EVERYDAY WITH PRACTICAL ELECTRONICS
NOVEMBER 1994
INCORPORATING ELECTRONICS MONTHLY
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VIDEO CONTROLLER MODULES
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POWER CONTROLLER
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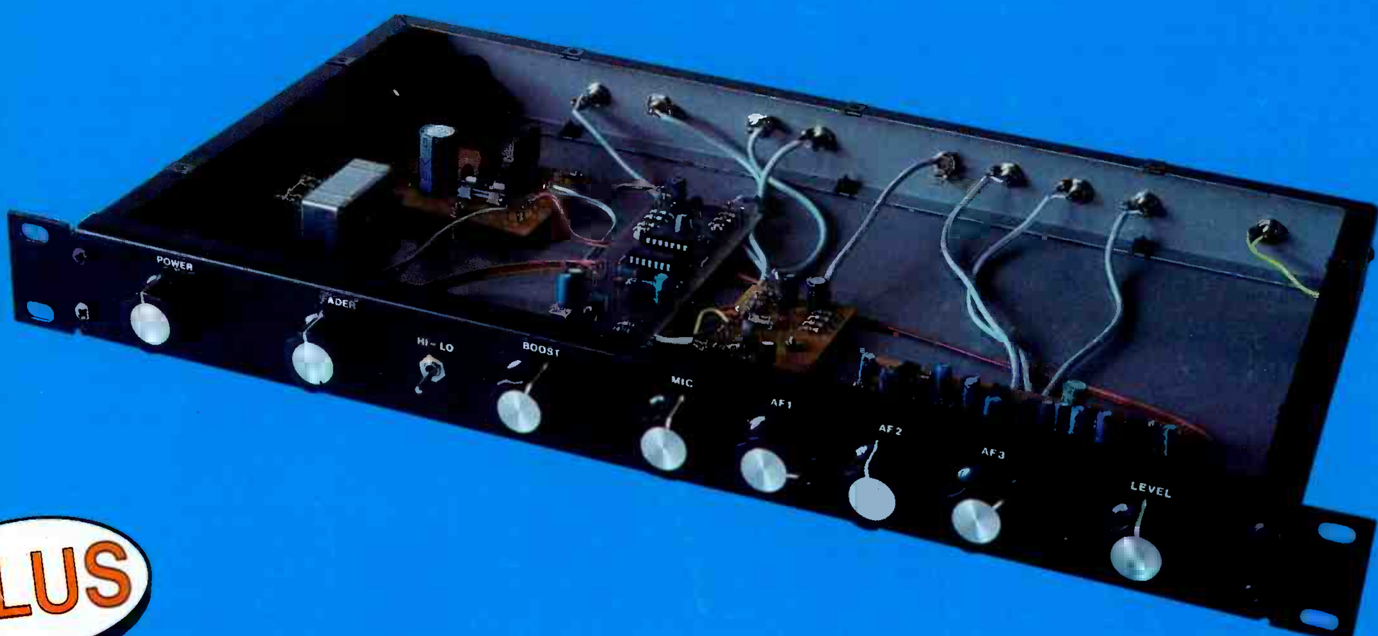

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SWITCHED MODE PSU ex equip, 60w +5v @5A, -5v@.5A, +12v@2A, -12v@.5A 120/220v cased 245x88x55mm IEC input socket £6.99 REF MAG7P1
PLUG IN PSU 9V 200mA DC £2.99 each REF MAG3P9
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ACORN ARCHIMEDES PSU +5v @ 4.4A. on/off sw uncased, selectable mains input, 145x100x45mm £7 REF MAG7P2
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9v DC POWER SUPPLY Standard plug in type 150ma 9v DC with lead and DC power plug. price for two is £2.99 ref AUG3P4.
AA NICAD PACK encapsulated pack of 8 AA nicad batteries (tagged) ex equip, 55x32x32mm. £3 a pack. REF MAG3P11
13.8V 1.9A psu cased with leads. Just £9.99 REF MAG10P3
360K 5.25 brand new half height floppy drives IBM compatible industry standard. Just £6.99 REF MAG7P3
PPC MODEM CARDS. These are high spec plug in cards made for the Amstrad laptop computers. 2400 baud dial up unit complete with leads. Clearance price is £5 **REF: MAG5P1**
INFRA RED REMOTE CONTROLLERS Originally made for hi spec satellite equipment but perfect for all sorts of remote control projects. Our clearance price is just £2 **REF: MAG2**
TOWERS INTERNATIONAL TRANSISTOR GUIDE. A very useful book for finding equivalent transistors, leadouts, specs etc. £20 **REF: MAG20P1**
SINCLAIR C5 MOTORS We have a few left without gearboxes. Spec is 12v DC 3,300rpm £25 ref **MAG25.**

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55A WORCESTER ST TEL 0902 22039

··················NEW PRODUCT··················

200 WATT INVERTER Converts 10-15v DC into either 110v or 240v AC. Fully cased 115x36x156mm, complete with heavy duty power lead, cigar plug, AC outlet socket. Auto overload shutdown, auto short circuit shut down, auto input over voltage shutdown, auto input under voltage shut down (with audible alarm), auto temp control, unit shuts down if overheated and sounds audible alarm. Fused reversed polarity protected. output frequency within 2%, voltage within 10%. A extremely well built unit at a very advantageous price!!! Price is £64.99 ref AUG65.

UNIVERSAL SPEED CONTROLLER KIT Designed by us for the C5 motor but ok for any 12v motor up to 30A. Complete with PCB etc. A heat sink may be required. £17.00 **REF: MAG17**
MAINSCABLE Precut black 2 core 2 metre lengths ideal for repairs, projects etc. 50 metres for £1.99 ref AUG2P7.
COMPUTER COMMUNICATIONS PACK Kit contains 100m of 6 core cable, 100 cable clips, 2 line drivers with RS232 interfaces and all connectors etc. Ideal low cost method of communicating between PC's over a long distance. Complete kit £15.99 Ref MAR16P2.
MINICYCLOPS PIR 52x62x40mm runs on PP3 battery complete with shrill sounder. Cheap protection at only £5.99 ref MAR6P4.
ELECTRIC MOTOR KIT Comprehensive educational kit includes all you need to build an electric motor. £9.99 ref MAR10P4.
VIDEO SENDER UNIT. Transmits both audio and video signals from either a video camera, video recorder, TV or Computer etc to any standard TV set in a 100' range! (tune TV to a spare channel) 12v DC op. Price is £15 **REF: MAG15** 12v psu is £5 extra **REF: MAG5P2**
***FM CORDLESS MICROPHONE** Small hand held unit with a 500' range! 2 transmit power levels. Reqs PP3 9v battery. Tuneable to any FM receiver. Price is £15 **REF: MAG15P1**
LOW COST WALKIE TALKIES Pair of battery operated units with a range of about 200'. Ideal for garden use or as an educational toy. Price is £8 a pair **REF: MAG 8P1** 2 x PP3 req'd.
***MINATURE RADIO TRANSCEIVERS** A pair of walkie talkies with a range of up to 2 kilometres in open country. Units measure 22x52x155mm. Complete with cases and earpieces. 2xPP3 req'd. £30.00 pair **REF: MAG30.**
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LQ3500 PRINTER ASSEMBLIES Made by Amstrad they are entire mechanical printer assemblies including printhead, stepper motors etc etc In fact everything bar the case and electronics, a good stripper! £5 **REF: MAG5P3** or 2 for £8 **REF: MAG8P3**
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LED PACK of 100 standard red 5m leds £5 **REF MAG5P4**
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***FM TRANSMITTER** housed in a standard working 13A adapter!! the bug runs directly off the mains so lasts forever! why pay £700? or price is £26 REF: MAG26 Transmits to any FM radio.
***FM BUG KIT** New design with PCB embedded coil for extra stability. Works to any FM radio. 9v battery req'd. £5 REF: MAG5P5
***FM BUG BUILT AND TESTED** superior design to kit. Supplied to detective agencies. 9v battery req'd. £14 REF: MAG14
TALKING COINBOX STRIPPER originally made to retail at £79 each, these units are designed to convert and ordinary phone into a payphone. The units have the locks missing and sometimes broken hinges. However they can be adapted for their original use or used for something else?? Price is just £3 **REF: MAG3P1**
100 WATT MOSFET PAIR Same spec as 2SK343 and 2SJ413 (8A,140v,100w) 1 N channel, 1 P channel, £3 a pair **REF: MAG3P2**
TOP QUALITY SPEAKERS Made for HI FI televisions these are 10 watt 4R Jap made 4" round with large shielded magnets. Good quality. £2 each **REF: MAG2P4** or 4 for £6 **REF: MAG6P2**
TWEETERS 2" diameter good quality tweeter 140R (ok with the above speaker) 2 for £2 **REF: MAG2P5** or 4 for £3 **REF: MAG3P4**
AT KEYBOARDS Made by Apricot these quality keyboards need just a small mod to run on any AT, they work perfectly but you will have to put up with 1 or 2 foreign keycaps! Price £6 **REF: MAG6P3**
PC CASES Again mixed types so you take a chance next one off the pile £12 **REF:MAG12** or two the same for £20 **REF: MAG20P4**
HEADPHONES Ex Virgin Atlantic. 8 pairs for £2 **REF:MAG2P8**
PROXIMITY SENSORS These are small PCB's with what look like a source and sensor LED on one end and lots of components on the rest of the PCB. Complete with fly leads. Pack of 5 £3 **REF: MAG: 3P5** or 20 for £8 **REF: MAG8P4**

***SOME OF OUR PRODUCTS MAY BE UNLICENSABLE IN THE UK**

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SNOOPERS EAR? Original made to clip over the earpiece of telephone to amplify the sound-it also works quite well on the cable running along the wall! Price is £5 **REF: MAG5P7**
DOS PACKS Microsoft version 3.3 or higher complete with all manuals or price just £5 **REF: MAG5P8** Worth it just for the very comprehensive manual! 5.25" only.
DOS PACK Microsoft version 5 Original software but no manuals hence only £3 **REF: MAG3P6** 5.25" only.
PIR DETECTOR Made by famous UK alarm manufacturer these are hi spec, long range internal units. 12v operation. Slight marks on case and unboxed (although brand new) £8 **REF: MAG8P5**
WINDUP SOLAR POWERED RADIO AM/FM radio complete with hand charger and solar panel! £14 REF: MAG14P1
MOBILE CAR PHONE £5.99 Well almost! complete in car phone excluding the box of electronics normally hidden under seat. Can be made to illuminate with 12v also has built in light sensor so display only illuminates when dark. Totally convincing! REF: MAG6P6
ALARM BEACONS Zenon strobe made to mount on an external bell box but could be used for caravans etc. 12v operation. Just connect up and it flashes regularly) £5 REF: MAG5P11
FIRE ALARM CONTROL PANEL High quality metal cased alarm panel 350x165x80mm.With key. Comes with electronics but no information. sale price 7.99 REF: MAG8P6
REMOTE CONTROL PCB These are receiver boards for garage door opening systems. Another use? £4 ea REF: MAG4P5
6"X12" AMORPHOUS SOLAR PANEL 12v 155x310mm 130mA. Bargain price just £5.99 ea REF MAG6P12.
FIBRE OPTIC CABLE BUMPER PACK 10 metres for £4.99 ref MAG5P13 ideal for experimenters! 30 m for £12.99 ref MAG13P1
LOPTX Line output transformers believed to be for IBM hi res colour monitors but useful for getting high voltages from low ones! £2 each REF: MAG2P12 bumper pack of 10 for £12 REF: MAG12P3.
HEATSINKS (finned) TO220, designed to mount vertically on a pcb 50x40x25mm you can have a pack of 4 for £1 ref JUN1P11.
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Second generation image intensifier complete with hand grip attachment with built in adjustable laser lamp for zero light conditions. Supplied with Pentax 42mm camera mount and normal eye piece. 1.6kg, uses 1xPP3,3xAA's (all supplied) £245+Vat

NEW HIGH POWER LASERS
15mW, Helium neon, 3 switchable wave lengths .63um,1.15um,3.39um (2 of them are infrared) 500:1 polarizer built in so good for holography. Supplied complete with mains power supply.790x65mm. Use with EXTREME CAUTION AND UNDER QUALIFIED GUIDANCE. £349+Vat.

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TURN YOUR SURPLUS STOCK INTO CASH.
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1994 CATALOGUE.
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3FT X 1FT 10WATT SOLAR PANELS
14.5v/700mA
£33.95
(PLUS £2.00 SPECIAL PACKAGING CHARGE)
TOP QUALITY AMORPHOUS SILICON CELLS HAVE ALMOST A TIMELESS LIFESPAN WITH AN INFINITE NUMBER OF POSSIBLE APPLICATIONS, SOME OF WHICH MAY BE CAR BATTERY CHARGING, FOR USE ON BOATS OR CARAVANS, OR ANYWHERE A PORTABLE 12V SUPPLY IS REQUIRED. REF: MAG34

PORTABLE RADIATION DETECTOR
£49.99
A Hand held personal Gamma and X Ray detector. This unit contains two Geiger Tubes, has a 4 digit LCD display with a Piezo speaker, giving an audio visual indication. The unit detects high energy electromagnetic quanta with an energy from 30K eV to over 1.2M eV and a measuring range of 5-9999 UR/h or 10-99990 Nr/h. Supplied complete with handbook.Ref MAG50.

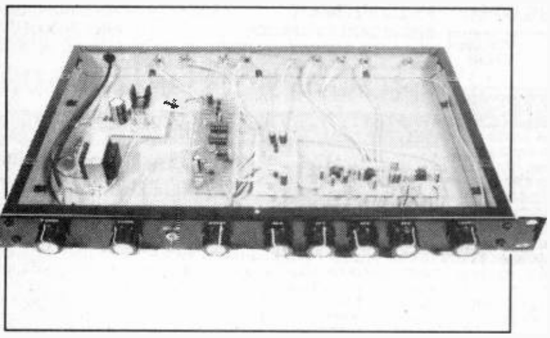
ISSN 0262 3617
PROJECTS . . . THEORY . . . NEWS . . .
COMMENT . . . POPULAR FEATURES . . .

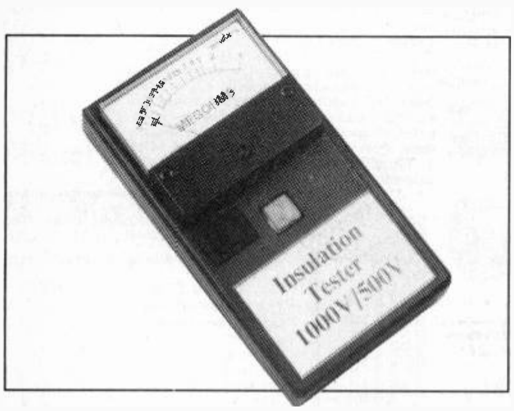
VOL. 23 No. 11 NOVEMBER 1994

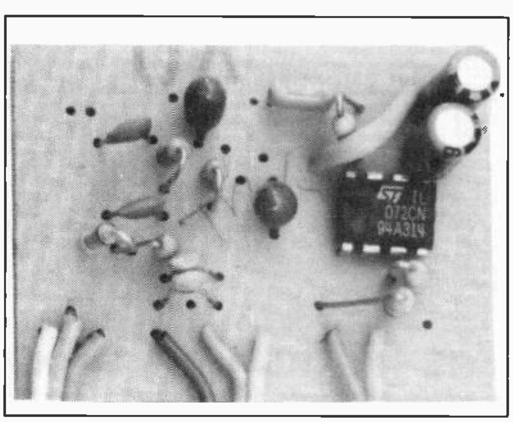
EVERYDAY WITH PRACTICAL ELECTRONICS

INCORPORATING ELECTRONICS MONTHLY

The No. 1 Independent Magazine for Electronics, Technology and Computer Projects







Projects

Series

Features

FREE

GREENWELD 1995 CATALOGUE (196-Pages)
BANDED WITH MAGAZINE

Our December '94 issue will be published on Friday, 4 November 1994. See page 811 for details.

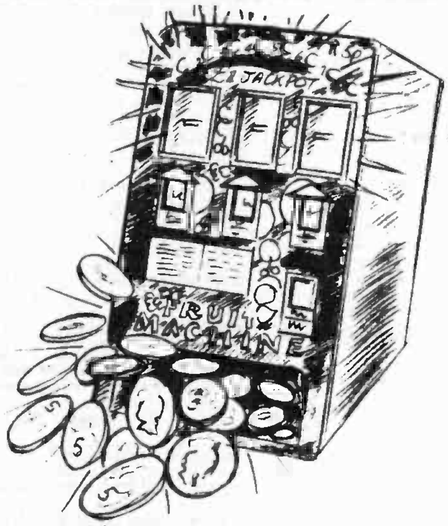
NEXT MONTH

FREE

BULL ELECTRICAL CATALOGUE

EPE FRUIT MACHINE

A Coin Operated Fruit Machine that really pays out!



With the advent of the single chip microcontroller it has become possible to design a Fruit Machine (or "One Armed Bandit") with reasonably simple circuitry. This unit employs a small p.c.b., is battery operated and has plenty of space left, in a smaller than shoe box case, for the single most important feature – a real payout mechanism.

This design, which we believe fits into the "executive toy" category, makes use of two simple-to-construct plastic coin mechanisms, a coin detector and a coin payout mechanism. Both mechanisms are designed to work with the new small five pence piece. This coin was chosen for two reasons. Firstly, the Fruit Machine had to be reasonably inexpensive to play while at the same time offering a high value jackpot. Secondly, since the five pence coin is the smallest, lower value coins will not fit through the slot, so no reject mechanism is required.

In order to minimise the number of mechanical components, large 7-segment displays are used instead of "reels" to reproduce "fruit" symbols. Animation techniques have been used to give the "reels" a realistic spinning action, and software algorithms have been designed to simulate the inertia, friction and sound of an equivalent mechanical system.

UNIVERSAL DIGITAL CODE LOCK

Designed to be used in a wide variety of applications this easy to build unit is based on a microcontroller chip which provides a four-digit programmable combination. This gives over 20,000 possible combinations which, together with a wrong combination warning alarm and keyboard disable timer, should provide excellent security.

VIDEO CONTROLLER MODULES

More modules to add to the three in this issue – the next modules are: Horizontal Wiper; Vertical Wiper; Audio Mixer and, space permitting, Dynamic Noise Limiter and PSU.

EVERYDAY WITH PRACTICAL ELECTRONICS

OUR DECEMBER ISSUE WILL BE PUBLISHED ON FRIDAY, NOVEMBER 4th

Take the

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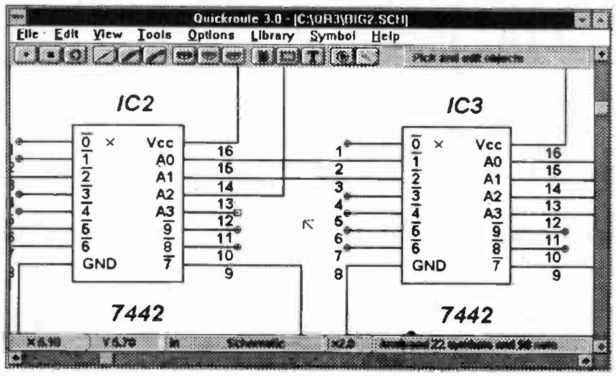
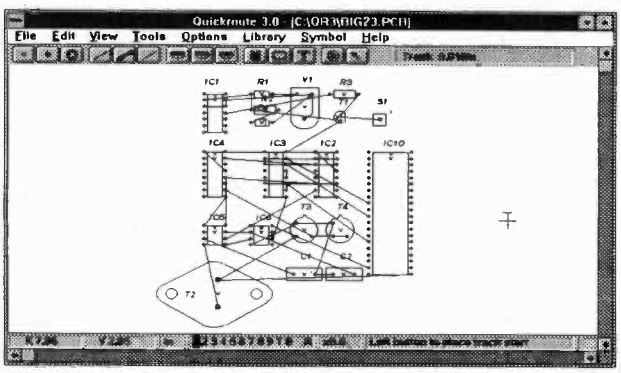


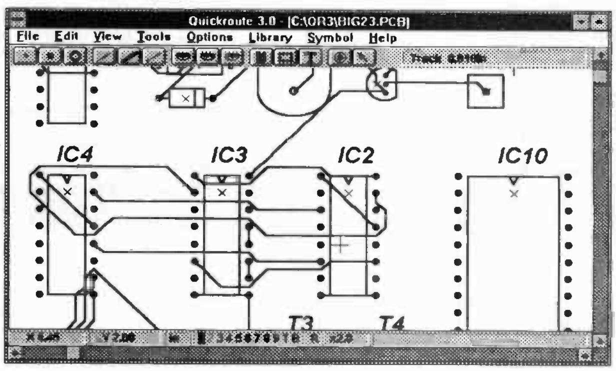
	Auto Router Max Layers	Schematic Capture	Gerber & NC-Drill	Design Size K nodes
DESIGNER	*2 Standard*	*None*	*None*	*10*
DESIGNER+	*2 Medium*	*None*	*Export*	*20*
PRO	*8 Fast*	*Standard*	*Export*	*30*
PRO+	*8 Fast*	*Advanced*	*Export/ Import**	*40*

***PRO+ can import Gerber files**

After schematic capture, components can be re-arranged prior to manual or automatic routing.



All versions include an auto-router.



Telephone or FAX POWERware on 061 449 7101

POWERware, 14 Ley Lane, Marple Bridge, Stockport, SK6 5DD, UK.

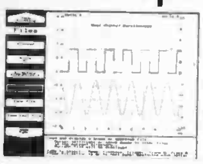
Quickroute 3.0 for Windows™ 3.1
DESIGNER £99.00 DESIGNER+ £149.00
PRO £199.00 PRO+ £299.00
All prices exclude post & packing, and V.A.T.

DEMO DISK Available

Low cost data acquisition for IBM PCs & compatibles

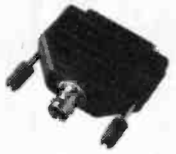
Easy to use data acquisition products that allow your PC to be used as a range of useful test and measurement instruments, or as an advanced data logger. Installed in seconds they simply plug into the parallel port (except the ADC-16 which connects to the serial port). They require no power supply and take up no expansion slots. Each comes with a comprehensive manual. Software drivers are included for users who wish to write their own software. Software supplied on 3.5" disk.

PicoScope



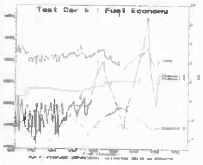
'Virtual instrument' software. Storage scope with trigger, timebase, rulers and offset. Real time spectrum analysis with min/max frequency and signal averaging. Multiple meters on screen (digital and bargraph). Printer and file handling support.

ADC-10/12



Single channel of analog input
8 bit resolution 22kHz sampling (ADC-10)
12 bit resolution 18kHz sampling (ADC-12)
(sampling speed based on 33MHz/386PC)
0-5V input range
BNC input allows use of scope probes

PicoLog



Advanced data logging software package. Collect, store, display and print data from 1 sample per ms to 1 per day. Record average, min/max or scaled values (linear, equation, table look-up). Report types: monitor (with min/max alarms), y-t graphs, x-y graphs, tabulation

NEW *ADC100* Virtual Instrument

Dual Channel 12-bit resolution

The ADC 100 offers both a high sampling rate (100kHz) and a high resolution. It is ideal as a general purpose test instrument either in the lab or in the field. A flexible input range (±200mV to ±20V) allows the unit to connect directly to a wide variety of signals.

- Digital Storage Scope
- Chart Recorder
- Spectrum Analyser
- Data Logger
- Frequency Meter
- Voltmeter

ADC-100 with PicoScope **£199**
ADC-100 with PicoScope & PicoLog **£209**

ADC-100

Prices

ADC-10 with PicoScope	£49
ADC-11 with PicoScope	£85
ADC-12 with PicoScope	£85
ADC-16 with PicoLog	£115

The ADC-10/11/12 are available with both Picoscope and PicoLog for an additional £10. Existing ADC-10/11/12 users can add PicoLog for £25.

PICO TECHNOLOGY

VISA

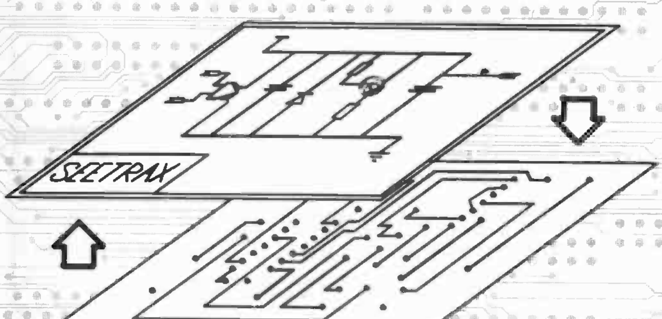
Pico Technology Ltd. Broadway House, 149-151 St Neots Road, Hardwick, Cambridge CB3 7QJ, UK
TEL: 0954-211716 FAX: 0954-211880

Phone or FAX for sales, ordering information, data sheets, technical support. All prices exclusive of VAT.

SEETRAX CAE - RANGER - PCB DESIGN

Ranger1 £100

* Schematic capture linked to PCB
* Parts and wiring list entry
* Outline (footprint) library editor
* Manual board layout
* Full design rule checker
* Back annotation (linked to schematic)
* Power, m[illegible]y and signal autorouter - £50



Ranger2 £599

All the features of Ranger1 plus

* Gate & pin swapping (linked to schematic)
* Track highlighting
* Auto track necking
* Copper flood fill
* Power planes (heat-relief & anti-pads)
* Rip-up & retry autorouter

Ranger3 £3500

All the features of Ranger2 plus

* UNIX or DOS versions
* 1 Micron resolution and angles to 1/10th degree
* Hierarchical or flat schematic
* Unlimited design size
* Any-shaped pad
* Split power planes
* Optional on-line DRC
* 100% rip-up & retry, push & shove autorouter

All systems upward compatible. Trade-in deals available.

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EVERYDAY WITH PRACTICAL ELECTRONICS

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INGENUITY . . .

The ingenuity of our readers and contributors is a never ending inspiration. Next month we will publish the *EPE Fruit Machine* which shows what can be achieved with a little ingenuity, simple mechanics and some careful software development for programmable logic. It is a tribute to the authors that this excellent project is relatively easy to build and great fun to play with. It's also a good way of saving money while enjoying yourself!

On the same subject you will notice that, with the brave assistance of Alan Winstanley, we have reintroduced one of the oldest features from *Practical Electronics – Ingenuity Unlimited* (IU) – this is a forum for reader's circuits (please note *not* mechanical, constructional or electrical tips). While these circuits have not been proven by us they will at least provide some food for thought and a basis for experiment.

If you have a circuit of your own design, that has not been published elsewhere, why not send it in for IU – it could earn you up to £50. Full details for sending in your ideas are given on the IU page.

. . . UNLIMITED

As I have indicated above, the range of projects we publish is virtually unlimited and this issue carries two projects that have been "in the pipeline" for some time. The *1000V/500V Insulation Tester* is a development of a design we published back in April 1985. A number of readers requested a unit that tested at a higher voltage level and this new project is the result.

The *Video Controller Modules* have also been under development for some time. We realised a couple of years ago that the need for this type of equipment was growing and we asked Robert Penfold if he could produce a range of low cost "mix and match" modules. This short series of projects is the result.

Two more excellent *EPE* projects which show the ingenuity of our contributors. There are plenty more in the pipleline for the months ahead.

Mike Kenward

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Certain back issues of EVERYDAY ELECTRONICS, PRACTICAL ELECTRONICS and EVERYDAY with PRACTICAL ELECTRONICS (from Nov '92 onwards) are available price £2.30 (£3 overseas surface mail) inclusive of postage and packing per copy – **£ sterling only please**, Visa and Access (MasterCard) accepted, minimum credit card order £5. Enquiries with remittance, made payable to Everyday with Practical Electronics, should be sent to Post Sales Department, Everyday with Practical Electronics, Allen House, East Borough, Wimborne, Dorset BH21 1PF Tel: 01202 881749. In the event of non-availability one article can be photostatted for the same price. *Normally sent within seven days but please allow 28 days for delivery.* **We have sold out of Jan, Feb, Mar, Apr, May, June, Oct, & Dec 88, Mar, May & Nov 89, Mar 90, April, Aug & Sept 91 Everyday Electronics, and can only supply back issues from Jan 92 to Aug 92 (excluding Mar 92) of Practical Electronics. Dec 92, Jan, Feb and March 93 Everyday with Practical Electronics are also unavailable.**

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We are unable to offer any advice on the use, purchase, repair or modification of commercial equipment or the incorporation or modification of designs published in the magazine. We regret that we cannot provide data or answer queries on articles or projects that are more than five years old. Letters requiring a personal reply *must* be accompanied by a **stamped self-addressed envelope** or a **self addressed envelope and international reply coupons.** Due to the cost **we cannot reply to queries by Fax.**

All reasonable precautions are taken to ensure that the advice and data given to readers is reliable. We cannot however guarantee it and we cannot accept legal responsibility for it.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured, these can be supplied by advertisers.

We advise readers to check that all parts are still available before commencing any project in a back-dated issue.

We regret that **we cannot provide data or answer queries on projects that are more than five years old.**

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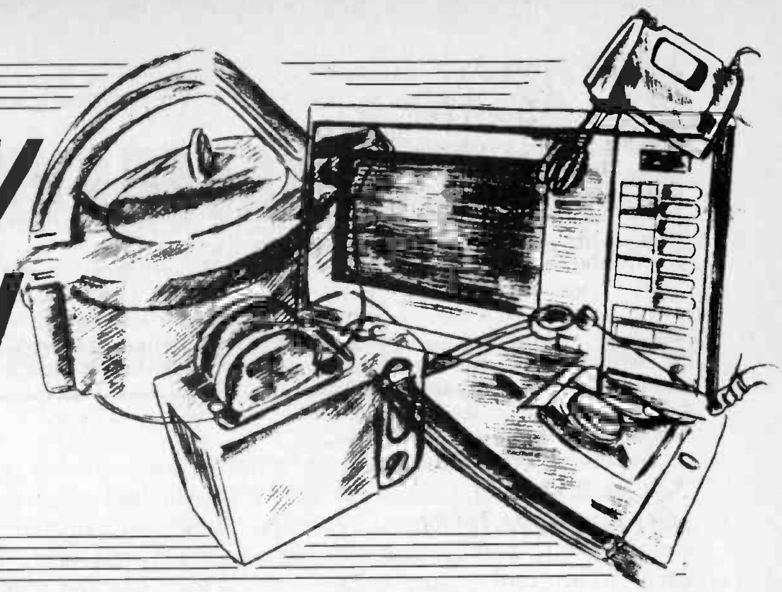
Constructional Project

1000V/500V INSULATION TESTER



MARK STUART

Carry out your own safety checks with this low-cost instrument

THE SAFETY of most electrical equipment relies upon insulation of various kinds. When insulation fails, the users can be exposed to mains voltage and are therefore in considerable danger.

Testing insulation with a normal ohms meter at low voltage is only useful if the insulation has failed completely, resulting in a very low resistance path. This type of failure is unusual however, and the type of failure more likely to occur is voltage dependent. Such failure may read perfectly at low voltage, but conduct heavily at mains voltage.

To test for this kind of fault requires a meter which applies a safe, current limited high voltage to the circuit and then measures the leakage current. The resulting current can then be displayed on a meter suitably calibrated to read insulation resistance.

A variety of excellent commercial designs are available, but these are expensive for occasional use.

This design provides a good quality accurate insulation tester which can test at 1000V and 500V, and indicate insulation resistance values from two Megohms to well over 200 Megohms. It is compact, portable, and safe, using a PP3 9V battery and a voltage converter circuit to produce a stabilised high test voltage with a current output limited to below 1mA.

The meter has a "dual scale" feature that spreads out the scale preventing cramped readings at one end. The voltage converter is efficient, and so battery consumption is also low. In normal use, the battery life should be several months.

CIRCUIT DESCRIPTION

The full circuit diagram for the 1000V/500V Insulation Tester is shown in Fig. 1. The heart of the design is the voltage converter circuit. This consists of transistor TR1, diode D4, and the special ferrite core resonant transformer L1 and its tuning capacitor C4.

The base (b) of TR1 is driven by square waves at between 80kHz and 40kHz depending on the circuit load. Each time TR1 is turned on, current builds up in L1, storing energy. As TR1 turns off, the energy is released and the tuned circuit L1/C4 "rings" producing a high voltage sine wave at the anode of D4.

If TR1 remained switched off, the ringing would tail away, giving a damped sine wave like a horizontal Christmas tree. The turn off time of TR1 is limited however, and carefully controlled so that TR1 is always turned on again during the first negative half cycle of the ringing waveform. The result is that after one complete cycle, the ringing stops and the current is again built up in L1 ready for the next cycle.

Diode D4 is very important as it allows the L1 voltage to swing negative below the supply voltage. Without it, the collector-base junction of TR1 would become forward biased and TR1 would happily conduct in the reverse direction short circuiting any attempt at a negative swing. (For those readers who remember, valves were much simpler in this respect, as there was no way that a negative biased valve anode could conduct.)

The peak-to-peak voltage swing across L1 is limited mainly by the breakdown voltage of TR1. Very high voltage transistors are available, but not without drawbacks, such as slow switching times, low current gain, and high saturation voltage.

A very good working compromise comes in the form of the ZTX455 device used, which has a breakdown voltage of 150V,

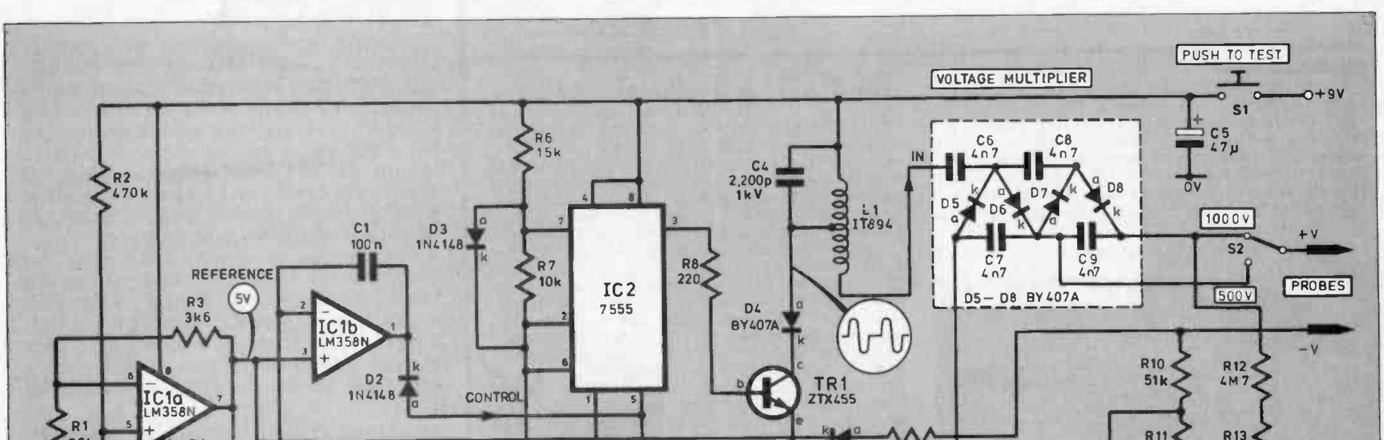


Fig. 1. Complete circuit diagram for the 1000V/500V Insulation Tester.

combined with excellent gain and low saturation voltage. This allows positive and negative swings of 125V giving a total working voltage swing of 250V peak-to-peak. Resonant transformer L1 has additional turns wound on from the tuned part, and so acts as an autotransformer. This steps up the voltage swing even further to give the 500V peak-to-peak required.

For higher voltages, a higher turns ratio could be used, but the increasing self capacitance of the winding results in high frequency ringing superimposed on the main waveform leading to inefficiency. As well as this, the lacquer insulation on the winding wire is more highly stressed, and careful winding techniques are required.

VOLTAGE MULTIPLIER

A simple "standard" voltage multiplier circuit is then used to rectify and raise the voltage to 500V and 1000V d.c. This voltage multiplier consists of two voltage doubler stages. The first stage, C6, C7, D5, and D6, takes the input and produces across capacitor C7 a d.c. output equal to the peak-to-peak a.c. input voltage.

The second identical stage takes the input voltage via C6 and C8 in series, and produces the same output voltage across capacitor C9. As capacitors C9 and C7 are in series their voltages add, giving 1000V.

The beauty of this circuit is that more stages can be cascaded to generate extremely high voltages, and that the components in each stage only need to have the same voltage rating as those in the first stage. In effect the components are in series to the high output d.c. voltage, but in parallel to the lower voltage a.c. input.

Transformer L1 and capacitor C4 need to be chosen very carefully as they must have very low losses and withstand high currents and voltages. The selection of C4 was particularly interesting, as a number of apparently good quality components got hot and absorbed a great deal of energy. The final choice of a *low loss polypropylene* dielectric capacitor *must* be used for the circuit to perform well, along with the *specified* transformer L1.

DRIVE CIRCUIT

The base current for transistor TR1 is provided via resistor R8 from the CMOS 555 oscillator IC2. This is configured as a standard oscillator circuit with an additional component diode D3.

Timing capacitor C2 is charged via R6 and diode D3, and discharged via resistor R7. This arrangement allows the charge time to be independent of discharge time.

The values of R6 and C2 determine the charge time which is the time that the output from pin 3 of the IC2 is high, and TR1 is turned ON, whilst the value of R7 determines the discharge time during which TR1 is turned OFF. The turn off time is set to seven microseconds which is three-quarters of the ringing cycle of L1/C4. This is ideal as it means that base drive is applied to TR1 whilst the voltage on the anode and diode D4 is *negative*.

Although TR1 has base drive it cannot turn on until the collector voltage becomes slightly positive, which happens as soon as the negative half cycle of ringing is over. The current in L1 then begins to build up, for as long as TR1 remains turned on. This time is set to 13 microseconds and allows the maximum amount of energy to be stored in L1. In this condition, the circuit is operating at maximum output.

Pin 5 of IC2 allows the switching times to be controlled, and feedback derived from the output voltage via IC1b is used to alter the times to regulate the output so that it remains constant for all loads, and battery voltages from 12V down to 7V.

CONTROL CIRCUIT

To control the output voltage, a proportion is sampled via a 200 : 1 potential divider consisting of resistors R12, R13, and R5. The output of this is applied to the inverting input (pin 2) of IC1b and will be 5V if the output is 1000V. The non-inverting input (pin 3) is fed by a 5V reference derived from Zener diode D1 via IC1a. If the output rises beyond 1000V, the voltage at the inverting input of IC1b exceeds the reference, and so the output goes negative. This pulls down the control pin (pin 5) of IC2 via diode D2 which shortens the time that TR1 is turned on, reducing the stored energy and output voltage. This process is self-adjusting, with just the right amount of control voltage applied to IC2 to keep the output at 1000V.

The oscilloscope traces Fig. 2a and Fig. 2b show the effect of the control on the turn on time which is the flat section of the trace between the ringing cycles. In Fig. 2a the output is lightly loaded and the turn on time is short, whilst in Fig. 2b, the output is loaded with a two megohm resistor and the turn on time is much longer. Although the feedback is only taken from the 1000V output, the two sections of the voltage multiplier are identical, and so the 500V output is also controlled.

VOLTAGE REFERENCE

A simple Zener diode and resistor could be used as a voltage reference, but the stability would not be very good as the current would vary with the battery voltage. The circuit around IC1a provides a constant current for the Zener diode D1 via resistor R4 and also allows the reference voltage to be adjusted to any value required by altering the gain of the circuit by R3 and R1.

Resistor R2 provides a small start-up current which is needed when the circuit is very lightly loaded as in this application.

METER CIRCUIT

The current flowing in the circuit being tested is measured by a meter in the negative return lead. Resistors R10 and R11 are

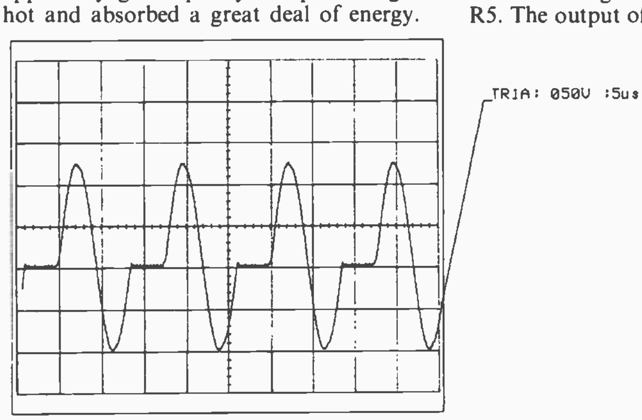


Fig. 2a. Output lightly loaded – turn on time short.

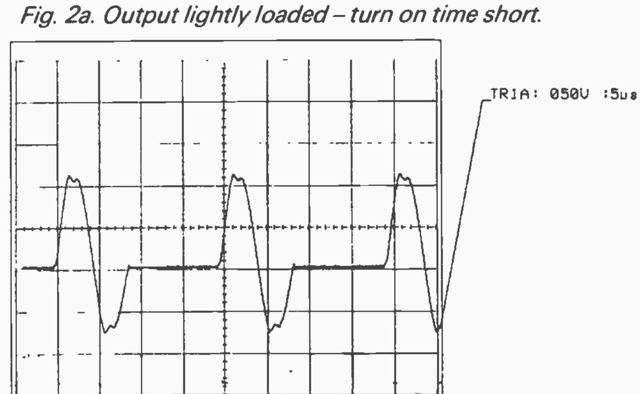


Fig. 2b. Loaded with 2M resistor – turn on time longer.

selected to drop 5V when the meter current is 50 microamps and 10V when the meter is at full scale.

Diode D9 is connected to the voltage reference so that when its anode (a) voltage rises above 5V, it begins to conduct and shunt resistor R9 is connected in parallel with the meter. The effect of this is to give the meter a sensitivity of 0 to 50 microamps for the first half of its scale, and 50 to 500 microamps for the second half of its scale. This allows a wider range of resistance values to be displayed than otherwise possible without a very cramped scale.

METER PROTECTION

When the meter is at full scale, the voltage across the series combination of R10 and R11 is 10V. At the junction of R10 and R11 it is just under 5V.

If the meter is driven any harder, diode D10 conducts and injects current into the control circuit in such a way that the output voltage is reduced. This in turn reduces the meter current so that the meter can never be driven beyond a point slightly over full scale.

CONSTRUCTION

The circuit is built on a small single-sided printed circuit board (p.c.b.) which fits closely into the case specified. (This board is available from the *EPE PCB Service*, code 906.)

The kit (see *Shoptalk*) is supplied with a ready cut-out case, but constructors wishing to use their own hardware will find it useful to use the bare p.c.b. as a template to mark out the positions of the fixing holes and the centre of switch S1. It is also a good idea to fit S1 first so that all of the case cutting can be completed and checked without having to handle the fully assembled board. The cardboard inset with the meter is also very useful as a cutting guide for the large meter hole and its four fixings.

Follow the component layout shown in Fig.3 (and screen printed onto the p.c.b.) and insert the resistors and diodes. Make sure all the diodes are correctly polarised with their cathode marking bands as indicated, and be careful not to mix up diode D1 with the others.

Apart from C5 all of the capacitors can be fitted either way round. C5 has its negative pin identified by a white strip and small minus (–) signs. IC1 and IC2 need to be fitted directly to the board as there is no space for sockets. This is because the board lies in the bottom of the battery compartment.

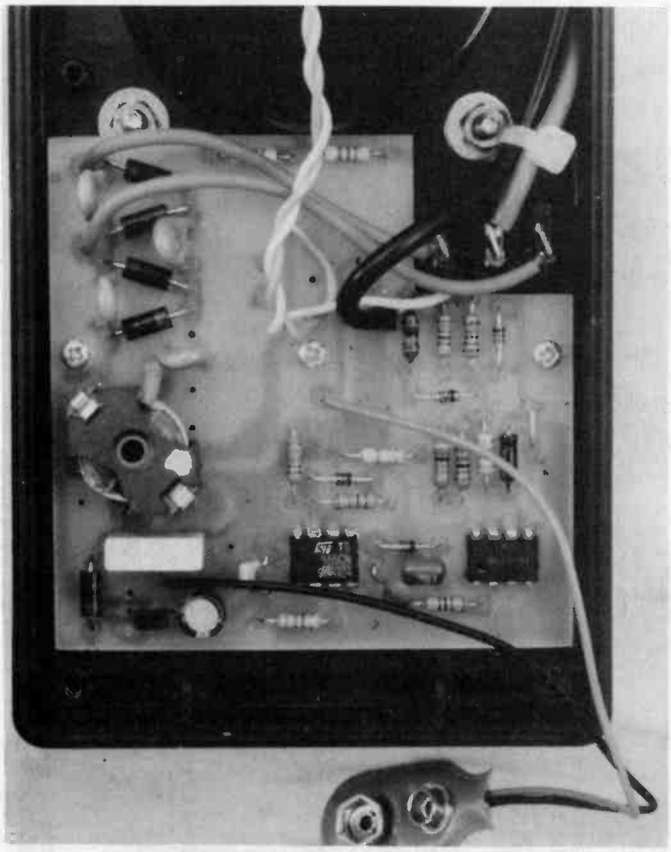
Transistor TR1 must be fitted the right way round with its slightly curved side as indicated. Resonant transformer L1 has a marker dot which should be nearest to the middle of the board.

The push-to-test switch S1 is fitted on the copper track side of the board. Make sure that it is pressed fully home with its alignment studs engaging with the holes provided.

Wire connections to the board are best made directly by passing the stripped ends of the wires through the board from the component side and soldering on the track side. Fit two wires 100mm long for the meter connections, and two 100mm long with thicker insulation for the output connections to switch S2. Fit the battery clip, and finally the lead from the negative probe.

The meter connections cannot be made using the normal screws if the specified case is used, because it is marginally too shallow. Instead the wires must be soldered directly to the sides of the two connecting posts.

This is easier if the surface is broken by filing, or even better if a small hacksaw is used to cut slots into which the wires can be pushed before soldering. Take care to protect the meter face (masking tape is very useful) and to keep filings from getting inside. The meter housing is made from a bakelite type of plastic and withstands soldering well.



The p.c.b. mounted on the rear of the case lid. Note that switch S1 is mounted on the copper side.

Fit the Voltage selector switch S2 into the case by pushing it through from the outside, and solder the positive probe lead to the centre tag. The 1000V and 500V wires from the board are made to the two outside tags.

Before fitting the board into the case it should be tested. Once operating correctly, fit the three mounting screws, and position a small piece of foam over the board to cushion it from the battery and prevent rattles. A small battery tray made from card gives a tidy finish. The leads for the probes are brought out of the end of the case through small "u-shaped" cutouts which should just be big enough to grip them.

METER

The meter scale must be changed. Fig.4 shows a full size reproduction of the correct scale which can be photocopied. Kit builders will be supplied with a photographically produced overlay.

In either case, it is necessary to remove the meter cover by taking out the two screws, and to remove the meter scale by taking out two more screws – carefully – without damaging the meter needle. The scale overlay should be cut to size and fitted in position on the original scale using a dry type adhesive such as "spray mount" or a lightweight double-sided tape (Pelican Roll-fix is ideal). Once correctly positioned, trim off any overlapping bits, and refit.

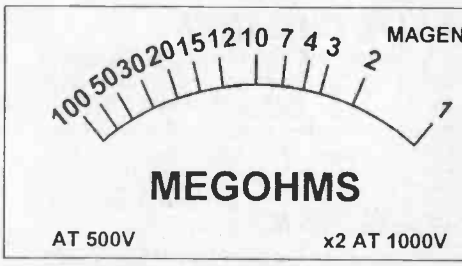


Fig. 4. Full size meter replacement scale.

COMPONENTS

Resistors

R1	22k
R2	470k 5%
R3	3k6
R4	120 5%
R5, R11	47k (2 off)
R6	15k
R7	10k
R8	220 5%
R9	11k
R10	51k
R12, R13	4M7 2% (2 off)

All 0·6W 1% carbon film, except where stated.

See SHOP TALK Page

Capacitors

C1	100n disc ceramic, 50V
C2	1n min. polyester, 2%
C3	10n ceramic plate
C4	2200p polypropylene, 1kV
C5	47µ radial elect. 10V
C6 to C9	4n7 ceramic disc, 1kV (4 off)

Semiconductors

D1	BZY88C 4·3V 400mW Zener diode, 5%
D2, D3, D9, D10	1N4148 diode (4 off)
D4 to D8	BY407A diode (5 off)
TR1	ZTX455 *npn* medium power transistor
IC1	LM358N dual op.amp
IC2	TS555CN CMOS timer

Miscellaneous

ME1	100µA 1k5 moving coil meter
L1	IT894 ferrite core transformer – see *Shoptalk*
S1	Push-to-make p.c.b. mounting switch, non latching
S2	Single-pole changeover rocker switch
B1	9V PP3 battery, with clips

Printed circuit board available from the *EPE PCB Service*, code 906; plastic case, size 80mm x 145mm x 35mm, with cutout see *Shoptalk*; probes and leads; connecting wire; piece of foam sponge; solder etc.

