

Copyright © 2008, Wimborne Publishing Ltd
(Sequoia House, 398a Ringwood Road, Ferndown, Dorset BH22 9AU, UK)
and TechBites Interactive Inc.,
(PO Box 857, Madison, Alabama 35758, USA)

All rights reserved.

The materials and works contained within EPE Online — which are made available by Wimborne Publishing Ltd and TechBites Interactive Inc — are copyrighted.

TechBites Interactive Inc and Wimborne Publishing Ltd have used their best efforts in preparing these materials and works. However, TechBites Interactive Inc and Wimborne Publishing Ltd make no warranties of any kind, expressed or implied, with regard to the documentation or data contained herein, and specifically disclaim, without limitation, any implied warranties of merchantability and fitness for a particular purpose.

Because of possible variances in the quality and condition of materials and workmanship used by readers, EPE Online, its publishers and agents disclaim any responsibility for the safe and proper functioning of reader-constructed projects based on or from information published in these materials and works.

In no event shall TechBites Interactive Inc or Wimborne Publishing Ltd be responsible or liable for any loss of profit or any other commercial damages, including but not limited to special, incidental, consequential, or any other damages in connection with or arising out of furnishing, performance, or use of these materials and works.

READERS' TECHNICAL ENQUIRIES

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. We are not able to answer technical queries on the phone.

PROJECTS AND CIRCUITS

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. A number of projects and circuits published in EPE employ voltages that can be lethal. You should not build, test, modify or renovate any item of mains-powered equipment unless you fully understand the safety aspects involved and you use an RCD adaptor.

COMPONENT SUPPLIES

We do not supply electronic components or kits for building the projects featured; these can be supplied by advertisers in our publication Practical Everyday Electronics. Our web site is located at www.epemag.com

We advise readers to check that all parts are still available before commencing any project.



To order your copy for only \$18.95 for 12 issues go to www.epemag.com

DOOR DEFENDER



STEVE DELLOW

Keep an armed guard on your door or valuables with this self-contained, truly portable, low-cost audio/visual alarm

WHETHER we are brave enough to admit it or not, we all suffer varying degrees of paranoia when it comes to the doors in our life. Was that someone sneaking in the front door? Did we leave the back door open? Where's the padlock on the shed door? Should we have a mortise or a night latch?

The list goes on and on . . . There isn't a day goes by when we don't suffer some stress event associated with a door!

Perhaps the circuit described here might help put some of those fears at rest. The Door Defender is a simple circuit intended to monitor the opening and closing of a single door, but it could easily be expanded into a comprehensive system.

It can be used with any type of internal or external opening, and consumes very low current in standby. For instance, the long battery life would make it ideal for protecting a garden shed. On the other hand, its small size could allow it to be a portable unit for protection when travelling.

DESIGN OVERVIEW

It was decided to create a door monitoring circuit based on the reliable reed switch and magnet method. This would

feed information into a circuit designed to indicate whether the door was open or shut. An "arming" sequence would begin with the door closed i.e. you're getting ready to leave, followed by a turn of a keyswitch to apply power to the circuit. The unit would signal that it had entered the arming sequence which prompts you to open the door and leave, closing it behind you.

The action of opening and shutting the door would be detected by the circuit which would then move into an "armed" mode. The next time the door was opened, the system would immediately turn on and latch the alarm. This would only be cleared by switching off the unit with the keyswitch, even if the door was closed again.

CIRCUIT DESCRIPTION

The complete circuit diagram for the Door Defender is shown in Fig.1. Power for the circuit comes from a 9V alkaline battery, which is ideal to supply the CMOS i.c.s that control the alarm process. As mentioned earlier, a reed switch, S2, is used to detect the opening and closing of the door. These items are standard in most

burglar alarm systems and are usually employed to monitor the entry/exit route.

They consist of two main components – the reed switch and a magnet. When the two are positioned adjacent and "in-line" i.e. when the door is properly closed, the reed switch physically aligns itself with the lines of flux from the magnet, causing the contacts to close. They are generally good enough to detect a door even slightly ajar.

Unfortunately, like all switches, the reed type is liable to "bounce" when closing. In other words, the contacts do not necessarily come together cleanly, and for a very brief fraction of a second, they may open again one or more times before they finally settle. The bounce may appear to us to be over very quickly, but in logic terms, it is a lifetime, and the circuit will detect every "bounce" as an opening and closing of the door! The ideal recipe for a very confused circuit!

Components R2, C1 and IC1b come to the rescue here, forming a "debounce" circuit. Basically we are using an RC slow-down network to drive the Schmitt trigger gate IC1b. The low-pass filter formed by resistor R2 and capacitor C1 smoothes out the bounces of the switch contacts so that IC1b makes only one transition. A time constant of 10ms to 25ms is generally enough.

ON GUARD

Now that we have a clean reliable signal telling us what the door is doing, we can

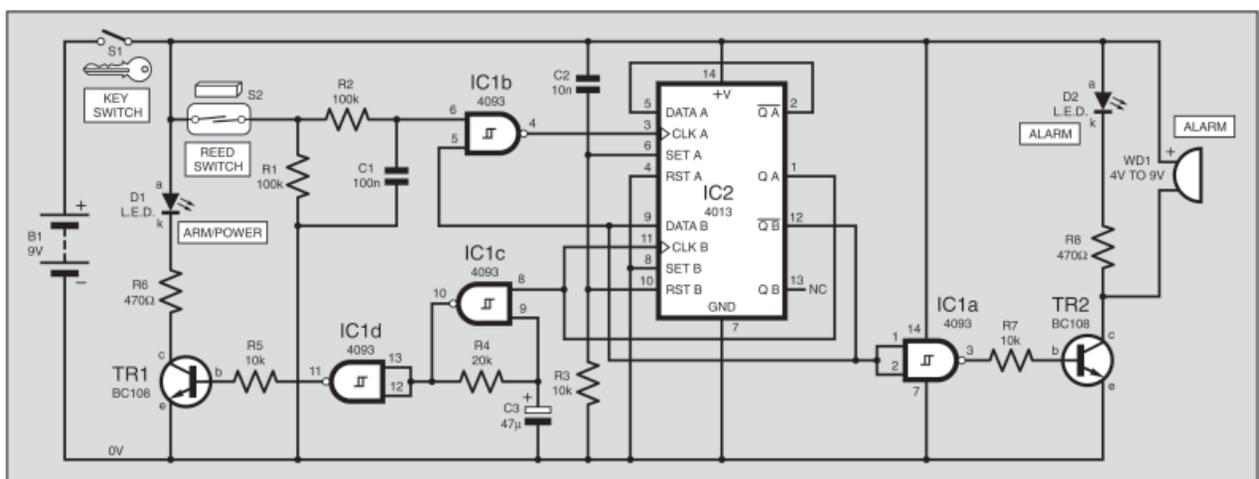


Fig.1. Complete circuit diagram for the Door Defender.

start doing something useful with that information.

When we look carefully at the design concept, it becomes clear that we need to produce a circuit that remembers the sequence of door movements so that we can correctly control the alarm operation. In a more complicated system we might use a microcontroller, but here the sequence is so simple we can use a couple of bistables, or flip-flops.

These circuit blocks are characterised by the fact that they are stable in one of two logic states (as opposed to monostables, which are stable in only one state, and astables, which continually oscillate between the two). The condition they adopt is dependent on changes of logic state at two or more inputs.

The type of flip-flop used here is a D-type (Data type), which is designed for data-related applications where it is desirable to “remember” the state of an input at a point in time defined by a clock signal. In this circuit it is actually wired as a T-type (Toggle-type), which results in the Q output “toggling” (switching to the opposite logic state) every time there is a rising edge at the clock input.

