TALKING ELECTRONICS

A MAGAZINE FOR EXPERIMENTERS

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Issue No.1

LED Zeppelin - a game of skill - see page 5

ISSN 0811 - 3742

Projects in this issue:

BUILD A KIT

Building projects is a very big part of learning electronics. These 8 projects will help you expand your knowledge and give you a great sense of accomplishment. All the projects come with a CAD PC board with a legend on the top showing where the parts go.

Let this issue be the start to your learning experience. There are over 12 books available from Talking Electronics to assist you with understanding the terminology and improve your skills at soldering. See the centre pages of this issue for the order form. You can also buy the PC boards separately if you wish - but you must make sure your parts are the right size and shape.

Capacitor Discharge Unit
(see P 16)
Parts & PC: **$10.20**
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A game of skill in which 6 LEDs are incrementally illuminated.

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(see P 58)
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A simple circuit to flash a LED.

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INTRODUCTION

This is a re-print of the first two issues of Talking Electronics plus a number of additional projects. TE started in 1981 and has prospered ever since. This is because it offers projects and articles that everyone wants. Many readers missed out on the early issues and we have been meaning to publish them for many years. We have now done it. This issue will start your library at the beginning of TE and let you collect everything we have produced. Look out for future issues in your local news-agent or electronics store or send for a subscription.

Talking Electronics has introduced a lot of innovations. In fact it is a new concept. It is half-way between a magazine and a book and offers the best of both. It's a magazine with minimal advertising and lots of articles, just like a book. But the best thing is the price. It has been kept low so everyone can afford it.

While we all appreciate the need for advertising, it has tended to dominate our lives in recent times. How often have you felt the articles of a magazine have been written on the back of the adverts? Or every time you open up a magazine, you land on an advert!

This is the situation we will be avoiding and our policy has been applauded. We have decided to keep the advertising to a minimum and it will be in the centre pages of the magazine when we eventually get around to notifying the advertisers. This way you can concentrate on the articles when you want to study electronics and look up the adverts when you want to buy something. This gives us a clean run for continuity of projects as you can see by this issue.

The other thing we will be doing is to number the issues rather than date them as a dated issue goes out of fashion very quickly.

The type of information we will be presenting does not date and will be relevant, even in years to come.

As the issues build up, you will get the equivalent of a mini encyclopaedia on electronics. We will be covering all those things you want to know and this will include a lot of basic facts.

Another very important feature of our magazine is the availability of kits and printed circuit boards for each of the major projects. These will be available from us and will give you a central location from which you can buy everything.

We have already produced over 150 kits and these will be presented in forthcoming issues. Every project has been designed for a purpose and they all fit together to build up a library of building blocks.

Since electronics is made up of lots of building blocks, we will be encouraging you to put theory into practice by building as many of the projects as you can.

Every circuit will be fully explained and will include a section on "If it doesn't work." This will help you fault-find the project and show you how to approach a project when a fault develops and get it working.

Each issue will contain a number of simple projects plus one or two more complex projects so that everyone is catered for.

We often make the point in an article that we hope a project will not work when first switched on, so you can get down and locate the fault. This is the first time such a concept has been presented in a magazine and it makes our approach unique. Most magazines expect a project to work first go for everyone. But this is totally unrealistic. Lots of things creep in to change the characteristics of a circuit and cause it to mal-function. We hope to make you aware of these possibilities and show you how to go about diagnosing the fault.

After all, it's only after you learn how to fix something that you begin to understand how it works.

Let me point out that when you purchase a kit from us, the chance and probability of the project not working is considerably reduced. This is because we have gone to great lengths to supply only the best components and ones that fit neatly on

CONTENTS

● **Kit available for this project**

All the main projects in this issue are available as a kit from Talking Electronics. See inside front cover for details and the order form on P 41 and 43. Use your own parts for the transistor projects on P 55, 56 and 57 as kits are not available for these.

This publication is designed and produced by: TALKING ELECTRONICS.

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20 03 96 - 50 - 20k

Cover price is recommended and maximum price only

the board.

Whenever a reader rings up with a problem, the first thing we ask is "Did you use one of our kits?" Invariably the answer is no. Unfortunately we cannot help anyone who does not use one of our kits as we have learnt that most of the faults lie in the use of the wrong value components. Simple things like fitting a 224 capacitor instead of 223 or a 10k resistor instead of 1k. We could spend an hour on the phone going through each component and trying to diagnose if the correct value has been used.

This is why we back every project with a kit. We want you to succeed but at the same time we don't mind if a small fault develops so that you gain from the experience.

This is our approach and has received enormous approval. Fault finding is the only way to learn electronics and comes from our experience of fixing lots of TV's and other products.

You will notice all our projects have been designed on printed circuit boards with an overlay showing exactly where each part is located. In fact you could build many of our projects without any further instruction. But to help those who may not be able to build without assistance, we always include full instructions and lots of other technical hints.

Our aim is to actively encourage you to pick up the soldering iron and build something so that the theory we cover in the articles is put into practice.

One of the most rewarding things we get is feedback from our readers who make comments such as "I read your books from cover to cover" or "at last I've finally understood . . . '

We want you to be in this category too.

Learning electronics is a long, continuing process and to make sure you get off to a good start we would like you to make a commitment to buy at least one kit per issue. This way you will really start to learn and be sure of continuing the learning process.

I am sure you will look back and say "this is the best thing I have ever done." But until we get a few issues out, you will not be able to see the whole picture.

In this issue we have included a few projects and pages from our other publications. The Capacitor Discharge Unit comes from Electronics for Model Railways Book No 1 and the LED Flasher comes from Learning Electronics Book 1. The three handwritten pages, P68, 69, 70, come from our Electronics Notebook series.

We have more than 12 different books available such as Notebooks 1-6, Learning Electronics 1&2, Digital Electronics REVEALED, Electronics for Model Railways 1&2, and the pages we have presented show you some of the content.

These books are completely different to anything you have seen before and you can order any of them by filling out the Order Form on P41.

I suggest you order as many as possible as we only have enough for 20% of our readers and then they will have to be reprinted, so don't delay and you won't be put on the waiting list.

That's all for now, I will get back to working on the next issue and supervising the orders. I hope to see your name among them with an order for a kit or two and a subscription.

Oh, I forgot about the subscription. At the moment we will be publishing every three months and a six issue subscription costing $18 will last for 18 months. Rather than having to look in the newsstand for each issue, you can have it sent to your address as soon as it is printed, simply by sending for a subscription. See the Order Form on page 41.

Don't forget, we send everything out the same day so you won't be waiting weeks and weeks for your kits and books to arrive. Just allow a few days and you can get started.

All the best,

Colin Mitchell.

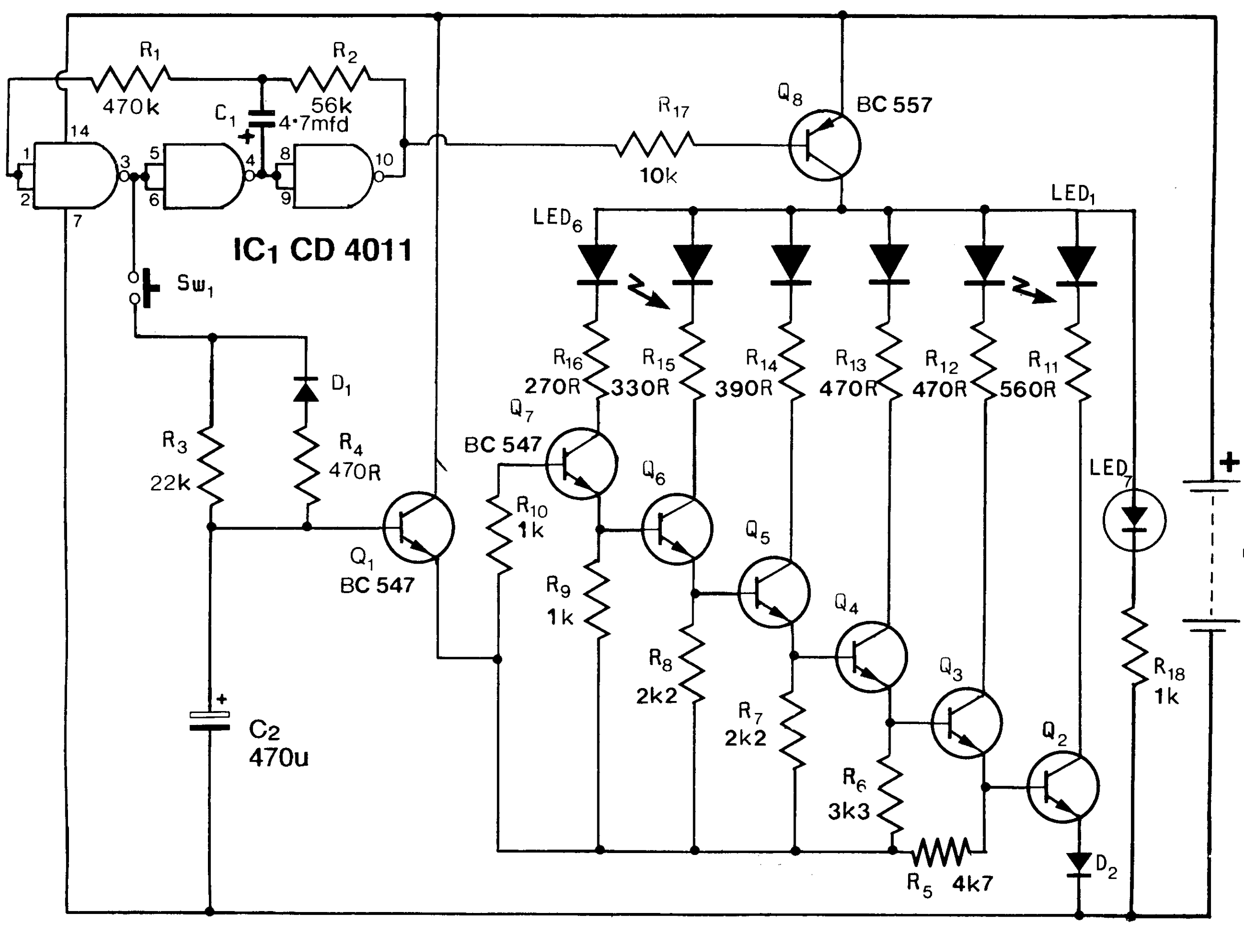
Colin Mitchell.

