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JULY 1977

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JULY 1977 Vol. 6 No. 7

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news digest

HANDY METER

Teletonic Altair U.K. announced the new M22 Digital Multimeter from Data Tech at this year's All Electronics Show in London last month. The M22 has five full functions, 0.1% accuracy, handheld portability, 200 hours battery life, ac or dc current to 20 A.

It measures dc volts from 100mV to 1 kV, ac volts from 100mV to 750V, resistance from 0.1 ohm to 20 megohms, and dc or ac current from 100 nanoamps to 20 A.

The Model 22 can be carried by hand, used on a bench stand or worn like a wrist watch for two handed probing and big wristed people. The reading hold feature should be used when measuring difficult to reach points. The reflective liquid crystal display gives clear, concise information and is easily readable from wide viewing angles. *Teletonic Altair U.K., 2 Castle Hill Terrace, Maidenhead, Berks, SL6 4JR.*

BIRTHDAY PRIZEWINNERS

Well, we said it wasn't easy! Our April competition attracted hundreds and hundreds of entries. Unfortunately just less than 10% were correct! Having thus insulted nine tenths of our readers, here are the CORRECT answers! *A) Skeleton preset pot B) Soldercon IC sockets C) Compression trimmer D) Fuse holder E) Phono plug F) Fuse holder cap and fuse G) Potted bridge rectifier (R.S.) H) Slider control knob*

The five stalwarts who emerged as winners were: *R. W. Hearn, 10 Spendwell Close, Pakefield, Lowestoft, Suffolk NR33 7DL; T. Davey, 2 Northernhay Square, Exeter, Devon EX4 3ES; A. P. Thomas, 40 Rowley Road, Tottenham, London N15 3; A. R. Sticklund, 18 Rupert Road, Newbury, Berks; R. P. Mildren, 95 Elm Close, Bristol BS12 6RS.* To all those who entered and failed, thank you for entering, better luck next time.

VOLUNTEERS NEEDED

Deaf Fax is a research group making and distributing Tele-text decoders to the deaf and the hard of hearing to enable them to pick up Ceefax and Oracle. The units are rented out to the people for a nominal sum. Deaf Fax have applied for charitable status, and make not a bent penny from the exercise.

However, someone has to build the units in the first place, and that's where you come in. If you're feeling like helping someone, and are in need of something challenging to put together, contact the Secretary Mrs Sheena Carter at 99 Wantage Road, Wallingford, London.

GRAPHICALLY CHEAP

Compelec Electronics have available a circuit board called the VTI which provides all the electronics to turn a television receiver or monitor into a VDU. In addition, the card provides an 8 bit parallel port for interface to a standard ASCII keyboard.

The card is designed to plug into any microcomputer system employing the S 100 bus structure. To the microcomputer the board 'looks like' 512 (1 024 as an option) memory locations. Data can be stored in or retrieved from this block of display memory by the microcomputer just like standard RAM. The character generator ROM contains the full ASCII upper and lower case alphabet, the Greek alphabet, a set of graphic characters and various symbols and punctuation marks.

In kit form the VTI with 1 024 bytes of RAM, providing a display of 16 lines of 64 characters, costs £210 plus VAT from *Compelec Electronics, 310 Kilburn High Road, London NW6.*

DEE TO EH?

Precision Monolithics have introduced a new series of 3-digit BCD monolithic multiplying D/A converters with fast settling time, complementary high compliance current outputs and universal logic inputs. Direct interfacing with CMOS, TTL, DTL, ECL and HTL is provided by an optional logic threshold adjustment. The DAC 20 is the first BCD DAC to interface directly with the high impedence NMOS and PMOS outputs of microprocessor RAMs. *Bourns (Trimpot) Limited, Hodford House, 17/27 High Street, Hounslow, Middx.*

I'M SORRY I'LL PRINT THAT AGAIN!

System 68, May 77. Link between common pin of Reg 3 and earth omitted on PCB layout.

SINTEL ATING NEWS!

A ather special ad appears on page 74 this month. Whilst not an actual ETI Reader Offer it will be of great interest to most readers. Sintel have chosen ETI through which to make a whole list of specially priced components available. You won't find these in any other electronics magazine should you be foolish enough to read any.

CRAFTY VIDEO?

Videocraft have released a Teletext decoder that costs less than half that of comparable decoders presently available. It is supplied as a complete kit comprising an (assembled and fully tested) Texas Tifax Teletext decoding module, power supply, interface module (supplied as a kit), an assembled and tested cable connected remote control and complete instructions for installation in most (common) television receivers. Due to the compact nature of the Tifax module and interface module installation within most receiver cabinets is no problem.

Facilities include seven colours, upper and lower case characters, graphics, time coded display and newsflash and subtitle inserts in the TV picture. To enable them to supply the correct interface module and instructions they must know your television set make, model and, if possible, chassis type. The kit costs £100 + 8% VAT. *Videocraft, Aberts House, Elverton Street, London SW1P 2QR*

I.T.T. v. THE REST

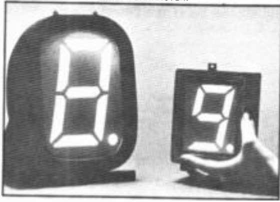
It may interest you to know that ordering a 74xx Series TTL chip is not as simple as it might at first seem. It has come to our notice that certain numbers in this series can refer to chips with completely different logic functions (nasty).

Although for most of the range it does not matter from which manufacturer the devices come, the table below shows that for a few chips I.T.T. have gone it alone in the allocation of numbers.

I.T.T.	
74 S	Quad 2 I/P nand Schmitt
74 1 8	Quad 2 I/P OR power driver (30 V 100 mA)
74 139	Quad 2 I/P OR power driver (15 V 100 mA)

THE REST	
74 S	Quad EX OR NOR gate
74 38	3 to 8 line decoder demultiplexer
74 139	Dual 2 to 4 line decoder/ demultiplexer

WHAT A CHARACTER!

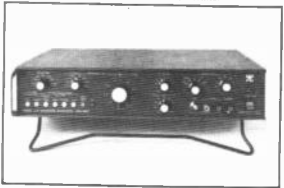


The English Electric Valve Company has developed a high brightness character display tube which operates on a different principle to the more usual stuff. The display can be manufactured in sizes up to about 25 inches diagonal and can display special characters.

The tube operates in a manner similar to a cathode ray tube: a front face plate carries a high luminance high-efficiency phosphor energised by a flood beam of electrons from the cathode. Placed between the cathode and the faceplate is a seven-segment mask with a lead from each of the segments brought out separately so they can be switched at high speeds using a control voltage of 5 V at 10 MΩ input resistance.

The supply voltage is 12 V dc. The power consumption is 2 W total for the 4-inch (E727) and 3 W total for the 8-inch tube (F728). *EEV, Chelmsford, Essex, CM1 2QU*

GENERATES FUNCTIONING BRITAINS?



The Pioneer Scientific Instruments 1211 Function Generator. Sine, square, triangle, ramp and variable duty cycle pulses. Frequency range 0.04 Hz to 5 MHz. And most important it's 100% British! A versatile unit with full sweep facility, and all the other bits and bobs these things are supposed to have. It is designed to compete with the likes of the H.P. 3310A, but at a cost of £425 is considerably cheaper. PSI Ltd, Lady Lane Industrial Estate, Hadleigh, Ipswich IP7 6DQ

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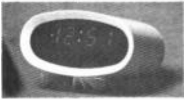

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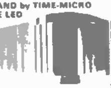
£26.95

THE SILVER BAND by TIME-MICRO BRITISH-MADE LED



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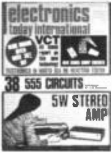
Gaps?

Gaps?



Gaps?

Gaps?

It can be a nuisance can't it, going from newsagent to newsagent? "Sorry squire, don't have it – next one should be out soon."

Although ETI is monthly, it's very rare to find it available after the first week. If it is available the newsagent's going to be sure to cut his order for the next issue – but we're glad to say it doesn't happen very often.

Do yourself, your newsagent and us a favour. Place a regular order for ETI; your newsagent will almost certainly be delighted. If not, you can take out a postal subscription so there's nothing for you to remember – we'll do it for you.

For a subscription, send us £6.00 (£7.00 overseas) and tell us which issue you want to start with. Please make your payment (in sterling please for overseas readers) to ETI Subscriptions and keep it separate from any other services you want at the same time.

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LEARN TO REDUCE TENSION WITH ETI's

GSR MONITOR

This galvanic skin response monitor provides a means of measuring the minute variations in skin resistance which research has linked to the emotional state of a person

THE BEST WAY to start experimenting with biofeedback is to use a galvanic skin response monitor, a device which measures changes in skin resistance. In March 1977, we published an article which covered the background and theory of biofeedback and we discussed the various types of biofeedback instruments which are available. The GSR monitor is the most simple to use: the electrodes can be simply attached to the fingers with straps and the technique of using the machine can be quickly learned.

Skin resistance changes with changes of emotional state. When tension increases the skin resistance falls — when tension decreases there is an increase in skin resistance. (Some biofeedback instruction manuals speak in terms of conductivity rather than resistance and state measurements in mhos, and the meter we use gives a positive deflection for decreasing resistance.)

The connection between skin resistance and tension is not fully understood. Tension affects sweat glands and with the changes in the sweat glands there is a change in the membrane permeability of the skin and this change in permeability is the major cause of changes in electrical activity.

Almost a century ago, a scientist named V. Ch. Fere discovered the resistance of the skin to a small electric current changed in response to aroused emotions. This information has since been used in various ways, one obvious example is the polygraph, or lie detector which responds to the tension generated when a person is lying.

It was not until 1961 that Dr. J. Kamiya, whilst conducting a series of

GSR MONITOR

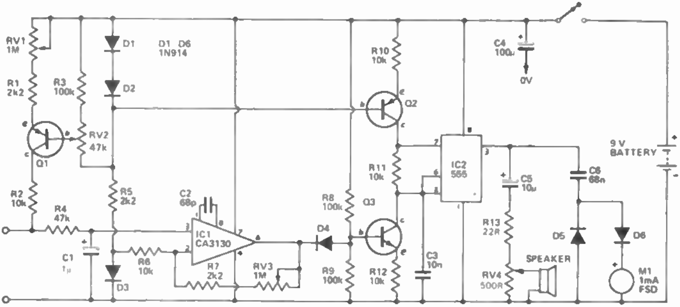
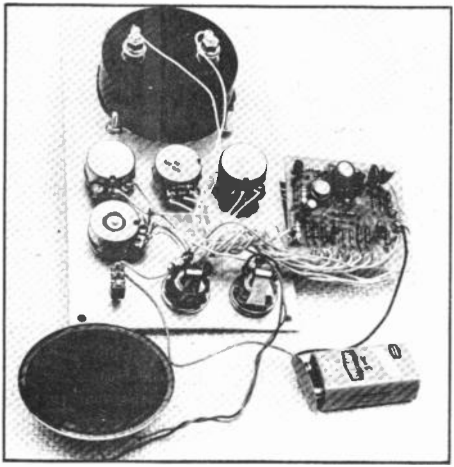


Fig. 1. Circuit diagram of the GSR monitor.

WARNING: THE GSR MONITOR SHOULD NOT BE USED WITH A MAINS POWER SUPPLY.



The picture above shows the internal layout of the GSR monitor. The wiring from the PCB to the front panel, loudspeaker and meter is clearly shown.

HOW IT WORKS

Transistor Q1 acts as a constant current source - the actual value can be varied over a large range by RV1 and over a limited range by RV2. These act as the coarse and fine level controls. This current is passed via R2 to the probes. The voltage developed across the probes is proportional to the skin resistance and is fed to the input of IC1. This amplifies the signal with reference to 0.6 V (drop across D3) and the gain is variable by RV3.

The second IC is an NE555 oscillator where Q2 provides a constant current (about 60 uA) to the capacitor C3. When the voltage on C3 reaches 6 V the IC detects this and shorts pin 7 to ground, discharging C3 via R11. This continues until the voltage reaches 3 V at which point the short on pin 7 is released, allowing C3 to recharge. The output of the oscillator is connected to a speaker via the volume potentiometer RV4 and the meter via C6 and the diodes D5 - 6. The meter operates in reverse sense to usual, a low resistance gives full scale (or high tone) and high resistance gives zero (or low tone).

We vary the frequency of the oscillator and the meter reading by robbing some of the current supplied by Q2 into Q3. In this way the frequency can be lowered and actually stopped. Transistor Q3 is controlled by IC1 completing the connection between the probes and the output.

Getting hold of components

Nothing here to trouble the constructor

Cost of construction

Should be about £5.00 excluding boxing and meter.

experiments with brain waves, found that with feedback his subjects developed the ability to produce 'Alpha waves' at will.

Dr. Kamiya's experiments created considerable interest and started investigations into whether other bodily functions could be brought under conscious control. Since that time it has been demonstrated that with feedback it is possible for people to control heart beat, blood pressure and temperature — all previously considered to be automatic bodily functions mostly beyond conscious control.

Of course it should be stated that various mystics and yogis have previously demonstrated this type of ability but the fascination of biofeedback is the speed and ease with which this type of control can be learned.

Biofeedback has exciting medical possibilities. GSR machines are being used by therapists for the treatment of many disorders related to tension. The average person will find a GSR machine mainly useful for relaxation training. With the GSR machine it is possible to recognise tension and learn how to decrease tension levels. This type of training is so effective that the machine quickly becomes unnecessary.

However not everyone suffers from tension. The biofeedback machine can be a fascinating toy to play with. Discovering that you can bring an internal bodily function under conscious control with the same ease that you can twitch your nose is most interesting. And of course you can then perfect this ability just as you perfect your ability at a game like tennis. For many people this is reason enough to build this machine.

What you do with it once you have built it

The ETI GSR monitor has an on/off sw tch a sensitivity control and fine and coarse level controls. The machine also has a connection for headphones.

To start relaxation training, you'll need a comfortable chair, low lighting and no distractions. Taking any type of drug can interfere with your ability to relax This applies to alcohol and c garettes Attach the electrodes to the fleshy part of the first two fingers on one hand — firm but not too tight (the non-dominant hand is recommended). Set the sensitiv ty control to minimum and the f ne level control to mid-range. Turn the volume control to minimum. Now you have to set the level with the

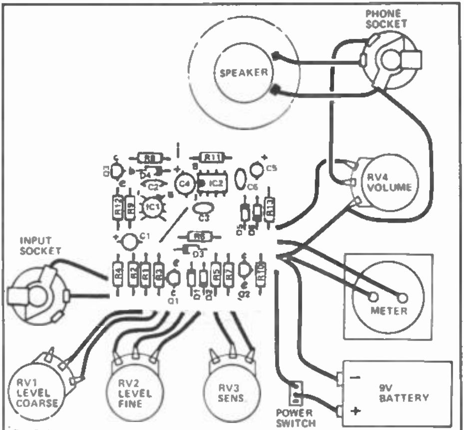


Fig. 2. Component overlay and interconnection diagram.

PARTS LIST

RESISTORS (all ½ W 5%)	
R1	2k2
R2	10 k
R3	100 k
R4	47 k
R5	2k2
R6	10 k
R7	2k2
R8,9	100 k
R10-12	10 k
R13	22 R

POTENTIOMETERS	
RV1	1 M log
RV2	47 k lin
RV3	1 M log
RV4	500 R lin

CAPACITORS	
C1	1 u 16 V electrolytic
C2	68 p ceramic
C3	10 n polyester
C4	100 u 16 V electrolytic
C5	10 u 16 V electrolytic
C6	68 n polyester

SEMICONDUCTORS	
D1-6	1N914
Q1,2	BC559 or BC179
Q3	BC549 or BC109
IC1	CA3130
IC2	NE555

MISCELLANEOUS
PC board ETI 546
Meter 1 mA FSD
Box 196 x 113 x 60 mm
Two phone jacks
Four knobs
Small speaker
PP3 or 9 V battery + holder
Pickup probes

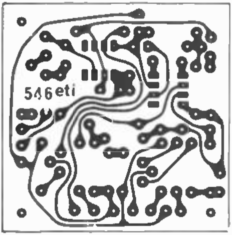
'coarse' level control (when the sensitivity is set low the 'fine' level control need not be used). Start with the 'coarse' control at full anticlockwise and turn it up until the meter needle starts to move Carefully set the needle to mid range. Now the instrument is set up in its minimum sensitivity position.

Having mastered setting up with minimum sensitivity try to set the GSR monitor with the sensitivity set halfway. It will require delicate adjustment of the 'coarse' level control. Now the effect of the 'fine' level control can be seen. This control enables you to set the level on a high sensitivity setting.

Although the GSR machine measures minute changes in skin resistance, the level of skin resistance varies considerably from person to person so a wide range of settings is provided.

Now turn up the volume and observe that the meter reading is accompanied by a medium pitched tone. (A convention has developed to link high-pitched tone with tension increase and low pitched tone with a decrease in tension.) Now you relax and bring the tone down and the needle back to zero.

How? Basically you are supposed to find this out for yourself. After watching the needle for some time you will notice it move up or down. Something has happened to cause a change in your skin resistance. You would be barely aware of what had caused the change but aware enough to try to reproduce the effect. Eventually your awareness grows and so does your ability to control your tension. Many people find that relaxation of the stomach muscles makes the difference. It varies from person to person.



There are several relaxation techniques which work very well. One method is to tense all the muscles of the body as hard as possible, hold them tense for several seconds then very deliberately relax all muscles. There are several books and cassettes available which describe relaxation techniques. The techniques work. The biofeedback machine makes it possible to monitor progress.

As you relax, the needle on the meter and the audible tone will decrease. When the needle reaches zero, reset it again towards the fsd end of the scale and repeat the procedure.

Twenty minutes is the recommended time for a training session. After about one or two weeks of daily relaxation training, it should be possible to produce the same level of relaxation without using the machine and the machine can simply be used occasionally as a reference.

Construction

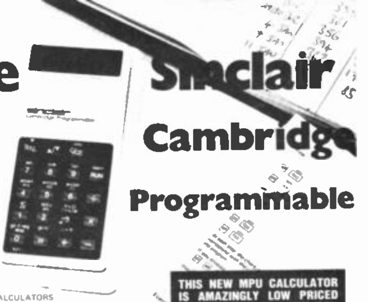
Construction is not critical although we recommend you use the pc board as it makes things easier. Before soldering the components made sure they are orientated correctly. External wiring can be done with the aid of the overlay-wiring diagram.

Probes

Probe construction and electrical contact is not nearly as critical as with most other biofeedback machines.

Commercial GSR machines use a pad of soft steel wool which is held firmly onto the finger by a short length of Velcro strap (Band-Aids work fine!). However, any method ensuring a firm contact between probe leads and the fleshy part of the finger will do. One method which works very well is to bind tinned copper wire around a guitar finger pick (or solder to a steel pick). Two probe connections are of course required — one for each of the first two fingers. ●

The Sinclair Cambridge Programmable



THIS NEW MPU CALCULATOR IS AMAZINGLY LOW PRICED BUT HOW GOOD IS IT? RON HARRIS INVESTIGATES

PROGRAMMABLE CALCULATORS have always had their market wherever a task must be repeated over and over with different data. Examples in electronics would include filter design optimising component values for given allowed parameter variations calculation of resistor networks for attenuators or to achieve a given R using paralleled units and perhaps even Fourier Analysis.

There are two types of calculator with this ability to remember a sequence of keystrikes, card programmables epitomised by the HP67 reviewed in ETI last month and keyboard programmables of which the CBM PR 100 is a good example. Price has up until now been a fairly high hurdle between the mass of potential users and the machines.

Until now.

The Sinclair Cambridge Programmable could well be the stepladder to solve that problem! Selling at around £15 discount including mains unit its 36 step program memory becomes accessable to even the most impercunious student.

Stepping into the limelight

Housed in the same case almost as its predecessor the Programmable is outwardly little different. Only the 'GT style' bulge on the battery compartment (to accept a PP3) and the actual word 'programmable' coyly added to the front panel artwork attest to the vital difference!

As a normal scientific the new Cambridge has more functions on the keys than its Daddy. Nearly all the buttons are three function in fact making a double shift key necessary. The advantage of the small case size wages a fierce war on keyboard convenience and display visibility which means the Cambridge is fiddly to use in this generation as the last.

But this is not a normal scientific far from it. This is a 36 step programmable calculator with conditional branching and step facilities altogether a different animal.

The nature of the beast

Along with the machine comes a desk stand instruction manual and sample program booklet. Full back-up is provided by Sinclair in the form of a 4 volume program library containing almost 300 programs. This is available at £4.95 complete.

Sinclairs library gives the basics of the calculation required and then lists the program in a three column table giving step number keystroke and 'check code'.

Scattered within the library pages are blank program sheets to enter your own creations for storage. We have a suggestion to make to Sinclair about that!

It seems to us that large number of potential users will be putting the machine to work 'in the field' as it were, and these people will like as not be unwilling or unable to hump around a book the size of a program library volume for reference to program listings. Why not a book of blank program sheets the same size as the calculator which could then fit within the carrying case supplied?

Within the case are just three components MPU chip, display driver and a capacitor! Both chips are from National Semi as is the display. The MPU is the 4 bit MM5799. The on chip memory of this MPU has made it possible for Sinclair to hold the price as low as they have. The mask program was written in America, where Sinclair concentrate their software expertise. According to them they only just made it all go into the space available, which means that they don't give anyone else a prayer of getting near the price for a long time.

It will be interesting to see how soon anybody does begin to compete or indeed if anyone bothers!

Using a Mallory PP3 gives around 30 hours use less if you keep the machine in program mode. With that desk stand under its body, the Cambridge is not at all bad for use

Cambridge Programmable

as a desk machine, although naturally its size doesn't help any!