Since the flip-flops can adopt either state at power-up, it is important to perform a reset operation every time at switch on. Components C2 and R3 form a rather unorthodox yet effective reset circuit. When power is applied, the “hot” end of resistor R3 initially goes high (about 9V), but this voltage drains away very quickly down to zero. Despite this voltage fall, it is high for long enough to put the two flip-flops into the desired states – IC2a has its Q output forced high, whereas the Q pin on IC2b is forced low. So we know we are starting from the same point every time.

ARMED GUARD

At power-up, we want to enter the “Arming” mode because we are getting ready to leave the room, and the circuit signals this visually by flashing l.e.d. D1 – just like an expensive system! This is driven by an oscillator formed around IC1c – it is configured so that the output cycles between high and low logic states at a rate of about 1Hz, this frequency being controlled by capacitor C3 and resistor R4.

The Q output of IC2a (pin 1) enables the oscillation process – the l.e.d. D1 will only flash if it is high. Therefore, in this enabled state IC1c now operates as a simple inverter.

While IC1c is operating as an inverter, pin 10 will always be the opposite logic level to pin 9, and when this pin is below the switching threshold, pin 10 is high and charge flows onto C3, causing the voltage on the capacitor to rise towards the supply voltage . . . but it never gets there! When the voltage on pin 9 reaches the upper Schmitt input threshold, the output switches i.e. pin 10 goes low, and the charge on capacitor C3 starts discharging again, the rate being controlled by resistor R4. Now the voltage falls (exponentially) towards the ground rail (0V), but once again, it never arrives. As the lower Schmitt threshold is reached it’s all change again, and pin 10 returns to a high state.

Because of this process the voltage on pin 9 moves continuously between the two threshold levels, producing an output



voltage at pin 10 that oscillates between supply and ground. That is one way to turn a standard l.e.d. into a flasher! The chosen values give a rate of about 1Hz.

To protect the charge/discharge process, we introduce a buffer stage in the form of IC1d. This is because we need to push some charge into transistor TR1 to make it drive the “Arming” l.e.d. – this way we do not upset the charge that’s moving around in the R4/C3 circuit. Series resistor R6 limits the current through the l.e.d. to a safe level, about 15mA.

The circuit remains in this state, with l.e.d. D1 flashing, until you open the door in preparation for departure.

Reed switch S2 detects the opening of the door, causing the voltage at the junction of resistors R1 and R2 to fall to 0V. The input conditioning at IC1b converts this to a logic level change that is fed into the clock input pin 3 of IC2a. The arrival of a rising edge (a change of state from low to high logic level) toggles the flip-flop and the Q output goes low, switching off “Arming” l.e.d. D1. Although the clock input to IC2b at pin 11 is connected to the Q output of IC2a, there is no change to its state, as it sees a *falling* edge.

ABSOLUTE MAYHEM

The closing of the door causes no further changes to the circuit, apart from the clock input to IC2a (pin 3) returning to the low state. There is no change to either of the flip-flop outputs as their clock inputs only respond to *rising* edges, and the Door Defender now settles into “Monitoring” mode – both the l.e.d.s are off, and it consumes very little current making sure that the battery is kept fresh for Alarm action!

Everything happens when the door reopens! – breaking the magnet/reed switch “influence”. A rising edge into the clock input of IC2a at pin 3 toggles the state of its outputs – the Q output moves from low to high which is a rising edge. This logic change is also seen at the clock input to IC2b (pin 11) causing it, too, to toggle the state of its outputs, since it is also wired as a T-type. The change in the state of IC2b sounds the alarm!

Using IC1a as a buffer to drive transistor TR2, the low output from pin 12 of IC2b brings on the Alarm l.e.d. D2 and also “fires” the warning Alarm sounder WD1. You may also note that the Arming l.e.d. starts flashing too! Absolute mayhem – just what we want!

COMPONENTS

Resistors

R1, R2	100k (2 off)
R3, R5, R7	10k (3 off)
R4	20k
R6, R8	470Ω (2 off)

All 0.6W 10% carbon film

See

**SHOP
TALK**
page

Capacitors

C1	100n disc ceramic
C2	10n disc ceramic
C3	47μ min. radial elect. 16V

Semiconductors

D1, D2	5mm l.e.d. red (2 off)
TR1, TR2	BC108 npn low power transistor (2 off)
IC1	4093 CMOS quad 2-input NAND Schmitt trigger
IC2	4013 CMOS dual D-type flip-flop

Miscellaneous

S1	single-pole make/break miniature round key-operated switch
S2	2-piece plastic moulded reed switch, with magnet
WD1	4V to 9V min. buzzer
B1	9V alkaline battery (PP3 type), with clips

Stripboard, size 21 holes x 23 strips; plastic handheld box, with battery compartment, size 105mm x 62mm x 28mm approx; 14-pin d.i.l. socket (2 off); multi-strand connecting wire; wire links; solder pins; solder etc.

Approx. Cost
Guidance Only

£16.50
excl. batt.

Now, the design requirement is that the Alarm shall continue to sound even when the door is shut again – in other words it “latches” until the authorised keyholder turns the power off. This is where the connection between IC2b pin 12 and IC1b input pin 5 comes in to play.

At switch-on, the reset circuit ensures that this line is high, and this allows the reed switch signals through to IC2a. We already know that IC2b toggles when the circuit goes into Alarm mode. This immediately changes the signal to IC1b and disables the gate, preventing further door signals being processed.

As long as pin 5 (IC1b) is low, the output of the gate can never go high and create a rising edge – the circuit is “latched” in the Alarm mode, and continues to sound no matter how many times you open and close the door! A turn of the keyswitch S1 is the only way.

CONSTRUCTION

The original concept was that the finished unit could be easily fixed to a bedroom or workshop door. The chosen enclosure results in a very compact fit but produces a handy little “Defender”. There’s no reason why it could not be housed in a larger box, especially if you’re thinking of expanding the circuit to create a full blown intruder detection system.

Construction should commence by preparing the case to accept the off-board components. A general layout guide can be seen in the accompanying photographs. Note the cutouts in the stripboard.

Start by preparing the stripboard to the suggested shape, the layout will be dictated by the off-board components used, particularly the clearance required for the keyswitch S1. Once you have cut the board to the desired shape, temporarily place it in the base of the case and check for a satisfactory fit.

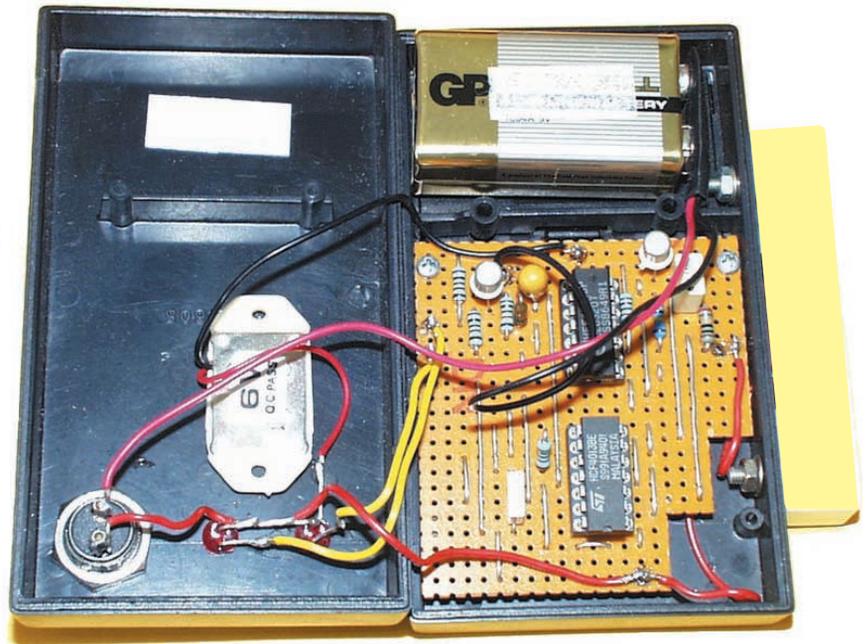
When you’re happy, remove it and begin to make the breaks in the copper tracks – there are 24 in all. A small handheld twist-drill or a dedicated stripboard cutter tool will do the trick. Examine the board carefully after each cut to make sure that the break is clean and complete – a magnifying glass will help here.