Approx cost guidance only **£33**

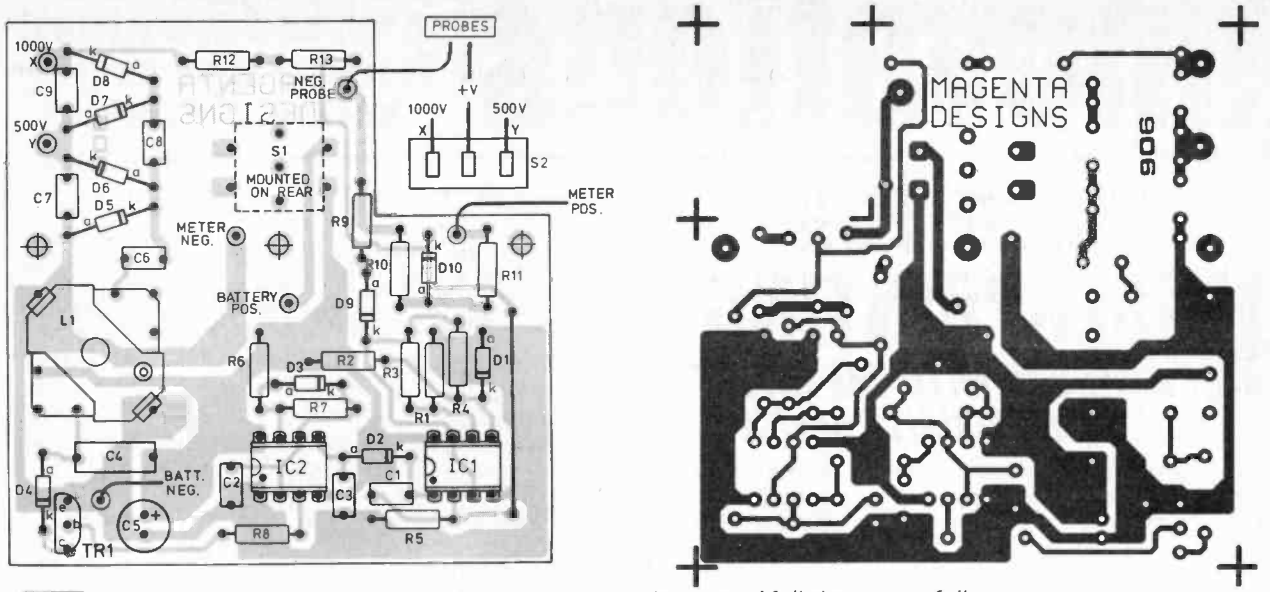


Fig. 3. Printed circuit board component layout and full size copper foil master.

TESTING

Before applying power check and double check everything. If there are any errors, it is odds on that they will be visible and pretty obvious once they have been found. Look especially for solder bridges, dry joints, and correct polarity of components.

Take care! The circuit produces only a small, safe, limited current, but it gives a nasty "nip".

If a current limited supply is available, set the limit to 100mA and gradually increase the voltage from 0V to 9V whilst pressing switch S1. If all is well the circuit will work, and a multimeter on the 500V output should rise and remain stable once the supply is above 7V or so. The current may be more than 100mA but something is wrong if it rises much above 150mA.

In the absence of a current limited supply, a PP3 battery with a 33 ohm resistor in series will provide a suitable supply and should not cause any damage if there are faults.

Check that the reference voltage is 5V, and that the voltage on the output of IC2 (pin 3) reads somewhere around 4V (It is actually pulsing very quickly between 0V and 9V, but a meter will simply read the average).

The output voltage should be close to the correct value, but can be trimmed if required by altering the value of resistor R5 very slightly. First make sure that the regulator is in its operating range by varying the supply voltage or load and checking that the output does not vary.

Resistor R5 can be altered by adding series or parallel resistance until exactly 500V and 1000V are produced but *do not* leave the R5 position open circuited or the full 1000V output will appear on IC3 pin 2! As an alternative a 100 kilohm preset can be fitted.

Once the output voltage is correct, check the meter by putting a range of known resistor values across the probes. A string of 10 megohms is useful for this, as it can be tapped at various intervals. The meter movement accuracy is 3 per cent, and the resistors 5 per cent so do not expect absolutely spot on readings.

Check that anything less than two Megohms simply stops the meter just over full scale, and that shorting the probes has a similar effect. Any insulation resistance of less than two Megohms represents a fault and so there is little point in reading such values.

The same meter scale is used for 500V and 1000V. It has been calibrated for 500V. Simply double the indicated reading when using 1000V.

OPERATION

The Insulation Tester is used in the same way as a multimeter on the Ohms scale. Take care though in circuits with capacitance which may be charged using the meter. These will usually be obvious as the needle will creep back as the capacitances charge up.

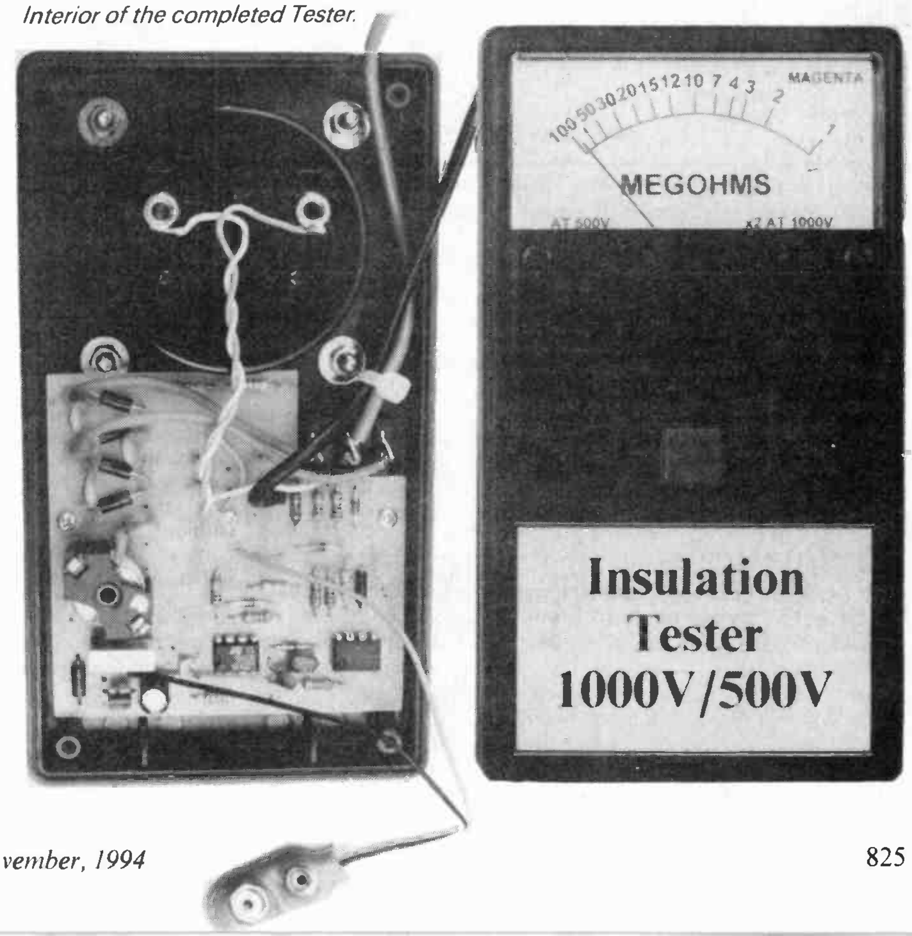
A discharge path does exist in the meter via resistors R12 and R13, so if the probes are held in position for a few seconds after S1 has been released the voltage will decay to a safe value. If circuits with capacitance are to be tested regularly, then reducing the values of R12 and R13 to 2M2 and R5 to 22k will halve the discharge time. The only penalty being an increase in battery current drain.

Domestic appliances are the most obvious items to test, especially "white goods" such as washing machines, cookers, and freezers. It is worth checking these regularly even if they appear sound, as increasing leakage can indicate dampness, or the beginning of insulation breakdown.

Take care when checking anything electronic. There is always a danger to sensitive circuits from high voltage discharges, and an insulation tester, by its nature, produces these. The tester is ideal for domestic wiring checks, and will quickly indicate potential problems especially in old wiring, or damp junction boxes.

Although the test voltage is high, the maximum current is limited to under one milliamp. This compares with sensitive RCCB trips which are designed to protect life and need 30 milliamps to operate. □

Interior of the completed Tester.



Innovations

A roundup of the latest Everyday News from the world of electronics

A CASE FOR FINGERPRINTING

KEEP IN-TOUCH WITH THE LATEST HIGH-TECH SECURITY DEVICE

ANYONE who's ever watched TV's top cops knows that fingerprints are about the surest form of personal identification around.

With that in mind, a Taiwanese professor, Wen Hsing Hsu, has invented Startek, FingerCheck, a fool-proof fingerprint device which can provide a unique high-tech security system. It is claimed, it can crack down on burglaries, do away with all those PIN numbers and keep sticky fingers out of your bank account.

The Startek fingerprint identification control system, which is now available in the UK, can be used wherever personal identification is needed to gain access into secure areas, such as computer rooms, banks, laboratories, private clubs, private garages and even at hole-in-the-wall cash machines.

The fingerprint verifier makes use of the unique and unchangeable characteristics of personal fingerprints to provide highly accurate identity verification. It works by comparing the live-scan fingerprint captured by the fingerprint reader with the one previously enrolled into the computer system. The whole verification process takes just three seconds!

The features of each live scan fingerprint are extracted into a minutia file for matching. By reducing the size of this file to only 256 bytes, database requirements are significantly reduced. The fingerprint template can easily be stored on card systems (e.g. smart cards, optical cards etc).

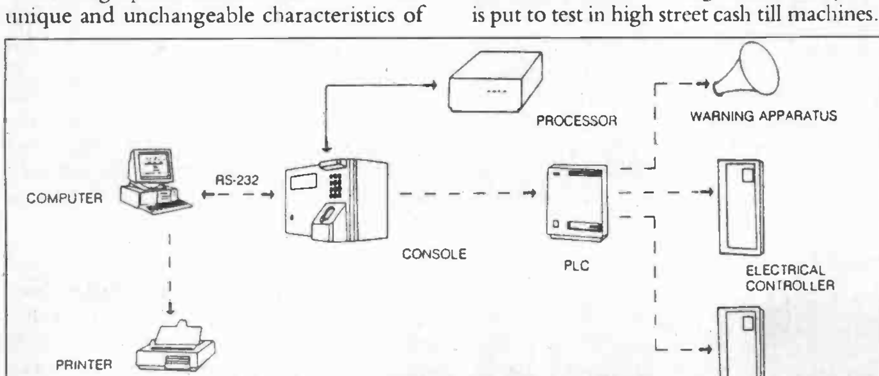
Applications

By integrating FingerCheck fingerprint verifier into computer or micro controller systems, it can serve in a variety of applications.

These include: Computer access or transaction control, computer database security control and physical access control by connecting it with control circuitry to activate door locks (stand-alone system). The stand-alone system can be connected to a computer network to perform other functions such as event recording and communications.

For law enforcement applications, the fingerprint verifier can work with card systems, such as smart cards and optical cards, to perform identity verification. It provides social welfare security by using cards such as ID card, drivers license, passport, credit card and so on.

The Startek device has already made its mark abroad and has been awarded the 1994 National Award of Excellence. According to Avalon Technology, the UK's sole distributor, it won't be long before the system is put to test in high street cash till machines.



P.S.–BASIC SYSTEM CONFIGURATION

To operate the system you put your card in the machine and put your fingerprint over a small scanning device that takes a "picture" of your fingerprint. Startek's screening software classifies your print patterns, immediately eliminating 90 per cent of the mismatches. The verification process takes no longer than it takes to check a PIN number now.

That's good news in order to thwart thieves who might steal your wallet and figure out your PIN number from a driver's license, birthdate, or telephone number (the most frequent PIN codes that people choose).

In the very near future, our fingers will definitely be doing the walking; we will be able to pay for our supermarket shopping, log into our computers and open doors by placing a finger on an accurate fingerprint verifier.

For more information contact: Startek Engineering Ltd. Dept EPE, 64 Sandback Road South, Alsager, Stoke-on-Trent, Staffs, ST7 2LP. Phone 0270 882 800.

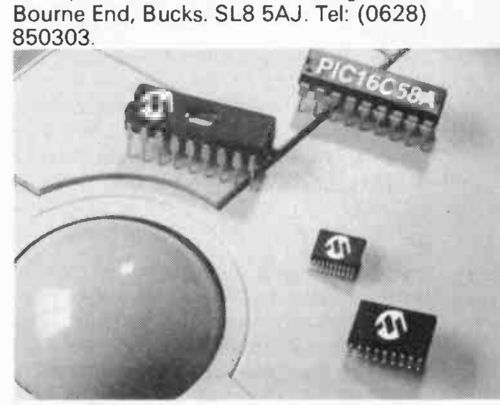
TAKE YOUR PIC

MICROCHIP'S new 8-bit EPROM-based microcontroller PIC16C58A is faster than any other in its class. With 2048 12-bit words of one-time programmable memory for program storage and 73 8-bit bytes of static RAM for data memory included on-chip, and up to 2-to-1 code compaction efficiency over non-RISC-based competitors, the new device provides one of the largest effective program storage capacities in the low-cost 8-bit microcontroller market.

All PIC16C5XA devices operate at up to 20MHz with 200ns instruction execution time. The PIC16C58A is the latest family member to be fabricated using the 0·9 micron dual layer metal process. Its on-chip peripherals include an 8-bit real-time clock/counter with programmable prescaler, oscillator, start-up timer, watchdog timer with R/C oscillator and 12 I/O lines with individual directional control. It also provides very low power consumption with 2.5 to 6.0 volt sources and a power down or sleep mode which substantially reduces current drain.

Microchip's new microcontrollers are supported by a complete range of Windows 3.X compatible application development and support tools, including an assembler, C compiler, software simulator, in-circuit emulator and programmer. The PIC16C58A is available in plastic DIP, SOIC and SSOP.

For further information contact: Arizona Microchip Technology Ltd., Unit 3, The Courtyard, Meadowbank, Furlong Road, Bourne End, Bucks. SL8 5AJ. Tel: (0628) 850303.



GROUND CONTROL

FOR the new digital *Inmarsat B* satellite system, ABB Nera in Norway has developed a digital terminal, Saturn BT, that is claimed to be ideally suited for use as a local fixed or semi-fixed telecommunication centre. It claims to provide regions with little or no infrastructure with opportunities for international telephone, telefax and data communication, at even a lower costs than before.

The *Inmarsat B* service, being digital, claims several advantages over *Inmarsat A*. It works faster and more reliably, providing noise-free high-quality voice and data communication. It also has much higher transmission capacity, which eliminates the congestion problems experienced in the A system.

The Saturn BT terminal is designed for fixed installations and consists of an antenna r.f. unit and a control unit that are connected by a single coaxial cable, which can be extended up to 100 metres. The system can be either d.c. or a.c. powered and is built to operate in the most adverse arctic and tropical weather conditions. Installation is simple and can be completed in five to ten minutes.

The unit is equipped with five extra telephone/fax outlets with separate numbers, in addition to hook-ups for modem, PC and a printer that will print out alarms, call logs, telex messages and broadcast messages. All operations are handled from keypads on a handset that is similar to that of a mobile phone.

Voice is digitally coded for transfer at 16Kbps, which provides noise-free speech. The telefax and data rates are 9600bps. Heavy data users could make additional large savings using a high-speed data option at 64,000 bps.

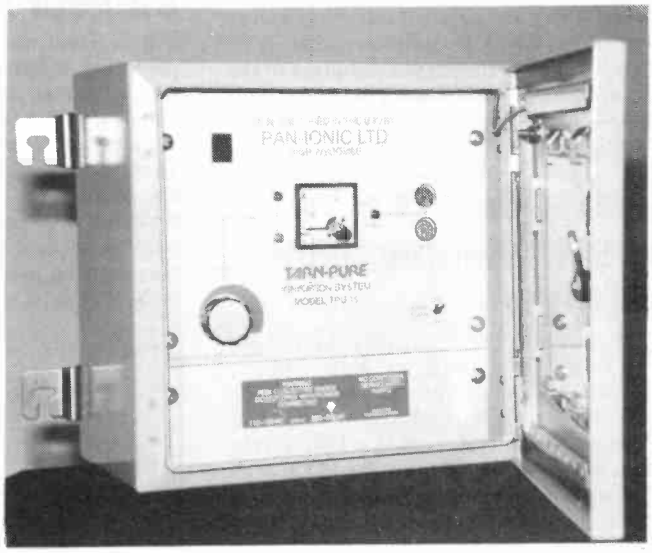
ELECTRONIC WATER PURIFICATION

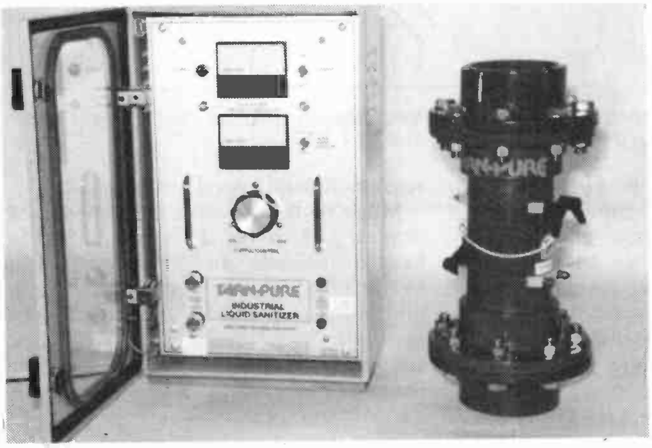
by Hazel Cavendish

ELECTRONICS have contributed to one of the most valuable discoveries in safeguarding public health in recent years. The ionisation of a nation's water supply has been found to destroy dangerous organisms, and guarantees that these can neither multiply nor reoccur providing the system is maintained.

Millions of pounds have been earned for Britain by the export of the Pan-Ionic Tarn Pure system, transforming the purity of water in many places around the world over the past 12 years.

Englishman John Hayes, who lives in High Wycombe, Bucks, confesses to having been "fanatical about electronics" since he was 12 years old and was aware that the principle of silver in solution acting as a biocide had been known for centuries. The Romans kept water in silver utensils to keep it fresh, and American pioneers travelling west put a silver dollar in their water bottles. Silver salts have been used medically as a disinfectant for many years, but it is comparatively recently that scientists have begun to understand the actions that take place in killing micro-organisms.

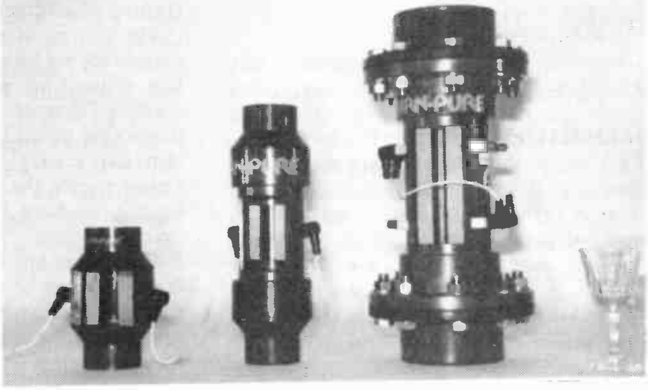




John Hayes formed a company called Pan-Ionic Tarn-Pure which has developed a purification process in which a minute stream of silver and copper ions are released by an electrode cell, powered by a solid state electronic control and monitoring system to permeate all areas of water circuits, including low usage outlets and "dead legs". The system has been developed, tested and installed worldwide over the last 12 years in some 12,000 sites. The treated water meets the criterion of wholesome (potable) water standards and is widely acknowledged to be the most effective "on line" means of controlling legionella and its harbouring biofilm without the necessity of chemical, pasteurisation, flushing and maintenance costs. Moreover it is environmentally friendly, imparts no odours or taste, and does not cause eye or skin irritants.

It is because modern electronics make it relatively simple to control the release of silver and copper into water that the disinfecting properties of ions in the solution have been made so effective. Metal ions are released in direct proportion to the current flowing between the electrodes, which are lethal to bacteria, viruses and algae, including legionella, listeria, salmonella, hepatitis, e.coli, coliform, pseudomonas etc., whilst having no ill effect on human beings. The silver level is maintained at no higher than 10 parts per million or 10 micrograms per litre, thereby falling within both EEC and EPA potable water standards.

Usefully, the Tarn Pure system is proving far more economical than other methods. Raising hot water temperatures for pasteurisation has wasted energy, and "blending valves" – introduced to prevent the danger of scalding when very hot water was deemed essential – are costly to fit and instal. Chlorinisation and the subsequent flushing of cold water tanks, pipework and outlets is disruptive and consumes valuable maintenance time, coupled with corrosion caused to both tanks and pipework.



New Technology Update

Ian Poole uncovers more messages about Hi-Tech display developments to meet new demands.

In view of the enormous demand for numerous varieties of displays, many companies are trying to develop new types that will fill gaps in the market. In fact in previous *New Technology Updates*, we have publicised a few display ideas which are surfacing from development laboratories.

Now news of another new display is beginning to surface. Called an Active Matrix Electroluminescent (a.m.e.l.) display, it has a number of advantages over other displays. It combines the lightweight and low-power consumption of the electroluminescent display with the very much higher definition of an active matrix display.

Active Matrix Electroluminescent Display

Prototypes of the display have been manufactured using a high voltage silicon-on-insulator or s.o.i. process. The circuit for each pixel consists of two transistors. One of these is a low voltage access transistor. The other is a high voltage one used as the final driver, and is an n-channel device and it is made using an *NDMOS* process.

The display operation cycle is split into two parts: a load period and a display period. During the load period the display is turned off and the logic level on the input data line is transferred through the access transistor onto the gate of the driver. Then, during the display period, the voltage level on the gate of the driver determines whether or not the pixel is illuminated.

Since the operation of the display is essentially digital and circuits are either fully on or fully off, the power dissipation in the circuit is very low. As the display is likely to be used in applications which include portable computers, power dissipation is important.

High Density

For the new display, a process was needed which could give a high pixel density, combined with an ability to withstand high voltages up to about 200V. To achieve this, the development team used thin film s.o.i. technology as the base. A high density CMOS process was used for much of the control and access circuitry. For the drivers, a high voltage DMOS process was employed. This allowed the electroluminescent material to be deposited on the top to complete the display.

Initial samples of the display have pixel sizes of around 24µm square, giving a final resolution of just over 1000 lines per inch. Although the display is currently in its prototype stages, it is expected that it should shortly be on line for manufacture. As such, it represents another development which will help to keep display technology up with current demands.

Outdoor Displays

It is never easy to produce large displays for applications such as railway station boards, or even for use outdoors. Often large and expensive arrays of l.e.d.s, or even incandescent bulbs are used. These function satisfactorily, but they are limited in their resolution and lack the flexibility of other displays. Where flexibility is needed, large liquid crystal displays can be used, but their cost is very high.

To overcome some of these problems, a Belgian company called Sunfire Europe has combined fibre-optic and piezoelectric technology in a new and interesting development. The manufacturers claim that they will ultimately be able to generate high brightness and definition levels which so far have been very difficult to achieve.

In essence, the system uses the piezoelectric effect to operate shutters which open and close over fibre-optic cables, turning small pixels of light on and off.

The display is split into modules each measuring 175mm square. Each module has a total of 900 fibres in a 30 × 30 matrix. These are illuminated by a newly developed metal halide lamp whose light is passed through an optical splitter. The optics enable the fibres to be illuminated equally or have the light split into red, green and blue.

The fibres are used to bring the light from the back of the module to the front where the shutters are located. There is one shutter for each fibre enabling its light to be turned on or off.

The shutter consists of two films of piezo-electric material glued together with an epoxy resin to form a structure which is similar to a bi-metallic strip – see Fig. 1. The strip is set up so that the application of a voltage causes one of the piezo-electric strips to expand and the other to contract. In this way it can be made to rise or fall, covering or uncovering the end of the optical fibre.

On Screen

As there is comparatively little mass to the shutter and the movement needed is only 2mm, it can respond in about 3ms. This makes it fast enough to operate as a video display making large outdoor television screens a possiblity.

To make up a complete display many modules are needed. The individual pixels are made up to suit a screen size of around 12 metres square. This gives sufficient resolution to give good picture quality.

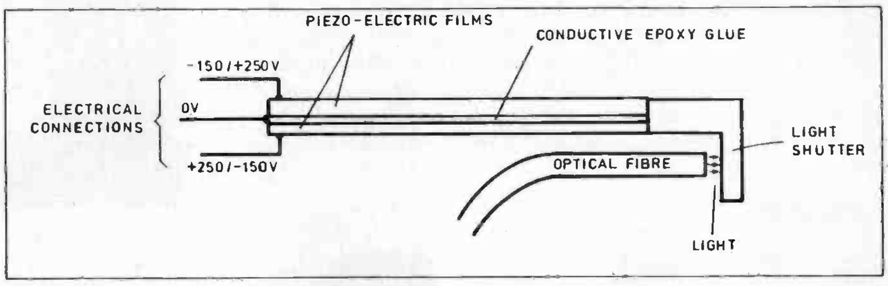


Fig. 1. Basic mechanism for the fibre optic/piezoelectric display. Split into 175mm square modules, each has a total of 900 fibres in a 30 × 30 matrix.

Much of the logic which controls the display and drives the shutters can be located remotely and the signals sent to the display over a wide-band telephone link (e.g. ISDN). By adopting this approach it is much easier to set up temporary displays. Even for more permanent installations this may prove to be a convenient solution.

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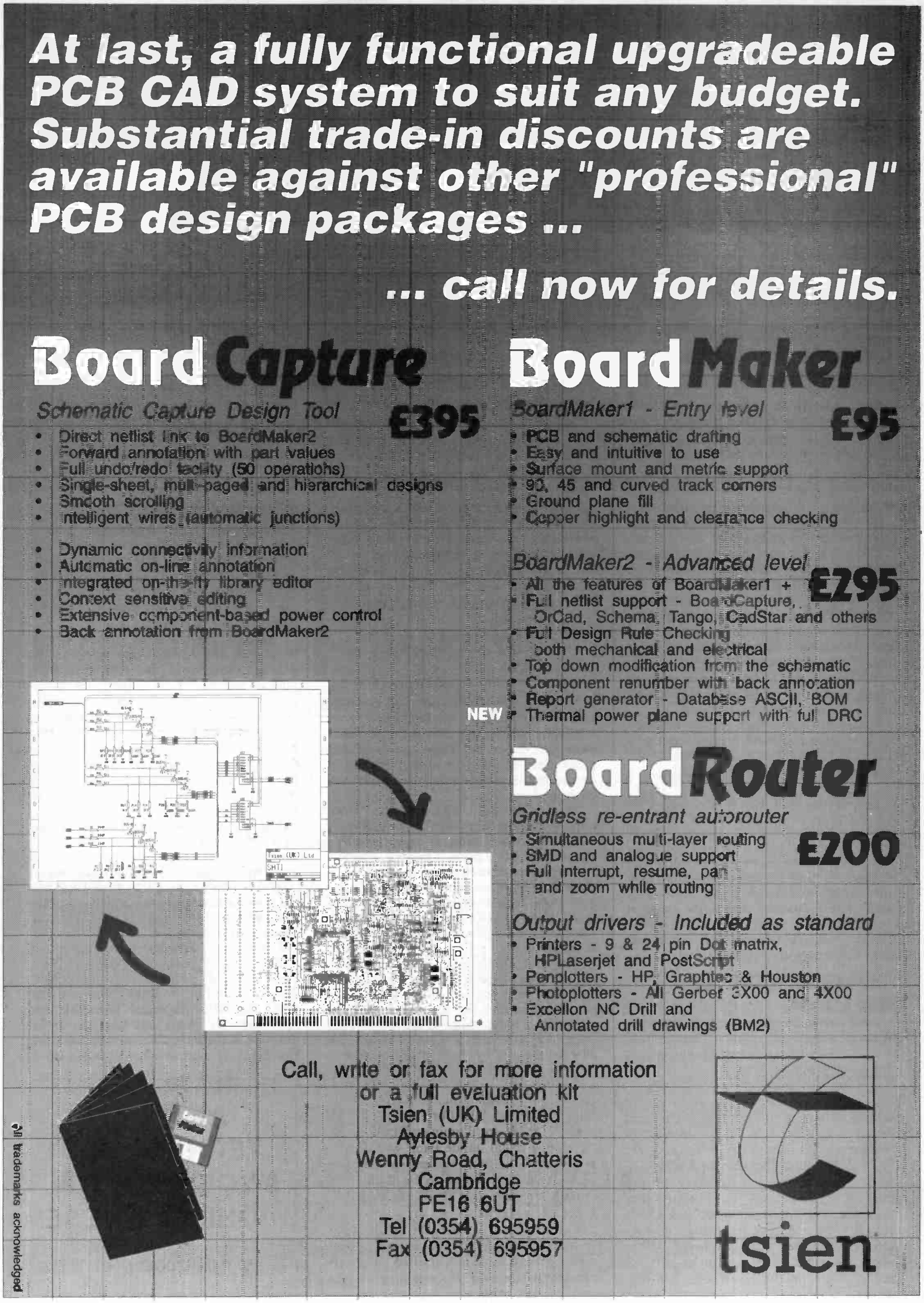
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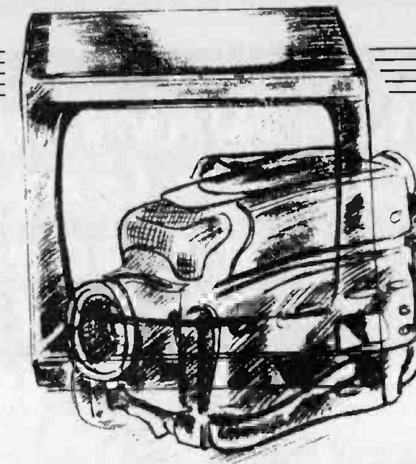
Constructional Project



VIDEO MODULES

ROBERT PENFOLD — Part One

Your home videos will take on a whole new meaning if you build these low cost modules. Professional presentations couldn't be easier! You can tailor the controller to meet your own special needs and budget.

- *Simple and Improved Faders* • *Horizontal and Vertical Wipers*
- *Video Enhancer* • *4-Channel Audio Mixer*
- *Audio Dynamic Noise Limiter* • *System PSU*

THE RISE in popularity of camcorders and home video productions over the past few years has been phenomenal. Camcorders are now standard consumer items which are available in every high street, and at surprisingly low prices.

Most users probably do not bother with editing of their tapes, but a tape of recorded highlights is much more watchable than one which simply includes all the recorded material. In fact a good video production is generally reckoned to be produced by using about 10 per cent of the recorded footage, and discarding the other 90 per cent.

With most camcorders and an ordinary video recorder it is possible to put together a tape which comprises the best bits of the source tape or tapes. This is basically just a matter of selecting the sections to be included in the final production, and then copying them from the camcorder using the normal video recorder.

With the right camcorder and video recorder this can be accomplished quite well without the need for any accessories other than suitable connecting leads. With practically any camcorder and video recorder combination it is possible to achieve the required editing, but results will not necessarily be particularly polished.

MAGNIFICENT SEVEN

Most video editing is easier if a few accessories are added to the system. Devices such as faders and wipers to process the video signal, and a mixer in the audio signal path, permit much more professional results to be obtained. In this series of articles seven video modules are covered, as follows:

Simple Video Fader – Improved Video Fader
Horizontal Wiper – Vertical Wiper
Video Enhancer
Four-Channel Audio Mixer (microphone plus three high level inputs)
Audio Dynamic Noise Limiter (D.N.L.)

Adopting a modular approach makes it easy for each constructor to build a video controller which only provides the functions that he or she really needs. There is actually an eighth module, which is a simple mains power supply unit for the other modules.

Mains operation represents the most economic means of powering the modules, but battery operation is also possible. However, a 12V supply is needed, and the current consumption of a typical video controller based on these modules will be quite high. A fairly high capacity battery is therefore needed (e.g. eight HP7 size cells in a holder), and the running costs are likely to be quite high.

Note that all the video processing modules are designed to operate with a standard PAL composite video signal at 75 ohms impedance. They are not designed to operate with a u.h.f. signal, and will not work at all when used with such a signal. Neither can they be used with any form of RGB signal.

SIMPLE FADER

These days most camcorders have a built-in video fader, but a few models still lack this facility, and it is certainly absent on many older units. Even where a camcorder does have this facility, many prefer to use an external unit that gives full manual control of the "fade-out".

The basic idea of using a fader is that it enables the end of one scene to be gradually faded out, and then the beginning of the next scene is faded up. Compared to the usual alternative of simply cutting straight from one scene to the next, this gives a smooth transition from scene to scene. This more gentle approach is more appropriate to many types of video production, and is certainly an option which most video editors would like to have available to them.

Although a video fader is the video equivalent to a volume control in audio equipment, it is rather more complex than a volume control. A PAL video signal consists of two main parts. First there are the synchronisation signals which are negative pulses and then there is the luminance signal, which is positive.

There are actually two types of synchronisation pulse, the frame type (also know as "field" pulses) and the line pulses. The frame pulses are longer than the line type, and their respective durations are approximately 160µs and 5µs. The pulse duration is the only difference between the two types of synchronisation pulse. In a

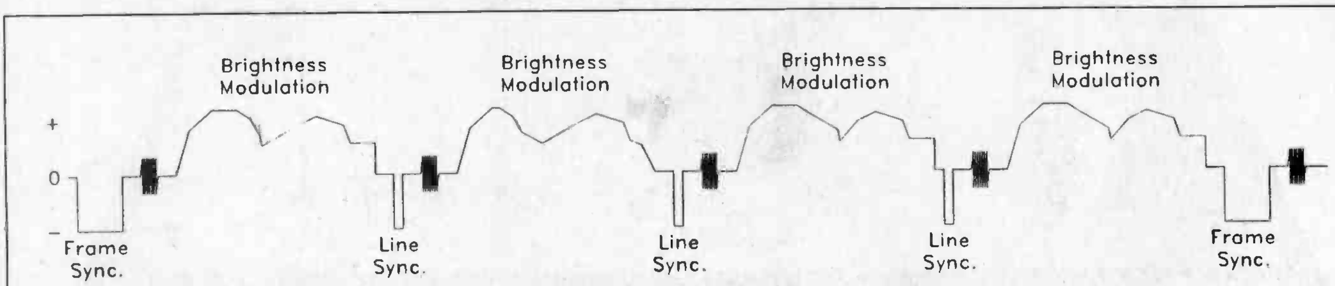
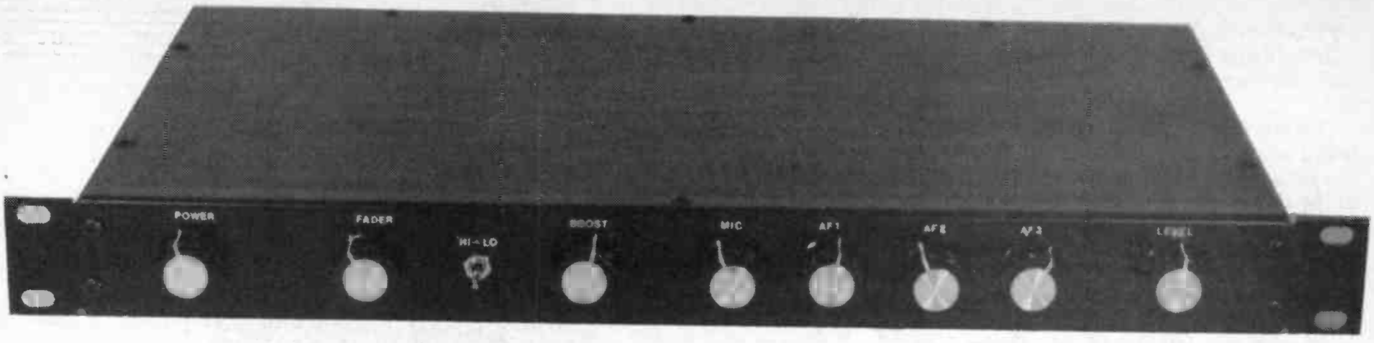


Fig. 1. A simplified version of a composite video signal.



Front panel layout and lettering on the slim-line case.

standard 75 ohm composite signal they both have an amplitude of about −0·5V.

The frame pulses are at a frequency of 50Hz, but a system of interlacing is used. This means that during each frame only every other line of the picture is scanned, and two complete scans are needed to produce one complete picture.

Although there are 50 frames per second, there are only 25 complete pictures each second. Interlacing is used in order to reduce picture flicker. There are 625 lines per complete picture, which gives a line synchronisation frequency of 15·625kHz.

ILLUMINATING

The luminance signal (i.e. the black and white picture information) is a positive signal which is between about 0V and +2V. The British PAL system uses a positive luminance signal, so white areas produce a signal at about +2V, and black areas produce a signal at around 0V.

The basic arrangement used for a composite PAL signal is shown in Fig. 1. This is a slightly simplified version of a composite PAL signal incidentally. A real PAL signal includes colour information.

It is only the luminance signal that must be attenuated by a video fader. The synchronisation signal must be left intact. Simply attenuating both signals would result in synchronisation being lost long before the luminance signal was properly faded out.

The most simple method of fading the signal is to use some form of adjustable clipping circuit. Normally the positive clipping level is set just high enough to ensure that the luminance signal can pass unaffected. To fade the signal the clipping level is gradually reduced. This results in the positive peaks of the signal being more and more heavily clipped, until the luminance signal is eventually removed altogether.

The type of fade-out this produces is not quite the same as that obtained by reducing the brightness control of a television set or monitor. The whole signal is not being attenuated as the fader control is operated.

First the brightest parts of the picture are affected, then those at intermediate levels of brightness, and finally the darker areas of the picture. Also, the colours in the well faded picture seem to be rather oversaturated. However, the fade-out effect is still quite acceptable, and should satisfy all but the most demanding of home video enthusiasts. The alternative methods are all much more complex.

CIRCUIT OPERATION

The circuit diagram shown in Fig. 2. is for the Simple Video Fader unit. This variable clipping circuit is a simple diode type based on D1 and D2.

The clipping level is controlled by the bias voltage fed to diode D1 via resistor R3. This voltage is provided by the potential divided circuit comprised of R1 and VR1 to VR3. Potentiometer VR2 is the Fader control. Presets VR1 and VR3 are adjusted to give a good control range from VR2.

Transistor TR1 is used as an emitter follower buffer stage at the output of the circuit. The circuit has a current consumption of approximately 10mA, which is mainly the current drawn by the output stage.

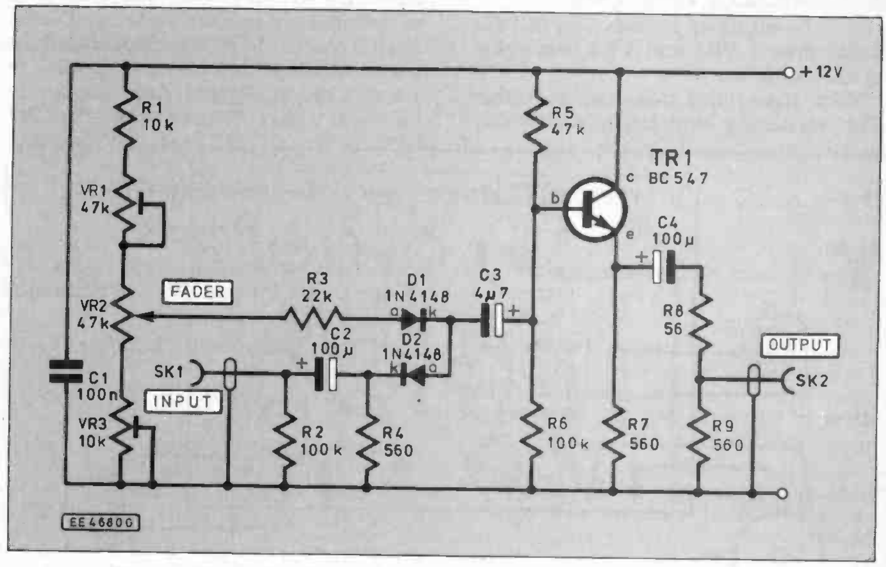
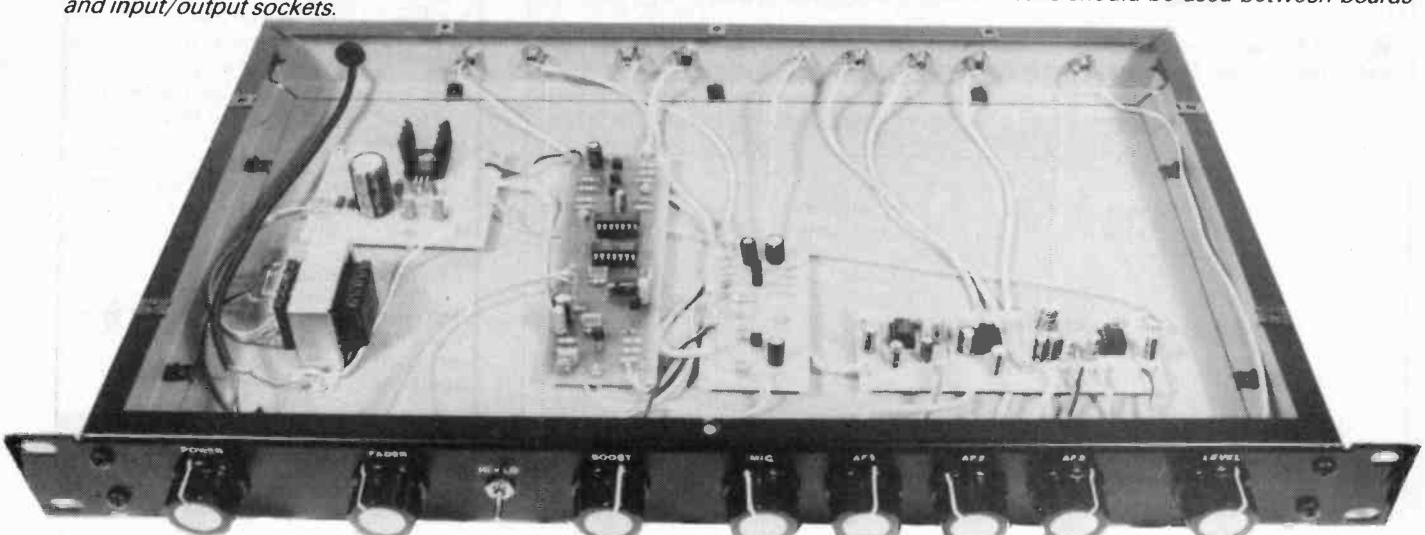


Fig. 2. Circuit diagram for the Simple Video Fader.

CONSTRUCTION

Details of the printed circuit board topside component layout and full size un-

Top removed from the case showing the general layout of modules. Note that screened leads should be used between boards and input/output sockets.

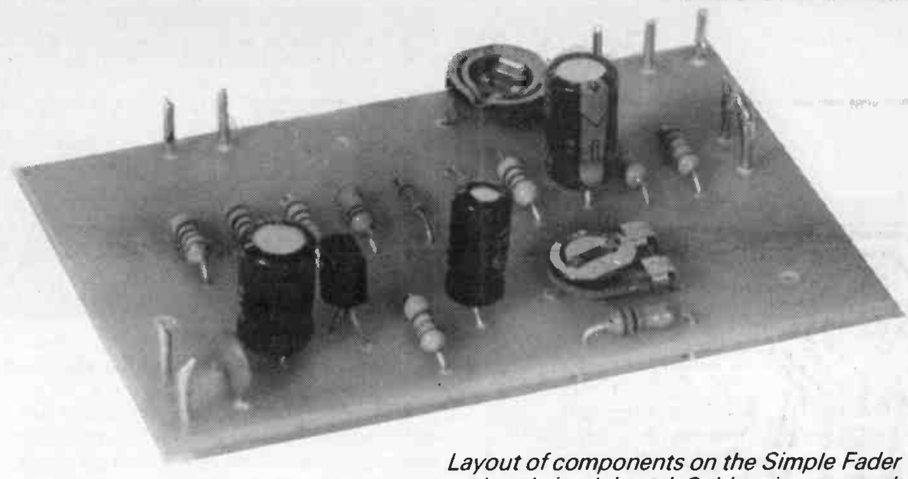


derside copper foil master for the Simple Fader are provided in Fig. 3. This board is available from the *EPE PCB Service*, code 910.

This is a very simple and straightforward board to construct and should not provide any real difficulties. However, be careful to fit the three electrolytic capacitors and the two diodes with the right polarity.

Presets VR1 and VR2 must be miniature horizontal mounting types if they are to fit onto the board properly. Fit single-sided solder pins to the board at the supply inputs and the points where connections to off-board components will be made.

The small amount of hard wiring is also shown in Fig. 3. There is no need to use screened leads to carry the connections from sockets SK1 and SK2 to the board, but these leads should be no longer than is really necessary.



Layout of components on the Simple Fader printed circuit board. Solder pins are used for all lead-off wires.

ADJUSTMENT

Start the setting-up procedure by first adjusting presets VR1 and VR3 to roughly middle settings.

When testing this unit, and the other video processing modules, it is probably best to connect the output of the camcorder to the input of a monitor via the unit under test. Of course, the monitor can actually be a television set driven via its A/V socket, or via a u.h.f. modulator. Any monitor or television that is compatible with the composite output signal of the camcorder is suitable.

The camcorder can be used to play back a tape, or it can simply be used as a camera. The only requirement is that it should provide a reasonable test signal (i.e. the signal should be a fairly high contrast type).

Adjusting the Fader control VR2, at this stage, should permit the picture to be faded up and down, but not necessarily from black to full brightness. With VR2 fully backed-off, set preset VR3 for the deepest fade that can be achieved. The setting of VR1 is less critical, and it can be given any setting that permits full brightness to be obtained.

For best results it should be given the highest resistance that permits full brightness to be obtained. VR2 should then have a good control characteristic which is free from a large "dead" area at the high brightness end of the range.

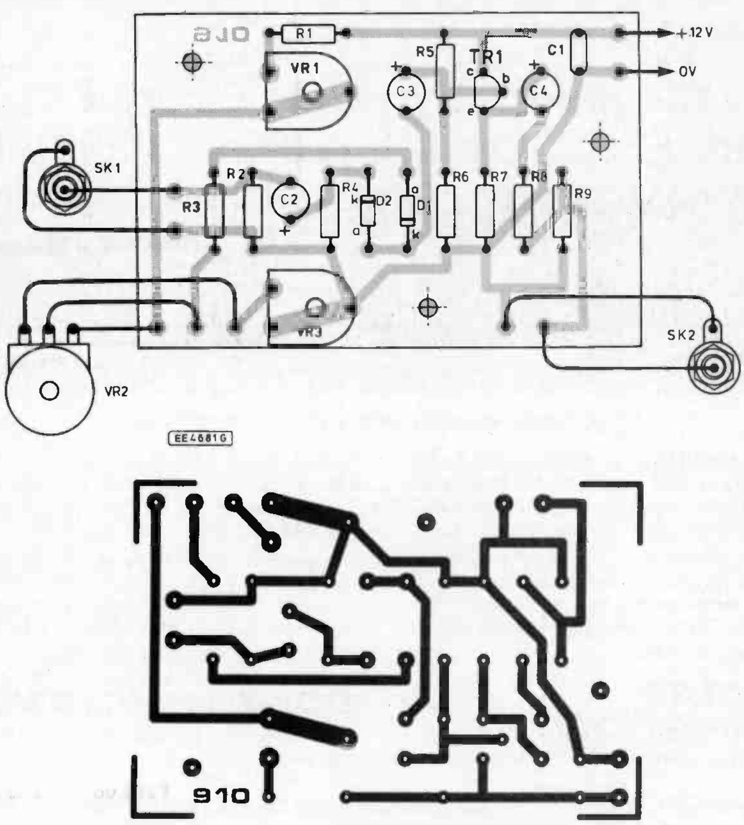
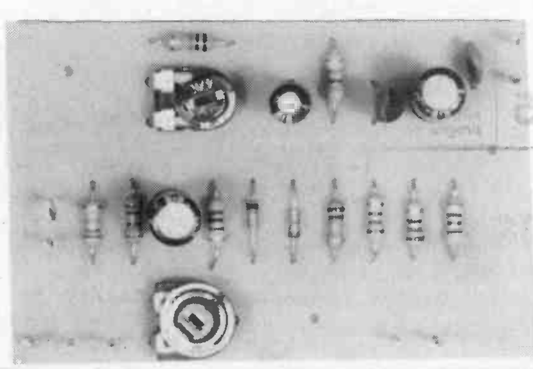


Fig. 3. Printed circuit board component layout and full size copper foil master for the Simple Fader. The completed board is shown below.