LED ZEPPELIN

Parts & PC: $10.85
PC board only: $2.85

A game of skill

> *Led Zeppelin is a game of patience. It's like getting a kite into the air. It goes up slowly but the slightest mistake will bring it down like a lead balloon.*



LED Zeppelin Circuit

The name of our game, LED ZEPPELIN, is a play on words. It comes not from the pop group of the same name but from Graf Von Zeppelin, a German army officer who invented the first rigid air ship in 1900.

The association fits perfectly. The game consists of six LEDs and an indicator LED which flashes at at a rate of about 2 cycles per second. A push button is the "Operations Control" and by carefully pushing the button in synchronisation with the flashing LED, the row of LEDs will gradually light up. But the slightest mistake will immediately extinguish one, two or three LEDs.

The aim of the game is to illuminate the 6 LEDs with the least number of pushes.

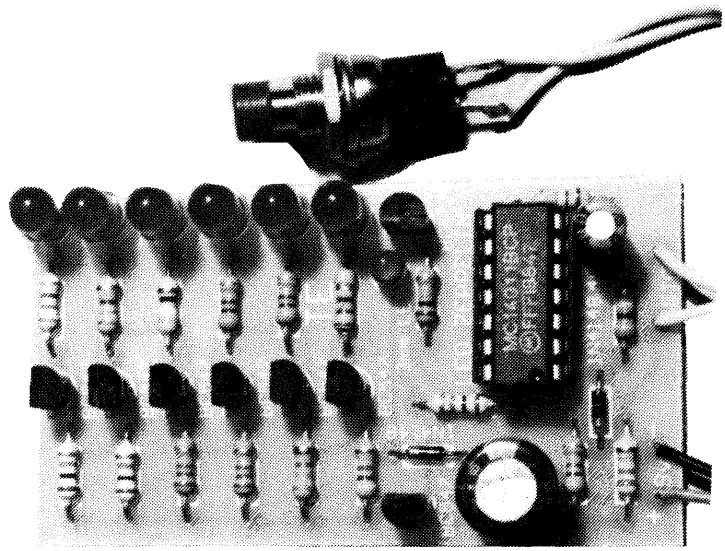
HOW THE CIRCUIT WORKS

The circuit consists of a three-inverter CMOS clock oscillator driving Q_8 which flashes the LEDs on and off. The other output from the oscillator is used to charge up the 470u electrolytic C_2, via R_3.

The output from pin 3 is in the form of a square wave only slightly less than the supply voltage and is about 7.5v to 8v in amplitude. The frequency at which the circuit works is governed by R_1, R_2 and C_1 and is approximately 2Hz.

Charging of the 470u electrolytic is exponential so that initially the voltage increments on the capacitor will be high when it is beginning to charge. Each time the button is pressed a small amount of energy is fed into C_2.

This voltage appears at the base of Q_1. Q_1 is connected as an emitter-follower and the same value of voltage will appear at the emitter, less the .6v base-



Note how the components mount neatly on the PC board

emitter voltage drop.

This voltage is then fed to the base of six transistors Q_2 to Q_7 that drive LEDs 1-6 via current limiting resistors. Each of these transistors will turn on according to the voltage on the 470mfd electrolytic.

When the voltage rises to .6v, Q_1 will turn on. For Q_2 to turn on its base must be .6v higher than the emitter. Q_2 has a forward-biased diode in its emitter and the voltage drop across it will be .6v. The base of Q_2 must be .6v above the emitter, making it .6v plus .6v or 1.2v This means the voltage on C_2 will be .6v plus .6v plus .6v or 1.8v for the first LED to be fully lit.

PARTS LIST

1 - 270R
1 - 330R
1 - 390R
3 - 470R
1 - 560R
3 - 1k
2 - 2k2
1 - 3k3
1 - 4k7
1 - 10k
1 - 22k
1 - 56k
1 - 470k
1 - 4u7 16v PC mount electrolytic
1 - 470u 16v PC mount electrolytic
7 - BC 547, or 2N 2222 transistors
1 - BC 557 or 2N 3906 transistor
1 - CD 4011 IC
1 - 3mm (1/8") red LED
6 - 5mm (1/4") red LEDs
2 - 1N 4148 signal diodes
1 - 14 pin IC socket
1 - push button
1 - battery snap

1 - LED Zeppelin PC board

TERMINOLOGY

Some of the terms used in our articles may be new to some readers.

We have used universally recognised symbols and standard component identification.

In the first few issues of our magazine we have a mixture of two different ways of drawing a resistor. Our older articles use the zig zag symbol but when we went to computer drafting this was changed to the box symbol. With the box symbol we are able to place the value of the resistor inside the box and it takes up less space.

In our older articles we use the term mfd for microfarad. This has now been updated and corrected to "u" or "uF."

The first thing you should do is go though the Experimenter Board and Experimenter Deck articles, and also the circuits on the Transistor page and change 1mfd to 1u, 10mfd to 10u, 0.01 to 10n and 0.1mfd to 100n.

This brings our circuit symbols in line with accepted practice and corresponds to the markings on the components.

For example, 1u is spoken as "one microfarad or one micky" and is printed on the component as 1µ or 1uF or 1/16 or 1/63. This represents one microfarad at 16volt or one microfarad at 63volt (this is the maximum working voltage for the electrolytic).

Similarly, 10mfd in our older articles has now been changed to 10u and this is shown on the body of an electrolytic as 10µ or 10µF or 10/16 or 10/25 and this indicates a ten microfarad electrolytic with a 16 or 25 volts as the maximum working voltage.

0.01mfd in our older articles is now 10n and this represents ten nanofarad. This is written on the body of the component as 103.

0.1mfd in our older articles is now written 100n. It is shown as 104 on the body of the capacitor.

The other fact you will appreciate with all our circuit diagrams is the inclusion of all component values on the diagram itself. Instead of having to search through the parts list for a particular component, they are all shown on the schematic.

That's because this magazine is written by practicing technicians. We use the circuits described in our publications and understand the importantacnce of having everything at your fingertips. A circuit diagram should be large, complete and clear. It should represent a "picture" and be laid out so that it is easy to read and follow.

The resistor values also conform to a standard in which the letter R represents ohms and the letters "k" and "M" are used in place of the decimal point. "k" stands for kilo (1,000) and "M" stands for Meg (1,000,000). There will be a 3-page article in issue 2 on this subject to help you understand resistor markings and the color code.

The letters LED stand for Light Emitting Diode.

A small LED is 3mm or 1/8", a large LED is 5mm or 1/4". A jumbo LED is 10mm or 1/2".

Most of the circuits use a general purpose NPN transistor. We have specified BC 547 or 2N 3904 or 2N 2222 for this, however there are many other types that will work equally well.

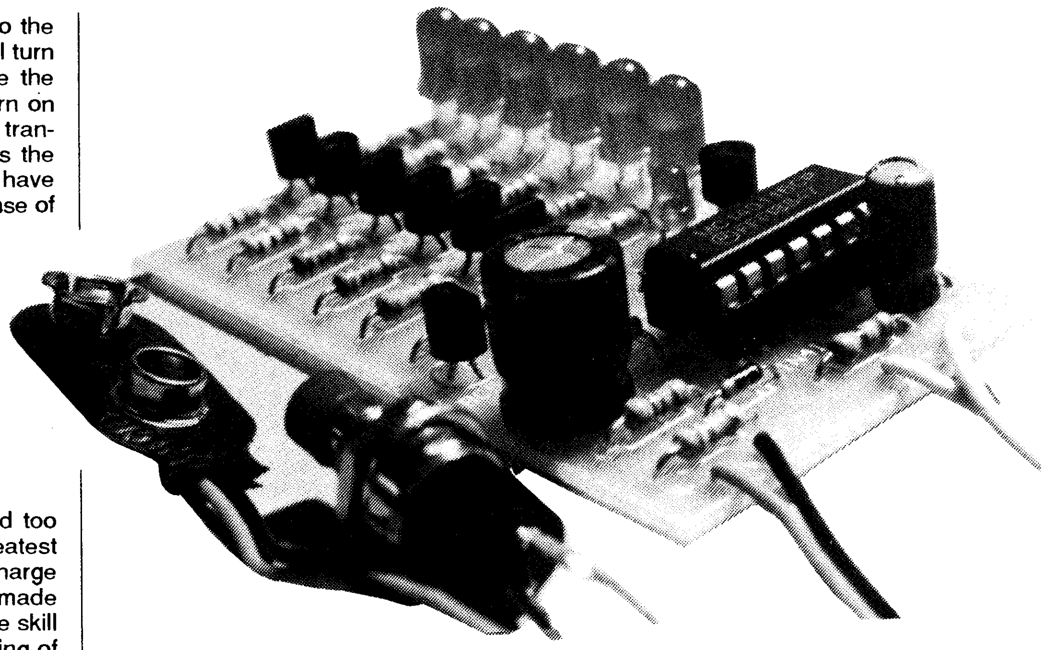
For the PNP general purpose transistor we have specified BC 557 or 2N 3906, however there are many other equally suitable types too.

ed.

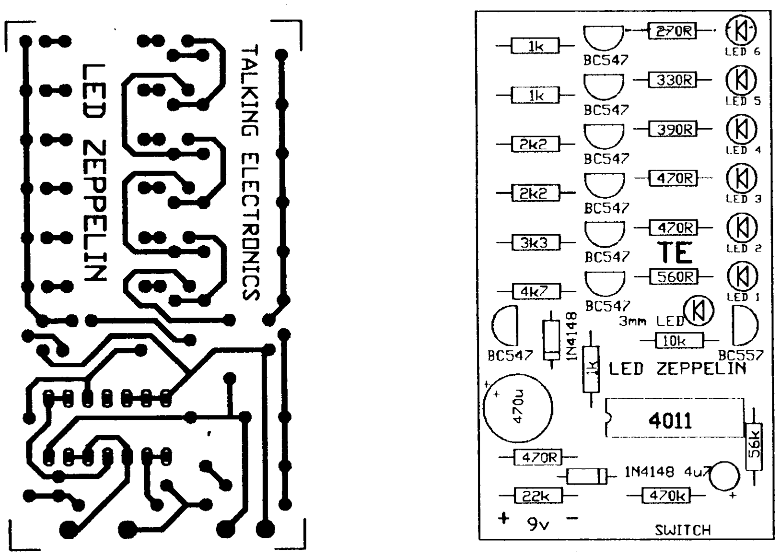
The emitter of Q_3 is connected to the base of Q_2 so that a further .6v will turn it on. At each successive .6v rise the next transistor in the chain will turn on until finally Q_7 will switch on. This transistor drives the top LED which is the highlight of the game. When you have LED 6 pulsing you really feel a sense of achievement.