The stripboard topside component layout and details of breaks required in the underside copper tracks are shown in Fig.2. The interwiring details to the off-board components are also shown in this diagram. The reed switch housing is bolted on one of the outside case panels – see photograph.

Fit all the lead-off solder pins and wire links – quite a tedious job but it helps define the layout. Again, keep checking against the layout drawing at every opportunity. Once all the links are in place, solder in the two 14-pin i.c. sockets, making sure that they’re the right way round. Don’t fit the chips yet.

Next, the resistors can now be added. Most lie flush to the board, but a few stand almost vertical. Then it’s on to the capacitors – C3 is polarity conscious so check that the positive (+) lead is in the right hole.

The final components are the two transistors. Again, have a careful look at Fig.2 to be sure that you’ve identified their pins correctly and then solder them in position.



Completed wiring between the two halves of the case.

Before continuing, take time to check the circuit board just one more time. It is not only a case of confirming that all the components are in the right place but also that there are no solder splashes, bridges, etc. on the copper side.

BOARD CHECK

The next job is to do some basic checks on the circuit board. Set your multimeter to the lowest resistance scale and measure across the +V and 0V terminals. What you

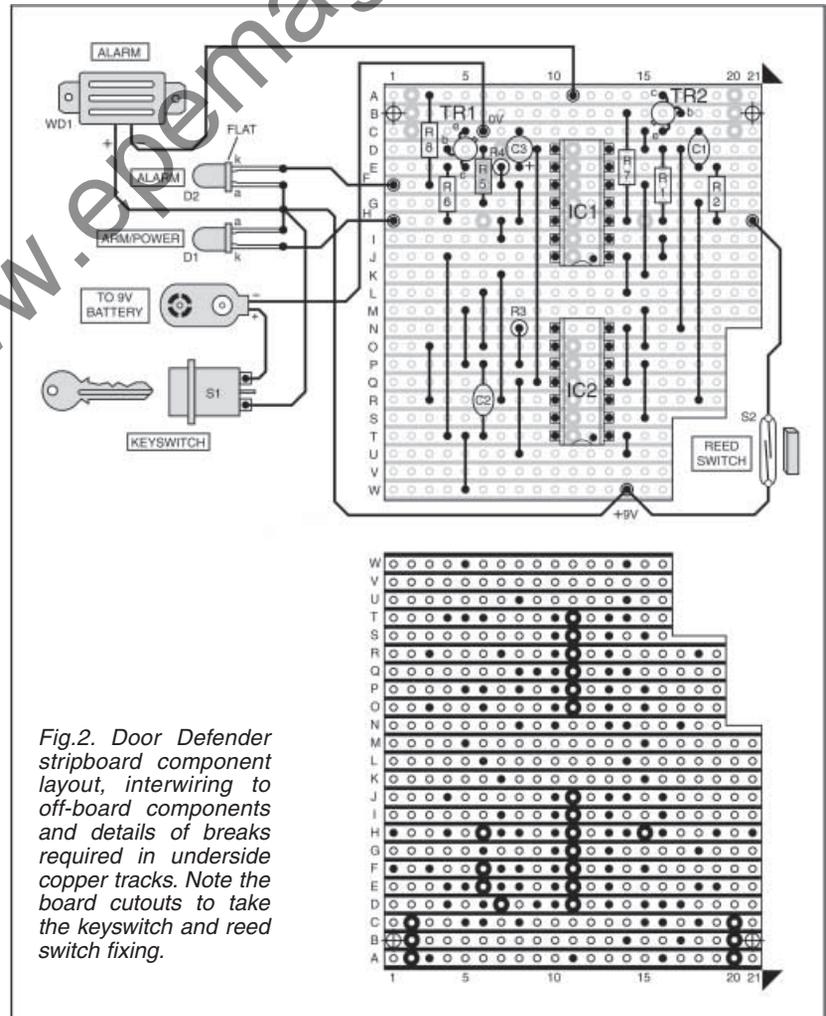


Fig.2. Door Defender stripboard component layout, interwiring to off-board components and details of breaks required in underside copper tracks. Note the board cutouts to take the keyswitch and reed switch fixing.

are looking for here is any short circuit between the rails, i.e. less than one or two ohms.

Once the multimeter is giving good news, attach a 9V battery across the same terminals. Check that there is a nice steady voltage across pin 7 and pin 14 of the i.c. sockets. If everything is okay go ahead and finish the installation.

FINAL ASSEMBLY

Start by taking the reed switch and attaching two lengths of wire to the internal terminals – measure the resistance across them. In isolation, the reading should be open circuit but if you bring the magnet alongside the reed switch there's a point where the contacts close. This is a good test to see if you've wired it up correctly and that the switch responds to the presence of the magnet. Make sure that the contacts open again when the magnet is removed.

The reed switch module can now be securely attached to the case side panel and the circuit board screwed securely in place. Now it's just a matter of doing the wiring-up – connecting the l.e.d.s, reed switch, buzzer, keyswitch, and battery clip as shown in Fig.2.

Finish by doing another multimeter check to confirm that no short circuits have crept in, and that the keyswitch S1 is working correctly. If everything looks good, insert the two i.c.s in their holders. Orientation is everything here, so make absolutely sure you've got them the right way round. Don't mix up the 4013 and 4093 and look out for pins bent underneath!

TESTING

Testing of the Door Defender is quite simple. Turn off the keyswitch, fit the battery, and temporarily tape the magnet block in line with the reed switch S2. Now turn the key to apply power to the circuit. Neither of the l.e.d.s should be lit and the buzzer WD1 should be silent.

Now detach the magnet, moving it well away from the reed switch. The "Arming" l.e.d. D1 should begin flashing, indicating that the circuit has detected that the contacts have opened. Now bring the magnet back in-line with the reed switch. The Arming l.e.d. should go out.

Finally, remove the magnet again. This time, both l.e.d.s (D1, D2) should light and buzzer WD1 sound. Replacing the magnet will have no effect and the only way to reset the system is by turning the keyswitch. If all is well, the box can be screwed together and the system is ready for use!

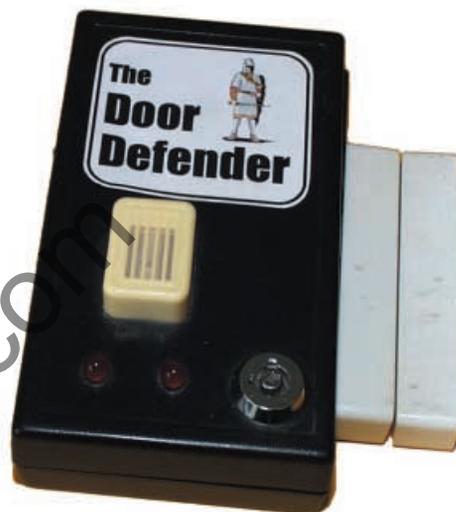
IN USE

The Door Defender will be found useful in all sorts of applications, although it should not be used in an unattended public position as it does not have an automatic cut-off time-out for the alarm sounder. Installation requirements are not critical, simply that the magnet and reed switch parts are consistently aligned when the door/window is shut. Also, there is no reason why the reed switch needs to be mounted on the box – you could locate the alarm unit remotely and run a cable to the sensor (reed/magnet). The intruder would be unaware of detection!

You could pack it in your suitcase and use it to protect a hotel door, or monitor

movements in and out of the workshop. Perhaps it might work as a child alarm, warning you if Junior has found their way into your den or wandered from their bedroom/playroom? What about using it to protect your toolbox from prying little hands?! Whatever the need, it can be quickly set up and provide sterling service.