COMPONENTS

SIMPLE VIDEO FADER

Resistors

R1	10k
R2, R6	100k (2 off)
R3	22k
R4, R7, R9	560 (3 off)
R5	47k
R8	56

All 0·25W 5% carbon film

See SHOP TALK Page

Potentiometers

VR1	47k min. preset, horizontal
VR2	47k rotary carbon, linear
VR3	10k min. preset, horizontal

Capacitors

C1	100n ceramic
C2, C4	100μ radial elect. 10V (2 off)
C3	4μ7 radial elect. 63V

Semiconductors

D1, D2	1N4148 signal diode (2 off)
TR1	BC547 *npn* silicon transistor

Miscellaneous

SK1, SK2 Phono socket (2 off)

Printed circuit board available from the *EPE PCB Service*, code 910; control knob; connecting wire; solder pins; solder etc.

Approx cost guidance only **£8**

IMPROVED VIDEO FADER

"Sparkling" fade-ins and outs for video pictures.

A FADER which gives an effect like a brightness control of a television set has to be very much more complex than a fader which works using the variable clipping principle. After trying a number of different approaches to the problem, only one method was found to give satisfactory results. The block diagram of Fig. 4 shows the basic scheme of things used in this improved fader.

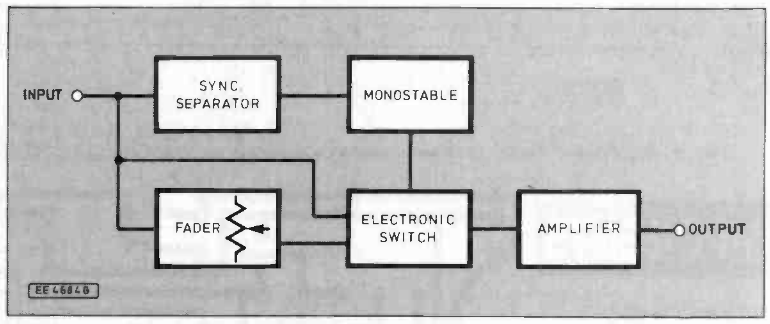


Fig. 4. Block diagram for the Improved Video Fader.

HOW IT WORKS

The input signal is applied to a synchronisation separator circuit, and in this case it is the line synchronisation pulses that are of interest. These are used to trigger a monostable that provides a short output pulse. The pulse duration is about 12µs.

The monostable controls an electronic changeover switch. Both inputs of the switch are fed with the composite input signal, but one input is fed with the raw signal, while the other is fed via a fader potentiometer. The output of the switch is fed to the output of the unit via a buffer amplifier.

At the beginning of each line the monostable is triggered, and it sets the electronic switch to couple the raw input signal through to the output. This results in the line synchronisation pulse being fed through to the output. The signal immediately after the line pulses is also let through, and this includes the burst signal.

However, once this initial part of the signal has been completed, the monostable pulse ends, and the faded signal is fed through to the output. The luminance signal is therefore fed through to the output via the Fader potentiometer.

The input signal is therefore processed on a line-by-line basis, with the synchronisation and burst signals being allowed through to the output unaltered, and the luminance signal being attenuated (rather than just clipped) by the desired amount. This gives an excellent fade-out characteristic.

CIRCUIT DESCRIPTION

Refer to Fig. 5 for the Improved Video Fader circuit diagram. The synchronisation separator is a simple two transistor circuit based on TR1 and TR2.

Transistor TR1 acts as an amplifier and inverter, which feeds into a single stage high-pass filter. TR2 acts as a pulse shaper and inverter which provides a low output level during each line synchronisation pulse.

A CMOS 4047BE astable/monostable, IC1, is used here as a negative edge triggered monostable, and it is therefore triggered at the beginning of each line synchronisation pulse. Capacitor C4 and resistor R8 are the timing components, and these set the output pulse duration at just under 12µs (2·48 C4 R8 seconds).

The electronic switch is not actually a true changeover type. It is two of the four analogue switches in a CMOS 4016BE connected to give a changeover action.

The switches are simple on/off types, but when connected as shown here they will provide a changeover action provided they are fed with anti-phase control signals. Then, when one switch is turned on and couples its signal through to the output, the other will be switched off and block its input signal. There is no need to generate anti-phase control signals, since the 4047BE provides these at its Q and $\overline{Q}$ outputs.

A raw input signal is fed to IC2a and IC2b

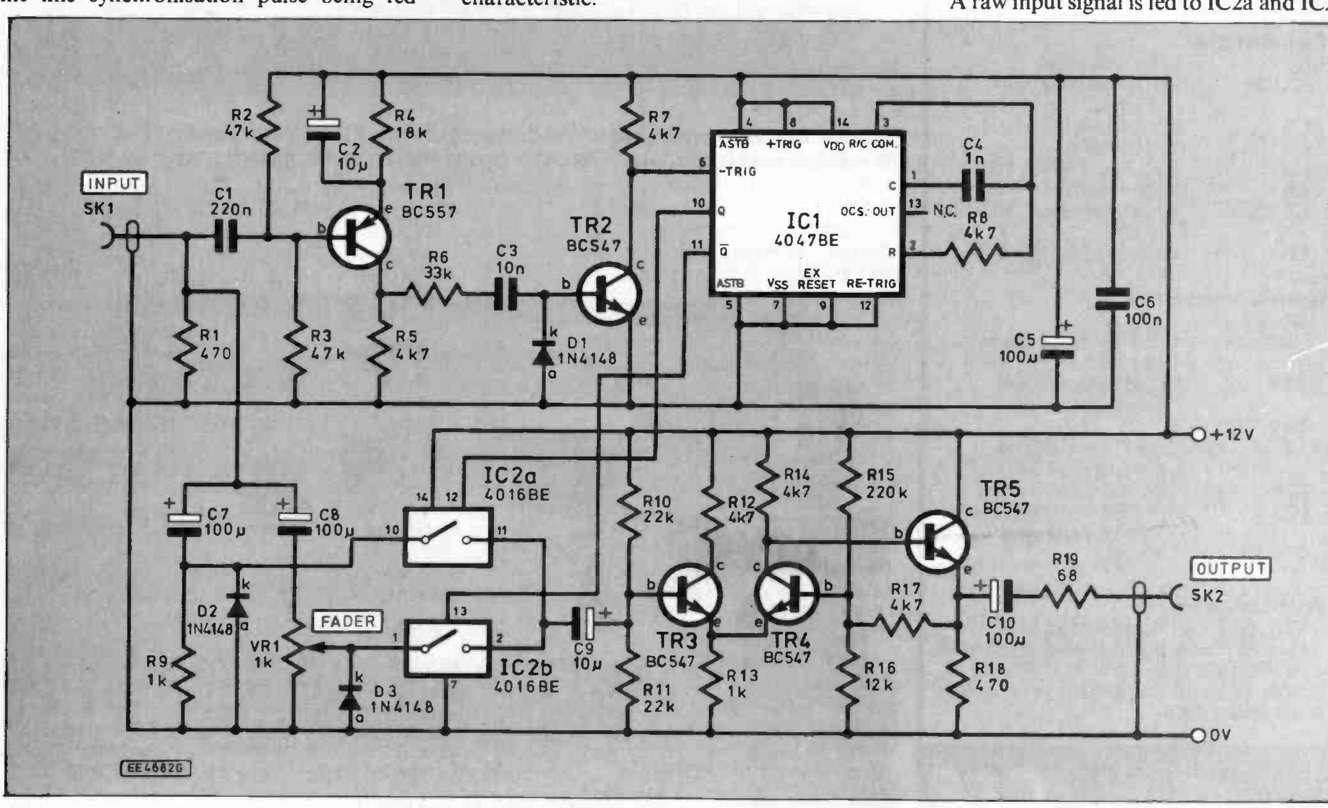


Fig. 5. Complete circuit diagram for the Improved Video Fader.

IMPROVED VIDEO FADER

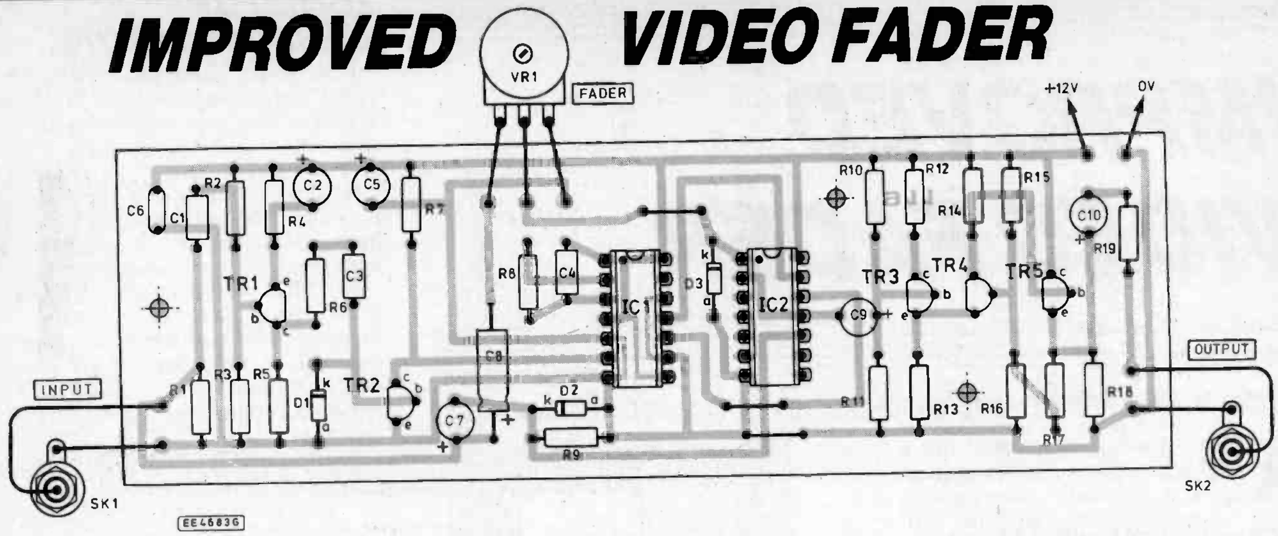
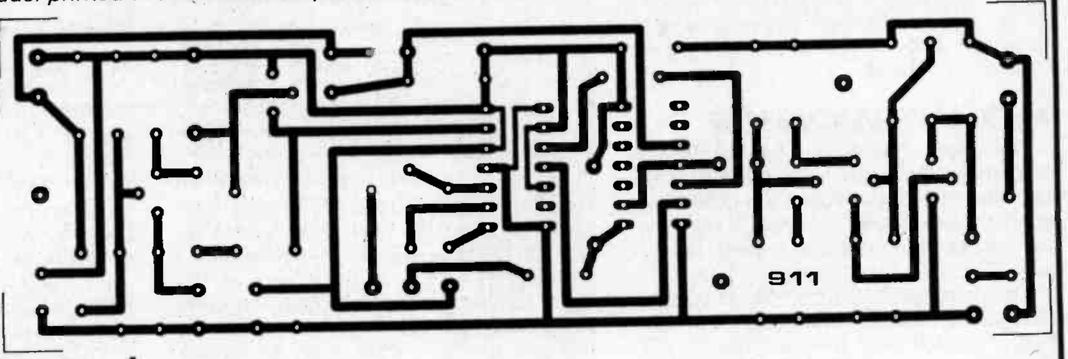


Fig. 6. Improved Fader printed circuit board component layout and (below) full size copper foil master pattern.



COMPONENTS

IMPROVED FADER

Resistors

R1, R18	470 (2 off)
R2, R3	47k (2 off)
R4	18k
R5, R7, R8, R12, R14, R17	4k7 (6 off)
R6	33k
R9, R13	1k (2 off)
R10, R11	22k (2 off)
R15	220k
R16	12k
R19	68

All 0·25W 5% carbon film

See SHOP TALK Page

Potentiometer

VR1	1k rotary carbon, linear

Capacitors

C1	220n polyester
C2, C9	10µ radial elect. 25V (2 off)
C3	10n polyester
C4	1n polyester
C5	100µ radial elect. 16V
C6	100n ceramic
C7, C10	100µ radial elect. 10V (2 off)
C8	100µ axial elect. 10V

Semiconductors

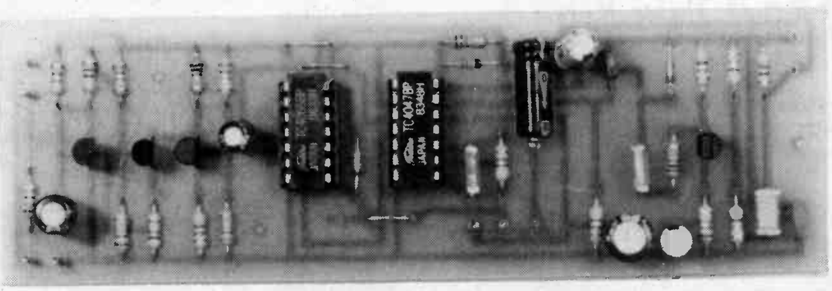
D1, D2, D3	1N4148 signal diode (3 off)
TR1	BC557 *pnp* silicon transistor
TR2, TR3, TR4, TR5	BC547 *npn* silicon transistor (4 off)
IC1	4047BE CMOS timer
IC2	4016BE or 4066BE CMOS analogue switch

Miscellaneous

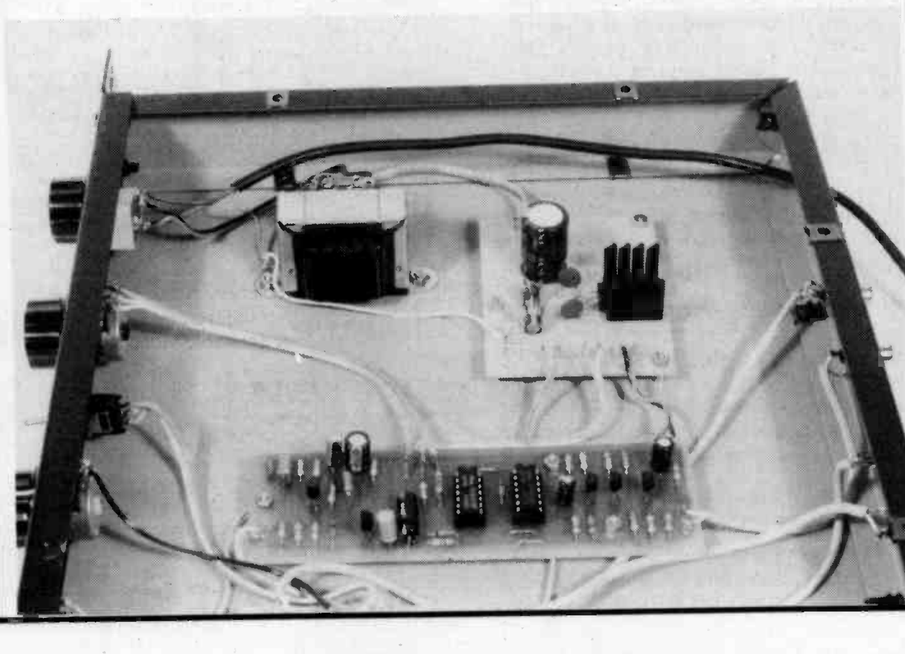
SK1, SK2 Phono socket (2 off)

Printed circuit board available from the *EPE PCB Service,* code 911; 14-pin i.c. holder (2 off); connecting wire; solder pins; solder etc.

Approx cost guidance only **£12**



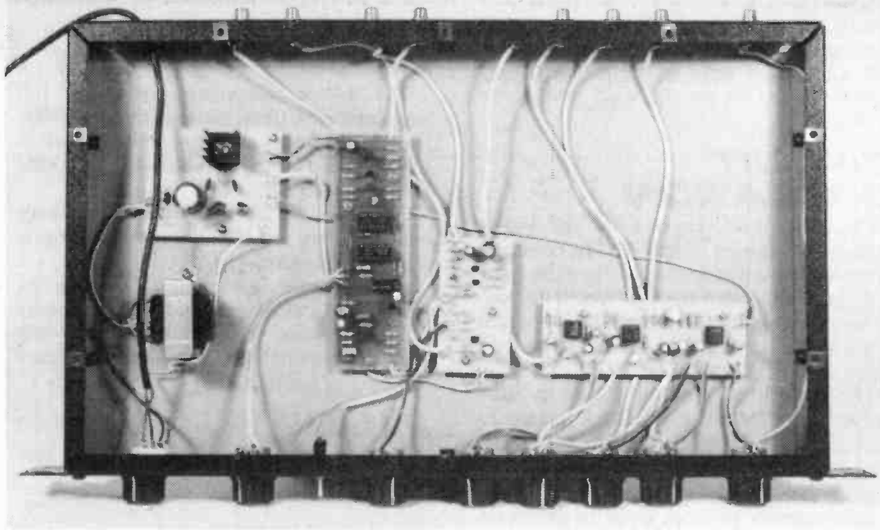
(Above) Component layout of the completed circuit board and below positioning of the module inside the case. The other board shown is the system power supply.



is fed from the input via the Fader potentiometer (VR1). D2 and D3 are d.c. restoration diodes which avoid any tendency for a significant d.c. offset voltage to build up between the faded and non-faded signals.

A PAL composite video signal has a bandwidth of a few megahertz. Frequencies as high as this tend to find their way around potentiometers due to stray capacitance, etc. In order to minimise this problem VR1 has been given a low value of one kilohm (1k). A higher value should not be used as this is the lowest value that will give good results.

Transistors TR3 to TR5 form a buffer amplifier which provides the circuit with suitable output characteristics. TR3 and TR4 operate as a so-called "long-tailed pair", and TR5 is an emitter follower stage. The current consumption of the circuit is a little under 25mA, and it is the output amplifier which accounts for the majority of the current drain.



Layout of modules inside the controller case showing (left to right) power supply, fader, enhancer and audio mixer.

CONSTRUCTION

Details of the printed circuit board component layout and underside copper foil master pattern for the improved Video Fader are shown in Fig. 6. This board is obtainable from the *EPE PCB Service*, code 911.

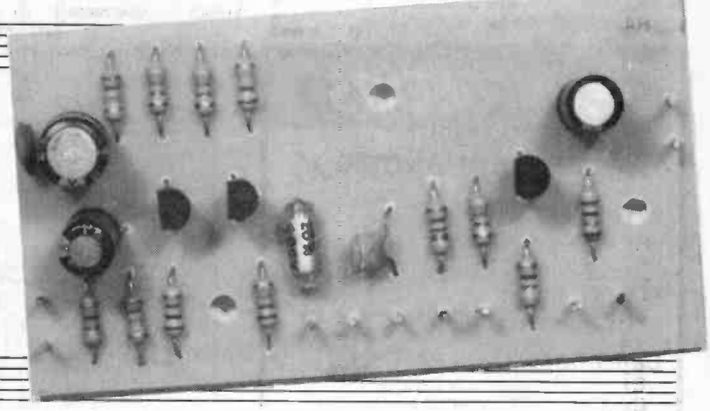
Construction of the board follows conventional lines, but remember that both the integrated circuits are CMOS types, and that they therefore require the standard anti-static handling precautions. Be careful to fit the diodes with the right polarity, and do not overlook the three link-wires.

The small amount of hard wiring (between the off-board components and the p.c.b.) is also shown in Fig. 6. The only point to note here is that the wiring to VR1 should be reasonably short. The shorter this wiring, the smaller the stray capacitance in the wiring, and the flatter the frequency response that will be produced for the faded luminance signal.

TESTING

Testing the unit is just a matter of wiring it between a camcorder and a monitor, and then checking that the Fader control VR1 provides the correct fader action. It is possible (but unlikely) that a narrow band down the extreme left hand side of the picture will not be faded; reducing resistor R8 to 4k3 should cure the problem.

VIDEO ENHANCER



Boost picture definition with this simple module

MODERN video recorders and camcorders have quite high levels of performance, and are certainly a great improvement on the models produced some years ago. Picture stability in particular, is much improved these days. Due to improvements in the tape formulations, the video heads and the electronics, noise performance is also much improved.

The one respect in which little has changed, is the video bandwidth. Hi-band camcorders and video recorders having wider bandwidths and higher definition pictures are produced, but they remain relatively expensive.

A Video Enhancer (also known as a "crispener") is a device which gives high frequency boost to the video signal. This does not really produce a significant increase in the bandwidth of the signal, but the boost in the response at the highest frequencies produces higher contrast in any fine detail.

This gives an apparent improvement in the picture definition, and a sharper looking picture. This is really just an illusion, and a close inspection of the screen will reveal what is really happening. Of course, the screen is normally viewed at a great enough distance to preserve the illusion.

Opinions vary regarding the best way to use a Video Enhancer. Some advocate using an enhancer when making an initial copy of a tape. Others prefer to use an enhancer only when playing back a tape. It is probably best to experiment a little to determine which method of operation you find the most acceptable.

It is not a good idea to use an enhancer when making a copy of a tape, and to then use it again when playing back the tape or making a further copy. This double enhancement would almost certainly produce an excessive peak in the frequency response that would give an unusable video signal.

SYSTEM OPERATION

A Video Enhancer can operate by simply applying a constant amount of high frequency boost, or by applying the boost dynamically. With the dynamic approach the signal is left unprocessed at low luminance levels, but high frequency boost is applied at middle and high levels.

This is achieved using a circuit which uses clipping, frequency response tailoring, and a phase cancelling process. This is something which is easily achieved at audio frequencies, but it is more difficult with the much wider bandwidth of a video signal. Getting the finished unit set up correctly can be quite involved.

Experiments showed that a simple enhancer having a preset amount of high frequency boost can give quite good results. The circuit can be very simple indeed, and no setting up is required once the unit has been built.

The final design featured here is a Video Enhancer which does not use dynamic filtering, but it does permit good control over the boost characteristic. This enables the response to be tailored to suit the signal source in use, and to suit individual tastes. Although the high frequency boost is applied to both the luminance and synchronisation parts of the signal, the amount of boost used is too low to significantly degrade the synchronisation pulses.

This enhancer will work well with most video sources, but it cannot be recommended for use with a source that has a poor signal-to-noise ratio. Using any good quality modern tape on a correctly adjusted recorder should give good noise performance, but the unit might not work well when used with old recordings, poor quality tapes, or an old and well worn recorder.

CIRCUIT OPERATION

The full circuit diagram for the Video Enhancer is shown in Fig. 7. The circuit is basically just an amplifier of the type used in some of the video circuits described previously. Transistors TR1 and TR2 operate as a long-tailed pair, and TR3 is an emitter follower buffer stage.

The voltage gain of the circuit is controlled by a negative feedback network. Resistor R10 is one arm of the feedback. The other arm is mainly comprised of the parallel resistance of R7 and R8.

This feedback network gives the circuit an overall voltage gain of approximately unity. However, at high frequencies the impedance of capacitor C4 is quite low, and some of the feedback is decoupled. This gives the required high frequency boost, with resistor R9 limiting the boost at very high frequencies to an acceptable level. Boost control VR1 can be used to further reduce the high frequency boost if desired.

The "Hi/Lo" switch S1 can be used to switch capacitor C5 into circuit in place of C4. As C5 has a value which is higher than that of C4, it starts to apply the boost at a lower frequency. This gives a stronger enhancement effect, but as before, VR1 can be used to reduce the amount of boost.

COMPONENTS

VIDEO ENHANCER

Resistors

R1, R11	470 (2 off)
R2, R3	22k (2 off)
R4, R6, R10	4k7 (3 off)
R5	1k
R7	120k
R8	12k
R9	2k2
R12	68

All 0·25 5% carbon film

See SHOP TALK Page

Potentiometers

VR1	22k rotary carbon, linear

Capacitors

C1	100n ceramic
C2	10µ radial elect. 16V
C3, C6	100µ radial elect. 10V (2 off)
C4	47p polystyrene or ceramic
C5	100p polystrene or ceramic

Semiconductors

TR1, TR2, TR3	BC547 *npn* silicon transistor (3 off)

Miscellaneous

S1	s.p.d.t. min. toggle switch
SK1, SK2	Phono socket (2 off)

Printed circuit board available from the *EPE PCB Service,* code 912; control knob; connecting wire; single-sided solder pins; solder etc.

Approx cost guidance only **£10**

The current consumption of the circuit is about 15mA or so.

CONSTRUCTION

The topside component layout and full size underside track pattern for the Video Enhancer printed circuit board is shown in Fig. 8. This board is available from the *EPE PCB Service,* code 912.

Construction of this perfectly ordinary board is very simple. The hard wiring is also very straightforward.

However, the wiring to VR1 and S1 must be reasonably short, so that stray capacitance and inductance in the wiring does not significantly affect the frequency response of the unit.

IN USE

Once again, it is best to test the unit by connecting it between a camcorder and a television set or monitor. With Boost control VR1 well backed-off in a counter-clockwise direction the Enhancer should have little or no noticeable effect. As VR1 is advanced in a clockwise direction the crispening effect should become apparent.

It will be most obvious on parts of the picture where there is high contrast, particularly if there is also some fairly fine detail. The effect should be noticeably stronger with S1 used to switch capacitor C5 into circuit in place of C4.

Interestingly, the crispening effect seems to work on parts of the picture that are slightly out of focus, giving an apparent increase in the depth of field.

Next Month: We provide details for adding horizontal and vertical "wiping" of the video picture.

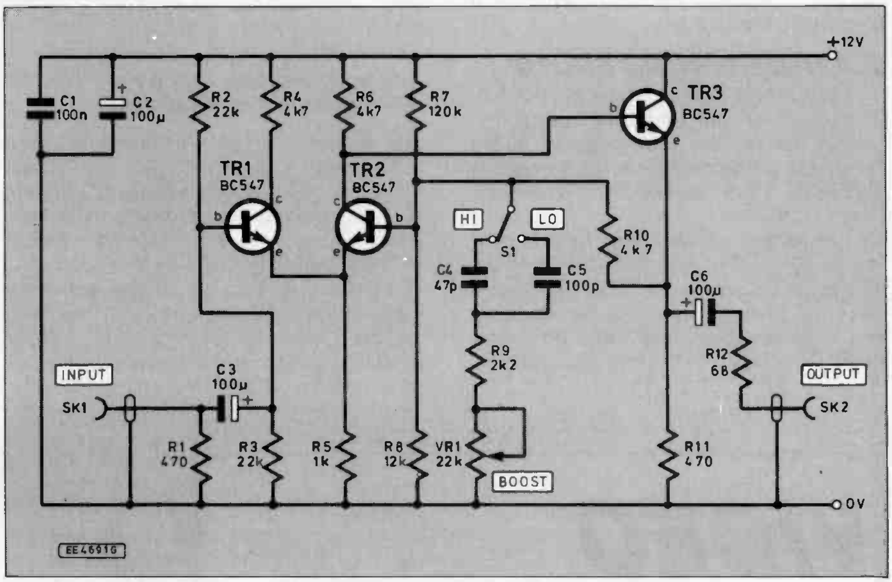


Fig. 7. Full circuit diagram for the Video Enhancer module.

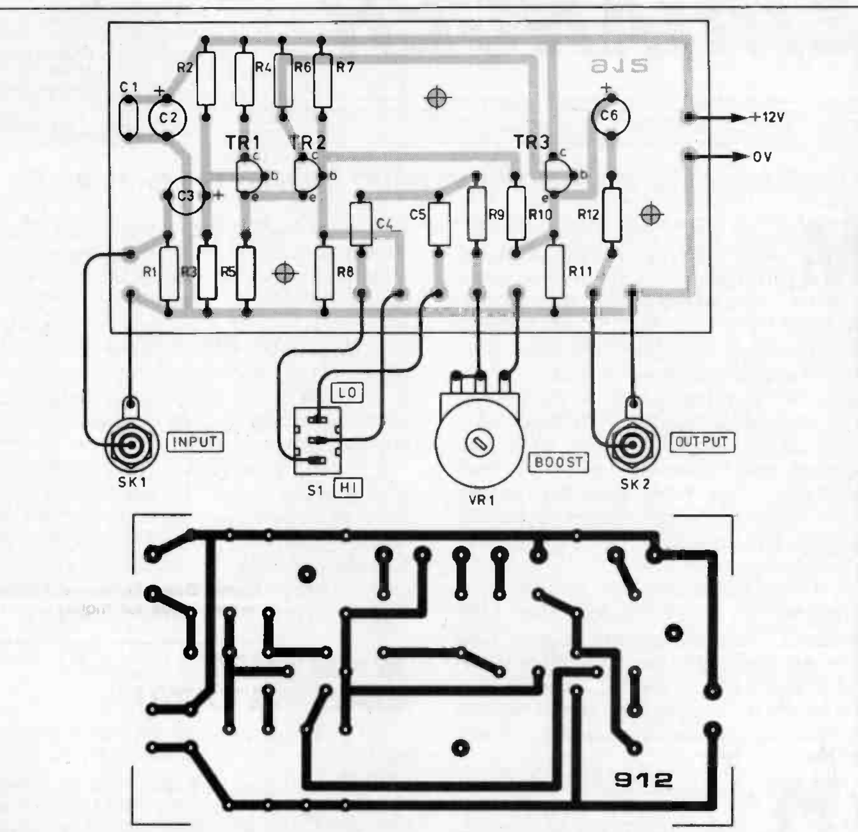


Fig. 8. Video Enhancer p.c.b. component layout and full size foil master.

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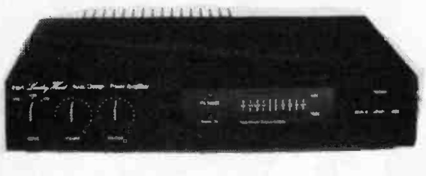

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TECHNICAL BOOKSHELF

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"DIGITAL AUDIO AND COMPACT DISC TECHNOLOGY" 2nd Edition. Baert, Theunissen and Vergult. (SONY Europe).
A thoroughly well written book covering the whole field of recording media starting with the Phonograph right through to modern professional PCM digital recording systems with particular and extensive coverage on the compact disc. All aspects of the recording and reproduction processes are explained with separate chapters on such things as compact disc encoding and the use of cross interleave Reed-Soloman error correction code (CIRC). This book is of course essential reading for engineers and students involved in the field but its very low prices makes it ideal for the enthusiast of recorded music who wants to know more about the hidden processes going on in his CD player.
1992/94 248 Pages. 247 x 190.
0-7506-0614-2 ....£17.95

INTRODUCING DIGITAL AUDIO CD, DAT AND SAMPLING 2nd Edition. Ian R. Sinclair.
For enthusiasts, technicians and students.
Covers CD and DAT, Philips DCC and Sony Mini Disc, the digital techniques involved are explained non-mathematically.
Digital audio involves methods and circuits that are totally alien to the technician or keen amateur who has previously worked with audio circuits. This book is intended to bridge the gap of understanding for the technician and enthusiast. The principles and methods are explained, but the mathematical background and theory are avoided other than to state the end product. This second edition has been updated to include sections on oversampling methods and bitstream techniques. The opportunity has also been taken to add a glossary of technical terms.
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0-85935-324-3 ....£3.95

"HOW TO USE OSCILLOSCOPES & OTHER TEST EQUIPMENT", R.A. Penfold, 112 pages. 178 x 111. Publ. 1989.
BP267 ....£3.50

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CHICAGO – CONSUMER ELECTRONICS SHOW

Barry Fox reports on developments from the annual Chicago Exhibition.

THIS year's *Consumer Electronics Show* in Chicago was, as many had predicted after last year's event, the last. Next year the show changes its name to *CES Interactive* and switches site to Philadelphia. The change and move is to accommodate the companies that are now the backbone of the event, the manufacturers of video games, computing and multimedia.

PROMISES PROMISES

In the 25 years of 50 shows (summer in Chicago, winter in Las Vegas) we have seen the launch of products like stereo TV, the VCR, camcorder and CD, which have gone on to become essential household luxuries. We have seen products like DAT (the digital audio tape format), VHD and CED (JVC's and RCA's capacitance video discs) that never succeeded commercially as a domestic product. We have seen promises which could not be kept, like 45 minutes of CD quality stereo on an ordinary floppy disc, and LVR, the linear video recorder which ran tape in a loop at high speed.

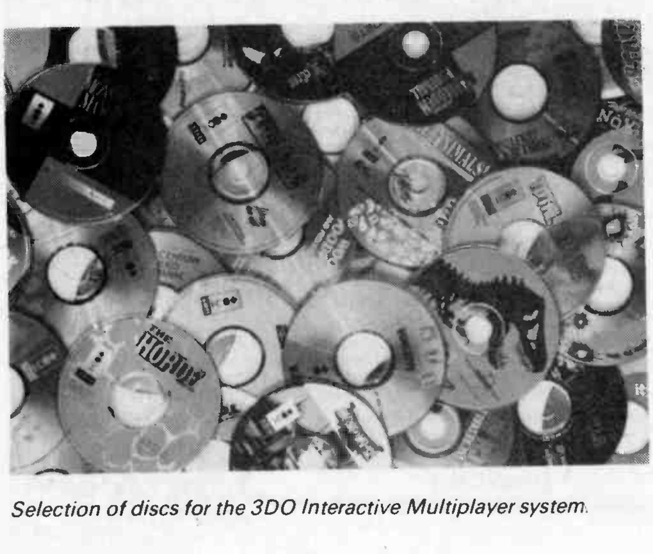
We have seen promises kept by those who did not make them, like the revolution in home computing and video games started by Texas Instruments, Commodore and Atari, but now hijacked by Sega, Nintendo and the IBM clone-makers. Most recently we have seen promises by people who may or may not be able to keep them, like the revolution in home digital audio recording promised by Sony with Mini Disc and Philips with the Digital Compact Cassette.

The Las Vegas Winter *CES* will continue, because there will always be some new developments in audio and video, but most of the electronic industry's effort now goes into exploring the new fields of multimedia and interactive gameplay, where there is far more room for genuinely new ideas. The consumer does not need or want a new VCR format, but will buy a new games system if it brings arcade quality into the living room.

NAME OF THE GAME

The video games industry is now worth $15 billion a year. Nintendo has sold over 30 million SNES (Super Nintendo Entertainment System) games consoles round the world. In the US 40 per cent of all homes now have one. Nintendo has sold 100 million games cartridges featuring its character Mario, the plumber. Nintendo's main rival, Sega of Japan, is fast catching up on Nintendo and has now sold 13 million consoles for its Genesis or Mega system.

Traditionally most games are developed for use in complex consoles installed in amusement arcades, and after a few years are modifed for domestic use. But game players now expect more from their home systems, with graphics and game complexity which match arcade quality.



Selection of discs for the 3DO Interactive Multiplayer system.

Howard Lincoln, US Chairman of Nintendo, predicting "a golden age of video games" at the opening address of the CES.

Significantly, the keynote speech which traditionally opens every CES was this year given by Howard Lincoln, US Chairman of Japanese games giant Nintendo. Breaking the unwritten rule of not using a keynote speech to plug a product, Lincoln unashamedly plugged Nintendo's new Donkey Kong 16-bit SNES game, before plugging Nintendo's plans for Ultra 64 (previously code named Project Reality). This is a 64-bit cartridge games system which Nintendo developed with computer graphics specialist Silicon Graphics and will launch into arcades this autumn, and homes a year later.

Lincoln compared the current video games market to Hollywood in the 1920s. "We are now in the golden age of video games", he declared, going on to predict that there will eventually be a games awards ceremony comparable to the Oscar Academy Awards for movies.

Lincoln also put up several propositions which he described as "popular technology myths", and proceeded to shoot them down. His main theme centred on the myth that "the first technology to the market does not necessarily win".

He seemed rather suprised to be asked afterwards who had actually said that "the first technology on the market wins" and could only fumble with vague references to Sega and 3DO.

Philips was splashing CD-i at Chicago, both in the consumer electronics hall alongside 3DO and Panasonic, and also in the games hall alongside Sega, Nintendo and Atari. Philips says it is still on track to have sold a million CD-i players by the end of this year. Panasonic's 3DO player is selling well in Japan, but slowly in the USA. 3DO and Panasonic claim they are now ready to launch in Europe, with PAL players, this autumn.

3DO's games software is now catching up with the company's previously over-ambitious promises. 3DO claims faster games play, by running the CD at twice the normal speed. One game under development, Demolition Man, blends sequences from the feature film of the same name with computer graphics and close up movie shots of Sylvester Stallone photographed specially for the game.

But CD-i remains well ahead with sales-ready software. In the USA Philips has now launched a second generation CD-i player, the 450, which is around half the size of previous players and costs only $299, despite being bundled with around $200 worth of free software.

Korean companies Samsung and Goldstar have already committed to CD-i and are now hedging bets with 3DO players as well. Sanyo also promises to sell a 3DO player.

The latest batch of Digital Video CD-i feature movies have been mastered to the new White Book standard, so that as well as playing on a CD-i player, they should also play on any other format player when fitted with an MPEG standard Full Motion Video decoder. Despite using the same data rate (1·4 MBit/s) as an audio CD, FMV CDs now deliver picture quality which matches or betters VHS tape, and digital stereo sound which matches CD.

CD-i game Seventh Guest recently topped the CD-based games chart in the UK. This game, about a haunted house, combines MPEG digital video sequences with computer graphics on the same five inch disc.

Mad Dog McCree, a shooting game originally developed for use in amusement arcades, has now been moodified for use on domestic CD-i players. The arcade version uses a 12 inch analogue Laser Disc to display moving video pictures of cowboys, while a games computer superimposes graphic images on the same screen and controls the Laser Disc player. As the user shoots at cowboy villains with an electronic gun, the LD player displays live action motion sequences which show the victims falling over. The CD-i game uses MPEG digital video to put both the live action video and computer graphics on the same five inch CD. MacCree on CD-i now awaits only bulk supplies of the electronic gun controller that will be bundled with the games disc.

PC GAMES

The PC games market remains buoyant, but industry insiders wonder for how long the bubble can go on growing. Incompatibility between different ROM drives, sound cards, PCs and software set-ups is driving more and more consumers to return ROM games in disgust and demand a refund. Both 3DO and Philips are planning to sell plug-in circuit boards which will convert a PC into a 3DO or CD-i player. The aim is to bring plug-and-play simplicity to the PC games world.

When fitted with an MPEG decoder, the same boards will play FMV digital Video CDs. But a compatibility issue could bedevil this plan. The agreed standards for FMV on CD-i or Video CD call for a CD-ROM drive which can read a type of ROM disc known as Mode 2/Form 2, at a sustained data rate of at least 170 kilobytes/second. Most top end ROM drives currently on the market can achieve this transfer speed or higher, but only with Mode 1 or Mode 2/Form 1 ROM discs. This is because Mode 2/Form 2 CDs rely on error correction performed inside the player. This slows the data transfer so the result is juddery pictures and stuttering sound from Video CDs.

So far only one manufacturer, Sony, has modified a ROM drive (the 33a) for discs of 2/2 type. This is why Sigma Designs, manufacturer of the ReelMagic MPEG decoder board for PCs, sells an "upgrade kit" which bundles the board with a Sony drive.

Philips now accepts that most of the millions of ROM drives already sold to PC users will need modifying, and in most places replacing, before they will work with the new PC boards. So Philips may sell its CD-i board only as part of an upgrade kit, bundled with a ROM drive which has been designed to be Video CD compatible.

NO RISC

The first video games, shown at *CES* nearly two decades ago, relied on an 8-bit computer in the console to work with control code stored in a Read Only Memory cartridge. Both the Sega and Nintendo games now use 16-bit computer chips to resolve more detail in the graphics on screen and manipulate moving objects faster. The ROMs are mass produced like computer chips, by photolithographic masking. This limits their storage capacity and even the most complex games, like Streetfighter, must make do with 24 or 32 Megabits of code, which is equivalent to 3 or 4 Megabytes of computer data or a similar number of floppy discs. The masked ROM cartridge costs up to $10 to manufacture, and cannot be re-used for another game if it does not sell well. Sega and Nintendo control manufacture and impose a very high royalty, up to $10 per cartridge. This must be paid at the time of manufacture, and is not refunded if the cartridge remains unsold.

Philips was first to use a standard 12cm CD to store multimedia code for CD-i. One single-sided disc can store over 600 Megabytes of data and costs less than $1 to press. Philips originally developed CD-i as a tool which blends education and entertainment. But "edutainment" did not sell well and Philips is now promoting CD-i as an advanced games machine which can emulate arcade systems.

Philips charges no extra royalty on CD-i games. All a developer has to do is pay $5000 for a licence to make any number of discs and games and then pay the same small royalty (three US cents on every disc pressed) that Philips charges for audio CDs. Industry insiders believe Philips could have won more software support for CD-i if the company had done a better job of publicising its no-royalty policy. 3DO promotes the fact that it charges only $3 per game.

Sega also sells a CD player which connects to its existing 16-bit console, but the system does not exploit the full interactive potential of the disc. Now Sega has demonstrated first prototypes of a new games system, to be called 32X. This uses two 32-bit RISC (reduced instruction set computing) microcompters made by Hitachi, to give a processing speed of 40 MIPS (40 million instructions per second) and so make the graphic images on screen move more smoothly. The new 32X games can be stored either on cartridge or CD, depending on their content. The new 32X consoles will play old 16-bit games as well as new 32-bit cartridges and discs.

Later this year Sony will launch its own new games system, called Playstation. This also uses CDs as the data store, but will be incompatible with all other systems. Sony has been working with semiconductor manufacturer LSI Logic to integrate all the 32-bit RISC processing, graphics control and compressed video decoding circuitry onto a single chip. Sony claims processing speeds of up to 200 MIPS. Sony will demand a royalty of around $8.50 on each disc pressed.

SOLID APPROACH

While all others turn to CD as a storage medium, Nintendo is sticking with solid state cartridges. Nintendo's next games system, previously code-named Project Reality and now called Ultra 64, has been jointly developed with Silicon Graphics, the computer company which specialises in industrial virtual reality systems and special effects for the movie industry. SG created the dinosaurs for *Jurassic Park* and made characters metamorphose in *Terminator 2*.

Nintendo says that although CDs can store large quantities of data, very cheaply, they suffer from slow access times which limit the speed of the gameplay. The data on a CD is recorded as a continuous stream so the laser must first find where the required section is stored, then move over it and wait for the spinning disc to bring the start of the data block to the correct position. Even if the player spins the disc at twice normal speed (as in the 3DO system), says Nintendo, access time for solid state storage is still a hundred times faster than for CD.

Ultra 64 will use 64-bit RISC processors running at 80MHz, which is as fast as the best office PC, and transfer bursts of data from the cartridge at 400MBytes/second. Nintendo claims that the vital trick, played by SG's custom chip set, is to store only key graphics images in the cartridge and rely on intelligence in the console to manipulate them. For example the cartridge stores the image of a hand, as a three-dimensional model, and the console then works like a virtual reality station to move the the position and perspective of the hand on the fly to suit the game play. This contrasts with the CD-based systems which store pre-processed animation on the disc and retrieve and display it as needed.

The latest game from Nintendo.

Nintendo will launch Ultra 64 as an arcade system this autumn, and as a consumer console a year later. The company pledges a consumer price of "under $250", with game play and graphics which are identical to the arcade version.

At private demonstrations given by Nintendo at Chicago, they showed prototype Ultra 64 systems and two games. One lets a driver race at high speed down surprisingly realistic roads, dodging or hitting traffic. The developers drove round San Francisco, with a video camera in a car, and then used the taped images to generate graphics for manipulation. The other game simply introduces more realism and fluidity of motion into yet another combat challenge. Animated characters fight to the death, with much vertical jumping into the air, summersaulting and slashing each other with vicious swords.

Perhaps this is what Howard Lincoln meant by the golden age of video games

ON THE MOVE

As if to reinforce the EIA's decision to scrap the summer *CES*, only Thomson (with its USA brand RCA) and Philips (with its US brand Magnavox) were showing any traditional consumer audio, video and TV hardware. But Thomson's TV sets and VCRs played second fiddle to the company's main splash on its DSS satellite system, and Philips was majoring on CD-i. Panasonic was present only to show its 3DO player.

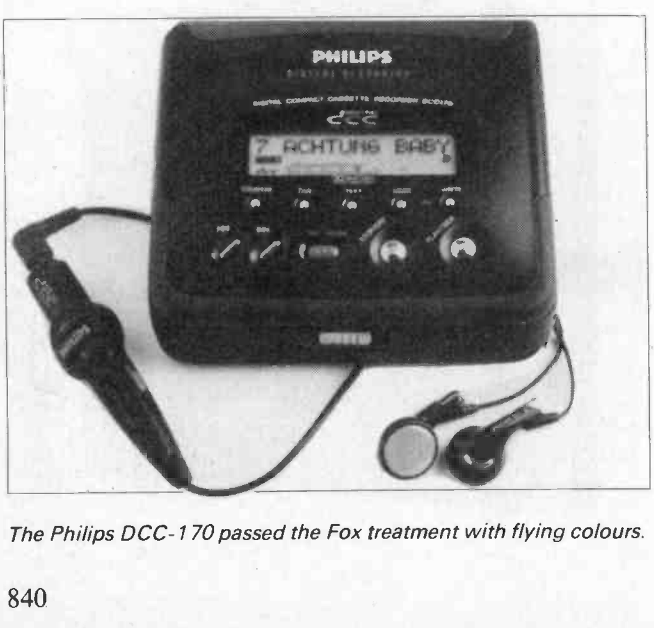
Sony did not officially exhibit at the show, hardening industry belief that both Sony and Philips now tacetly acknowledge that the market is not yet ready for a new digital home recording system. CD sales show no signs of flagging as early as previously predicted and the conventional analogue cassette remains the best bet for inexpensive music on the move. Even big name companies, like Sanyo, can now sell a stereo cassette player for under $15 or £10. And a new generation of CD players, like Sanyo's CDP-67, has a memory buffer which lets them play on the move, without skipping, like Mini Disc.

Although the main thrust of Philips stand at Chicago was on CD-i, the company staged a surprisingly strong show of DCC. Most interesting, the DCC-170 portable both records and plays back, and is reassuringly small, with two hours of recording time and three hours of playback time from its NiCad rechargeable batteries.

Although Sony has understandably played it down, Mini Disc can only provide jog-free playback, not recording. The buffer memory can only work on data which has already been stored. If the MD unit is jogged during recording, it skips. This makes the system useless to broadcasters or anyone wanting to make recordings with a handheld or pocket unit. Because DCC is a tape-based system, it can withstand jogs during recording as well as during playback.

At Chicago I tried shaking the DCC-170 violently, during playback, and it carried on working with no audible effect. This suggests that the 170 would be equally robust during recording. If so broadcasters will be able to use it as a portable tool, instead of their existing Sony Pro-Walkman analogue cassette or DAT units. For dubbing and editing the digital optical socket on the rear of the 170 cleverly doubles as an analogue line output socket.

It is a pity that the Philips' literature does so little to emphasise the benefits of jog free recording; it is also confusing and may mislead people into believing that the DCC-170 only has a digital output.



The Philips DCC-170 passed the Fox treatment with flying colours.

The Sanyo CDP-67 "anti-shock" CD player.

STAR WARS II

In a *déjà vu* re-run of what happened in the UK five years ago, two broadcasting consortia in the US, DirecTV and Primestar, are offering rival digital satellite services. Both claim to be first in the world to transmit digital video direct into consumers' homes. They use different transmission technology, and different satellites, so the two systems are completely incompatible and must now fight to the death for survival of the fittest.

The British struggle ended when BSB collpased into merger with Sky, and had to abandon its high-priced, high-tech technology in favour of Sky's much cheaper, lower-tech approach. The US rivals are making the same mistakes as their British forerunners, expecting consumers to pay high prices for pioneering technology and promising that it is "easy" for amateurs to install their own satellite aerials.

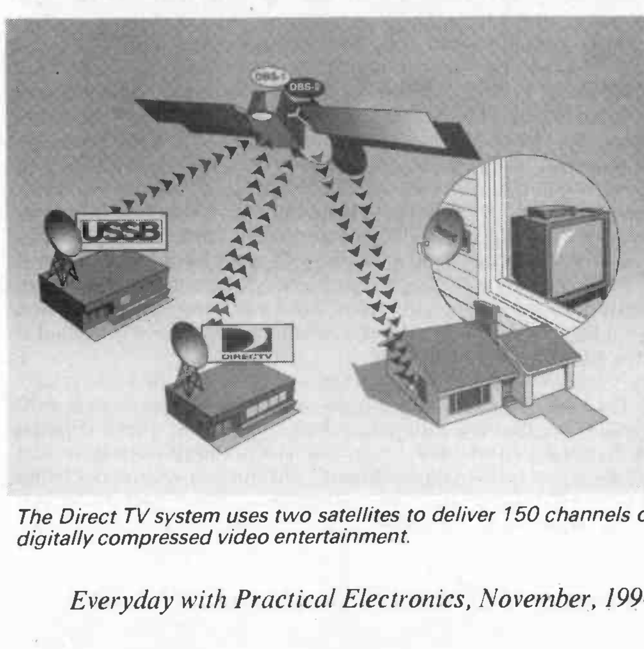
DirecTV is owned by aerospace giant, G M Hughes Electronics, and backed by RCA (the US subsidiary of French company Thomson Consumer Electronics) with extra entertainment programming provided by USSB (United States Satellite Broadcasting). Thomson makes the receivers in the US and labels them DSS, short for Digital Satellite System.