Putting it in to get it out

Using the Cambridge as a programmable machine takes perhaps an hour or so to get used to, aided by the excellent manual and examples provided. Simply the best method to learn to program this calculator is to play with it! Once familiar with its little ways and means (i.e. the four key sequence to get into program mode, and a further two to get it to listen to what you're telling it!) entering sequences is no problem at all.

We doubt that anyone short of Dr Who could simply pick up the little white box and get it to run programs, but within half an hour all should be well. This is a complex instrument of course, and it would be unreasonable to expect otherwise.

Once entered, a program is checked by 'stepping' through and comparing a list of 'check codes' with the displayed characters. The codes are written on the keyboard too, just so you can be sure.

The greatest advantage of such an instrument is perhaps the fact that once programmed up operation is by use of a single 'RUN' key. This means that untrained operators can use it to good advantage. As an example we did out a short program to calculate an invoice amount, in which a certain number of magazines are sold at a discount of say 30%.

The calculations needed for each bill are thus (nos of magazines) x (price), 30% of this and then total less 30%. On an normal calculator this could involve the following sequence:

(enter number) x 35 = (total amount) x 30 100 (discount amount) and then (total amount) (discount amount) = invoice total.

This would be shortened with memory or percentage key functions we realise, and 30% could be calculated as 0.3 more easily but bear with us we're only trying to make things clear!

In good voice

Now if only one invoice is to be made up, then no advantage is gained by use of the program. However most businesses use this kind of invoice procedure many times in any given period, and once the number exceeds three the program will save the time it takes to enter it.

Our programme is listed out below, with the check codes next to it. Each step is simply the button to operate at that point in the sequence.

To use this listing to work out invoices for you you would simply go through the sequence, check it, and then clear the display.

Enter the number of magazines to be sold on the first invoice. Press RUN. Displayed now is the first total to be typed in. Press RUN again. The display now gives you the 30% discount on the previous total. Type this and then give RUN a third jab. The number now sitting there is the final total.

On 20 such invoices, using the Programmable is shorter by over 600 keystrokes, thus removing 600 possible errors, and making a tedious task far less time consuming.

Game for a few reservations

We found the Sinclair an excellent introduction to programmable calculators. As an ordinary scientific we have reservations, but surely few people would use it as such. The key spacing is quite tight, and the display does have a limited viewing angle to it.

One beautiful aspect to the business of running programs is the fact that you can get the machine to play games with you! Sinclair give three games programs in the library, including a decent version of moon-landing. The four arithmetic function keys all do something different if operated twice and this can be used to advantage within a program. For example the sequence x x will square a number.

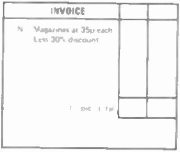
If you intend to buy a Cambridge, don't begrudge the £4.95 for the program library, it is worth far more and extends the usefulness of the machine immeasurably.

So to conclude!

All in all then an amazing presentation for the money, and a machine which will probably create its own market. (We suspect Sinclair themselves will be surprised at the reaction this calculator may elicit).

For our part we can recommend it enthusiastically despite the reservations expressed earlier. It is worth its asking price for the games its capable of playing! ●

CODE	STEP
	x
3	÷
3	3
5	5
7	[illegible]
0	step
9	[illegible]
	x
3	÷
3	3
0	0
6	
3	÷
1	1
0	0
0	0
–	
0	step
0	–
5	[illegible]
5	step
6	▼
2	go to
0	0
0	0



The example program referred to in text is shown on the left and the type of invoice it works out is illustrated above. The 'CODE' column shows what appears on the display at each step of inserting the program.

Using the check code enables the program listing to be checked before running.

Software Techniques

A CONSIDERATION OF THE METHODS USED TO APPLY DIGITAL CIRCUIT

THE WEALTH OF EXPERIENCE possessed by engineers and technicians involved with digital hardware can be enormously valuable to them in their transition to microprocessor based designs. The thought of programming may distress the hardware man howevever to write efficient assembly language programs demands an intimate familiarity with the hardware structure of the particular microcomputer being used.

The flowchart forms the basis of program writing by ensuring that the logical sequence of events has been crystallised. Consider as an example a process control situation depicted in Fig 1. After a controlled start, system initialisation can commence by processing the input data to check given interlock requirements. Satisfactory results allow the process to begin otherwise the interlock failure is annunciated and a system stop ordered.

As the process continues towards a designated goal periodic status checks of the system are required so that control action can be implemented. To ensure that actuators operate correctly the response to an action command is fed back for the system to monitor. This outline scheme typifies the use of flowcharts. Of course each block could be examined further resulting in a more detailed diagram.

Program Power

The real power of programs is their ability to make decisions. Examples of assembly language conditional instructions are

JUMP and

INCREMENT SKIP IF ZERO

Jump instructions can either be mandatory thus directing the program to an address which is accessed in all cases or jumps can be conditional as illustrated by the following examples

JZ could mean Jump if accumulator = 0

JC could mean Jump if accumulator carry = 1

JCN could mean Jump if a given CPU pin = 1

The number and type of jump instructions provided depends upon the particular microprocessor in use. The Increment Skip if Zero (ISZ) is useful for decision making because it can distinguish between zero and non-zero contents of index registers. A designated path can be followed in each case.

Interesting Routine

A program sector which is frequently used during a process forms a prime candidate for a SUBROUTINE. In Fig 1, the block performing

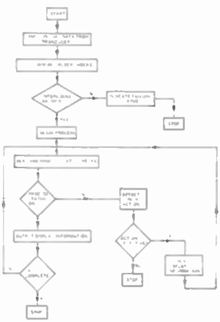


Fig 1. A flow chart depicting a process control situation requiring several interlock checks

process status checks would clearly be used repeatedly. Two of the three paths leading to this block are the result of decisions made during the on-going process. The subroutine would therefore be called into action by an instruction such as JMS 70 (Jump to subroutine at address 70).

To perform process status checks, data has to be input from transducers stored and then a number of successive decisions made based upon the data. These requirements can be met by using NESTED SUBROUTINES. A number of subroutines are written each one called by a preceeding member of the set. Fig 2 shows subroutines nested to a depth of three.

After servicing a subroutine the micro processor needs to know the re-entry point in the program. This information is normally provided by a section of memory store known as a push-down stack. As each further level is entered in a nested subroutine system the latest return address is placed at the top of the stack thus causing previously entered return addresses to be pushed-down.

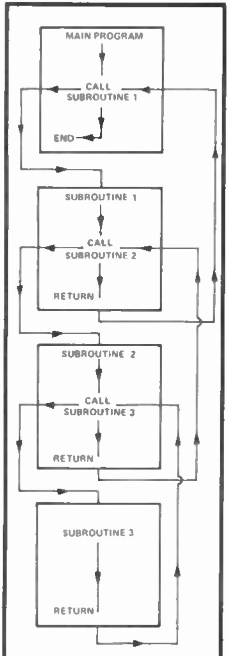


Fig 2. An example of nested subroutines in this case to a depth of three

For Hardware Men!

DESIGN TECHNIQUES TO SOFTWARE ROUTINES BY R. WILSON MSc

Displaying Versatility

A main application area of microprocessor systems is in replacing hard-wired logic by a stored program. A multiplexed seven-segment LED system for numeric display is usually implemented by interconnecting integrated circuits. The function of some of the circuits can be duplicated by a sequence of assembly language instructions.

Flowing Charts

A flowchart for a subroutine which controls the indications of four BCD digits by seven-segment displays is shown in Fig. 3. When this subroutine is called, a four-bit index register which acts as a loop counter is set to 1100 in binary (12 in decimal). By using the ISZ instruction the decision can be programmed simply. The loop counter is incremented each time this instruction is executed. After three loops the index register would contain binary 1111 (15 in decimal). When incremented this becomes 0000 ensuring that after four loops the alternative path is selected by the *"skip if zero"* part of ISZ.

Routine Subs

The subroutine multiplexes the four displays by successively sending 0001, 0010, 0100 and 1000 as digit drive data during the progression of the program from the first to the fourth loop. The BCD digits represented as segment drive data are thus automatically routed to the correct display from a common highway.

Each BCD digit was stored by four bits of random access memory (RAM). The read/write facility was essential as variable data was being processed. When programming for dynamically changing data the locations of the various data sets in RAM must be constantly reviewed. A RAM map (Fig. 4) is a straightforward visual aid which makes this task easier. A diagram is drawn showing the empty memory locations then as the instructions are written, the space in RAM can be thoughtfully allocated, modified and updated as necessary.

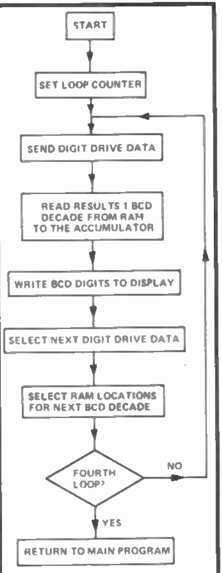


Fig. 3. This subroutine is to run four seven segment displays, multiplexed and with each digit stored in RAM.

Finding Bugs

Engineers know that the phrase *"nothing ever works first time"* usually applies to hardwired designs. It also applies to software designs. When a comprehensive program has been written it will contain errors, therefore a means of examining the program operation is required. The main sections of a microcomputer hardware structure, the CPU, memory, I/O and clock can be simulated either by software in the form of a computer package or by special purpose hardware. Software simulators are available through various commercial time share networks whereas hardware simulators can be obtained direct from microprocessor distributors.

The source program written in memonics needs to be translated into numeric patterns. The resulting data called object code is generated from the source code by using an assembler. Again hardware and software assemblers are available. The object code version of the program can then be presented to the simulator for testing.

Program testing is not a simple task but the following suggestions might be helpful. If possible assemble the whole program from the outset, or at least assemble substantial segments such as subroutines. This ensures that the actual program is examined rather than a simplified version. By mentally working through the selected program segment using chosen test data the expected outcome can be predicted before beginning a test-run. The RAM map is often useful during this procedure. If a teletype is used to communicate with the simulator during a program test-run a printed record of the test process can be preserved for analysis later. As each section is tested, modified and eventually verified as correct, further segments can be processed. The aim is to commit the whole of the validated program to PROM.

The hardware man can be comforted in his venture into software by remembering that a microcomputer is, after all, an engineer's computer.

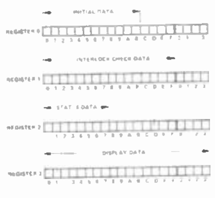


Fig. 4. A RAM map. This shows the memory locations available and what is stored in each.

BE A CATHODE RAY COWBOY WITH OUR

TV GAMES RIFLE

FROM CIRCUIT AND TEXT BY WATFORD ELECTRONICS

THE TV GAMES UNIT featured in our May 77 issue has provision for the addition of two rifle games In both games a target appears on the TV screen and the object is to hit this with the TV rifle When the trigger of the rifle is pulled a shot counter is incremented by one and if the rifle is on target the hit counter is incremented a hit noise produced and the target blanked for a while

The difference between the two game options is that in one the target moves randomly about the screen and in the second the target traverses the screen from left to right under the control of the manual serve button

Unlike the other games the score does not appear on the screen during the game since this might confuse the player instead the score appears after 15 shots The score is displayed with the number of shots (i e 15) on the left and the number of hits on the right

Seeing the light

The rifle uses a photodarlington to detect the target on the TV screen but relies on careful construction of the optics involved to ensure adequate sensitivity is obtained from the unit We also arranged for the rifle to ignore any sources of light other than the target on the TV screen

Though we called this project a TV rifle game we finally settled on what might more accurately be described as a pistol The general method of construction used in the pistol is shown in Fig 1

Getting started

The butt is made from a fairly hard wood and after being fashioned to the shape shown in the drawing the top was dished with half round file to accommodate the barrel The next step is to drill a hole vertically through the butt to take the connecting cable between the pistol and games unit The trigger switch is mounted by drilling two holes one above the other and chiselling out the remaining wood to form an oblong hole A small aluminium plate was then drilled to accept the switch and two small wood screws used to secure the plate to the butt

Roll out the barrel

The barrel is made from 28mm dia metal tube 8½in in length To fit it to the butt two holes were drilled at one end, and two further holes drilled diametrically opposite the first pair By passing a screwdriver through the top holes the barrel may be secured to the butt

The lens used in the pistol had a focal length of 2½in and came from an old jeweller s eye glass this was mounted in a B9A valve screening can The photodarlington should be carefully positioned at the focal point of the lens We mounted the photodarlington on a piece of veroboard which enabled us to slide it back and forth until its position was correct

The assembly may then be mounted in the barrel

End in sight

The front sight was formed from a 4BA bolt which was filed to provide a sight tip The rear sight is formed from a ⅜in wide strip of aluminium about 2½in long One end is bent up and a V slot filed with a needle file

At this stage the p c b may be assembled The only thing to note about the components used is that they must be as small as possible we used tantalum beads for C3 C5 and sub miniature electrolytic types

When the board has been assembled wire it to

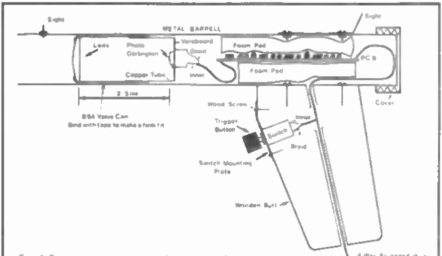
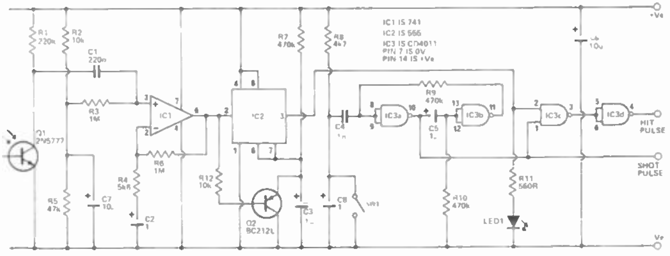


Fig 1 Suggested construction Trigger switch is a S P S T momentary action type



Full circuit diagram of the TV games rifle

PARTS LIST

RESISTORS (all ½ W 5%)

R1 220 k
R2 10 k
R3 1 M
R4 5k6
R5 47 k
R6 1 M
R7 470 k
R8 4k7
R9 470 k
R10 470 k
R11 560 R
R12 10 k

CAPACITORS

C1 220p polystyrene
C2 1µ 16 V electrolytic
C3 1µ 35 V tantalum
C4 1 n polystyrene
C5 1µ 35 V tantalum
C6 10µ 16 V electrolytic
C7 10µ 16 V electrolytic
C8 1µ 16 V electrolytic

SEMICONDUCTORS

LED1 TIL209
Q1 2N5777
Q2 BC212L
IC1 741
IC2 555
IC3 CD4011

MISCELLANEOUS

PCB
Trigger switch - see text
Lens - 2½" focal length, 1" diameter
Metal tube 8½" long
Wood for butt
4 core screened cable
Misc hardware for sights etc.
A complete kit is available from Watford Electronics, including lens, tube and butt

HOW IT WORKS

Q1 is the photodarlington detector. Signals appearing at its collector, due to the target on the TV screen, are coupled by C1 and R1 from the high pass filter required to reject spurious light sources. IC1 has a gain of about 200 at high frequencies, but its gain drops to unity at dc, due to the effect of C2 included in its feedback loop.

The no signal level of the output is set by R2 and R5 to about one volt lower than the supply rail.

When the target is detected, the output of IC1 falls and triggers IC2 which is arranged to operate as a monostable. Pin 3 of IC3 will go high. Q2 is included to make IC2 re-triggerable, its output will remain high until one period after the input signal returns high.

The output of IC2 is fed to IC3c and to the on-target LED.

The trigger switch SW1 is coupled to a monostable formed by IC3a and IC3b. The output of IC3a is normally low and goes high for a few milliseconds when SW1 is operated. This output is the 'shot pulse' and is fed to IC3c, where it is 'NANDed' with the on-target pulse, resulting in a hit pulse which is inverted by IC3d.

The hit pulse is fed to pin 27 of the AY3 8500 and the shot pulse is fed to pin 26 of the games chip.

C6 decouples the supply rail.

GETTING HOLD OF COMPONENTS

Watford Electronics will supply a complete set of parts including lens, barrel and butt.

COST OF CONSTRUCTION

The cost of the Watford Electonics kit for this project is £10.50.

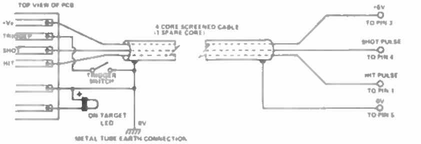
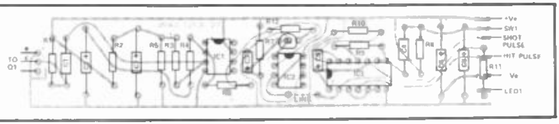
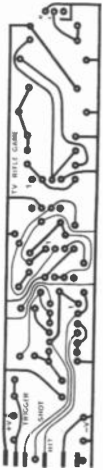


Diagram showing the connections between the PCB and ETI's TV games unit. Pin numbers shown correspond to those on the games unit PCB

Component overlay for games rifle board shown full size



TV GAMES RIFLE



the trigger switch and to the connecting cable. It may then be mounted at the rear of the barrel by gluing it to a foam pad which may in turn be stuck to the barrel.

The connecting wire we used was four core screened cable and should be connected to the games unit as follows: (via DIN plug)

0V	to pin 5
6V	to pin 3
Hit pulse	to pin 1
Shot pulse	to pin 4

Testing

The games unit should now be connected to your TV and the brilliance control of the TV adjusted until the target is bright and the background just visible. If the rifle is now aimed at the target, at close range initially, the On Target LED should glow and a blip should be heard from the speaker when the trigger is pressed.

To adjust the sights use the score display which appears at the end of the game. Block off all the screen except one digit of the score. The sight may then be adjusted so that the hit LED is on when the pistol is aimed at the score.

To play

Select the rifle option required with SW2 and press the reset and serve buttons. The target should appear on the screen and bounce around the screen until hit. ●

The PCB layout is shown full size on the left. Above is a picture showing the games rifle.

DESIGNING & USING ACTIVE FILTERS PART 1

A SHORT SERIES BY TIM ORR WHICH WILL ENABLE THE HOME CONSTRUCTOR TO UTILISE CIRCUITS OF HIGH COMPLEXITY AS EASILY AS PLUGGING IN A RESISTOR!

THERE IS NO DOUBT that active filters are very useful devices. Also, there is no shortage of literature on the subject. This would seem to suggest that designing active filters is a fairly straightforward business. Well, it is and it isn't. It is if you read *this* article. It isn't if you read the aforementioned literature. Most of the books on this subject have filled our heads with terms such as poles and zeros, Laplace transforms, transfer functions etc. which haven't actually helped *us* to design anything!

Some basic theory

It is advisable quickly to run through some basic terms and expressions. Firstly, consider a simple low pass filter Fig. 1a. The frequency response (Fig. 1b) is nearly flat until the break point, denoted by fb. After this point the response rolls off at 6dB/octave, that is signals above this frequency are increasingly attenuated. The break point is defined as being the frequency where the resistance equals the capacitive reactance. When this occurs, the output is attenuated to 0.707(−3dB) of the input. Although the resistance equals the capacitive reactance the output is *not* half of the input. (This is because it is the vector sum of the two and hence equals 0.707 of the input!)

As the frequency response is a rather complex curve it is very useful to use a straight line approximation to it. These lines are called asymtotes (Fig. 1c). Note that the frequency response graph uses the convention of logarithmic scales, octaves or decades along the frequency axis, and dBs along the vertical axis representing output voltage divided by input voltage.

Phase shift with respect to frequency is also often plotted as in Fig. 1d. These two (the phase and frequency response plots) are known as Bode diagrams and are generally considered the most useful way of representing a filter's performance.

You will note that for the lowpass filter of Fig. 1a, the phase shift starts at 0°, is 45° at fb and then approaches 90° as the frequency approaches infinity. This is not an *active* filter, it is composed entirely of *passive* components which means that its output cannot be effectively loaded without changing its performance.

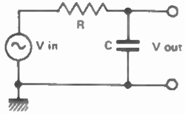


Fig. 1a Simple low pass filter

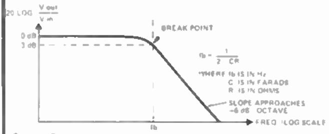


Fig. 1b Frequency response of above

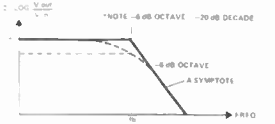


Fig. 1c Approximation to response

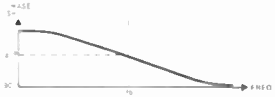


Fig. 1d Phase shift v Frequency plot

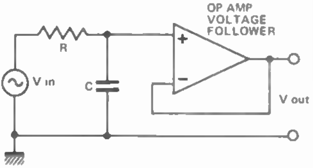


Fig. 1e Active filter to perform the same task as the passive circuit of Fig. 1a

Fig. 1e shows the same filter but in its active form, the op amp being used as a voltage follower serving only to isolate the filter's output. This type of filter is known as a First Order filter — a measure of the roll off slope.

When a more rapid slope is required, a higher order filter structure (one with more reactive elements) must be used. This is dealt with later.