Should the button be pressed when the oscillator is low, diode D_1 is forward biased and the charge on C_2 will rapidly discharge through R_4. Since the voltage increments become smaller as the 470u becomes fully charged, to light the top LED requires significantly more pushes than LEDs 1 and 2.

If, however, the button is pushed too long, the discharge will be greatest when the capacitor is nearing full charge and an error here will lose the gain made by many pushes. This is where the skill of the game comes in. The charging of the capacitor is "out of phase" with the flashing of the LEDs. This means the button must be pressed when the LEDs are extinguished.



Completed LED Zeppelin



Full-size artwork for the LED Zeppelin.

To turn the game off or restart it, push the button when the LEDs are lit. This will remove the charge on C2 and eventually every LED will go out.

CONSTRUCTION

All the components are mounted on the Printed Circuit Board. Follow the layout diagram for the identification of each part. You will notice all the components are placed neatly on the board with Q2 - Q7 fitted the same way around and all LEDs mount the same way.

For the transistors, the overlay shows the shape of the case and this allows the transistor to be fitted only one way around.

Both electrolytics are identified with their positive lead on the overlay. This lead is the longer of the two leads on a single-ended electrolytic and if both leads have been cut the same length, you will have to refer to the stripe on the side of the case for the negative lead.

The IC socket is the next to be fitted and this is done so that the cut-out at the end of the socket goes over the shape on the overlay.

The IC is inserted into the IC socket so that the cut-out at the end of the chip fits over the cut-out at the end of the socket.

The last two items to connect are the two wires for the switch and the battery snap. Check all soldering and the orientation of the transistors. I always connect a milliammeter in one battery lead before I switch on a project for the first time to check if a short-circuit is present or excessive current is being drawn - you should do this if you have a multimeter.

HOW TO PLAY

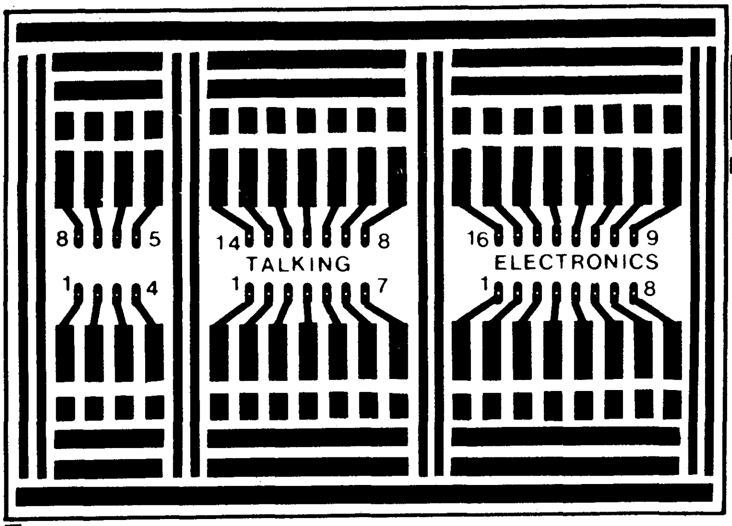
The 3mm (1/8") LED begins to flash when the battery is connected. This indicates the flash rate. To start the staircase of LEDs flashing, push the switch a number times when the LED is extinguished. After a few pushes you will see the first LED flash faintly. Keep in step with the off periods and you will gradually increase the illumination. The rest is up to you.

The LED ZEPPELIN game can be played a number of ways. The most popular way is to count the number of pushes required to get the top LED flashing with reasonable brightness. The player with the least number of pushes wins.

Another variation is to cover the six LEDs with black tape leaving just the indicator LED flashing. The object of the game is to see how many LEDs can be set flashing with a certain number of pushes. Start with 50 pushes per player. Push the button 50 times then remove the tape and read your score. You can make certain adjustments such as 3.5 or just over two LEDs flashing.

When used competitively like this, the game provides a means of assessing your reflex time and co-ordination.

Designed for:
TALKING ELECTRONICS



INTRODUCING THE.....

Parts & PC: $19.75
PC Board (only) $2.85

A PC board you can use again and again......

This series of articles is designed around the TALKING ELECTRONICS IC EXPERIMENTER BOARD. This PC board is made for these 3 IC's:
8 pin IC
14 pin IC
16 pin IC

All the components including the IC's are mounted on TOP of the board. This type of construction is called "bread-boarding" and has 3 major advantages for the experimenter:
1. The board can be used again and again.
2. The parts – including the IC's – can be easily removed.
3. The board is very easy to use – it doesn't have to be turned over to follow the copper tracks.

All this adds up to an inexpensive way to produce quick projects which can be transferred to a home-made PC board if the circuit needs to be kept or made to look more professional, if not they can be removed.

The IC EXPERIMENTER BOARD has been specially designed for newcomers unaccustomed to soldering integrated circuits or in fact anyone wishing to use the same components in future projects. The .1" matrix which is now universally used for all electronic components has been enlarged a little to make soldering easier. This is why the solder lands for the IC's have been spread out from the socket. **Interconnection between IC's has been provided by the double copper tracks at the top and bottom. The extreme outside tracks form the positive and negative rails.**

You shouldn't have any difficulty following the simple projects in this series. The layout diagrams will help you to position the parts accurately.

USING IC's

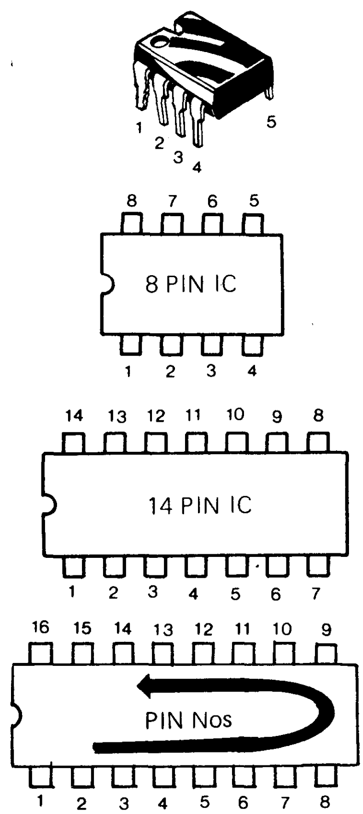
For those who have never handled IC's, there are basically two types of IC which we will be using in these projects. The older type called TTL stands for Transistor-Transistor-Logic. They are quite robust and can be soldered into circuit without any fear of damaging them provided you keep your fingers on the body of the IC as a heat-sink while soldering the pins.

The second type is CMOS, standing for Complementary-Metal Oxide Semiconductor. These types are sold to you with their leads fitted through tin-foil to prevent any static electricity build-up damaging their input gates. Once you remove the foil, solder them into circuit making sure the IC is heat-sinked with your fingers.

PIN NUMBERING

All IC's are numbered in an anticlockwise direction when looking at them soldered onto a printed circuit board. Pin 1 is identified by either a keyway or notch in the end of the IC or a dimple near the pin. Don't take any notice of any other holes, they are just push-pin holes created when the IC is pushed out of its manufacturing cavity.

Pin numbering is always ANTICLOCKWISE



16 PIN IC

Viewed from above

Boards are available from: TALKING ELECTRONICS

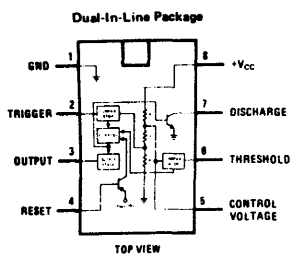
EXPERIMENTER BOARD

THE 555 TIMER

One of the handiest IC's to be invented is the 555 timer. It is contained in a tiny 8 pin package and consists of a complex array of transistors which only need a few external components to produce an accurate time delay.

555 BLOCK DIAGRAM

In this diagram you can see a free-running flip-flop which is triggered via pins 2 and 6 to drive the output pin 3. The 555 timer can provide time delays ranging from several minutes for one cycle of operation to many



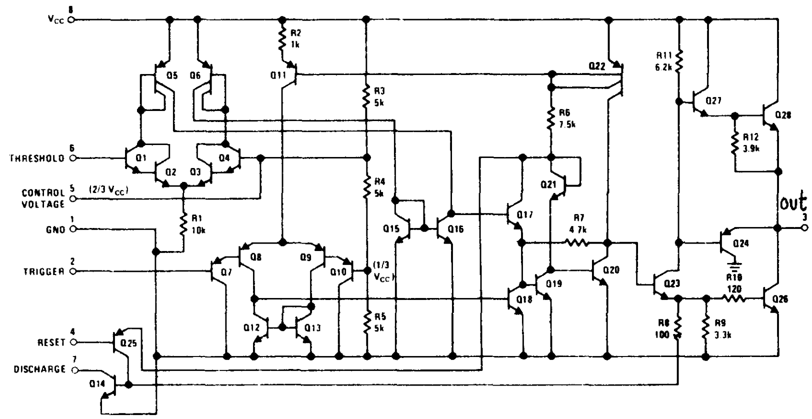
thousands of cycles per second. Any circuit which cycles more than a few times per second is called an oscillator. Below this frequency we cay it is "cycling" The frequency of oscillation is measured in cycles per second (cps) — now called Hertz (Hz) in honour of the scientist H.R. Hertz 1857-94 who experimented with electromagnetic waves which he called hertzian or radio waves — thus the name Hertz.

Only two external resistors and one capacitor are needed to provide timing for the 555 timer. The output can drive a load such as a LED which will flash each time the timer is cycled.