Primestar is backed by six cable stations, including Tele-Communications Inc, Cox Cable Communications and Time Warner. General Instrument makes its receivers.

DirecTV will use two satellites made by Hughes to deliver 150 channels of digitally compressed video entertainment, direct into the home. One satellite is already working, and the second was due for launch in July. Primestar is broadcasting 35 channels from transmitters it has leased on the *Satcom K-1* communications satellite, and will lease more soon to double the number of TV channels.

Although both systems rely on data compression to squeeze at least four digital TV channels into the transmission bandwidth needed for one analogue channel, they use different and incompatible technology.

Primestar uses the DigiCipher system developed by GI in



The Direct TV system uses two satellites to deliver 150 channels of digitally compressed video entertainment.

1990, before the electronics industry's Moving Picture Experts Group had agreed its MPEG compression standards. DSS uses the MPEG-1 standard, which is intended for digital video discs, but at much higher data rates (up to 6MB/s for DSS instead of 1·4MB/s for CD). Both DirecTV and Primestar say they will change to the higher quality MPEG-2 standard next year when the necessary encoding equipment is ready. Although this could build a compatibility bridge between the rival receivers, the two services will still not work together. They use different encryption systems to scramble their programmes.

There can be no compatibility between reception aerials, either. The Hughes and Satcom satellites are at different positions in geostationary orbit, so one dish cannot receive from both at the same time. DirecTV's transmitters run at high power, pumping out 120 watts for each channel. So viewers need use only small dishes with DSS receivers, around 45cm in diameter. Primestar broadcasts from the *Satcom K-1* communications satellite, which has 50 watt transmitters. So viewers need a large dish, around 100 cm, to receive Primestar's weak signals.

Just as happened in the UK, between BSB and Sky, DirecTV and Primestar are now squabbling publicly about dish size and digital technology. Following BSB's high tech role model, RCA published pictures unfavourably comparing the size of Primestar's dish aerial with is own. Under the headline, "DBS without the BS", Primestar responded in Sky's style, "We don't sell technology, we just bring people the television programming they want to see. They don't care about algorithms, data compression or any of the whiz-bang stuff that is the talk of this new industry."

Watching either system is not cheap. In the style of British TV and VCR rental, Primestar leases receivers with free installation (at least inititally) and service. But Primestar charges a minimum of $1 a day depending on how many entertainment channels the viewer wants to watch. When the viewer stops paying, the receiver is taken away.

RCA sells DSS receivers and aerials outright. The basic hardware costs between $700 and $900, plus around $150 for dish installation. Although RCA says DIY installation is "easy", the British experience teaches that most people find it much easier to pay a professional installer, than learn how to secure and align a dish from the top of a ladder. Because Hughes' satellites do not carry terrestrial services, if viewers want to watch the national TV networks they must either install a terrestrial TV aerial or pay another $10 a month to a cable station.

Depending on what channels viewers want to watch, DSS subscriptions cost between $6 and $57 a month, with pay-per-view movies an extra $3 each. These are broadcast using a technique called NVOD, or Near Video On Demand. The same movie runs simultaneously on four channels, at intervals staggered by 30 minutes. So the viewer is always within half an hour of the start. A smart card in the receiver controls viewing, stores a record of pay-per-view movies watched, and automatically sends data down the viewer's home telephone line to a billing station during the night.

Despite the high cost, Joseph P Clayton, Executive Vice-President of Thomson Consumer Electronics, says DSS is the "dawning of a new era in home entertainment, overshadowing the earlier introductions of colour television and the VCR".

Clayton predicts sales of over 200,000 DSS units by the end of this year, with 10 million household receivers in homes by the year 2000.

Receivers initially went on sale only in two towns, Jackson, Mississippi and Shreveport, Lousianna. The first batch sold out immediately, with many receivers bought by rival electronics companies anxious to pry into the digital technology.

DOWN TO EARTH

Back down to earth, US company Starsight has effectively re-invented the European teletext system, to provide on screen programming and timer control of a VCR. Like teletext, Starsight transmits data in the Vertical Blanking Interval, but unlike teletext it relies on the TV set storing the data in memory. This lets the system provide very rapid access to a week of television programme listings with programmes sorted by time, title or theme.

Enhanced stereo sound systems, such as Q Sound and SRS, work by adding artificial phase shifts between the left and right channels, to widen the stereo effect. The hi fi fraternity has given these systems the thumbs down and they are now being used to trick up the sound of video games.

One exhibitor was offering people the chance to listen to TV sound, without watching the pictures. The trick is to receive the TV sound on a TV tuner, and then re-transmit it on a V.H.F. frequency to a car or portable f.m. radio. Although a neat idea, this is likely to fall foul of the law in the UK.

The Noisebuster, from Noise Cancellation Technologies of

TeleWatch cordless telephone and personal intercom.

Stamford, is a low cost anti-sound unit. The user wears headphones, which connect to a portable unit, rather like a Walkman personal stereo. This until has a microphone which analyses any continuous background sound, and generates a mirror image which is in exactly the opposite phase, and thus cancels it out. So the user hears less background noise, but conversation through the microphone comes through loud and clear. *(Sounds a bit like Robert Penfold's "Experimental Noise Cancelling Unit" (Aug.'94) – Ed.).*

At around $150, the Noise Buster is suggested for anyone travelling in a plane, bus, truck, train or boat, operating a weed whacker(?), working in a noisy home or office or using a multimedia computer.

MicroTalk Technologies promises a telephone wrist watch. Actually it is a cordless telephone, that works with a base station. The watch is decidedly bulky, and perhaps wisely the company has not yet fixed even a ballpark price.

The "Sales Appeal" is a new idea for the passive infra-red sensors now widely used in burglar alarms, and to switch on security lights when any hot animal body approaches. The Sales Appeal connects a PIR to a solid state digital recorder, which can store a 20 second message. Supermarkets will put the units alongside special offers. Whenever an unwary customer approaches, the PIR will sense their presence, and chirp out a greeting like, "Did you see our special offer on cornflakes?"

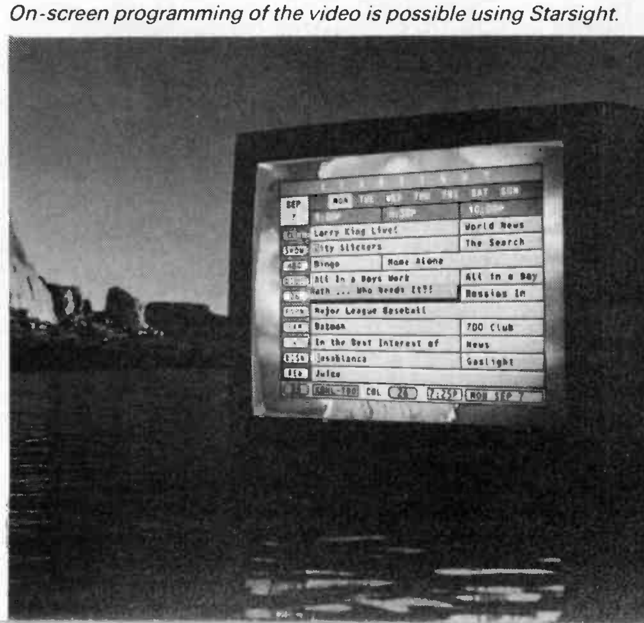
What promised to be the most intriguing event of the show failed to materialise. For the last three years start-up company EMC 2 (now EMC 3) has been promising a new kind of VCR which will work in conjunction with any broadcaster who transmits digitally encoded video programmes at high speed, so that a hundred minute movie is broadcast in just a few minutes. The EMC 3 VCR will tape the high speed transmission, and then replay at slow speed, to recreate the full running time.

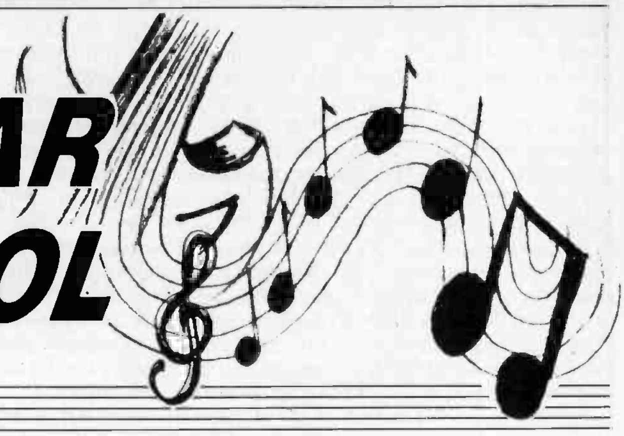
Despite many promises, no-one has yet seen an EMC recorder playing this clever trick. The advance notices for the Chicago show listed EMC 3 as staging a press conference. Although the press turned up, EMC 3 did not. Later the EIA organisers confirmed that the booking had been firm. Back in London, I telephoned the "contact person" listed on the advance note of the press conference which never took place.

"We are sorry", said a recorded announcement, "but the number you have called has been disconnected or is no longer in service".

Draw your own conclusions. Back to the drawing board?

On-screen programming of the video is possible using Starsight.





ACTIVE GUITAR TONE CONTROL

JOHN CHATWIN

Be active, set the right image and "turn up the volume" on the quality of sound from your guitar.

MOST guitar tone controls are "passive", which simply means that they filter away parts of a signal. This is fine if what is going into the filter is of a reasonable quality to start off with. However, many cheaper electric guitars and basses have a pretty poor basic sound, and using a tone control that takes away from what little there is, usually just makes for a "muddier" signal.

The tone control circuit described here is "active". Instead of just taking frequencies away, it can be used to "boost" and "cut" areas of sound, allowing for a much wider range of tonal colours.

The circuit is not limited only to electric guitars. It will handle just about any audio input and could be used as an add-on unit to improve the versatility of amplifiers and PAs. On its own, it forms an ideal input stage for driving a power amp and could form the basis of a simple practice amplifier.

CIRCUIT DESCRIPTION

The circuit diagram for the Active Guitar Tone Control is shown in Fig. 1. The design is based around a TL072 dual low noise op.amp. This type of i.c. being chosen because it gives a good range of performance and is still relatively cheap. An ultra low noise op.amp like the 4227G could have been used, but at this level of design, not a great deal of improvement would be noticed.

Signals enter the circuit via the input capacitor C1 and are amplified by op.amp IC1a. This is wired as an inverting amplifier with potentiometer VR1 controlling the amount of negative feedback, and therefore the gain. Actual gain can be found by dividing the value of VR1 by the value of resistor R1, which in this case gives a maximum gain of 10, which is equal to 20dB.

Potentiometer VR1 can be used to match the circuit to various types of input, from small signal sources such as guitars and microphones, to much higher levels from tape decks or pre-amps.

The amplified signal from IC1a is coupled to the next section of the circuit via capacitor C3. This is the actual tone control, and consists of a standard Baxandall arrangement for bass and treble cut and boost.

It consists basically of two filters connected in parallel, a high pass for the treble, and a low pass for the bass. With both control potentiometers in mid-track position the circuit will have a flat response. The filter section has little gain, and needs the boost given by op.amp IC1a if low level signals are involved.

The output signal is taken from IC1b pin 7 via capacitor C8. Power for the circuit can be from around 6V to 15V, so a PP3 type battery is ideal if you want to build the tone control into a small effects style case.

Resistors R2 and R3 form a voltage divider that provides a mid-point for the non-inverting inputs of the op.amps. Capacitors C2 and C9 are essential even if batteries are to be used. They become even more important if a mains power supply unit is connected since they decouple the power rails and help to reduce ripple and hum.

CONSTRUCTION

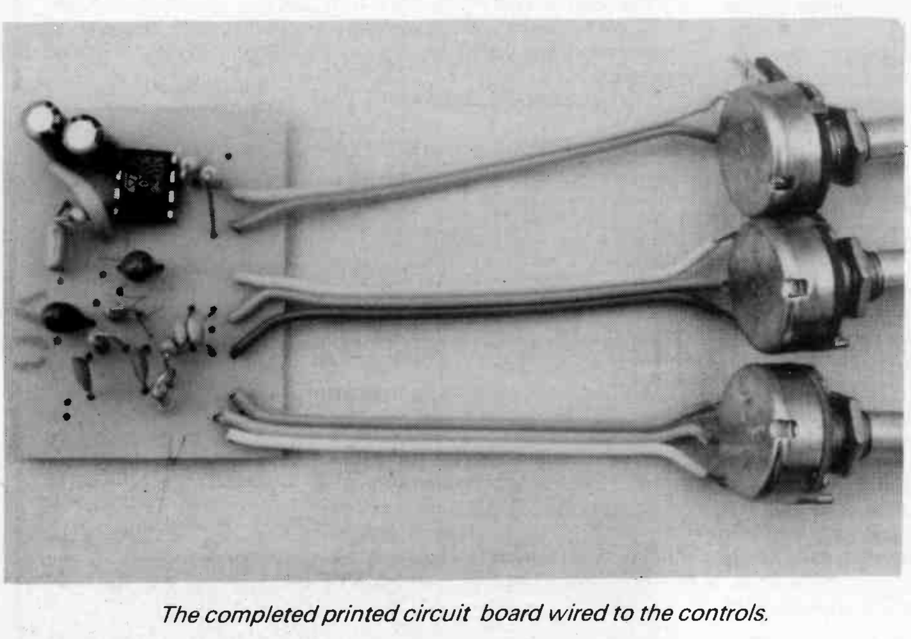
The printed circuit board (p.c.b.) component layout and full size copper foil master pattern are shown in Fig. 2. This board is available from the *EPE PCB Service*, code 907.

There should be no problem assembling the p.c.b. if you take the usual precautions and check everything at least three times! Assemble the components in order of resistors, i.c. socket, and then the capacitors.

You can use the unit either as a stand alone effect in its own case or fitted inside a guitar or bass. The latter, though, may require three extra holes to be drilled for the control pots, and might not be a good idea if your guitar is at all valuable to you. A stereo jack can be used in place of the regular mono one, so that overall on/off switching can be achieved when a mono guitar lead is plugged in, shorting across the first two terminals and connecting the battery to the negative supply rail.

Two pads have been left on the p.c.b. so that the switch and battery clip negative lead can be joined. A d.p.d.t. switch is used to bypass the circuit when in use. See the wiring diagram Fig. 3.

However you may decide to use the circuit, pay attention to screening as this can make a lot of difference to the levels of noise that it produces. It is also worthwhile experimenting with the values of the filter capacitors C4, C5, C6, and C7 as the characteristics of the whole circuit depend on these components. □



The completed printed circuit board wired to the controls.

ACTIVE GUITAR TONE CONTROL

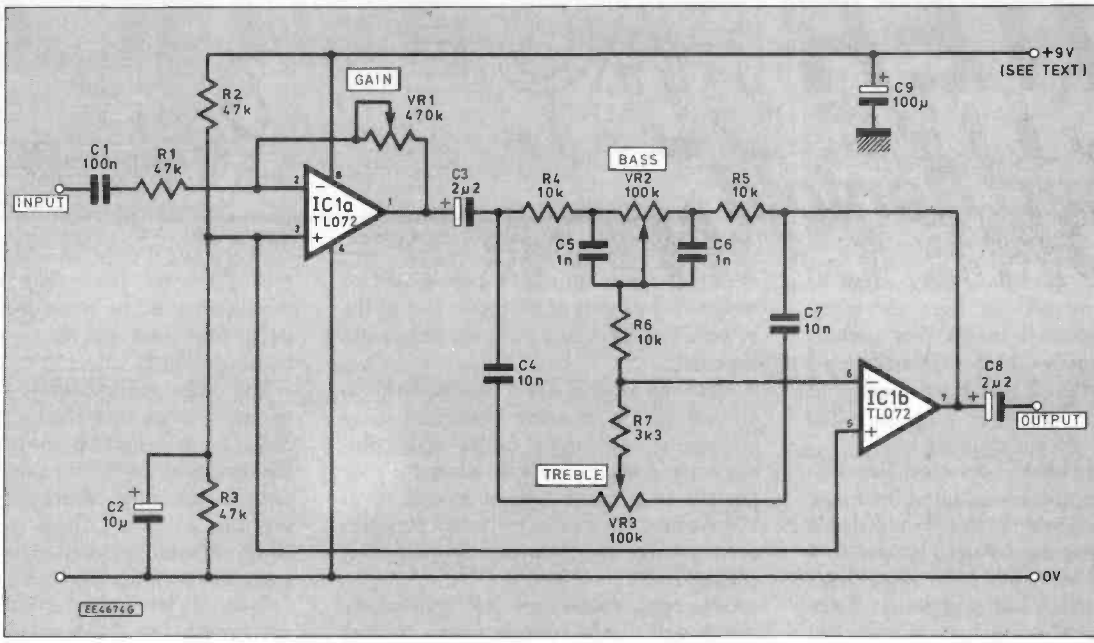
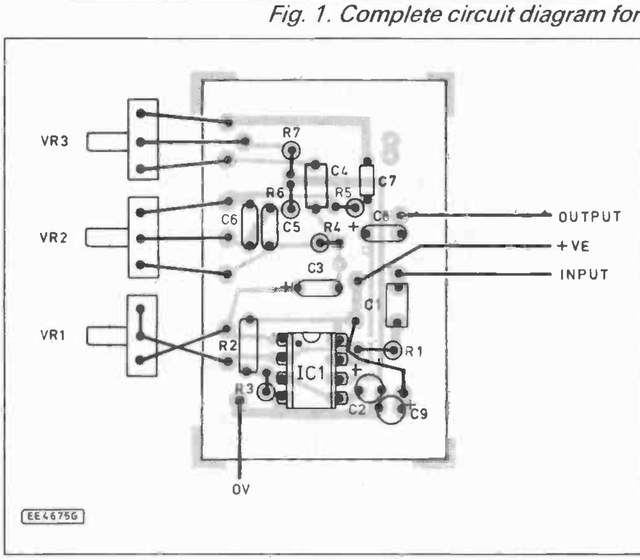


Fig. 1. Complete circuit diagram for the Active Guitar Tone Control.



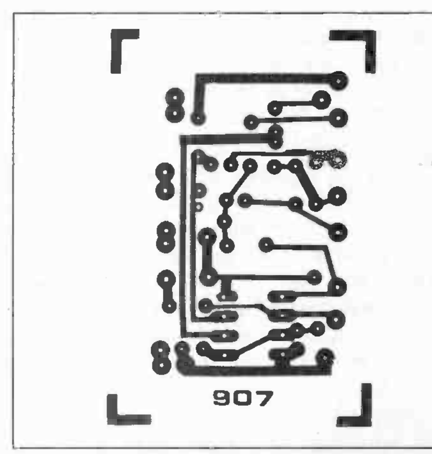


Fig. 2. Printed circuit board component layout and (right) fulll size copper foil master pattern.

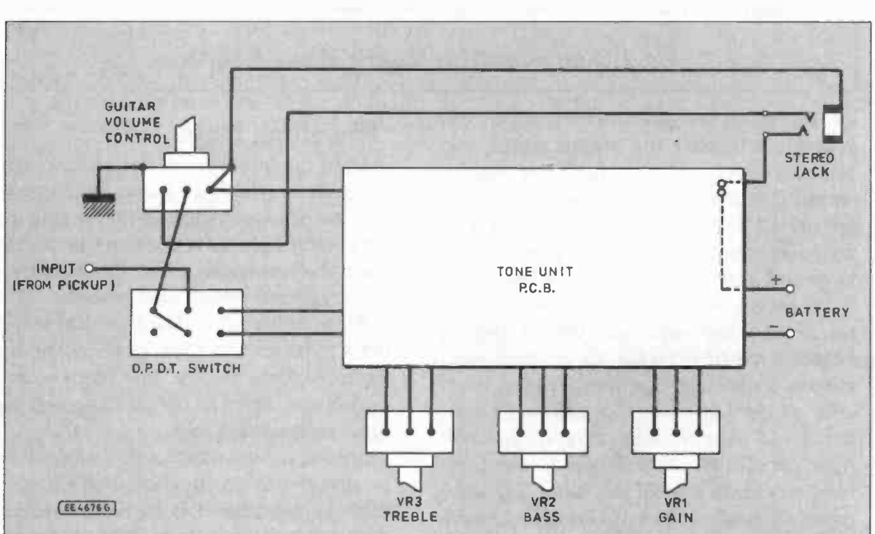


Fig. 3. Typical set-up for the Tone Control using an additional bypass switch and a stereo jack socket for on/off switching. Screened leads should be used for off-board wiring.

COMPONENTS

See SHOP TALK Page

Resistors

R1, R2, R3	47k (3 off)
R4, R5, R6	10k (3 off)
R7	3k3

All 0·25W 5% carbon film or better.

Potentiometers

VR1	470K rotary carbon, lin
VR2, VR3	100K rotary carbon, lin (2 off)

Capacitors

C1	100n polyester
C2	10µ radial elect. 25V
C3, C8	2µ2 tantalum bead 16V (2 off)
C4, C7	10n polyester (2 off)
C5, C6	1n polyester (2 off)
C9	100µ radial elect. 25V

Semiconductors

IC1	TL072 Dual op.amp

Miscellaneous

Printed circuit board available from the EPE PCB Service, code 907; plastic case, if required; screened cable; stereo jack socket (optional); d.p.l.t. toggle switch (optional); connecting wire; solder etc.

Approx cost guidance only **£10**

INTERFACE

Robert Penfold

FIBRE-OPTIC cables have been about to revolutionise all our lives for many years now. Now it seems that various technical difficulties, higher than expected costs, etc., have all been sorted out, and the amount of fibre-optic cable threaded around the country is growing fast.

At one time there was much speculation that fibre-optics would find their way into the home in ordinary electronic gadgets, but this has failed to happen to a significant degree. Apart from digital links in some up-market hi-fi equipment, fibre-optics have failed to have much impact in the home.

Opto-Advantages

Even where it is not necessary to transfer gigabits of information over vast distances, fibre-optic cables still have some advantages over simple electrical cables. One of these is complete electrical isolation between the sending and receiving devices. This can avoid potential problems with "hum" and earth loops, digital noise being coupled into audio circuits, and high voltages between equipment having non-earthed chassis.

One important potential advantage is that optical-fibres provide no fire risk. They do not carry an electrical signal which could cause sparking or overheating.

Another advantage of optical cables is that there is no risk of them radiating electrical interference. Even when they are used for something like a high speed serial computer link (which could contain signals having harmonics at frequencies of a few MHz) there is no risk of the non-electrical cable radiating electrical interference. It also works the other way round, and there is clearly no risk of an optical cable picking up electrical interference.

Obviously there could be problems with extraneous light entering a cable, but in practice the opaque sleeving on fibre-optic cables completely eliminates this problem. This sleeving also completely removes any risk of crosstalk, even when two long optical cables are run side-by- side.

A further advantage of optical cables is their relatively small size. Most fibre-optic cables are only about two millimetres in diameter, which is substantially less than most screened cables. This makes it much easier to conceal fibre-optic cables.

Opto-Drawbacks

Fibre-optic cables are not without a few drawbacks, and the most obvious of these is that they are not compatible with normal computer ports, etc. You cannot simply link two computer serial ports using just an optical fibre. Some extra electronics are needed at each end of the system to convert the electrical signals into light signals, and to reverse the process at the other end of the system. This obviously produces some extra expense.

Although optical fibres can be used to provide links over many kilometres, using inexpensive fibre-optic cables and opto-electronic components it is generally only possible to obtain ranges of around 10 to 100 metres. Of course, for many purposes even a range of 10 metres is more than adequate.

Fibre-optic cables are not particularly cheap, and would typically seem to cost almost one pound per metre. Surplus fibre-optic cable is available from time to time at a somewhat lower cost, but an average coaxial cable is still likely to cost somewhat less.

A point that should be borne in mind when dealing with fibre-optic cables is that they usually have recommended minimum bend radius of about 50mm to 80mm. There are various jokes in the electronics world about tying knots in electrical cables in order to make it harder for the electricity to pass down the cable. Taking an optical fibre cable beyond its minimum recommended radius can severely attenuate the output signal, and tying a knot in one of these cables would presumably be an effective way of restricting the signal flow! It could also seriously damage the cable, producing a large and permanent loss of efficiency.

Whatever the "pros and cons" of optical fibres, they represent an interesting field of investigation for the amateur electronics enthusiast. *For those readers interested in further studies of "Fibre Optics", a new 58 minute video tape is available from our Direct Book Service – see* Electronics Videos *page in this issue. The video covers the fundamentals of fibre optic technology through cable manufacture to connectors, transmitters and receivers – Ed.*

Practical Cables

A fibre-optic cable does not merely consist of a glass filament having an opaque plastic sleeving. These days the core is almost certain to be made from a polymer rather than glass, and the core is actually a twin type (Fig.1).

The main (central) core has a higher refractive index than the outer skin of the core. Due to refraction where the core and the skin meet, a light ray entering the cable can pass along the cable by bouncing from one side to other. There is effectively a highly efficient mirrored surface where the inner core and outer skin meet.

Even if the cable is taken through numerous bends, this bouncing process still works, although the transmission efficiency of the cable might suffer slightly. Taking the cable through too tight a bend can produce damage where the inner core and outer skin meet, and it is this factor that imposes a minimum bend radius.

Some cables have a graduated core, which simply means that there is a gradual transition from the higher refractive index of the inner core to the lower refractive index of the outer skin. The light travels down the cable in a more curved fashion than for a normal cable, but in use the two types of cable are much the same.

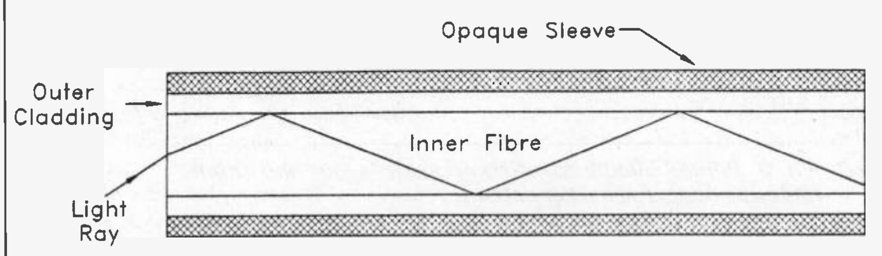


Fig. 1. A fibre-optic cable has a twin polymer core.

Travelling Light

Light can travel down the cable in high or low order mode. Fig.1 shows the high order method of propagation. With the low order variety the light travels down the cable at a more shallow angle, and it therefore travels a much greater distance per bounce.

More importantly, the light has less distance to travel, and it therefore travels down the cable more quickly. This tends to smear signals sent down an optical cable, and limits the maximum data rate.

Special cables which only support high or low order propagation ("single mode" cables) are produced, but are not needed for do-it-yourself fibre-optic links. Any smearing of the signal is insignificant with something like a computer serial link operating over a range 20 metres.

Practical fibre-optic cables come in a variety of sizes, but for the amateur user it is

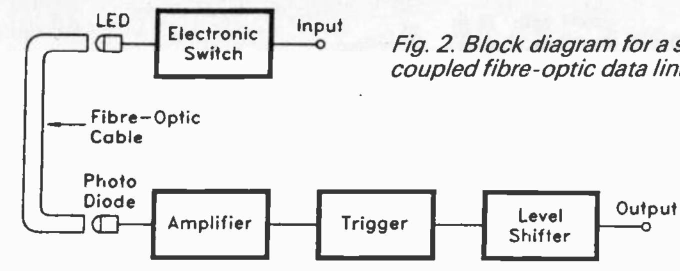


Fig. 2. Block diagram for a simple d.c. coupled fibre-optic data link.

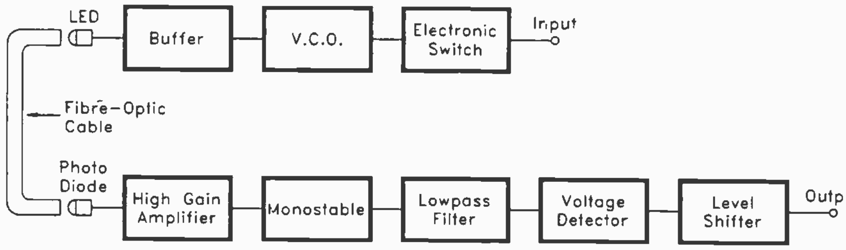


Fig. 3. Block diagram for an f.s.k. fibre-optic data link.

probably best to only buy the type which has a filament diameter of one millimetre, and an overall diameter of 2·2mm. This cable seems to be the nearest thing to a standard optical type, and it is compatible with most fibre-optic l.e.d.s, photodiodes, connector systems, etc.

Losses through long coaxial cables can usually be kept down to quite low levels, but there are usually quite appreciable losses through even short pieces of fibre-optic cable. An inexpensive cable would typically provide a 6dB loss through about five metres of cable (i.e. the light intensity would be reduced by 50 per cent through a five metre length of cable).

Computer Links

Technically it is not particularly difficult to send serial digital data or audio signals down a fibre-optic cable, and a serial link can actually be very simple indeed. With a digital signal there is are no linearity problems to contend with.

If only a modest maximum range is required (up to about 10 or 20 metres), a simple d.c. coupled circuit will suffice. The basic setup for a link of this type is illustrated in the block diagram of Fig.2.

An electronic switch controlling a l.e.d. is basically all that is needed at the transmitting end of the system. When the digital input signal is high the l.e.d. is switched on – when it is low the l.e.d. is switched off.

The photodiode at the receiver feeds into an amplifier. As the circuit is d.c. coupled the amplifier can only offer a modest amount of gain, or there will be problems with drift.

The amplifier must provide an output signal of several volts peak-to-peak in order to drive the next stage properly. This means that the light output from the fibre-optic cable must be quite high in order to provide an adequate output signal from the amplifier, which in turn tends to limit the maximum range of the system.

The output from the amplifier drives a trigger circuit. This provides an output signal that switches cleanly and rapidly from one logic level to the other.

In practice the trigger threshold is normally made adjustable so that the mark-space ratio of the output signal can be adjusted to precisely match that of the input signal. This is necessary due to the relatively slow switching speed of the photodiode, which can produce significant signal smearing at high baud rates.

An RS232C signal does not operate at normal 5V logic levels, but instead uses nominal signal voltages of plus and minus 12V. The minimum acceptable loaded voltage is plus and minus 3 volts. A level shifter at the output of the unit provides RS232C compatible signal levels.

Two-Tone

Greater range can be obtained using the method outlined in Fig.3, which is basically just a standard f.s.k. (frequency shift keying) system. The high and low logic levels are represented by two different frequencies.

The input signal drives an electronic switch which in turn drives the control input of a v.c.o. (voltage controlled oscillator). With a low input level the v.c.o. operates at its normal frequency, but with a high input level the electronic switch is activated and the v.c.o. is pulled to a higher operating frequency. A buffer stage enables the v.c.o. to drive the l.e.d. at a suitably high current.

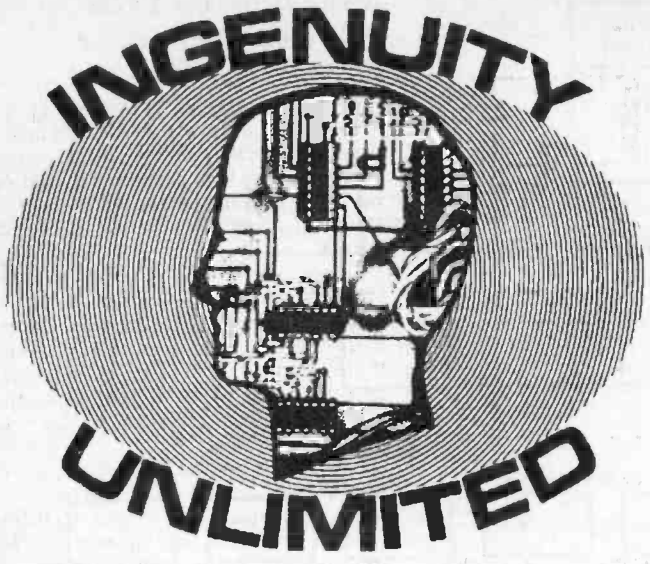
The pulsed signal from the photodiode is fed to a high gain amplifier. It is possible to use a very large amount of voltage gain here because the amplifier can be a.c. coupled.

Drift is not a problem, and any distortion of the input signal's mark-space ratio is equally unimportant. It is electrical noise that limits the amount of voltage gain that can be utilized.

The output from the amplifier must be fed to some form of frequency to voltage converter. There is no need to use anything particularly elaborate here, since linearity is of no consequence in a digital application such as this. Something as basic as a monostable and a high slope lowpass filter is perfectly acceptable.

A voltage detector circuit is used to produce an output signal that switches cleanly from one logic level to the other, and this also enables the mark-space ratio of the output signal to be matched to the original signal. A level shifter produces an output signal at RS232C compatible voltages.

Next Month: Some practical circuits for d.c. coupled and f.s.k. fibre-optic data links will be considered.



WE ARE delighted to welcome back our *Ingenuity Unlimited* column – the circuit showcase of readers' own designs, re-introduced by popular demand from former *Practical Electronics* enthusiasts. Well over twenty years old, no less, this pedigree page invites readers to submit their own circuit ideas for possible publication. We pay between £10-£50 for all material published, depending on length and merit. Note that we're looking for novel applications and circuit tips, *not simply mechanical or "electrical" ideas.*

The circuits shown have *NOT* been proven by us. *Ingenuity Unlimited* is open to *ALL* abilities, but items for consideration in this column should preferably be typed or word processed, with a brief circuit description showing all relevant component values. Please draw all circuit schematics as clearly as possible. If you have a circuit idea to pass on to your fellow constructors, then why not submit it for possible publication in *Ingenuity Unlimited?*

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Auto Power Down Circuit

– with many uses

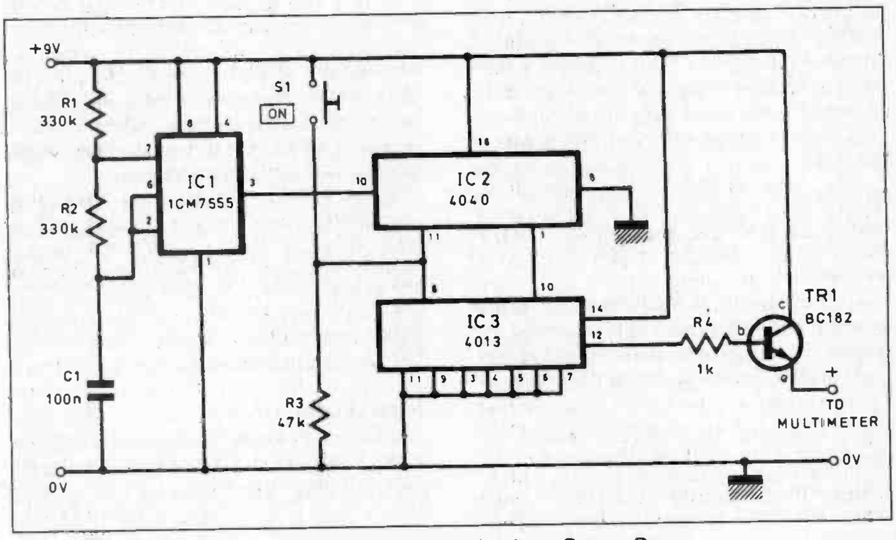

Fig. 1. Circuit diagram for the Auto Power Down.

The circuit diagram of Fig. 1 was designed to turn off my multimeter after roughly five minutes operation – the cost in batteries due to my absent-mindedness was horrendous! It switches off a piece of equipment after a preset time to avoid unnecessary drain on the batteries.

IC1 is a 7555 acting as an oscillator running at a frequency of about 15Hz. The frequency of astable operation of the 7555 is given by the formula:

$$f = \frac{1{\cdot}44}{(R1 + 2R2)C} \text{Hertz.}$$

This clocks the binary divider IC2 which divides the clock signal by 2^{12}, resulting in a pulse every five minutes or so. Pressing the "on" switch S1 sets the S-R latch IC3 (one half of the dual device being used), and resets the binary divider. The Q output of IC3 will then go high, turning on transistor TR1 which feeds power to the multimeter.

After approximately five minutes the output of IC2 will go high, resetting the latch, thus turning the equipment off. The delay time can be adjusted by varying the frequency of the oscillator: the frequency required for a set period is given by:

$$\text{Period} = \frac{2^{12}}{\text{frequency}}$$

Tom Baldwin,
Romsey, Hants.

Liquid Crystal Display Tester

– helps unscramble pinouts

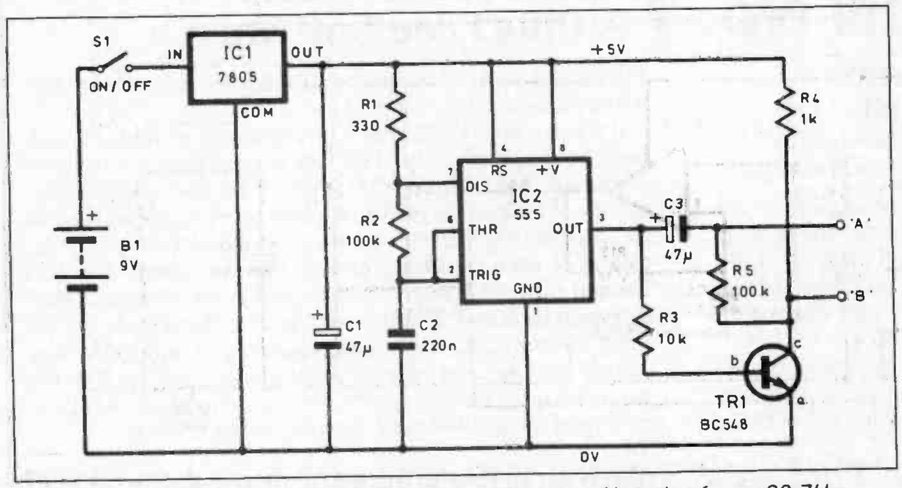

Fig. 2. Liquid Crystal Display Tester circuit diagram. Note that $f_{OUT} = 32{\cdot}7Hz$

Liquid Crystal Displays (LCDs) cannot be tested by direct connection to a d.c. supply such as a battery. My circuit, Fig. 2, produces an a.c. output which is suitable for driving l.c.d.s and can be used to determine the pin functions of displays when connection data is not available.

The unit is powered by a 9V d.c. battery and a 7805 voltage regulator, IC1, provides a 5V rail for the display, and is decoupled by capacitor C1. The 555 timer, IC1, is connected as an astable multivibrator running at 32·7Hz. Resistor R1 is a low value which gives approximately a 50 per cent duty cycle.

Transistor TR1, resistors R3 and R4 invert the output square wave whilst capacitor C3 blocks any d.c. content of the output. The resistor R5 provides a current path through C3 which produces a p.d. between points *A* and *B*. These terminals are connected to different pins on the l.c.d., the segment connected to the pins turning black so that these pins can be labelled accordingly.

Andrew Hutton,
Pensby, Wirral.

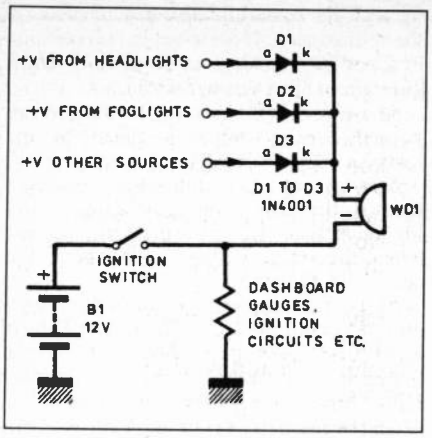

Fig. 3a. Lights-On Alert circuit.

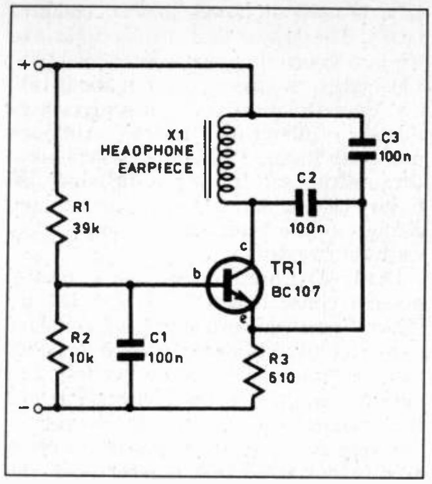

Fig. 3b. Audio tone oscillator.

Simple Lights-On Alert

– helps avoid flat batteries

When driving in rainy or foggy weather it's very easy to forget that you have left your headlights on, and to return to a car with a flat battery which is incapable of starting the engine. If your car isn't fitted with a warning device then you can "do-it-yourself" with my simple circuit shown in Fig. 3a. It costs less than £1 and is easy to connect.

The design consists of a sounder driven by a logic circuit such that whenever the lights are ON, and the ignition is OFF, the sounder is enabled. A piezo type could be used which simply requires a d.c. supply, alternatively a sounder element such as a headphone earpiece could be utilised if driven by a suitable oscillator (e.g. Fig. 3b).

Typical discrete logic circuits use transistors in order to enable the sounder only when the lights are *on* and the ignition is *off*. However, my circuit offers the ultimate in simplicity – consisting only of diodes acting simultaneously as a diode switch which turns off when the ignition is on, plus an OR circuit which detect when any lights or other loads are on.

When the ignition is ON, the battery voltage is applied through the sounder to the cathodes (k) of the diodes, which are reverse biased and therefore do not conduct. If a light or other load is on, then the anode (a) of the corresponding diode is at the positive supply voltage also, so the sounder will still not operate.

However when the ignition is OFF, then the negative lead of the sounder will be shunted to earth via dashboard gauges, ignition circuitry, panel lights etc. If any of the headlamps are on, then its corresponding diode becomes forward biased and so the sounder will now operate.

The resistance of the dashboard and ignition circuits is negligible compared with the sounder's resistance and creates little voltage drop. The circuit can also warn against other loads being left switched on, by adding a diode as necessary.

Plamen Petkov,
London W14.

Voltage Drop Car Alarm

– guards against car crime

The circuit diagram shown in Fig. 4 is a Simple Voltage Drop Car Alarm which will trigger on opening the car doors, provided that a courtesy light is fitted. Exit and entry delays are included to allow the alarm to be armed by a small concealed switch within the car.

On entering the car, a low power sounder operates indicating that the alarm has triggered. The owner then has several seconds to disarm the alarm before a siren sounds. If the alarm is not de-activated then the siren will continue to sound for approximately 45 seconds, after which the alarm is automatically reset.

The circuit of the Voltage Drop Car Alarm is divided into four sections – exit, entry and alarm delays plus volt drop sensing. In Fig. 4, once power has been applied to the alarm circuit via a concealed switch (i.e. +12V to P1) capacitor C2 charges through resistor R2; this generates an exit delay of approximately 12 seconds before the Schmitt inverter IC3a sets the monostable IC1 out of its previous reset condition by taking IC1 pin 4 "high".

The voltage drop created by the door operated courtesy light is amplified by IC2. Two non-inverting cascaded op.amps together with associated components set the voltage gain at a level sufficient to provide consistent alarm triggering.

As the courtesy lamp illuminates, the initial voltage-drop sensed is amplified to the point where pin 2 (trigger) of the monostable IC1 is taken below its trigger threshold of approximately 4V. At this point, the monostable is triggered and the low power sounder WD1. operates. Capacitor C3 now charges through R3 allowing an entry delay of about 10 seconds.

After this time has elapsed, the output of the Schmitt inverters IC3c and IC3d (pins

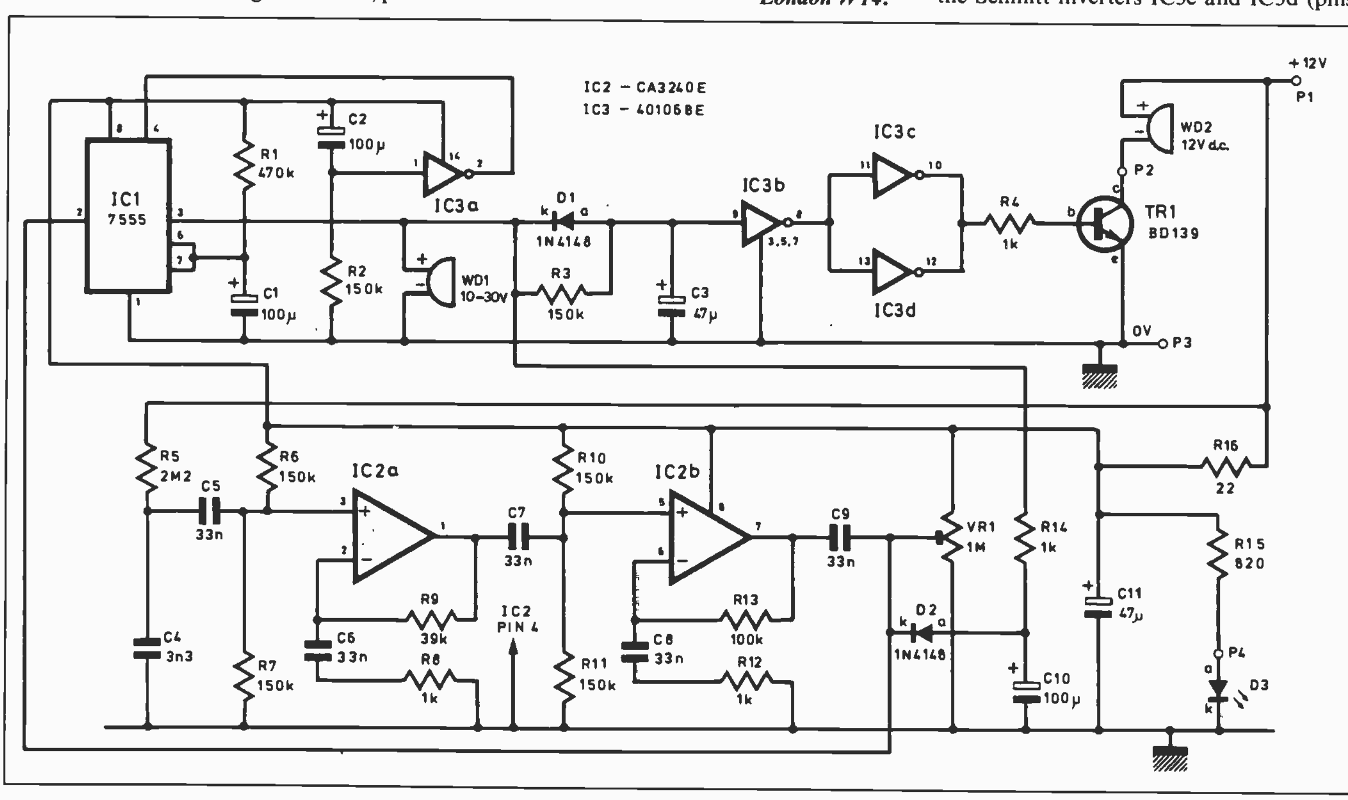

Fig. 4. Circuit diagram for a Voltage Drop Car Alarm. WD1 is a low power p.c.b. mounting piezo sounder operating from 10V to 30V and WD2 is a high power miniature piezo siren capable of 115dB output.

10 and 12 respectively) go high, switching on transistor TR1. This completes the circuit to the high power siren WD2 which sounds. Further alarm triggering is disabled since R14 together with diode D2 hold IC1 pin 2 high until the monostable has timed out – approximately 50 seconds. Then the voltage on IC1 pin 2 falls as C10 discharges. Whilst the alarm is not triggered, the voltage at IC1 pin 2 should settle at 7V (nominally set by VR1), allowing the alarm to trigger again if necessary.

It's probably best to mount siren WD2 in the engine compartment away from hot components, with the alarm circuit fitted into a suitable box placed out of sight in the passenger compartment. Connect to the 12V rail via a 1A in-line fuse connected as close as possible to the origin of the supply. In order to deter opportunists, the l.e.d. D3 should be positioned in clear view and connected by a suitable lead.

Guy Nicholson,
Harlow, Essex.

L.E.D. Voltmeter

– for car, caravan or boat

An L.E.D. Voltmeter circuit diagram designed for automotive, caravanning or possibly marine use is shown in Fig. 5. When the electrical supply voltage is between 12V to 14V volts then everything could be considered as "normal" but if the voltage ever falls outside of this range then this circuit will offer an immediate warning.

