in early 1981 as Assistant Editor and now is Editor of Computing Now! His replacement, Bill Markwick is now Editor of this magazine. Our first regular freelancer, Roger Allan, is now on staff as Editor of our magazine Computers in Education. Ed Zapletal, the Assistant Editor of ETI, started with us as a summer student and later joined the staff.

Electronics Today has become the parent of several other magazines. We introduced Teaching Electronics and Computing (TEC) in February 1982. In April 1983 we launched Computing Now!

We bought a magazine called Computers in the Classroom in January 1984 and amalgamated it with TEC to form Computers in Education. We launched Software Now! in late 1984 but there was not the market and we closed this just over a year later.

Pets Magazine was acquired in April 1985 and we have just taken over a fifth title, Government Purchasing Guide. The last two are about as far as one can get from the electronics/computing markets but this is deliberate, we don't want to be dependent on any single market for our future.

Where Next in Electronics?

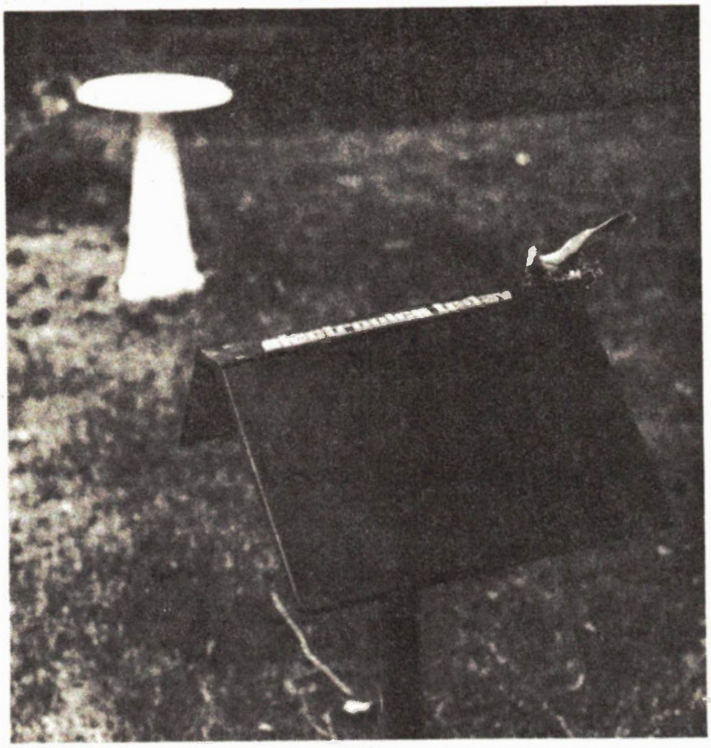
Where next for ETI? The electronics market has changed dramatically in the last ten years. The electronic novelties which formed the backbone of many projects are now being produced in the far east in enormous quantities and varieties at very low prices. Sophisticated electronics in the home ten years ago was limited to a colour TV set; now there are video recorders, compact discs, camcorders, synthesizers, cellular phones and home computers with a power unimaginable ten years ago. Canadians, like the rest of the western world, have become hooked on owning high technology.

When it was suggested that I do a personal piece for first issue, I was asked to look into the crystal ball about what would happen in the next ten years; I'm going to skip that. I did a piece in Britain about twelve years ago guessing what things would be like today - I got it about 99 wrong! I imagined personal calculators of enormous power hooked by radio to a Telidon-like data base - a sort of personal portable computer terminal - to a giant mainframe. I can join in the laughter at myself, I wish I had never written it, especially as it went into syndication and was reprinted heaven knows where. We want to forget our mistakes. If I guessed now, I would probably be just as wrong.

The only thing I am prepared to stick my neck out on is that our love affair with high technology has being going on since long before that term was adopted and, unless there is a massive move back to nature and a major rejection of technology, this will continue.

The 1920's were a very exciting time for rapid adoption of technology. Although that decade was nothing special as far as invention was concerned, it was a time of enormous change. The period opened with a lifestyle that was not so very different from a hundred years before but closed with radio a major force, widespread use of the phone, motor car and above all, electricity with all the domestic uses that this made possible. From that time until the last ten years, there has only been television and hi-fi as a major new technologies to find its way into the home. Since then? Well, it has been incredible and I don't see it stopping now. Maybe robots...

No, I said I wouldn't guess; I don't want to have my guesswork in print to haunt me! ■



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One of our favourite binder ads, from the October 1983 issue.

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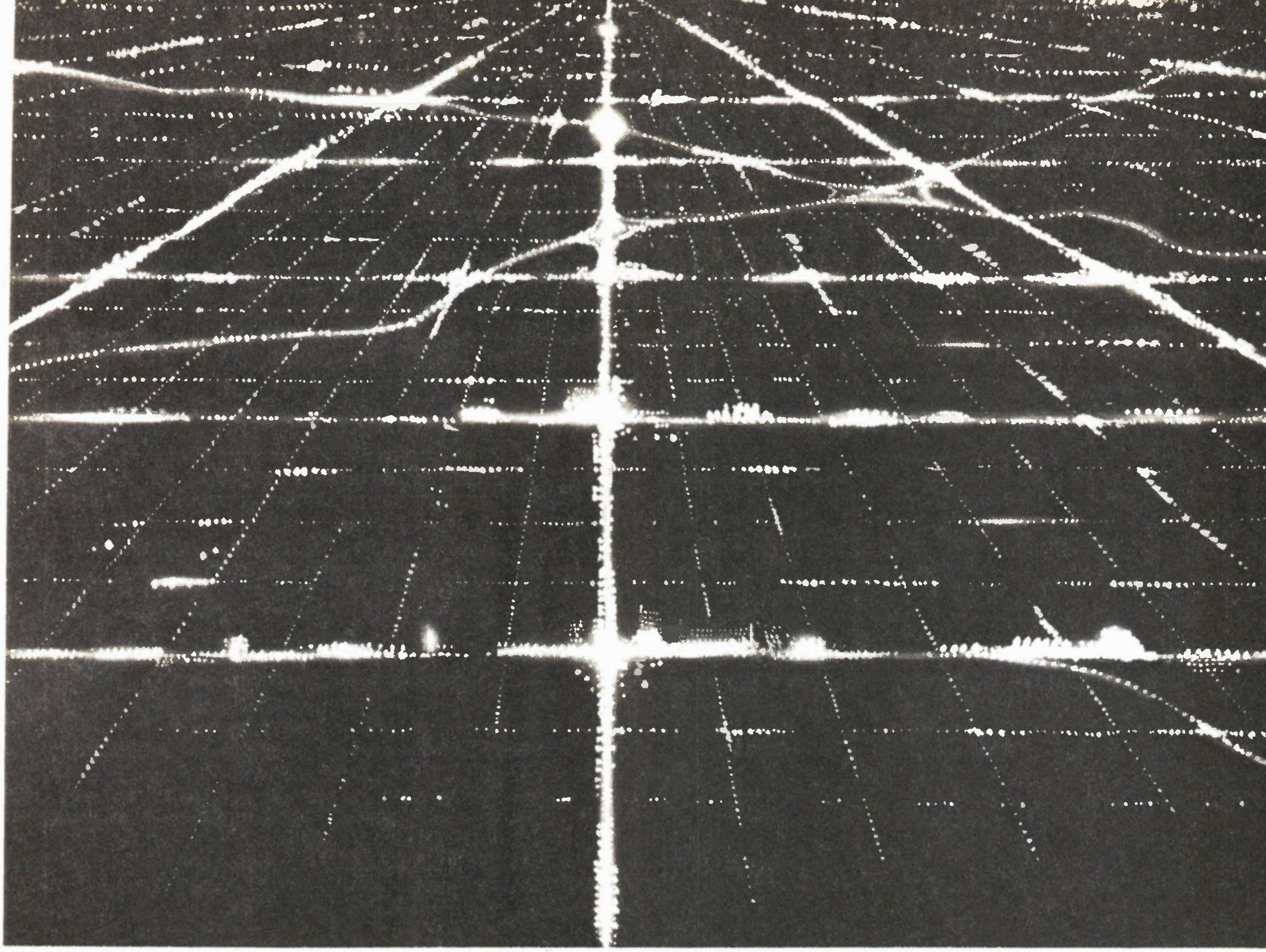


8088 Programming: Interrupts Part 2

More on how MS-DOS uses interrupts in handling in/out routines.

By Ellery Henn

TWO issues ago an in-depth foundation was laid regarding BIOS and DOS interrupts, and we're going to pick up this month with a closer look at screen interrupts specifically, and screen handling in general. We'll also look at printer interrupts. The only supplementary program you'll need for the 8088 assembler examples shown below is DEBUG.COM, one of the utilities on your DOS master disk.

One of the problems computer salesmen have in selling IBM computers and compatibles to interested clients is explaining the various video cards available, their usual lack of compatibility with each other, what monitor is best with a given card, and what software will die a horrible death if it attempts to use a given card. For example, IBM's standard colour graphics adaptor (CGA) generally gives you universal software compatibility, but at a cost of screen resolution. IBM's monochrome TTL adaptor offers laudable text resolution, but your copy of Exploding Poultry from Beyond with the latest in real-time graphics animation isn't compatible with it. A Hercules monochrome graphics adaptor will allow many graphics programs to operate on a high resolution TTL monitor, but most games programs like Exploding Poultry still won't work. Of late, video cards from third-party vendors such as ATI and Emulex have more effectively bridged the gap by offering CGA emulation on a monochrome TTL screen. We won't even attempt to get into the higher resolution cards like the EGA and PGA.