FULL 555 SCHEMATIC

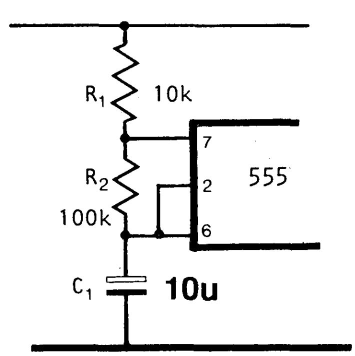
The full schematic diagram is reproduced here mainly to show its complexity. Obviously it would not be worthwhile making this circuit from individual components as the whole chip costs less than 40 cents! It incorporates 28 transistors and a set of resistors housed inside the 8 pin package. The schematic can be simplified somewhat to a block diagram making the operation of the circuit slightly easier to understand.

schematic diagram



HOW DOES THE 555 TIMER WORK?

The 555 timer operates by sensing voltage levels on pin 2 and 6.



TIMING COMPRISES R_1 R_2 & C_1

When the IC is connected to the supply, the capacitor C_1 begins to charge. When its voltage rises to 2/3 of the supply voltage, pin 6 detects this level and turns the IC off. The pin is then effectively disconnected from the circuit and does not have any further function until the IC is turned back on again. At the same instant pin 7 becomes connected to the negative rail via circuitry inside the IC so that the capacitor begins to discharge via R_2. As this occurs, the voltage on pin 2 is reducing to a point where it becomes 1/3 of the supply voltage. Pin 2 detects this and turns the IC on again. It removes the short on pin 7 so that the capacitor C_1 can charge up again. During this charging period pin 2 has no effect on the charge-time as it is virtually disconnected.
In summary: the IC triggers between two voltage limits to turn the LED on and off.

PROJECT ONE

flashing LED

One of the simplest and most effective circuits using the 555 timer is a low frequency oscillator driving a LED. In this first project the components have been chosen to give a frequency of about 2 cycles per second (2Hz). This means the LED will blink twice per second.

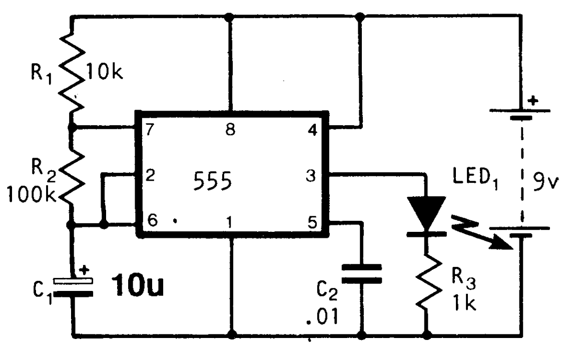
The whole circuit uses just 7 components. These are soldered onto the top of the experimenter board as shown in the layout diagram. You will need 7 jumper wires to connect the IC pins to the parts via the copper tracks. Use a 9v battery to power the LED and connect the battery snap to the positive and negative tracks as shown.

Before connecting the battery, check over these 5 points:

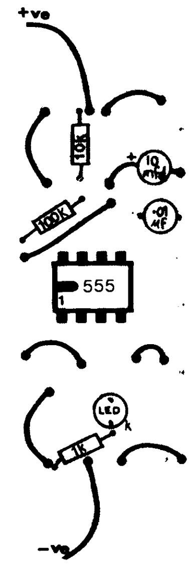
1. Does the dot on the end of the IC align with pin 1 on the board?
2. Does the long lead of the LED connect to pin 3?
3. Does the positive of the 10mfd electrolytic connect to pins 6 and 2?
4. Are the 7 jumper wires in position?
5. Are all the 8 pins of the IC connected?

Connect the battery. With a little bit of luck the LED will flash at 2Hz! If it doesn't, don't despair. Read the project through again. Look for these 6 possible faults:

1. Battery connected around the wrong way.
2. Solder bridging the copper tracks near the IC.
3. Parts touching.
4. LED inserted the wrong way around.
5. A missing jumper wire or part.
6. Weak battery.



Circuit 1 **FLASHING LED**



FLASHING LED LAYOUT

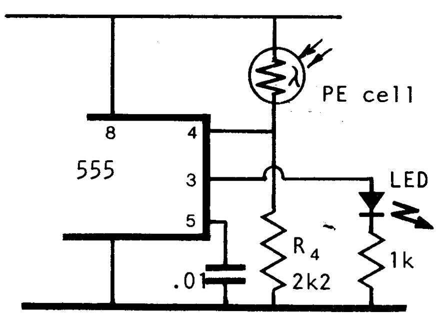
PROJECT TWO

LIGHT ACTIVATED FLASHING LED

With the addition of only two components we can create three different effects on the flashing LED in the first circuit. A Light Dependent Resistor (LDR), more commonly known as a photocell can be combined with a resistor and connected into the circuit so that the LED flashes only when the room is illuminated or conversely, only when the room is in darkness. Another effect is achieved by wiring the LDR between pins 6 and 7. This will alter the flash frequency according to the amount of light falling on the LDR.

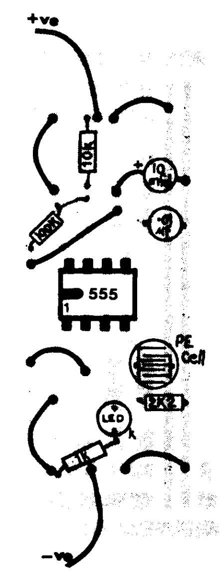
FLASHING LED WITH PHOTOCELL

Circuit 2 shows the photocell connected to pin 4. A 2.2k resistor is used to bias pin 4 at ground potential. When no light falls on the photocell pin 4 is effectively grounded. As the light intensity is increased the resistance of the photocell is reduced thus increasing the voltage on pin



Circuit 2 **HIGH ILLUMINATION WILL TURN LED OFF**

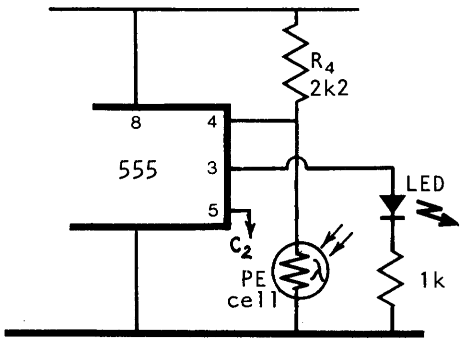
4. A voltage level of about .8v is reached which is detected by pin 4 to turn on the oscillator. The sensitivity of the photocell can be adjusted by varying R4. By experimenting and finding a suitable value for R4, the LED may be made to turn on at the first sign of light.



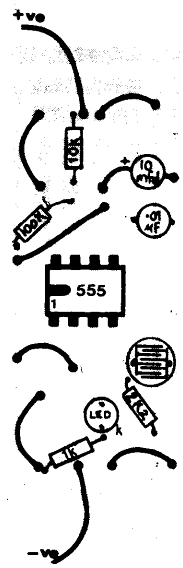
PROJECT THREE

If you want to reverse the effect – namely to extinguish the LED when the light is reduced, circuit 3 will create this effect.

It merely reverses the photocell and biasing resistor. As the light falling on the LDR increases, its resistance decreases and bring the voltage at pin 4 down to a point where the 555 timer will turn off.

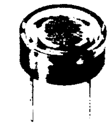


Circuit 3 HIGH ILLUMINATION WILL TURN LED ON



WHAT IS A PHOTOCELL?

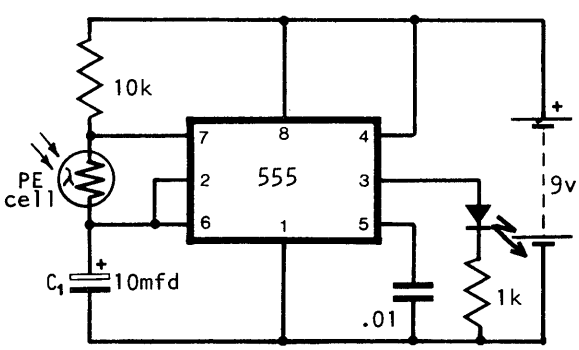
A Photocell is a thin sheet of semiconductor material such as selenium, germanium or silicon which is sensitive to light. It has



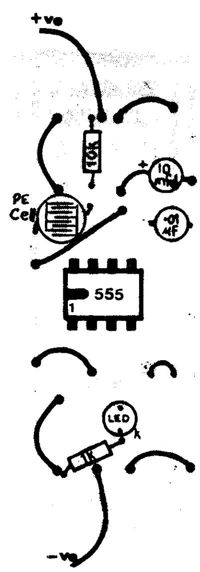
a parallel grid of 2 conducting wires etched over its face to increase the effective area of conduction. These two wires connect to 2 leads. The whole assembly is mounted behind a clear glass window so that light falling on the cell will change its resistance. Under very bright light its resistance will be in the order of only a few hundred ohms. This increase to over 1 meg in total darkness. This large change in resistance can be used to trigger the IC at specific illuminations or modulate the timing circuit to alter the rate of flashing.

PROJECT FOUR

To vary the frequency of flash we need only to replace R_2 with the photocell. As the light intensity on the photocell changes the charge time for C_1 will vary so that the LED will flash from one cycle every few minutes to a rate so high that it will be beyond your speed of counting. It will appear as if the LED is constantly glowing.