The warning is effected by a row of ten l.e.d.s. which light at different voltages over the required range. The device was primarily designed for a car where I mainly needed to know, at a glance, whether conditions had changed from their normal values.

An LM3914 bar driver integrated circuit, IC1, is used to power the ten coloured l.e.d.s. The lowest l.e.d. extinguishes and the next lowest illuminates at about 11·5V. The highest two change over at about 15V, and intermediate l.e.d.s light progressively in steps of about 0·4V to 0·5V. Although not quite linear, I find this system ideal because one can quickly learn which arbitrary l.e.d. is normally alight so that any change in the l.e.d. display immediately warns of an event.

Diode D1 protects against a reverse polarity connection. D2, D3 and D4 are Zener diodes which were to hand and gave a correct overall Zener voltage together with a reasonable mix of positive and negative temperature co-efficients. Pin 9 of IC1 connects to pin 11 to provide a "moving dot" display. In practice, I never need to look at the l.e.d. numbers, only the change in the l.e.d. colour pattern.

Resistor R1a/b controls the current through the l.e.d.s and also has an effect on the voltage span. It consisted of two resistors in series to produce a value of 1k47 which gives about 8mA through each l.e.d.

Resistor R2 also controls the overall voltmeter range which is given by the formula $1{\cdot}25\,(1 + R2/R1)$.

Because of the fluctuating current through the Zeners, the span is marginally higher. Resistor R3 limits the Zener current when the input voltage rises above the combined Zener voltage.

All l.e.d.s extinguish at about 10·5 volts and this could the first sign of engine starting troubles, perhaps poor connections or a failing battery. When in my case increasingly "higher" l.e.d.s consistently came on when the engine was running, I checked the electrical system and cured it by changing a faulty voltage regulator in my alternator.

David L. Dewey,
Bovingdon, Herts.

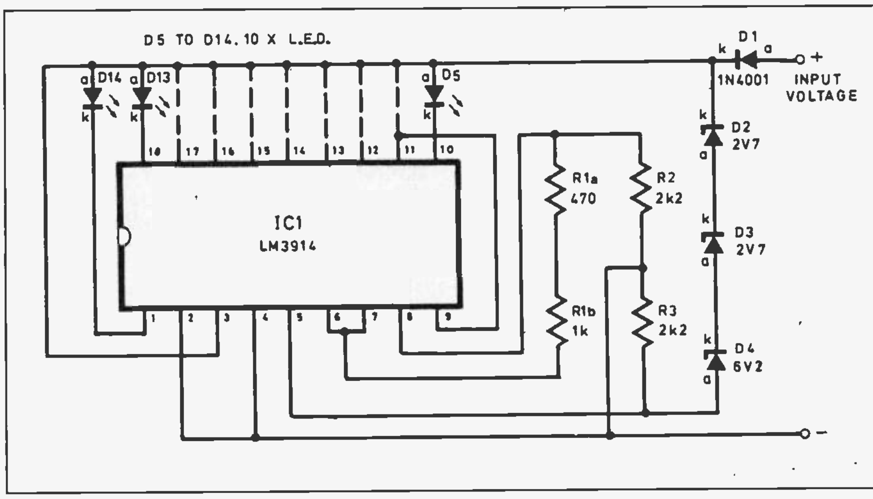

Fig. 5. Circuit diagram for the L.E.D. Voltmeter.

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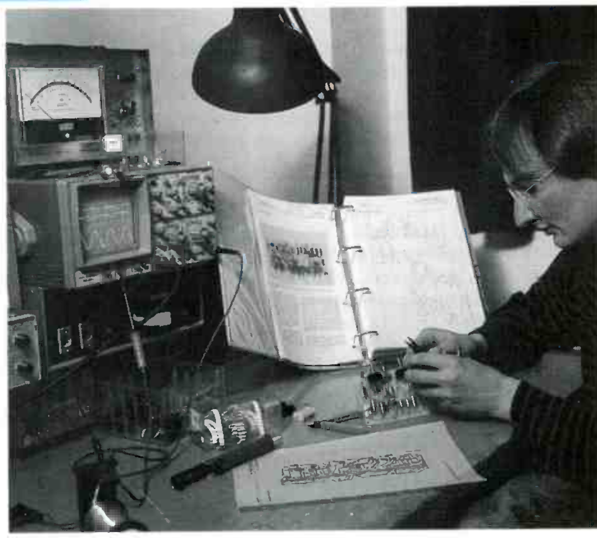

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Electronics from the Ground Up

Mike Tooley, BA

Part 2

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In this second part we introduce a number of important new concepts including capacitance, inductance, reactance and impedance. We also introduce the use of the function generator and oscilloscope and make use of both of these instruments to investigate the behaviour of wave-shaping and phase-shifting circuits.

CAPACITANCE

A pair of parallel plates is said to exhibit capacitance since a quantity of charge must be placed on the plates in order to produce a potential difference between them. As a consequence, any change in the potential difference between the plates of a capacitor will result in a change in the amount of charge present.

A capacitor is, in effect, a *reservoir* for charge. Typical applications include reservoir and smoothing capacitance for use in power supplies, coupling a.c. signals between the stages of amplifiers, and decoupling supply rails (i.e., effectively grounding the supply rails to residual a.c. signals and noise).

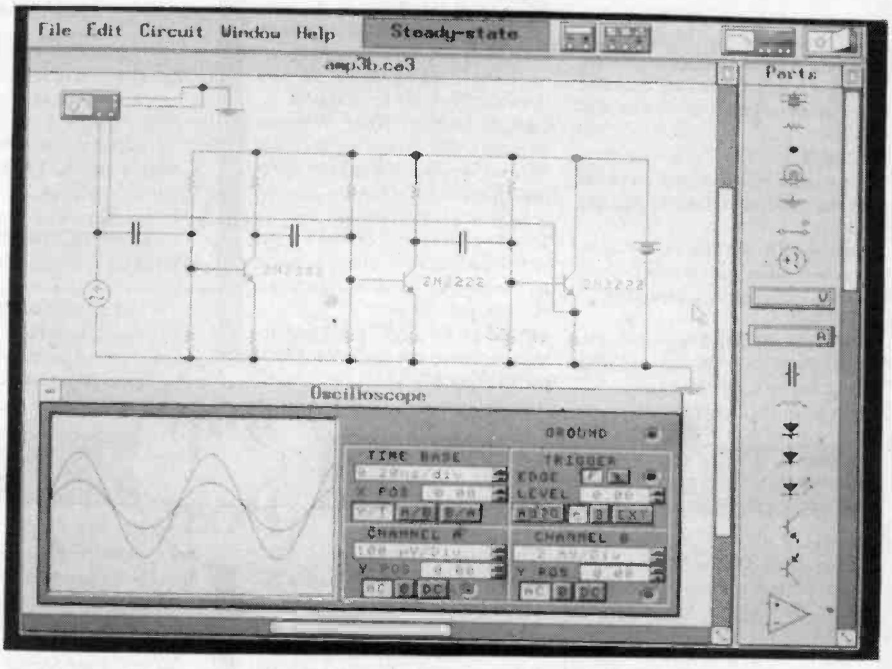
A capacitor need consist of nothing more than two parallel metal plates as shown in Fig. 2.1. The material between the plates (air, mica, polystyrene, etc) is known as the dielectric).

When the capacitor in Fig. 2.1 is connected to a battery (Fig. 2.2) the potential difference (Voltage, V) will cause a positive charge to appear on plate A and an equal, but opposite, negative charge to appear on plate B. In this condition, an electric field will be set up in the space between the plates (i.e., within the dielectric material). The electric field lines show the direction in which a free positive charge would move. If the battery is reversed, the charge and field lines will simply be reversed (as shown in Fig. 2.3.).

In order to explain the action of a capacitor, assume that the capacitor shown in Fig. 2.1 is placed in the circuit shown in Fig. 2.4a. If the switch is left open, no charge will appear on the plates and in this condition there will be no electric field in the space between the plates nor any charge stored in the capacitor.

If, however, the switch is closed (as shown in Fig. 2.4b), electrons will be attracted from the positive plate to the positive terminal of the battery. At the same time, a similar number of electrons will move from the negative terminal of the battery to the negative plate. This sudden movement of electrons will manifest itself in a momentary surge of current (current will flow from the positive terminal of the battery into the positive terminal of the capacitor).

Eventually, enough electrons will have



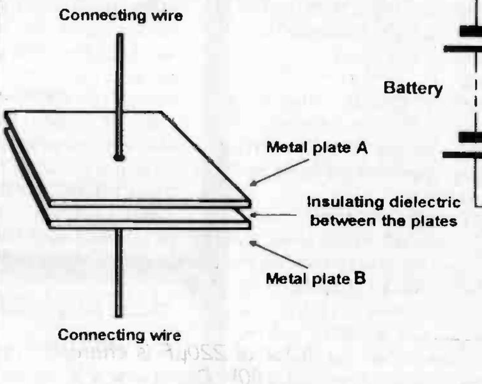


Fig. 2.1 A simple parallel-plate capacitor.

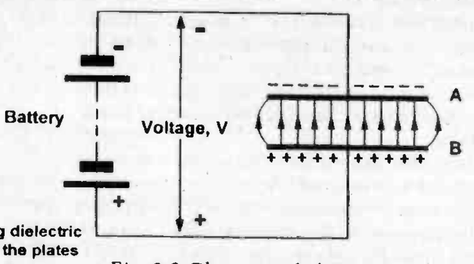


Fig. 2.2 Charge and electric field lines within a capacitor when a voltage is applied to it.

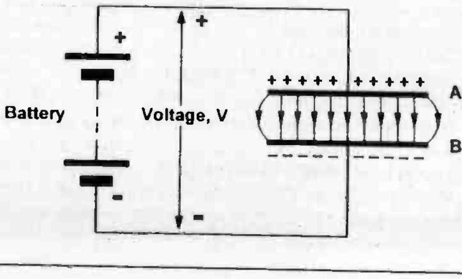


Fig. 2.3 (Right) Effect of reversing the applied voltage in Fig. 2.2.

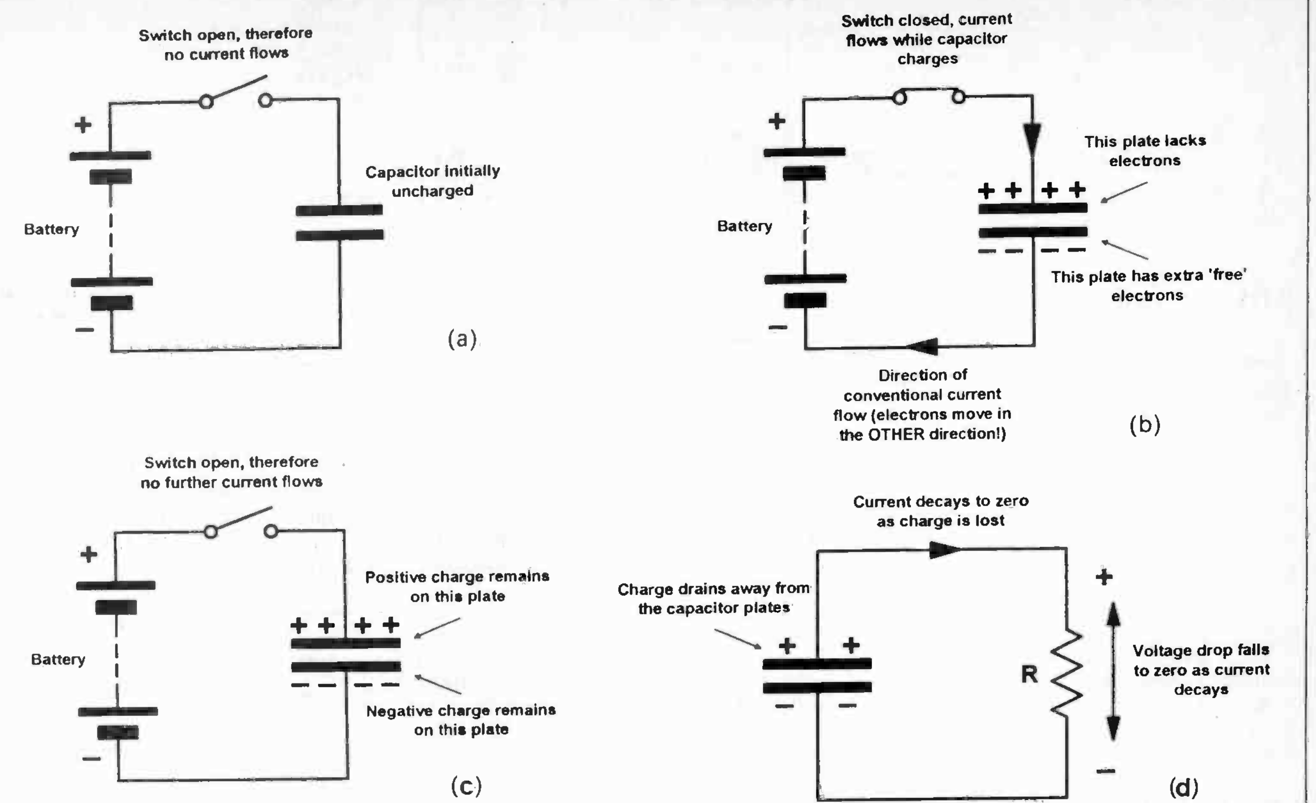


Fig. 2.4 Circuit to illustrate capacitor action: (a) Initial condition, switch open, capacitor uncharged; (b) Switch closed, capacitor charges rapidly; (c) Switch open, charge remains within the capacitor; (d) Stored charge draining away through a resistor.

moved to make the e.m.f. (electromotive force) between the plates the same as that of the battery. In this state, the capacitor is said to be fully charged and an electric field will be present in the space between the two plates. The voltage across the plates increases at a rate which depends upon the product of capacitance (C) and resistance (R) present in the circuit. This quantity (C × R) is known as the *time constant* of the circuit.

If, at some later time the switch is opened (as shown in Fig. 2.4c), the positive plate will be left with a deficiency of electrons whilst the negative plate will be left with a surplus. Furthermore, since there is no path for current to flow between the two plates the capacitor will remain charged and a potential difference will be maintained between the plates.

Now assume that a resistor is connected to the capacitor (as shown in Fig. 2.4d). The excess electrons on the negative plate will flow through the resistor to the positive plate until a neutral state once again exists (i.e., until there is no excess charge on either plate). In this state the capacitor is said to be fully discharged and the electric field between the plates will have disappeared. The movement of electrons during the discharging of the capacitor will again result in a momentary flow of current (current will flow from the positive terminal of the capacitor into the resistor).

THE FARAD

The unit of capacitance is the Farad (F) and a capacitor is said to exhibit a capacitance of 1F if a voltage of 1V would appear across its plates when a charge of 1C is present.

(Note that, conventionally in *EPE*, the 'F' suffix is omitted from units of capacitance, though for this series it will be included where appropriate.)

The charge or quantity of electricity that can be stored in the electric field between the capacitor plates is proportional to the applied voltage and the capacitance of the capacitor. Thus:

$$Q = C\,V$$

where Q is the charge (in Coulombs), C is the capacitance (in Farads), and V is the potential difference (in Volts).

Example

A 10µF capacitor is charged to a potential of 50V. Determine the charge stored.

The charge stored will be given by:

$$Q = C \times V = 10 \times 10^{-6} \times 50 = 500\mu C$$

(microCoulombs)

Energy storage

The energy stored in a capacitor is proportional to the product of the capacitance and the square of the potential difference. Thus:

$$E = \tfrac{1}{2}CV^2$$

where E is the energy (in Joules), C is the capacitance (in Farads), and V is the potential difference (in Volts).

Example

A capacitor of 220µF is charged from a supply of 100V. Determine the energy stored in the capacitor.

Since $E = \tfrac{1}{2}CV^2$ the energy stored within the capacitor will be given by:

$$E = \tfrac{1}{2} \times 220 \times 10^{-6} \times (100^2)$$
$$= 110 \times 10^{-6} \times 10^4$$
$$= 110 \times 10^{-2} = 0{\cdot}11J$$

Example

A capacitor of 47µF is required to store an energy of 4J. Determine the potential difference which must be applied.

The foregoing formula can be re-arranged to make V the subject as follows:

$$V = \left(\frac{E}{0{\cdot}5C}\right)^{0\cdot5} = \left(\frac{2E}{C}\right)^{0\cdot5} = \left(\frac{2 \times 4}{47 \times 10^{-6}}\right)^{0\cdot5}$$

$$= 413V$$

Practical assignment 2.1: Capacitors

In this you will investigate the behaviour of a simple C-R circuit.

Objectives:

2.1.1 To investigate the growth of potential difference across the plates of a capacitor whilst it is being charged.

2.1.2 To investigate the decay of potential difference across the plates of a capacitor whilst it is being discharged.

Instructions:

1. Connect the circuit shown in Fig. 2.5. The voltmeter is used to indicate the potential difference across the capacitor plates whilst the switch (which can be operated using the 1 key on your keyboard) determines whether the capacitor is being charged via a 100kΩ resistor from the 10V supply or discharged through another 100kΩ resistor.
2. Switch on the power to your circuit. Operate the switch (using the 1 key) and allow the capacitor to charge. Using the built-in clock display at the top of the screen, measure the potential difference across the capacitor plates after each interval of 50s. Record your results in Table 2.1.
3. When the time reaches 600s, the capacitor can be considered to be fully

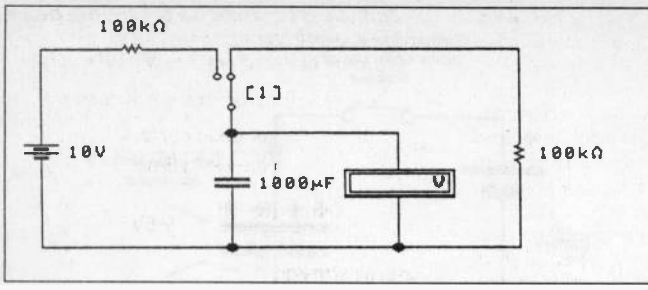


Fig. 2.5 Circuit for Assignment 2.1.

Table 2.1 Measured values for Assignment 2.1.

Time (s)	0	50	100	150	200	250	300	350	400	450	500	550	600
Voltage (V)													

Table 2.2 Measured values for Assignment 2.1.

Time (s)	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
Voltage (V)													

charged (the potential difference across the plates should be very close to 10V). Now operate the switch (using the 1 key) to allow the capacitor to discharge. Continue recording the potential difference after each interval of 50s. Show your results in Table 2.2.

4. Use the results from Tables 2.1 and 2.2 to plot graphs showing potential difference plotted against time for charge and discharge respectively. Note that the time axis values for the discharge graph are found by subtracting 600 (the point at which you initiated the discharge cycle) from each clock reading. Your graphs should look like those shown in Fig. 2.6 and Fig. 2.7.
5. Determine the time constant (C × R) of the circuit and mark this on the time scale of each graph. Determine the voltage that appears across the plates of the capacitor at this point.

Conclusions:

To what extent have the objectives for this assignment been met? Comment on the shape of the graphs. After what time is it reasonable to consider that the capacitor is fully charged or fully discharged? Relate this to the time constant.

Series and parallel combination of capacitors

In order to obtain a particular value of capacitance, fixed capacitors may be arranged in either series or parallel (Fig. 2.8 and Fig. 2.9).

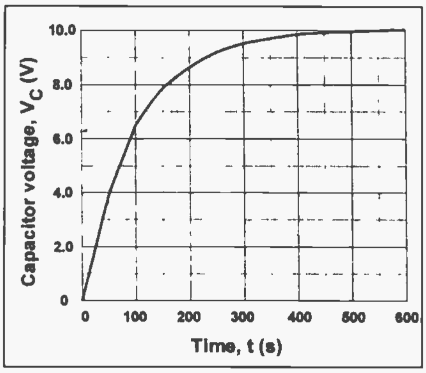


Fig. 2.6 Capacitor voltage plotted against time (charge).

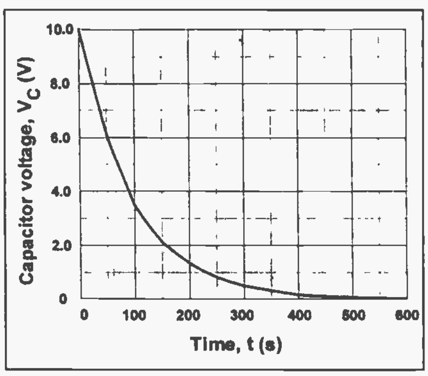


Fig. 2.7 Capacitor voltage plotted against time (discharge).

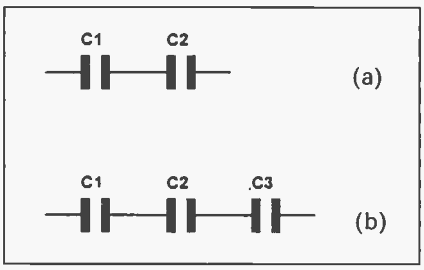


Fig. 2.8 Series connected capacitors: (a) two capacitors in series; (b) three capacitors in series.

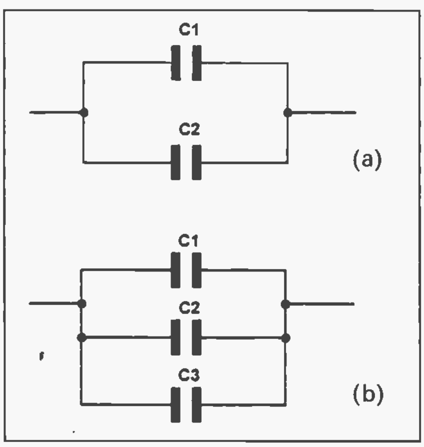


Fig. 2.9 Parallel connected capacitors: (a) two capacitors in parallel; (b) three capacitors in parallel.

The reciprocal of the effective capacitance of each of the series circuits shown in Fig. 2.8 is equal to the sum of the reciprocals of the individual capacitances. Hence, for Fig. 2.8a:

$$\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}$$

whilst for Fig. 2.8b:

$$\frac{1}{C}=\frac{1}{C_1}+\frac{1}{C_2}+\frac{1}{C_3}$$

In the former case, the formula can be more conveniently re-arranged as follows:

$$C=\frac{C_1\times C_2}{C_1+C_2}$$

(This can be simply remembered as the product of the two capacitor values divided by the sum of the two values.)

For parallel arrangements of capacitors, the effective capacitance of the circuit is simply equal to the sum of the individual capacitances. Hence, for Fig. 2.9a:

$$C = C_1+C_2$$

Whilst for Fig. 2.9b:

$$C = C_1+C_2+C_3$$

Example

What value of capacitance should be connected in parallel with a 1µF capacitor to make a total capacitance of 3·2µF?

Now $C=C_1+C_2$ where $C=3{\cdot}2\mu F$
and $C_1=1\mu F$

thus $C_2=C-C_1=3{\cdot}2\mu F-1\mu F=2{\cdot}2\mu F$

Example

Two capacitors, each of 10nF are wired in series. Determine the effective capacitance of this combination.

Now $C=\dfrac{C_1\times C_2}{C_1+C_2}$ where $C_1=C_2=10nF$

thus $C=\dfrac{10n\times 10n}{10n+10n}=\dfrac{100n}{20n}=5nF$

INDUCTANCE

Inductance is the property of a coiled conductor that opposes a change in the value of current flowing in it. Any change in the current applied to a coil/inductor will result in an induced voltage appearing across it. An inductor need consist of nothing more than a coiled conductor wound onto an air or ferromagnetic core, as shown in Fig. 2.10.

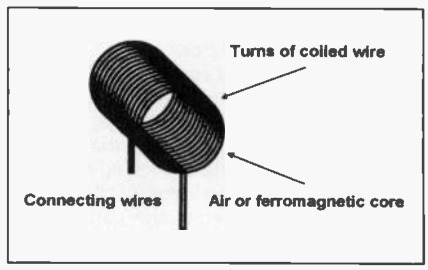


Fig. 2.10 A simple air-cored inductor.

In practice every coil comprises both inductance and resistance and the circuit of Fig. 2.11 shows these as two discrete components. In reality the inductance and resistance are both distributed throughout the component but it is convenient to treat the inductance and resistance as separate components in a detailed analysis of the circuit.

In order to explain the action of an inductor, assume that the inductor shown in Fig. 2.10 is wound on a magnetic core, as

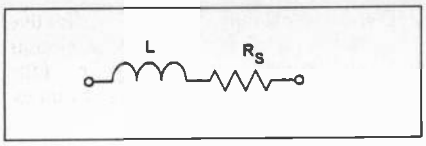


Fig. 2.11 Equivalent circuit of a coil or choke containing inductance and series loss resistance.

shown in Fig. 2.12. When the inductor is connected to a battery, a current will flow in the inductor and a magnetic field will be set up in the core. The magnetic field lines show the direction in which a free north pole would move. If the battery (and current) is reversed, the field lines will simply be reversed (as shown in Fig. 2.13).

Now consider the circuit shown in Fig. 2.14 which shows the inductor together with its d.c. loss resistance connected to a battery via a switch. If the switch is left open (Fig. 2.14a), no current will flow and no magnetic field will appear in the core.

If the switch is now closed (Fig. 2.14b), current will begin to flow as energy is taken from the supply in order to establish the magnetic field. However, the change in magnetic flux resulting from the appearance of current creates a voltage (an induced e.m.f.) across the coil which *opposes* the applied e.m.f. from the battery.

The induced e.m.f. results from the changing flux and it effectively prevents an instantaneous rise in current in the circuit. Instead, the current increases slowly to a maximum at a rate which depends upon the ratio of inductance (L) to resistance (R) present in the circuit. This quantity (L/R) is known as the *time constant* of the circuit.

After a while, a steady state condition will be reached in which the voltage across the inductor will have decayed to zero and the current will have reached a maximum value (determined by the ratio of V to R, i.e., Ohm's Law).

If, after this steady state condition has been achieved, the switch is opened (Fig. 2.14c), the magnetic field will suddenly collapse and the energy will be returned to the circuit in the form of a "back e.m.f." which will appear across the coil as the field collapses.

The Henry

The unit of inductance is the Henry (H) and a coil is said to have an inductance of 1H if a voltage of 1V is induced across it when a current changing at the rate of 1A/s is flowing in it.

The voltage induced across the terminals of an inductor will thus be proportional to the product of the inductance (L) and the rate of change of current. Hence:

$$e = -L \times \text{(rate of change of current)}$$

(Note that the minus sign indicates the polarity of the voltage, i.e., in opposition to the change.)

Example

A current increases uniformly from 2A to 6A in a period of 250ms. If this current is applied to an inductor of 600mH, determine the voltage induced.

Now the induced voltage will be given by:

$$e = -L \times \text{(rate of change of current)}$$

$$\text{thus } e = -L \times \frac{\text{change in current}}{\text{change in time}}$$

$$= \frac{0{\cdot}6 \times (6-2)}{0{\cdot}25} = -9{\cdot}6\text{V}$$

Energy storage

The energy stored in an inductor is proportional to the product of the inductance and the square of the current. Thus:

$$E = \tfrac{1}{2} L I^2$$

where E is the energy (in Joules), L is the inductance (in Henries), and I is the current (in Amps).

Example

An inductor of 20mH is required to store an energy of 2·5J. Determine the current which must be applied.

The foregoing formula can be re-arranged to make I the subject as follows:

$$I = \left(\frac{E}{0{\cdot}5\ L}\right)^{0{\cdot}5} = \left(\frac{2E}{L}\right)^{0{\cdot}5}$$

$$= \left(\frac{2 \times 2{\cdot}5}{20 \times 10^{-3}}\right)^{0{\cdot}5} = 15{\cdot}811\text{A}$$

Practical assignment 2.2: Inductors

In this assignment you will investigate the behaviour of a simple L-R circuit.

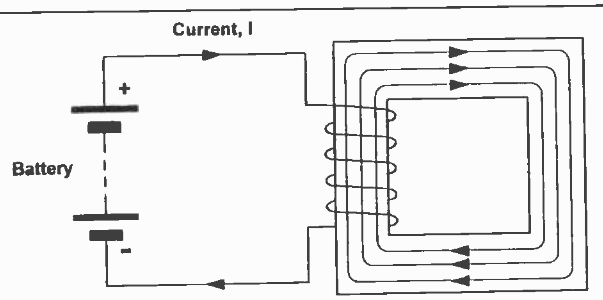


Fig. 2.12 Magnetic field lines within an inductor when current is flowing through it.

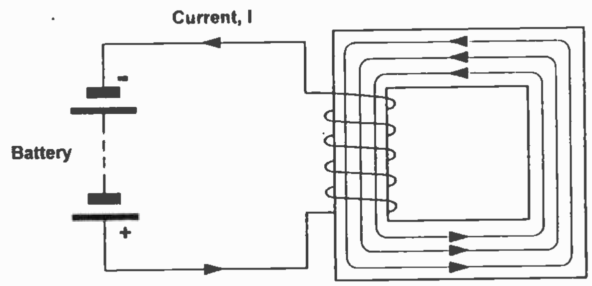
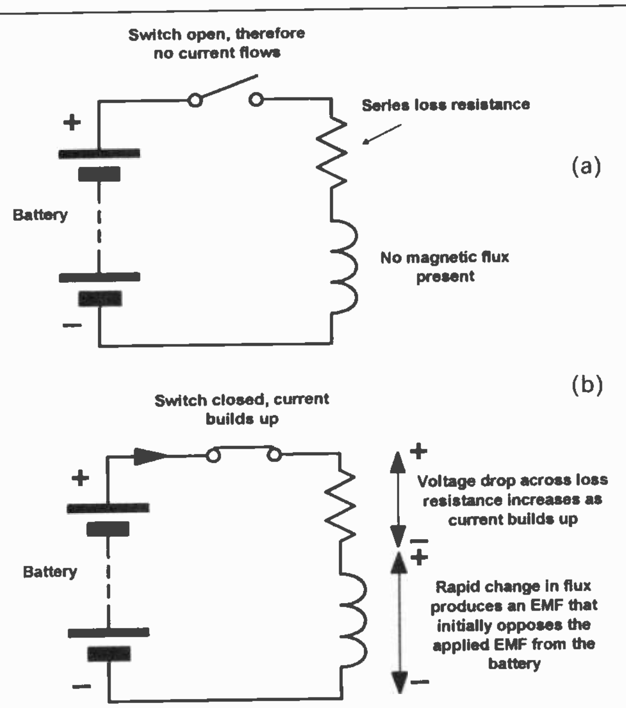


Fig. 2.13 Effect of reversing the current in Fig. 2.2.



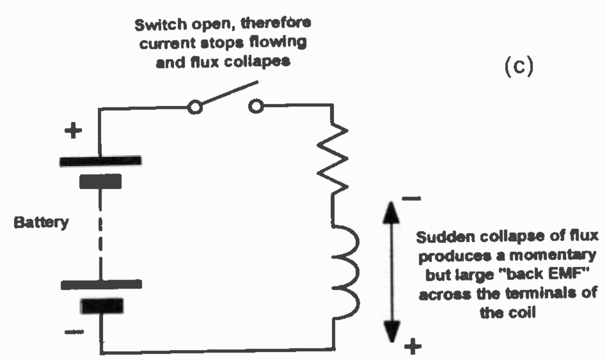


Fig. 2.14 Circuit to illustrate inductor action: (a) Initial condition, switch open, no flux present; (b) Switch closed, current and flux build up rapidly; (c) Switch open, flux collapses as current is removed.

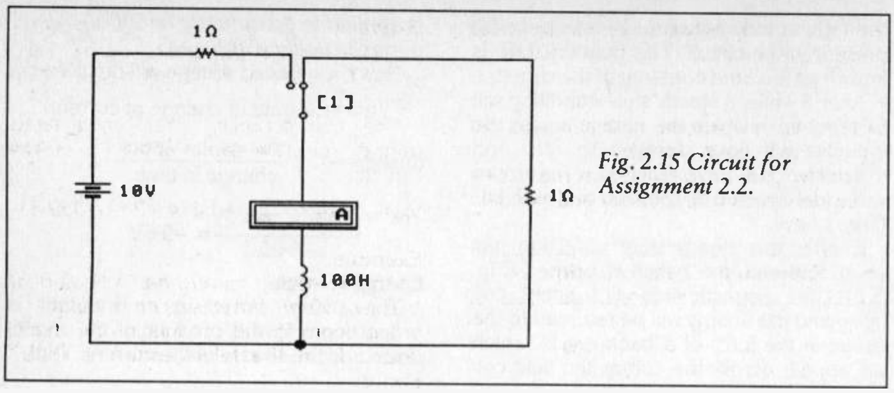


Fig. 2.15 Circuit for Assignment 2.2.

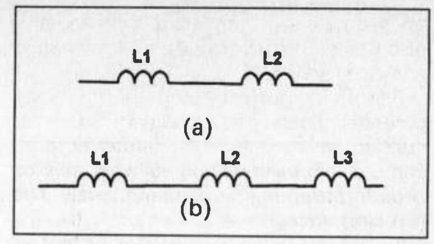


Fig. 2.18 Series connected inductors: (a) two inductors in series; (b) three inductors in series.

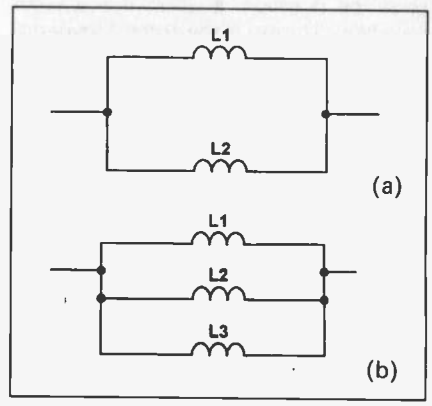


Fig. 2.19 Parallel connected inductors: (a) two inductors in parallel; (b) three inductors in parallel.

Table 2.3 Measured values for Assignment 2.2.

Time (s)	0	50	100	150	200	250	300	350	400	450	500	550	600
Current (A)													

Table 2.4 Measured values for Assignment 2.2.

Time (s)	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200
Current (A)													

Objectives:

2.2.1 To investigate the growth of current in an inductor when it is connected to a supply.

2.2.2 To investigate the decay of current in an inductor when it is disconnected from a supply.

Instructions:

1. Connect the circuit shown in Fig. 2.15. The ammeter is used to indicate the current in the inductor whilst the switch (which can be operated using the 1 key on your keyboard) determines whether the inductor is connected to, or disconnected from, the supply.
2. Switch on the power to your circuit. Operate the switch (using the 1 key) and connect the inductor to the supply. Using the built-in clock display at the top of the screen, measure the current flowing in the inductor after each interval of 50s. Record your results in Table 2.3.
3. When the time reaches 600s, (the current flowing should be very close to 10A). Now operate the switch (using the 1 key) to disconnect the inductor from the supply. Continue recording the current flowing after each interval of 50s. Show your results in Table 2.4.
4. Use the results from Tables 2.3 and 2.4 to plot graphs showing current plotted against time in the same way as for Assignment 2.1. respectively. Note that the time axis values for the second graph are found by subtracting 600 (the point at which you operated the switch) from each clock reading. Your graphs should look like those shown in Fig. 2.16 and Fig. 2.17.
5. Determine the time constant (L/R) of the circuit and mark this on the time scale of each graph. Determine the current that flows in the inductor at this point.

Conclusions:

To what extent have the objectives for this assignment been met? Comment on the shape of the graphs. After what time is it reasonable to consider that there is no further change in the inductor current? Relate this to the time constant.

Series and parallel combinations of inductors

In order to obtain a particular value of inductance, fixed inductors may be arranged in either series or parallel as shown in Fig. 2.18 and Fig. 2.19.

The effective inductance of each of the series circuits shown in Fig. 2.18 are simply equal to the sum of the individual inductances. Hence, for Fig. 2.18a:

$$L = L_1 + L_2$$

Whilst for Fig. 2.18b:

$$L = L_1 + L_2 + L_3$$

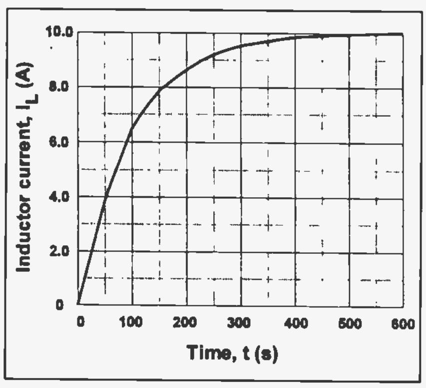


Fig. 2.16 Inductor current plotted against time (current growth).

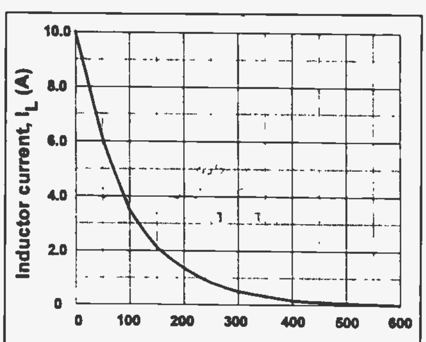


Fig. 2.17 Inductor current plotted against time (current decay).

Turning to the parallel inductors shown in Fig. 2.19, the reciprocal of the effective inductance of each circuit is equal to the sum of the reciprocals of the individual inductances. Hence, for Fig. 2.19a:

$$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2}$$

whilst for Fig. 2.19b:

$$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

In the former case, the formula can be more conveniently re-arranged as follows:

$$L = \frac{L_1 \times L_2}{L_1 + L_2}$$

(This can be simply remembered as the product of the two inductance values divided by the sum of the two values.)

Example

A 10mH inductor is connected in parallel with a 47mH inductor. What is the effective inductance of this combination?

$$\text{Now} \quad L = \frac{L_1 \times L_2}{L_1 + L_2} = \frac{10\text{m} \times 47\text{m}}{10\text{m} + 47\text{m}}$$

$$= \frac{470\text{m}}{57\text{m}} = 8{\cdot}25\text{mH}$$

Example

Three inductors of 27mH are connected in series. Determine the effective inductance of this combination.

$$\text{Now} \quad L = L_1 + L_2 + L_3$$
$$= 27\text{m} + 27\text{m} + 27\text{m} = 81\text{mH}$$

AC CIRCUITS

So far in *Electronics from the Ground Up* we have dealt with currents that, even though their magnitudes may vary, essentially flow only in one direction. These are direct currents. Alternating currents, on the other hand, are bidirectional and continuously reversing their direction of flow. The polarity of the e.m.f. which produces an alternating current must consequently also be changing from positive to negative, and vice versa.

Alternating currents produce alternating potential differences (voltages) in the circuits in which they flow. Furthermore, in some circuits, alternating voltages may be superimposed on direct voltage levels. The resulting voltage may be unipolar (i.e., always positive or always negative) or bipolar (i.e., partly positive and partly negative).

Waveforms

A graph showing the variation of voltage or current present in a circuit is known as a waveform. The are many common types of waveform encountered in electrical circuits including sine (or sinusoidal), square, triangle, ramp or sawtooth (which may be either positive or negative going), and pulse. Complex waveforms like speech or music usually comprise many components at different frequencies. Pulse waveforms are often categorized as either repetitive or non-repetitive (the former comprises a pattern of pulses which regularly repeats, whilst the latter comprises pulses which constitute a unique event). Several of the most common waveform types are shown in Fig. 2.20.

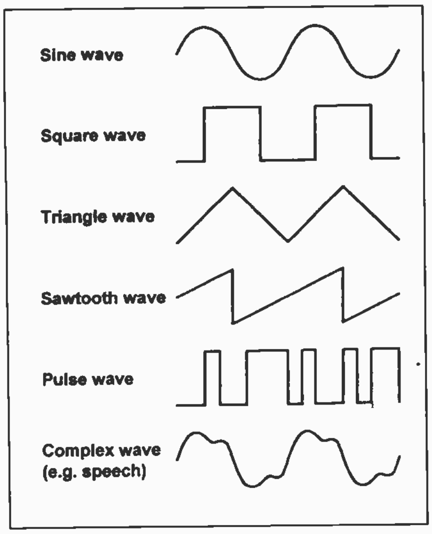


Fig. 2.20 Some common waveforms.

Frequency and periodic time

The frequency of a repetitive waveform is the number of cycles of the waveform which occur in unit time. Frequency is expressed in Hertz (Hz). A frequency of 1Hz is equivalent to one cycle per second. Hence, if a voltage has a frequency of 400Hz, 400 cycles will occur in every second.

The periodic time (or period) of a waveform is the time taken for one complete cycle of the wave (see Fig. 2.21).

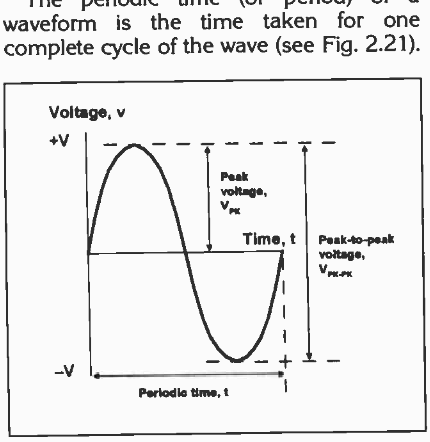


Fig. 2.21 One cycle of a sine wave.

The relationship between periodic time and frequency is thus:

$$t = 1/f \quad \text{or} \quad f = 1/t$$

where t is the periodic time (in seconds) and f is the frequency (in Hz).

The following table gives some representative values of frequency and periodic time:

Frequency	Periodic time
1Hz	1s
10Hz	100ms
50Hz	20ms
100Hz	10ms
400Hz	2·5ms
1kHz	1ms
10kHz	100µs
100kHz	10µs
1MHz	1µs

Example

A waveform has a frequency of 400Hz. What is the periodic time of the waveform?

$$t = 1/f = 1/400 = 0{\cdot}0025\text{s (or } 2{\cdot}5\text{ms)}$$

Hence the waveform has a periodic time of 2·5ms.

Example

A waveform has a periodic time of 40ms. What is its frequency?

$$f = 1/t = \frac{1}{40 \times 10^{-3}} = \frac{1}{0{\cdot}04} = 25\text{Hz}$$

Hence the frequency is 25Hz.

Average, peak, peak-peak, and r.m.s. values

The average value of an alternating current which swings symmetrically above and below zero will obviously be zero when measured over a long period of time. Hence average values of currents and voltages are invariably taken over a complete half-cycle (either positive or negative) rather than over on complete full-cycle (which would result in an average value of zero).

The amplitude (or peak value) of a waveform is a measure of the extent of its voltage or current excursion from the resting value (usually zero). The peak-to-peak value for a wave which is symmetrical about its resting value is twice its peak value (see Fig. 2.21).

The root mean square (r.m.s. or effective) value of an alternating voltage or current is the value which would produce the same heat energy in a resistor as a direct voltage or current of the same magnitude. The r.m.s. value of a waveform is very much dependent upon its shape. Thus r.m.s. values are, therefore, only meaningful when dealing with a waveform of known shape. Where the shape of a waveform is not specified, r.m.s. values are normally assumed to refer to sinusoidal conditions.

For a given waveform, a set of fixed relationships exists between average, peak, peak-peak, and r.m.s. values. The required multiplying factors are summarized below for sinusoidal voltages and currents:

Given qty.	Wanted quantity			
	av.	peak	p-p	r.m.s.
average	1	1·57	3·14	1·11
peak	0·636	1	2	0·707
peak-peak	0·318	0·5	1	0·353
r.m.s.	0·9	1·414	2·828	1

Example

A sinusoidal voltage has an r.m.s. value of 240V. What is the peak value of the voltage?

The corresponding multiplying factor (found from the table above) is 1·414. Hence:

$$V_{pk} = 1{\cdot}414 \times V_{r.m.s.} = 1{\cdot}414 \times 240 = 339{\cdot}4\text{ V}$$

Example

An alternating current has a peak-peak value of 50mA. What is its r.m.s. value?

The corresponding multiplying factor (found from the table above) is 0·353. Hence:

$$I_{r.m.s.} = 0{\cdot}353 \times I_{pk\text{-}pk}$$
$$= 0{\cdot}353 \times 0{\cdot}05 = 0{\cdot}0177\text{A (or } 17{\cdot}7\text{mA)}$$

Example

A sinusoidal voltage 10V pk-pk is applied to a resistor of 1kΩ. What value of r.m.s. current will flow in the resistor?

This problem must be solved in two stages. First we will determine the peak-peak current in the resistor and then we shall convert this value into a corresponding r.m.s. quantity.

Since: $I = V/R$, $I_{pk\text{-}pk} = V_{pk\text{-}pk}/R$

Hence: $I_{pk\text{-}pk} = 10V_{pk\text{-}pk}/1k\Omega = 10mA_{pk\text{-}pk}$

The required multiplying factor (peak-peak to r.m.s.) is 0·353. Thus:

$$I_{r.m.s.} = 0{\cdot}353 \times I_{pk\text{-}pk}$$
$$= 0{\cdot}353 \times 10\text{mA} = 3{\cdot}53\text{ mA}$$

THE FUNCTION GENERATOR

Electronics Workbench provides a versatile function generator that can be used to generate sine, square and triangle waveforms having a specified frequency, duty cycle, amplitude and d.c. offset. The instrument provides positive and negative (complementary) outputs (this simply means that the voltage at the "–" output is the inverse (opposite) of the voltage at the "+" output). In most applications we only need to use the "+" output and the "com" (common) terminal is taken to ground.

Like ordinary components, you can use the mouse to move the function generator around within the breadboard area. Connections to the function generator are made using the three terminals marked "+", "–" and "com". You can reveal the function generator's front-panel display by simply double clicking on its symbol. Function generator settings can then be very easily adjusted simply by clicking the mouse on the scroll bars or by clicking and entering values in the relevant text box.

THE OSCILLOSCOPE

The oscilloscope in *Electronics Workbench* provides you with a very similar set of controls to those found on a real instrument. The oscilloscope has two channels (A and B) and each channel corresponds to a separate screen trace. The vertical (Y) calibration, in terms of volts per division ("V/Div") can be individually adjusted using the appropriate scroll bars, as can be the vertical offset (using the "Y POS") controls. The input source can be switched between "AC", "0" (ground), and "DC" (you should normally use the "AC" setting when a d.c. voltage is present along with the a.c. signal that you wish to display).

In order to display time related waveforms the "Y/T" button should be selected and the horizontal (X) calibration (in terms of time per division ("ms/div") adjusted to provide

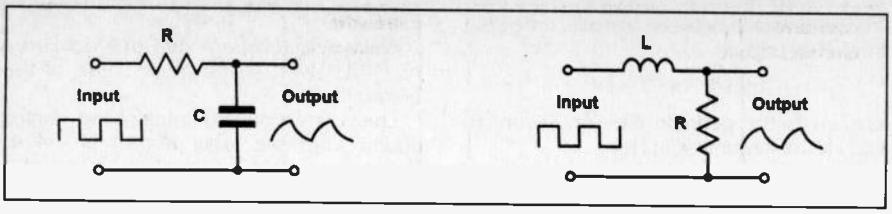


Fig. 2.22 Integrating circuits.

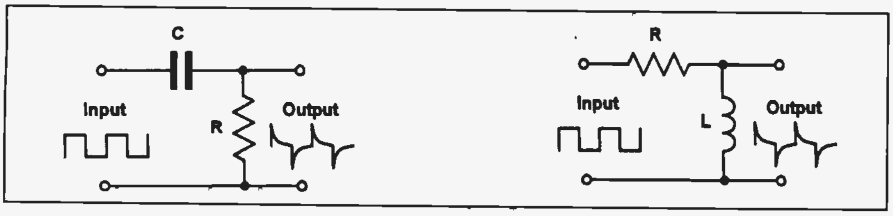


Fig. 2.23 Differentiating circuits.

a suitable time scale. The oscilloscope timebase can be triggered from either channel A or channel B or from an external trigger source. There is also an automatic setting "AUTO" which can cope with most situations. Triggering can also be selected on either the positive or negative edge of an input signal using the "EDGE" selector buttons.

WAVESHAPING CIRCUITS

Simple capacitor-resistor (C-R) and inductor-resistor (L-R) circuits can be used to modify the shape of a square wave or rectangular pulse. A square wave can be converted into a triangle wave approximation by means of the integrating circuits shown in Fig. 2.22. Alternatively, a series of short pulses can be produced by the differentiating circuits shown in Fig. 2.23. The effectiveness of the circuits is determined by the value of time constant (C × R or L/R, as appropriate) in relation to the periodic time. In the case of the integrating circuits, the time constant should be very much larger than the periodic time of the signal. For the differentiating circuits, the time constant should be very much smaller than the periodic time of the signal.

Practical assignment 2.3:

C-R waveshaping circuit

In this assignment you will investigate the behaviour of a simple C-R integrating circuit using a function generator and an oscilloscope.