Foregoing graphics for the moment, what all this means is that, of the various ways of getting characters onto an IBM's screen, a programmer will generally opt for a method that will allow his program to operate successfully on most available video cards, unless speed is a requirement.

A Pig and a POKE

Various methods are available for the IBM assembler programmer to introduce characters to the screen. These include routines through BIOS Interrupt 10H and DOS Interrupt 21H, and video card-specific POKEing. Note that BIOS interrupts, while more than acceptable for IBMs and true compatibles, may not be quite the same in other machines which are compatible only in the estimation of the fellows who sell them. We'll have a look at DOS Interrupt 21H first.

Our present objective, noble as it is, is to simply print a happy face on the screen. By introducing the value of 2 into the AH register and the ASCII value of the character you want to print on-screen into the DL register, that character is printed when you call Interrupt 21H. We did this with the letter 'A' last month, but to refresh your memory, put your DOS disk in drive A:, and call up DEBUG ...

```
A: DEBUG
-A100
2E96:0100 MOV AH,2
2E96:0102 MOV DL,2
2E96:0104 INT 21
2E96:0106 INT 20
2E96:0108
-G=100
```

As mentioned last month, the 2E96 shown above is the segment address in RAM that we're assembling in. The chances are very good that your segment address won't match it. Don't pay it any attention.

When you've typed G=100, your eight-byte program will immediately execute from address 100H, and -- no matter what video card you're using -- you'll be staring at a happy face on your monitor if you've typed everything in correctly. DEBUG will give you the message 'Program Terminated Normally'.

This technique is limited, though, in that you may only print a character wherever the cursor happens to be. You'd be in for a lot of programming if you wanted to centre the happy face on the screen using only Interrupt 21H. Fortunately, BIOS Interrupt 10H allows you to position your cursor anywhere on the screen by MOVing the value of 2 into the AH register, the row number into register DH, the column number into the DL register and the page number (useful for animation, but we'll be using page zero for now) into the BH register. To approximately centre a character on an 80 by 25 matrix, we'll use 0DH (13 decimal) for the row, and 27H (39 decimal) for the column. The program we're about to write will position the cursor and print the happy face. So, back to DEBUG:

```
-A100
2E96:0100 MOV AH,2
2E96:0102 MOV DH,0D
2E96:0104 MOV DL,27
2E96:0106 MOV BH,0
2E96:0108 INT 10
2E96:010A MOV AH,2
2E96:010C MOV DL,2
2E96:010E INT 21
2E96:0110 INT 20
2E96:0112
-G=100
```

When the dust settles, the happy face will be in the centre of your screen, and your cursor will be displaced a line or two underneath the happy face.

Oddly, most of the programming you'll be doing -- unless you're writing a text animation program -- will involve more than one character. In fact, you'll probably want to print a whole pile of them onto the screen. Interrupt 21H allows you to accomplish this by taking text strings terminated with a dollar sign from memory and dumping them consecutively onto the screen.

Using a dedicated assembler like MASM, text strings are placed into memory through DB (Define Byte) statements like this:

```
TEXT1   DB 'Tutorial',0DH,0AH,'$'
```

Through DEBUG, however, the text string has to be entered in hexadecimal either before or after the assembler code. I usually prefer to type it in afterward, so I needn't bother learning the new start address of the code.

You may use the cursor positioning code to print a string anywhere on your monitor if you like, but in the following example we're going to print the word Tutorial wherever the cursor happens to be. In hexadecimal, 'Tutorial' followed by a return, linefeed and dollar sign looks like this:

```
54 75 74 6F 72 69 61 6C 0D 0A 24
```

After typing in the code, we'll be using the Enter function of DEBUG which permits you to change individual bytes of memory. The bytes that appear as '00' below are the bytes that we're changing. To go to the next byte, hit your spacebar. When you've finished entering them in, hit return. Here's what to type from DEBUG:

```
-A100
2E96:0100 MOV AH,9
2E96:0102 MOV DX,0109
2E96:0105 INT 21
2E96:0107 INT 20
2E96:0109
-E109
2E96:0109  00.54  00.75  00.74  00.6F
00.72  00.69  00.61
2E96:0110  00.6C  00.0D  00.0A  00.24
-G=100
```

For your efforts, you should see the word 'Tutorial' and the 'Program Terminated Normally' string.

By MOVing 9 into the AH register, Interrupt 21H knows we want to print a string, so it looks at the DX register to find the address where the string starts. It finds an address of 109H and proceeds to print each subsequent character it finds from there until it sees a dollar sign (24H). The program then continues to INT 20, which wraps things up.

POKEing Fun

No matter what video card you happen to be using, it has a given amount of RAM on it for its text video display. A minimum of 4K is required for an 80x25 (2000 bytes) character screen and their screen attributes (another 2000 bytes), which we'll be getting into shortly. A screen of 640x200 graphics would require 16K to display. Because there is on-board video RAM, we can choose to POKE characters directly to it. This has the benefit of speed, as we're dealing directly with the video card, and not with long routines to gently print characters to it. Two disadvantages remain, though. The CGA's RAM begins at segment:address Hex B800:0000, whereas the monochrome adaptor's RAM starts at segment:address Hex B000:0000. So, where you POKE makes a difference. Also, POKEing directly to screen RAM on the colour graphics adaptor has the unusual side affect of "bumping" the display; it jumps visibly and white "static" may appear for the duration of the POKEing process. You may have noticed this when using Borland's *SideKick*, for instance. This method is generally used in animation or programs where text must appear on-screen, but not permanently displace the text already there.

DEBUG experimenting with screen RAM POKEing is easy. Before we get to it though, permit me a small discourse pertaining to the way screen RAM is mapped out. IBM character RAM on the CGA begins at segment:address B800:0000 and ends (on-screen) at B800:0FA0. For the monochrome TTL card, the addresses are the same, but the segment is B000 Hex. Characters cannot be POKEd into consecutive addresses, however, as after every character location resides an attribute location dedicated to it. So, on the CGA where B800:0000 is a character address, B800:0001 is its attribute address. B800:0002 would be another character address, and so on.

Attributes are what give characters ... character. By POKEing an appropriate value into an attribute byte, its related character may turn bright, flash, become an inverse character, or turn into any combination of colours, among other things. While you won't get colour on a monochrome TTL card, you can get on-screen underlined characters this way. Here are a few attributes in hexadecimal you can try out on the DEBUG session below:

Normal Intensity - 07
Reverse - 70
Blinking - 87
High Intensity - 0F
High Intensity Blinking - 8F
Blinking Reverse - F8

If you're still in DEBUG, type Q to get out of it, as you'll want to clear the screen to see what you're doing. Then type:

```
A:CLS
A:DEBUG
-EB800:0000
B800:0000 20.41 07.70 20.41 07.8F
```

Remember to use the spacebar to go from byte to byte. Also remember to type EB000:0000 if you've got a monochrome TTL card.

When you type in the above with the CGA card, you'll end up with two A's beside each other, one reversed, and one brighter than the other and blinking. Experiment with the given attributes, and, if you've got a colour monitor, try random hexadecimal numbers for the attribute bytes.

A La MODE

The colour graphics adaptor has a few other tricks up its sleeve. You may, for instance, have a use for its 40 by 25 character text capability. Or, perhaps you'd prefer the nonexistent cursor (but slower scrolling) that the 640x200 mode has. Whatever your preference, Interrupt 10H can handle it. Available video modes through INT 10 are 40x25 B/W alpha, 40x25 colour alpha, 80x25 B/W alpha, 80x25 colour alpha, 320x200 colour graphics, 320x200 B/W graphics and 640x200 B/W graphics. To accomplish each mode, the AL register should have one of these values in it. Respectively, 0,1,2,3,4,5 or 6.

If you haven't guessed, this is what the MODE command accomplishes through DOS. A DEBUG example to plop you into 40x25 black and white text would go like this:

```
-A100
2E96:0100 MOV AH,0
2E96:0102 MOV AL,0
2E96:0104 INT 10
2E96:0106 INT 20
2E96:0108
-G=100
```

To get back to the more comfortable 80x25 black and white text, type:

```
-E103
2E96:0103  00.02
-G=100
```

Should you be playing with the graphics modes, you may want to POKE numbers onto your screen using the method used earlier. There are a few differences to be noted, however. There aren't any attributes in the graphics modes, as they're not necessary. Also, you can't POKE letters onto the graphics pages unless you want to do it the hard way ... by taking their bit patterns and POKEing them in. Note that it'll take eight bytes per letter to do so. You may, however, use the previously discussed methods through INT 10 and INT 21 to print characters on these pages.

There is a 2000H offset between each graphic line on the graphic pages. This means that to print four one-byte lines underneath each other on the upper left corner of the screen, the addresses to POKE FFH into would be B800:0000, B800:2000, B800:0050 and B800:2050. We'll get further into graphics in a later issue.

Hold the Presses

If you've got a printer attached to your IBM, actually getting it to print through 8088 assembler isn't all that difficult. In fact, it's almost unavoidable as there are two dedicated interrupts for printing, and INT 21 can handle a print function as well.

Not surprisingly, we can hook into the **PrtSc** function (printing a screen of text) through assembler, using INT 5. In fact, all you have to do is make sure your printer is on and type:

```
-A100
2E96:0100 INT 5
2E96:0102 INT 20
2E96:0104
-G=100
```

Mind, if you've got a daisywheel, you may not want to do this that often unless you've got a lot of time or a print spooler installed.