If you're feeling adventurous, why not expand the basic system to create something more comprehensive? Further switches could be added (normally closed types wired in series) to monitor windows and other doors, while the l.e.d.s could be replaced with relays or opto-isolators to drive flood-lamps, strobes, or sirens. There's nothing like going over the top!



NEXT MONTH – IT'S FULL SPEED AHEAD!

★ PIC WIND SPEED MONITOR ★

PLUS: EPE MINDER
F.M. FREQUENCY SURFER

Annual subscription rates:

6 Months: UK £15.50, Overseas £18.50 (standard air service),
£27.50 (express airmail)

1 Year: UK £29.50, Overseas £35.50 (standard air service)
£53 (express airmail)

2 Years: UK £54.00, Overseas £66.00 (standard air service)
£101 (express airmail)

To: Everyday Practical Electronics,
Wimborne Publishing Ltd., 408 Wimborne Road East,
Ferndown, Dorset BH22 9ND

Tel: 01202 873872 Fax: 01202 874562

E-mail: subs@epemag.wimborne.co.uk

Order from our online shop at:

www.epemag.wimborne.co.uk/shopdoor.htm



TAKE ADVANTAGE NOW!



SUBSCRIPTION ORDER FORM

I enclose payment of £
(cheque/PO in £ sterling only),
payable to Everyday Practical Electronics

My card number is:
Please print clearly, and check that you have the number correct

Signature

Card Ex. Date Switch Issue No.

Subscriptions can only start with the next available issue.
For back numbers see the Back Issues page.

Name

Address

Post code Tel.

If you do not wish to cut your issue, send a letter or a copy of this form.

12/02

£1 BARGAIN PACKS Selected Items

PIEZO ELECTRIC SOUNDER, also operates efficiently as a microphone. Approximately 30mm diameter, easily mountable, 2 for £1. Order Ref: 1084.

LIQUID CRYSTAL DISPLAY on p.c.b. with i.c.s etc. to drive it to give 2 rows of 8 figures or letters with data. Order Ref: 1085.

30A PANEL MOUNTING TOGGLE SWITCH. Double-pole. Order Ref: 166.

SUB MIN TOGGLE SWITCHES. Pack of 3. Order Ref: 214.

HIGH POWER 3in. SPEAKER (11W 8ohm). Order Ref: 246.

MEDIUM WAVE PERMEABILITY TUNER. It's almost a complete radio with circuit. Order Ref: 247.

HEATING ELEMENT, mains voltage 100W, brass encased. Order Ref: 8.

MAINS MOTOR with gearbox giving 1 rev per 24 hours. Order Ref: 89.

ROUND POINTER KNOBS for flatted ¼in. spindles. Pack of 10. Order Ref: 295.

CERAMIC WAVE-CHANGE SWITCH. 12-pole, 3-way with ¼in. spindle. Order Ref: 303.

REVERSING SWITCH. 20A double-pole or 40A single pole. Order Ref: 343.

LUMINOUS PUSH-ON PUSH-OFF SWITCHES. Pack of 3. Order Ref: 373.

SLIDE SWITCHES. Single pole changeover. Pack of 10. Order Ref: 1053.

PAXOLIN PANEL. Approximately 12in. x 12in. Order Ref: 1033.

CLOCKWORK MOTOR. Suitable for up to 6 hours. Order Ref: 1038.

HIGH CURRENT RELAY, 12V d.c. or 24V a.c., operates changeover contacts. Order Ref: 1026.

3-CONTACT MICROSWITCHES, operated with slightest touch, pack of 2. Order Ref: 861.

HIVAC NUMICATOR TUBE, Hivac ref XN3. Order Ref: 865 or XN11 Order Ref: 866.

2IN. ROUND LOUDSPEAKERS. 50Ω coil. Pack of 2. Order Ref: 908.

5K POT, standard size with DP switch, good length ¼in. spindle, pack of 2. Order Ref: 11R24.

13A PLUG, fully legal with insulated legs, pack of 3. Order Ref: GR19.

OPTO-SWITCH on p.c.b., size 2in. x 1in., pack of 2. Order Ref: GR21.

COMPONENT MOUNTING PANEL, heavy paxolin 10in. x 2in., 32 pairs of brass pillars for soldering binding components. Order Ref: 7RC26.

HIGH AMP THYRISTOR, normal 2 contacts from top, heavy threaded fixing underneath, think amperage to be at least 25A, pack of 2. Order Ref: 7FC43.

BRIDGE RECTIFIER, ideal for 12V to 24V charger at 5A, pack of 2. Order Ref: 1070.

TEST PRODS FOR MULTIMETER with 4mm sockets. Good length flexible lead. Order Ref: D86.

LUMINOUS ROCKER SWITCH, approximately 30mm square, pack of 2. Order Ref: D64.

MES LAMPHOLDERS slide on to ¼in. tag, pack of 10. Order Ref: 1054.

HALL EFFECT DEVICES, mounted on small heatsink, pack of 2. Order Ref: 1022.

LARGE MICROSWITCHES, 20mm x 6mm x 10mm, changeover contacts, pack of 2. Order Ref: 826.

MAINS RELAY with 15A changeover contacts. Order Ref: 965.

COPPER CLAD PANELS, size 7in. x 4in., pack of 2. Order Ref: 973.

100M COIL OF CONNECTING WIRE. Order Ref: 685.

WHITE PROJECT BOX, 78mm x 115mm x 35mm. Order Ref: 106.

LEVER-OPERATED MICROSWITCHES, ex-equipment, batch tested, any faulty would be replaced, pack of 10. Order Ref: 755.

MAINS TRANSFORMER, 12V-0V-12V, 6W. Order Ref: 811.

OVER 1,000 PACKS are described in our latest packs list, but as this costs us approximately £1 to produce, please send this amount if you would like details of these packs. The £1 will be credited to you directly you buy £10 worth of packs.

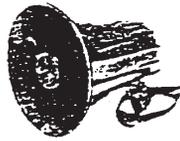
SOME SPECIAL HALF PRICE OFFERS

DYNAMIC MICROPHONE. 500 ohm, plastic body with black mesh head, on/off switch, good length lead and terminated with audio plug. Price £1. Order Ref: 2P220.



HORN SPEAKER

Polished metal with base, 8 ohm 5W, £2 or 100 for £150. Order Ref: 7BOT43.



BRIDGE RECTIFIER.

3A 250V. For p.c.b. or normal mounting. 4 for £1. Order Ref: 1083.



1A SOLAR CELL. Best type, has bubble lens on face. £1 each. Order Ref: 35P2.

VERY UP TO DATE 35MM CAMERA. This is motorised, is focus free, has autoflash, autofilm advance, autofilm rewind and DX coating. This is brand new and nicely boxed. Price to you £5. Order Ref: 10P161.

IT IS VERY POWERFUL. In fact it is almost ¼h.p. and can be driven by a 12V battery, so one on each wheel would drive a go-kart and its passenger. Made by the famous Smiths company, this motor should give a good, long, trouble-free service. Offered at £12 each or if you order a pair, then you can have the pair for £20. Order Ref: 12P41.



SELLING WELL BUT STILL AVAILABLE

IT IS A DIGITAL MULTITESTER, complete with back-rest to stand it and hands-free test prod holder. This tester measures d.c. volts up to 1,000 and a.c. volts up to 750; d.c. current up to 10A and resistance up to 2 megs. Also tests transistors and diodes and has an internal buzzer for continuity tests. Comes complete with test prods, battery and instructions. Price £6.99. Order Ref: 7P29.

INSULATION TESTER WITH MULTIMETER. Internally generates voltages which enable you to read insulation directly in megohms. The multimeter has four ranges, AC/DC volts, 3 ranges DC milliamps, 3 ranges resistance and 5 amp range. These instruments are ex-British Telecom but in very good condition, tested and guaranteed OK, probably cost at least £50 each, yours for only £7.50 with leads, carrying case £2 extra. Order Ref: 7.5P4.