Objectives:

2.3.1 To investigate the action of a C-R integrating circuit.

2.3.2 To use a function generator and oscilloscope to generate and examine waveforms.

Instructions:

1. Connect the circuit shown in Fig. 2.24 using a capacitor of 1μF. The function generator provides a square wave input voltage whilst the oscilloscope is used to simultaneously display the input and output waveforms. The function generator and oscilloscope should be initially adjusted as shown in Fig. 2.24.
2. Display the waveforms on the screen of the oscilloscope (you should take this opportunity to experiment with the instrument settings until you become familiar with their function). Note the shape of the output waveform (you might like to make a sketch of it) and measure its peak-peak voltage using the vertical scale.
3. Change the value of capacitance to 10μF and repeat stage 2 (you may have to make some adjustment to the channel A calibration and Y position in order to obtain a suitable display).
4. Change the value of capacitance to 0·1μF and repeat stage 2 (again, you may have to make some adjustment to the channel A calibration and Y position in order to obtain a suitable display).
5. Calculate the time constant for each value of capacitor (1μF, 10μF and 0·1μF). Mark the time constant on your waveform sketches.

Conclusions:

To what extent have the objectives for this assignment been met? Can you explain, in your own words, how the circuit works (relate this to Assignment 2.1)? Which value of time constant produces the most effective integration of the waveform? How does this value of time constant relate to the periodic time of the signal?

Practical assignment 2.4:
L-R waveshaping circuit

In this assignment you will investigate the behaviour of a simple L-R differentiating circuit using a function generator and an oscilloscope.

Objectives:

2.4.1 To investigate the action of an L-R integrating circuit.

Fig. 2.24 Circuit and instrument settings for Assignment 2.3.

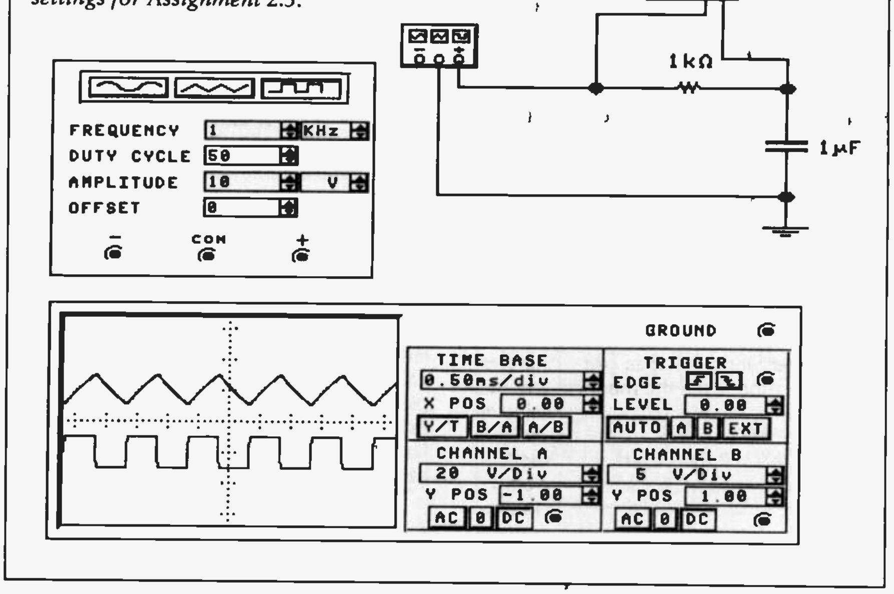
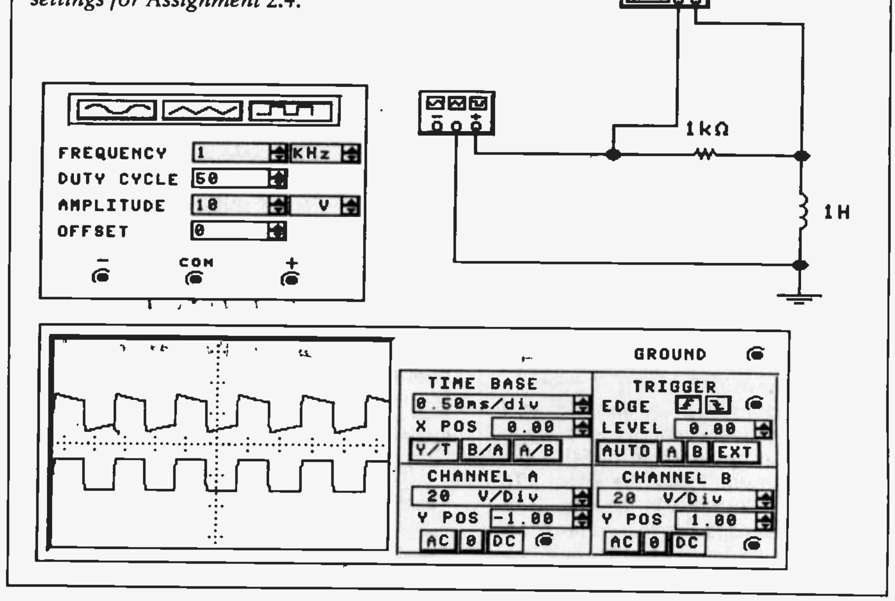


Fig. 2.25 Circuit and instrument settings for Assignment 2.4.



2.4.2 To use a function generator and oscilloscope to generate and examine waveforms.

Instructions:

1. Connect the circuit shown in Fig. 2.25 using an inductor of 1H. The function generator provides a square wave input voltage whilst the oscilloscope is used to simultaneously display the input and output waveforms. The function generator and oscilloscope should be initially adjusted as shown in Fig. 2.25.
2. Display the waveforms on the screen of the oscilloscope (once again, you should take this opportunity to experiment with the instrument settings until you become familiar with their function). Note the shape of the output waveform (you might like to make a sketch of it) and measure its peak-peak voltage using the vertical scale.
3. Change the value of inductance to 10H and repeat stage 2 (you may have to make some adjustment to the channel A calibration and Y position in order to obtain a suitable display).
4. Change the value of inductance to 0·1H and repeat stage 2 (again, you may have to make some adjustment to the channel A calibration and Y position in order to obtain a suitable display).
5. Calculate the time constant for each value of inductor (1H, 10H and 0·1H). Mark the time constant on your waveform sketches.

Conclusions:

To what extent have the objectives for this assignment been met? Can you explain, in your own words, how the circuit works (relate this to Assignment 2.2)? Which value of time constant produces the most effective differentiation of the waveform? How does this value of time constant relate to the periodic time of the signal?

REACTANCE AND IMPEDANCE

When alternating voltages are applied to capacitors or inductors the magnitude of the current flowing will depend upon the value of capacitance or inductance and on the frequency of the voltage. In effect, capacitors and inductors oppose the flow of current in much the same way as a resistor. The important difference being that the effective resistance (or reactance) of the component varies with frequency (unlike the case of a conventional resistor where the magnitude of the current does not change with frequency).

Capacitive reactance

The reactance of a capacitor is defined as the ratio of applied voltage to current and, like resistance, it is measured in Ω. The reactance of a capacitor is inversely proportional to both the value of capacitance and the frequency of the applied voltage. Capacitive reactance can be found by applying the following formula:

$$X_C = \frac{V_C}{I_C} = \frac{1}{2\pi f C}$$

where X_C is the reactance in Ω, f is the frequency in Hz, and C is the capacitance in F.

Capacitive reactance falls as frequency increases, as shown in Fig. 2.26.

The applied voltage, V_C, and current, I_C, flowing in a pure capacitive reactance will differ in phase by an angle of 90° or $\pi/2$ radians (the current "leads" the voltage). This relationship is illustrated in the current and voltage waveforms (drawn to a common time scale) shown in Fig. 2.27 and as a phasor diagram shown in Fig. 2.28.

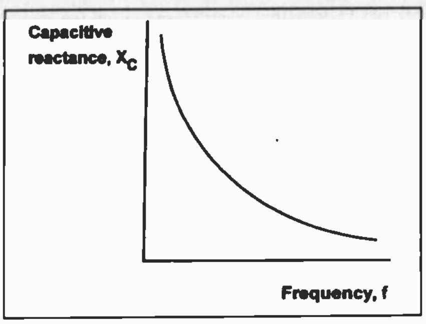


Fig. 2.26 Variation of capacitive reactance with frequency.

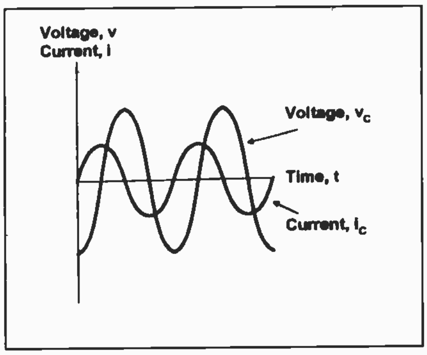


Fig. 2.27 Relationship between voltage and current for a pure capacitive reactance.

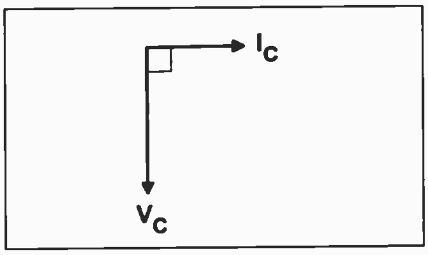


Fig. 2.28 Phasor diagram for Fig. 2.27.

Example

Determine the reactance of a 1μF capacitor at (a) 100Hz and (b) 10kHz.

(a) At 100Hz, $X_C = \frac{1}{2 \times \pi \times 100 \times 1 \times 10^{-6}}$

or $X_C = \frac{0{\cdot}159}{10^{-4}} = 0{\cdot}159 \times 10^4$

Thus $X_C = 1{\cdot}59\text{k}\Omega$

(b) At 10kHz, $X_C = \frac{1}{2 \times \pi \times 10000 \times 1 \times 10^{-6}}$

or $X_C = \frac{0{\cdot}159}{10^{-2}} = 0{\cdot}159 \times 10^2$

Thus $X_C = 15{\cdot}9\Omega$

Example

A 100nF capacitor is to form part of a filter connected across a 240V 50Hz mains supply. What current will flow in the capacitor?

First we must find the reactance of the capacitor:

$$X_C = \frac{1}{2 \times \pi \times 50 \times 100 \times 10^{-9}} = 31{\cdot}8\text{k}\Omega$$

The r.m.s. current flowing in the capacitor will be:

$$I_C = \frac{V_C}{X_C} = \frac{240\text{V}}{31{\cdot}8\text{k}\Omega} = 7{\cdot}5\text{mA}$$

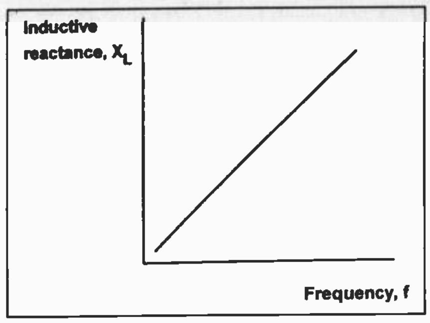


Fig. 2.29 Variation of inductive reactance with frequency.

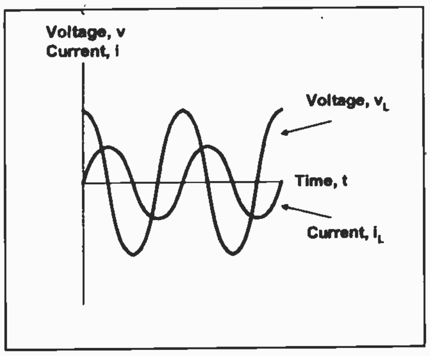


Fig. 2.30 Relationship between voltage and current for a pure inductive reactance.

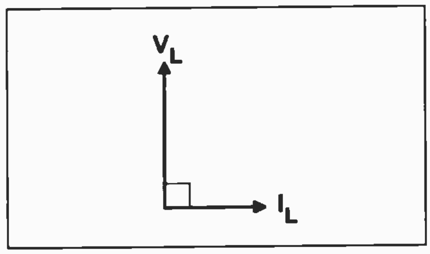


Fig. 2.31 Phasor diagram for Fig. 2.30.

Inductive reactance

The reactance of an inductor is defined as the ratio of applied voltage to current and, like resistance, it is measured in Ω. The reactance of an inductor is directly proportional to both the value of inductance and the frequency of the applied voltage. Inductive reactance can be found by applying the formula:

$$X_L = \frac{V_L}{I_L} = 2\pi f L$$

where X_L is the reactance in Ω, f is the frequency in Hz, and L is the inductance in H.

Inductive reactance increases linearly with frequency as shown in Fig. 2.29.

The applied current, I_L, and voltage, V_L, developed across a pure inductive reactance will differ in phase by an angle of 90° or $\pi/2$ radians (the current lags the voltage). This relationship is illustrated in the current and voltage waveforms (drawn to a common time scale) shown in Fig. 2.30 and as a phasor diagram shown in Fig. 2.31.

Example

Determine the reactance of a 10mH inductor at (a) 100Hz and (b) at 10kHz.

(a) At 100Hz, $X_L = 2\pi \times 100 \times 10 \times 10^{-3}$

Thus $X_L = 6{\cdot}28\ \Omega$

(b) At 10kHz, $X_L = 2\pi \times 10000 \times 10 \times 10^{-3}$

Thus $X_L = 628\ \Omega$

Example

A 100mH inductor is to form part of a

filter which carries a current of 20mA at 400Hz. What voltage drop will be developed across the inductor?

The reactance of the inductor will be given by:

$$X_L = 2\pi \times 400 \times 100 \times 10^{-3} = 251\ \Omega$$

The r.m.s. voltage developed across the inductor will be given by:

$$V_L = I_L \times X_L = 20\text{mA} \times 251\Omega = 5{\cdot}02\text{V}$$

In this example, it is important to note that we have assumed that the d.c. resistance of the inductor is negligible by comparison with its reactance. Where this is not the case, it is necessary to determine the impedance of the component and use this to determine the voltage drop.

Impedance

Two circuits are shown in Fig. 2.32 which contain both resistance and reactance. These circuits are said to exhibit impedance (a combination of resistance and reactance). Like resistance and reactance, impedance is measured in Ω. In the case of the circuits shown in Fig. 2.32, it is simply the ratio of applied voltage (V_S) to current (I_S).

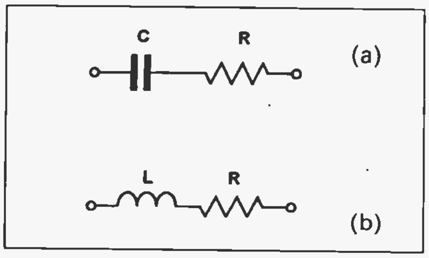


Fig. 2.32 Circuits containing reactance and resistance: (a) a C-R circuit; (b) an L-R circuit.

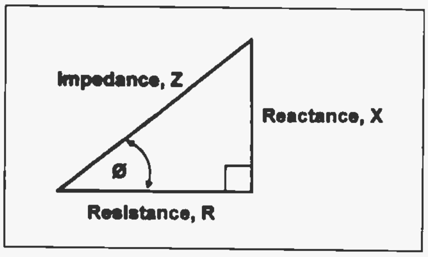


Fig. 2.33 The impedance triangle.

The impedance of the simple C-R and L-R circuits shown in Fig. 2.32 can be found by using the impedance triangle shown in Fig. 2.33.

In either case, the impedance of the circuit is given by:

$$Z = \sqrt{(X^2 + R^2)}$$

and the phase angle (between V_S and I_S) is given by:

$$\phi = \tan^{-1}(X/R)$$

where Z is the impedance (in Ω), X is the reactance, either capacitive or inductive (expressed in Ω), R is the resistance (in Ω), and ϕ is the phase angle in radians.

Example

A 2µF capacitor is connected in series with a 100Ω resistor across a 115V 400Hz a.c. supply. Determine the impedance of the circuit, the current taken from the supply and the voltage dropped across the capacitor.

First we must find the reactance of the capacitor, X_C:

$$X_C = \frac{1}{2\pi fC} = \frac{1}{6{\cdot}28 \times 400 \times 2 \times 10^{-6}}$$

$$= \frac{10^6}{5024} = 199\Omega$$

Now we can find the impedance of the C-R series circuit:

$$Z = \sqrt{(X_C^2 + R^2)} = \sqrt{(199^2 + 100^2)} = \sqrt{49601} = 223\Omega$$

The current taken from the supply can now be found:

$$I_S = V_S / Z = 115/223 = 0{\cdot}52\text{ A}$$

Finally, we can determine the voltage dropped across the capacitor by applying Ohm's Law:

$$V_C = I_S \times X_C = 0{\cdot}52 \times 199 = 103{\cdot}480\text{V}$$

Practical assignment 2.5
C-R phase shift circuit

In this assignment you will investigate the behaviour of a simple C-R phase shifting circuit using a function generator and an oscilloscope.

Objectives:

2.5.1 To investigate the action of a C-R phase shifting circuit.

2.5.2 To use a function generator and oscilloscope to measure voltage and phase shift.

Instructions:

1. Connect the circuit shown in Fig. 2.34. The function generator provides a sine wave input voltage whilst the oscilloscope is used to simultaneously display the input and output waveforms. The function generator and oscilloscope should initially be set as shown in Fig. 2.34.
2. Display the input and output waveforms on the screen. Measure the amplitude of the output voltage and its phase angle relative to the input voltage.
3. Calculate the reactance of the 220nF capacitor at 1kHz, the voltage drop across the capacitor and the phase shift produced by the circuit (see previous example). Compare the calculated values with the measured values.

Conclusions:

To what extent have the objectives for this assignment been met? Do the measured values of output voltage and phase shift agree with those obtained by calculation? If not, why? Over what range of angles can the circuit provide phase shift? Suggest how the phase shift produced by this circuit could be made variable.

Fig. 2.34 Circuit and instrument settings for Assignment 2.5.

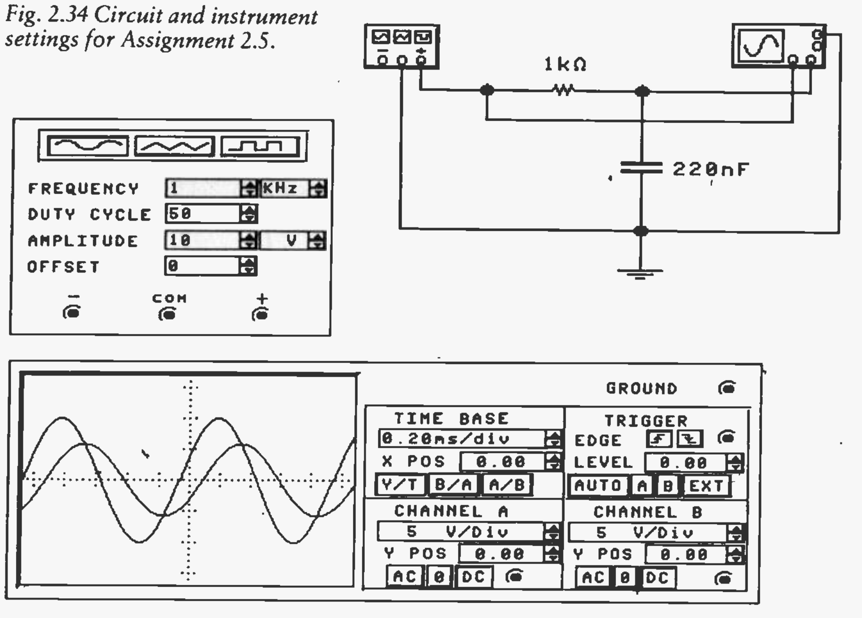
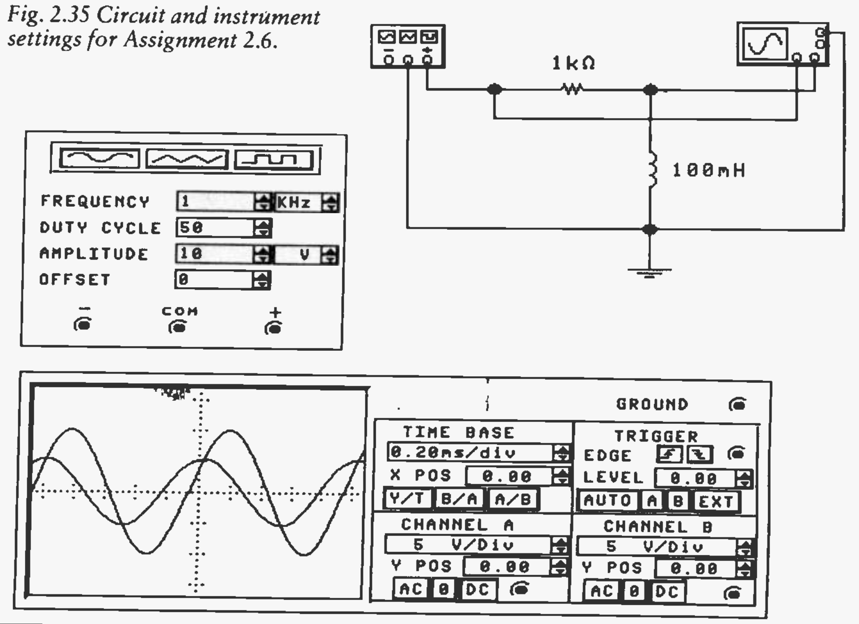


Fig. 2.35 Circuit and instrument settings for Assignment 2.6.



Practical assignment 2.6
L-R phase shift circuit

In this assignment you will investigate the behaviour of a simple L-R phase shifting circuit using a function generator and an oscilloscope.

Objectives:

2.6.1 To investigate the action of an L-R phase shifting circuit.

2.6.2 To use a function generator and oscilloscope to measure voltage and phase shift.

Instructions:

1. Connect the circuit shown in Fig. 2.35. The function generator provides a sine wave input voltage whilst the oscilloscope is used to simultaneously display the input and output waveforms. The function generator and oscilloscope should initially be set as shown in Fig. 2.35.
2. Display the input and output waveforms on the screen. Measure the amplitude of the output voltage and its phase angle relative to the input voltage.
3. Calculate the reactance of the 100mH inductor at 1kHz, the voltage drop across the inductor and the phase shift produced by the circuit (as for Assignment 2.5). Compare the calculated values with the measured values.

Conclusions:

To what extent have the objectives for this assignment been met? Do the measured values of output voltage and phase shift agree with those obtained by calculation? If not, why? Over what range of angles can the circuit provide phase shift? Suggest how the phase shift produced by this circuit could be made variable.

L-C circuits

Two forms of L-C circuits are illustrated in Fig. 2.36 and Fig. 2.37. Fig. 2.36 is a series resonant circuit whilst Fig. 2.37 constitutes a parallel resonant circuit. The impedance of both circuits varies in a complex manner with frequency.

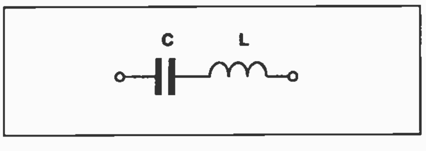


Fig. 2.36 Series resonant L-C circuit.

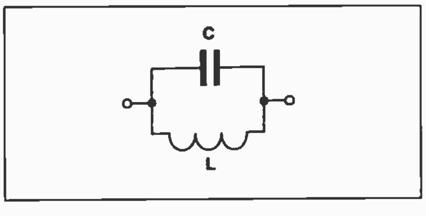


Fig. 2.37 Parallel resonant L-C circuit.

The impedance of the series circuit in Fig. 2.36 is given by:

$$Z = \sqrt{(X_L - X_C)^2}$$

where Z is the impedance of the circuit (in Ω), and X_L and X_C are the reactances of the inductor and capacitor respectively (both expressed in Ω).

The phase angle (between the supply voltage and current) will be $+\pi/2$ rad (i.e. $+90°$) when $X_L > X_C$ (above resonance) or $-\pi/2$ rad (or $-90°$) when $X_C > X_L$ (below resonance).

At a particular frequency (known as the series resonant frequency) the reactance of the capacitor (X_C) will be equal in magnitude (but of opposite sign) to that of the inductor (X_L). The impedance of the circuit will thus be zero at resonance. The supply current will have a maximum value at resonance (infinite in the case of a perfect parallel resonant circuit supplied from an ideal voltage source!).

The impedance of the parallel circuit in Fig. 2.37 is given by:

$$Z = \frac{X_L \times X_C}{(X_L - X_C)^2}$$

where Z is the impedance of the circuit (in Ω), and X_L and X_C are the reactances of the inductor and capacitor respectively (both expressed in Ω).

The phase angle (between the supply voltage and current) will be $+\pi/2$ rad (i.e. $+90°$) when $X_L > X_C$ (above resonance) or $-\pi/2$ rad (or $-90°$) when $X_C > X_L$ (below resonance).

At a particular frequency (known as the parallel resonant frequency) the reactance of the capacitor (X_C) will be equal in magnitude (but of opposite sign) to that of the inductor (X_L). At resonance, the denominator in the formula for impedance becomes zero and thus the circuit has an infinite impedance at resonance. The supply current will have a minimum value at resonance (zero in the case of a perfect parallel resonant circuit).

L-C-R NETWORKS

Two forms of L-C-R network are illustrated in Fig. 2.38 and Fig. 2.39; Fig. 2.38 is series resonant whilst Fig. 2.39 is parallel resonant. As in the case of their simpler L-C counterparts, the impedance of each circuit varies in a complex manner with frequency.

The impedance of the series circuit of Fig. 2.38 is given by:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

where Z is the impedance of the series circuit (in Ω), R is the resistance (in Ω), X_L is the inductive reactance (in Ω) and X_C is the capacitive reactance (also in Ω). At resonance the circuit has a minimum impedance (equal to R).

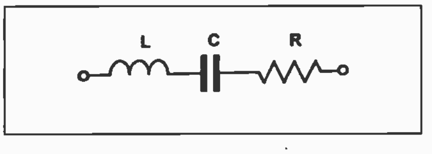


Fig. 2.38 Series resonant L-C-R circuit.

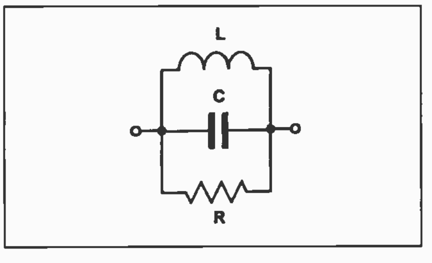


Fig. 2.39 Parallel resonant L-C-R circuit.

The phase angle (between the supply voltage and current) will be given by:

$$\phi = \tan^{-1} \frac{(X_L - X_C)}{R}$$

The impedance of the parallel circuit of Fig. 2.39 is given by:

$$Z = \frac{R \times X_L \times X_C}{\sqrt{(X_L^2 \times X_C^2) + R^2 (X_L - X_C)^2}}$$

where Z is the impedance of the parallel circuit (in Ω), R is the resistance (in Ω), X_L is the inductive reactance (in Ω) and X_C is the capacitive reactance (also in Ω). At resonance the circuit has a maximum impedance (equal to R).

The phase angle (between the supply voltage and current) will be given by:

$$\phi = \tan^{-1} \frac{R(X_C - X_L)}{X_L \times X_C}$$

RESONANCE

The frequency at which the impedance is minimum for a series resonant circuit or maximum in the case of a parallel resonant circuit is known as the resonant frequency. The resonant frequency is given by:

$$f_o = \frac{1}{2\pi\sqrt{(LC)}} \text{ Hz}$$

where f_o is the resonant frequency (in Hertz), L is the inductance (in Henries) and C is the capacitance (in Farads).

Typical impedance–frequency characteristics for series and parallel tuned circuits are shown in Fig. 2.40 and Fig. 2.41. The series L-C-R tuned circuit has a minimum impedance at resonance (equal to R) and thus maximum current will flow. The circuit is consequently known as an acceptor circuit. The parallel L-C-R tuned circuit has a maximum impedance at resonance (equal to R) and thus minimum current will flow. The circuit is consequently known as a rejector circuit.

QUALITY FACTOR

The quality of a resonant (or tuned) circuit is measured by its Q-factor (sometimes also known as "voltage magnification factor"). The higher the Q-factor, the sharper the response (narrower bandwidth), conversely the lower the Q-factor, the flatter the response (wider bandwidth). In the case of the series tuned circuit, the Q-factor will increase as the resistance, R, decreases. In the case of the parallel tuned circuit, the Q-factor will increase as the resistance, R, increases.

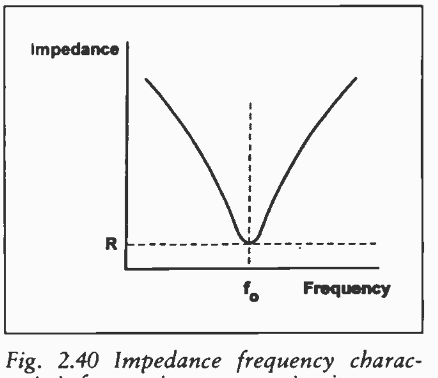


Fig. 2.40 Impedance frequency characteristic for a series resonant circuit.

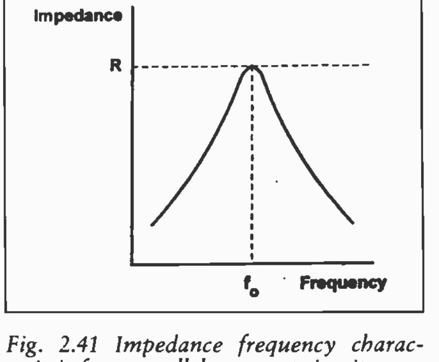


Fig. 2.41 Impedance frequency characteristic for a parallel resonant circuit.

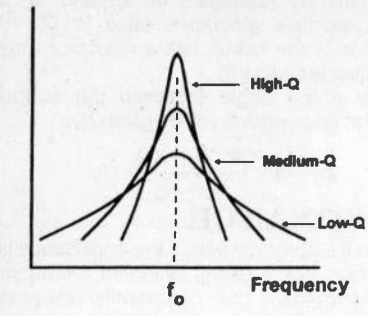


Fig. 2.42 Tuned circuit response showing the effect of different Q-factors.

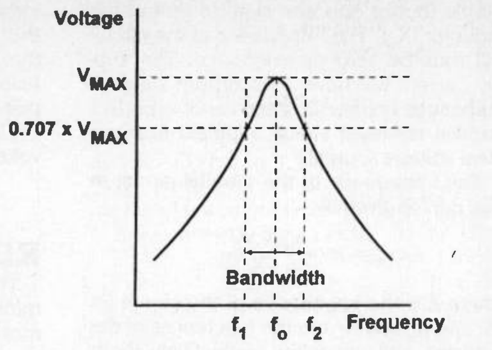


Fig. 2.43 Bandwidth of a tuned circuit.

The response of a tuned circuit can be modified by incorporating a resistance of appropriate value to either "dampen" or "sharpen" the response (see Fig. 2.42).

The relationship between bandwidth and Q-factor (see Fig. 2.43) is:

$$\text{Bandwidth} = f_2 - f_1 = \frac{f_o}{Q}\ \text{Hz}$$

For a series L-C-R tuned circuit, the Q-factor is given by:

$$Q = \frac{V_C}{V_R} = \frac{V_L}{V_R} \text{ (note that, at resonance, } V_C = V_L)$$

Now since $V_L = I_S \times X_L$, $V_R = I_S \times R$,

and $X_L = 2\pi f_o L$

$$Q = \frac{I_S \times 2\pi f_o L}{I_S \times R} = \frac{2\pi f_o L}{R}$$

Example

A parallel L-C circuit is to be resonant at a frequency of 400Hz. If a 100mH inductor is available, determine the value of capacitance required.

Re-arranging the formula $f_o = \dfrac{1}{2\pi\sqrt{(LC)}}$

to make C the subject gives:

$$C = \frac{1}{f_o^2 (2\pi)^2 L}$$

$$\text{Thus } C = \frac{1}{400^2 \times 39{\cdot}4 \times 100 \times 10^{-3}}$$

$$\text{or } C = \frac{1}{160 \times 10^3 \times 39{\cdot}4 \times 100 \times 10^{-3}} \text{F}$$

Hence $C = 1{\cdot}58\mu F$

Example

A series L-C-R circuit comprises an inductor of 20mH, a capacitor of 10nF, and a resistor of 100Ω. If the circuit is supplied with a sinusoidal signal of 1·5V at a frequency of 2kHz, determine the current supplied and the voltage developed across the resistor.

First we need to determine the values of inductive reactance (X_L) and capacitive reactance (X_C):

$$X_L = 2\pi f L = 6{\cdot}28 \times 2 \times 10^3 \times 20 \times 10^{-3}$$

thus $X_L = 251{\cdot}2\ \Omega$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{6{\cdot}28 \times 2 \times 10^3 \times 100 \times 10^{-9}}$$

thus $X_C = 796{\cdot}2\ \Omega$

The impedance of the series circuit can now be calculated:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$= \sqrt{100^2 + (251{\cdot}2 - 796{\cdot}2)^2}$$

thus $Z = \sqrt{10000 + 297025}$

$$= \sqrt{307025} = 554\Omega$$

The current flowing in the series circuit will be given by:

$$I = V/Z = 1{\cdot}5/554 = 2{\cdot}7 \text{ mA}$$

The voltage developed across the resistor can now be calculated using:

$$V = I\,R = 2{\cdot}7\text{mA} \times 100\Omega = 270\text{mV}$$

Practical assignment 2.7
L-C-R circuit

In this assignment you will investigate the behaviour of an L-C-R tuned circuit using a function generator and an oscilloscope.

Objectives:

2.7.1 To investigate the action of an L-C-R tuned circuit.

2.7.2 To use a function generator and oscilloscope to measure the response, resonant frequency and Q-factor of a tuned circuit.

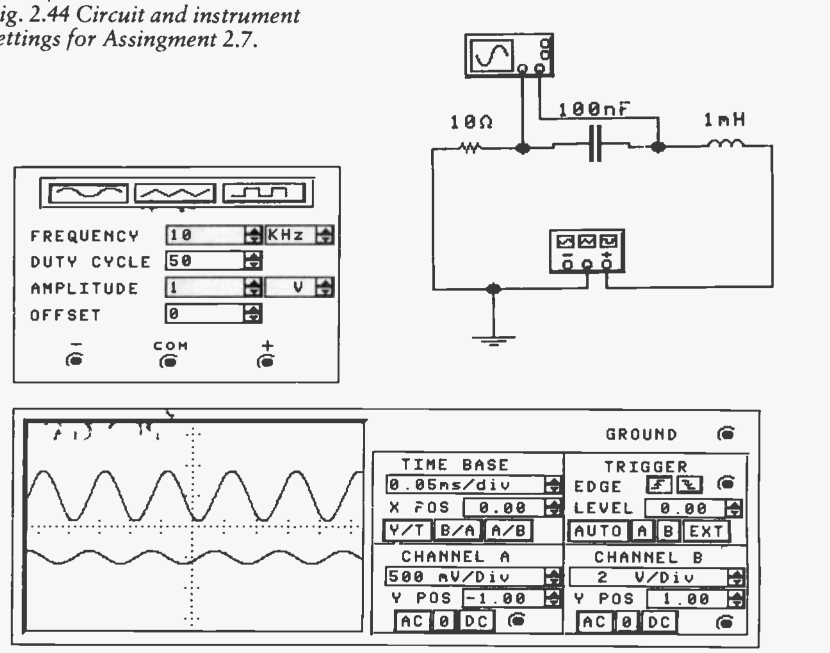
Instructions:

1. Connect the circuit shown in Fig. 2.44. The function generator provides a variable frequency sine wave input voltage whilst the oscilloscope is used to simultaneously display the voltages across the resistor and capacitor (note that the resistor voltage is used to give an indication of the current flowing in the circuit). The function generator and oscilloscope should initially be set as shown in Fig. 2.44.
2. Display the resistor and capacitor waveforms on the screen. Vary the frequency of the function generator's output over the range 10kHz to 24kHz using the values shown in Table 2.5. At each frequency, measure and record the peak-peak value of the resistor and capacitor voltages. Also determine the current flowing in the circuit and record this in Table 2.5.
3. Use the measured values from Table 2.5 to plot graphs showing how the capacitor voltage and supply current vary with frequency over the range 10kHz to 24kHz. Determine the resonant frequency from

Table 2.5 Measured values for Assignment 2.7.

Frequency (kHz)	10k	12k	14k	15k	16k	17k	18k	20k	24k
Capacitor voltage (V_C)									
Resistor voltage (V_R)									
Supply current ($I_S = V_R/R$)									

Fig. 2.44 Circuit and instrument settings for Assingment 2.7.



the graph and compare this with the calculated value.

4. Use the graph to determine the peak-peak value of capacitor voltage at resonance and the Q-factor of the circuit. Calculate the measured Q-factor for the circuit with the calculated value.

Conclusions:

To what extent have the objectives for this assignment been met? Do the measured values of resonant frequency and Q-factor agree with those obtained by calculation? If not, why? Suggest how the resonant frequency of the circuit could be made variable. Suggest how the Q-factor of the circuit could be increased.

Answers to last month's problems

1. 333mA, 9W
2. 200Ω
3. 30
4. 7·48V
5. 14·96kΩ, 100kΩ
6. 90·9mA
7. 10mA, 3·33mA
8. 14·1V, 9·9V
9. 200mA, 220mA
10. 7·5mA, 4·5V

BRAIN TEASER

This month's challenge for those of you who are using the full *Electronics Workbench* package is shown in Fig. 2.45. All you have to do is determine the frequency at which the phase shift between points A and B is precisely 90°.

Answer to last month's Brain Teaser

8.33Ω

This problem is best solved by assuming that a current of 1A flows into the network at one corner. This current will divide into three equal currents of 1/3A. Then each current will divide again into two equal currents of 1/6A. By this means, you can determine the current in each resistor and calculate the corresponding voltage drop.

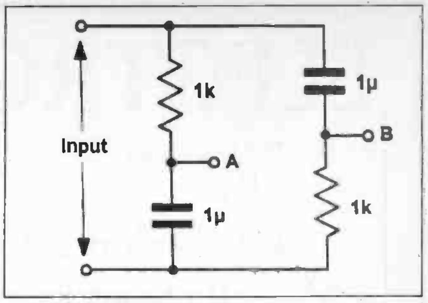


Fig. 2.45 Circuit for this month's Brain Teaser.

The next stage is to apply Kirchhoff's Voltage Law taking any one path through the network. This will provide you with three voltage drops which can be added together to find the total voltage drop across the network. Having done this you can simply apply Ohm's Law to determine the effective resistance of the network between any two opposite corners.

DOWN TO EARTH

George Hylton

DIODE RATINGS

Signal diodes such as the ubiquitous 1N4148 can handle fairly substantial voltages and currents. It's sometimes tempting to use them in mains power units where the current output needed is modest. Published designs do occasionally specify them.

Let's see how to find out whether a signal diode can safely be used in such an application.

PEAK VOLTAGE

In a conventional push-pull rectifier circuit (Fig. 1) capacitor C1 is charged by current from diodes D1 and D2 alternately to something approaching the peak value of the a.c. voltage across each half of the centre-tapped secondary winding of the transformer T1. If the rated voltage is 10V-0V-10V r.m.s. then the peak is a bit more than 14V.

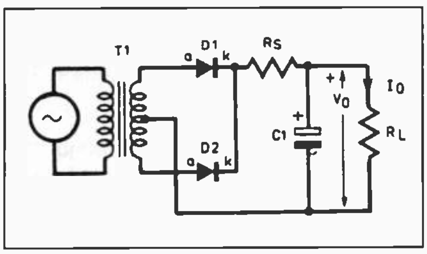


Fig. 1. Transformer-rectifier power unit. Rs represents the resistance of the transformer windings, R_L the d.c. load.

A diode can withstand only a certain amount of reverse voltage. How much does it get in this circuit?

Assume the circuit to have been working long enough for C1 to be fully charged. Then there is (with 10V r.m.s. input) some +14V at the cathodes (k).

This is a reverse voltage – but not the only one. Whichever diode happens to be non-conducting has, at its anode (a), the negative half cycle of the 10V r.m.s. input. This, at its peak, is also about 14V.

So the diode has –14V on its anode and +14V on its cathode. This makes a total of 28V trying to force a reverse current.

For safe working the peak inverse voltage (p.i.v.) rating must be comfortably in excess of 28V. Diode data varies, but mine gives 75 p.i.v. for the 1N148. This implies possible inputs up to (75/2)V peak, which is 26·5V r.m.s.

But don't push your luck! That 75V is an absolute maximum rating which leaves no room for accidents such as mains surges. If you prudently downrate it by a third you can still use the diode for d.c. outputs up to about 18V, which covers most needs.

CURRENT RATINGS

My data gives two current ratings: 75mA average d.c. and 200mA peak a.c. In a push-pull circuit each rectifier supplies half the current so two at 75mA average should be able to supply 150mA. The peak current rating, however, makes this difficult.

In Fig. 1 the only limit on current flowing via a diode into capacitor C1 is resistor Rs. This is a fictitious resistance which I've put in to represent the resistance of the transformer windings.

This consists of the d.c. resistance of a half-secondary plus the transformed resistance of the primary, seen from a half-secondary. The transformed resistance is the d.c. primary resistance divided by the turns ratio squared.

Complicated? Not really. Let's take a particular case. I have a miniature mains transformer rated at 240V input, 18V centre-tapped output (otherwise known as 9V-0V-9V). Makers often "up" the secondary voltage a bit to allow for loading losses. My transformer, off load, measures 10V-0V-10V.

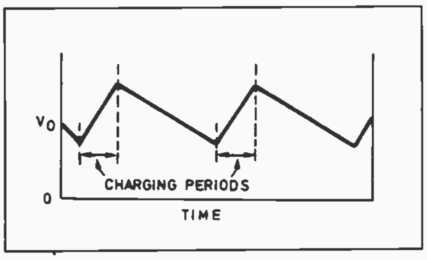


Fig. 2. Output voltage with ripple. During the sharp rises the rectifiers must deliver large pulses of current.

This gives a turns ratio of primary to half-secondary of 24. The primary resistance is 2200 ohms. Dividing this by 24 × 24 gives 3·8 ohms.

The resistance of one half-primary is 19·5 ohms and the other, 19·8 ohms. (This may seem odd, since each must have the same number of turns, but one is wound on top of the other, so the length of a turn is greater. More wire, more resistance.) Either way the resistance totals about 24 ohms, and this is effectively in series with each diode.

If capacitor C1 is discharged and the circuit switched on at a peak of the mains voltage (giving a peak of 14V at the half-secondary), the current is momentarily 14V/24 ohms = 583mA. In practice, a bit less, because the diode drops about a volt. Clearly, this peak current is in excess of the peak rating.

Proper rectifier diodes have a special rating for switch-on current – usually with a time limit of half a mains period, or some similar brief interval. The only figure found for a 1N4148 was a rather vague "non-repetitive peak forward current" of 500mA, with no quoted time limit. This shows that 583mA is outside the rating and that caution is advisable.

STEADY STATE

When the circuit is working away steadily the output V_0 is not constant but carries a sawtooth ripple (Fig. 2). During the brief "ups", C1 charges. During the much longer "downs" it discharges through the load R_L.

To maintain the average voltage the quantity of charge must equal the quantity of discharge. It follows that the average charging current must equal the load current.

Common sense suggests that if charging has to be done (during an "up") in a fifth of the time of discharging (in a "down") then the charging current must be five times the average discharge current, in other words five times the load current.

For a load current of 100mA the peak would then be 500mA. This applies to one combination of load and C1. If the load current is increased, or C1 increased to reduce ripple then the peak current must increase. Clearly, the current rating could be exceeded during steady operation as well as at switch-on.

LIMITING CURRENT

This limits the usefulness of signal diodes as rectifiers to cases where the load current is modest, say a few tens of milliamps. You could, of course, add resistance to reduce peak current but then output voltage would fall and ripple rise.

In the old days when iron-cored inductors were used liberally, a better solution was available (Fig. 3). The inductance of the input choke L1 limited the peak current but the resistance was low and didn't cause much d.c. loss. The on-load output voltage was low, because C1 never had time to charge fully.

Suitable chokes are heavy and expensive. Better to spend more on the rectifiers. All the same, Fig. 3 does hint at a way of dealing with the problem.

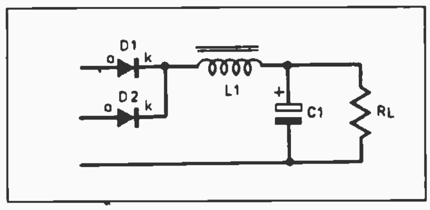


Fig. 3. Choke-input smoothing filter. L1 limits the peak current.

The inductance, in opposing any sudden increase in current, extends the charging periods. It also spreads out the charging current in time. You can, as mentioned earlier, do this with added resistance, but at a price.

When Rs was increased to 75 ohms the output fell from 14V off load to 7V at 50mA load. This would be all right if your load needed only 7V and drew an unvarying current, but many real-life loads draw a varying current but need a steady voltage.

TRANSISTOR LIMITER

If there is voltage to spare and you have plenty of components in stock the circuit in Fig. 4 may help. This uses a transistor, TR1, to limit the peak current and a Zener diode, D3, to stabilize the voltage.

The circuit is fed by the unsmoothed output of the push-pull diodes D1 and D2. This is a train of half-sine-waves, positive-going. These drive base current of transistor TR1, via resistor R1, and the resulting pulses of emitter current charge capacitor C1.

However, once the base voltage is enough to turn on Zener D3 it is clamped at the Zener voltage. Output voltage cannot exceed the Zener voltage minus the base-emitter voltage of TR1. The base current is limited by resistor R1, which can be chosen to limit the emitter current pulses to a safe value.

In tests, the peak currents in D1 and D2 were about twice the d.c. output current. So TR1 must be able to handle the average load current while taking peaks of twice the load current. The shaded parts of the waveform in Fig. 4 show how the Zener limits the base voltage.

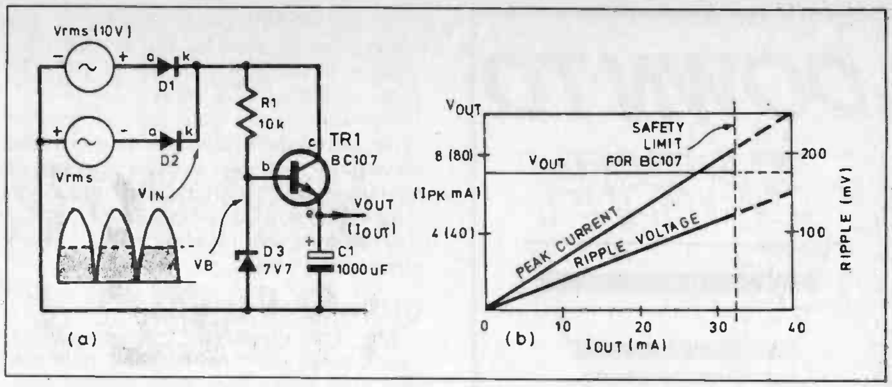


Fig. 4. (a) Circuit diagram for a transistor limiter-stabiliser and (b) performance curves.

SHOP TALK
with David Barrington

Video Modules
The case shown housing the *Video Modules* in the photographs, and on the front cover, has not been specified in the components list because readers may choose to select their own according to the number of modules constructed. Another factor is the cost. The case is a "19 inch rack instrument enclosure" and usually sells for £30 plus.

The one shown, and used by the author, is known as a "1U" type and measures 432mm (W) x 45mm (H) x 254mm (D), the front plate is, of course, 19 inch (482mm) wide. This was originally purchased many months ago from **Rackz Products** (☎ *0749 840102)*. Most of our advertisers will be able to offer something similar.

All the components listed for the *Simple Fader, Improved Fader* and *Video Enhancer* appear to be standard "off-the-shelf" items and should be easily obtainable from your regular component supplier/advertiser. The printed circuit boards are available from the *EPE PCB Service,* codes 910 (Simple Fader), 911 (Improved Fader) and 912 (Video Enhancer).

Power Controller
Although relatively straightforward in construction, the *Power Controller* was not designed with the absolute beginner in mind and is aimed more at those constructors who possess some experience of *mains-operated* projects. See the Specification panel regarding its suitability for use with particular electrical appliances.

The design utilises a couple of "specials" which are available from the larger mail order suppliers. In particular the SL443A zero voltage switch i.c. is supplied by **Electromail** (☎ *0536 204555),* Stock No. 307-985, also **Farnell** (☎ *0532 636311)* list the SL443ADP. The author advises that the similar-sounding SL441CD from **Maplin** (DB53H) would appear to be identical, judging by the published specification.

Most important is the triac specification. This **MUST** be an *"isolated tab"* type such as the BTA16-600 16A 600V which is available from all the sources mentioned earlier. To avoid a shock hazard, under no circumstances substitute an alternative without determining whether a TO220 insulating kit is necessary or not.