INT 17 is also a dedicated printer interrupt, albeit somewhat more versatile. To initialize your printer through 8088 assembler, MOVe the value of 1 into AH, the printer number (usually zero) into DX, then call INT 17. Similarly, if you want to print a character, MOVe the value of zero into AH, the hex value of the character you want printed into AL, the printer number into DX and call INT 17. For instance,

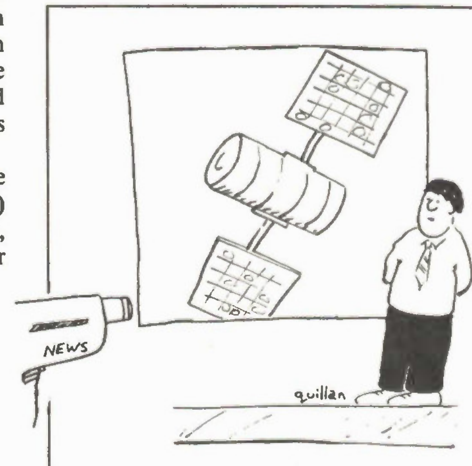
```
-A100
2E96:0100 MOV AH,0
2E96:0102 MOV AL,41
2E96:0104 MOV DX,0
2E96:0106 INT 17
2E96:0108 INT 20
2E96:010A
-G=100
```

... will waste a sheet of paper by printing an "A" on it. Interrupt 17H also reads the status of your printer into the AH register. Check out the IBM Technical Reference Manual for more information.

Interrupt 21H will do for a fast print without any printer status checking (dangerous if you've run out of paper). Typing this in will do the same thing as the last example except INT 21 will be used.

```
-A100
2E96:0100 MOV AH,5
2E96:0102 MOV DL,41
2E96:0104 INT 21
2E96:0106 INT 20
2E96:0108
-G=100
```

Using quick DEBUG examples, we've covered a few of the more popular ways of getting characters onto your screen and printer through 8088 assembler. ■



"THE SATELLITE PICTURE DOES NOT TELL US MUCH ABOUT TOMORROW'S WEATHER."

MIDI Thru Box

This simple Thru Box tidies up one small problem with MIDI: it provides ports for up to four instruments to achieve data output simultaneously, avoiding chaining delays.

By Simon Leadly and Michael Horn

THE MIDI STANDARD allows synthesizers from one manufacturer to send and receive information from completely different synths or sequencers.

Most MIDI instruments these days are equipped with a MIDI-in, a MIDI-out and a MIDI-thru port. No doubt you're familiar with these, but just in case your not, here's a re-cap.

Think of your synth (or drum machine) in two parts: the 'controller' (eg the keyboard) and the 'sound generating module' (the part that actually puts out the sound). MIDI information is control information; it's the messages sent from a keyboard, say, to a sound generator in a synth. If you press a 'D' on a keyboard, for example, this information is sent from the MIDI-out socket ('play a D') and goes to the sound generator of another synth via its MIDI-in socket. Both synths then play a D.

When you connect two synths this way (MIDI-out from one to MIDI-in on the other), the keyboard on the second instrument is not active (control info is coming from the first keyboard), so no MIDI-out information is present at the second (slave) keyboard's MIDI-out socket. End of the line.

However, the clever people who developed the MIDI specification realized that you might want to connect more than two instruments, so they included a MIDI-thru socket which is basically a replica of that control info coming into the MIDI-in from the first keyboard. Using MIDI-thru, therefore, you can pass control info down a 'chain' of instruments; MIDI-out to MIDI-in, MIDI-thru to MIDI-in etc.

Theoretically this chaining can go on forever, but there's a catch. For various reasons, like the need to simplify the grounding situation, MIDI information is not transmitted *physically* from instrument to instrument. Instruments are coupled 'optically' using optocouplers, i.e., the message is translated to light and back at each MIDI connection. This translation process takes time, not a noticeable amount of time for a setup which includes only a couple of instruments, but it accumulates with the more instruments you chain together. If you were to chain four or five keyboards one after the other (**Fig. 2 top**), you might notice that the last one played a little after the first.

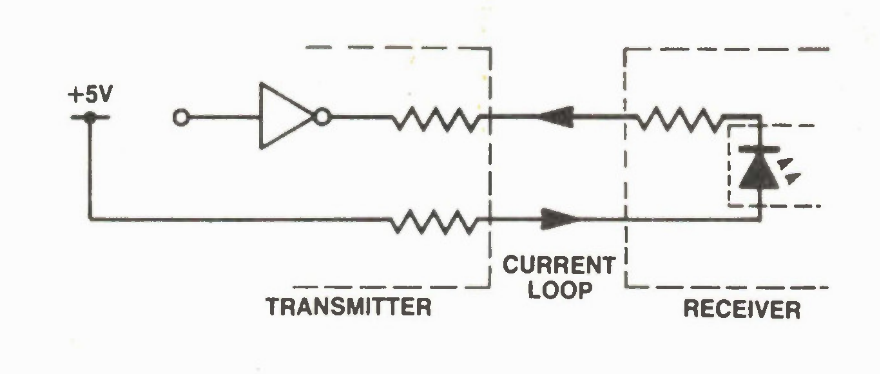


Fig. 1 The current loop system; the transmitter provides the loop current and is electrically isolated to obviate loops that can cause ground hum.

The MIDI Thru box will alleviate this problem by allowing you to connect you instruments in a 'star' configuration, rather than a chain (**Fig. 2 bottom**). In this case, the delay caused by the optocouplers is the same for all instruments connected to the MIDI-thru ports. It doesn't accumulate, and therefore shouldn't be noticeable.

The Circuitry

The Thru Box is a very simple device, really only a buffer that takes one input and provides four identical outputs. The MIDI standard uses a current loop system for the data transfer so that it is relatively immune to noise that could otherwise find its way on to the data lines, but MIDI Spec 1.0 limits the length of the connec-