REPAIRABLE METERS. We have some of the above testers but slightly faulty, not working on all ranges, should be repairable, we supply diagram, £3. Order Ref: 3P176.

1mA PANEL METER. Approximately 80mm x 55mm, front engraved 0-100. Price £1.50 each. Order Ref: 1/16R2.

VERY THIN DRILLS. 12 assorted sizes vary between 0.6mm and 1.6mm. Price £1. Order Ref: 128.

EVEN THINNER DRILLS. 12 that vary between 0.1mm and 0.5mm. Price £1. Order Ref: 129.

D.C. MOTOR WITH GEARBOX. Size 60mm long, 30mm diameter. Very powerful, operates off any voltage between 6V and 24V D.C. Speed at 6V is 200 rpm, speed controller available. Special price £3 each. Order Ref: 3P108.

FLASHING BEACON. Ideal for putting on a van, a tractor or any vehicle that should always be seen. Uses a Xenon tube and has an amber coloured dome. Separate fixing base is included so unit can be put away if desirable. Price £5. Order Ref: 5P267.

MOST USEFUL POWER SUPPLY. Rated at 9V 1A, this plugs into a 13A socket, is really nicely boxed. £2. Order Ref: 2P733.

MOTOR SPEED CONTROLLER. These are suitable for D.C. motors for voltages up to 12V and any power up to 1/6h.p. They reduce the speed by intermittent full voltage pulses so there should be no loss of power. Made up and tested, £15. Order Ref: 20P39.

BALANCE ASSEMBLY KITS. Japanese made, when assembled ideal for chemical experiments, complete with tweezers and 6 weights 0.5 to 5 grams. Price £2. Order Ref: 2P44.

CYCLE LAMP BARGAIN. You can have 100 6V 0.2A MES bulbs for just £2.50 or 1,000 for £20. They are beautifully made, slightly larger than the standard 6.3V pilot bulb so they would be ideal for making displays for night lights and similar applications.

HEAVY DUTY POT. Rated at 25W, this is 20 ohm resistance so it could be just right for speed controlling a d.c. motor or device or to control the output of a high current amplifier. Price £1. Order Ref: 1/33L1.

RELAYS

We have thousands of relays of various sorts in stock, so if you need anything special give us a ring. A few new ones that have just arrived are special in that they are plug-in and come complete with a special base which enables you to check voltages of connections of it without having to go underneath. We have 6 different types with varying coil voltages and contact arrangements.



Coil Voltage	Contacts	Price	Order Ref.
12V DC	4-pole changeover	£2.00	FR10
24V DC	2-pole changeover	£1.50	FR12
24V DC	4-pole changeover	£2.00	FR13

Prices include base

MINI POWER RELAYS

For p.c.b. mounting, size 28mm x 25mm x 12mm, all have 16A changeover contacts for up to 250V. Four versions available, they all look the same but have different coils:

6V Order Ref: FR17

12V Order Ref: FR18

24V Order Ref: FR19

48V Order Ref: FR20

Price £1 each less 10% if

ordered in quantities of 10,

same or mixed values.

4 CIRCUIT 12V RELAY.

Quite small, clear plastic

enclosed and with plug-in

tags, £1. Order Ref: 205N.

NOT MUCH BIGGER THAN AN OXO CUBE. Another

relay just arrived is extra small with a 12V coil and 6A

changeover contacts. It is sealed so it can be mounted in

any position or on a p.c.b. Price 75p each, 10 for £6 or 100

for £50. Order Ref: FR16.

BIG POWER RELAY. These are open type fixed by

screws into the threaded base. Made by Omron, their

ref: MM4. These have 4 sets of 25A changeover con-

tacts. The coil is operated by 50V AC or 24V DC, price

£6. Order Ref: 6P.

SIMILAR RELAY but smaller and with only 2 sets of

25A changeover contacts. Coil voltage 24V DC, 50V

AC, £4. Order Ref: 4P.

BIG POWER LATCHING RELAY. Again by Omron, their

ref: MM2K. This looks like a double relay, one on top of the

other. The bottom one has double-pole 20A changeover

contacts. The top one has no contacts but when energised

it will lock the lower relay either on or off depending on how

it is set. Price £6. Order Ref: 6P.

RECHARGEABLE NICAD BATTERIES. AA size, 25p

each, which is a real bargain considering many firms

charge as much as £2 each. These are in packs of 10,

coupled together with an output lead so are a 12V unit

but easily dividable into 2 x 6V or 10 x 1.2V. £2.50 per

pack, 10 packs for £25 including carriage. Order Ref:

2.5P34.

THREE NEW BUY ONE GET ONE FREE OFFERS

CUPBOARD ALARM. Activated by light. When set, this alert is designed to let you know when small hands open medicine cupboards, drawers, desks or other places they shouldn't. Price £3. Order Ref: 3P155.

WATER LEVEL ALARM. When water reaches its sense head, its internal alarm sounds. It is a ready-built unit which you fix above where you want to know the water has risen. It then sounds its internal alarm. Needs only a battery. Price £3. Order Ref: 3P156.

THE GUEST 35MM MOTORIZED CAMERA. It is focus free, auto flash, auto film advance, auto film rewind and has DX coating. Brand new, recently offered at £10 each, now you get 2 for £10. Order Ref: 7BOT16.

1.5V-6V MOTOR WITH GEARBOX.

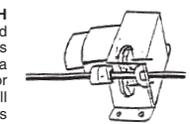
Motor is mounted on the gearbox which has interchangeable gears giving a range of speeds and motor torques. Comes with full instructions for changing gears and calculating speeds, £7. Order Ref: 7P26.

MINI BLOWER HEATER. 1kW, ideal for under desk or airing cupboard, etc., needs only a simple mounting frame, price £5. Order Ref: 5P23.

TERMS

Send cash, uncrossed PO, cheque or quote credit card number. If order is £25 or over deduct 10% but add postage, £3.50 if under 2 kilo, £6 if under 4 kilo, £9 if over 4 kilo.

J & N FACTORS
Pilgrim Works (Dept.E.E.)
Stairbridge Lane, Bolney
Sussex RH17 5PA
Telephone: 01444 881965
E-mail: jnufactors@aol.com



ALTERNATIVE USES FOR TRANSISTORS

NED STEPHENS

A look at the other uses to which transistors can be applied

TRANSISTORS have many uses which are well known, such as amplifiers, oscillators and switches, but have many further uses, some of which are not as well known. A knowledge of these other uses can be helpful when a particular component is not immediately available but is required for gadgeteering or experimentation.

For instance, if a Zener diode of a particular voltage is needed for a constructional project, but is not available in the spares box, then it may be possible to use a transistor instead. Transistors may also be used in place of signal diodes, rectifier diodes, varicap diodes, tunnel diodes, constant current sources, and even solar cells.

In some cases, a transistor pressed into such service may be superior to a purpose made part and may reduce the circuit's total parts count.

SIGNAL DIODES

When a current is passed through a diode in the forward direction, the diode acts as a non-linear resistor, such that the effective resistance is large at small voltages, but reduces as the voltage increases. This has the effect that there is no appreciable current flow through the diode until the voltage across it has risen above a certain value. In the case of a germanium diode this is approximately 0.3 volts, and in the case of a silicon diode it is about 0.7 volts.

If you wish to detect a small r.f. voltage in a crystal set, for instance, then it is better to use a diode with the lowest possible voltage drop, i.e. a germanium one.

So much for standard practice – results are better if we use a transistor instead. A transistor measured with an ohmmeter appears to be two diodes, one connected from base to emitter and the other between base and collector. Either of these apparent diodes may be used as real diodes, the third connection of the transistor being left open circuit.

We can, however, do better than this by connecting the base of the transistor to the collector and using that common connection as one diode connection, whilst the other

diode connection goes to the transistor emitter, making a so-called "superdiode". Which of these connections is the diode anode (a) and which is the cathode (k) depends on whether you are using a *pnp* or an *npn* transistor.