The Maplin's '94 Catalogue misleadingly implies that the BTA16-600B triac does *not* have an isolated tab (Page 481, 1994 catalogue). This is not the case: it *does* have a fully insulated tab for better insulation, so no mounting/insulating kit is needed with this type. For further confirmation, see the Electromail specification (Stock No. 658-738) in their catalogue.

Also worth mentioning is the unusual 16A screw terminal block with built-in fuseholder used by the author, an excellent idea which saves some mains interwiring, from Electromail (452-619, supplied in 10's) or Farnell (151-999, available singly). It is possible that the 6W rating, vitreous enamelled cased wire wound power resistor may be difficult to find locally. However, most of our mail order component advertisers may stock them or may offer a *higher* rating (7W) ceramic encased type. Check you can fit them on the p.c.b.

The small printed circuit board is available from the *EPE PCB Service,* code 905.

1000V/500V Insulation Tester
A couple of components needed to construct the *1000V/500V Insulation Tester* are special items and only available from one source. Also the "high voltage" capacitors must be used where indicated.

The special ferrite-core resonant transformer is only available from **Magenta Electronics** (☎ *0283 565435*). They also stock the meter and high voltage capacitors.

A complete kit of parts to build the Tester, including transformer, cut-out case, meter (with replacement scale) and screen-printed p.c.b., is obtainable from **Magenta Electronics, Dept EPE, 135 Hunter Street, Burton-on-Trent, Staffs, DE14 2ST,** for the sum of £32.95 plus £3 post and packing. Quote kit code 848 when ordering.

The printed circuit board is available from the *EPE PCB Service,* code 906 – see page 887.

TV Off-er
You must heed the warnings given about mains operation and ratings of components highlighted in the *TV Off-er* project. If you do not the unit could become hazardous and breakdown with dire consequences.

We have been unable to locate readily available rotary switches capable of switching more than 150mA, whereas many TVs require more than 250mA, some even 500mA. This is the reason for adding the additional mains on/off switch not included on the prototype model.

The 12V relay used is rated at 15A. The coil resistance will be about 200 ohms. Most advertisers stock a p.c.b. mounting relay rated at 16A which should handle this application quite comfortably. Check that the relay will fit on the p.c.b. correctly.

The two printed circuit boards are available as a pair from the *EPE PCB Service,* codes 908/909.

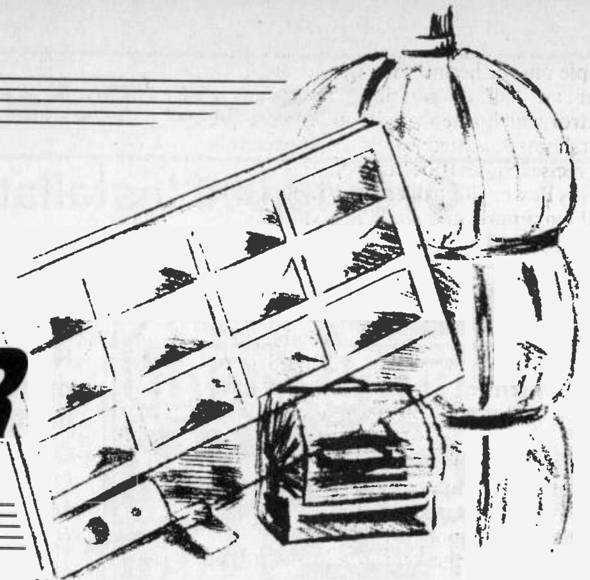
Active Guitar Tone Control
We cannot foresee any component buying problems when ordering parts for the *Active Guitar Tone Control* circuit. No details are given for a suitable case as most constructors will, no doubt, mount the circuit board in or on the electric guitar body itself.

The small printed circuit board is available from the *EPE PCB Service,* code 907.

Ingenuity Unlimited
The *Voltage Drop Car Alarm,* one of this month's *Ingenuity Unlimited* circuits, calls for two different piezoelectric sounders. The low power "entry" sounder is the p.c.b. mounting disc type similar to one supplied by **Maplin**, code JH24B. The loud "alarm" siren is the miniature piezo siren also from the same source, code JK43W.

Constructional Project

POWER CONTROLLER



ALAN WINSTANLEY

Build a 13A cost-cutting controller for immersion heaters, electric fire elements and large heaters. Zero crossing ensures freedom from r.f. interference.

HAVE you got an electric fire blazing away, racking up a large fuel bill? The Chancellor of the Exchequer will be delighted! For the benefit of our many overseas readers, Her Majesty's Government has now taken a shine to our fuel bills, so much so that it has added Value Added Tax to them, much to the chagrin of your scribe. Hence any device which helps to cut those electricity bills will be welcomed, by everyone apart from the Chancellor that is!

Power control techniques can be used in certain circumstances to adjust the power consumption of particular electrical appliances. An ordinary lamp "dimmer switch" uses the *phase control* system to interrupt the mains sine wave, thereby dimming and reducing the power consumption of the lamp.

In a similar way, a basic two-speed electric drill might use a rectifier to chop one half of the sinewave, to reduce the speed of the drill. Even vacuum cleaners occasionally have an in-built power controller, to offer some marginal "boost" when the going gets tough, or to cut the speed when needed.

A typical phase control device will be described in a future constructional article. Amongst other things, such designs are suitable for electric fires with or without coal effects (**not** fan heaters) and their main advantage is that they are straightforward in operation and construction; however such circuits are notorious for generating r.f.i. (Radio Frequency Interference) on an unacceptable scale unless suitable suppression is incorporated, which can add considerably to the construction cost.

Specification ...

Type:	Burst Firing
Features:	Zero crossing: Interference free
Ideal for:	Resistive heating elements 0·5-3kW (e.g. Electric Bar Fires; Immersion Heater Elements; Oil-filled Electric Radiators; Convector Heaters, Electric Irons)
Not suitable for:	Coal-effect Electric Fires, Fan Heaters, Motors, Lighting, Low Loads (e.g. Soldering Irons).

BURST FIRING

There is, however, another method of controlling power with a technique which is inherently interference-free. The system of **burst firing** is often used to control larger heating elements such as those found in kilns, ovens or certain types of machinery. Instead of modifying or chopping the mains sine wave, the burst firing technique sends a train of sine waves to the load, at regular intervals. Fig. 1(a) shows how short bursts of sine waves are transmitted to a load which operates at a low power level. By increasing the length of the bursts, the power delivered to the load is increased.

In the case of a simple resistive heating element, it is feasible to deliver such bursts once every few seconds, or even just a few times every minute, since the thermal inertia of the load averages out the bursts. The user will then observe a simple rise or fall in heater power dissipation depending on the frequency of the bursts.

The device to be described here is a burst firing power controller which includes a **zero crossing** system. This synchronises the a.c. sine wave output, to ensure that only *complete* sine waves are allowed to reach the control element (a triac).

By avoiding chopping the sine wave as in the phase control system, no r.f.i. is generated and absolutely no suppression is needed. The system is completely interference free, making it ideal for use in the domestic environment. It is however *not suitable* for certain types of load, see the separate Specification panel.

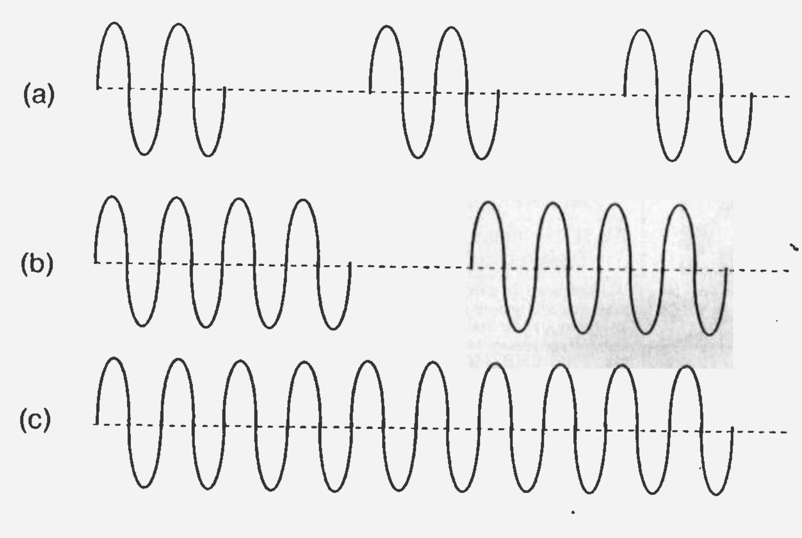


Fig. 1. Zero crossing burst firing power control (a) low (b) medium (c) full power.

APPLICATIONS

Many appliances based on resistive heating elements (e.g. an oil-filled radiator, convector, or immersion heater) incorporate a bi-metallic strip which provides simple on-off thermostatic operation. They offer an "all or nothing" approach to control which often results in temperature overshoots – wasted power – and generally imprecise temperature control.

This Power Controller will handle a 3kW load maximum, and could actually *complement* a thermostat if fitted to a domestic appliance. By burst-firing the appliance in the first place, the average power delivered to the heater is controlled more precisely which provides a more controllable temperature, as the appliance will be delivering an "average" power rather than all or nothing when controlled by a bi-metallic strip.

Apart from offering a finer degree of control, rather than using a heater continuously at full setting, this design will also help save money by enabling the user to "turn down" the heat to a lower setting – especially if the heater doesn't even have a bi-metallic thermostat.

HOW IT WORKS

The circuit diagram of the Power Controller is shown in Fig. 2. Operation is centred around IC1, an SL443 zero-crossing burst firing chip. It provides all the necessary timing signals to a control device – a suitably-rated triac in this case – to provide totally interference-free control of a suitable resistive load.

The i.c. has a built-in power supply section. 240V a.c. mains is supplied by two dropper resistors R2 and R3, to pin 2. Two power resistors are used because a total of nearly 350V *peak* is dropped across them under worst case conditions, therefore each is conservatively rated to withstand 200V at 6W.

The resultant low a.c. voltage is rectified and regulated within the i.c. to produce about 14V d.c. which is smoothed by the external capacitor C3, and is in turn passed to an internal 7V stabiliser. This is fed via pin 5 and resistor R1 to the power control potentiometer VR1 which taps the voltage at its wiper, connecting the output signal to pin 8.

The i.c. drives the gate terminal triac CSR1 directly from pin 4 which delivers a series of suitably-timed trigger pulses. A conservatively-rated 16A device was used for CSR1 which also has an *isolated tab*. This improves the insulation of the final assembly and reduces the risk of accidental short circuits. As will be described later, the triac needs to be fitted to a heatsink to aid heat dissipation when operating under peak conditions.

It is the d.c. voltage on the wiper of potentiometer VR1 which ultimately determines the time period of the "bursts". The SL443 internal logic generates a sawtooth-like ramp voltage and compares this against the d.c. voltage set up by VR1. By adjusting the voltage at pin 8, the overall length of the bursts sent to the triac is varied accordingly, see Fig. 3. The SL443 compares the d.c. signal voltage at pin 8 against the ramp

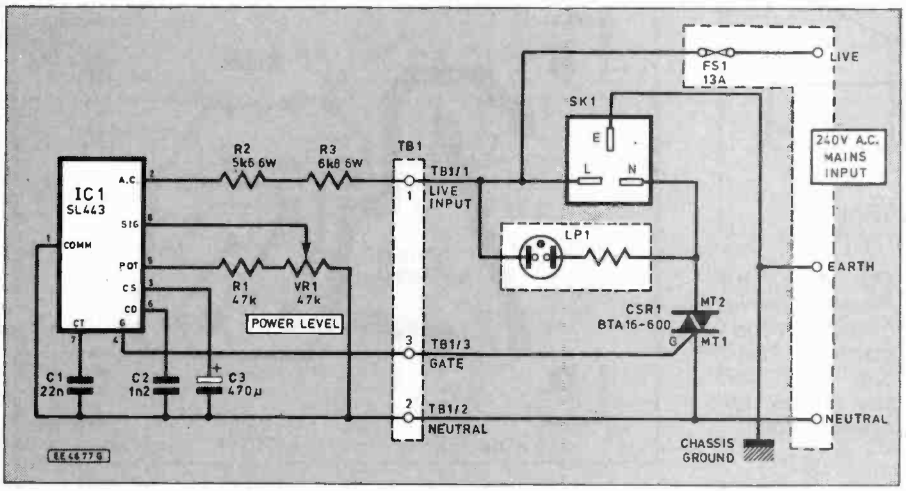


Fig. 2. Full circuit diagram for the Power Controller.

It does have one drawback in that because of its mode of operation – sending *pulses* to the load at regular intervals – it is not really suited to electric fires which have flickering coal effect lamps; it would cause the lamps to flash on and off repetitively, although the unit controls the heater elements perfectly. Nor must the unit be used with anything incorporating a synchronous motor such as a fan heater.

Additionally, trials showed that the unit does require a *minimum* load for correct operation, of roughly 500W or more. This design is not suitable for controlling a low-power soldering iron or similar small loads for example. It is designed for larger *resistive* loads such as ordinary electric bar fires or immersion heater elements rated up to 3kW, especially where r.f.i. could otherwise be a problem. The unit has a simple visual indication showing the burst firing system in actual operation, to help gauge the level of power being delivered.

BE AWARE

The circuit operates directly from the mains and has a built-in transformerless power supply, and is quite straightforward to assemble, but some skill with a soldering iron is required to make neat solder joints, some of which are at mains voltage, and care is needed when assembling to allow for certain parts which become hot in operation. Therefore, it is not really recommended for the absolute beginner due to the hazards associated with the mixture of mains and low voltages.

COMPONENTS

Resistors

R1	47k 0·25W 5% carbon film
R2	5k6 6W 200V wirewound (W22 type)
R3	6k8 6W 200V wirewound (W22 type)

See SHOP TALK Page

Potentiometer

VR1	47k 0·4W rotary carbon, linear

Capacitors

C1	22nF polyester 5mm
C2	1n2 polyester or polystyrene
C3	470µF radial axial elect. 25V

Semiconductors

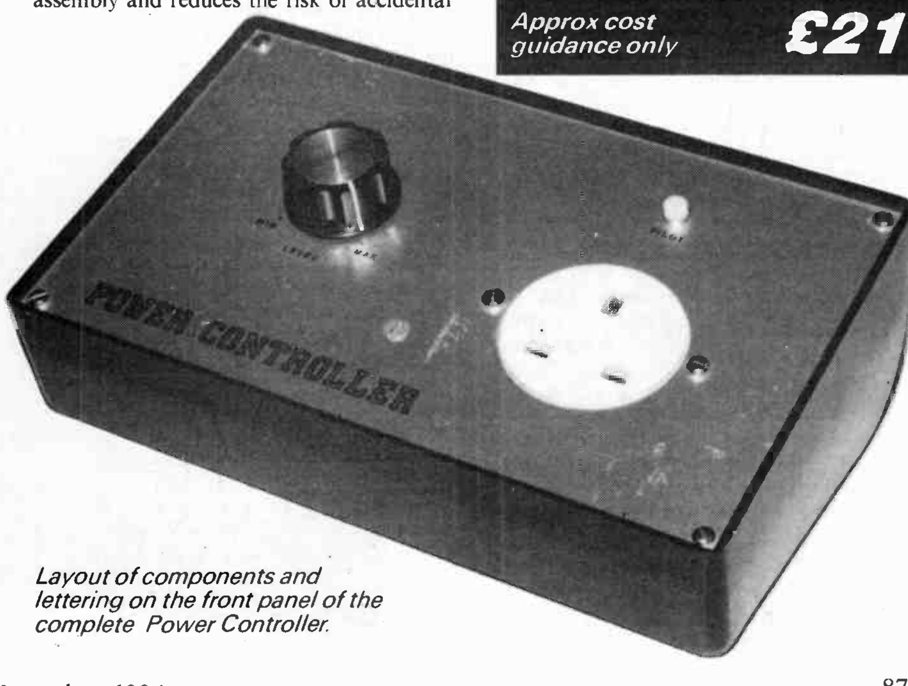
IC1	SL443A zero crossing burst firing i.c.
CSR1	BTA16-600B 600V triac *isolated tab* ***ABSOLUTELY VITAL!!!***

Miscellaneous

SK1	Panel mounting 13A socket
LP1	240V neon mains panel indicator (see text)
FS1	chassis mounting fuseholder with 13A fuse – see text
TB1	3-way p.c.b. terminal block

Printed circuit board available from *EPE PCB Service*, code 905; plastic case with sloped aluminium panel, 215mm x 130mm x 78/47mm; 3-way 13A mains screw terminal block; 8-pin d.i.l. socket; control knob; P-clip; grommet; M3 x 6mm fastener; fully insulated p.c.b. mounting hardware; tie wrap with adhesive base; 13A cable; wire; solder etc.

Approx cost guidance only **£21**



Layout of components and lettering on the front panel of the complete Power Controller.

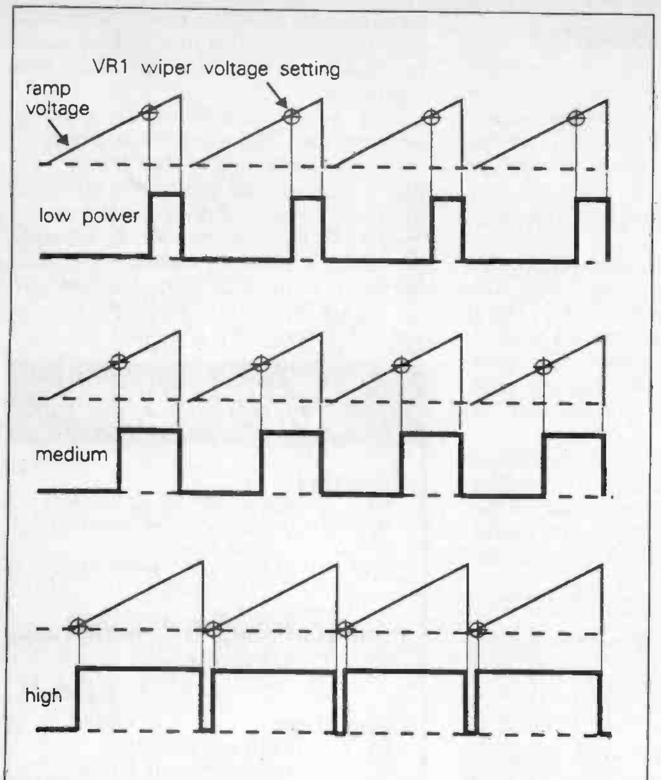


Fig. 3. SL443 ramp voltage waveforms.

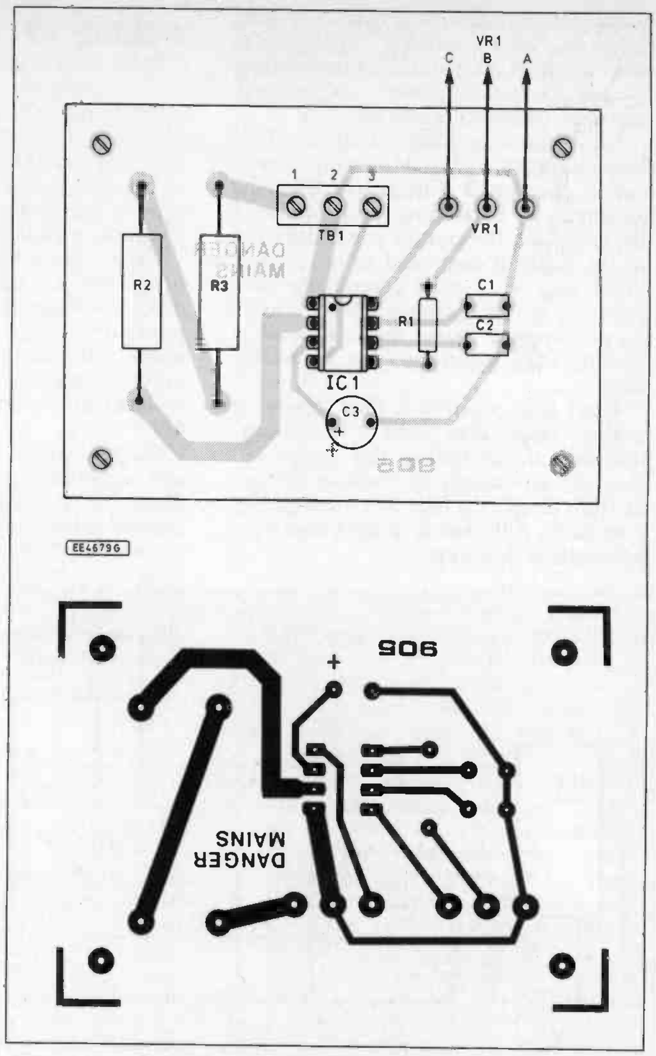


Fig. 4. (right) Printed circuit board component layout and full size copper foil master pattern.

voltage, and the power output of the unit is set by that fraction of the sawtooth during which the triac is conducting – as denoted by the square wave, which represents bursts of complete sine waves driving the load.

It was felt it would be safer to include a certain degree of "offset" by adding resistor R1. This means that there is always a minimum voltage at VR1 wiper so that the Power Controller is never turned fully off.

In the case of electric fire elements, they can still dissipate heat even though they may not be glowing brightly. Under these circumstances the user could mistakenly think that the fire was turned off altogether, although in reality it may be partially on. In order to prevent a fire hazard, the offset resistor ensures that the load is always switched on to some extent, which should then be apparent to the user.

BURST FIRING

A zero-crossing detector is also incorporated in the SL443. The triac firing pulse from pin 4 is synchronised to ensure that triac CSR1 conducts at the start of a sine wave half cycle without chopping it. The value of capacitor C2 is calculated to ensure that the triac receives a triggering pulse of an adequate length, whilst capacitor C1 determines the ramp period or *repetition rate* of the bursts.

The value of C1 was calculated for a one second period, which as a result of tests enables the project to be used with *visible* heater elements such as electric fires. A longer period (several seconds or more) would result in electric fires alternately glowing red hot and then dimming.

The burst rate is probably of less consequence with hidden heating elements used in kilns or immersion heaters, but is clearly relevant if the electric element is also supposed to give a comforting glow: it shouldn't be pulsating in a menacing manner! (Though the author's does anyway, courtesy of Yorkshire Electricity.) For this reason, it is not feasible to use the Power Controller with electric coal-effect fires, because the "fireglow" bulbs will indeed flash on and off. (There is probably no finer demonstration of burst firing, with the coal effect flashing disco-like whilst the heater bars average out the bursts. Impress your friends!)

The Power Controller will deliver bursts of sine waves to the load based on a fixed cycle time of one second. By adjusting potentiometer VR1, the *length* of the bursts is determined, i.e. it controls the duty cycle. At minimum power, shorter bursts of a.c. mains are delivered every second (under 50% duty cycle), whilst at maximum output the circuit delivers a continuous sine wave (100% duty cycle).

Neon indicator LP1 is in parallel with the load and this clearly reflects the burst firing repetition rate, and acts as a monitor. It will flash according to the setting of VR1, and could be omitted if necessary. If nothing else, it's useful when first testing the completed design. Finally, as mentioned earlier, the circuit requires a minimum load of, say, 500W to operate successfully, otherwise CSR1 may fail to trigger properly or hold its conduction.

CONSTRUCTION

Construction starts with printed circuit board (p.c.b.) assembly, then front panel details and finally, interwiring and finishing off. The circuit itself has a low component count and is straightforward to build. However, some parts are at mains voltage and therefore the ability to solder neatly is

essential, in order to prevent accidental short circuits or unreliable operation.

A printed circuit board simplifies assembly and is probably *essential* these days for this type of project. The p.c.b. component layout and full size copper foil master pattern for the Power Controller are shown in Fig. 4. This board is available from the *EPE PCB Service*, code 905.

The prototype p.c.b. is housed in a plastic case which has a sloping aluminium front panel, and measures 215mm x 130mm x 78/47mm. An alternative choice might be a diecast aluminium box or other all-metal housing, since the metal front panel is used as a heatsink for triac CSR1.

The triac will become quite hot when the Power Controller is set for maximum output. Under these circumstances, the triac is passing peak continuous current and dissipates an appreciable amount of heat (which is negligible compared with the power dissipation of the load, though).

The specified case has proven acceptable in this application, however a golden rule with this project is that when selecting your own housing, allow plenty of room inside for air circulation around the components and do not be tempted to opt for too small a box. In fact ventilation slots, though not compulsory, would do no harm provided that tiny fingers cannot poke objects into the box and make contact with live terminals.

Continue construction by using the empty p.c.b. as a template on the box to mark the drilling centres for the insulated mounting hardware (see later). Then proceed with the assembly of the circuit board in accordance with Fig. 4. Power resistors R2 and R3 ***must*** be mounted proud of the board to permit air circulation around them, so stand them off by about 10mm – do not solder them flush to the p.c.b.

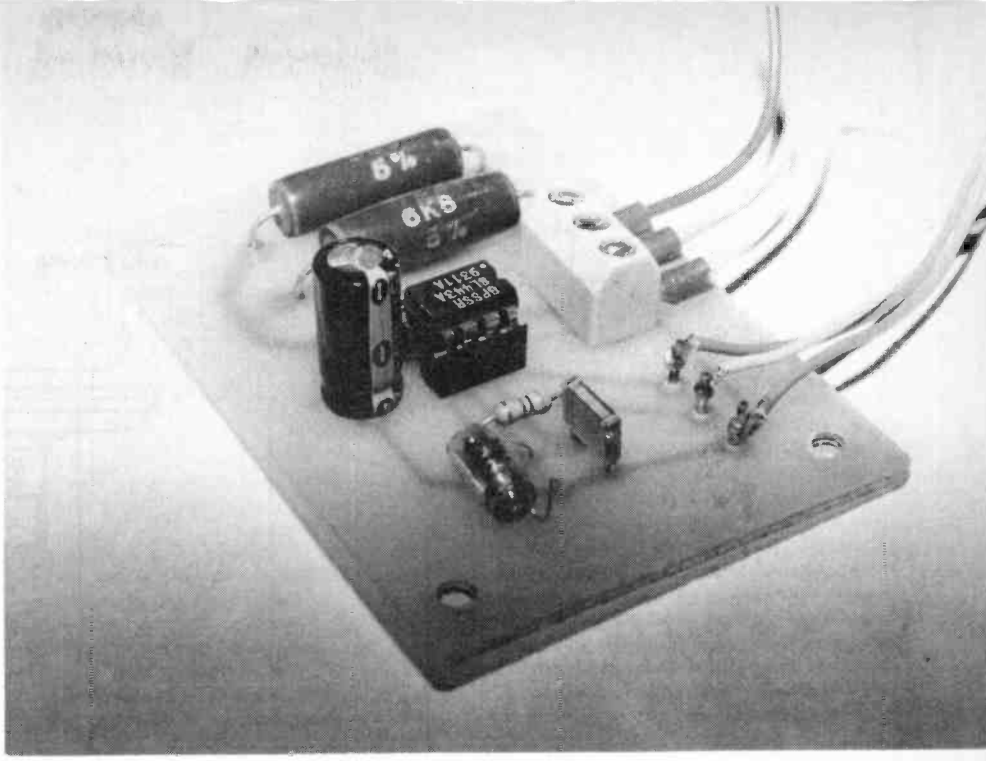
The i.c. should be fitted using an 8-pin d.i.l. socket and the electrolytic capacitor C3 must be correctly polarised. A three-way screw terminal block is used for TB1, this being safer and more reliable in the long term than soldering mains wires directly to the board.

CASE PREPARATION

Case preparation can start with the front panel which carries the panel-mounting 13A mains socket, together with neon LP1 and potentiometer VR1. It is necessary to mount the triac on the aluminium panel too, to act as a heatsink. Note that the triac ***must*** have an ***insulated*** tab. The front panel must be laid out in such a way that when the box is closed together, nothing fitted on the front panel interferes with any parts within the box.

Start off with preparation for the mains socket SK1. If a socket similar to that of the prototype is used, a 50mm diameter hole is needed in the panel. Do this with a Q-Max punch if available – a two minute job. Otherwise drill a series of small holes inside the circumference of the hole, then join them together to form a rough cut-out which can then be gradually smoothed to shape, using a half-round file – hard work!

Once the large cut-out has been prepared, drill the two adjacent mounting holes for the socket such that it will align correctly when finally fitted into position. Alternatively, use a surface-mounting 13A socket which mounts on the front of the panel, although they tend to look quite cumbersome.

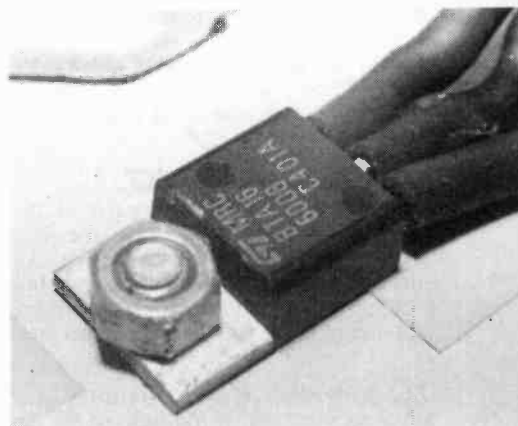


Completed p.c.b. The power resistors must be mounted proud of the board.

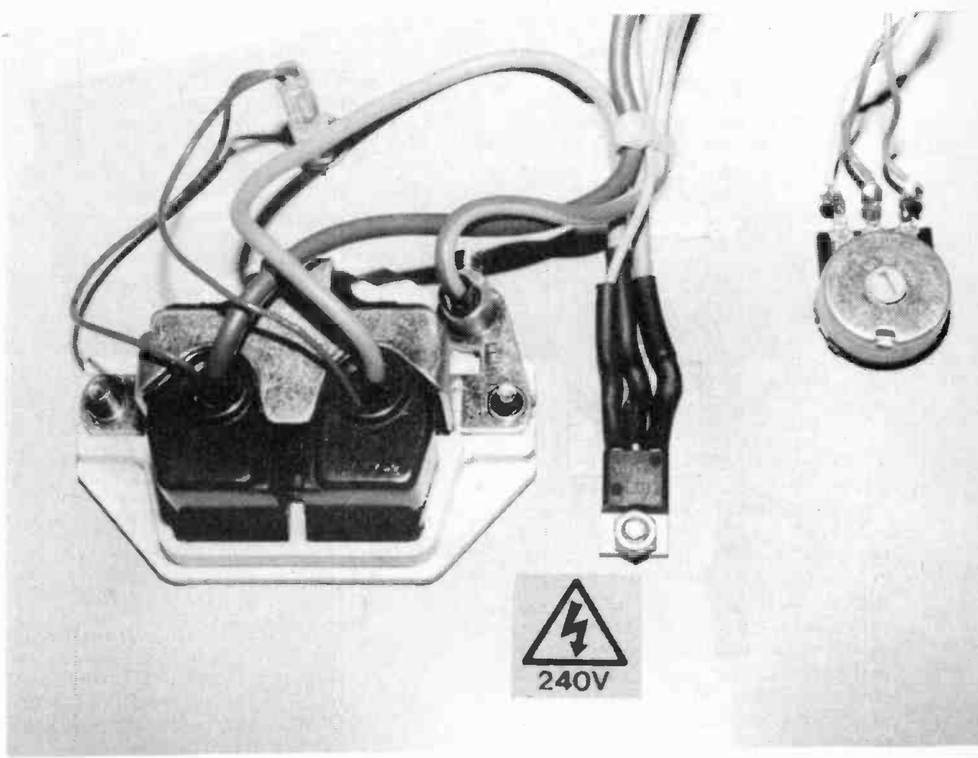
Also drill or punch the holes for potentiometer VR1 and the neon, followed by a 3mm hole centrally in the panel which will permit mounting of the triac directly using a countersunk or panel-head M3 x 6mm fastener. Although no insulation kit is needed it may be worth placing some insulation tape on the panel under the triac leads, just as a precaution to prevent against any errant strands of copper wire etc. shorting to the (earthed) panel.

Finally, once the panel has been prepared, it can be labelled with rub-down lettering as required, followed by a coat of protective spray-on lacquer to enhance the finish. Then fit all the panel-mounting parts and move onto the case.

The casing used with the prototype was made of plastic which eases any work. It needs to be prepared to accept the p.c.b., mains cable inlet and cable restraint. The



The metal front panel acts as the triac heatsink. Insulating tape under the sleeved pins provides extra protection.



Layout of components on the rear of the metal front panel.

layout of the interior is crucial, since adequate clearance must be allowed for the rear projection of the mains socket, potentiometer etc. once the front panel is secured.

The p.c.b. ***must*** be mounted with ***fully-insulated*** hardware for safety, e.g. nylon stand-offs or p.v.c. pillars using short self tapping screws at each end. Once again, organise the internal layout so that the unit will fit together without any obstructions being encountered. Also do ensure that the p.v.c. insulation of any wiring is kept away from the power resistors, whose *surface* temperature is just about adequate to melt ordinary insulation.

Still on the theme of safety, the prototype used a unique three-way 16A terminal block which incorporates a fuseholder within the Live feed. This entirely dispensed with the need to fit a separate fuseholder, also it automatically earths its own mounting bolt. If a separate fuseholder is used, it must be adequately rated (13A or more) and a 1 inch or 1·25 inch fuse type will therefore be called for.

The hole made in the box for the mains cable inlet is best fitted with a 10mm (internal diameter) grommet, to help prevent chafing or wearing of the cable insulation: it also helps to seal the hole. The three-core mains cable is rated at 13A and must of course be held in place with a cable restraint such as a nylon "P-clip" to prevent the cable from being pulled out or working loose.

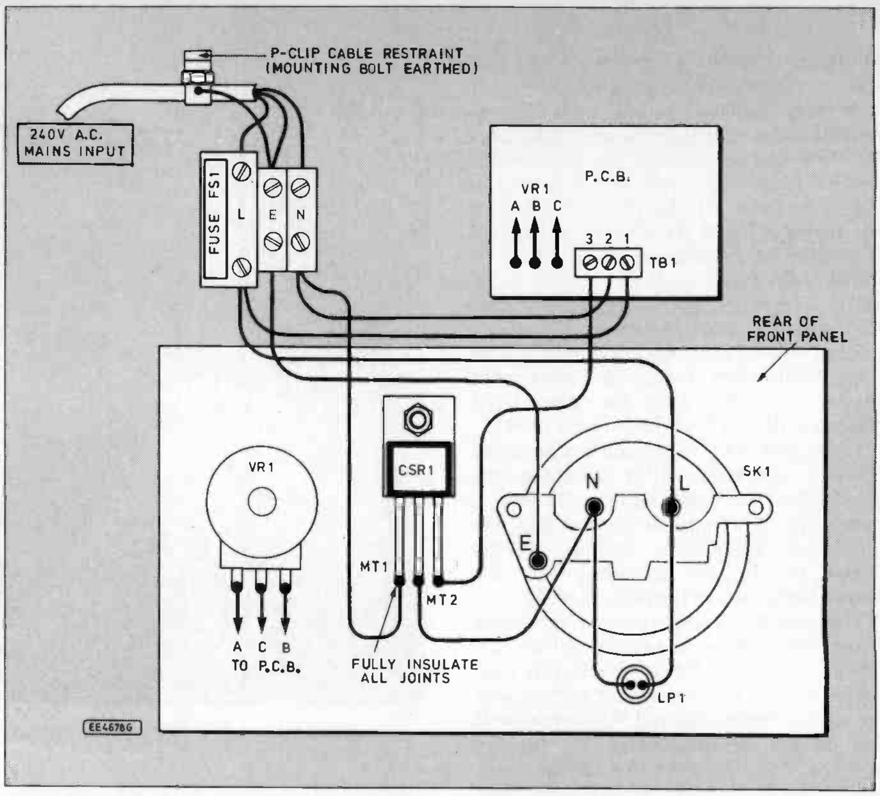


Fig. 5. Interwiring between components and p.c.b. Mains rated cable must be used between the mains terminal block, 13A socket and pins MT1, MT2 of the triac.

INTERWIRING

Having located the main parts of the Power Controller into position, the final aspect of assembly is the interwiring. All wiring which might potentially carry a full load (up to 13A) must be adequately rated with this in mind, see Fig. 5. In actual fact, only the wiring to and from the mains inlet terminal block, the 13A socket and the triac (MT1, MT2 pins) require 13A cable.

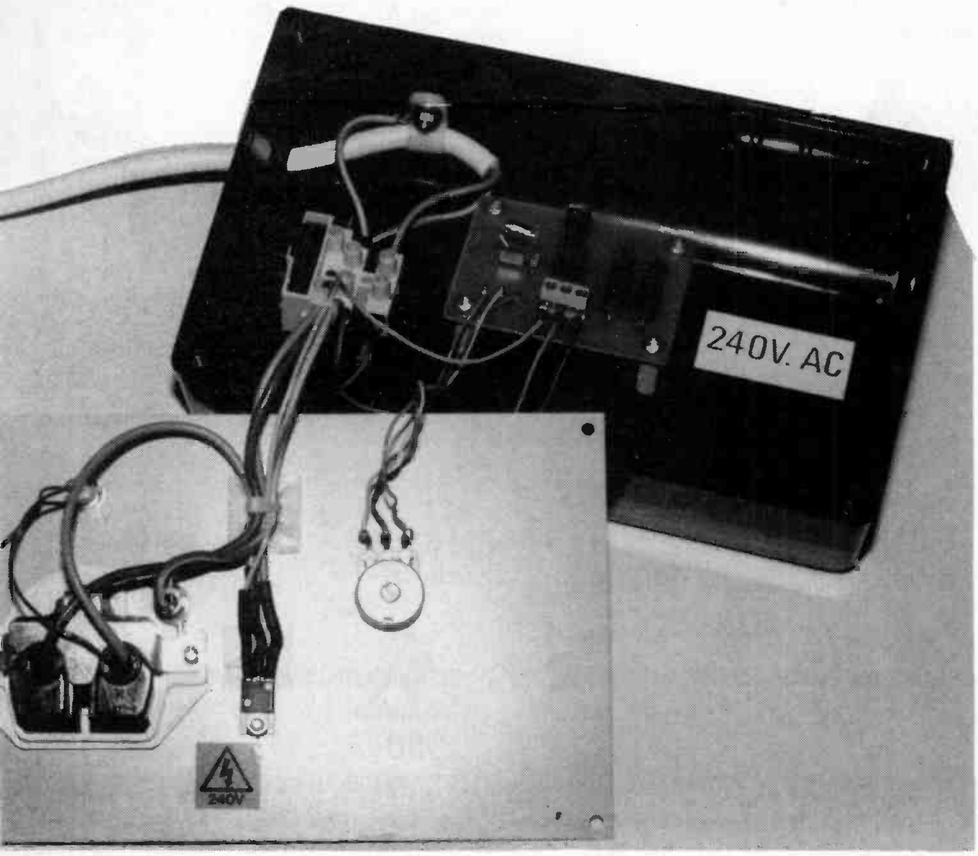
The potentiometer can be connected to the printed circuit board with ordinary insulated hook-up wire (7/0·2mm). All other connections can be effected with 3A wire (16/0·2mm) chosen more for its insulation strength since the mains connections to the p.c.b. itself only carry a few milliamps.

The triac wiring requires special mention: it is straightforward enough to solder the 13A wires to the appropriate leads, however because of the relative mass of the wires, precautions are needed to prevent these wires from straining the triac leads, which would undoubtedly break away if repeatedly flexed (metal fatigue). Hence, use generous lengths of p.v.c. or heatshrink sleeving on the triac wiring and leads to fully insulate them, and also provide a *strain relief* using a stick-on tie wrap base nearby. This will prevent unnecessary strain being applied to the leads.

Note also that the front panel will automatically be earthed through the Earth connection to the socket, which it will be seen is connected to the mounting screws. The P-clip mounting screw should be earthed with a separate wire, connected to a solder tag under the mounting bolt as shown.

Finally, fit a fused 13A plug and check all wiring for errors or omissions, inspecting mains joints very closely to ensure that they are adequately insulated. Having confirmed that all wiring is secured out of the way of the two power resistors, close up the case, ready for testing.

The completed Power Controller with the front panel removed to show components mounted in the base of the case. The "well" to the right side of the p.c.b. accommodates the mains socket SK1.



POWER UP

For maximum protection it is recommended that initial testing is performed through an ELCB/RCD Powerbreaker device, to protect against electric shock. The unit will not operate properly unless a reasonable load is connected, because the triac will not be able to conduct.

However, without a load, applying the mains will power the SL443 i.c. through the mains dropper resistors, which will become hot after a short period. Although various voltage measurements could be taken on the p.c.b. to confirm correct operation (e.g. the 7V d.c. across the potentiometer track), it is probably best to discourage any such testing because of the mixture of low voltage and full mains potential which exists on the board.

Testing is therefore restricted to ensuring the power resistors become hot – after a short period, unplug the Power

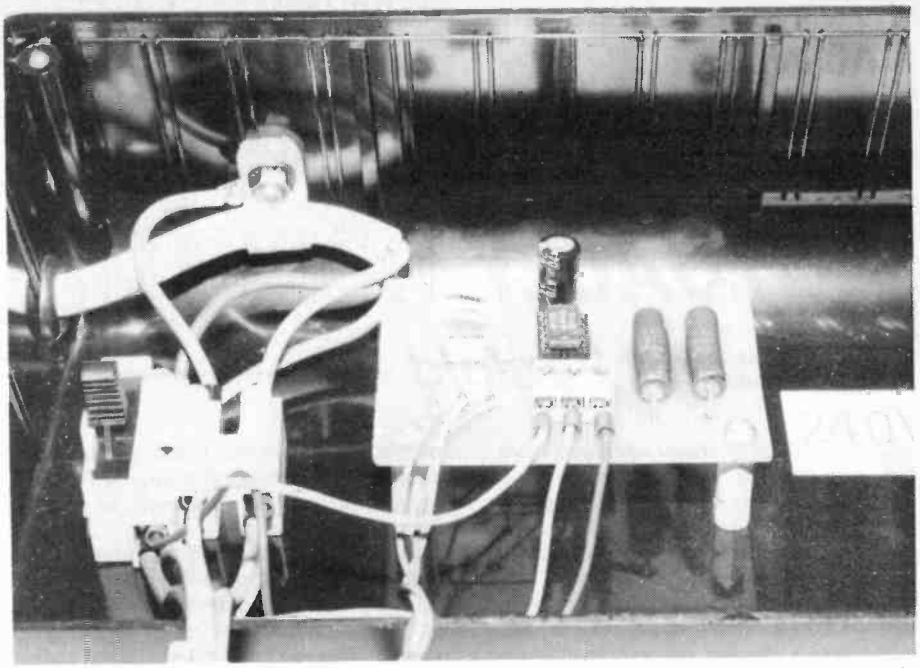
Controller completely from the mains and then check their temperature cautiously. Finally a suitable mains load can be attached, such as an electric fire (*not* a fan heater) or even an ordinary iron.

The neon indicator LP1 should flash at a rate determined by the setting of VR1 – at "maximum" output, the neon should be continuously alight. At "minimum" setting, the neon will be blinking, indicating that short bursts of mains voltage are being applied to the load.

If everything is satisfactory so far, then apply a full load such as a two or three-bar electric fire, double checking that the burst-firing is fully variable using potentiometer VR1. As another check, the temperature of the triac mounting screw will rise when the Controller is on its maximum setting.

Monitor the prototype under full load test conditions for a good hour or more. Then unplug from the mains, inspect the interior to ensure that no insulation had caught on the power resistors and that there are no other visible problems, after which the Power Controller is ready for use.

Use the Power Controller directly on immersion heater elements or other resistive elements such as certain greenhouse heaters, oil-filled electric radiators or traditional electric bar fires. Bear in mind that a certain minimum load of say 500W is necessary for the triac to conduct properly. Below this, the burst firing may seem a little erratic.



The one-piece 16A terminal block, incorporating a fuseholder, and the p.c.b. mounted on plastic stand-off pillars

FURTHER NOTES

If readers wish to install the Power Controller as a permanently-sited unit – perhaps adjacent to an immersion heater – then bear in mind the heat generated by the power resistors. The p.c.b. should be placed such that this heat will flow *away* from the i.c., not over it.

Also, in general terms, do ensure that adequate heatsinking is provided for the triac, and the size of the aluminium panel suggested by the prototype (212mm × 127mm) should be considered the *minimum* dimensions to enable the unit to handle maximum output conditions. The use of a metal box or panel as a heatsink has proven adequate for general purpose use but a ready-made heatsink would enable the design to cope more readily with extreme operating levels.

If it is likely that the Power Controller will be operated at peak output for several hours or more, the triac will dissipate maximum heat under these circumstances and it may be preferable to use a commercial heatsink rated at say 7·5°C/Watt or so, and the size of the case will need revising to accommodate this. □

Techniques

ACTUALLY DOING IT!

– by Robert Penfold

A NUMBER of major changes have occurred over the twenty five years or so that I have been designing electronic circuits. One of the more obvious of these is the rise in popularity of integrated circuits.

Twenty five years ago there were plenty of integrated circuits on sale, but nothing like the vast range currently on offer. Most of the devices in those days were quite simple by today's standards.

For the home constructor integrated circuits had a very strong novelty value at that time. Times change, and integrated circuits now form the basis of practically every electronic project. These days projects based on valves seem to have more novelty value than projects using the latest thing in VLSI technology!

Charged Up

Using integrated circuits is largely straightforward, but there are a few pitfalls awaiting lackadaisical constructors. A minor problem with many modern integrated circuits is that they are vulnerable to damage from static electricity. Any semiconductor device can be "zapped" by a large static charge, but charges of this magnitude are not likely to be found in the average house.

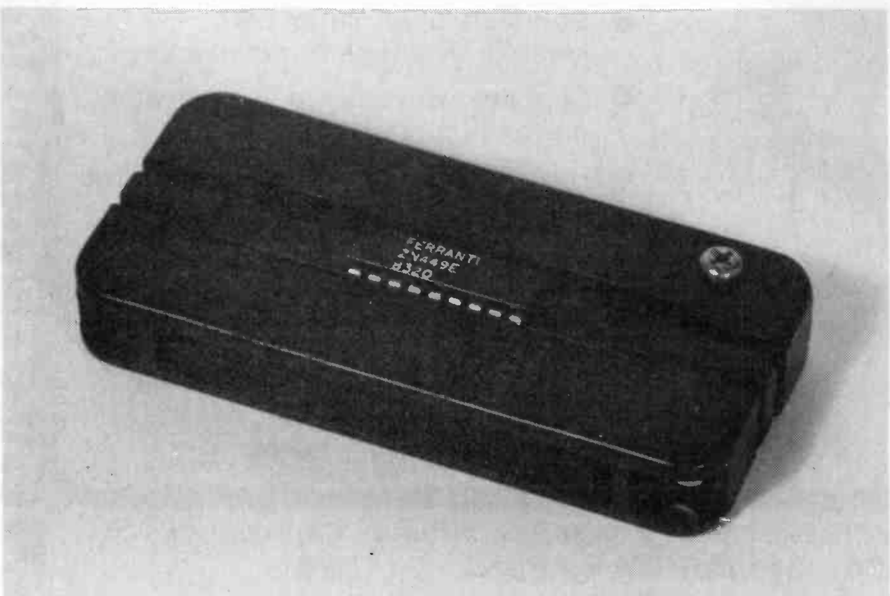
The components that are most vulnerable to static charges are any semiconductors that are based on some form of MOS (metal oxide silicon, or metal oxide semiconductor) technology. These can be "zapped" by relatively small charges.

In fact they can be destroyed by such minor charges, that having just "zapped" one it is unlikely that you would be aware anything had happened. You would simply find that the device had mysteriously ceased to function.

Early MOS devices were very vulnerable to damage from static charges, but most modern MOS devices have built-in protection circuits. With a few exceptions these are not 100 per cent effective, but they do significantly reduce the risk of static damage.

The reason that MOS integrated circuits are vulnerable to static charges is that they have very high input impedances. In most cases the input impedance to a MOS device is over one million megohms. This enables high voltage charges to build up across pins of the device, with the voltage possibly building up to the point where the input breaks down, there is a discharge into the input, and the device is "zapped".

This does not occur with integrated circuits that are based on bipolar transistors, because components of this type have quite low input resistances. Apparently, this results in static charges being rapidly leaked away, and never having a chance to build up to dangerous levels.



A simple but effective device for straightening the pins of d.i.l. i.c.s.

Sensitive Types

So which are the integrated circuits that use MOS technology and are vulnerable to static charges? If a project utilizes one or more static sensitive devices, suitable warnings should be given in the text. These general guidelines should also help you to identify vulnerable components.

All CMOS logic integrated circuits are static sensitive. This includes the 4000 series, plus 74HC, 74HCT, 74AC and 74ACT series TTL logic chips. However, the standard 74 and 74LS series of TTL chips are not based on MOS technology.

Virtually all microprocessors are MOS devices, as are the vast majority of computer support chips. This includes 68**, 65**, and 82** series support chips, plus the 6402 UART and similar devices.