ACTIVE FILTERS

Summary of low pass filter of Fig 1

Filter type	Low pass
Filter order	First order
Roll off slope	−6dB/octave or −20dB/decade (the same)
Breakpoint fb	fb = 1/2πCR Hz
Phase shift at fb	45

TABLE 1

Passing highs

Next, let us consider the simple high pass filter of Fig 2a It is the complement of the low pass filter, the elements having been interchanged Therefore it is not difficult to accept the complementary phase and frequency response curves of Fig 2b Note that the break point is the same and so is the roll off slope

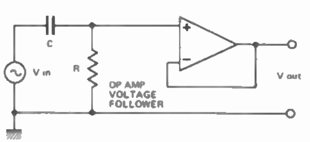


Fig 2a Simple high-pass active filter

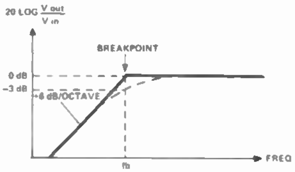


Fig 2b Frequency response of the high pass filter

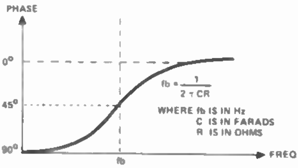


Fig. 2c Phase v frequency plot of the same filter

Summary of the high pass filter of Fig. 2

Filter type	High pass
Filter order	First order
Roll off slope	+6dB/octave or +20dB/decade
Break point fb	fb = 1/2πCR Hz
Phase shift at fb	45

TABLE 2

Passing bands

The next type to be considered is a simple band pass filter shown in Fig 3a. Although it uses an inductor it is only to illustrate the bandpass theory Later on in this series, inductors will be replaced by their active equivalents

The frequency response (Fig. 3b) shows that this circuit is symmetrical, having roll off slopes of 6dB/octave on either side of its RESONANT peak This filter is known as a second order filter because it has two reactive sections the L and the C The C is responsible for the +6dB/octave portion of the slope, the L for the −6dB/octave portion But where these two slopes should meet the response of the filter peaks and the slopes become much larger (Reson-

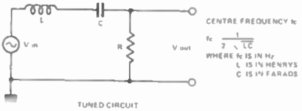


Fig 3a Simple band-pass filter

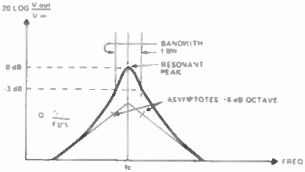


Fig 3b Band-pass frequency response

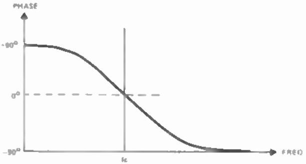


Fig 3c Band-pass phase response

ance) The sharpness of this peak is described as the Quality of the filter the Q factor Resonance occurs at a frequency known as the Centre frequency denoted by fc

The bandpass filter is so called because it only passes signals within a certain bandwidth, which is defined as being the frequency range contained between the two points that are 3dB below the resonant peak There is a fixed relationship between Centre frequency (fc) bandwidth (fbw) and Q factor given by Q=fc fbw

The centre frequency is given by $fc \simeq 1/2\pi\sqrt{LC}$ Hz This is only approximate, as it assumes that the value of R is relatively low As R decreases the Q factor increases Thus R has the effect of damping the resonances and so as it approaches zero ohms Q approaches infinity

The phase shift is shown in Fig 3c As this filter is a second order structure then the total phase movement will be twice that for a first order structure i e 180 Fig 3d shows the phase and frequency responses for different values of Q Note that a high Q has a very rapid rate of change of phase a low Q has only a slow rate of change

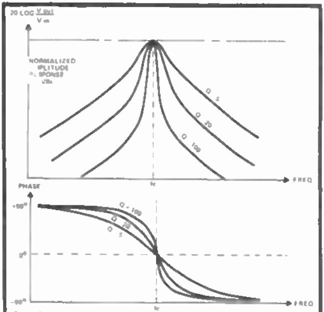


Fig 3d Effect of varying Q on the frequency and phase characteristics

Time please

Bandpass filters also have a time response as opposed to their frequency response When an impulse is applied to a bandpass filter it rings (Fig 3e) The filter oscillates at the centre frequency fc the amplitude of the oscillations decaying exponentially in time The ringing time T_r is the time taken for the oscillations to decay to 37% of their initial value Ringing time is related to the Q and fc by the following equation

$$T_r = Q/2\pi fc$$

When a high Q filter has been constructed it may prove difficult to measure its Q factor accurately due to the narrowness of its bandwidth However if the filter is made to ring a reasonably accurate measurement of the Q can be obtained by measuring T_r and fc

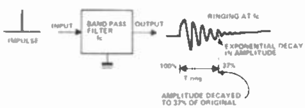


Fig 3e Ringing in a band pass filter

Filter type	Band pass
Filter order	Second order
Roll off slopes	+ and −6dB/octave greater near to resonance
Centre frequency fc	$fc \sim 1/2\pi\sqrt{LC}$
Phase shift at fc	0
Q factor	fc/fbw where fbw is the 3dB bandwidth
3dB bandwidth fbw	fc Q
Ringing time T_r	$Q/2\pi fc$

TABLE 3 Summary of band pass filter

Failed band

Another common filter structure is the band reject or notch filter There are many ways of realising this filter, one of which is shown in Fig 4 The input signal is subtracted from the bandpass output By adjusting Ra with respect to R complete cancellation can be obtained at fc

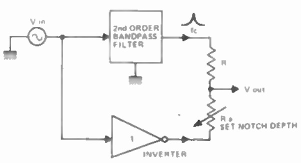


Fig 4 Notch filter using Op Amps

Thus the centre frequency of the bandpass filter is the centre frequency of the notch whose depth can be varied by altering Ra

Very deep notches are possible 50dB is easily obtained As the Q of the bandpass filter is increased, so is the Q of the notch filter However, Ra will have to be reset for each value of Q

Filter Order

Consider the ideal low pass filter shown in Fig 5a Its response is flat right up until the break frequency fb Frequencies above fb are attenuated to nothing! You won t be surprised to learn that filters like this don t exist However it is a common requirement to produce filters with very steep roll off slopes and this is achieved by designing filters with lots of sections to increase the filter order. Each reactive element in the filter increases the filter order by one, therefore a low pass active filter with three capacitors is known as a third order filter and will have an ultimate roll off of three times 6dB/octave which is 18dB/octave.

However, designing a third order lowpass filter is not just a simple case of sticking three first order RC circuits in a line. What you get when you do this is a very soggy curve indeed! The filter should be flat in the pass band, then it should turn over and rapidly assume its ultimate roll off slope. Examples of this type of Maximally flat filter are shown in Figs 5b and c. The effect of order number upon a bandpass filter is shown in Fig. 5d.

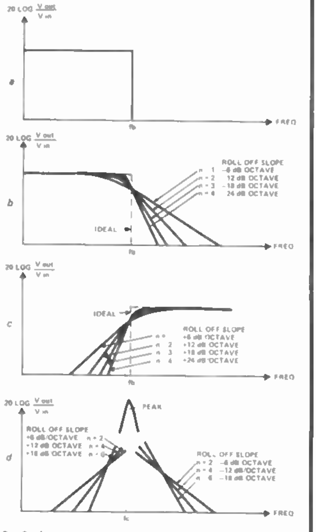


Fig. 5a. Ideal low-pass response,
b. Examples of maximally flat,
c. Filter responses,
d. Effect upon band-pass filter of increasing order number.

Later on in this series the circuit diagrams and design charts are given for various filter types and order numbers. It would seem that to get a filter to approach its ideal response, all that is needed is to increase the order number. This is in fact true, but there are certain tolerance problems. (When 8th order filters are designed, component tolerances of about 1% are required!)

Which filter shape?

The type of filter that is chosen to do a particular job will depend on what parameters are thought to be important. There are three basic characteristics to be considered (lowpass and highpass filters only):

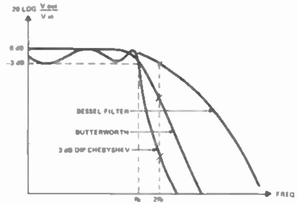
1. Good transient response
2. Maximum flatness of the filter within its passband
3. Maximum rolloff slope outside the passband

The type of filter used should be chosen to fit the job that they are being designed for. The filters have been categorised into three basic types for the purpose of simplicity.

Filter number 1 is known as a Bessel filter. Its phase changes almost linearly with frequency. It is useful for systems where a good transient response is required, such as joining the dots up on the output of a digital to analogue converter. It has a very poor initial roll off slope.

Filter number 2 is known as a Butterworth filter. It has the flattest pass band possible. Its other two parameters are a compromise. That is it has a reasonable overshoot and a fairly fast initial roll off.

Filter number 3 is known as a Chebyshev filter. It has some ripple in its pass band, although this is small, and a very fast initial roll off, and a poor transient response.



ATTENUATION AT FIRST OCTAVE (2 fb)

*3 dB CHEBYSHEV	17	28	39	51	62	75
BUTTERWORTH	12	18	24	30	36	42
η/FILTER ORDER	2	3	4	5	6	7

*NOTE THE IMPROVED ATTENUATION

Fig. 6. Response of all three types of filter discussed, with table showing variation in attenuation between them.

Next Month: Full design charts and circuits for three types of Active Filter.

KEEP THIEVES AWAY — WITH OUR INVALUABLE

ALARM ALARM

ONE PROBLEM WITH BURGLAR alarms is that they don't 'go off' until the burglar has broken in, but here is a project which can be installed in a car to warn thieves that a burglar alarm is operating. It should warn a thief to go and find a car which is not owned by an ETI reader! Even if there is actually no burglar alarm, the 'alarm alarm' can still be used. It's what the car thief believes that counts – and he's not going to investigate to see whether there really is an alarm.

The unit is simply a box containing two lamps which flash slowly on and off, together, and shine through a Perspex panel to illuminate the words ALARM ACTIVE. It uses a 555 timer IC, which is used as an astable multivibrator.

As the circuitry is isolated from the box this alarm can be used with any car having a 12 volt battery - whether the positive or negative terminal is connected to the chassis. Take care to see that the unit is correctly connected.

Installation

The unit can be permanently mounted in a car near one corner of the windscreen and the wiring neatly run to a switch below the dashboard. Alternatively it may simply be placed in position when required, and plugged in to the cigarette lighter socket. To work effectively it should be prominent day or night.

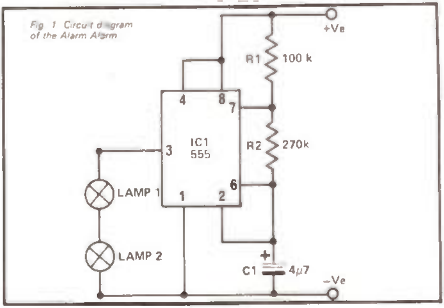
Construction

We mounted the components on an 'L' shaped bracket which is ideal for fitting to the dashboard. Lamps 1 and 2 are push fitted into two rubber grommets mounted on an aluminium bracket, and arranged to illuminate the perspex panel as shown. We used Letraset for the panel lettering.

The components are assembled onto the small PCB according to the component overlay, taking care that the 555 and C1 are correctly orientated.

We fitted an On/Off switch but if the car actually has a burglar alarm,

Fig. 1. Circuit diagram of the Alarm Alarm



HOW IT WORKS

The 555 IC is used as an astable (i.e. not stable) multivibrator. As soon as it is connected to the supply it starts to oscillate (slowly in this case) and the output voltage at pin 3 changes regularly and suddenly from high to low and low to high as the capacitor is charged and discharged.

The charge time (during which the output is high and the lamps are on) is given by the formula:

$Tc = 0.69\,(R1 + R2) \times C$ and is in seconds when R1 and R2 are in megohms and C is in microfarads. So

$Tc = 0.69\,(0.1 + 0.27) \times 4.7$
$= 1.2$ seconds

The discharge time (during which the output is low and the lamps are off) is given by the formula

$Td = 0.69 \times R2 \times C$
$= 0.69 \times 0.27 \times 4.7$
$= 0.88$ seconds

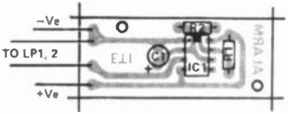
Total time of one oscillation = Tc + Td = 2.08 seconds. So, we have a flasher which is on for about 1 second in 2. The exact timing depends on the actual capacitance of the capacitor C, and this may differ from its rated value by as much as −20% and +50%.

The rate of flashing may be changed by changing the values of R1 and R2. Higher values cause slower flashing then this device should be connected so that it is activated as the burglar alarm is energised.

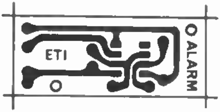
The parts list specifies two 6 volt lamps of 60 mA rating which are connected in series. The current consumption is so low that the unit could be left operating for many hours without any danger of running down a car battery.

The IC is actually capable of switching up to 200 mA through pin 3, so there is no reason why two or even three slave units (with lamps only) should not be run in parallel with the lamps in the master unit. This could provide warnings at all vulnerable points in a car.

This same device can be used in windows of homes as a discouragement to house burglars. In this case it could be operated from a simple power supply running from the mains.



Component overlay of Alarm Alarm. Because of the small size, miniature components should be used



Foil pattern shown full size

PARTS LIST

RESISTORS (all ¼ W 5%)
R1 100 k
R2 270 k

CAPACITOR
C1 4u7 16 V tantalum

SEMICONDUCTOR
IC1 555 timer

LAMPS
LP1,2 6 V .06 A MES type

SWITCH
See text

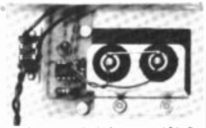
MISCELLANEOUS
Nuts, bolts, spacers, etc.
Aluminium for front panel and bracket
Grommets, flex, red translucent perspex
PCB as pattern.

GETTING HOLD OF COMPONENTS

All the components used in this project should be available from most component suppliers.

COST OF CONSTRUCTION

The total cost of this project should be about £2 00.



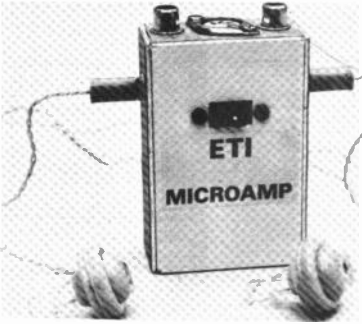
Picture showing method of mounting LP1, 2 on angled bracket

microAMP

THERE IS OFTEN A NEED for a piece of equipment which can give a reliable answer as to another unit's state of being. In audio, for instance, a repaired amplifier might need to be tried without risking a pair of expensive monitor loudspeakers, or even headphones (which are worth a few bob themselves these days!).

Our micro-amp is designed to be a portable stereo test amp, capable of betraying any faults or distortions inherent in the suspect unit. The transducers utilised are low-cost crystal earpieces, for which the design has been optimised. Although there are only a handful of components in the design, the amp gives exceptionally good sound quality suitable, say, in checking whether that cassette deck in 'Rip-Off Hi-Fi' has 1% or 100% distortion.

Quality is ultimately limited by the earpieces, but they are capable of doing better than the two-transistor 'Super-Squark' portable radios to which they are more usually mated.

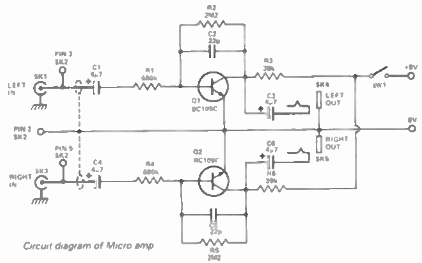


View of completed Micro amp

In and Out and In . . .

In the prototype, sockets were provided for a 'tape input' type of signal, i.e. from a cassette recorder at the DIN socket pins 3 and 5. If a signal is to be input from a tuner or amplifier, either use the phono sockets or pins 1 and 4 so that you keep things standard.

Input level is ideally around 100 mV; if vastly different to this, R1 can be juggled in value to compensate. Increase if the level is higher.



Circuit diagram of Micro amp

PARTS LIST

RESISTORS (all ¼ W 5%)

R1,4	680 k
R2,5	2M2
R3,6	39 k

CAPACITORS

C1,3,4,6	4u7 tantalum
C2,5	22 p polystyrene

SEMICONDUCTORS

Q1,2	BC109 C - see text

SWITCH

SW1	On-off rocker, or slide type

SOCKETS

SK1,3	Chassis phono sockets (Doram: 478 093 red, or: 477 848 black)
SK2	Chassis 5 pin DIN 180° socket
SK4,5	3.5 mm chassis jack socket

CASE

Norman type AB12 or similar (3 x 2 x 1")

MISCELLANEOUS

PP3 battery, clip to suit,
Miniature screened wire flex
Nuts, bolts, spacers etc.
PCB as pattern
2 off crystal earpieces with 3.5 mm jack plugs,

HOW IT WORKS

Q1 and Q2 are base biased single stage amplifiers. The feedback capacitors C2 and C5 are there to provide high frequency correction, and experimentation with the value will change the resultant sound quite noticeably.

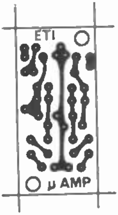
C1 and C4 decouple the input from preceding circuits, and the resistors R1 and R4 will set the level seen by the amplifier, and hence by the earpieces. No volume controls are provided, as none proved to be necessary with the prototype. C3 and C6 serve to decouple output from dc. Crystal earpieces only are recommended.

GETTING HOLD OF COMPONENTS

Most components should be readily available from a number of suppliers. We have listed Doram part numbers for the phono sockets and Norman's reference for the box we used in our microamp.

COST OF CONSTRUCTION

The total cost of this project should be about £3.50 inc VAT.



Foil pattern of PCB is shown full size

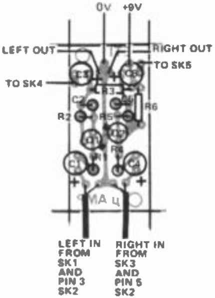
As seems to be usual for us nowadays, space within the box is very restricted, but it *will* go into the case if you take some care over the layout. Perhaps our photographs will help.

Power and Construction

A PP3 is all that will fit into our box and is all that is needed. Current drain is around 300 uA (hence the name!) and so even this will have a life-span approaching that which it *would* have enjoyed had you left it sat sitting merrily on a shelf.

The PCB is smaller than most, so take care when soldering it up: too long with the iron in one place, and the track will become emotionally attached to the bit, and not wish to leave it!

BC109Cs must be used to give a high enough output from the specified input. Surplus transistors will obviously work, but don't blame us if the sound is bad!



Component overlay of Micro amp

CONVERT ANY 1mA METER MOVEMENT INTO AN ACCURATE TACHO FOR YOUR CAR WITH OUR

TACHOMETER

This design uses a single integrated circuit to provide an easily calibrated unit that will provide rpm indications of a wide range of engine speeds. It is suitable for 4 or 6 cylinder engines.

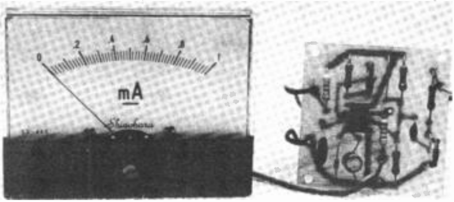
UNTIL TEN OR SO YEARS AGO, car tacho's were cumbersome mechanical devices usually driven via a flexible cable from gearing attached to the shaft of the vehicle's dynamo — or sometimes via the distributor shaft.

The advent of transistor technology changed all this and since then almost all car tacho's are electronically operated.

The basic principle is much the same for all electronic tacho's an electrical signal taken from the low tension side of the distributor is converted into a voltage proportional to engine rpm and this voltage is displayed on a meter calibrated accordingly.

Most car tacho's are complex and expensive devices — but here's one with a difference! It is simple yet extremely effective. Its simplicity is due to our using one single integrated circuit rather than the more conventional multiplicity of individual transistors.

The unit will operate on both positive and negative earth vehicles and will also operate successfully and without modification with most types of electronic ignition systems as well as the more common electro-mechanical systems.



Photograph showing a view of the completed pcb connected to a 1mA meter with 120 movement. The compact layout of our single integrated circuit design is apparent from this picture.

Construction

As there are so few components, construction is very simple and straightforward. Do make sure though that the 555 IC is soldered in the right way round — ditto the two diodes. Compare your work against our layout drawing as a final check.

Any type of meter that has one milliamp full scale deflection can be used. This is a very common type of instrument and you should be able to obtain one new or secondhand with no difficulty. Ideally you should choose one that has 180° or 280° movement but these tend to be rather expensive. The meter size should be chosen to suit your proposed housing.

When the meter has been assembled connect it to the vehicle's battery and connect the input to the contact breaker side of the coil.

Calibration

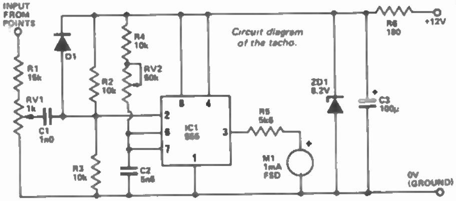
We can think of three ways to calibrate this unit. The easiest method is to borrow an already calibrated tacho which can be temporarily connected to your car. RV2 may then be adjusted until the two readings agree over a range of engine speeds.

The unit may also be calibrated by the use of a signal generator by recognising that with a four cylinder engine there are two sparks per engine revolution. To calibrate the unit, take the output from a signal generator to the tacho (via an amplifier if necessary) and adjust RV2 until the reading on M1 satisfies the relationship: f = 2M where f = frequency in Hz, and M = meter reading in r.p.m.

Our final method is to calculate the vehicle speed per 1000 r.p.m. in top gear and adjust RV2 accordingly. Needless to say, this is a *two* person operation.

If the adjustment of RV2 is found to be too coarse its value may be reduced to 25k or lower. If this is done it will be necessary to increase the value of R4 accordingly.

Before making final calibration, adjust RV1 to eliminate any false triggering - check at all engine speeds. This unit may be used with either +Ve or —Ve earth vehicles simply connect the battery leads as shown.



Circuit diagram of the tacho.