Due to the amplifying action of the transistor, the effective resistance of this new superdiode is as low as, or lower than, that of a purpose built diode, so that its use in signal circuits will enable the detection of smaller r.f. voltages. Table 1 shows forward voltage drops of base-emitter junctions and superdiodes, and the drops of germanium and silicon purpose built diodes for comparison.

We see that this trick of connecting a transistor as a superdiode is much more successful with germanium transistors than with silicon. With germanium the forward voltage drop may be more than halved, but for all the many different types of silicon transistor that were tried the forward voltage was only reduced by about 10 per cent or so.

It is apparent that a germanium transistor connected as a superdiode, i.e. with the base connected to the collector, begins to conduct in the forward direction with much smaller applied voltages. In order to check out the characteristics of this new device the circuit of Fig.1 may be used.

Sample curves of an OC72 germanium transistor used in this fashion are shown in Fig.2, along with the curve of a germanium diode type OA91 for comparison. Practical tests with a standard crystal set circuit show that a germanium diode is indeed better than one made of silicon, but a germanium r.f. transistor in the superdiode configuration is best of all.

RECTIFIER DIODES

Large power transistors may be used as rectifiers in this fashion and, as above, germanium transistors used in the superdiode configuration at low currents show much more reduction of forward voltage drop than do silicon types. The list in Table 1, however, is for signal diodes and refers to only small diode currents. It should be noted that the voltage drop at higher currents will be less for silicon than for germanium, so that when substituting components germanium should be used for low currents and silicon for anything above about 10mA.

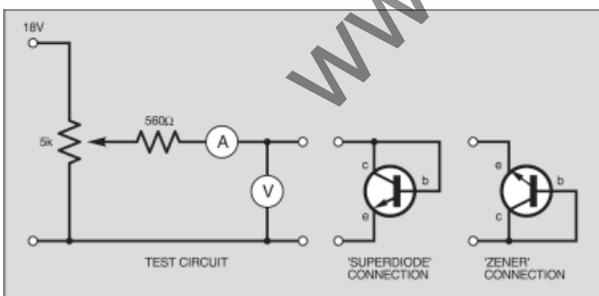


Fig.1. Test circuit for "transistor" superdiode and Zener diode.

Table 1: Forward voltage drop comparisons

Diode	Construction	Emitter-base junction at 100µA	Superdiode at 100µA
OA91	Germanium diode	0.184V	
1N914	Silicon diode	0.509V	
2N1307	Germanium transistor	0.137V	0.077V
AC128	Germanium transistor	0.105V	0.046V
OC71	Germanium transistor	0.097V	0.038V
BC107	Silicon transistor	0.610V	0.553V
BCY31	Silicon transistor	0.511V	0.487V
2N3904	Silicon transistor	0.640V	0.627V

It must be remembered that the current flow is through the base-emitter junction of the transistor, which is not its normal mode of operation. The author has been unable to find any data relating to the maximum permissible base currents. However, data books listing transistor saturation voltages quote the base current used, in the case of the BD239 this is 200mA and for a BUX98 it is 4.0 amps (Ref.1), with most silicon power transistors quoted as using base currents between these two figures. Using transistors in place of rectifier diodes at these current levels will be fine, but care should be taken if exceeding them by a large margin.

ZENER DIODES

If the superdiode connection is used in the reverse direction then it will be seen that the transistor now exhibits a Zener characteristic. Several different types of transistor were tested using the circuit in Fig.1 to see which Zener voltages were available. The results are shown in Table 2.

Table 2: Transistors as Zener diodes

Transistor	Voltage	Transistor	Voltage
2N3553	5.57	BFY18	8.11
2N3703	6.06	BSY26	8.15
2N2846	6.18	2N13107	8.22
2N4037	6.35	BC148	8.38
BFX29	6.40	BFX85	8.44
2S847	7.16	BSX23	8.72
BSY27	7.38	BC639	8.83
2N3904	7.66	BC109	9.05
BC107	7.97	2N696	9.21
2N1613	8.08	BSY85	9.43

The same formula may be used except that the constant should be approximately doubled, i.e. to approx. $1.10((R1 + R2)/R2)$ volts. The methods of connecting these "Zeners" is shown in Fig.4.

LOW LEAKAGE DIODES

If a diode with infinitesimal reverse leakage current is required then one can be made from an ordinary *n*-channel f.e.t. By

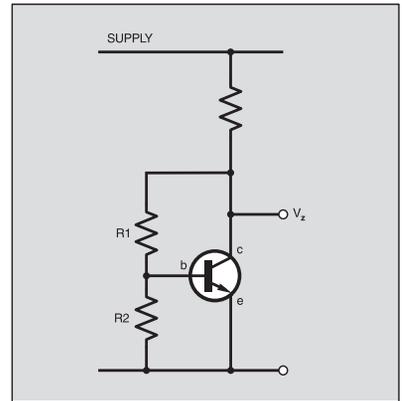


Fig.3. Circuit for selecting the Zener voltage by varying the ratio of R1, R2.

beginning when biased by around 600mV. This again is not the normal f.e.t. mode of operation and care should be taken that the f.e.t. is not overloaded, as the manufacturers have not designed the device with gate current in mind.

VARICAP DIODES

Diodes used in the reverse bias mode exhibit capacitance between the anode and cathode connection, the capacitance decreasing as the applied voltage is increased. Diodes used in this fashion are known as *varicap diodes*, and are specially made so that this characteristic is exhibited to a greater extent than in normal signal diodes.

Varicaps are commonly used in tuned circuits in the r.f. stages of TVs and car radios to enable them to be tuned electronically with no moving parts. Radio amateurs have for many years used cheap general purpose diodes in place of the more expensive varicap diodes, but it is unusual to use a transistor instead, even though it is simple to achieve results with them.

The test circuit of Fig.5 was built and the frequency measured with different values of tuning capacitor to enable the stray capacitance to be calculated. The oscillator frequency was then set at precisely 6.0MHz and the transistor under test was connected. The resulting oscillator frequency was measured at different tuning voltages to enable the capacitance swing to be calculated.

The results are shown in Table 3 for various types of transistor, the maximum frequency and minimum capacitance figures refer to a tuning voltage of 12V, whilst the minimum frequency and maximum capacitance figures refer to zero tuning voltage.

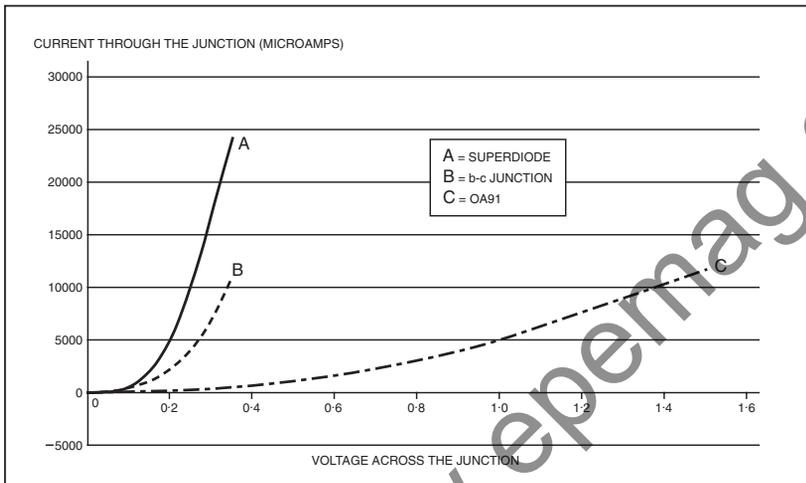


Fig.2. Forward biased germanium junctions.

These were all measured with a current of 1mA flowing through the device. In some cases several different individual transistors with the same type number were tested and all gave results within five per cent of each other.