Circuit 4 LIGHT FALLING ON LDR WILL ALTER FLASH RATE



PARTS LIST

For circuits 1 - 5

Resistors:

1 - 1k
1 - 2k2
1 - 10k
1 - 100k

Capacitors:

1 - .01mfd ceramic
1 - .1mfd ceramic
1 - 10mfd electro

IC's:

1 - 555 IC (or NE 555)
(or SE 555)
(or LM 555)
1 - CD 4017 IC

1 - PE cell ORP 12
2 - Red LED's
1 - Push-on Switch
1 - 9v battery
1 - Battery clip

1 - 3-IC EXPERIMENTER BOARD

PROJECT FIVE

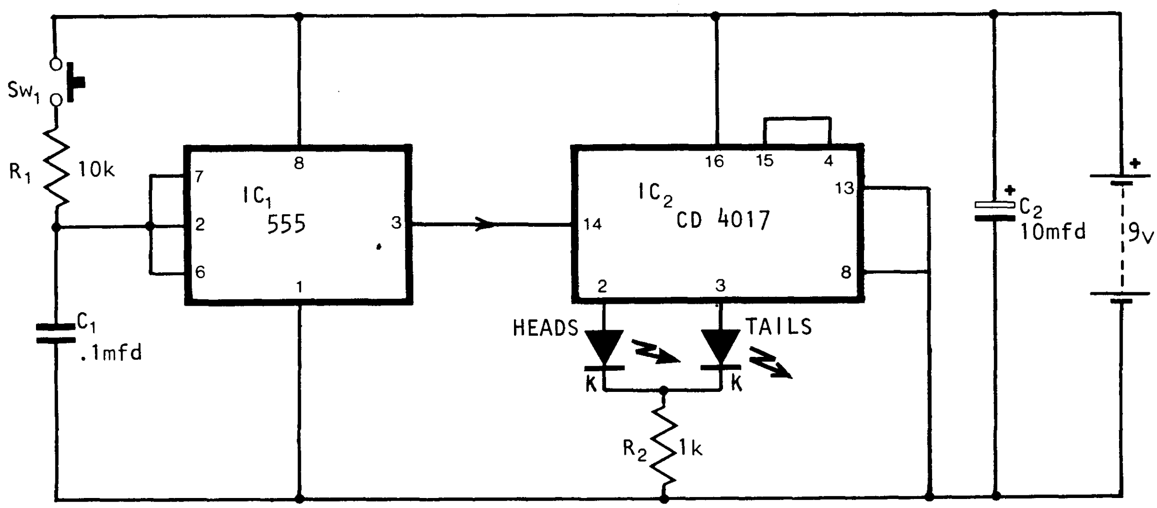
Heads or Tails?

A very simple circuit using a 555 timer and a counting IC.

Have you seen the electronic descision makers on the market? A number of models have been released. Most retail for around $15 to $30 and come in a variety of styles displaying either "HEADS/TAILS" or "YES" and "NO" or "DO IT NOW/DO IT TOMORROW". Effectively they are all the same – consisting of 2 red LEDS on a colourful background displaying the appropriate messages. They make a wonderful gift for a procrastinator or as a party game. A push button starts the LEDs flashing and they gradually slow down to a stable state of either yes or no.

The circuit for the HEADS or TAILS project uses IC's and 2 LEDs. The first IC is a 555 timer The time-constant components comprising the 10k resistor R_1 and .1mfd capacitor C_1 have been chosen to enable the timer to oscillate at a frequency of 1500 Hz. The output at pin 3 feeds directly into the second IC, a CD 4017 decade counter. It is capable of counting up to ten then setting automatically to begin again. The IC can be programmed or to put it another way, can be adjusted to count up to 2,3,4,5,6,7,8 or 9 simply by connecting the next output to the reset pin. For instance: If you wish to count to 7, connect output 8 to the reset pin and the IC will count to 7 then reset again.

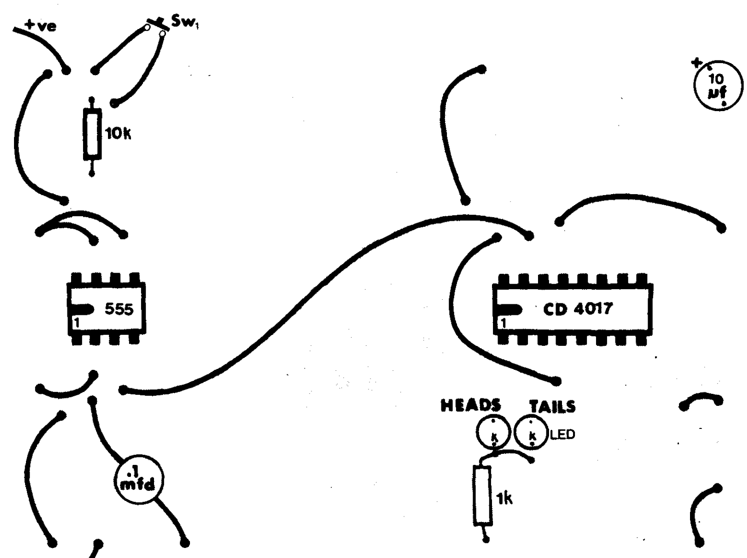
In this project we use only the first two outputs: pin 3 is the first output and pin 2 is the second output. The outputs do not correspond to the IC pin numbers but happen to fall in this order: 3-2-4-10-1-5-6-9-11. If we connect the third output (pin 4) to the reset pin 15, the IC will clock from 3 to 2 then reset back to 3 again. In other words it will oscillate between 3 and 2 at 750Hz at each output. Actually we are using a very complex IC for this simple project however, we will be utilizing more of the IC in the next project so don't worry about the cost at this stage.



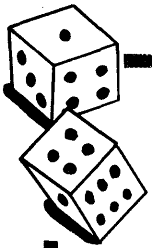
Circuit 5. HEADS or TAILS.

Basically, this project performs the same task. Except that it doesn't have the sophistication of allowing the LEDs to slow down before locking into one stable state.

However, this breadboard project could be fitted into a small box and with a little imagination a colourful front panel could be designed to brighten it up and save yourself a lot of money over the bought model. Two very simple panels are included here to give you ideas to work from.



HEADS or TAILS LAYOUT



PROJECT SIX

EXPERIMEN

LED DICE

...WITH SLOW DOWN

Each project in this series needs just a few extra components in addition to the previous project to create a completely different circuit and add a new dimension to the possibilities of electronics. This is one such circuit.

Being electronically minded, have you ever wished you could throw away the old dice used in snakes and ladders and replace it with an electronic dice? Well now you can. With this LED DICE the full realism of waiting for a dice to stop rolling or a spinner to stop spinning is re-created with an electronic circuit. It works like this: after placing your finger on the TOUCH PLATE the LEDs begin to flash rapidly. After a second or two they reduce speed to a running sequence. Then they slow down to a walk and finally a crawl. At this stage you are hoping they will jump one more step to make a six. You're in luck! It jumps to a six! But wait, the capacitor may not be fully discharged. You will have to wait a few more seconds to see if the 555 oscillator will clock the CD 4017 one more step. It does. You lose. You get a single solitary ONE for your turn.

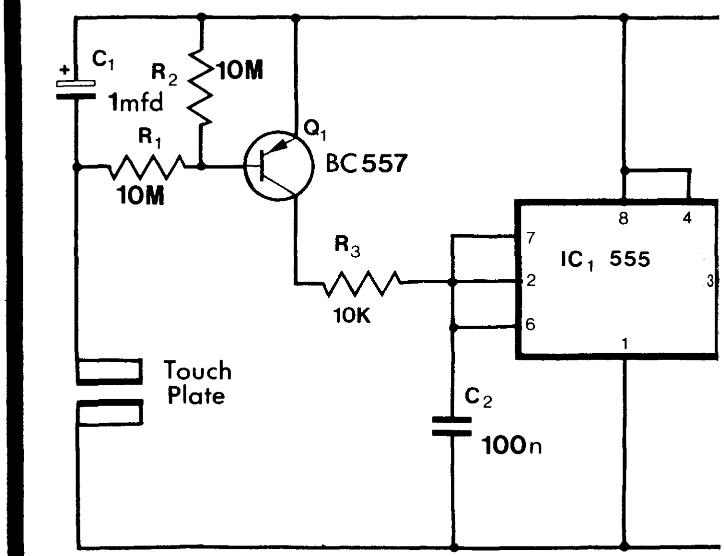
That's the luck of the game. I've never been lucky at cards, dice or poker but I'm sure this game will bring you luck. Even if you don't win at Ludo or Monopoly you will generate a lot of interest from your family and friends - especially since there is no way of "loading" the circuit; it gives a completely random unbiased result.

How it works:

When the battery is connected, the BC 557 transistor Q_1 is biased off via resistor R_2. This means that no voltage will be present at the collector. When the TOUCH PLATE is touched with your finger, C_1 charges and provides a base-emitter potential to turn on Q_1. This potential must be higher than the turn-on voltage of .6v, to turn on Q_1. The collector now provides a voltage at its output. Pin 7 of the 555 timer detects this voltage as described in the beginning of the series. It will oscillate at a frequency determined by the voltage on pin 7 and the value of C_2.

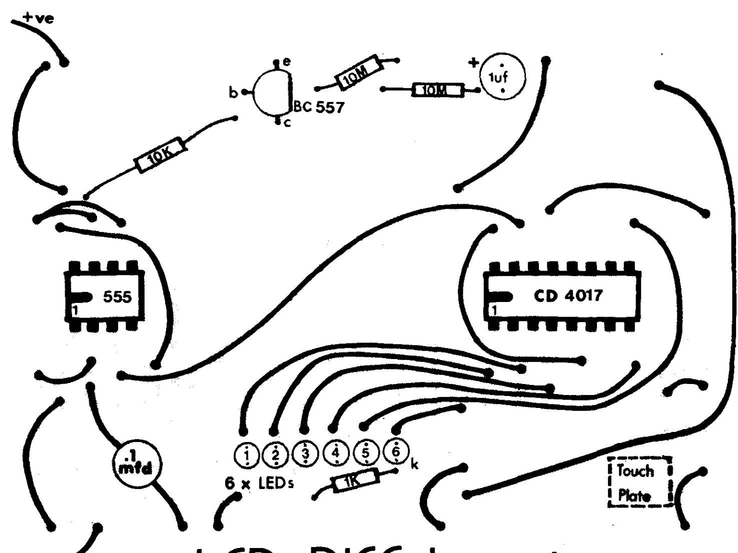
When your finger is removed from the TOUCH PLATE the voltage on capacitor C_1 is gradually removed via the two 10M bleed resistors. As this voltage reduces, the base voltage reduces and the transistor provides a reducing voltage at its collector and also on pin 7 of the 555 oscillator. Thus the output frequency of the 555 slows down and finally comes to a complete halt.

The output of the 555 drives a CD 4017 decade counter which lights each LED in turn. We are using 6 of its 10 outputs. So that only the first six are clocked, the 7th output is connected to the reset pin number 15.