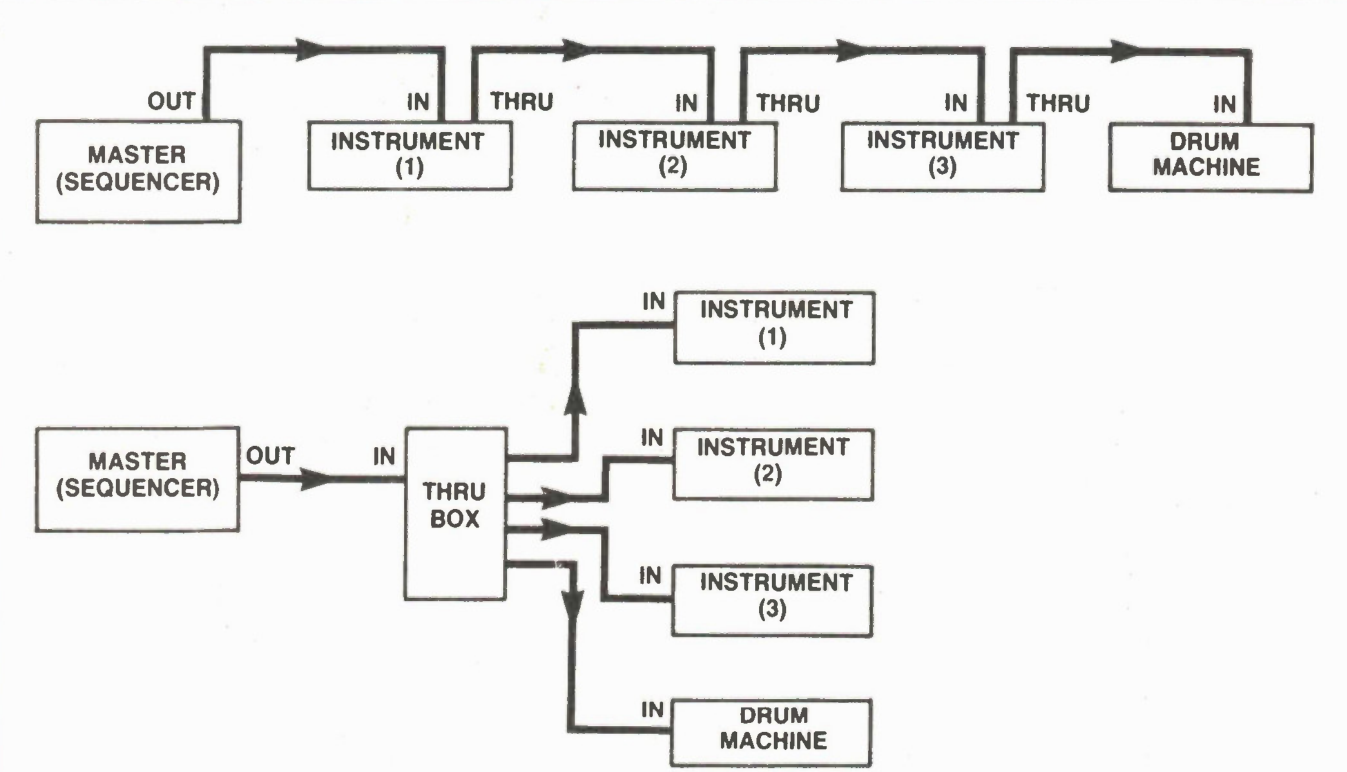
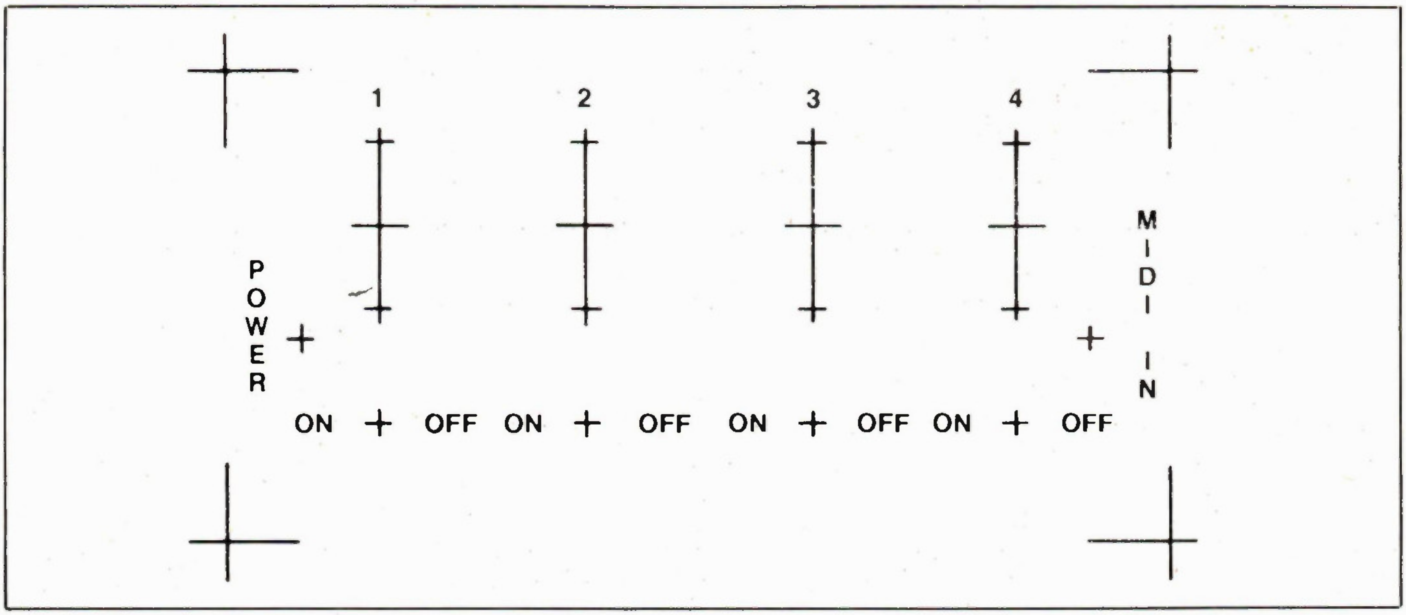
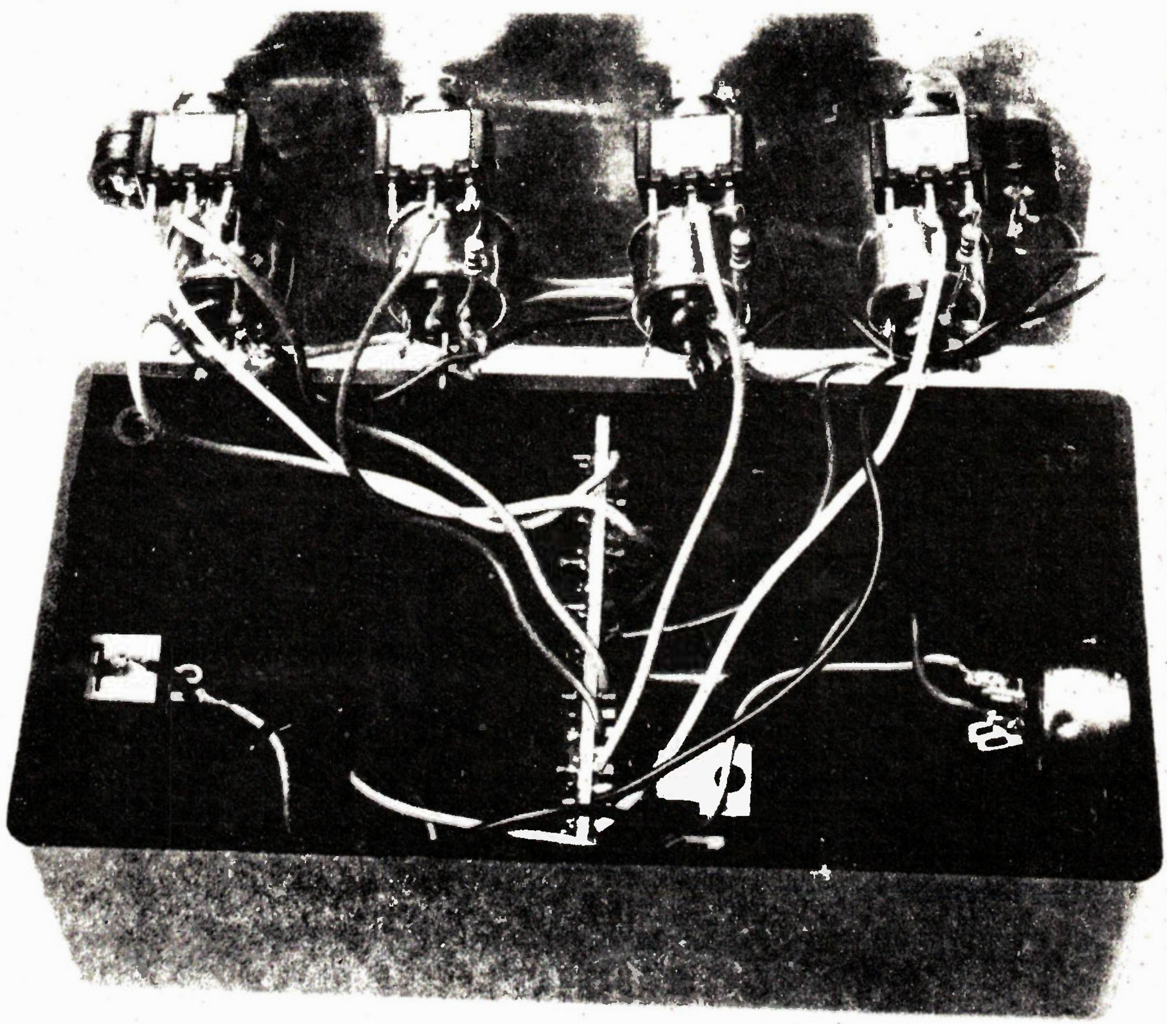
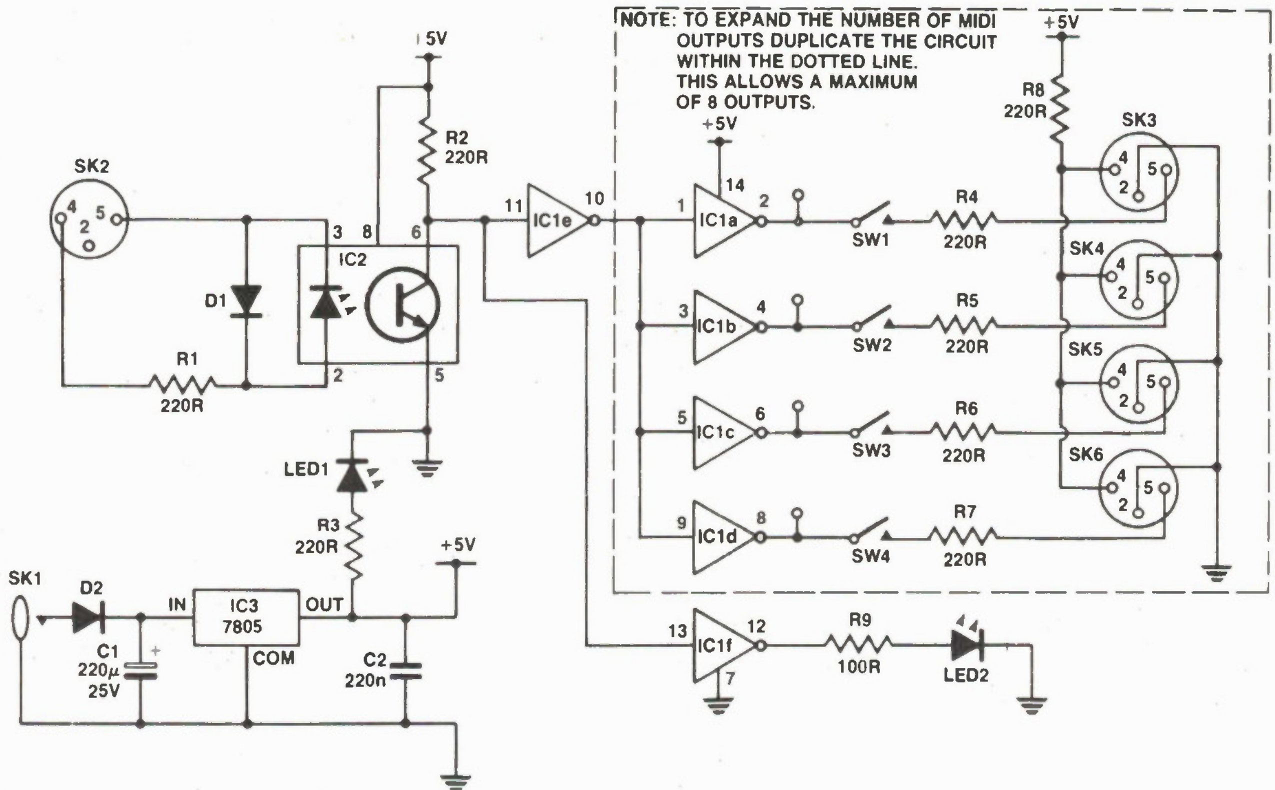