In addition to the use of a transistor in this fashion to obtain a fixed Zener voltage, we may connect one in a way that we are able to select our own Zener voltage. By connecting a transistor as shown in Fig.3, a "Zener" may be made with any desired Zener voltage by varying the ratio of the two resistors.

For instance, when using a BC109 at a current of 1.0mA, the Zener voltage is given by $0.63((R1 + R2)/R2)$ volts. Examples of this method are: using $R1 = R2 = 10k\Omega$ the Zener voltage is 1.25V, and using $R1 = 30k\Omega$, $R2 = 10k\Omega$ then we obtain 2.50V, both measured with a Zener current of 1.0mA.

Plotting the voltage/current curves of this connection shows that there is quite a high slope resistance, but this may be overcome by using a Darlington transistor, or two transistors wired as such, and with this lower slope resistance better voltage stabilisation will result.

connecting the drain and source leads together and using this connection as the diode cathode and the f.e.t. gate as the anode then such a diode is obtained. These anode and cathode connections should be reversed if using a *p*-channel f.e.t.

Several species of f.e.t. were tested and the reverse current in all cases was undetectable with the equipment to hand, whilst in the forward direction the f.e.t.s behaved as normal silicon diodes with conduction

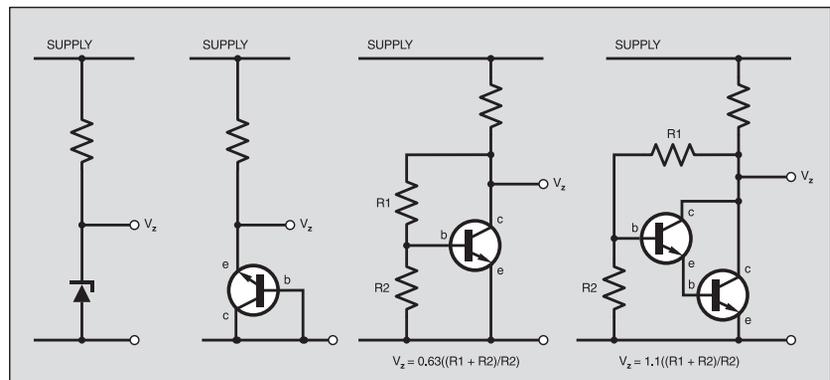


Fig.4. The use of transistors as Zener diodes.

Whilst it is easy to tune an oscillator in this fashion, the use of tuning transistors in the signal circuits of radios may lead to disappointment as, although the transistor used has a large capacitance swing, it may have a low Q. Because of their relatively large leakage currents, germanium transistors will be worse in this respect than will silicon transistors.

Due to the need to keep the transistor "diodes" reverse biased, only *pn*p transistors have been used with this test circuit, although it would be possible to use *np*n types if the polarity of the tuning voltage rail were changed.

CONSTANT CURRENT SOURCES

Constant current sources, whilst not seen very often, are very useful field effect devices which over a large voltage range will keep the current through the device at a given value. Motorola have a range 1N5283 to 1N5314, which have preset currents between 0.22mA and 4.70mA (Ref.2), Siliconix have a similar range which has device numbers easier to understand, i.e. CR390 has a constant current of 3.9mA and CR470 has a constant current of 4.7mA. These devices may be easily made from f.e.t.s (field effect transistors) by connecting them as shown in Fig.6a.

Looking at I_{dss} in transistor characteristic tables gives some idea of the constant current that can be obtained, but this will only be approximate because the spread in characteristics of f.e.t.s is quite wide. For example, the 2N3823 is quoted with a figure between 4mA and 20mA, and the 2N4391 between 50mA and 150mA (Ref.1). We can, however, obtain any current value less than I_{dss} by inserting a resistor in the source lead of our chosen f.e.t., as in Fig.6b.

A sample of 2N3819 that was tested with no source resistor gave a constant current of 12mA. When 100 ohms was inserted, the current was 9mA, 7.5mA with 200

ohms, and 6mA with 300 ohms. A sample of 2N4391 with no resistor gave 55mA, which dropped to 25mA, 15mA, and 11mA when used with 100, 200 and 300 ohms respectively. The only things to bear in mind when using f.e.t.s as constant current sources is that the maximum permitted voltage across the device is around 30V and the dissipated power should not exceed the device rating.

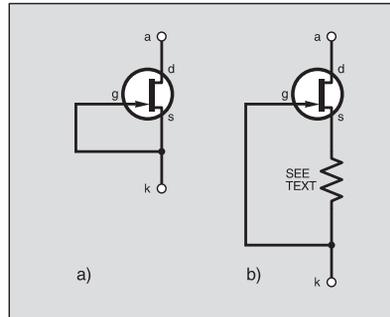


Fig.6. Constant current source using f.e.t.s.

SOLAR CELLS

Back in the dim distant past of transistors, their cases were constructed of glass, which was painted black on the outside to stop light affecting the innards. One of the common transistors then available, an OC71, a *pn*p germanium a.f. transistor, was also made in another version, OCP71, which in effect had a hole in the paint so that it could be used as a phototransistor.

What the manufacturers did not tell us, however, is that if all the black paint was scraped off an OC71, or any other glass transistor of similar construction, then it could be used as a photovoltaic cell to generate electricity. Brightly lit it will produce up to 160mV when not driving a load, although this drops off sharply when a load is applied.

As an experiment, the author cut the top off a BC109 and the voltage in full sunlight was measured. An output of 400mV was obtained when measured on a digital voltmeter. However, when loaded with a moving coil meter it gave no discernible output due to the high internal resistance of the very small

junction area which was illuminated, the inside of a BC109 still being pretty light-proof even with its top cut off.

Metal cased power transistors such as the 2N3055 may also be used as solar cells if the top of the metal case is carefully sawn away. Output voltages around 0.7V were obtained at currents up to about 15mA by using one junction, and double this by using both junctions, i.e. by using the base of the transistor as one connection and the collector and emitter tied together as the other.

NEGATIVE RESISTANCE DEVICES

Tunnel diodes are rare but useful two terminal devices which exhibit a region of "negative resistance" over a small applied voltage range, enabling amplifiers and oscillators to be easily built. Silicon tunnel diodes show this effect when biased between 65mV and 420mV, gallium arsenide between 150mV and 500mV, and germanium from 55mV to 320mV (Ref.3). They were more popular in years gone past, though, and are now difficult to obtain.

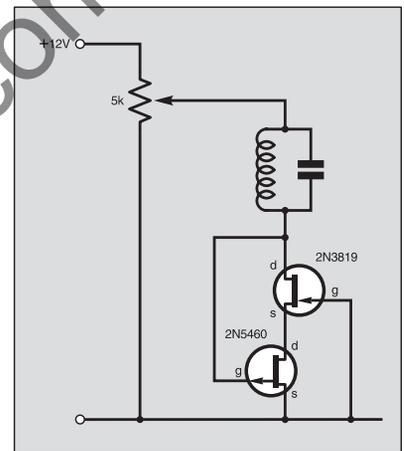


Fig.7. Using n and p-channel f.e.t.s in a lambda configuration to produce a "tunnel diode" effect oscillator circuit.

By using an *n*-channel f.e.t. in connection with a *p*-channel f.e.t. the same negative resistance effect may be obtained cheaply and simply, although in this case the applied bias is somewhat higher. This combination of two different types of f.e.t. is called a *lambda* circuit, one of which was constructed from a 2N3819 *n*-channel f.e.t. and a 2N5460 *p*-channel f.e.t., connected to an old 10.7MHz i.f. transformer, as shown in Fig.7.

The power supply voltage was varied and it was found that the circuit oscillated with bias voltages between 2.7V and 6.5V, although it was found impossible to measure these values precisely due to the circuit suddenly jumping from one current value to another as the supply voltage was increased. Nevertheless, the circuit oscillated well at the 10.7MHz test frequency used. This really is a simple and easy little oscillator circuit and deserves to be more widely known.