HOW IT WORKS

The 555 timer IC is used as a monostable which, in effect, converts the signal pulse from the breaker points to a single positive pulse the width of which is determined by the value of R4 + RV2 and C2. The mathematical formula is T= 1.1 x R x C where R= R4 + RV2 (the section of RV2 in use) and C= 5.6×10^{-9} (Farads), and T= pulse length in seconds.

Resistors R2 and R3 set a voltage of about 4 volts at pin 2 of IC1. The IC is triggered if this voltage is reduced to less than approx. 2.7 volts (1/3 of supply voltage) and this occurs due to the voltage swing which the breaker points open.

An adjustment potentiometer RV1 enables the input level to be set to avoid false triggering.

Zener diode ZD1 and the 180 ohm resistor stabilise the unit against voltage variations.

PARTS LIST

RESISTORS (all ½ W 5%)
R1 15 k
R2-4 10 k
R5 5k6
R6 180 R

CAPACITORS
C1 1n0 polyester
C2 5n6 polyester
C3 100 u 10 V electrolytic

SEMICONDUCTORS
D1 1N914
ZD1 8V2 300 mW
IC1 NE555

POTENTIOMETERS
RV1 1 k
RV2 50 k

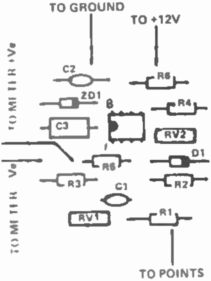
MISCELLANEOUS
PC board ETI 081
Meter 1 mA FSD

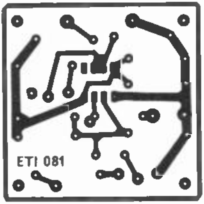
GETTING HOLD OF COMPONENTS

There should be nothing here to trouble the constructor — the 555 is advertised by a number of firms in this issue and the other semi-conductors and passive components should be readily available.

COST OF CONSTRUCTION

Cost of components for this project should be about £2.00. This includes the PCB but is exclusive of meter M1.





The foil pattern of the printed circuit is shown full size above and to the right is the component overlay for the PCB

VALVE SOUND – on the rebound?

GEORGE CHKIANTZ
AND
RICHARD ELEN

TWO PROFESSIONAL SOUND ENGINEERS HAVE A NEW AND HIGHLY CONTROVERSIAL THEORY TO ADD TO THE CONTINUING DEBATE AROUND THE SUPPOSED SUPERIORITY OF VALVE AMPLIFIERS

IMAGINE YOU ARE SITTING in front of a pair of monitor speakers listening to some master tapes. The first track you hear is a very good high quality mix such as one could find on a fair proportion of modern albums. But the second one is something else.

It too is of very high quality, but in addition it seems to possess an undefinable something. Could one call it clarity? Rightness? It's hard to put into words, but there is something about that mix which makes it stand out from the rest — an unknown factor which is nonetheless sufficiently noticeable for you to be able to tell the difference every time. Yet you know that the two recordings were made in the same studio, on the same desk, the same tape machines — every link in the chain from microphone to master tape was duplicated. But with one subtle change. The first mix was monitored on a pair of loudspeakers driven by a modern high-power transistor amplifer with a rated output of 300 W.

The second, on the other hand, was reproduced using a pair of old glowing valve amps running a mere 50 W — and unaccountably sounding just as loud.

Why the difference?

Valves versus Transistors

It is important to state at the outset that this is intended to be a *qualitative* analysis of points that we have found to be significant over the past few years during our work as sound recording engineers. Some of the points we are raising are nowadays being discussed, but not all. One reason for this is that several of them are not easily measured — rather, they are experienced.

Until a couple of years ago, the standard answer you *would* get from any audio engineer worth his salt when asked the question *"Why do valve amps sound better than transistors?"* would have been *"Well, valves produce more even-harmonic distortion, and you like the distortion, which is more 'musical' than the distortion produced by a transistor amp. And after all, transistors are more distortion-free than valves ever were."* He would not give the same answer today, unless he spent all his time listening to test instruments instead of real signals.

A big question that needs to be discussed is *"Is distortion just a variable you can measure with test equipment or is high fidelity, in the words of a well-respected manufacturer, 'the closest approach to the original sound'"*? What does it mean to have 0.0001% distortion when it *still* doesn't sound like the original (and when the speakers are adding a further 2%)?

Distorted assumption

The tacit assumption in the design of so-called valve sound musical instrument amplifiers is *"Musicians like the sound of a valve amp. Valve amps may have more distortion. Therefore musicians like the distortion."*

Manufacturers thus have produced special boxes which may introduce up to 25% second harmonic distortion and come up with a 'valve-sound' which some musicians like, but many describe as sounding more like a fuzz box than an AC30.

This seems to suggest that maybe we aren't just talking about distortion. And when we come on to studio monitoring amplifiers, we find that there is little significant difference in distortion figures between solid state and thermionic equipment. It must be remembered, however, that we are *not* suggesting that *all* valve amps are 'nice' or that *all* transistor amps are 'nasty'. The major problems inherent in transistor amplifier design are the direct result of developments made on valve circuits. Also, these problems, as will be seen, do not necessarily apply to low-power transistor amplifiers as usually encountered in Hi-Fi systems, for example. The problems seem to arise in the method and amount of negative feedback application.

Feedback and Its Misuse

There are two major ways of applying negative feedback to an amplifier: in the form of an overall feedback loop from one end of the amp to the other, or by the application of an individual feedback path per stage. Valve amplifers like the Leak 'triple loop feedback' series primarily used the latter method with little additional overall feedback (typically about 10dB). Certain other valve amps relied mainly on a high

VALVE SOUND

deg ees of overall feedback producing sound much closer to that of transistor amps. The main reason for the choice of overall feedback was probably economic; a glance at the handful of components underneath a certain well respected H.Fi amplifier will indicate how cheap they must have been to produce. But it appears that the amps which used a feedback loop on each individual stage that produce the oft mentioned "valve sound".

OK, you may well ask, what's so bad about high levels of overall feedback? Well there are three main reasons, one well known, the others totally unheard of.

T.I.D.

Almost everyone has heard of manufacturers recent efforts to eliminate the newly-discovered menace of Transient Intermodulation Distortion but in case you missed the blurb it may be broadly described as the type of distortion produced when the rising edge of a waveform applied to the amplifier input is rising faster than the total transit time i.e. the time taken for a signal to pass through the amplifier. This may result in a spike of pure 100% distortion whose output power may well be limited only by the peak handling capacity of the PSU.

There are two ways of dealing with this. Either the initial stages of the amplifier must be capable of taking the maximum level of applied signal with no feedback applied or the rising edges must be slowed down to avoid the effect. This latter solution is the one generally used today and is equivalent to placing a low pass filter on the input to limit the frequency response to something below the level of flat from DC to Light.

TID was not so prevalent in certain valve amplifiers because of a) locally applied feedback on the stage itself thus reducing the transit time (and perhaps electrons crawl more slowly across semiconductors than they travel in vacuo?) and b) because the linear portion of the valve transfer curve is longer than the corresponding area of transistor characteristics.

The Ricochet Effect

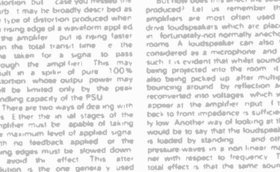
A point often not considered in amplifier design is that as negative feedback across the amp is increased the back to front impedance (ie the impedance from the output looking back up the feedback loop towards the input) is reduced. Some high power transistor amps have loops with an impedance of only a few ohms. This is because transistors are generally low impedance devices.

But how does this affect the sound produced? Let us remember that amplifiers are most often used to drive loudspeakers which are placed in fortunately-not normally anechoic rooms. A loudspeaker can also be considered as a microphone and as such it is evident that whilst sound is being projected into the room it is also being picked up after multiple bouncing around by reflection and reconverted into voltages which will appear at the amplifier input if the back to front impedance is sufficiently low. Another way of looking at this would be to say that the loudspeaker is loaded by standing and other pressure-waves in a non linear manner with respect to frequency. The total effect is that the same source amplifier speaker system will sound different in various locations whilst a system without this effect will vary only slightly according to room acoustics. We noticed this whilst working in a studio fitted with Tannoy Monitor Reds in Lockwood cabinets (over)driven by well-known 300 W transistor power amps. The act of panning a signal from left to right changed its sound dramatically, far more than one would expect in an acoustically treated studio environment. Replacing the studio amps with our venerable bottles however removed the effect almost entirely (most other factors (including subjective SPL) remaining equal. The transistor amps of course had a high level of overall feedback, unlike the valve system.

Frequency Response

One problem with evaluating the Ricochet Effect and to some extent TID is that they are very hard to measure objectively. You should be able to pick them out by listening critically but using normal test procedures it will often be found that there is little descernible difference between nice and nasty sounding amps on the test bench. However one point of comparison has emerged. It was found that a number of nasty sounding amplifiers had a very limited frequency response with the feedback loop removed (one specimen managed 3 dB points at 250 Hz and 8 kHz approx with 40 Hz and 15 kHz over 10 dB down) whereas our nicest amplifier was found to be nearly flat under similar conditions (3 dB points at 40Hz and 15 Khz approx). However this point required further investigation and removing a feedback loop is not always as easy as one would wish.

As far as the ricochet effect is concerned we have so far found no other satisfactory explanation for the phenomenon (try it and see).



The Quad 405 current dumper. This fine amplifier is finding support from the advocates of thermionic emission amplification for its non transistor sound. A possible explanation of this is the absence of the usual feedback arrangements in the circuit. Operation of the current dumping output stages is basically that of a high current switch controlled by a low power class A amplifier.

Conclusions

The result of a few years of subjective listening tests has indicated very firmly to us that the second harmonic distortion explanation for the valve sound *IS LARGELY A FALLACY*. And after all we were always taught at college that push-pull output stages *cancelled out* even harmonic distortion. Where is it all coming from?

We feel that the major reason for *certain* valve amps sounding better than *certain* transistor amps is largely the result of the use of smaller amounts of overall feedback in the former, resulting in less TID and a reduction of what we have termed the hypothetical Ricochet Effect.

Some transistor amps — mainly low power types — sound particularly good because they have better linearity, lower transit times etc and hence less Ricochet and less objectionable TID (the 100% momentary distortion of TID is far more painful if the amplifier is capable of delivering 500 W than if it can only manage 2!).

And more conclusions

We have found that a well-designed high quality valve amplifier can provide adequate power reserve (remember that a Tannoy Red for instance only takes 35 W not 300) and distortion figures and is capable of reproducing the textural subtlty of the original performance with ease, whatever the apparent performance on non-typical test tones may indicate. After all, it is usually music we are listening to, with all its transients and non-cyclic waveforms, rather than what to us are rather boring sine waves. This aspect of high fidelity — the ability of the system to reproduce the subtle nuances of the original instruments — is something that few transistor amplifiers (with the possible exception of amps like the Quad 405 with its totally different feedback technique, the H H monitoring amplifier with its special attention to TID, and the Vertical FET amplifier Yamaha, which seems to exhibit all the niceness of a valve amplifier) have shown themselves able to do.

Of course, a few people will contest our results, which are admittedly only preliminary: we say to them, listen for yourself and see. It is likely that more distortion will be caused by a closed mind than will be exhibited by the valve amplifier under examination!

*ABOUT THE AUTHORS.

George Chkiantz is a freelance sound recording engineer of long experience with many of the world's top recording groups, including Family, King Crimson, Led Zeppelin (including "Whole Lotta Love"), Hawkwind and many others. He also received a Gold Disc for the Rolling Stones album "It's Only Rock 'N' Roll".

Richard Elen is Studio Manager of KPM Sound Studios, Denmark Street (a part of EMI Music Publishing). He is quite clever as well.

Both are moderately sensible.

electronics today international

What to look for in the August issue: On sale July 1st

SOIL MOISTURE INDICATOR

HOW TO KEEP YOUR HORTICULTURE HAPPY

"THE ANSWER lies in the soil." Used to be a standard joke but it's true especially of household plants.

SWEEP GENERATOR

3-TRANSISTOR RADIO

PICKUP PRINCIPLES

ETI'S COVER PRICE

FREE INSIDE THE AUGUST ISSUE

MARSHALLS CATALOGUE

ETI DATA SUPPLEMENT

PRESENTED FREE WITH ELECTRONICS TODAY INTERNATIONAL JULY 1977

- Hexadecimal and Decimal conversion tables
- Logic family comparisons
- Logic symbols and Truth tables
- Laws of Boolean algebra
- Transistor and Fet characteristics
- Rectifier and Diode characteristics
- Component codes
- TTL to CMOS functional equivalents
- Standard Op Amp circuits
- Standard Power supply configurations
- Microprocessor Glossary

HEXADECIMAL AND DECIMAL INTEGER CONVERSATION TABLE

8		7		6		5		4		3		2		1	
Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal	Hex	Decimal
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	268 435 456	1	16 777 216	1	1 048 576	1	65 536	1	4 096	1	256	1	16	1	1
2	536 870 912	2	33 554 432	2	2 097 152	2	131 072	2	8 192	2	512	2	32	2	2
3	805,306,368	3	50 331 648	3	3 145 728	3	196 608	3	12 288	3	768	3	48	3	3
4	1,073,741 824	4	67 108 864	4	4 194 304	4	262 144	4	16 384	4	1 024	4	64	4	4
5	1,342 177,280	5	83 886 080	5	5 242 880	5	327 680	5	20 480	5	1 280	5	80	5	5
6	1,610,612 736	6	100 663 296	6	6 291 456	6	393 216	6	24 576	6	1 536	6	96	6	6
7	1,879,048 192	7	117 440 512	7	7 340 032	7	458 752	7	28 672	7	1 792	7	112	7	7
8	2 147 483 648	8	134 217,728	8	8 388 608	8	524 288	8	32 768	8	2 048	8	128	8	8
9	2,415 919 104	9	150 994 944	9	9 437 184	9	589 824	9	36 864	9	2 304	9	144	9	9
A	2,684 354,560	A	167 772 160	A	10 485 760	A	655 360	A	40 960	A	2 560	A	160	A	10
B	2,952,790 016	B	184 549,376	B	11 534 336	B	720 896	B	45 056	B	2,816	B	176	B	11
C	3,221 225 472	C	201 326 592	C	12 582 912	C	786 432	C	49 152	C	3 072	C	192	C	12
D	3,489,660 928	D	218 103 808	D	13 631,488	D	851 968	D	53 248	D	3,328	D	208	D	13
E	3,758 096 384	E	234,881,024	E	14 680 064	E	917 504	E	57 344	E	3 584	E	224	E	14
F	4 026,531 840	F	251 658 240	F	15 728,640	F	983 040	F	61 440	F	3,840	F	240	F	15
8		7		6		5		4		3		2		1	

TO CONVERT HEXADECIMAL TO DECIMAL

1 Locate column of decimal numbers corresponding to left most digit or letter of hexadecimal select from this column and record number that corresponds to position of hexadecimal digit or letter
2 Repeat step 1 for next (second from left) position
3 Repeat step 1 for units (third from left) position
4 Add numbers selected from table to form decimal number

TO CONVERT DECIMAL TO HEXADECIMAL

1 (A) Select from table highest decimal number that is equal to or less than number to be converted
(B) Record hexadecimal of column containing selected number
(C) Subtract selected decimal from number to be converted
2 Using remainder from step 1 (C) repeat all of step 1 to develop second position of hexadecimal (and remainder)
3 Using remainder from step 2 repeat all of step 1 to develop units position of hexadecimal
4 Combine terms to form hexadecimal number

COMPARISON OF STANDARD LOGIC FAMILIES

Logic family	Noise Immunity Volts	Prop. delay nS	Fan Out	Max. Toggle Speed MHZ	Supply Voltage Nominal V	Min. V	Max. V	Power Diss. per package mW (typ)	Decoupling and other requirements
74 Series	0.4	9	10	15	5.0	4.75	5.25	40	0.1 uF Ceramic capacitor for every 8 packages to eliminate switching current spike
74H Series	0.4	6	10	40	5.0	4.75	5.25	60	
74S Series	0.3	3	10	125	5.0	4.75	5.25	40	
74LS Series	0.3	9	10	25	5.0	4.75	5.25	8	
CMOS	4.5	30	>50	10	–	3.0	18.0	0.01	No special precautions

TTL BIPOLAR LOGIC

The 74 Series of transistor-transistor logic is a medium speed family of saturating integrated circuit logic designed for general digital logic application requiring clock frequencies to 30MHz and switching speeds in the 7-11 nS range under moderate capacitive loading.

The circuits are identified by a multiple emitter input transistor and an active "pull up" in the upper output network. Clamp diodes are provided at each input to limit the undershoot that occurs in typical system applications such as driving long interconnect wiring. The active pull-up output configuration provides low output impedance in the high output state. The resulting low impedances in both output states ensures excellent a.c. noise immunity and allows a high-speed operation with capacitive loads.

COMPLEMENTARY MOS (CMOS)

Complementary MOS is the newest of the general purpose logic families.

The following are primary design features of the whole of the COS/MOS and McMOS ranges

- Double diode protection on all inputs.
- Noise immunity typically 45% of VDD, 30% of VDD minimum.
- Buffered output compatible with MHTL and Low Power TTL.
- Low quiescent power dissipation: 25nW typ. per package.
- Wide power supply voltage: 3-18 Volt dependent on type
- Single supply operation
- High fanout: greater than 50
- High input impedance: 10 ohms typ.
- Low input capacitance: 5pf typ.

BASIC LOGIC SYMBOLS AND TRUTH TABLES

BUFFER

A	C
0	0
1	1

INVERTER

A	C
0	1
1	0

AND GATE

A	B	C
0	0	0
1	0	0
0	1	0
1	1	1

NAND GATE

A	B	C
0	0	1
1	0	1
0	1	1
1	1	0

OR GATE

A	B	C
0	0	0
1	0	1
0	1	1
1	1	1

NOR GATE

A	B	C
0	0	1
1	0	0
0	1	0
1	1	0

EXCLUSIVE OR GATE

A	B	C
0	0	0
1	0	1
0	1	1
1	1	0

EXCLUSIVE NOR GATE

A	B	C
0	0	1
1	0	0
0	1	0
1	1	1

LAWS OF BOOLEAN ALGEBRA

$A + 0 = A$ $\quad$ $A \cdot A = A$

$A + 1 = 1$ $\quad$ $A + \overline{A} = 1$

$A \cdot 0 = 0$ $\quad$ $A \cdot \overline{A} = 0$

$A + A = A$ $\quad$ $A \cdot 1 = A$

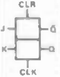
$AB + AC = A(B + C)$

$A + BC = (A + B)(A + C)$

$\overline{ABC} = A + B + C$

$A\overline{B}C = A + \overline{B + C}$

J-K Flip Flop



INPUTS				OUTPUTS	
CLR	CLK	J	K	Q	$\overline{Q}$
0	X	X	X	0	1
1	⎍	0	0	Qo	$\overline{Qo}$
1	⎍	1	0	1	0
1	⎍	0	1	0	1
1	⎍	1	1	TOGGLE	

⎍ — HIGH LEVEL PULSE. DATA IS TRANSFERRED ON FALLING EDGE OF PULSE

Qo — THE LEVEL OF Q BEFORE INDICATED INPUT CONDITIONS WERE ESTABLISHED

TOGGLE — EACH OUTPUT CHANGES TO ITS COMPLEMENT ON EACH ACTIVE TRANSITION (PULSE OF CLOCK)

COMMON TRANSISTOR AND

TYPE	CASE	POL MAT	Vce	Vcb	IC mA	Vce ● IC mA		Hfe ● IC mA		Ft MHz ● IC mA		Ptot mW	Use	Comparable Types
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

..D FET CHARACTERISTICS

TYPE	CASE	POL MAT	Vce	Vcb	IC mA	Vcesat @ IC mA		Hfe @	IC mA	Ft MHz @	IC mA	Ptot mW	Use	Comparable Types
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

FETS

	CASE													Ptot mW	Use/Comments
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

RECTIFIERS AND DIODE CHARACTERISTICS

TYPE	MAT	V_R	I_F (A)	V_F	@ I_F (A)	I_R (μA)	@ V_R	USE
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DIODES

	CASE	V_R	I_F (mA)	C_d (pF)	V_F	@ I_F (mA)	I_R (μA)	@ V_R	T_{rr} (nS)	USE	COMPARABLE TYPES
Germanium											
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Silicon											
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

STANDARD COMPONENT CODES

RESISTOR VALUES WILL BE REPRESENTED THUS:

0.47 Ω	will be shown as	R 47	100 Ω	will be shown as	100 R
1 Ω	will be shown as	1R	1 kΩ	will be shown as	1k
4.7 Ω	will be shown as	4R7	10 kΩ	will be shown as	10 k
47 Ω	will be shown as	47 R	10 MΩ	will be shown as	10 M

CAPACITOR VALUES WILL BE REPRESENTED THUS:

10 pF	will be shown as	10 p
1000 pF	will be shown as	1n
1 uF	will be shown as	1u
4.7 uF	will be shown as	4u7
100 uF	will be shown as	100 u

TTL TO CMOS FUNCTIONALLY EQUIVALENT TYPES

TTL	CMOS		TTL	CMOS		TTL	CMOS	
[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	
[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
[illegible]	4001		[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	
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[illegible]	4010	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	4044	
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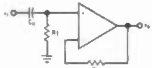
[illegible]	[illegible]		[illegible]	[illegible]		[illegible]	4520	
[illegible]	[illegible]		[illegible]	[illegible]				
[illegible]	[illegible]							

STANDARD OPERATIONAL AMPLIFIER CIRCUITS

Non-Inverting Buffer



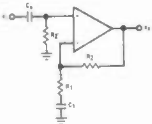
$A_v = 1$

$R_{in} = R_1$

$f_o = \frac{1}{2\pi R_1 C_o}$

Definitions
Av = Closed loop AC Gain
fo = Low frequency −3dB corner
Rin = Input impedance

Non-Inverting AC Amplifier

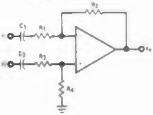


$A_v = 1 + \frac{R_2}{R_1}$

$R_{in} = R_3$

$f_o = \frac{1}{2\pi R_3 C_o} = \frac{1}{2\pi R_1 C_1}$

Difference Amplifier



$e_o = \left(\frac{R_1 + R_2}{R_3 + R_4}\right)\frac{R_4}{R_1} e_2 - \frac{R_2}{R_1} e_1$

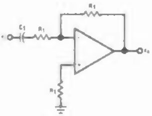
IF $R_1 = R_3$ AND $R_2 = R_4$ THEN

$e_o = \frac{R_2}{R_1}(e_2 - e_1)$

$f_o = \frac{1}{2\pi R_1 C_1} = \frac{1}{2\pi (R_3 + R_4) C_2}$

$R_2 = R_4$ FOR MINIMUM OFFSET ERROR

Inverting Buffer

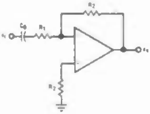


$A_v = -1$

$R_{in} = R_1$

$f_o = \frac{1}{2\pi R_1 C_1}$

Inverting AC Amplifier

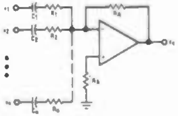


$A_v = -\frac{R_2}{R_1}$

$R_{in} = R_1$

$f_o = \frac{1}{2\pi R_1 C_o}$

Inverting Summing Amplifier



$e_o = -R_A\left(\frac{e_1}{R_1} + \frac{e_2}{R_2} + \cdots + \frac{e_n}{R_n}\right)$

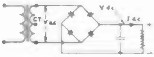
IF $R_1 = R_2 = \cdots = R_n$ THEN

$e_o = -\frac{R_A}{R_1}(e_1 + e_2 + \cdots + e_n)$

THE SUPPLY CONNECTIONS HAVE BEEN OMITTED IN THE ABOVE CONFIGURATIONS FOR THE SAKE OF CLARITY.