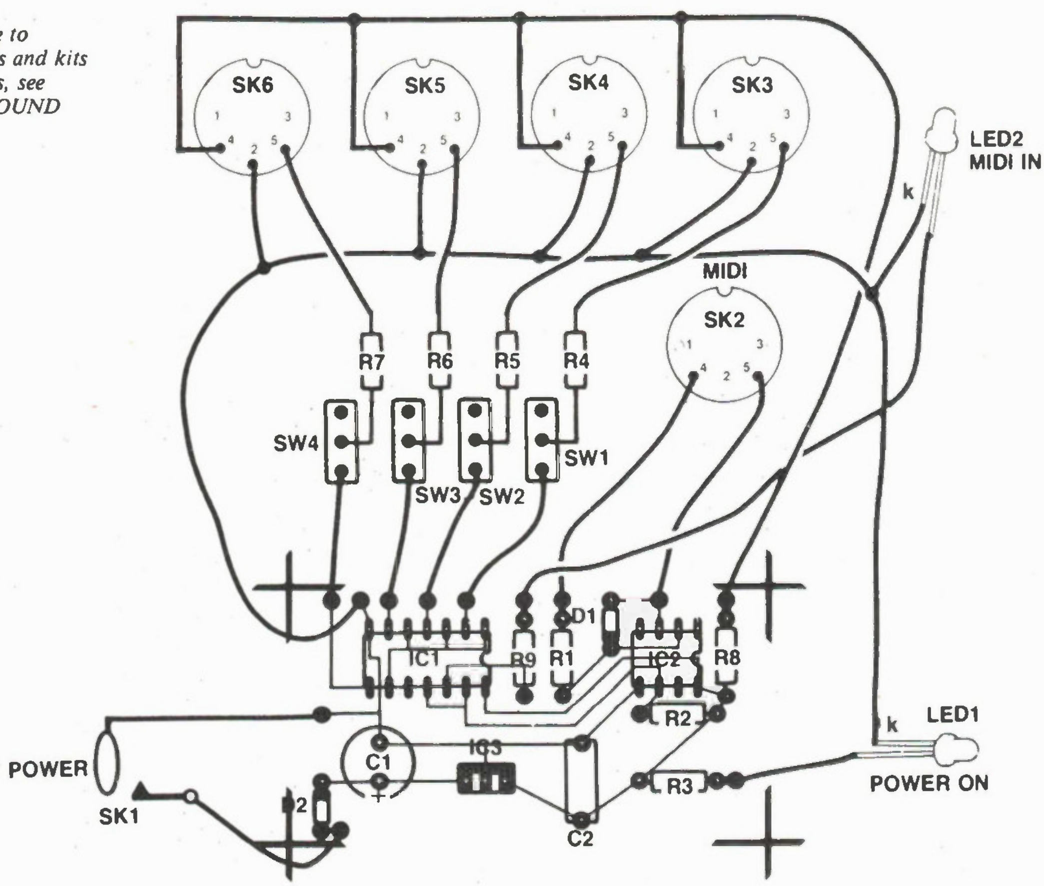
Fig. 2 Setting up the Thru Box. Top is the chained arrangement without the Thru Box in which delays occur in the instruments last in the chain. Underneath shows an arrangement with no chaining delays, each instrument receives the MIDI data at the same time. An instrument may be disabled by using the MIDI disable switch on the Thru Box.


1
2
3
4
POWER
MIDI IN
ON
OFF
ON
OFF
ON
OFF
ON
OFF





For a guide to components and kits for projects, see SHOP AROUND this issue.



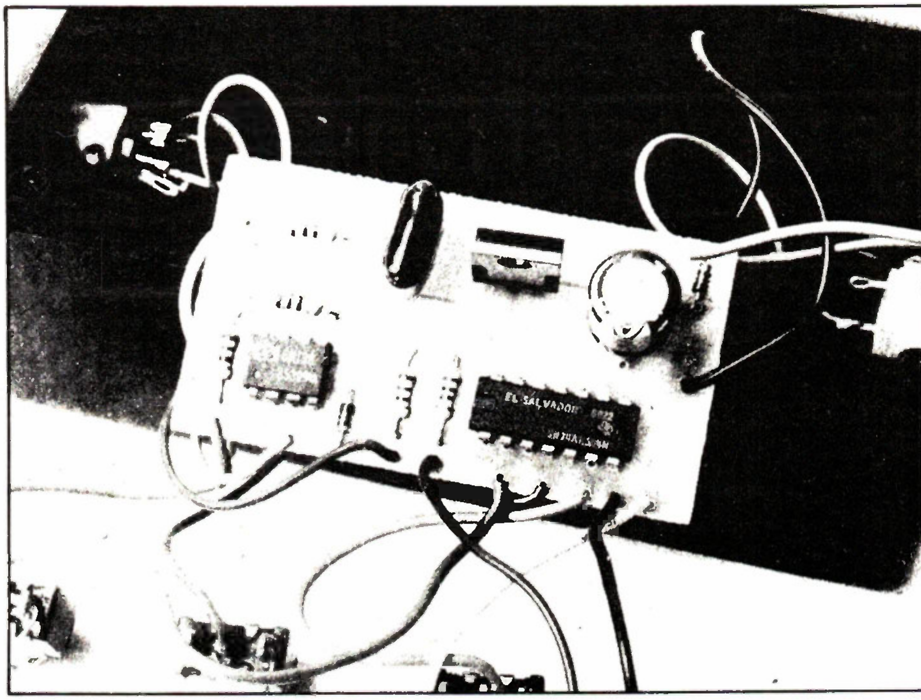
How It Works

MIDI information is applied to the input socket. A current loop is formed by the diode in the optocoupler sitting in parallel with the input pins. Diode, D1, guards against reverse polarity.

Output from the optocoupler is taken by an inverter at the beginning of the output chain. Since the 74LS04 is a TTL device, up to eight inverters can be driven by the one output while still remaining within TTL rules. Provision has been made for four outputs on this board, although more could be added very simply in parallel.

The output current loop is provided via the 220 ohm resistor to pin 4 of the four output sockets, then through the device hanging off the output and finally back in pin 5 of the Thru Box outputs. The state of the output buffers dictates whether current will flow.

To provide an indication of whether the MIDI input is being exercised, one of the inverters on IC1 is used to drive LED2. This will light whenever pin 12 of IC1 goes high. LED 1 is taken from the output of the 7805 so it provides a power-on indicator. D2 functions to protect the regulator IC3 against incorrect polarity on the connection, which needs to be 9VDC.



ting leads to 15 meters.

The incoming data is converted to a standard TTL level by the 6N138 optocoupler. This is buffered by the 7404 TTL hex inverter and converted to a current drive, presented at each MIDI-out socket. Four outputs are provided but this number may be increased simply by adding more of the inverter sections and connecting their inputs to the optocoupler output.

One inverter and an LED are used to provide the unit with a visual indication of incoming MIDI data.

The power supply is fed from a 9V plugpack, filtered and regulated to give a 5V supply. An LED is placed at the output of the regulator to give indication that power is being applied to the unit.

Construction

All the components are contained on a small PC board. Begin by placing all the resistors and capacitors on the board taking care to orient the electrolytic capacitor correctly. Next, mount the ICs again checking for correct orientation.

When you are sure that they are all in the right place start wielding the soldering iron. Since all the resistors are the same value there should be no problems here. Wire up the LEDs with flying leads.

All that is needed now is to connect the power input and the MIDI sockets to the board. It is essential that you wire them exactly as shown or the unit will fail to

Parts List

Resistors (all 1/4W, 5%)

R1-8	220R
R9	100R

Capacitors

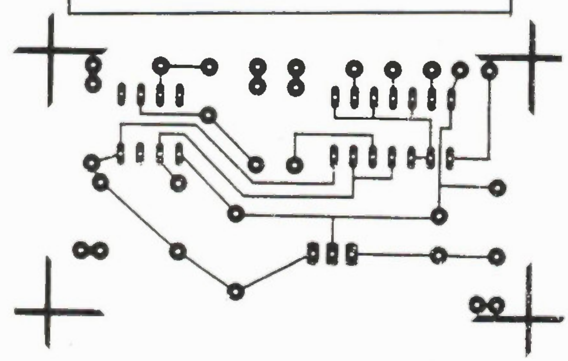
C1	220u, 25V elect.
C2	220n greencap

Semiconductors

D1,2	1N914
IC1	74LS04
IC2	6N138
IC3	7805
LED1	red 3mm
LED2	green 3mm

Miscellaneous

5 x 5 DIN plugs; 1 socket for plugpack; 1 9V plugpack; 4 SPST mini switches; small 310 x 182 x 105mm case.



function. The pin numbers of the DIN plugs are usually found on the plugs themselves. If not, refer to the diagram.

When you have triple checked the wiring connect the plugpack and confirm operation of the power LED, then connect a MIDI keyboard to the MIDI-in jack on the Thru Box from the MIDI-out. Playing notes on the keyboard should cause the MIDI-in LED to light; if it doesn't power down and check all you wiring particularly to the LEDs.