CONNECTING IT ALL TOGETHER

Having explored a constant current source and a constant voltage source, the

Table 3: Transistors as varicap diodes

Transistor	Measured Frequency		Calculated Capacitance	
	Max MHz	Min MHz	Min pF	Max pF
2N1132	5.82	5.65	6.4	13.0
2N1303	5.92	5.86	2.8	4.9
2N1307	5.93	5.83	2.4	6.0
2N4036	5.77	5.55	8.3	17.2
BCY31	5.81	5.47	6.78	20.7
BFX29	5.81	5.75	6.8	9.1
OC201	5.76	5.52	8.7	18.5

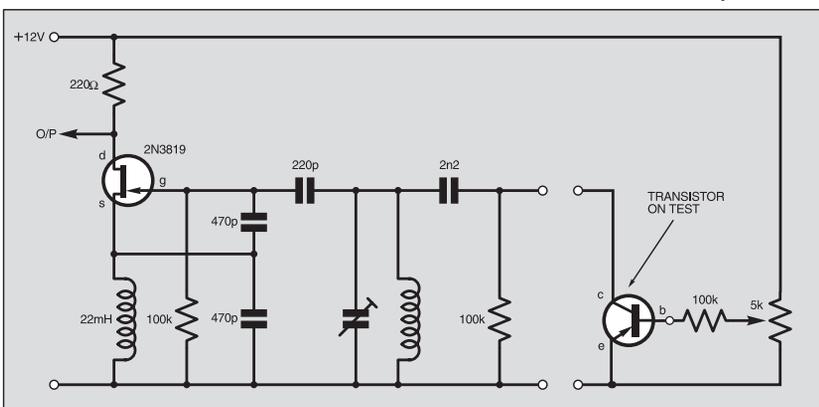


Fig.5. Test circuit for using transistors as varicap diodes.

References

1. Mullard Semiconductors Quick Reference Guide 1982.
2. Motorola Semiconductors Condensed Catalogue.
3. *Semiconductors, Basic Theory and Devices*, I. J. Kappel, Newnes-Butterworth.

two can now be connected together to form a low current stabilised power supply which may be used to supply the lambda circuit. The tuned circuit attached to the lambda circuit can be tuned by a *pnp* transistor taking the place of a varicap diode pair (Fig.8).

The total circuit for a simple oscillator circuit thus consists of five transistors, two resistors, a fixed capacitor and a tuned circuit. This may be reduced even further if the "varicap" part of the circuit is not required.

You may well be asking whether this unlikely looking circuit does actually work: after an initial 30 minutes wait for the circuit to achieve thermal equilibrium (during which time the frequency drifted by

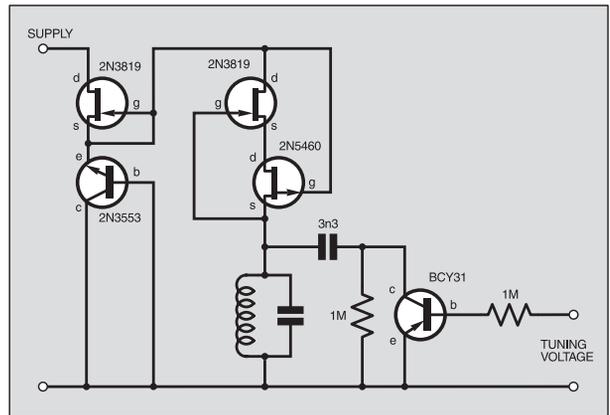


Fig.8. Simple oscillator circuit using an npn transistor to tune the lambda-based circuit.

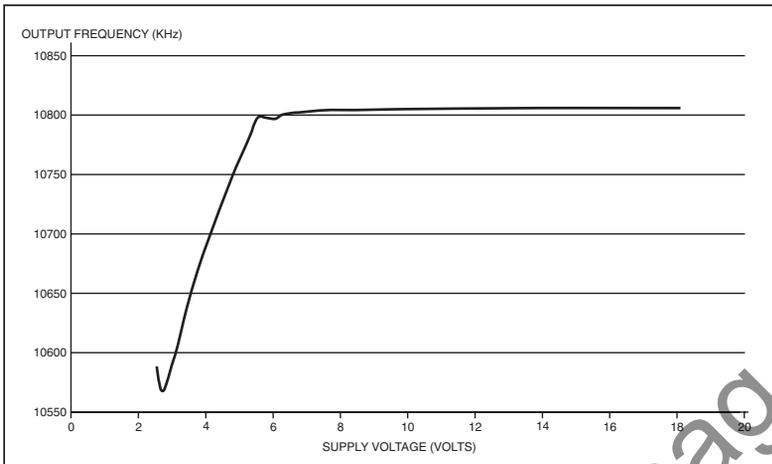


Fig.9. Negative resistance oscillator output frequency.

113Hz), the oscillator output frequency was measured with different supply voltages. The results are shown in Fig.9, which shows that for best results the supply voltage should be kept within the range 6V to 18V, the output frequency varying by only 26Hz between these voltage limits.

Varying the tuning voltage from zero to 10V reduced the output frequency by 550kHz. The circuit of this oscillator shows that transistor substitution is well worth doing as the component count is very small and the only component selection required is that the transistor acting as a Zener should have its "Zener" voltage within the negative resistance range of the lambda circuit, i.e. between 2.7V and 6.5V. □



A COMPLETE RANGE OF INVERTERS 150W TO 2500W - 12V & 24V

A Complete range of regulated inverters to power 220V and 240V AC equipment via a car, lorry or boat battery. Due to their high performance (>90%) the inverters generate very little heat. The high stability of the output frequency (+/-1%) makes them equally suitable to power sensitive devices.

These inverters generate a modified sine wave, which are considerably superior to the square waves which are produced by most other inverters. Due to this superior feature they are capable of powering electrical equipment such as TV,s, videos, desktop & notepad computers, microwave ovens, electrical lamps, pumps, battery chargers, etc.

Low Battery Alarm

The inverters give an audible warning signal when the battery voltage is lower than 10.5V (21V for the 24V version). The inverter automatically shuts off when the battery voltage drops below 10V (20V for the 24V version). Fuse protected input circuitry.

Order Code	Power	Voltage	Price
651.581	150W Continuous	12V	£36.39
651.578	150W Continuous	24V	£36.39
651.582	300W Continuous	12V	£50.64
651.585	300W Continuous	24V	£50.64
651.583	600W Continuous	12V	£101.59
651.593	600W Continuous	24V	£101.59
651.587	1000W Continuous	12V	£177.18
651.597	1000W Continuous	24V	£177.18
651.602	1500W Continuous	12V	£314.52
651.605	1500W Continuous	24V	£314.52
651.589	2500W Continuous	12V	£490.54
651.599	2500W Continuous	24V	£490.54



ILLUSTRATION SHOWN IS 651.583 600W VERSION

All prices are inclusive of V.A.T. Carriage £6.00 Per Order

Many uses include:- * Fetes * Fairgrounds * Airshows * Picnics * Camping * Caravans * Boats * Carnivals * Field Research and * Amateur Radio field days * Powering Desktop & Notepad Computers.



B.K. ELECTRONICS



UNIT 1, COMET WAY, SOUTHEND-ON-SEA, ESSEX. SS2 6TR
TEL: +44(0)1702-527572 FAX: +44(0)1702-420243

DELIVERY CHARGES ARE £6-00 PER ORDER. OFFICIAL ORDERS FROM SCHOOLS, COLLEGES, GOVT. BODIES, PLC,S ETC. PRICES ARE INCLUSIVE OF V.A.T. SALES COUNTER. VISA AND ACCESS ACCEPTED BY POST, PHONE OR FAX, OR EMAIL US AT SALES@BKELEC.COM ALTERNATIVELY SEND CHEQUE OR POSTAL ORDERS MADE PAYABLE TO BK ELECTRONICS.

For Full Specifications View our web site at:-

WWW.BKELEC.COM/INVERTERS.HTM