STANDARD POWER SUPPLY CONFIGURATIONS

FULL-WAVE BRIDGE – CAPACITIVE INPUT FILTER



Vdc = 1.41 × Vac
Idc = 0.62 × Iac

FULL-WAVE BRIDGE – RESISTIVE LOAD

Vdc = 0.90 × Vac
Idc = 0.90 × Iac

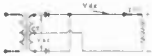
HALF-WAVE – CAPACITIVE INPUT FILTER

Vdc = 1.41 × Vac
Idc = 0.28 × Iac

FULL-WAVE – CAPACITIVE INPUT FILTER

Vdc = 0.71 × Vac
Idc = 1.0 × Iac

FULL-WAVE – RESISTIVE LOAD



Vdc = 0.45 × Vac
Idc = 1.27 × Iac

HALF-WAVE – RESISTIVE LOAD

Vdc = 0.45 × Vac
Idc = 0.64 × Iac

MICROPROCESSOR GLOSSARY

TECHNICAL BOOKS FROM ETI TECHNICAL BOOKS FROM ETI TECHNICAL BOOKS FROM ETI TECHNICAL BOOKS FROM ETI

CALCULATORS

[illegible] APPLICATIONS FOR POCKET CALCULATORS [illegible]

GETTING THE MOST OUT OF YOUR ELECTRONIC CALCULATOR [illegible]

COMMUNICATION

[illegible] SYSTEMS [illegible] SIGNALS & NOISE [illegible]

DIGITAL SIGNAL PROCESSING THEORY & APPLICATIONS [illegible]

[illegible] COMMUNICATION SYSTEMS [illegible]

FREQUENCY SYNTHESIS THEORY & DESIGN [illegible]

PRINCIPLES OF COMMUNICATION SYSTEMS [illegible]

COMPUTER AND MICROPROCESSORS

[illegible]

ELECTRONICS

[illegible]

SEMICONDUCTOR DATA

[illegible]

RADIO, TELEVISION AND AUDIO

[illegible]

TEST EQUIPMENT AND OSCILLOSCOPES

[illegible]

MICROFILE

Gary Evans, ETI's resident microprocessor man, powers up microfile to report on a new personal computing system and Europe's first conference for home computer builders.

THE HOMEBREW COMPUTER market in this country seems about to 'take off'. With sales of manufacturer's development kits on the increase, and signs that many firms are beginning to move into the hardware/software supply field, it seems that this sector of the hobby electronics market will be one of the major growth areas over the next few years.

This month we report on two recent events which reflect this growing interest in the home computing field. The interest ranges from the large manufacturers ready to sell complete systems, to the smaller supplier specialising in the provision of hardware and software for the D.I.Y. market.

Our astronaut is seen landing her LEM with the help of PET's moon landing program. A wide variety of software is available for PET covering applications in the home, for example storing recipes, to programs for small industrial users. The 9in. CRT with graphic handling capability, the calculator style keyboard and cassette interface can be seen in our picture.

Household Pet

First off we look at CBM's announcement that they intend to launch their PET Model 2001 towards the end of this year. PET (Personal Electronics Transaction) is a compact and very versatile home computer system, complete with display screen, cassette interface and a calculator style keyboard.

The basic unit's display screen is a nine inch CRT, capable of a 1000 character display arranged as 40 columns x 25 lines. The display has a standard 64 character ASCII set as well as 64 graphics related characters.

Input to PET is via a calculator style keyboard which allows the basic 64 characters to be entered without shift, while the shift control allows the graphics characters to be entered. Various screen editing and control functions are also available from the keyboard.

Model 2001 provides a cassette interface which uses standard audio cassette tapes to provide program and data storage for the system. The cassette storage system has a number of facilities which allow easy editing and management of user programs.

PET is based on the MOS Technology's (not MOSTEK) MOS 6502 microprocessor. This micro is popular in the States but has not been seen very much over here, although with the recent announcement that Rockwell are to second source this chip, the situation might change.

The system memory is provided by 12 K of ROM and 4 K of RAM (expandable to 32 K). The ROM is divided into two blocks. The first block of 4 K provides the operating system. This will allow Machine Language accessability and is capable of supporting multiple languages.

The resident high level language is BASIC, and is provided by an interpreter occupying the remaining 8 K of system ROM. CBM claim that this BASIC interpreter is 20% faster than other 8 K BASICs. The interpreter provides facilities for handling strings, integer and multiple dimension arrays as well as providing a random number generator.

CBM hope to provide a large range of cassette based software for the system. The programs will cover such areas as video games, list management and inventory control. As well as CBM's software, there is a vast amount of material already available in BASIC language.

There are plans to produce peripherals that will extend the scope of PET's activities, floppy disks, printers and a MODEM are at present under development.

PET will even tell you when it is sick. A self-diagnostic trouble light will tell the operator if any of the boards are not working properly.

The unit should be in production during the summer with a target production figure of 1 000 (yes one thousand) per day. The price in this country is expected to be — wait for it — £600.

At this price, not much more than a teletext decoder or a large colour TV set, CBM see a vast potential in the home and small industrial markets. They are reducing their commitments to electronic calculators and plan to devote much of their energies to the manufacture and supply of PET.

About the only thing this PET will not do is come when you call it, and CBM may well be working on that.

MICROFILE

Doing It Your Way

Of more interest to the person who wants to build his own system was the first European D.I.Y. Computing Conference held in London during May. The event took place at the IEE and was organised by Online Conferences. More than 500 delegates attended, while many had to be turned away.

The conference featured speakers having a wide variety of experience with microprocessors, both in the professional and amateur fields.

The morning began with an introductory Teach In which took delegates through the basic terminology and concepts that were to be developed during the conference. As the day progressed a wide variety of topics covering both the hardware and software aspects of home computing were discussed.

In addition to the formal conference activity, constructors had the chance to see a wide range of displays at a Constructor's Forum. This was held in the rooms surrounding the main hall.

Among the firms with their products on display were SINTEL, who were showing a new Z80 based system which they hope to market in kit form later this year. Amongst other interesting features this system has a very versatile VDU.

System 68 was seen in action on the Bywood Electronics stand while nearby Penny and Giles were showing their new VDU kit. Unlike most VDU kits this comes complete with CRT, keyboard and attractive case.

At the conference Computer Workshop showed for the first time their four terminal, multi user system, developed in conjunction with Technical Systems Consultants running a time-sharing BASIC software package.

The system is aimed at educational establishments and Computer Workshop think that it will fill a need that they have at a price they can afford.

The apparatus is to be manufactured in the U.K. with production scheduled to commence shortly.

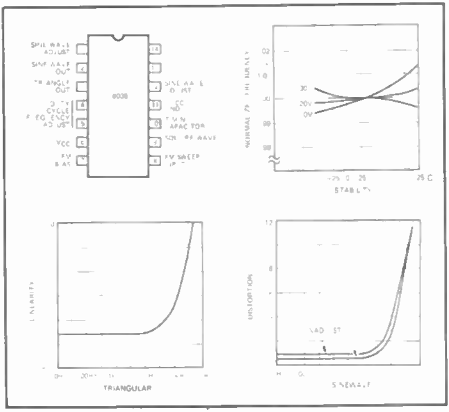
This Time Next Year

The conference proved a great success and Online hope to make this an annual event. We just hope that any future conference can be held at a larger venue as, judging by the response to this first event, the interest in home computing is already large and growing every day.

ETI DATA SHEET

ICL 8038 WAVEFORM GENERATOR/V.C.O. — INTERSIL

The 8038 has been around for about 5 years — which is a long time in electronics. In fact it has reached the position of becoming an Industry Standard on a par with the 741. An inherently versatile device it has its drawbacks like most chips — but overall has a lot going for it. Intersil even produced a very honest application bulletin (A013) called Everything you always wanted to know about the 8038 which explained how to get the best out of this device and admitted its defects — an uncommon event with most manufacturers! Some of the data from A013 has been included in this data sheet but for fuller information ask Rapid Recall for A013, A012 and the latest information sheet (strangely referenceless but brown in colour!)



Description

The 8038 Waveform Generator is a monolithic integrated circuit capable of producing sine, square, triangular, sawtooth and pulse waveforms of high accuracy. The frequency (or repetition rate) can be selected externally over a range of less than 1/1000 Hz to more than 1 MHz and is highly stable over a wide temperature and supply voltage range. Frequency modulation and sweeping can be accomplished with an external voltage and the frequency can be programmed digitally through the use of either resistors or capacitors. The Waveform Generator utilizes advanced monolithic technology such as thin film resistors and Schottky barrier diodes.

Theory of operation

A block diagram of the waveform generator is shown in Figure 1. An external capacitor C is charged and discharged by two current sources. Current source #2 is switched on and off by a flip-flop while current source #1 is on continuously. Assuming that the flip-flop is in a state such that current source #2 is off then the capacitor is charged with a current I. Thus the voltage across the capacitor rises linearly with time. When this voltage reaches the level of comparator #1 (set at 2/3 of the supply voltage) the flip flop is triggered, changes states and releases current source #2. This current source normally carries a current 2I, thus the capacitor is discharged with a net-current I and the voltage across it drops linearly with time. When it has reached the level of comparator #2 (set at 1/3 of the supply voltage) the flip flop is triggered into its original state and the cycle starts anew.

Four waveforms are readily obtainable from this basic generator circuit. With the current sources set at I and 2I respectively the charge and discharge times are equal

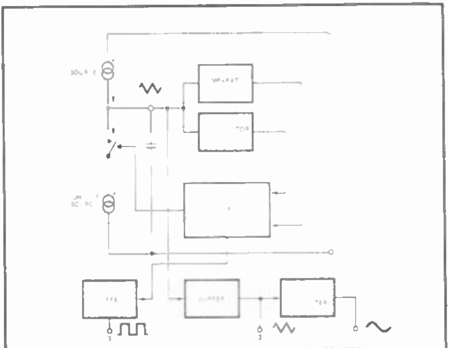


Fig 1. BLOCK DIAGRAM OF WAVEFORM GENERATOR

Thus a triangle waveform is created across the capacitor and the flip-flop produces a square-wave. Both waveforms are fed to buffer stages and are available at pins 3 and 9.

The levels of the current sources can, however, be selected over a wide range with two external resistors. Therefore, with the two currents set at values different from I and 2I, an asymmetrical sawtooth appears at terminal 3 and pulses with a duty cycle from less than 1% to greater than 99% are available at terminal 9.

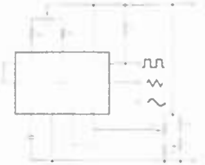
The sine-wave is created by feeding the triangle-wave into a non-linear network (sine-converter). This network provides a decreasing shunt-impedance as the potential of the triangle moves toward the two extremes.

Power Supply

The waveform generator can be operated either from a single power supply (10 to 30 Volts) or a dual power supply (±5 to ±15 Volts). With a single power supply the average levels of the triangle and sine-wave are at exactly one-half of the supply voltage, while the square wave alternates between +V and ground. A split power supply has the advantage that all waveforms move symmetrically about ground.

Also notice that the square wave output is not committed. The load resistor can be connected to a different power supply, as long as the applied voltage remains within the breakdown capability of the waveform generator (30 V). In this way, for example, the square-wave output be made TTL compatible (load resistor connected to +5 volts) while the waveform generator itself is powered from a much higher voltage.

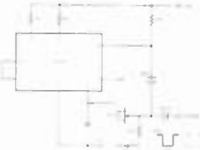
Purity



The symmetry of all waveforms can be adjusted with the external timing resistors. To minimize sine-wave distortion the resistors between pins 11 and 12 are best made variable ones. With this arrangement distortion of less than 1% is achievable. To reduce this even further, two potentiometers can be connected as shown. This configuration allows a reduction of sinewave distortion close to 0.5%.

Both the sine-wave and triangular outputs are only useful up to about 20kHz if a reasonably pure signal is required. A perusal of the graphs will show why.

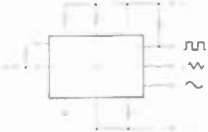
Strobe



With a dual supply voltage (e.g. ±15V) the external capacitor (pin 10) can be shorted to ground so that the sine wave and triangle would always begin at a zero crossing point. Random switching has a 50/50 chance of starting on a positive or negative slope. A simple AND gate using pin 9 will allow the strobe to act only on one slope or the other.

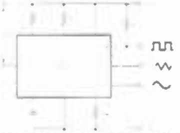
Using only a single supply, the capacitor (pin 10) can be switched either to V+ or ground to force the comparator to set in either the charge or discharge mode. The disadvantage of this technique is that the beginning cycle of the next burst will be 30% longer than the normal cycle.

F.M. and Sweeping



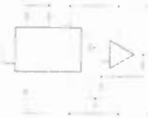
The frequency of the waveform generator is a direct function of the DC voltage at terminal 8 (measured from +VCC). Thus by altering this voltage, frequency modulation is achieved.

For small deviations (i.e. ±10%) the modulating signal can be applied directly to pin 8, merely providing dc decoupling with a capacitor. An external resistor between pins 7 and 8 is not necessary, but it can be used to increase input impedance. Without it (i.e. terminals 7 and 8 connected together), the input impedance is 8k; with it, this impedance increases to (R + 8k).



For larger FM deviations or for frequency sweeping, the modulating signal is applied between the positive supply voltage and pin 8. In this way the entire bias for the current sources is created by the modulating signal and a very large (e.g. 1000:1) sweep range is created (f = 0 at V_{sweep} = 0). Care must be taken, however, to regulate the supply voltage; in this configuration the charge current is no longer a function of the supply voltage (yet the trigger thresholds still are) and thus the frequency becomes dependent on the supply voltage. The potential on pin 8 may be swept from V_{CC} to about 2/3 V_{CC}.

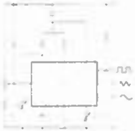
Buffering



The sine wave output has a relatively high output impedance (1k Typ). The circuit provides buffering, gain and amplitude adjustment. A simple op amp follower could also be used.

If the available outputs are all fed through a buffer, extra resistors can be inserted in series with the signal before a switch. Values of 47k (square wave), 18k (triangular) and 10k (sine wave) will ensure equal amplitude signals.

Audio Oscillator



To obtain a 1000:1 Sweep Range on the 8038 the voltage across external resistors RA and RB must decrease to nearly zero. This requires that the highest voltage on control Pin 8 exceed the voltage at the top of RA and RB by a few hundred millivolts.

The Circuit achieves this by using a diode to lower the effective supply voltage on the 8038. The large resistor on pin 5 helps reduce duty cycle variations with sweep. The range of this circuit is 20Hz to 20 kHz. An output buffer can be added to make a general purpose bench unit.

Points to Note!

The 8038 runs hot to touch, this is normal, and is due to the resistive nature of the sinewave shaping network.

The optimum supply voltage for minimum temperature drift is 20V, this can be seen in the stability graph.

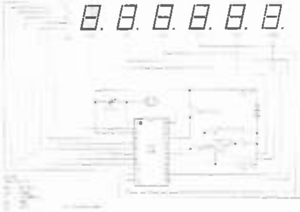
The 8038 is available from **Rapid Recall Ltd., 9 Betterton Street, Drury Lane, London WC2H 9BS.** Price for 1 off is **£4.08** inclusive.

The Intersil ICM 7205 is a relatively new device, main points of interest are: on chip display drivers, fully protected against static - no special handling precautions required, average current of only 10 mA when in operation (including display!)

The ICM 7205 is a fully integrated CMOS six digit stop watch circuit. The circuit interfaces directly with a six digit/ seven segement common cathode LED display. The low battery indicator can be connected to the decimal point anode or to a separate LED lamp. The only components required for a complete stopwatch besides the display are: three SPST switches, a 3.2768 MHz crystal, a trimming capacitor, three AA batteries, and an on-off switch. For a two function stopwatch one additional switch would be required.

The circuit divides the oscillator frequency by 2^{15} to obtain 100 Hz which is fed to the fractional seconds, seconds and minutes counters. An intermediate frequency is used to obtain the 1/6 duty cycle 1.07 kHz multiplex waveforms. The blanking logic provides leading zero blanking for seconds and minutes independently of the clock. The ICM7205 is packaged in a 24 lead plastic DIP.

Stopwatch Circuit



Switch Characteristics

The ICM7205 is designed for use with SPST switches throughout. On the display unlock and reset inputs the characteristics of the switches are unimportant, since the circuit responds to a logic level held for any length of time, however short. Switch bouce on these inputs does not need to be specified. The Start/Stop input, however, responds to an edge and it requires a switch with less than 15 ms of switch bounce. The bounce protection circuitry has been specifically designed to let the circuit respond to the first edge of the signal, so as to preserve the full accuracy of the system.

Low Battery Indicator

The on-chip low battery indicator is intended for use with a small LED lamp or with the decimal points on a standard LED display. The output is the drain of a P channel transistor of approximately half the size of one of the segment drivers. The LBI circuitry is designed always to provide a voltage difference between the LBI trigger voltage and the minimum operating voltage, i.e. the lower the LBI trigger voltage the lower the the minimum operating voltage. In this way a stopwatch using three AA batteries will provide at least 15 minutes of accurate timekeeping after the LBI comes on.

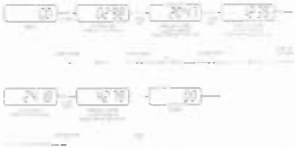
Functional Operation

Turning on the stopwatch will bring up the reset state where the fractional seconds are on displaying 00 and the other digits are blanked. This display always indicates that the stopwatch is ready to go.

Start/Stop

The Start/Stop modes can be used for a single event timing with the Split/Taylor input in either state. The illustration indicates the operations and the results. To time another event the reset switch must be used prior to the start of the event. Seconds will be diplayed after one second, minutes after one minute. The range of the stopwatch is 59 minutes 59.99 seconds. If an event exceeds one hour, the number of hours must be remembered by the user. Leading zeros are not blanked after one hour.

Taylor



When the Split/Taylor input is left open circuit or is connected to Vss, the stopwatch can be used in the Taylor or sequential mode. As depicted graphically above, each split time is measured from zero in the Taylor mode, i.e. after stopping the watch, the counters reset to zero momentarily and start counting the next interval. The time displayed is the time elapsed since the last activation of Start/Stop. The display is stationary after the first interval unless the display unlock is used to show the running clock. Reset can be used at any time.

Split

When the Split/Taylor input is connected to VDD, the stopwatch is in the Split mode. The Split mode differs from the Taylor in that the lap times are cumulative in the Split mode. The counters do not reset or stop after the first start until reset is activated. Any time displayed is the cumulative time elapsed since the first start after reset. Display unlock can be used to let the display 'catch up' with the clock. Reset can be used at any time.

Points to Note!

Absolute maximum supply voltage is 5V5. Never short outputs to earth or low impedence power supply as this will destroy the device.

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Described by John Miller-Kirkpatrick

LAST MONTH WE LEFT YOU with board A completed and checked by temporarily connecting the address generator outputs to the data inputs. All of these temporary connections are now removed and a ribbon cable connected to the points marked. The reason for using ribbon cable is for neatness and sanity (for connection of about 9 in of 20-way cable is needed).

Assembly Board B

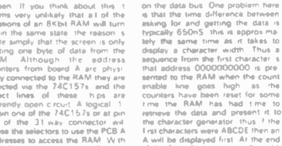
As with PCB A the first thing to do is insert all of the through hole links, solder and test for continuity. Sockets can then be installed in all IC locations and, if required, in the keyboard input connector. The 31 way connector should be installed at this stage and mounted on to the PCB with nuts and bolts through the holes provided.