Optional Extras

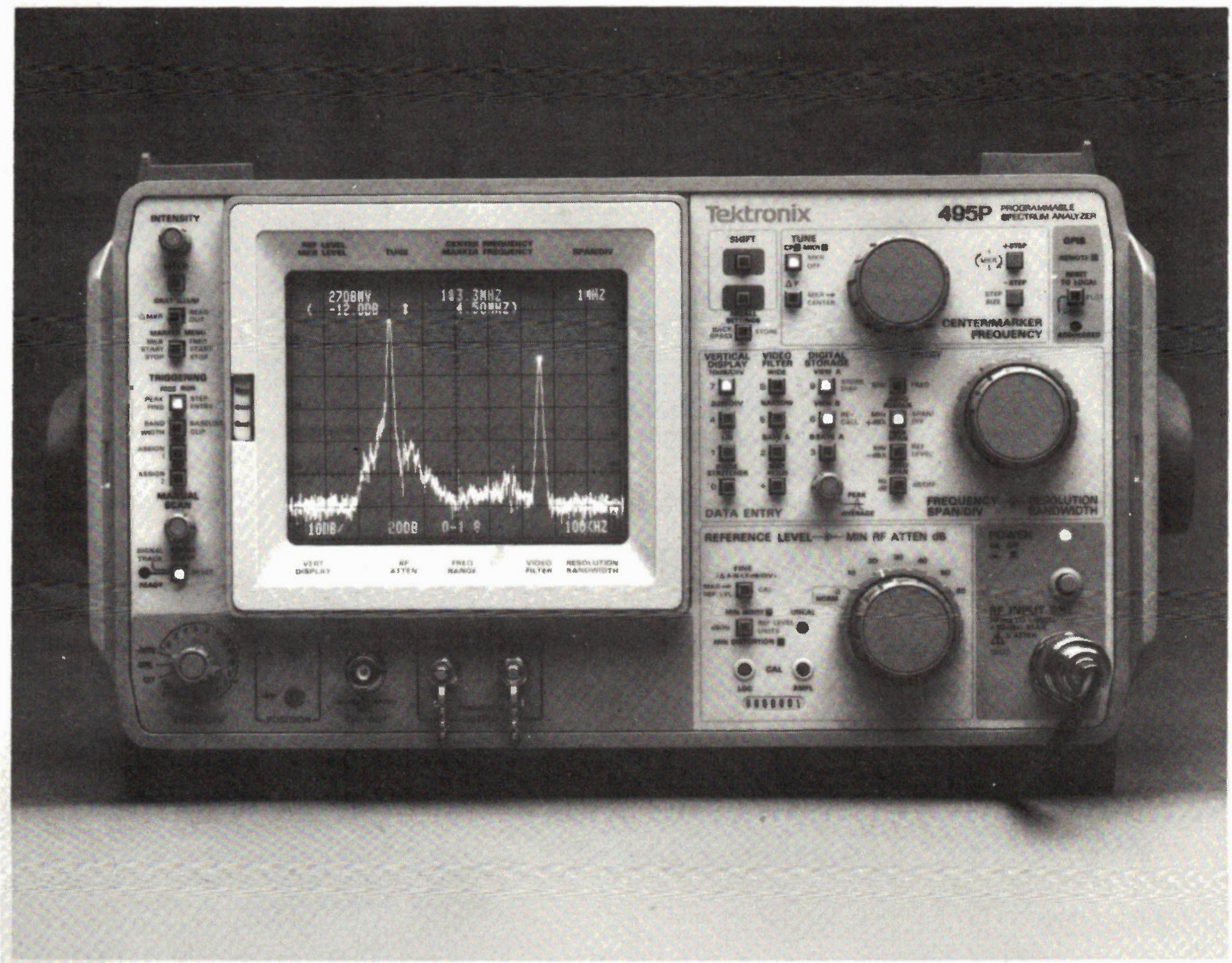
If you wish to have more outputs, all you have to do is get another board and build the hex inverting section leaving out the power supply and the MIDI-in indicator and then connect up as shown.

Switchable outputs can be connected to the unit to disable the MIDI to a particular instrument. This practice of switching the data lines can cause problems particularly if you switch while playing which may cause notes to hang on because no MIDI note off info is received after the switch is turned off. Similarly, some sequencers or drum machines are constantly outputting information on the MIDI bus and can be upset by having the connection broken. ■

A Look at Spectrum Analyzers

The spectrum analyzer opens up a world of information about signals - how it works and how to use it.

By Dr. H. Varani



AS a designer and sometime installer of TVRO systems and equipment, I find the one piece of kit I most depend upon is the spectrum analyzer. When I need to know what is happening in the RF system, with regard to frequency, power levels (signal and noise, power), response, bandwidth, interference, intermodulation and all such things that cannot be left to chance, this instrument is indispensable. A multimeter will check DC power conditions, a signal level meter will assist in accurate antenna pointing, an oscilloscope will tell me a little more about video quality than I can easily deduce from a TV picture, but the ability to view the frequency domain lets me know whether the system is performing as it should, and lets me pinpoint any problem areas.

The spectrum analyzer has generally been a professional's tool, most at home on the microwave engineer's testbench, not because its application is particularly specialized, but because of its high cost. Low-cost analyzers have been produced for American cable TV applications up to 450 MHz, but these are of little use in today's block IF environment. Now we can see Japanese-made general-purpose analyzers breaking the 1GHz barrier at modest prices, and newly emerged in the United States is the simplified budget-priced spectrum analyzer specifically designed for TVRO use.

The spectrum analyzer is a receiver. Unlike most receivers, which are tuned to a specific frequency and remain there for some time, the analyzer is continuously scanned, or swept, over a band of frequencies. In order for us to make sense of what the receiver sees while it scans, its output is presented as a cathode ray tube (CRT) display of signal amplitude (vertical) against frequency (horizontal). The result is a panoramic view of the amplitudes and frequencies of all the signals present in the frequency range being scanned. Just as the familiar oscilloscope allows us to view a signal in the time domain (amplitude against time), the spectrum analyzer gives a frequency domain view of one or more signals.

Frequency Calibration

In order for this scanning receiver with panoramic display to qualify as a spectrum analyzer, it must be calibrated in both amplitude and frequency. The frequency calibration allows the user to set the limits of the band being swept. For instance, he may wish to view an IF block spanning 950 to 1450MHz or to look at a single transponder downconverted to lie between 55 and 85MHz, or indeed to measure a beacon at 4.199GHz plus or minus 0.5MHz. The display (and hence sweep) is normally calibrated at either its start (lefthand edge of display) or centre and this point will be tunable over the SA's full range, from a low of a few kilohertz (or sometimes to 10MHz) right up to the analyzer's limit, which might be 450MHz, 1.8GHz, 12.4GHz, 22GHz or even higher. Frequencies above 2 or 3GHz will be tuned using harmonics of the SA's swept oscillator. Having set the sweep start or centre frequency, a second control determines sweep width or frequency span, over a range from zero (sweep off), through convenient values of kHz and MHz per horizontal division, right up to the analyzer's full sweep width, typically 2GHz for a microwave instrument. The absolute accuracy of a spectrum analyzer's frequency readout is poor (plus or minus 5MHz), but careful use of a calibration oscillator will enable signal frequencies to be read to within plus or minus 1MHz.

Log Display

The amplitude display must be able to show signal level in absolute and relative units (using power rather than voltage). If a linear amplitude detector were used, a tenfold increase in voltage would take the display from 10 percent to 100 percent of screen height, considerably limiting the dynamic range of signals which could be viewed at one time. Instead a logarithmic detector is employed, scaled to make each large vertical division on the screen (usually 1/8 of screen height) represent 10dB or 10 times the power ratio. The screen can then hold a total of 80dB, representing a 100 million-to-one range of signal power, the same as a 10,000-to-one range of voltage. In practice, the usable dynamic range may be 70 rather than 80dB, the bottom 10dB of the screen displaying system noise. To further expand the instrument's handling of signal levels, stepped gain and input attenuation controls are included, the gain being calibrated at each step so that the user knows just what power level is represented by each vertical division on the screen (in dBm, where 0dB equals one milliwatt). The top line of the display is usually the reference and may be set to represent values between -90 and +30dBm (1 picowatt to 1 watt), depending on the range of the attenuators. Absolute accuracy here may be within plus or minus 3dB with a good instrument, and will be improved by careful calibration at the frequency of interest.

Milliwatts, Millivolts, dBm

For those unsure about dB notation, Table 1 relates dBm values to voltage and power units in a 50-ohm system. Using a spectrum analyzer is a sure way to gain familiarity with the decibel. In a 75-ohm environment the relations will be different, and the more specialized 75-ohm analyzer is often calibrated not in dBm but in dB relative to microvolts (dB/uV) or millivolts (dBmV), units more familiar to cable TV technicians.

Bandwidth

The spectrum analyzer also offers control of resolution bandwidth, the IF selectivity of its swept receiver. Too wide and it will be impossible to separate closely spaced carriers or sidebands, or to measure a weak signal embedded in system noise. Too narrow and the receiver will not respond to the highest modulation frequencies in the signal being analyzed. Typical maximum bandwidth is 1MHz or 3MHz, and the minimum will generally be around 10kHz. Sweep rate is also adjustable, and a slow scan speed (with attendant flicker) may be necessary with certain types of signal, or when the spectrum analyzer is used on its narrowest resolution bandwidth ranges. Analyzer with storage displays allow these scan rates to be used without flicker. A variable-video low-pass filter completes the signal processing controls, and enables the HF "grass" (and high-frequency modulation information) to be smoothed out on the CRT display.