Most analogue-to-digital and digital-to-analogue converters are MOS devices, but the popular Ferranti devices (ZN427E, etc.) are exceptions. Apart from the non-MOS devices mentioned here, virtually all current digital integrated circuits seem to be based on some form of MOS technology.

The situation is very different for analogue integrated circuits. These are mainly based on bipolar transistors, and MOS devices are relatively rare. There are a few exceptions, such as the CA3130E, CA3140E, CA3240E, and CA3160E operational amplifiers.

The MN30** series of "bucket brigade" delay-line chips and matching clock generator devices are also MOS devices. Obviously all forms of MOSFET transistor are static-sensitive, but junction gate field effect devices (Jfets) and ordinary bipolar transistors are not.

It seems to be increasingly common for non-MOS devices to be supplied in some form of anti-static packaging. I had always presumed that this was due to manufacturers finding it easier to use a standard method of packing for all devices, rather than using different types for MOS and non-MOS components. To some extent this would certainly seem to be the case, but the data sheets for some non-MOS semiconductors do contain warnings about the possibility of damage due to static charges.

In particular, many of the more up-market opto-isolators (6N138, 6N139, etc.) are supplied in anti-static packing, and the manufacturers recommend that the normal anti-static precautions should be observed when handling devices such as these. Apparently these components contain small-junction bipolar transistors that are vulnerable to static charges.

I think that I am correct in saying that the potential problem is not a gradual build-up of a static charge, as with MOS components. It is more a problem of sudden static discharges. Due to the small physical size of the transistors, they are vulnerable to damage from small discharges that would not have any effect on normal bipolar semiconductors.

Protection Racket

If any device is supplied in some form of anti-static packing it is probably best to treat it as a static-sensitive component. There are four standard forms of anti-static packing, and conductive plastic foam is probably the most common of these.

Normal plastics have extremely high resistances indeed, but an additive in this black plastic foam material produces a fairly low resistance. In fact it is low enough to be measured using an ordinary multimeter set to a middle resistance range. On testing a few small pieces of this material readings of about 20 kilohms were obtained.

The more expensive integrated circuits are often supplied in simple four-sided plastic holders. Like the foam packing, these are made from a black conductive plastic. Again, the resistance through the plastic is low enough to be measured using an ordinary multimeter, and is low enough to ensure that there is no build-up of static charges.

In both cases the purpose of the plastic is to provide a low resistance path which prevents high voltages from building up across the pins of any component within the packing. Bear in mind that it is a high voltage between two pins that causes damage, not a high static charge *per se*.

Presumably conductive packing also diverts any sudden static discharges away from the device within the packing. In addition to protection against high static voltages, the plastic holders also provide good protection against physical damage.

It is increasingly common for integrated circuits and some other semiconductors to be supplied in a small blister pack. The clear plastic front of the pack probably helps to insulate the device inside from high static voltages, but the main protection is in the form of metal foil over the backing card. This effectively provides a short circuit across the pins of the component within the blister pack, and prevents any damage.

The fourth type of anti-static packing is a plastic tube, which is often quite long and used to store a dozen or more integrated circuits. The plastic is not conductive, and this type of packing is apparently designed to insulate the integrated circuits from any high voltages in the outside world.

Precautions

Whatever type of packing devices are supplied in, the most important thing is to leave them in the packing until it is time to fit them onto the circuit board. This is not until *all* the wiring has been completed and the project is otherwise complete. *Handle static-sensitive devices as little as possible.*

Although constructors are sometimes advised not to touch the pins of static-sensitive integrated circuits at all, I am not sure that this is really a practical piece of advice.

The pins of d.i.l. integrated circuits are usually splayed outwards slightly. I assume that this is done in order to aid certain types of automated construction, but it makes life more difficult for the home constructor. The two rows of pins must be pinched inwards slightly before the components will fit into holders or on a circuit board.

The pins can simply be bent inwards using your fingers, but it is difficult to keep each row neatly aligned using this method. Many constructors find that neat results can be obtained by pressing each row of pins against a tabletop, and gently bending them into place.

There is actually an inexpensive gadget that will do the job almost instantly. It is double-sided, taking 0·3 inch pitch devices on one side, and 0·6 inch types on the other.

You simply drop the device into place, squeeze the gadget, and remove the integrated circuit. It will then drop into place with no difficulty. I am not generally keen on clever little gadgets, but I have to admit that this one is well worth having.

Down to Earth

Whichever method you use, try to handle the pins as little as possible. Always use a holder for static-sensitive components unless the instructions in the article state that the device must be connected directly to the board. This is only necessary with some of the more exotic MOS devices, such as certain high frequency MOSFETs and most power MOSFETs.

If you do have to make connections direct to a MOS device, always use a soldering iron having an "earthed" bit. Most modern electric soldering irons are of this type, and if an iron's mains lead has an Earth wire the bit is almost certain to be earthed to this lead. However, if in doubt you can use a continuity tester to check that the earth pin of the mains plug is connected to the bit.

As supplied, some MOSFETs have a small wire clip which short circuits all the leads to the metal body. This is a very simple but effective method of static protection, but do not forget to remove the clip once the device has been fitted to the circuit board.

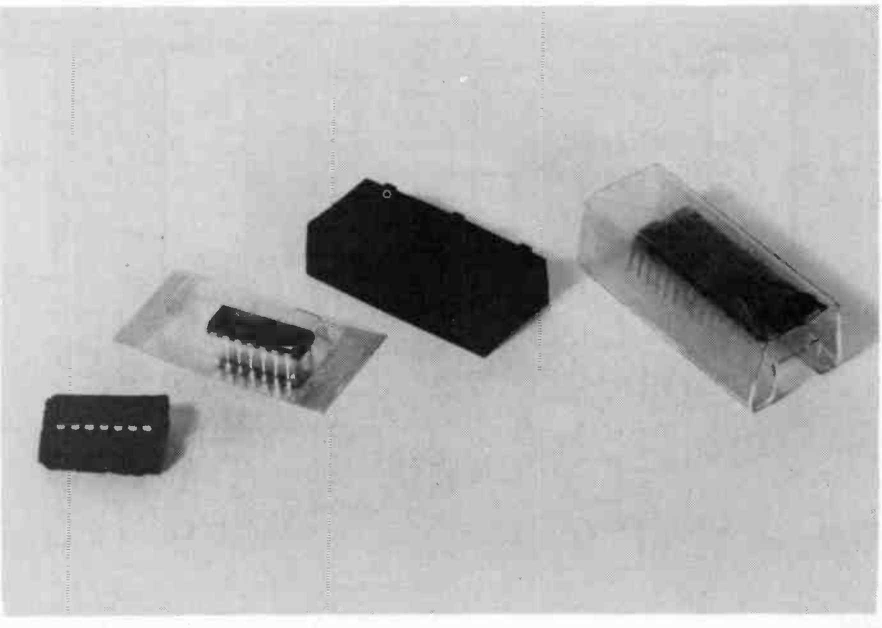
There will inevitably be a short time between a device being removed from its packing and plugged into its holder, and it is vulnerable to static charges during this time. It makes sense to keep the work area free from any obvious sources of high static voltages, especially during this in-between period.

Do not wear clothes that are known to be good static generators. Clothes manufactured from 100 per cent man-made fibres are the most likely cause of problems, but these seem to be something of a rarity these days.

Fabrics which contain at least a reasonable percentage of natural fibres are not likely to generate significant static charges. Definitely do not set up your home workshop in a room which has a carpet that is apt to produce static charges, and keep the work area free from anything that is known to produce the familiar "clicks" and sparks of static discharges. (*Keep the cat away! – Ed.*).

There is an enormous range of anti-static goods on sale, and you will find a fair selection in the tools section of practically any electronic component catalogues. The items on offer include earthed anti-static mats and wrist bands, special furniture, and cleaning sprays. These are mainly aimed at professional users, and are probably not a worthwhile proposition for the hobbyist.

The cost of some basic anti-static equipment is likely to be far greater than the value of any components it saves from being "zapped". Provided you take a few basic precautions there should not really be any need for anti-static mats, etc.



Four types of anti-static packing. From left to right these are: conductive foam, a blister pack, a conductive plastic holder and a plastic insulating tube.

Constructional Project

TV OFF-ER

CHRIS BROWN

Put your TV safely to sleep when you nod off for the night.

MOST modern TVs have infra-red remote controls to operate virtually every feature, from increasing the volume to lowering the brightness, from changing channels to turning the whole thing off.

The latter is, in most cases, a compromise in that it still leaves part of the electronics functioning; you simply press a channel key and it all springs to life again. Some people may use this feature to switch off their bedroom TV once they wish to settle down for the night, but this could present a potential fire risk due to internal circuitry still being active.

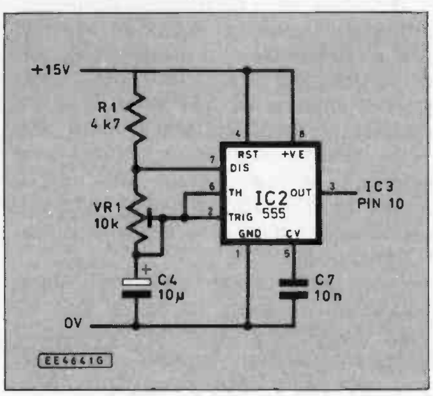


Fig. 1. Timing oscillator stage.

The circuit described here allows you to pre-select a time limit between 15 minutes and 60 minutes, after which the whole TV is turned off by a relay which switches off the mains power. The unit will still contain live mains voltage inside, but it is only used to drive a neon indicator.

In operation, having "dialled in" a 60 minute delay period, four light emitting diodes (l.e.d.s) are turned on, each representing 15 minutes delay. These l.e.d.s are turned off in sequence at 15 minute intervals.

When less than five minutes delay remains, another set of five l.e.d.s is turned on. These are then turned off individually in sequence at one minute intervals. When the final l.e.d. is turned off, both the TV and this control unit are turned off as well.

The idea is that if, for example, you see the last five minutes indicator turned on, and your TV program still has 10 minutes more to run before ending, you can select a further 15 minutes delay time.

HOW IT WORKS

The circuit diagram for the main timing oscillator is shown in Fig. 1. In the drawing, a 555 timer, IC2, is wired in astable mode in which it generates a square wave output of about 11Hz, as set by resistor R1, preset potentiometer VR1 and capacitor C4. The clock frequency output from IC2 pin 3 is sent to the clock input pin 10 of IC3, as shown in Fig. 2.

IC3 is a 14-stage ripple counter of which only seven outputs are used. Output Q4 goes high every 0·8 seconds, and output Q14 produces the 15 minutes timing clock pulse. Either of these outputs can be routed via switch S1c to the clock input pin 15 of the presettable up/down counter IC5. The role of the other used outputs of IC3 will be described shortly.

When rotary switch S1 is in position one (as shown in Fig. 2) the up/down control input of IC5, pin 10, is taken high via S1b, and S1c routes the 0·8 seconds pulse to the clock input of IC5 pin 15. In this mode, IC5 counts upwards, incrementing its total count by one for each clock pulse received.

At each fourth clock pulse, IC5 output Q3 resets this counter via its reset pin 1. This means that the counter will be repeatedly cycled through a count sequence of zero to three, with each output count value remaining "selectable" for 0·8 seconds for as long as switch S1 in position one.

When a new timing sequence is initiated (by switch S1 being switched from position two to position one), a pulse is generated across the network consisting of capacitor C5 and resistors R2 and R3. This resets counter IC3 back to zero. Resistors R4 and R5 hold IC5 pin 10 and pin 15 at 0V during the change over between switch positions one and two.

The Q1 and Q2 binary outputs of IC5 are connected to the A and B control inputs of

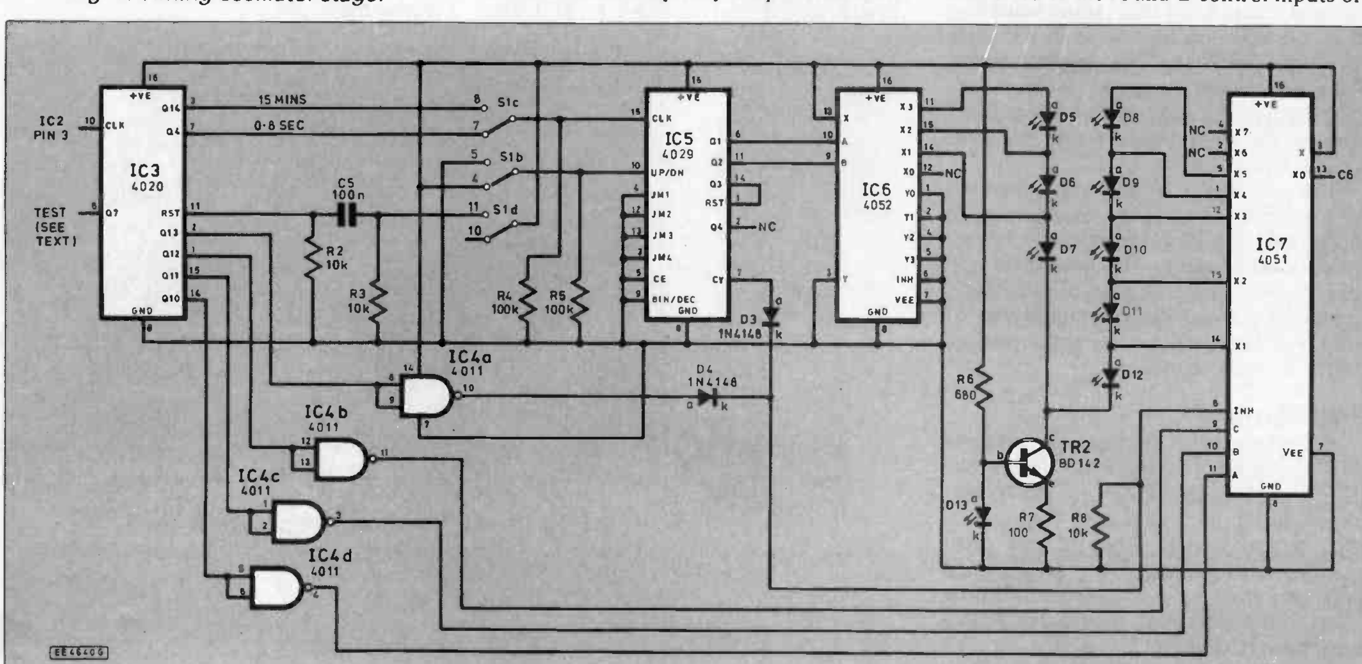


Fig. 2. Circuit diagram for the control stage of the TV Off-er.

a dual 4-way analogue multiplexer, IC6. In this circuit, only one half of the chip is used, and the controls route the positive voltage on the X input to one of the X0 to X3 outputs, as selected by the code on control inputs A and B. The Y paths of IC6 are not used and so are connected to the 0V power line.

COUNT DOWN

Outputs X1, X2 and X3 of IC6 are connected to three l.e.d.s, D5, D6 and D7. These l.e.d.s are wired in series and indicate delay-time multiples of 15 minutes, plus a further 15 minutes, during which the counters will continue to "tick" away. For example, when all three l.e.d.s are on, the display represents a delay of one hour (3 × 15 + 15 minutes). The source of the extra 15 minutes will be explained shortly.

When rotary switch S1 is moved to its second position, it connects the 15 minute signal to IC5 pin 15, the clock input, and takes low IC5 pin 10, the up/down input. Each clock pulse now decrements IC5's count value and successively each of the l.e.d.s D5 to D7 is turned off in sequence.

Note that IC6, being an analogue multiplexer, can only have one output "active" at any one time. Its other outputs are simply held open circuit. Thus, the only route that the l.e.d. current can take is through transistor TR2. The latter, in conjunction with resistors R6 and R7, and l.e.d. D13, is connected as a constant current sink for all l.e.d.s D5 to D12.

Consequently, however many of these l.e.d.s are turned on, they will all be at the same brightness. The l.e.d. D13 is additionally used as the "five minutes remaining" indicator.

As soon as counter IC5 reaches its terminal (zero) count, or the 15 minutes period has been selected (which also sets the counter to zero), its carry-out pin 7 goes low. This is connected via diode D3 to IC7's inhibit pin 6. IC7 is an 8-way analogue multiplexer which is wired with its X input pin 3 connected to the positive line. Its outputs X1 to X5 control the series of five l.e.d.s, D8 to D12, in response to binary codes applied to its control inputs A, B and C.

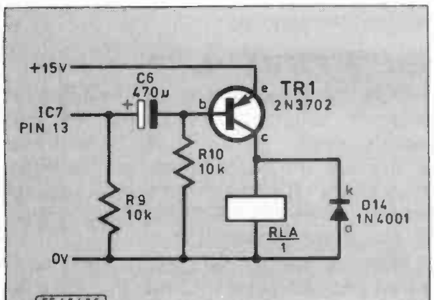


Fig. 3. Relay driver stage circuit diagram.

The latter binary control codes, and an additional inhibit signal, are supplied by outputs Q10 to Q13 of counter IC3, and inverted by the four NAND gates IC4a to IC4d. The least significant bit (output Q10 via IC4d) of this output group is clocked at a rate of one pulse per minute.

When output Q13 is low, the inverted signal from IC4a via diode D4 holds IC7 in an inhibited condition. During this time, l.e.d.s D8 to D12 are turned off as no power is supplied to them. IC7 remains inhibited until IC3 output Q13 goes high, at which time IC3 outputs Q10 to Q12 will go low, thus applying binary code 7 to the control inputs of IC7 via gates IC4b to IC4d.

Two minutes later, the control code on IC7 changes to binary 5, so switching power through to l.e.d. D8, and on through l.e.d.s D9 to D12 as well. Consequently, all five of these l.e.d.s are turned on. As the count progresses through IC3, the control code applied to IC7 changes at one minute intervals. Thus IC7 switches the power line routing to successive outputs and the l.e.d.s are turned off in sequence.

Eventually, when the control code applied to IC7 reaches zero, IC7 output X0 (pin 13) goes high, causing a positive-going pulse to be generated across capacitor C6 in Fig. 3. The negative side of C6 is connected to the base of transistor TR1.

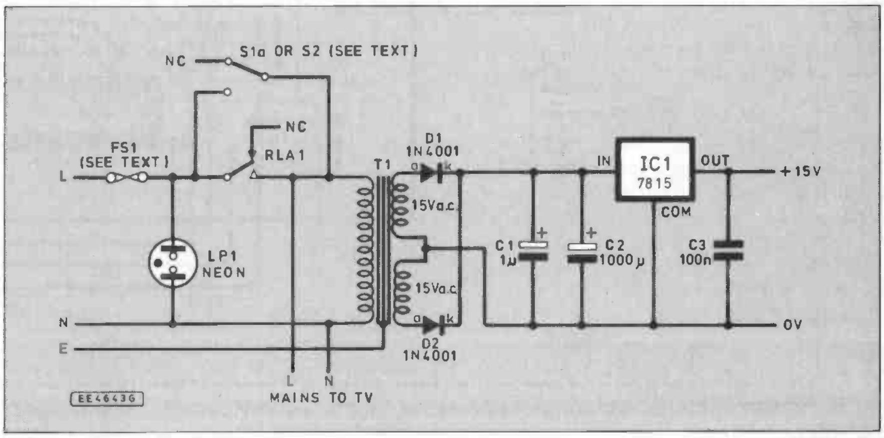


Fig. 4. Circuit diagram for the power supply stage and arrangement of the relay "by-pass" switch S1a or S2.

RELAYING POWER

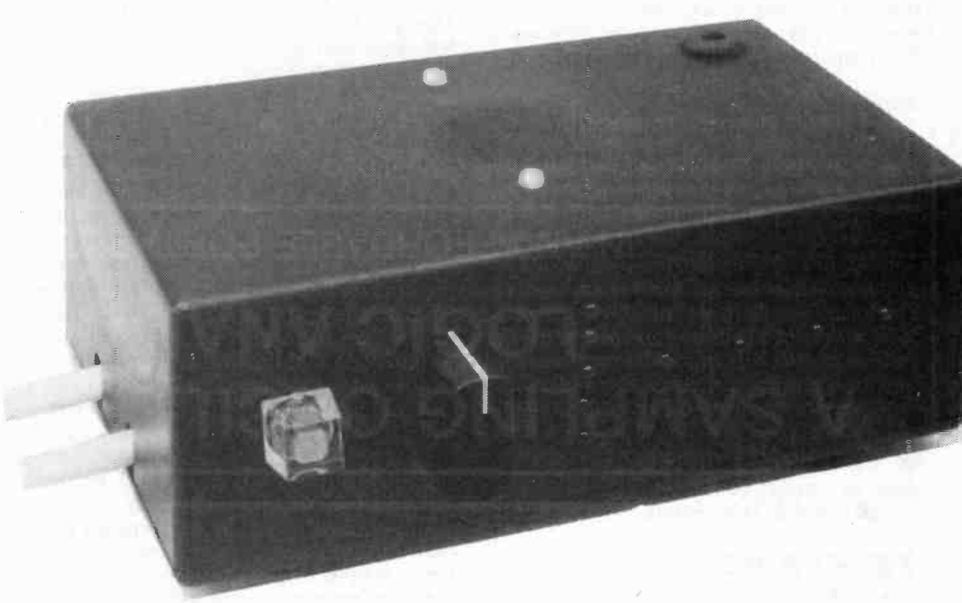
Transistor TR1 is a *pnp* type which has its base biased via resistor R10. Normally, TR1 is held in a conducting state by its base bias, and current flows through the coil of relay RLA and the relay contacts RLA1 switch mains power to the TV and to the unit's transformer T1.

On receipt of the brief pulse via capacitor C6, TR1 ceases to conduct and the relay contacts open (see Fig.4), so switching off the TV and the unit's mains power. Resistor R9 simply allows capacitor C6 to discharge when the circuit is turned off. Diode D14 protects TR1 from the back e.m.f. voltage generated when the relay coil is switched off.

The purpose of diodes D3 and D4 together with resistor R8 in Fig.2 is to act as a wired-AND gate which allows the inhibit pin of IC7 to be controlled by positive level signals from IC4a and IC5. When neither diode has a positive voltage across it, the inhibit pin of IC7 is held low by resistor R8.

Referring to the power supply circuit of Fig. 4, mains power is brought into transformer T1, which produces an output from its twin secondary windings of about 15V a.c. Diodes D1 and D2 rectify the a.c. voltage, which is then smoothed by capacitors C1 and C2. The peak off-load rectified voltage at the input to regulator chip IC1 will be approximately 15V × 1·41 = 21·2V d.c., although this may vary depending on the transformer's manufacturing tolerance. IC1 regulates the rectified voltage down to 15V d.c.

The contacts of RLA1 are operated when the relay coil in Fig. 3 is energised. Choice of which relay by-passing switch is used, S1a or S2 in Fig. 4, is discussed at the end of the article.



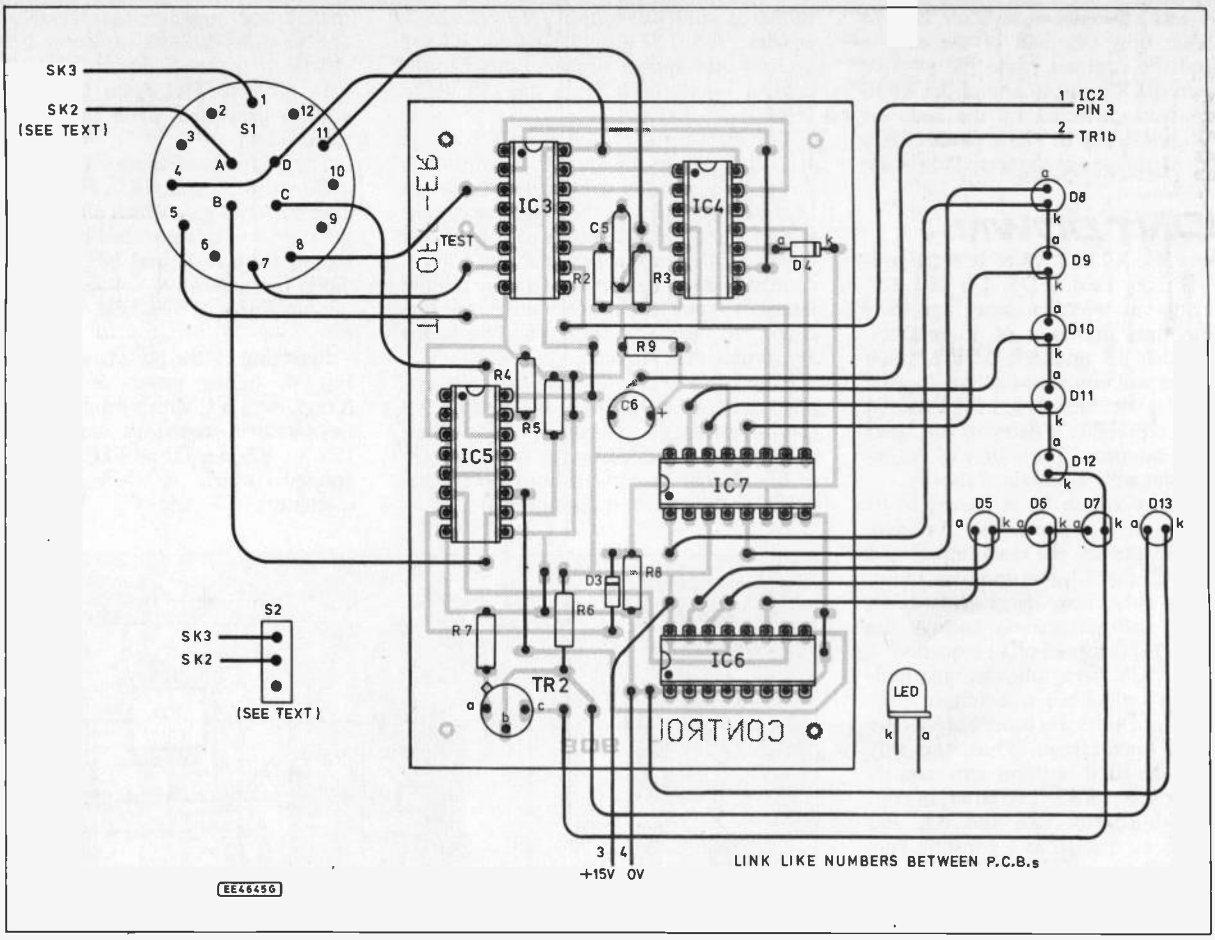


Fig. 5. Printed circuit board component layout for the Control circuit. The full size copper foil master pattern is shown opposite, top left.

CONSTRUCTION

The printed circuit board (p.c.b.) topside component layouts and full size copper foil master patterns for the TV Off-er are shown in Fig. 5 and Fig. 6. The boards are available as a combined set from the *EPE PCB Service*, code 908/909.

It is preferable to use sockets for all the d.i.l. i.c.s. Remember to include the link wires, and to correctly orientate the electrolytic capacitors and all the semiconductors as shown. It is best to omit all i.c.s except IC1 until the unit has been initially tested. The lugged locating washer of switch S1 should be adjusted so that only positions one and two can be selected. Position three of the switch is not used.

Warning

Once the boards are assembled, it is essential they are tested. When working on the unit, beware that mains voltages can be lethal and that extreme care must always be taken. Ensure that no mains voltages can come into contact with any part of the low-voltage circuits or components.

Although a separate fuse was not used in the mains power line at the entry point to the prototype unit, it is strongly recommended that one should be included, as shown in Fig. 4 and Fig. 6. The fuseholder should be mounted through a hole drilled in the side of the case and the fuse rating selected to suit the TV being controlled. If in any doubt about any aspect of the mains connections, consult a qualified electrician.

TESTING

In view of the potential hazards caused by incautiously working with a mains powered unit, it is best during the initial testing stages to use, if possible, a bench power supply delivering about 20V d.c. Connect the d.c. supply to the input and common pins of regulator IC1, observing the correct polarity. Verify that the regulator is working properly by connecting a voltmeter across the common and output pins of IC1. A voltage of close to +15V d.c. should be present.

Insert the remaining i.c.s. Set the wiper of preset potentiometer VR1 to about its mid-way position, and with the voltmeter monitor the output of IC2, at pin 3. The meter reading should fluctuate quite rapidly indicating that IC2 is generating pulses. With the meter, monitor IC3 pin 7. This time the meter should show a series of high/low readings, each cycle taking approximately one second.

Switch S1 to position one and monitor IC5 pin 6 and then IC5 pin 11. It should be apparent that the outputs are toggling up and down and that the output rate for IC5 pin 11 is half the rate of IC5 pin 6. If these tests are satisfactory, it is likely that the remaining circuitry is functioning correctly.

If you are feeling patient, you could similarly use the meter to monitor the control inputs to IC7 at its pins 9, 10 and 11. Even more patient observation of all the l.e.d.s should verify that they are being correctly controlled.

The mains power cables can now be connected via the terminal blocks on the p.c.b. The mains cable used with the unit must have a current carrying capability greater than the current drawn by the TV set. It is advisable to remove all i.c.s except for IC1 until it has been verified that the complete power supply is functioning correctly.

For safety reasons, the unit should now be mounted into its case. The case chosen for the prototype was not, perhaps, the best choice as it had p.c.b. guides on the internal walls. These had to be filed out before the l.e.d.s would protrude through far enough, and to enable rotary switch S1 to be sited correctly. You may find that a different style of case, but having similar dimensions, may suit your needs better.

Once the unit has been housed, and observing the mains-safety warning given earlier, switch on the mains power and check that the voltage regulator IC1 still delivers an output of 15V d.c. If not, immediately switch off and recheck your connections. If satisfied, switch off and re-insert the removed i.c.s.

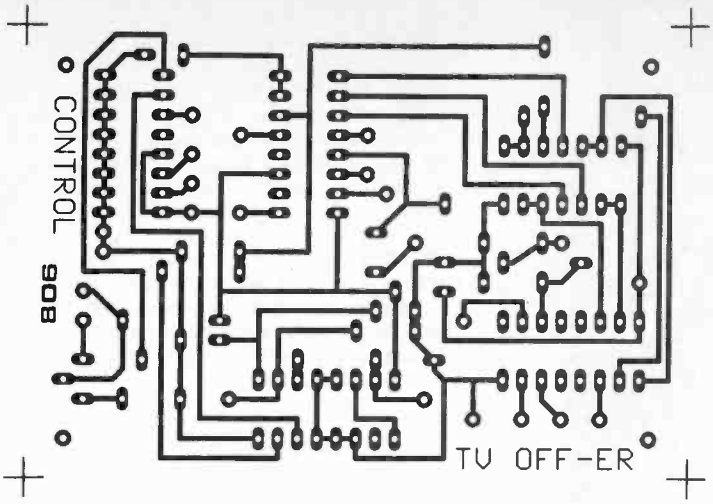
SETTING UP

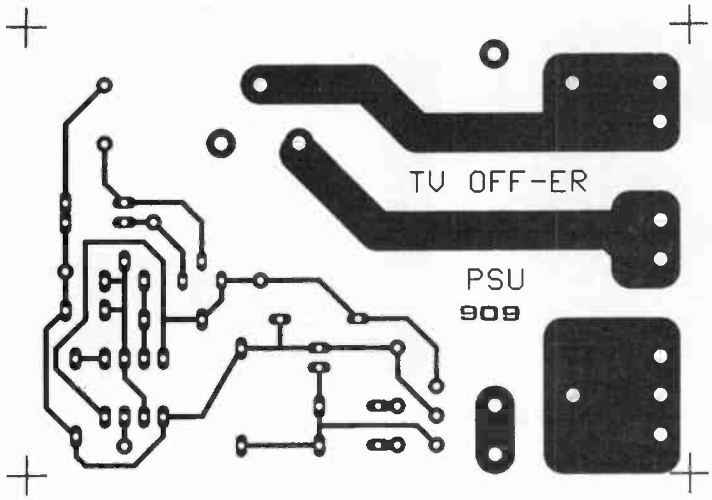
Only one minor setting-up procedure is required: adjusting the output of the master clock generator IC2 so that it delivers 0·109375 pulses per second! Thankfully, that amounts to a readily readable pulse rate of about 14 seconds at IC3 pin 6, the Q7 output.

With the meter, monitor this pin and adjust potentiometer VR1 (see Fig. 1) until this rate is achieved. Alternatively, if you are especially patient, you could monitor IC3 pin 3 (output Q14) and adjust VR1 until it delivers a 15 minute rate!

IN USE

When plugged into the mains, no power will reach the circuit or TV when the relay contacts are open. This situation is changed by turning rotary switch S1 to position one, which bridges the relay contacts. When this is done, the 30 to 60 minute l.e.d.s come on one by one, changing at intervals of 0·8 seconds. The 15 minute indicator remains on all the time but may dim slightly when it is the only l.e.d. turned on, due to the fact that the collector of TR2 has no load at this time.





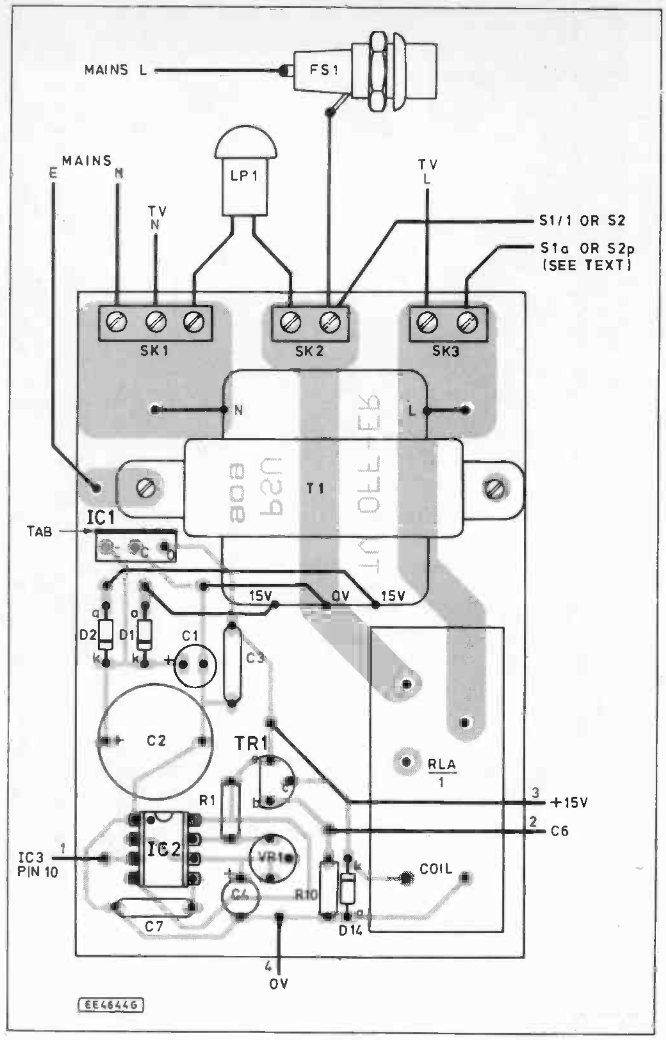


Fig. 6. (above left) Full size power supply board foil master and, above right, the topside component layout.

Once the chosen time is reached, switching S1 to position two will start the timing count-down sequence. The switch can be set back to position one at any time to select a new timing range. Should the unit be plugged in with switch S1 set to position two, nothing will happen. In which case, simply set S1 back to position one and proceed as above.

Obviously, while the unit is running in a real-life situation, switch S1 should not be moved to position one as this would simply bridge the relay contacts, so preventing the unit from switching off the TV when the allotted time has run.

SWITCH RATING

It should be noted that the use of rotary switch S1 for switching mains voltages is subject to its voltage and current switching capabilities. The standard midget wafer switches commonly available are rated at 250V a.c. at a maximum switching current of 150mA. Often a secondary current is quoted for the switches, typically of 4A or 5A. This secondary rating is the maximum current carrying load that the switch will withstand across its *motionless* contacts. It is not the maximum current than can actually be switched.

It is likely that many TV sets will draw more than 150mA and therefore, in this instance, the standard midget wafer switches must not be used to switch the TV mains power supply on and off. The current rating of your TV will be quoted either on a label on the back, or in its operating manual. If the set draws less than 150mA then the *TV Off-er* circuit may be used fully as described above.

If the TV current drawn is greater than 150mA then a high-current mains rated second switch, S2 as shown in Fig. 4 and Fig. 6, must be used as the by-pass on/off switch across relay RLA1. In this event, the live mains leads are connected to switch S2

COMPONENTS

See SHOP TALK Page

Resistors

R1	4k7
R2, R3, R8, R9, R10	10k (5 off)
R4, R5	100k (2 off)
R6	680
R7	100

All 0·25W 5% carbon film or better

Potentiometer

VR1	10k sub-min round preset

Capacitors

C1	1µ radial elect. 63V
C2	1000µ radial elect. 25V
C3, C5	100n polyester (2 off)
C4	10µ radial elect. 25V
C6	470µ radial elect. 25V
C7	10n polyester

Semiconductors

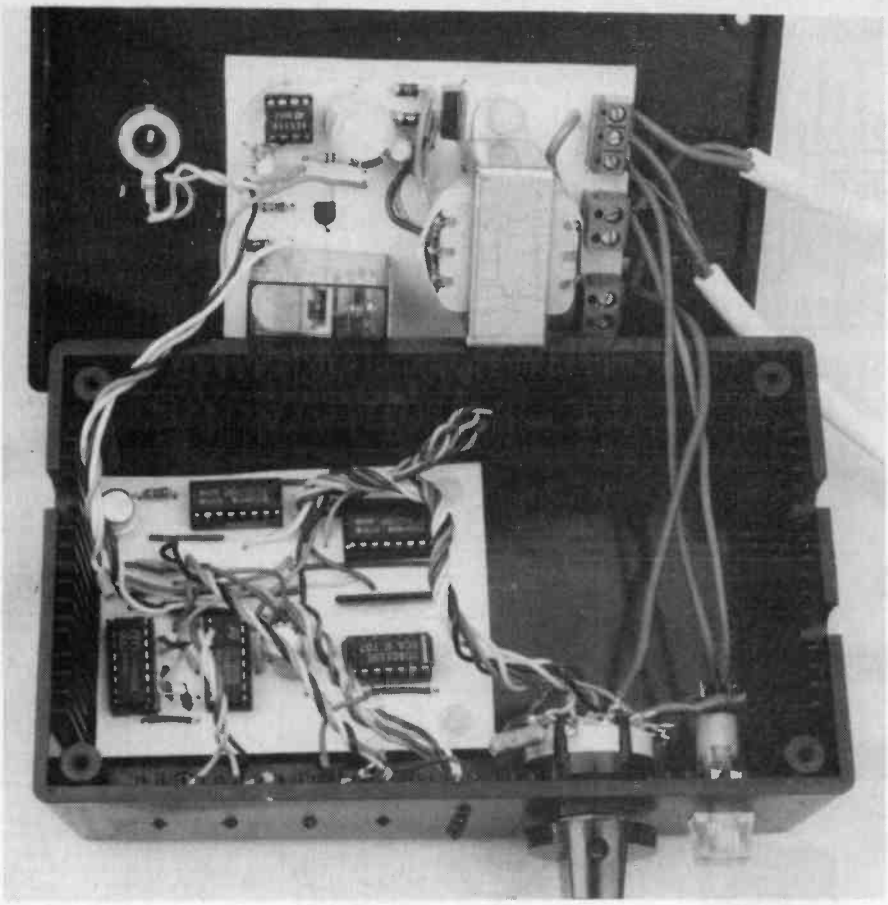
D1, D2, D14	1N4001 rectifier diode (3 off)
D3, D4	1N4148 signal diode (2 off)
D5 to D13	sub-min. red l.e.d. (9 off)
TR1	2N3702 *pnp* transistor
TR2	BC142 *npn* transistor
IC1	7815 1A 15V regulator
IC2	555 timer
IC3	4020 14-stage binary counter
IC4	4011 quad 2-input NAND gate
IC5	4029 4-stage up/down counter
IC6	4052 dual 4-way analogue multiplexer
IC7	4051 8-way analogue multiplexer

Miscellaneous

S1	4-pole 3-way mains-rated rotary switch (see text)
S2	mains rated on/off switch (see text)
RLA	12V p.c.b. mounting relay, with s.p.c.o. 15A 250V a.c. contacts

Printed circuit boards available from *EPE PCB Service,* code 908/909 (pair); mains transformer with 15V-0V-15V 100mA secondary winding; mains neon; panel mounting fuseholder, fuse to suit; 2-way p.c.b. mounting mains connector block (2 off); 3-way p.c.b. mounting mains connector block; 2BA nylon nuts and bolts (6 off); knob; 8-pin d.i.l. socket; 14-pin d.i.l. socket; 16-pin d.i.l. socket (4 off); plastic case 138mm × 96mm × 55mm (L × W × H); stick-on rubber feet (4 off); cable; connecting wire; solder etc.

Approx cost guidance only **£30**



Layout of components inside the prototype model. The preset potentiometer has now been incorporated on the p.c.b.

and not to switch section S1a. The low voltage connections to S1 remain as shown (switch sections S1b, S1c and S1d).

Operation of the *TV Off-er* is still basically as described above, except that switch S2 has to be used to apply power to the TV before relay RLA1 contacts have been closed by the timing circuit. Once the relay is active, then switch S2 should be switched off, allowing the circuit to switch off the TV via the relay at the end of the timed period.

Readers are advised to check with their supplier the mains voltage and current rating of any rotary wafer switch bought for use with the *TV Off-er*. □

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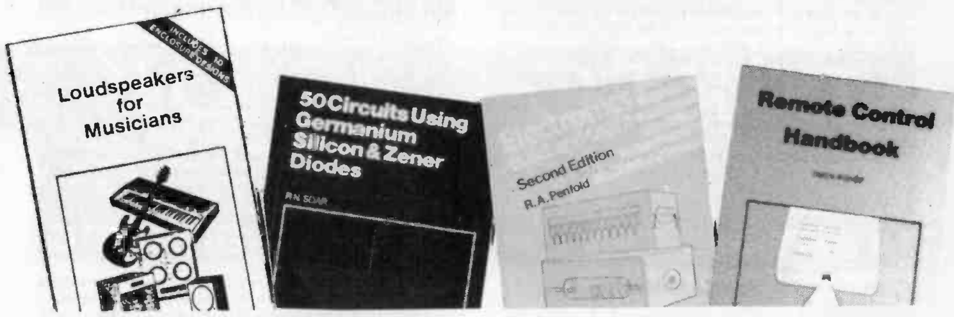

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REPORTING AMATEUR RADIO

Tony Smith G4FAI

AMATEUR LICENCE CHANGES

On 18 July 1994, a number of changes were made to the terms and conditions of the Amateur Radio and Amateur Radio (Novice) licences, as follows:

The maximum power level permitted in the whole of the 1·8MHz band (top band) is now the same as that in most other amateur bands, i.e., 26dBW (400W peak envelope power). Until a few years ago, power in this band was limited to 15dBW (32W p.e.p.).

Power levels were then increased but restrictions remained on 1·810MHz to 1·850MHz pending the removal of other services from this sub-band which might otherwise have suffered interference from more powerful amateur transmissions. These services have now been removed and the full amateur power limit is permitted in all parts of the band.

Power restrictions also applied to the 50MHz band, where there were restrictions on the height of antennas and maritime mobile operation was not permitted. The last two restrictions have now been lifted for the whole band, 50MHz to 52MHz, and the full 26dBW may now be used in the frequencies 50MHz to 51MHz.

The list of countries belonging to the CEPT, the European Conference of Postal and Telecommunications Administrations, has been updated to include several Eastern European countries that have now joined CEPT. Not all members take part in the CEPT Amateur Radio Common Licence agreement, but it is hoped that the newcomers will soon adopt the agreement thus extending the opportunities for temporary operation by amateurs in foreign countries with the minimum of formality.

NEW RESTRICTIONS

Although the changes mainly represent improvements for radio amateurs, there are also some newly imposed restrictions. It is now necessary for unattended digital operation to be notified to the local office of the Radio Investigation Service. This follows a number of problems experienced with unattended packet operation, and licensees now have to agree emergency close-down arrangements with the RIS.

A further new requirement relates to the production of information when stations are inspected and the station log is kept on computer. A "hard copy" of the log must be produced on request or a copy of the magnetic media on which the log is kept must be supplied to take away, to be followed by a hard copy as soon as is reasonably practicable thereafter.

SATELLITE PROGRESS REPORT

Last March I wrote about the projected *Phase 3D* amateur satellite. This will provide much better operating facilities for radio amateurs than have been available previously, including longer access periods, higher power transmitters and higher gain receivers. With an expected life of around 10 to 15 years, the project is designed to bring satellite operation within the reach of many more amateurs, worldwide, who will be able to use relatively simple equipment.

A progress report, in the July 1994 issue of *IARU Region 1 News*, reports that eleven countries around the world are participating in the construction of the satellite and additionally logistical support and assistance for fuel tanks has come from Russia.

The satellite is being built under the leadership of Dr Karl Meinzer, DJ4ZC, of Germany's amateur satellite organisation, AMSAT-DL. As at the date of the report, March 16, 1994, all hardware was under construction and some flight hardware was already finished.

The cost of the satellite is expected to be 3·5M US dollars and $2·5M has been raised so far, including a contribution of $50,000 from AMSAT-UK.

There is an urgent need to raise the balance. Fund-raising continues to this end and the International Amateur Radio Union Region 1 has invited all member societies to help finance the project by directly sponsoring parts of the satellite.

The frequencies to be used by the new satellite are 21MHz uplink and 29MHz downlink; 145MHz uplink and downlink; 435MHz uplink and downlink; 1·2GHz uplink; 2·4GHz uplink and downlink; 5·7GHz uplink and downlink; 10·4GHz downlink; and 24GHz downlink.

Several experiments in the field of digital communications are to be included at the same time as the analogue communications modes, CW and SSB. Camera experiments will provide colour pictures of outstanding views and high quality communications are expected due to the 3-axis stabilised spacecraft.

A special control system (LEILA) will provide protection for low power users and keep the satellite receiver as sensitive as possible. The 16-hour specially selected orbit will give radio amateurs all over the world communication possibilities during evening and early morning hours for at least two thirds of the time says the report.

MORSE 2000 CONFERENCE

The University of Wisconsin-Eau-Claire, is tentatively planning an intriguing conference to take place in the Spring of 1996. A draft summary of the scope of the conference states (in part):

"Individuals of all ages who have severe motoric and/or sensory disabilities are using newly-developed adapted-access software programs, hardware peripherals, and learning methods that allow them full use of microprocessor devices via Morse input from switches external to the computer. . .

"This alternative computer access method can help bestow the power of speech output, writing, typing, dialing, graphics, music, and other modes of expression. Also, Morse code input to activate mobility and environmental control devices may open worlds of educational, vocational, and recreational opportunities to many persons previously shut out of these pursuits. . .

"More than 30 manufacturers/-developers of Morse-input hardware or software (for these applications) have been identified to date. However, beyond standard Morse encoding patterns for letters, numbers, and basic punctuation, each manufacturer appears to be developing their own non-standard 'Morse-type' patterns for keyboard functions not addressed in the original code. Some examples of these functions include Shift, Alt, Delete, Enter, and other non-alphanumeric commands/functions found on computers as well as cursor control via mouse or keyboard arrow inputs."

It is felt by the organizers that "a unified, global effort to promote use of, research in, and standardization of Morse code in rehabilitation contexts, as well as in other specialized communication settings appears essential at this time. *Morse 2000* will begin to address these needs."

FURTHER IDEAS SOUGHT

The conference goals therefore, are to:

"Develop and maintain an international repository world centre for, and database of research in, Morse code applications in rehabilitation.

"Apply research and clinical findings to establish and promote use of standardized Morse-type entry patterns for all currently-used keyboard functions and mouse emulation.

"Promulgate a standardized methodology of Morse Pattern creation for representing new keyboard functions as they are developed by manufacturers.

"Influence the computer industry to include Morse code access as a standard transparent access alternative built in to all new computers. (Access could be from space bar, shift keys, or from external switches via serial port, etc.)

"Expand Morse literacy and awareness for potential users and the general public globally.

"Continue to research and develop enhanced, efficient methods of learning Morse code for various expressive and receptive communication applications.

"Publish a regular scholarly journal focusing on Morse code research. . ."

At this early stage, the University is looking for additional suggestions and ideas for matters to be considered. Undoubtedly many handicapped radio amateurs who use computers to control their radio activities, or those who have helped in setting up such systems for them, will be interested in the scope of this conference and may be able to contribute further ideas for consideration.

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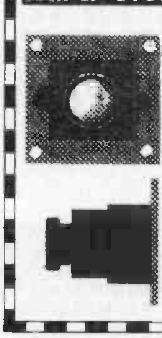

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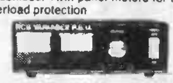

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