LED DICE cir

As the decay of capacitor C_1 is exponential, the CD 4017 is clocked slower and slower so that suspense is built up when the LEDs are about to stop. You will never quite know whether the CD 4017 will clock just one more time or sit on your lucky number six!



LED DICE layout.

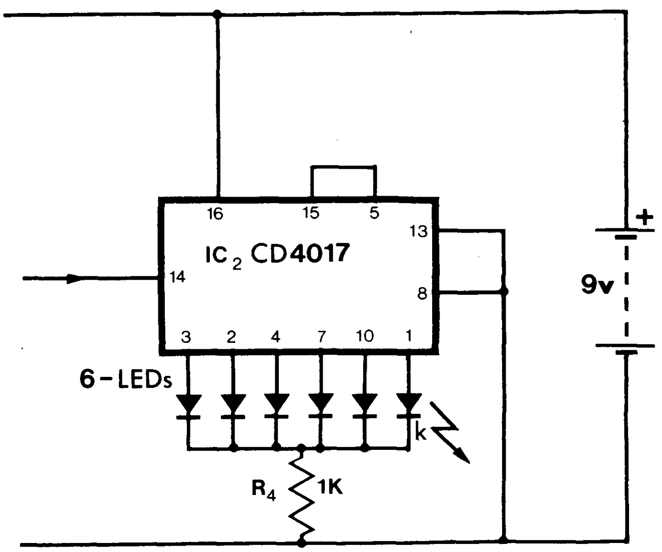
series

TER BOARD

mkI

Project cost: $2.50

After building project five.



uit.

Building the circuit:

The idea behind this progressive series is to add to each of the previous projects to make a more complex project. This way you will be adding a minimum of components and building new ideas at the least expense. Remove the HEADS and TAILS LEDs from the previous project and all the other parts which will not be needed. Notice that some of the wiring will remain in place so refer to the layout diagram before starting. Fit the six LEDs in the centre of the board as shown. They will need connecting wires to the output pins of the CD 4017 so follow the layout diagram carefully. Solder the other components in place and re-check all wiring. Connect the battery and the circuit will come on with one LED illuminated. Touching the TOUCH PLATE will cause the LEDs to flash at a very fast rate and gradually slow down with just one of them lit.

We claim that the circuit is unbiased. But don't take our word for it. Complete your own statistical analysis of the circuit by taking 100 samples and putting the results in the following table:

No:	Count:	Total
1		
2		
3		
4		
5		
6		

Each time the LEDs stop, place a stroke in the appropriate space thus: / after each four strokes: //// the fifth stroke is placed across the four thus: ~~////~~ This makes the final counting easy as they are now in groups of five. Look at your results. Are the totals of each LED nearly the same?

In an article to be presented in a few months, we will be adding a couple more components to this circuit and presenting it as a complete project on a printed circuit board. So wait for it.

Parts list:

R1	resistor	10M	¼watt
R2	"	10M	"
R3	"	10k	"
R4	"	1k	"
C1	electrolytic	1mfd	16v
C2	capacitor	100n	100v
Q1	transistor	BC 557	
IC_1	timer IC	NE 555	
IC_2	decade counter	CD 4017	

LED_1 - LED_6 Large Red LEDs

battery clip
9v battery
approx 30cm hook-up wire

"Experimenter Board 3-ICs"

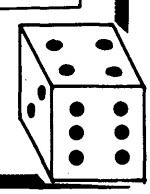
LED DICE

○○○○○○
1 2 3 4 5 6

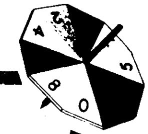
or

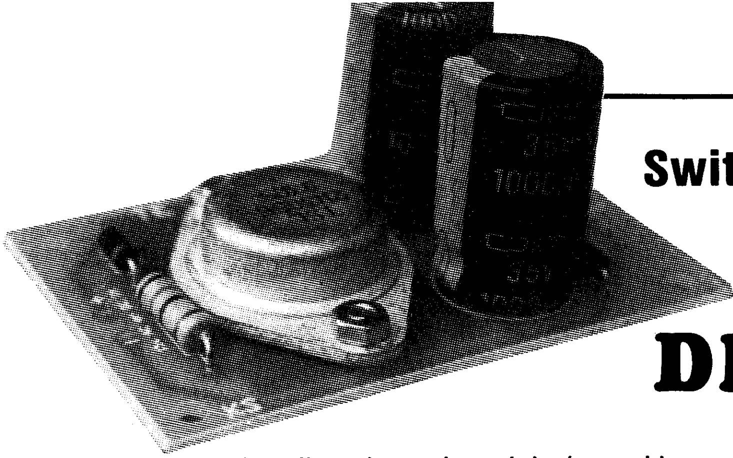
LED DICE

○○○○○○
1 2 3 4 5 6



"Cut-out" display cards





Parts & PC: $10.20
PC board (only): $3.85

Switch your points with this . . .

CAPACITOR DISCHARGE UNIT

Every model railway has points. I don't consider a layout to be complete without at least one. Without them, the layout is a train set!

Many of these points are switched remotely due to their distance from the operator or inaccessibility in tunnels etc.

Their method of control is usually electrical and up to now a number of problems have been associated with these circuits. They had the tendency to overheat the solenoids and even burn them out. If this happened, the points, and even the track, could be damaged.

The electrical control of a set of points is simple. Electrical energy is converted to mechancial movement via a solenoid actuator. This device is called a 'POINT MOTOR'. They are mounted under or near the point in such a way that the movement sets the blades of the points for one direction or the other.

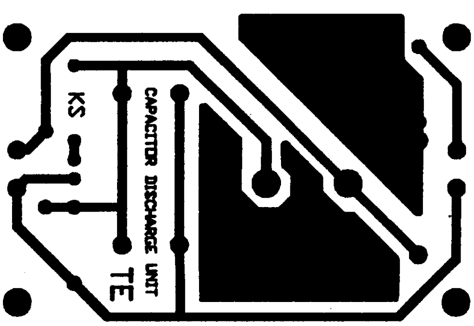
This involves a linear movement of about 5mm. To create this movement, the simplest device is the solenoid. It is simply a coil of wire wound on a former. Inside the former is an iron actuator or slug which can be pulled into the coil when the power is applied. By placing two of these coils end-to-end, a forward and reverse motion can be created. These arrangements are called 'Switch Machines' or 'Point Motors'.

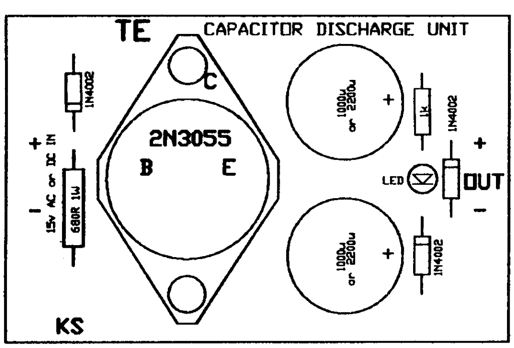
These two-solenoid point-motors are usually switched by short pulses of electricity. The pulse length is often determined by the operator or by a simple spring-loaded switch.

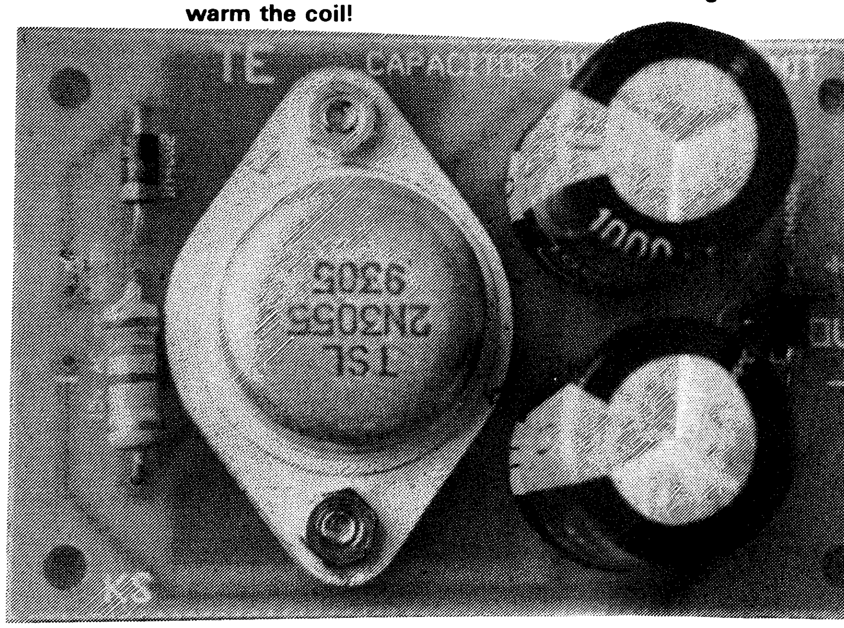
But there are several problems with this arrangement. Point motors require a considerable amount of current for their operation. This means the full capacity of the transformer will be needed. Any other items using the same supply will suffer.