TVRO Applications

The spectrum analyzer is unique among our tools in presenting a continuous view of the entire frequency band of interest. The analyzer can be set to display a block IF of 270-770MHz, 450-950MHz, 700-1700MHz, or whatever conversion scheme may be in use. It will show us at a glance the whereabouts of a signal in the band, how strong the signal is, how far above the noise, and to some extent the type of modulation present. This makes it ideal for use when seeking a satellite for the first time, when the receiver's tuning may not be calibrated or the active transponder is not known. By its very nature this situation is more common in the international arena than in North America, where satellites with 24 fully loaded transponders are the norm. **Fig. 1** shows the Statsionar 4 Gorizont downlink band, 3650 to 3950MHz as seen in the United Kingdom at an IF of 850 to 1150MHz (frequency span 50MHz/div., bandwidth 1MHz). **Fig. 2**and **Fig. 3** show a 950-to-1700MHz IF (100MHz/div) representing 10.95 to 11.7GHz, looking at Eutelsat I-F1 (mixed polarization) and Intelsat VA F11, respectively.

Care should be taken in connecting a

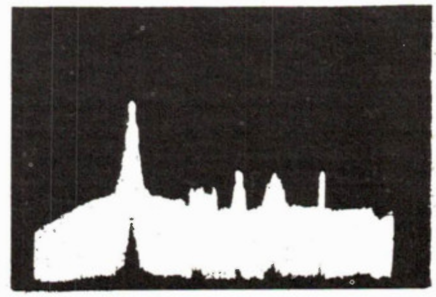


Fig. 1 Gorizont 7 spectrum showing the 3650 — 3950 MHz range.

spectrum analyzer to the IF feed line. Line powering with DC voltages between 12 and 28V is standard in our industry, and most spectrum analyzers (all of the general-purpose instruments) have DC-coupled 50-ohm inputs. A DC power block or bias tee is required, specified for the IF band in use. In practice most of the common 4GHz DC blocks are adequate for IGs down to 270MHz, for non-critical applications.

Detection Sensitivity

A further advantage in satellite-seeking is the analyzer's ability to reveal the presence of a signal just 1 or 2dB above the noise level, in bandwidth considerably less than that of a satellite receiver. A 300kHz bandwidth can be employed for a full band sweep and gives an effective 20dB sensitivity improvement over a receiver's 30MHz (say) IF bandwidth, for a similar detection criterion. The comparison is reasonable, as in each case (SA versus satellite receiver) a 3dB carrier/noise ratio will usually correspond to positive identification of the signal above the system noise floor. When aligning an antenna this 20dB advantage will considerably simplify initial acquisition of the satellite.

Antenna Alignment

Having found the satellite, the analyzer can then be used to point the antenna accurately for maximum signal. The display is switchable to represent 1dB (instead of 10dB) per large division. This expanded vertical scale provides a very sensitive indication of signal strength, and the effects of small adjustments to an antenna or

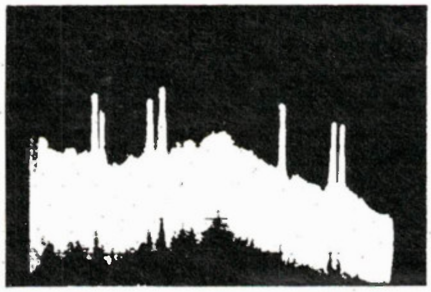


Fig. 2 ECS F1 spectrum showing mixed X and Y polarization and poor LNB response. Transponder 4 is off.

feed system are readily seen. Likewise, polarization null adjustments are best performed using the analyzer, or the final 15dB of cross-polar rejection will be lost below the wideband receiver's noise level.

Interference

Adjacent satellite interference 20dB below the wanted signal is unlikely to be noticed on a TV picture, but it is quite clearly seen and quantified on the spectrum analyzer display. Potentially harmful interference may be identified and antenna adjustments or improvements made before it becomes a problem. Terrestrial microwave interference can be impossible to distinguish from a high level of system noise in a satellite TV receiver, but with a spectrum analyzer, the carrier-to-interference ratios can be measured with the interfering signal's frequency and direction assessed, enabling filtering or shielding solutions to be specified.

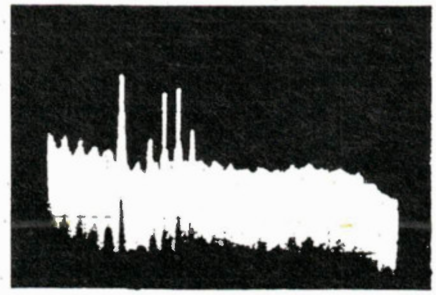
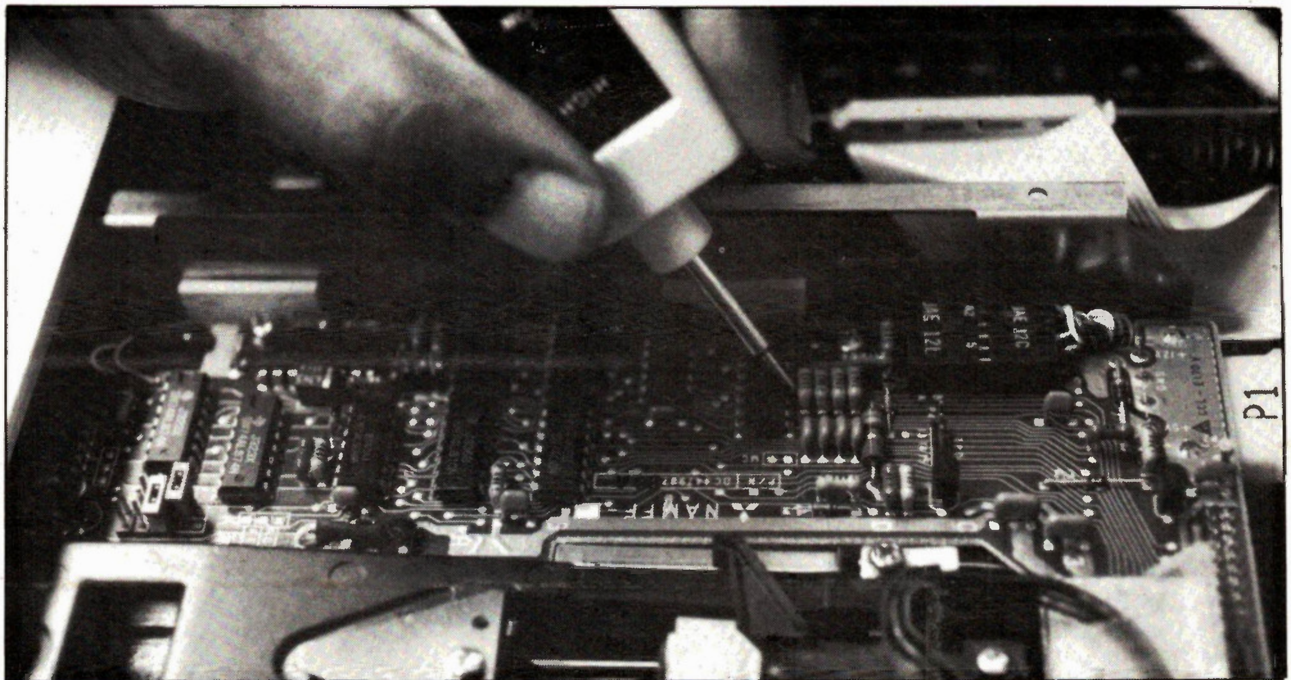


Fig. 3 Intelsat VA F10 spectrum showing half-transponder transmissions in transponders 1 - 2 and 5 - 6, and amplitude ripple on feed line.

Intermodulation distortion, associated with nonlinearities in an amplification or distribution system can result in poor carrier-to-noise ratio (C/N) and the generation of spurious products within the band. In **Fig. 3**, the effect of intermodulation in a satellite receiver can be seen. Channel spacing is 40MHz and the display clearly shows another pair of carriers, lower in level, spaced by a further 40Mhz at either side. These are third-order products (2f1-f2 and 2f2-f1) generated within the transponder's 10-watt travelling-wave-tube-amplifier and passed by its output fundamental carriers. The intermods carry a mixture of the program modulation on two primary channels, but it is not the best way to keep an eye on the big fight while watching a movie. These intermodulation products are accepted by BTL, Intelsat and other programmers, as they cause no interference to other services. The higher-level carrier lower down the band is that of Premier/Children's Channel, half-transponder channel 2W in transponder 1-2, but operating at signal-carrier saturation when this shot was taken. ■



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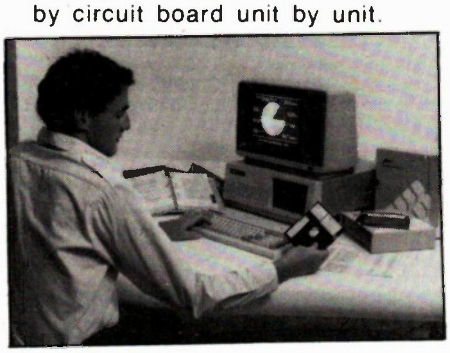

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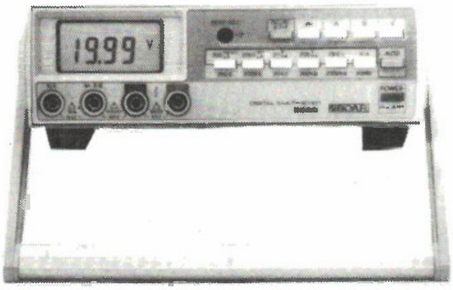