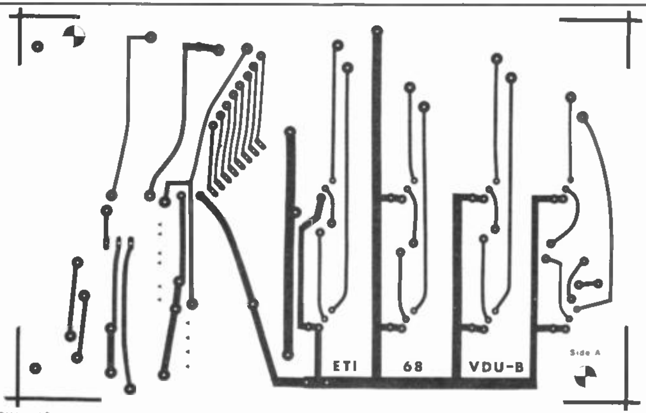
The ribbon cable from PCB A is wired to connect the addresses from board A to B, the data from B to A and a power supply from B to A. A second cable carries the video signal, the video invert signal and ground to the front panel. With all of the soldering completed the ICs can be inserted and power applied to PCB B (and thus also to A).

How it works and why it doesn't

When the power is applied the sync oscillator may be out of alignment and need adjustment, but leave the unit for about 30 seconds before making any adjustment as the oscillator seems to need a warm-up time. With the sync locked the display will probably show the same character in all locations on the screen. If you think about this it seems very unlikely that all of the locations of an 8Kbit RAM will turn on in the same state; the reason is quite simply that the screen is only getting one byte of data from the RAM. Although the address counters from board A are physically connected to the RAM they are directed via the 74C157s and the select lines of these chips are currently open circuit. A logical 1 at pin one of the 74C157s or at pin 15 of the 31 way connector will cause the selectors to use the PCB A addresses to access the RAM. With an MPU connected to the VDU this is the state that the selectors are normally in. If the MPU wishes to access the RAM it will signal that it wishes to do so by taking the VDU select line to logical 0.

As each RAM location is addressed by board A so the data for that location becomes available on the data bus. One problem here is that the time difference between asking for and getting the data is typically 650nS; this is approximately the same time as it takes to display a character width. Thus a sequence from the first character is that address 0000000000 is presented to the RAM when the count enable line goes high, as the counters have been reset for some time the RAM has had time to retrieve the data and present it to the character generator; thus if the first characters were ABCDE then an A will be displayed first. At the end of the first character time the address 0000000001 is given to the RAM but during the 650nS before


View of the A and B boards ready for insertion into mainframe



VDU board B component side foil pattern shown full size

the data for 'B' is available at the character generator the generator has data for an 'A' and thus the display now shows 'AA'. At some time near the end of the second character time the data for 'B' will become available at the character generator but as the RAMs can react at different times different bits become true at different times thus making the second half of the second character change to a 'B'. Similarly the third character will become a B C the fourth a C/D and so on up to the end of a character row. At the end of the line the display enable turns off the character display, but the characters keep going until the count enable halts the count. The data for the last character is not available until just before the display is disabled but it is available for nearly 650nS after the display has been disabled.

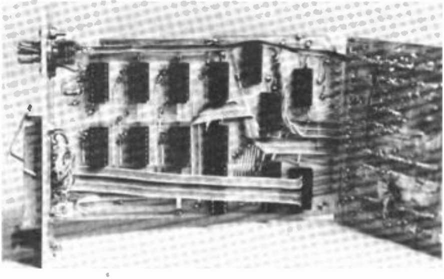
Problems

There are thus two problems the first to latch the data bits at a specific time during each character to stop the ragged change from one displayed character to another the second problem is then to lose the double first character and retrieve the last.

The DM8678 has an internal latch and can thus handle the latching for six data bits (if an 8679 is used in tandem then seven bits will be latched) leaving the extra data bits (if used) to be latched with the 7475. This latching was not shown in the circuit for PCB A but no additional ICs are required. Pin 4 of the DM8678 is connected to the inverse of the load signal on pin 10. Ideally the store signal should occur one bit time before the load but in practise it was found that the inverse of the load could be used. This is available at the output of IC11c.

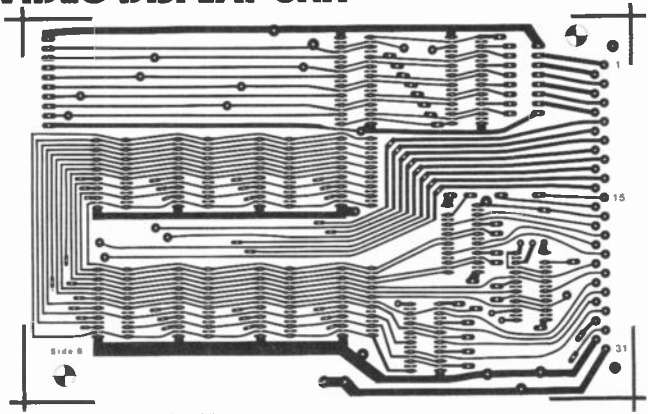
To solve the second problem it would be useful if the whole display enable area could be moved one position to the right. A simple way to do this is to break the signal from IC7 to IC12 and process this via the 7475 latch. As this latch is operated at the same time as the DM8678 Load and Store it means that the display enable signal is delayed by about one character time. This means that the enable is now turned on at the start of the second character and off at the start of character time after the last character in the row.

If at this time the display is not nearly perfect then it is best to



The two boards opened out to give general idea of cable layout

VIDEO DISPLAY UNIT



VDU board B underside foil pattern shown full size

PARTS LIST

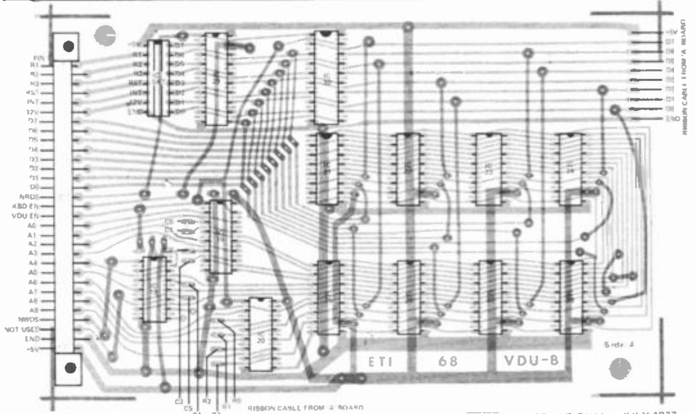
INTEGRATED CIRCUITS	
IC 18 20	74C157
IC 21 28	MM2102-2
IC 29-28	DM81L595
MISCELLANEOUS	
SW1	SPDT 316-709)*
D1	1N4148*

HARDWARE
16 pin dil plug 401-841)
IC socket strips 401 902) + holders 401-920)
ETI 68VDU board B *Crofton*)
Terminal pins 433 860)

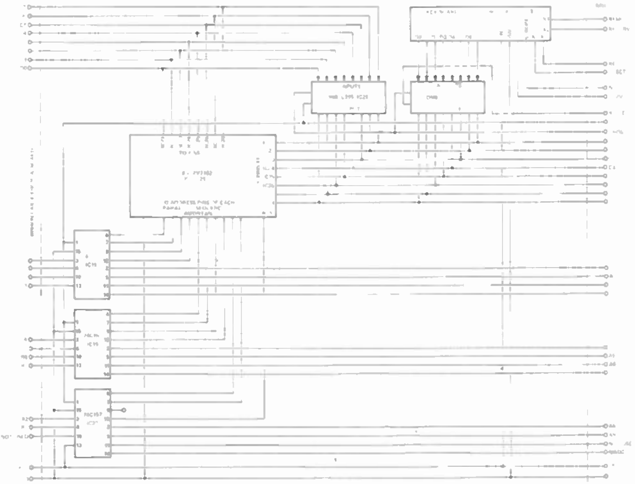
* Omitted from last month s parts l st

Doram RS) numbers in brackets

A complete kit of all parts including pcbs) is available from **Bywood Electronics**



Component overlay for VDU board B



Full circuit diagram of the B board, in conjunction with last month's A board forms complete VDU module

assume race conditions in the ICs to be a problem. CMOS will not work much above 1 MHz at 5v so check that there are no 74C series where there should be 74 series and vice-versa. It is also advisable to check for solder runs as we found a couple causing problems in the prototype. Problems with this type of equipment can be very difficult to cure without a very fast scope or a lot of thinking; thinking is usually cheaper than scopes so use the circuit to narrow down faults and they soon become apparent.

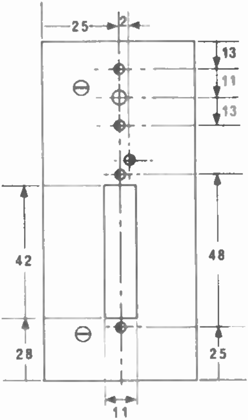
Keyboard Interface

In addition to the VDU interface this PCB also allows an ASCII keyboard to be connected into the system; as VDUs and keyboards go together in most applications it makes sense to have them on one interface board. If you are not using the System 68 case you may prefer to connect the keyboard into the PCB using a standard 16-pin socket and pin header/plug. With the System 68 case we use a 2 in front panel module to carry the Video output socket, video invert switch and keyboard connector. We have used professional 25-way plugs and sockets wherever required as these tend to be an industry standard on this type of equipment. As the keyboard can be disconnected at the front panel the front panel connector can be wired into the 16-pin socket holes.

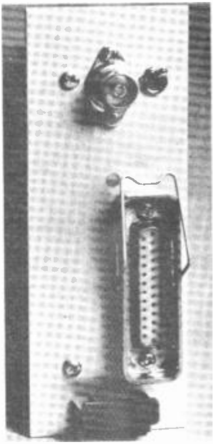
Whichever way you do it this connector carries 16 signals to/from the keyboard. We have allowed eight bit ASCII whereas a lot of keyboards have only six or seven bit output; the unused inputs can be connected to ground or to the keyboard strobe signal. Most keyboards feed on a diet of +5v, GND and -12v and so we have provided for these lines to be keyboard. The other line we have to have is a strobe signal which should be negative going, ie, it is normally logic '1' unless a key is pressed in which case it goes to logic '0' until the key is released. We have four of our 16 leads unconnected; these are reserved for additional I/O signals to/from the keyboard. Such signals could be switches to the interupt and/or reset pins of the MPU or could be status LEDs mounted on the keyboard.

Checking out

Checking out is very tedious without an MPU because you have to simulate the control signals and that involves a lot of logic state changing and testing. It's worth doing at this stage because you then know that the VDU element works. A check sequence is given



● DRILL 1 HOLE 2BA
◑ DRILL 1 HOLE 4BA
◐ DRILL 4 HOLES 6BA



Alternative positioning of sockets on front panel

Folding up

Now is the time to fold up the two boards and check that they will fit in the case. Note that only PCB B is screwed to the front panel. A is held parallel to B by the card guides in the case: they should fit 1.2 in apart and thus fit into adjacent card guides. If you have fitted your keyboard connector slightly off centre then you may find that the boards fit better 1 in apart: either is acceptable. Slide the unit into the case in the correct location and mark the position of the 31 way connector: slide the unit out, fit the 31-way socket, slide the unit home and feel that satisfying click as it locks into place.

Next month

How to use the VDU with an MPU: data and address buffers and things.

System 68 VDU Checkout

This checkout routine involves a couple of subroutines called TEST BUS; this involves checking each bit of the appropriate data bus, unless you wish to do the FULLCHECK. It is only necessary to convince yourself that no data bit is affecting another (solder bridge) and that all are connected at the appropriate points (open circuit, broken track).

	KBD EN	VDU EN	NWDS	NRDS	
START	1	1	1	1	TEST BUS AT VDU – BUS AT RAM
WRITE TO VDU	1	0	0	1	TEST BUS AT RAM – BUS AT INPUT
READ FROM VDU	1	0	1	0	Ditto
READ FROM KBD	0	1	1	0	TEST BUS KBD – BUS AT INPUT
FULLCHECK	1	0	0	1	ADDR AT INPUT – 00000000
LOOP 1					DATA AT INPUT – 10101010
READ	1	0	1	0	DATA AT RAM – 10101010
WRITE	1	0	0	1	DATA AT INPUT – 01010101
READ 2	1	0	1	0	DATA AT RAM – 01010101

GOTO LOOP 1 after incrementing INPUT ADDR by 1

RESISTOR CODES PART 11

An explanation of the colour codings on all types of resistors

THE VALUE AND TOLERANCE, and other pertinent characteristics, of resistors may be marked on the body of the component in one of three ways. Viz:

(1) By marking directly on the body.

(2) By using a standard colour code – coloured bands or dots, etc, read in sequence.

(3) By using an appropriate typographic code, consisting of letters and numerals arranged according to a convention.

Which method is used depends on the type and physical size of the component to a large extent and also according to the manufacturer's preference. The larger components, such as power resistors (particularly wire-wound types), usually have the value, tolerance and wattage rating marked directly on the body. Most common low power resistors, from 0.05 W to 2 W, use the standard resistor colour code. Some manufacturers use a typographic code on their resistors, physical size allowing (usually radial-lead types having wattage ratings between 0.25 W and 10 W). The special resistors (PTC, NTC thermistors and Varistors) also may be marked with a colour code or typographic code to indicate their value and characteristics.

The Standard Colour Code and Markings

The common axial-lead, composition and film-type resistors are marked with a series of coloured bands, as shown in Figure 1, which are read according to the standard colour code table in Table 1. The standard E24 (5%), E12 (10%) and E6 (20%) series components are marked with either three or four bands. Components below 10 ohms in the E6 series may have only two bands indicating the value. Resistor values in the E48 (2%) and E96 (1%) series are marked with five bands.

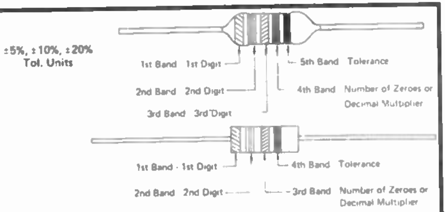
The bands are located on the component towards one end. If the resistor is oriented with that end towards the left, the bands are read from left to right as shown. The extreme left (or first) band colour indicates the value of the first digit of the component value; the next, or second, band indicates the second digit of the value and so on. If the bands are not clearly oriented towards one end of the resistor it is best sorted out by trying to locate the tolerance band first. As the most commonly used resistors these days are either E12 or E24 series, the tolerance band is either silver or gold respectively. If still in doubt – resort to an ohmmeter.

The body colour of modern resistors is also used to indicate the resistor type. Carbon film resistors have a very light tan body, and carbon composition resistors have a medium tan body – somewhat darker than the carbon film body colour. Metal film resistors have a brown body colour – quite distinguishable from composition resistors and metal glazed film resistors have a light blue body colour.

High stability resistors (E48, E96, E192 series) are distinguished by salmon-pink 5th band or body colour. For those who have difficulty remembering the resistor colour code, Table 2 lists the most commonly used values in the E12 series, between 4R7 and 2M2.

Old-Style Resistors

Prior to the standardisation of the banded system of resistor marking, resistors were colour coded with their value and tolerance by either one of two systems. These were the "Body-End-Dot" and the "Body-End-Band" systems, which are illustrated in Figure 2 (a) and (b) respectively. The body colour represents the first digit of the resistor value, the end colour the second digit, the dot or band colour, the multiplier. The tolerance was indicated



STANDARD RESISTOR COLOUR CODE

COLOUR	DIGIT VALUE	MULTIPLIER (No. of zeroes)	TOLERANCE ± %
BLACK	0	1	
BROWN	1	10	1
RED	2	10^2 or 100	2
ORANGE	3	10^3 or 1k	
YELLOW	4	10^4 or 10k	
GREEN	5	10^5 or 100k	
BLUE	6	10^6 or 1M	
VIOLET	7	10^7 or 10M	
GREY	8	10^8 or 100M	
WHITE	9	10^9 or 1000M	
GOLD	-	0.1 or 10^{-1}	5
SILVER	–	0.01 or 10^{-2}	10
none		– – – – – –	20

* High Stability (grade 1) resistors are distinguished by a salmon-pink fifth ring or body colour.

Fig 1. The Standard Resistor colour code marking.

RESISTOR CODES

by a coloured spot which partially covered the end of the resistor opposite the 'end' colour or a band much narrower than the 'end' colour. In the booy end-dot system, the dot was generally located midway along the body. In the body-end-band system the band was generally located closer to the 'end' colour. Omission of the tolerance colour indicated a tolerance of ± 20%.

Some other manufacturers indicate the component value and tolerance by a series of dots or small bands which do not completely encircle the resistor body. This system of marking is commonly used on radial-lead and upright mounting styles of resistor from some manufacturers (particularly Erie Co., and some Japanese firms); these are illustrated in Fig. 2c. With the upright mounting style of resistor, the colour code is located towards the upper end of the body. The colour closest to the upper end indicates the first digit of the value, the next colour down, the second digit and so on.

Typographic Codes and Markings

Resistors may be marked with a combination of letters and figures to indicate the value, and tolerance. Alternatively a combination of direct marking and typographic code may be employed.

The typographic codes used are illustrated in Figure 4. A series of three letters, R,k,M, are used to indicate multipliers of x1, x1000 and x 1000 000. The significant figures of the value are indicated directly with figures, the position of the multiplier indicating the decimal point. For example:–

4R7	=	4.7 ohms
330R	=	330 ohms
5k6	=	5 6k (5600 ohms)
68K	=	68k (68,000 ohms)
1M8	=	1 8M (1.8 megohms)
22M	=	22M (22 megohms)

The tolerance is indicated by one of five letters (see Figure 4) which immediately follow the value code on components which are marked completely with a typographic code Some examples of the complete code are as follows:

2k2F	=	2.2k, ± 1%
120kG	=	120k, ± 2%
2M2J	=	2.2M, ± 5%
150RK	=	150 ohm, ± 10%
6R8M	=	6 8 ohm, ± 20%

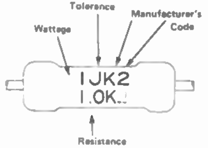
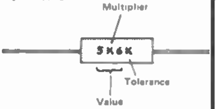


Fig. 4. Typographic codes used on resistors.

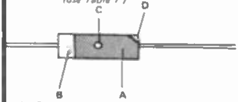


MULTIPLIER			TOLERANCE		
R	=	x1	F	=	±1%
K	=	x1000	G	=	±2%
M	=	x1 000 000	J	=	±5%
			K	=	±10%
			M	=	±20%

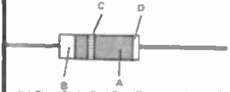
**Position of the multiplier indicates the position of the decimal point in the value.*

Fig 2 Other styles of resistor colour code markings

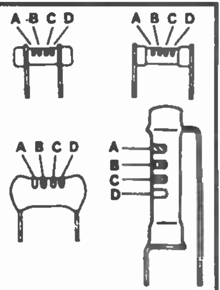
A 1st Digit
B 2nd Digit
C Multiplier
D Tolerance
(use Table 1)



(a) The "Body End Dot" system of resistor marking common on many older resistors.



(b) The "Body End-Band" system also used on many older resistors



(c) Markings on radial lead and upright mounting resistor styles

Direct Marking

This style of marking a resistor is commonly used on power resistors (usually from 2 W), wirewound and precision resistors It usually includes a manufacturer's code indicating the type of resistor perhaps including a date code indicating when the component was manufactured. Figure 3 illustrates a 1 k, ± 5%, 2 W resistor.

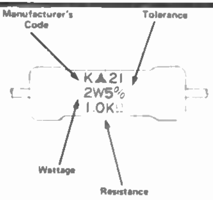


Fig. 3. Resistor with characteristics and value marked directly on the body.

THERMISTOR MARKING CODES

Thermistors may be marked with a colour code or a typographic code, or may have no markings at all! The manner in which they are marked depends largely on their construction and the preference of the manufacturer NTC thermistors may be marked with either a colour code or typographic code (or not at all) but PTC thermistors are marked with a typographic code only – when they are marked!

Whatever marking is employed, the resistance value at 25°C (R_{25}), and its tolerance at that temperature (if included) are generally the basic characteristics indicated. Other parameters (such as the B value) may be indicated when a typographic code is employed. The manufacturer's data should be consulted for the complete thermistor characteristics.

Colour Coded NTC Thermistors

Two basic methods of colour coding NTC thermistors are used, illustrated in Figure 5. The value of R_{25} is found by reference to the standard resistor colour

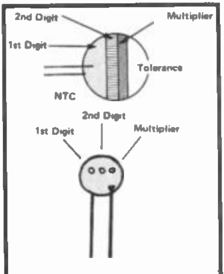


Fig. 5 Colour code systems used on NTC thermistors. The resistance value at 25°C (R_{25}) is found by reference to the standard resistor colour code table.

code table. The tolerance is sometimes omitted. The marking method illustrated on the left in Figure 5 distinguishes NTC thermistors from varistors (see Figure 8).

Typographic Coded NTC Thermistors

The typographic code occasionally employed on NTC thermistors is illustrated in Figure 6. This code is from the American EIA system of component designation. The tolerance range of NTC thermistors extends from ±5% to ±40% and two extra letters are added to the standard typographic tolerance code. The temperature constant B, is also indicated with the typographic code and reference to the manufacturer's data for the basic parameters is not necessary. However, if the dissipation, wattage rating, etc. are needed then the manufacturer's data will need to be consulted.

The typographic code consists of a prefix which may be 'ERT' to indicate and NTC thermistor or simply NTC. The value and characteristics may follow immediately or a manufacturer's code may precede it (usually indicating component type). However, the characteristics are always the last group.