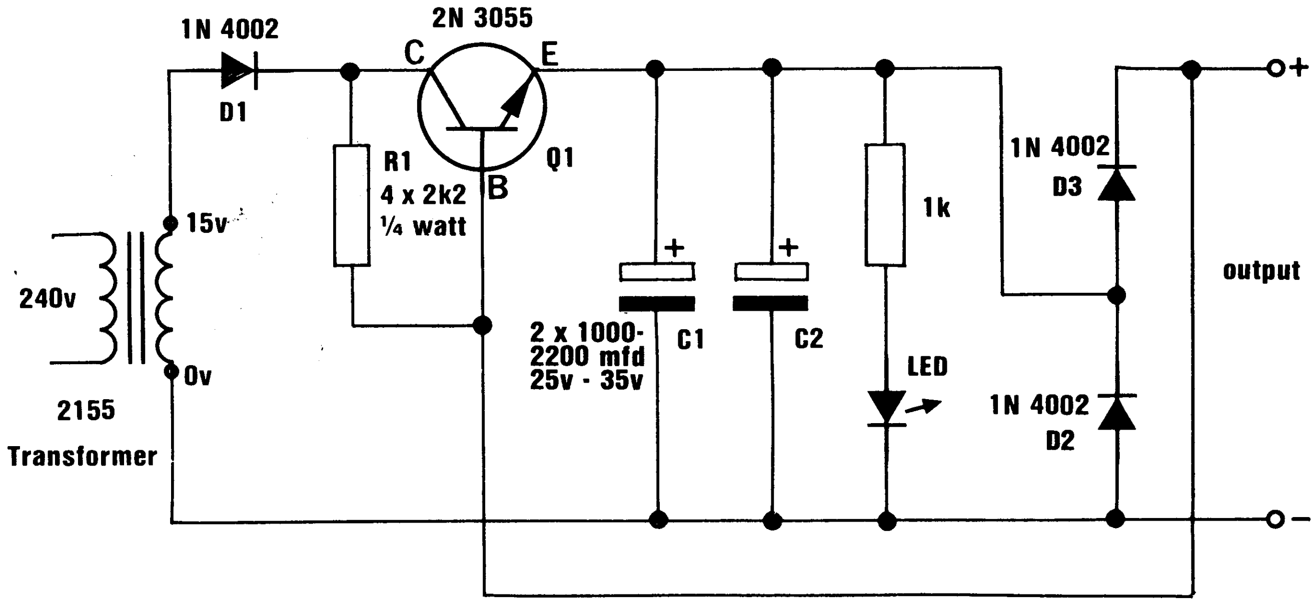
There are other problems too. The high currents will play havoc with switches. The back emf (reverse voltage) generated by the solenoid is sometimes sufficient to weld the switch closed. This will keep the current flowing through the solenoid and it will over-heat very quickly.

Our CAPACITOR DISCHARGE UNIT overcomes all these problems. Capacitor Discharge Units (CDU) supply a high current 'burst' to the solenoid. This current burst is over by the time the switch contacts open, thus eliminating back emf across the switch contacts. Should a solenoid be left in circuit, the current flowing through it (after the initial surge) will be less than 50mA. This won't even be enough to warm the coil!









Very few components are needed to make this unit, as can be seen from the simplicity of the circuit diagram. R1 can be a 470R 1 watt resistor or four 2K2 ¼ watt resistors in parallel.

HOW DOES IT WORK?

The AC voltage (16v) at the input of the CDU is rectified by D1. This diode passes every positive half-cycle of the AC and blocks the negative half-cycle.

Assuming no solenoid is connected to the CDU, R1 pulls the base of Q1 high, switching ON the transistor and allowing current to flow through it (from C to E), to charge the capacitors C1 and C2. These are the reservoir capacitors that will supply the surge of current to the solenoid.

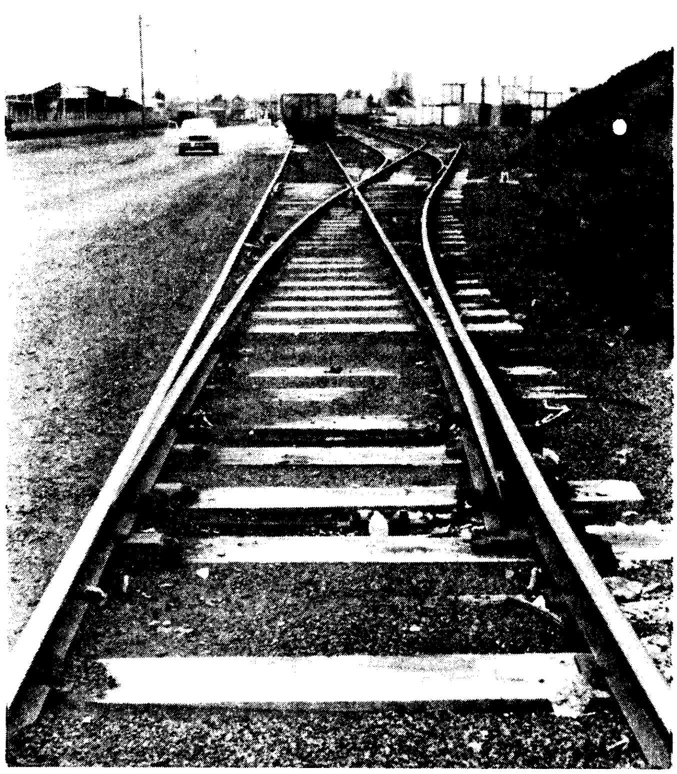
D2 and D3 are protection diodes which prevent any back emf from damaging the transistor or capacitors.

This is what happens when a solenoid is connected across the output of the CDU:
The reservoir capacitors will discharge through D3 into the solenoid. The low impedance of the solenoid (typically 3 ohms) is now holding the base of the transistor LOW, switching it OFF. The only current now flowing is going through R1 and the solenoid. This current is less than 50mA. The transistor remains OFF preventing the charge-current reaching the solenoid.

Removing the solenoid from the output of the CDU will allow the base of the transistor to be pulled HIGH by R1. The transistor will turn on and charge the reservoir capacitors again, ready for the next operation. Recharge time is less than half a second.

CONSTRUCTION

Assembly of the PC board is straight-forward. Four 2k2 ¼watt resistors are wired in parallel to form R1. A 470R 1 watt resistor could be used but ¼watt resistors will look much neater. The transistor is



bolted to the PC board with its base and emitter leads soldered and trimmed. It requires no insulation or heatsink.

The capacitors can be rated at 25v if the unit is to be operated on 15 -16v AC. If connected to 18 -20v, the capacitors must be rated at 35vw.

Note: Train transformers often have an output of 15 to 16v when labelled 12v, so this must be taken into account. (They drop to 12v on full load).

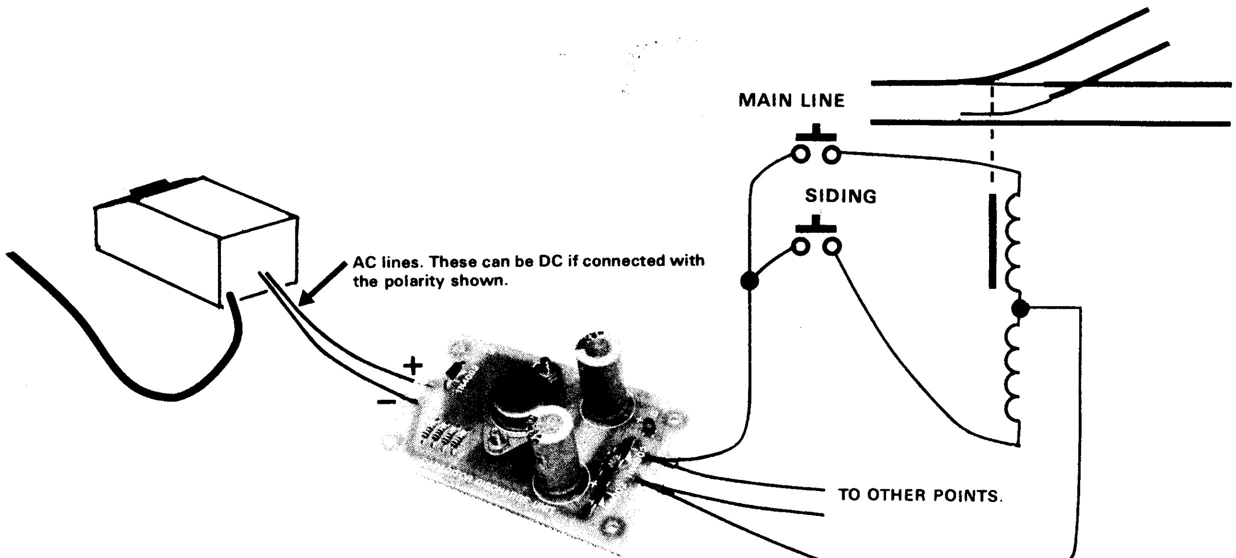
A single 2200mfd capacitor can be substituted for the two 1000 mfd capacitors. If a more powerful unit is required, an extra 2200mfd capacitor can be added.

Care must be taken with orientation of all components other than the resistors. Any error will result in damage to some or all the components.

CONNECTING THE UNIT

Disconnect the wires of your existing system from the transformer and connect them to the output of the CDU. Connect the input of the CDU to the transformer. The system is now ready for operation. See the completed wiring diagram for the connections to the capacitor discharge unit.

The LED can be placed on the main control panel of the layout to indicate the condition of the unit. The LED will light to indicate when the unit is ready. When a point is operated, the LED will extinguish, then come back on as the capacitor charges. If it remains extinguished, it indicates a fault is present and the solenoid may still be in circuit. No other points can be operated until this is fixed, but at least the solenoids will not be damaged!



How to wire the capacitor discharge unit into your point switching system.

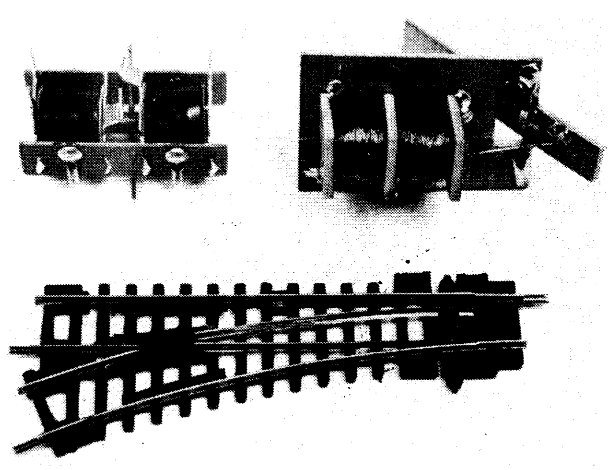
Capacitor Discharge Unit Parts List

1 - 1K
4 - 2K2

2 - 1000 mfd 25v-35v. See text.

3 - 1N4002 diodes
1 - 3mm red LED
1 - 2N3055

2 - Nuts & bolts
1 - Capacitor Discharge Unit PCB



A commercial point motor and a home made point motor alongside an N gauge point.