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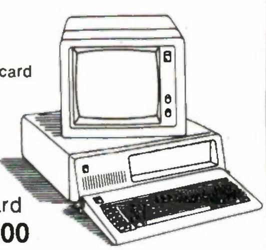

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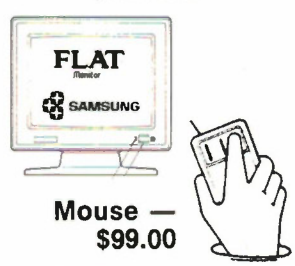

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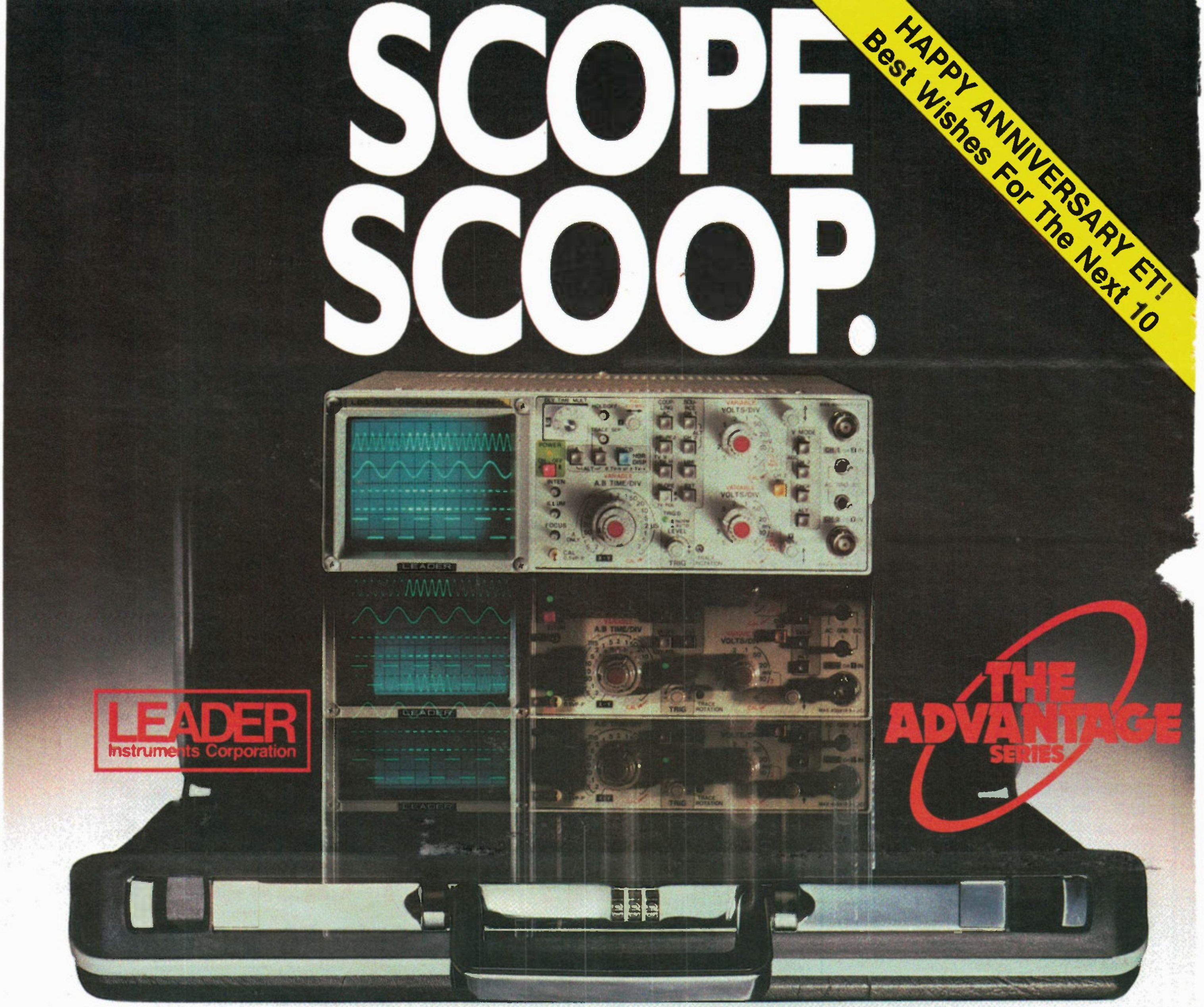

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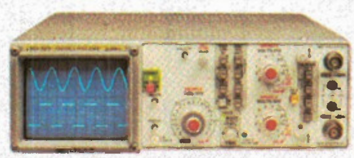

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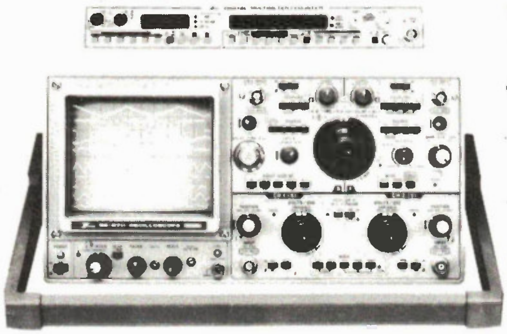

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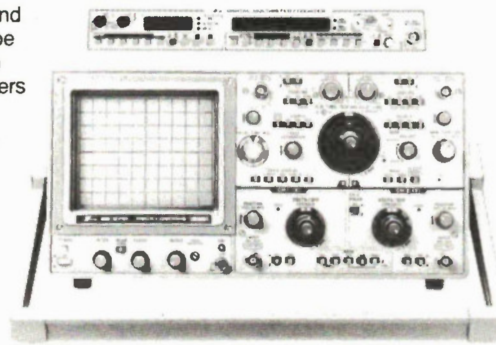

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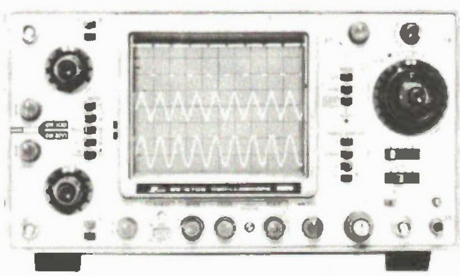

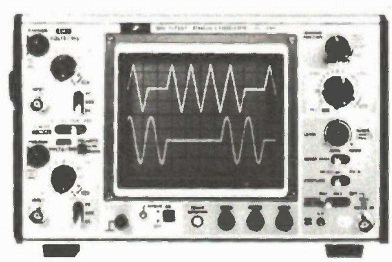

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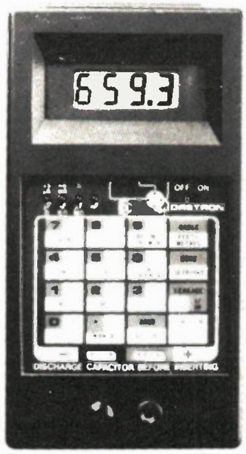

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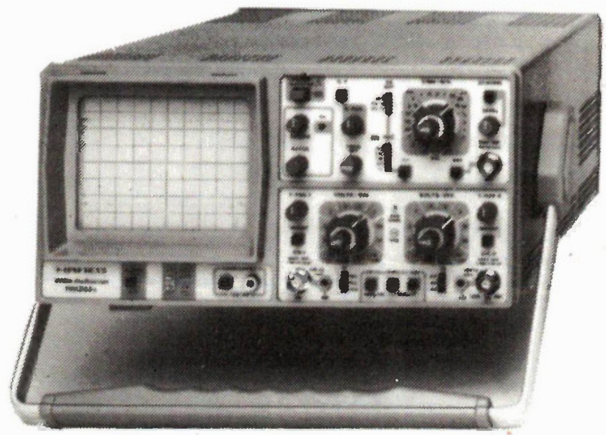

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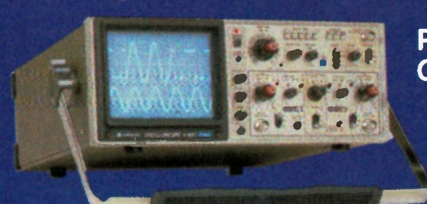

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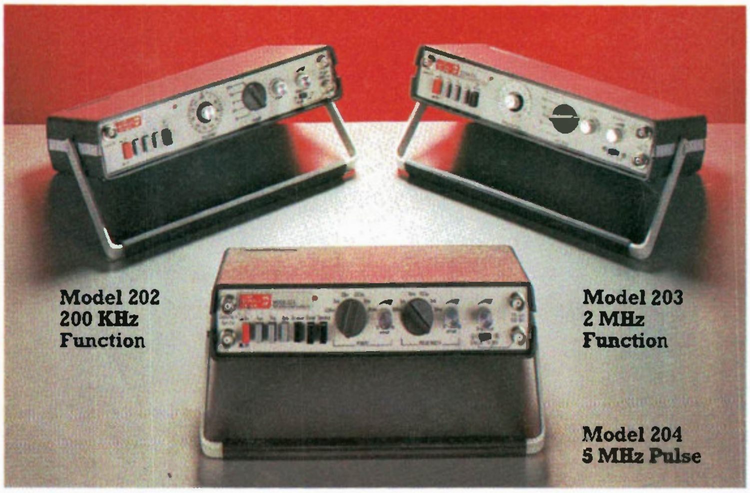

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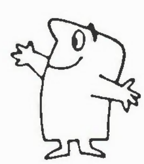


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