TOLERANCE	CONSTANT(B), °K (at 25°C)
J = ±5%	A = up to 1000
K = ±10%	B = 1000–1500
L = ±15%	C = 1501–2000
M = ±20%	E = 2501–3000
R = ±40%	F = 3001–3500
	G = 3501–4000
	H = 4001–4500
	I = 4501–5000
	J = 5001–5500
	K = 5501–6000
	L = over 6001

PTC Thermistor Marking Codes

The typographic code that may be used on PTC thermistors is from the EIA system code, illustrated in Figure 7. The prefix ERP indicates that the component is a PTC thermistor. The suffix is divided into three portions. The first consists of a letter and a numeral indicating the prime characteristic of the component. If it is an A-type PTC thermistor the temperature coefficient is indicated, as shown in the accompanying table. If it is a B type, which changes resistance abruptly at a specified temperature (the 'switching' temperature), then the switching temperature is indicated as shown in the Table.

The tolerance and the resistance at 25°C (R_{25}) follow, and are read off in the same way as for NTC thermistors — see Figure 6.

PTC thermistors are often not marked, but their packaging may contain the above typographic code along with a manufacturer's component code.

Varistor Marking Codes

Both colour and typographic codes are used to mark varistors. As they are voltage dependent devices, the voltage value and its tolerance are given. The colour code that is used on ZNR and SiC varistors is illustrated in Figure 8. The value and tolerance is found from the standard colour code table (see section on Component Marking Codes). The tolerance is the first band on these components when held with the colour bands at the left as illustrated. Just to confuse matters, some manufacturers use the 1st, 2nd and 3rd digit bands to indicate the last three digits of their type number!

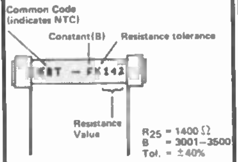
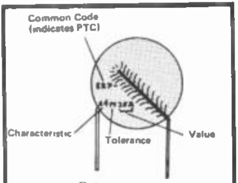


Fig. 6 Typographic code used on NTC thermistors (from EIA system standard). The first two figures of the value are the two significant figures of resistance at 25°C (R_{25}), the third figure indicates the number of following zeroes (i.e. the multiplier). If value below ten ohms, the decimal point is indicated by R (i.e. 1.5 = 1R5).



R25 = 250 Ω ±20%
α = 4.5%/°C

CHARACTERISTICS

A–TYPE	B–TYPE
A2 = 2.5%/°C	B0 = 50°C
A3 = 3.5%/°C	B1 = 75°C
A4 = 4.5%/°C	B2 = 90°C
Temp. Coeff (α)	B3 = 120°C
	Switching Temp.
	B3 = 120°C

Fig. 7 Typographic code used on PTC thermistors (from EIA system standard). The value and tolerance are read off as for the typographic code used on NTC thermistors.

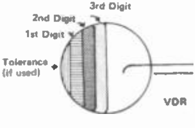


Fig 8 Colour code used on some varistors. The tolerance refers to the voltage tolerance, and is found from the standard colour code table. The 1st and 2nd digits indicate the two significant figures of the voltage, the third digit indicating the number of following zeroes (i.e. the multiplier), the values being read from the standard colour code table. Some manufacturers indicate the last three digits of their type number. Very confusing!

Ceramic Diode (Variatite) Varistors

These devices have an asymmetric voltage characteristic and it is the value of the forward voltage that is of interest. They are generally made to a specified forward voltage and a colour code is used to indicate the value as illustrated in Figure 9. A single colour spot is used, and it is applied to the cathode side of the device.

RESISTOR CODES

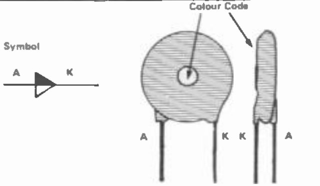
ZNR Varistor Typographic Code

The typographic code used on ZNR varistors is usually arranged in one of two ways, as indicated in Figure 10. The disc-shaped varistors are generally marked in the manner illustrated, the ZNR marking directly indicating the type of component. This is followed by a single letter indicating the voltage tolerance followed by the voltage value. A 220 V, ± 15% varistor is illustrated.

The cylindrical body style of varistor is generally marked according to the EIA system standard, as illustrated on the right in Figure 10. This code gives a more complete specification of the component's characteristics. The wattage rating and shape may sometimes be omitted. Reading this sort of code on any component can be confusing – it is best to first identify the component by the prefix and then read the code groups commencing from the right. The voltage value is always indicated last – but watch it again . . . the manufacturer may attach a suffix for his own purpose! It is usually a single letter and thus the voltage value group is easily recognised.

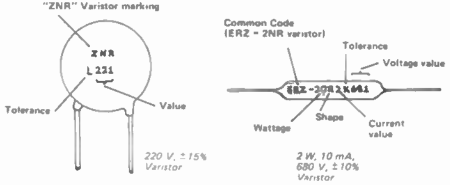
Silicon Carbide (SiC) Varistor Marking

These varistors are also generally marked using the EIA system code, in a similar manner to ZNR varistors. The two basic marking styles are illustrated in Figure 11. The common code signifying a SiC varistor, ERV, prefix is invariably marked on both disc and cylindrical shaped components, the disc-shaped varistors generally having an abbreviated code indicating only the voltage value and measuring current. The cylindrical-shaped varistors have the more complete code marked on the component body, as illustrated on the right in Figure 10. The wattage rating, measuring current, voltage value and voltage tolerance are the characteristics indicated. Note that the wattage rating code differs from that for ZNR varistors in that only a single figure is used to indicate components having a wattage rating of 1 W and 2W respectively. ●



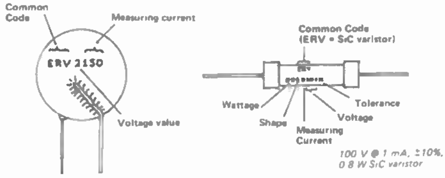
COLOUR	RATED FORWARD VOLTAGE
BLACK	1.0
BROWN	1.1
RED	1.2
ORANGE	1.3
YELLOW	1.4
GREEN	1.5
WHITE	2.2
SILVER	3.0

Fig 9. Colour code used on Ceramic Diode (varistite) varistors. These have an asymmetric voltage characteristic and the colour code, indicating the rated forward voltage, is marked on the cathode.



TOLERANCE	WATTAGE	CURRENT VALUE	VOLTAGE SUPPLY
J = ± 5%	03 = 0.3 watts	2 = 10 mA	First two digits are the two significant figures, the third digit being the number of following zeroes. Decimal point is indicated by R.
K = ± 10%	08 = 0.8 watts	3 = 1 mA	
L = ± 15%	15 = 1.5 watts	4 = 0.1 mA	
M = ± 20%	20 = 2.0 watts	9 = 0.5 mA	
S = ± 3%	60 = 6.0 watts		
	80 = 8.0 watts		
	1A = 10 watts		
	1B = 15 watts		
	1C = 20 watts		

Fig 10. Typographic code combinations used on common (ZNR) varistors. The more complete form is shown on the right. It may be abbreviated however as indicated on the left. The current value is sometimes included as well, the wattage rating is usually only included where the more complete form of the EIA code is used.



WATTAGE	MEASURING CURRENT	VOLTAGE VALUE	TOLERANCE
01 = 0.1 watts	1 = 100 mA DC	First two digits are the two significant figures, the third digit being the number of following zeroes. Decimal is indicated by R.	J = ± 5%
02 = 0.2 watts	2 = 10 mA DC		K = ± 10%
03 = 0.3 watts	3 = 1 mA DC		L = ± 15%
08 = 0.8 watts			M = ± 20%
10 = 1.0 watts			
15 = 1.5 watts			
20 = 2.0 watts			

Fig 11. Typographic code combinations used on Silicon Carbide (SiC) varistors. The complete form of the code is illustrated on the right. It is also used in an abbreviated form, as illustrated on the left, only the voltage value and current being indicated, although the tolerance is sometimes also included.

E12 SERIES RESISTOR COLOUR CODE

OHMS	BAND 1	BAND 2	BAND 3
4.7	yellow	violet	none
5.6	green	blue	none
6.8	blue	grey	none
8.2	grey	red	none
10	brown	black	black
12	brown	red	black
15	brown	green	black
18	brown	grey	black
22	red	red	black
27	red	violet	black
33	orange	orange	black
39	orange	white	black
47	yellow	violet	black
56	green	blue	black
68	blue	grey	black
82	grey	red	black
100	brown	black	brown
120	brown	red	brown
150	brown	green	brown
180	brown	grey	brown
220	red	red	brown
270	red	violet	brown
330	orange	orange	brown
390	orange	white	brown
470	yellow	violet	brown
560	green	blue	brown
680	blue	grey	brown
820	grey	red	brown
1k	brown	black	red
1k2	brown	red	red
1k5	brown	green	red
1k8	brown	grey	red
2k2	red	red	red
2k7	red	violet	red

OHMS	BAND 1	BAND 2	BAND 3
3k3	orange	orange	red
3k9	orange	white	red
4k7	yellow	violet	red
5k6	green	blue	red
6k8	blue	grey	red
8k2	grey	red	red
10k	brown	black	orange
12k	brown	red	orange
15k	brown	green	orange
18k	brown	grey	orange
22k	red	red	orange
27k	red	violet	orange
33k	orange	orange	orange
39k	orange	white	orange
47k	yellow	violet	orange
56k	green	blue	orange
68k	blue	grey	orange
82k	grey	red	orange
100k	brown	black	yellow
120k	brown	red	yellow
150k	brown	green	yellow
180k	brown	grey	yellow
220k	red	red	yellow
270k	red	violet	yellow
330k	orange	orange	yellow
390k	orange	white	yellow
470k	yellow	violet	yellow
560k	green	blue	yellow
680k	blue	grey	yellow
820k	grey	red	yellow
1M	brown	black	green
1M2	brown	red	green
1M5	brown	green	green
1M8	brown	grey	green
2M2	red	red	green

ELECTRONICS —it's easy!

PART 41

Oscilloscopes; The refinements

MANY MEASUREMENTS IN electronics can be handled by the relatively unsophisticated oscilloscopes described in the last part of this series. More capability can be provided at greater cost and this can be valuable if the user understands how to make the most of it. This part describes refinements that will be encountered in more advanced oscilloscopes.

IMAGE STORAGE

Screen persistence. Repetitive signals, such as a sinewave signal, can be made to repeat on the screen overlapping the previous trace produced. If the time-base frequency is sufficiently high — from thirty or forty hertz upward — the screen provides an apparently stationary signal of constant and adequate intensity. This is primarily because the eye cannot detect individual scans (as in motion pictures and television) and secondly because the phosphor, at frequencies above a few hundred hertz, is re-energized before its light emission due to the previous scan has decayed away.

Phosphors with large time-constants are available (such as P2, which takes one second to reduce to 10% of original brightness and P7 which takes three seconds) and oscilloscopes have been manufactured which use these to enable signals of less than one hertz to be studied. This feature, however, largely restricts the use of the instrument to low frequency work because medium and high frequency signals that are not well synchronised will produce separate traces which remain and add up with time to produce an unclear picture. This method of studying slow transient phenomena has not been developed to any great degree because of this and other factors (such as poor resistance to burning). In addition the retained image times are still inadequate for many applications.

CAMERAS

Storage requirements fall into two classes — those where the transient is unique and therefore needs to be recorded only long enough to allow the trace to be studied and those where a permanent record is needed.

The oscilloscope fulfils both these needs. Until the advent of the Polaroid Land process this involved a time-consuming development process before the operator was certain of having even recorded the trace. Most oscilloscope makers now offer specially built trace-recording cameras that **fasten onto the large bezel** surrounding the screen.

Such cameras use a Polaroid Land film pack of some kind and often incorporate a 35 mm roll film facility also. A Dumont unit is shown in Fig. 1. The user sets the CRO controls until satisfied that the trace will be as needed. This is done using the viewing aperture which reflects the screen image to the observer via a mirror. It is essential that the camera has the correct focal distance set for the CRO concerned, so in general cameras relate to specific units. Some models incorporate adjustable object-image ratios, a few are fixed ratio. With experience it is even possible to capture multiple trace events (by multiple exposure) for comparison purposes.

A considerable amount of film and patience can be consumed trying to record once-only events. Cameras can be quite expensive — several hundred pounds — but they do provide a permanent record for reports which no other storage system can provide and the price of a camera is not as great as the extra cost of the variable persistence storage units to be discussed later.

STORAGE OSCILLOSCOPE

Most of the objections of the above storage methods, with the exception of permanent photographic reproduction, are overcome by using an advanced form of the basic CRO tube. It is called a variable persistence storage tube and is a development of early 1950's storage tubes — in which the waveform could only be held at a constant intensity without the feature of gradual fade-out. In fact variable persistence is a feature of tube operating circuitry, not the tube itself.

The construction of a typical storage tube is given in Fig. 2. The phosphor viewing screen, having 0.1 s persistence time from P31 material, and the writing electron gun shown are similar to those used in the simple cathode ray tube. Additional components are the flooding electron gun system, a storage mesh which is coated

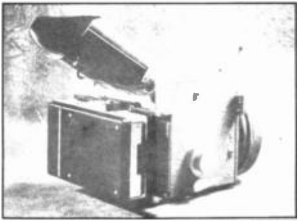


Fig. 1. Recording camera using Polaroid film pack.

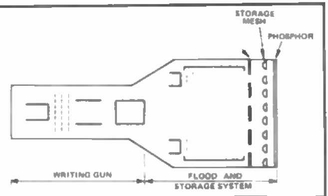


Fig. 2. Schematic construction of storage cathode ray tube

with a non-conducting, highly-resistive material such as magnesium fluoride, and a collector mesh which is held at a positive potential.

To store a trace the writing gun is scanned over the storage surface. Where the beam strikes the storage mesh electrons are knocked loose leaving a positive-charge pattern. The high-resistivity of the surface prevents the charges moving toward a neutral state: the scan is thus stored – and can be held for at least an hour (one maker offers four hours) in a reduced intensity mode.

To make the trace visible, low velocity electrons are sprayed by the flood guns onto the entire mesh surface. These electrons are allowed to pass through to the phosphor in proportion to the amount of positive charge at each aperture of the storage mesh. The positive field pulls many electrons through causing them to pass on to hit the phosphor.

The collector mesh is provided to help accelerate the flood electrons, to repel the positive ions generated by the flood guns; (which would otherwise write the whole screen bright) and to absorb the emitted secondary emission electrons produced whilst writing is in operation. It is not possible to store the trace in the view mode for as long as in the store mode. one to ten minutes of viewing time are typical for various makers' designs.

Erasure is done by applying a large positive voltage to the storage mesh which charges capacitively to the same value. The mesh voltage is then brought back to a small positive value whereupon the flood guns reduce the voltage to zero. A small sudden negative excursion is finally applied to the mesh making it ready to write. (This procedure is automatically initiated at the single action of a switch.)

Variable persistence is incorporated by changing the time taken to erase the picture. In the Hewlett Packard unit, shown in Fig.3, this is achieved by using a variable-width pulse generator that applies erase voltage pulses to the storage mesh. The positive-ions created by the flood guns limit this mode to a maximum of 10 minutes persistence.

Storage oscilloscopes can be used as conventional units by applying about 30 volts to the storage and collector meshes. Long persistence has many virtues – it enables successive traces resulting from adjustments to a system response to be overlaid together for comparison purposes. It also allows us to see very low-frequency scans, and to plot scans of spectrum analysers. Long persistence also finds use in time-domain reflectometry where the time between send and receive pulse needs measuring.

By stacking sweeps on top of each other a long persistence time can be used to integrate or average a set of traces. Variable-persistence storage oscilloscopes are extremely versatile but the high price restricts their use to large laboratory groups.

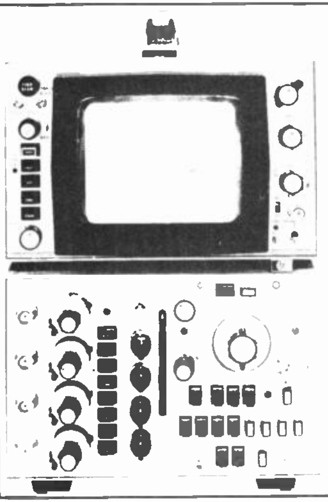


Fig. 3 Hewlett Packard Model 184A variable persistence and storage oscilloscope. Controls for storage are on the left-hand side of the screen.

STORAGE USING DIGITAL MEMORY

Figure 4 shows a unit marketed around 1972. The transient recorder unit accepts the analogue signal, converts it to a digital equivalent with respect to time and stores the values in digital registers. Readout can be obtained by using digital to-analogue conversion of the stored increments which are scanned sequentially, the resultant analogue voltage being fed to an oscilloscope or chart recorder. Digital print-out is taken direct from the scanned store locations.

This method is less common than the storage oscilloscope alternative but the ever-reducing cost of digital methods may put this technique into a competitive price region.

Another method of capturing difficult to see, once-only transient signals, and very slowly changing waveforms is to record the level of the signal, increment by increment, as the signal occurs, using a digital memory. The concept is simple and the method offers certain advantages. These include ability to speed up or slow down the timescale of the original event, ease of providing a permanent numberical printout and the facility to process the signal before display.

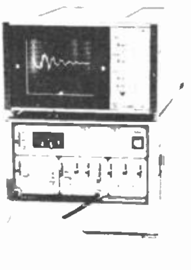


Fig 4. Storage can also be obtained using a digital memory to capture the event which can be displayed at will on an oscilloscope or recorder (Datalab DL 905).

SAMPLING OSCILLOSCOPES

How to capture a very fast repetitive event, say near to the GHz region where scan times of 0.1 ns/division are needed, is a problem because the electron beam cannot transfer enough energy into the phosphor to obtain a useable trace brilliance. Further it becomes increasingly difficult to deflect the beam at such speeds. The sampling oscilloscope offers a solution to these problems

The sampling oscilloscope makes use of the stroboscope concept to look at a waveform, which must therefore be repetitive (as shown in Fig.5). The beam is set to illuminate the screen at point 1 in the diagram, waiting there until the next cycle where it moves to point 2 – and so on. The trace therefore gradually works its way through the complete cyclic waveform and because the scan speed is slower than with a conventional sweep system the cathode-ray tube system can operate with a lower bandwidth than the signal. The waveform produced is an average of many so the display is not only sharper but more uniform. (This may be a disadvantage in some applications for the sampling unit is effectively smoothing the unknown true original signal) Sample and hold methods were discussed in the previous part discussing D-A and A-D conversion.

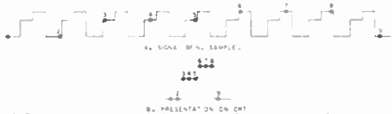


Fig. 5. The sampling oscilloscope builds up the waveform on the screen from sampled values taken from the original.

In practice a sampling oscilloscope is a normal high quality scope which can accept a sampling plug-in Fig 6 is the panel of a dual sampling unit.

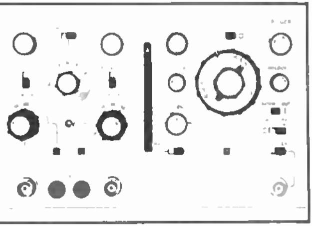


Fig 6. 1 GHz dual channel sampling plug-in. (Hewlett Packard Model 1810A). The controls are designed to provide operation as for those on normal real-time oscilloscopes With such a unit it is possible to view nanosecond rise time signals of repetitive nature.

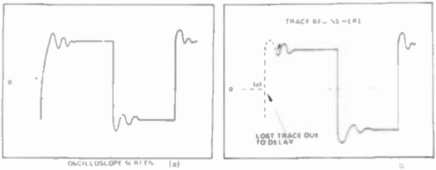


Fig 7 Inherent trigger delay, if not compensated for, will lose the leading edge of a waveform.

DELAY FACILITIES

Often one needs to study a certain part of a repetitive waveform – the very beginning, for instance An example is the ringing of a non-ideal square wave shown in Fig 7a The trace is triggered, to begin the sweep, by a fast-going edge. Due to circuit response times, the trace does not begin to sweep at exactly that time but begins a little later. The result is loss of the leading edge region of the wave as shown in Fig.7b. The following waveform may provide the information sought but attempts to widen the waveform in the horizontal direction lead to the second front disappearing. The simplest solution to this problem is to incorporate an appropriate fixed delay into the triggering circuits and this is often provided within the circuits A slightly better method is to provide an adjustable delay control on the trigger panel.

A more difficult problem is capturing a point on the signal train that is remote from the triggering transient. Consider the signal shown in Fig.8(a), where the problem is to investigate the spike transient on the pedestals of the square wave. Triggering is best achieved by using the edge (a). But this means that scale expansion puts the spike off scale when the horizontal expansion scale is great enough to provide information about the spike structure.

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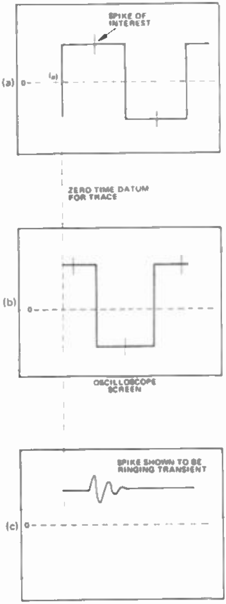


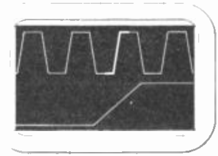
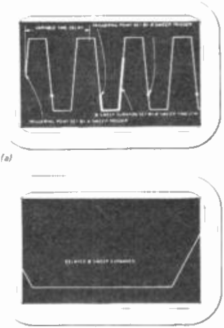


Fig 9 Trace brightening is used to show which part of the waveform is to be expanded. In this display the expanded portion is also displayed on the second trace of the CRO



(a)

(b)

Fig 10 Use of dual delayed triggering point (a) original (b) expanded

Fig. 8 Use of introduced delay in triggering to enable an event away from trigger transient to be investigated.
(a) Original spike on pedestal of square wave
(b) Delay introduced to bring spike back to time origin
(c) Scale expanded to reveal true nature of spike.

Variable delayed sweep is the answer. The trigger circuit is set by the (a) edge but trace scan does not begin until after a period, as in 8(b). Thus the trace captures the spike at the left hand side of the screen and scale expansion will now be possible as in 8(c)

To make this workable in practice the operator must know just where triggering occurs for there may be several somewhat similar events along the trace It is vital to know which one is being viewed A refinement provided in variable delay circuits is to brighten the original display from the point where triggering will begin. Taking the idea one step further leads to a second delay that effectively decides where the trace stops Fig 9 shows the waveform brightened to show the portion that will be expanded and the second trace of the dual-beam unit is used to show the expanded part. Another useful feature is to be able to use a trigger point not on the origin of the first trace set up – as in Fig 10. Here a marker dot is provided to help the operator.

PROBES

Passive probes for voltage measurement In Nos from May 77 the importance of providing the right matching conditions between two electronic systems was stressed This is also important when connecting an oscilloscope to a circuit for each putput and input has certain resistive and reactive conditions which must be properly combined to get realistic signal transfer

The oscilloscope can be represented as an ideal termination shunted by a large R and an adequately small C value – or at least they appear this way at first sight Fig 11 is the most common approximate equivalent circuit others used include 50 ohms with negligible reactance in certain applications) Referring to the chart in Fig 12 it can be seen that with 20pF at 10 mHz the circuit being measured must have the equivalent output resistance of no more than 8 ohms!

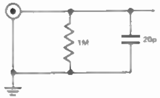


Fig. 11. Most oscilloscopes have this input equivalent circuit Although the values seem insignificant, at high frequencies they become dominant requiring the use of special probes.

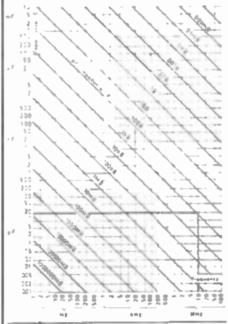


Fig 12 Chart for obtaining reactance of capacitors at various frequencies of operation

For high frequencies, those above 100 kHz say, we therefore need a better connection method. To further compound the problem the oscilloscope input leads can easily increase the equivalent C value to 100 pF — leads for 1 1 connection must therefore be carefully designed to ensure known loading conditions which can be allowed for in signal measurement corrections. It is very bad practice to use any piece of coaxial cable and connector for frequencies beyond 100 kHz.

The first improvement is to use a probe which has 10:1 attenuation built in, for these are designed to have a lower effective cable capacitance — see Fig 13 a) Still better is a special correction arrangement that balances the shunt against series capacitance to provide a wider bandwidth — see Fig 13 b) By the use of inductive tuning a further improvement in bandwidth can be obtained — Fig 13 c) Probes with division ratio of 100 1 also are manufactured — these can provide equivalent termination conditions of 5K/0 7 pF, 10M/1 8 pF, 1 M/1 pF. The reason for different pair combinations arises from the need to alter the trade offs between rise time and signal loss in high frequency and very fast transient measurements.

There is no easy answer to the question of which attenuator probe to use. These guides are the start. For amplitude measurements select a minimum-impedance source point to measure from. The best probe to use here is one with the highest impedance at the frequency of interest. Capacitance is less important here than resistance for it alters edge shapes, not amplitude.

For fast risetime measurements again select a low impedance source point and use a probe with lowest effective capacitance — signal attenuation is less important than transient edge shape changes.

ACTIVE PROBES FOR VOLTAGE MEASUREMENT

The above probes make use of passive matching arrangements But for the extremes of frequency and/or risetime measurements the values of components required in passive probes become impractical. However active amplifiers interposed between the circuit and the oscilloscope can be used to improve performance by increasing input resistance and lowering capacitance (short loads). FET probes are marketed to meet this.

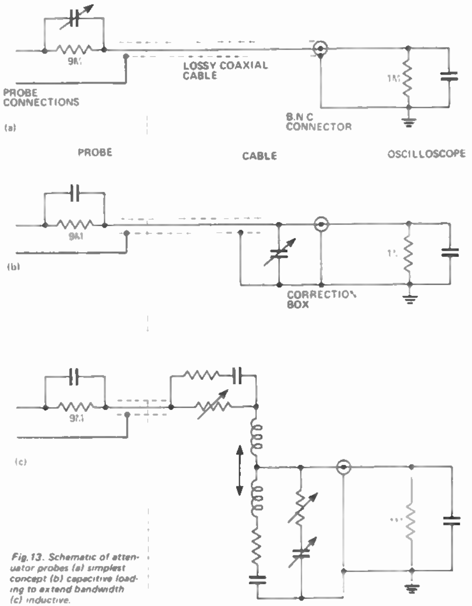


Fig.13. Schematic of attenuator probes (a) simplest concept (b) capacitive loading to extend bandwidth (c) inductive.

OTHER PROBES

Voltage measurements are by far the most frequent measurements made but in some instances it may not be possible to determine voltages, and current measurement is used instead. An example is the current flowing in a direct-coupled Darlington pair configuration where no significant resistance exists over which a voltage can be developed. DC current probes (see Fig 14) clip over the wire in question coupling the dc magnetic field created by the current flowing in the wire into a Hall effect transducer which generates a voltage equivalent to the current flowing These will also measure ac currents The maker specifies the conversion constant — typically 1 mV mA AC only, current

Fig.14 D C current probe

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probes are also made using a current transformer principle

Probes for use in digital circuits are also available. These may incorporate a logic gate that combines the outputs from up to 6 circuit points as shown in Fig. 15. Power for the gate is obtained from the circuit under test.

SPECIAL PLUG-INS

The oscilloscope, due to its extensive flexibility, can form a major part of many test systems, thereby reducing the overall price of advanced measurement systems where a suitable CRO already is available. Special plug-ins are offered (to suit certain main cost is concerned) is the CRT itself for frames) that will convert an oscilloscope into a spectrum analyser or into a semiconductor characteristic-curve tracer. Another plug-in is offered that converts the CRO into a four trace unit.

A basic need in manual measurement is the provision of output form that best suits the operator. In many tasks a visual output in the form of a picture or graph is better than having to view many traces of a time sequence taken over the whole system. Already we have logic analysers which it is just about the last remnant of thermionic device technology remain-

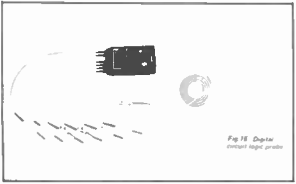


Fig 15. Digital circuit logic probe

display space plane information on the CRO screen, multi-meter CRO units that write digital values on the screen and units that provide axes information on screen graphs. With the reducing cost of advanced processing it will not be long before the microprocessor and memory (already in use in very sophisticated units) are introduced into quite moderately priced oscilloscopes for converting the information taken from the circuit into better forms of display. Display monitors are already available with many display forms. The next stage must be the marrying of the basic CRO unit to such capability via a wider range of sophisticated plug-ins. The colour oscilloscope will also soon be with us extending the information rate at which the operator can be informed about a system via a CRO.

The only weak link in present systems (as far as robustness ... is and ...ing in general use. This too will soon be replaced by a solid state equivalent. Perhaps this will take the form of a matrix of three-colour LEDs in a flat display ... making maximum use of the low cost production advantages of LSI techniques.

Continued next month

FURTHER READING

Due to the versatility of the oscilloscope most books on electronic instrumentation include basic descriptions of how oscilloscopes work and how to perform basic measurements with them. Many books are devoted entirely to the oscilloscope.

General considerations are discussed in "Test and measuring instruments — 1974 Catalogue" (Philips). Tektronix, Hewlett Packard, Dumont and Marconi outlets also provide basic articles on the selection and use of oscilloscopes. ●

ELECTRONICS TOMORROW

by John Miller-Kirkpatrick

Standardisation et al.

I WAS READING IN an American magazine how programs written for SWTP6800 don't work on an Altair 6800 8080 programs not ... a different mainframe and other such non standardisation. What that means if you're not quite up in MPU jargon is that a program written in machine coding for one manufacturer's MPU will not work in another manufacturer's version of the same MPU kit. Exchanging programs must involve careful checking of the code to ensure that any subroutines required are available and in the correct locations. As different manufacturers of microcomputer systems use different decoding techniques for device addresses they have a different MONITOR or DEBUG program.

The monitor program is a program which is operated upon after Power-up or Reset has been signalled to the MPU. The Monitor sets up any variables or pointer registers and then branches to an I/O routine for a command from the operator. This command is a programming code which instructs the Monitor to perform a set of tasks which will result in the required operation. Examples of such commands are Print Memory, Alter Memory, Execute Program, Store and Read.

The monitor program must reside in a fixed location memory (HICORE for 6800 8080, LOCORE for SC/MP etc) and is usually sold in the form of PROM. On some machines the basic monitor program is simply a BOOTSTRAP: this is a program entered via data and address switches. The program is usually only 40 or so bytes and it causes data to be read into RAM and then that program data to be executed. The program data read is in the usual form of monitor described earlier.

Because the Monitor program requires to branch to I/O routines these sub-routines must also be in fixed location in memory and thus they are usually stored in the same PROM. These subroutines are useful and convenient: useful because they are probably the first MPU programs you will get to know well and convenient because any programs that you write can use the same sub routines for I/O. Here lies the biggest problem you are likely to come across in MPUs. Any programs you write may not work on another MPU system based on the same chip. Conversely any programs you require from a library must have been written with your system in mind. Hardware standardisation is much simpler: you either go for one of the big systems with 100 or more parallel connectors or a minibus with just the bare essentials paralleled. Standardisation of hardware is being discussed variously at present, whether it be bus structure or pin and signal compatability between MPUs. Interface and communication standardisation is supported by 20mA loops, CUTS, ASCII, etc.

Software standardisation seems to be based solely in the idea of using the 50 or so characters on a keyboard in whatever sequence seems right at the time. I have been guilty of doing this myself but I have now seen the light and feel that I should pass on the message to all concerned.

Instead of basing everything on a fixed location monitor use a fixed location STACK or Working Storage RAM. You still need your basic monitor or a switch entry system at reset but once set up the system no longer needs that program. Any parameters such as data or addresses to be passed to/from subroutines or I/O devices are stored in this WS RAM. The Monitor stores, for instance, the address of the I/O routines in the PROM at fixed locations in the WS RAM; in order to branch to a routine it must first load the data from the WS-RAM into a branching register and then jump to that address.

Any programs you write can use the same I/O routines by simply following the address load and branch sequence. Any subroutines you write use the same technique of somehow storing their location at a fixed location in WS RAM; if the subroutine happens to be an I/O routine then its address could replace the address of the PROM I/O routine in WS RAM. Any reference by a program to the PROM I/O routine will now use your routine instead; if something goes wrong in your routine hit Reset and you are back with the standard I/O.

Perhaps you are an old hand at MPUs or computers and you think in terms of a programming language such as BASIC, FORTRAN, COBOL or PL. At least one English language compiler is available for most MPUs and some have several optional compilers. Some compilers end up with a machine code program while others work as interpreters of the stored program text. Back in the bad old days of IBM 360s, 1400s, System 4s etc manufactured by large international companies 1400 COBOL didn't work on 360s, IBM FORTRAN had to be modified for ICL or whoever. The mainframe boys made a bad start in software standardisation so please lets have some sense with MPU software.

Time on my hands

After my appeal for information on DCF77 I have received several letters with copies of articles on DCF77 time code receivers, all in German. My thanks to all of those who sent in this data and to those who correctly assumed my knowledge of German and offered translations.

One point about DCF77 which I feel that I should point out to any prospective users is that there is an annual licence fee of 2 000DM but presumably this is only payable for reception in Germany. ●

tech-tips

Tech-Tips is an ideas forum and is not aimed at the beginner. We regret we cannot answer queries on these items.

ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, 25-27 Oxford St., London W1R 1RF.

TTL KEYER

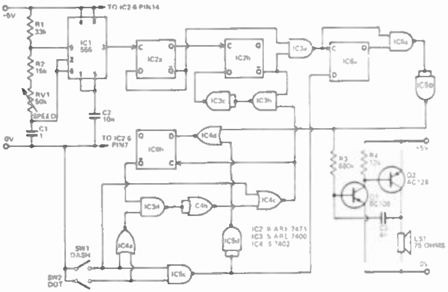
This device can be used to send perfectly spaced Morse at very high speeds - up to twice as fast as with an ordinary Morse key. It uses six integrated circuits, and also requires two special switches, SW1 and SW2, which are described later.

To describe the operation of the circuit fully would take up over a page of ETI, and so a simplified explanation is given here. IC1 is a 555 timer connected as an astable multivibrator, whose frequency is varied by RV1. The output is fed to IC2a, a D flip-flop, which divides the input frequency by 2, producing a square-wave with a 1:1 mark-space ratio (dots).

If SW1 and SW2 are both open, the D inputs of IC2b and IC6a are both at logic 0, so that the dots from IC2a are inverted by IC3a, but blocked by IC5a. IC5b output is a 0, and so the audio oscillator made up of Q1 and Q2 and the associated components is disabled and no tone is fed to the speaker

If SW2 is closed, IC6a's D input becomes logic 1. However IC6a's output can only change state on the rising edge of a clock pulse (i.e. the beginning of a dot). Hence if a dot has already started when SW2 is closed, it will not get through to the speaker, but the next dot will, because it will make IC6a's Q output to go to 1. Hence the dots now get through to the oscillator and successively enable and disable it, causing dots to be heard coming from the speaker. When SW2 is opened, if a dot is in progress it will continue until it has finished, and then at the beginning of the next dot, IC5a output will go low and no more dots will be heard. There is a short delay between the beginning of the dot and the Q output going low, which does cause a short 'blip' at IC5b output, but the blip is too fast to be heard.

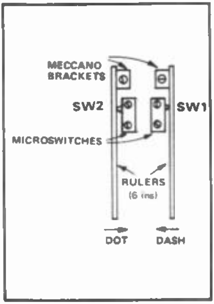
If SW2 is closed, but SW1 open, IC4c output goes to 1 and IC2b's $\overline{Q}$ output is effectively shorted to its D input. This causes IC2b to divide the string of dots from IC2a by two. The outputs of IC2a and IC2b are combined by IC3a to produce a waveform with a 3:1 mark-space ratio (dashes). These are passed on to the audio oscillator just as before. The dashes, like the dots, are self-completing. Notice that IC4c output determines whether dots or dashes are produced.



While SW1 or SW2 is closed, IC6b's D input is fed from IC4c output and clock pulses come from IC5b. If SW1 and SW2 are both operated together, IC4a allows the output of IC6b to pass to IC4c, and IC4d inverts IC4c output again, so that IC6b $\overline{Q}$ output is shorted to its D input. Thus IC6b changes state every time a dot or dash begins at the output, and causes alternate dots and dashes to be produced. This is useful when sending a letter like C (dash-dot-dash-dot), as the switches SW1 and SW2 each need to be closed and opened just once.

It was found after the unit had been built, that it was difficult to send a letter like A (dot-dash) at high speed because SW1 had to be closed a fraction of a second after SW2, which was difficult to achieve at the first attempt. Hence IC5d and IC4d were added. When both switches are released, IC6b input becomes 0. A clock pulse is then applied to IC6b by the 'blip' described earlier. This makes the output go high, and if now SW1 and SW2 are closed simultaneously, the first thing to be heard in the speaker will be a dot.

SW1 and SW2 are push-button microswitches, and these are operated by means of a lever arrangement as shown in the diagram. Plastic rulers were used on the unit built because they are flexible



The component values shown around IC1 give a speed range of 11-30 words per minute. The upper limit can be raised by decreasing R2. I have so far reached a speed of 20 wpm on the unit, after only a week or so of using it. As it stands it is a Morse practise unit, but if IC5b output is taken to a transistor driving a relay, the relay contacts could be used in place of an ordinary Morse key in a C.W. transmitter.

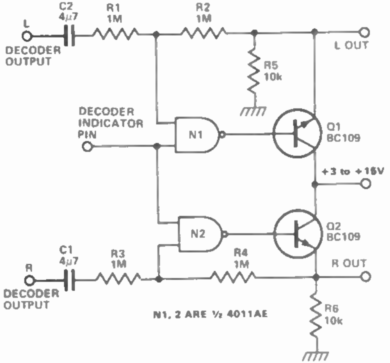
SIMPLE STEREO SWITCH

A device to switch the audio from a stereo tuner only when a stereo signal is being received.

Two CMOS NAND gates and two transistors are employed. One of the inputs from each gate is connected together and to the indicator output of the decoder IC.

The other gate inputs are connected to the emitter's of Q1 and Q2 respectively, by means of the feedback resistors R2 and R4. On reception of a stereo signal the indicator output of the decoder goes high and the feedback resistors bias the gates into the linear region passing the signal. On reception of a mono signal or interstation noise no signals pass through the gates the circuit providing a mute function.

N.B. Some CMOS will not function in the linear mode. CMOS that *will not* work include R.S., Doram, Signetics. CMOS that *will* work include N.S., R.C.A., Motorola. All unused inputs should be connected to ground.

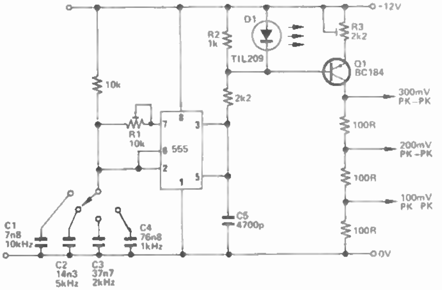


VOLTAGE AND FREQUENCY CALIBRATOR

This circuit provides simultaneous voltage and frequency calibrations by generation of a precision squarewave.

The 555 timer IC is used in a slightly unusual configuration, having the advantage that an exact 50:50 mark/space ratio may be attained by trimming R1. The frequncy of oscillation may be set between 10 kHz and 1 kHz by switching timing capacitors C1-4. C5 decouples the internal reference potential-divider of the 555 from supply-transients.

The squarewave output from pin 3 of the IC, while stable in frequency, is not stable in peak-to-peak voltage as this depends on the supply voltage. This is used to switch on and off a temperature-compensated constant-current source Q1. R2 ensures that the current-source turns off completely when pin 3 goes high. The current-source output, trimmed by R3 to be exactly 1 mA, drives a resistor ladder network so that a series of precise squarewave voltages are generated. The advantage of current drive rather than voltage drive for this sort of network is that calibration is much easier. A simple ladder network is shown by way of example and more complex ones may simply be constructed to give a wider variety of output voltages.



The non-standard component values used were obtained by paralleling standard values. For the timing capacitors several in parallel had to be used, and only the resultant value is shown on the diagram.

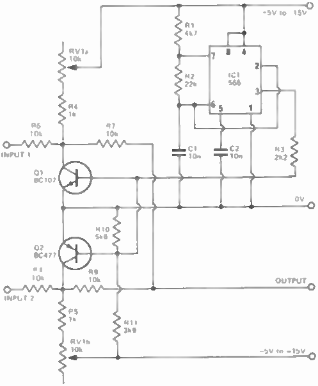
tech-tips

BEAM SPLITTER FOR OSCILLOSCOPE

The basis of the beam splitter is a 555 timer connected as an astable multivibrator, components R1, R2 and C1 being selected to give approximately equal high/low pulses of about 3 kHz.

Resistor R3 couples the output of the oscillator to the npn/pnp pair Q1 and Q2. When the output of the oscillator is low, resistors R10 and R11 allow Q2 to be on so that any signal applied to input 2 is effectively short-circuited via resistor R8 to the common line of the power supply. At the same time, the npn transistor Q1 is off, so that any signal at input 1, plus a positive voltage provided by RV1a and R4, appears at the output via R7.

Conversely, when the output of the oscillator is high, Q1 is biased on whilst Q2 is off. A signal at input 2 plus a negative voltage via RV1b and R5 appears at the output via R9. Thus signals at the two inputs are alternately displayed on the oscilloscope with a clear separation between them. The separation is controlled by the tandem potentiometer RV1a/b which also varies the amplitude of the traces.



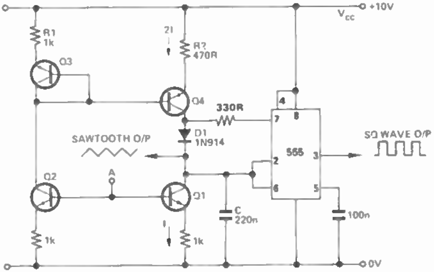
A SIMPLE V.C.O.

This circuit generates sawtooth and triangle waveforms at a frequency set by an external control voltage.

Current source Q1 draws a current I from timing capacitor C. Simultaneously current source Q2 draws the same current from current mirror Q3, Q4; this is set up (by R1 and R2) to deliver (from the collector of Q4) twice the current leaving Q2.

Hence C receives a current 2 I from the top rail, at the same time delivering I to the bottom rail, the net effect being that the capacitor is charged by a constant current I, its voltage rising linearly until the 555's upper trigger point (at 2/3Vcc) is reached.

The output (pin 3) then goes low, as does the open-collector discharge output at pin 7. The latter shunts the output of the current mirror to earth, D1 becoming reverse-biased and isolating C.



Now only current source Q1 is connected to the timing capacitor which is now linearly discharged by current I. In this way C is alternately charged and discharged. When the voltage on C falls to the 555's lower trigger point at 1/3Vcc, the output and discharge pins go high, and the cycle recommences; the repetition frequency is determined by the magnitude of I, which is set by the voltage applied at the input point A.

With the component values shown, the frequency range is from approx. 2.5 kHz to less than 10 Hz, as the control voltage varies from +10 V to zero; the frequency is directly proportional to the control voltage. Other ranges may be obtained by altering the value of C.

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