EXPERIMENTER DECK

Parts & PC: $24.30   PC Board (only) $5.95

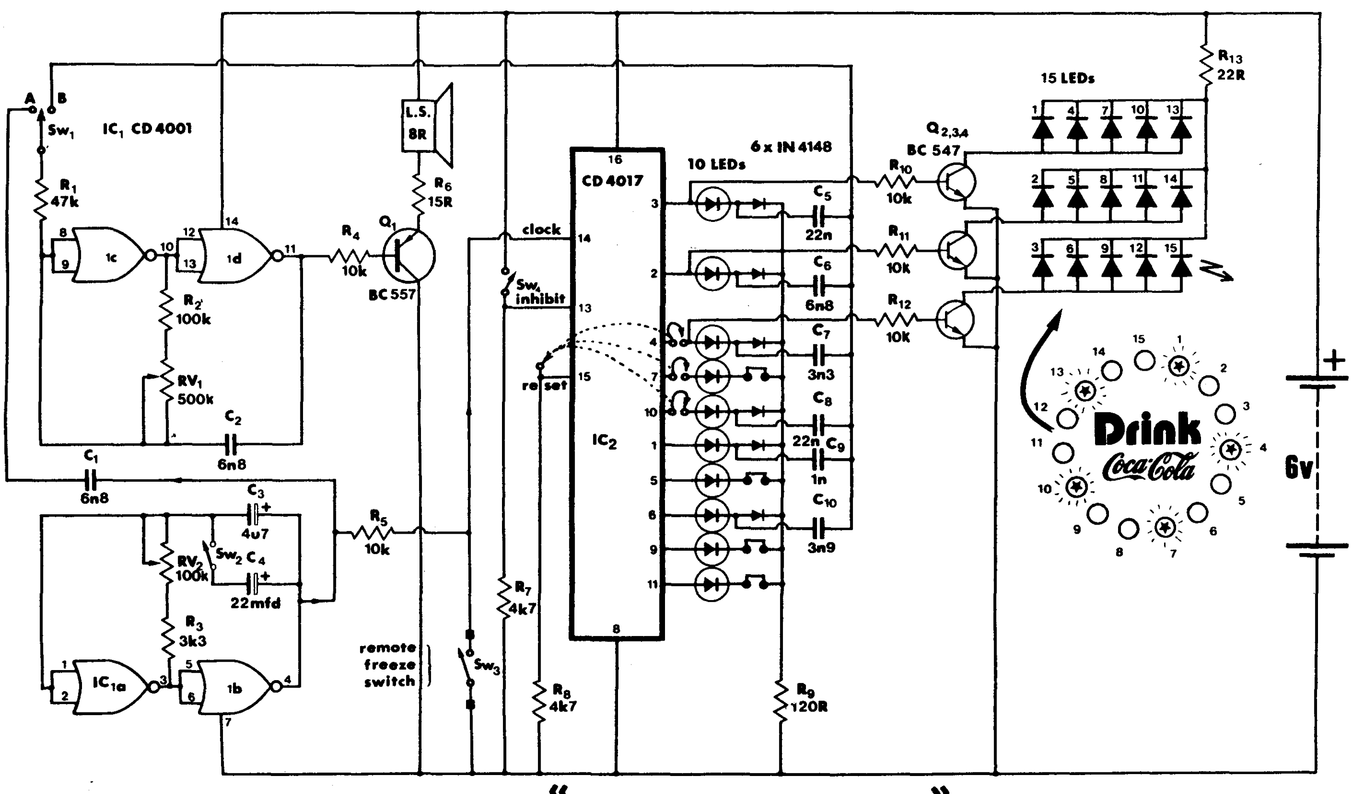
BUILD THESE 10 EXPERIMENTS ON ONE PC BOARD:

1. HEE HAW SIREN
2. HEADS or TAILS?
3. DECISION MAKER
4. RUNNING LIGHT
5. CRICKET GAME
6. TIMER
7. TEST YOU REFLEX TIME
8. TUNE
9. MAKING MUSIC
10. ADVERTISING SIGN

'THE DECK'.... What does it do?

These 10 projects are presented in a graduated form. The first project "HEE HAW SIREN" uses only 25% of the parts --- each preceeding project uses either additional parts or a different combination of switches or potentiometer settings to give a completely different experiment. This gives the EXPERIMENTER DECK a wide variety of uses and an allowance has been made for additional experimenting such as in project number 8, in which the pre-programmed tune can be re-programmed to any tune or scale you wish.
The circuit board builds up to the final project THE ADVERTISING SIGN which uses all the parts including the circle of 15 LEDs to flash in a similar manner to lights running round a neon sign or movie screen at a drive-in. The combination of the duel frequency tone from the speaker, 3 LEDs from the train of LEDs acting in a pump-like manner and the 15 circulating LEDs, is really captivating in a darkened room. It's like a miniature sound-and-light display.

Only the first 4 projects are presented in this issue. We advise, however, to purchase the full kit in readiness for the next issue. Keep them in a sale place. The complete circuit may look complex but each individual project is simple.



COMPLETE "10 EXPERIMENT" CIRCUIT

Complete list of parts for the 10 projects:

1 - EXPERIMENTER DECK No1 PC board

1 - CD 4001 IC
1 - CD 4017 IC

R1 Resistor 47k $\frac{1}{4}$watt
R2 " 100k "
R3 " 3k3 "
R4 " 10k "
R5 " 10k "
R6 " 15R "
R7 " 4k7 "
R8 " 4k7 "
R9 " 120R "
R10 " 10k "
R11 " 10k "
R12 " 10k "
R13 " 22R "

C1 Capacitor 6n8 100v (6800pf,.0068)
C2 " 6n8 " (" ")
C3 Electrolytic 4u7 10 - 35v (4.7mfd)
C4 " 22mfd 10 - 16v
C5 Capacitor 22n 100v (.022mfd)
C6 " 6n8 " (6800pf,.0068)
C7 " 3n3 " (3300pf,.0033)
C8 " 22n " (.022mfd)
C9 " 1n " (1000pf,.001)
C10 " 3n9 " (3900pf,.0039)

6 - Diodes IN 4148 or IN 914

RV1 - Mini trim pot 500k Cermet type VTP
RV2 - Mini trim pot 100k Cermet type VTP

25 - LEDs or 24 red LEDs & 1 green LED.

Q1 - Transistor BC 557 or any PNP type
Q2 - " BC 547 or any NPN type
Q3 - " " "
Q4 - " " "

1 - Speaker 2¼", either 3Ω,8Ω,15Ω or 33Ω.

30cm of 10 core ribbon cable or 10 pieces of coloured hook-up flex

1 - Length of tinned copper wire or pieces cut from resistors

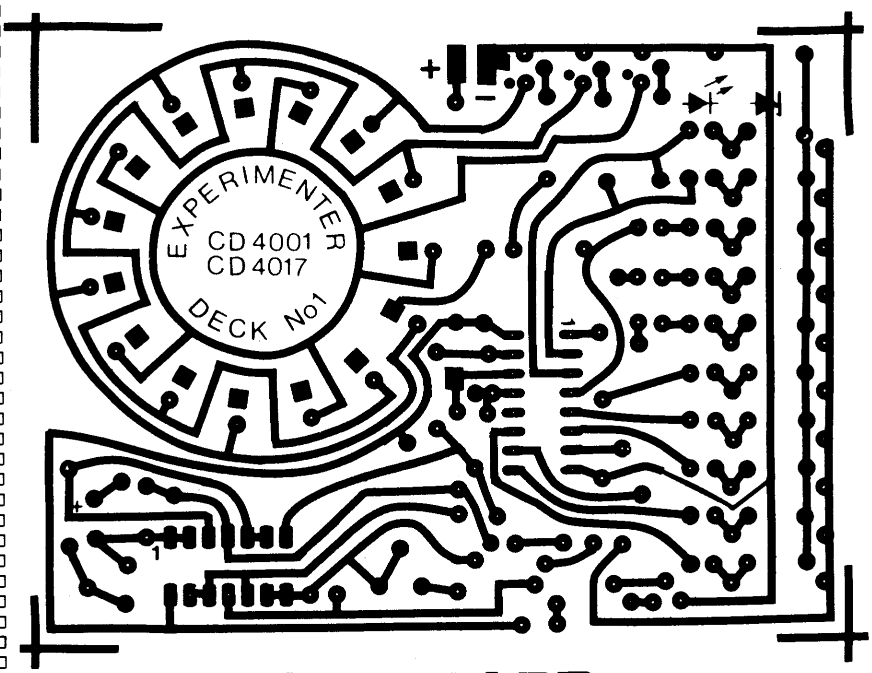
1 - 6v lantern battery

Roll of fine solder (as thin as resistor leads)

Soldering iron - preferably a constant-heat type or a small mains-voltage iron. But NOT an instant heat iron as it will lift the copper circuit off the board.

Side-cutters

This is the full-size artwork for the EXPERIMENTER DECK. The new boards have been laid out on CAD (Computer Aided Design) and have an overlay on the top to show where all the components are placed and re-flow tinned trackwork to make soldering easy. All the PC board artwork for the projects has been included to help you with fault-finding, should a problem occur.
PC boards are available separately and since the cost is so low, it is not worthwhile making them yourself.



PC BOARD

Cut out the sign and paste it onto the PC board inside the ring of 15 LEDs for the ADVERTISING SIGN PROJECT.

HEE HAW SIREN

PROJECT ONE

A Hee Haw siren reminds us of police, fire and ambulance. The idea of emitting two different notes is not new. Its effectiveness in alerting our attention is well known. Take, for instance, a simple two-tone door bell or the telephone bell. They are considerably more alerting than a constantly ringing bell because a continuous note tends to blend in with the background noise. However a constantly ringing bell on board ship is the most frightening of all as it signifies FIRE!

This project uses a single IC to give two tones. A transistor amplifies this to drive a speaker. The resulting HEE HAW can be adjusted via two mini trim pots to sound just like a fire truck or re-adjusted to sound like a computer gone wild.

Parts for this project:

1 - EXPERIMENTER DECK PC board
R1 Resistor 47k
R2 " 100k
R3 " 3k3
R4 " 10k
R6 " 15R

C1 Capacitor 6n8 100v
C2 " 6n8 "
C3 Electrolytic 4u7 10v
C4 " 22mfd 10v

RV1 Mini trim pot 500k Cermet
RV2 Mini trim pot 100k Cermet

Q1 Transistor BC 557 or similar

IC1 CD 4001

1 2¼" speaker

Hook-up flex

Tinned copper wire

6v lantern battery

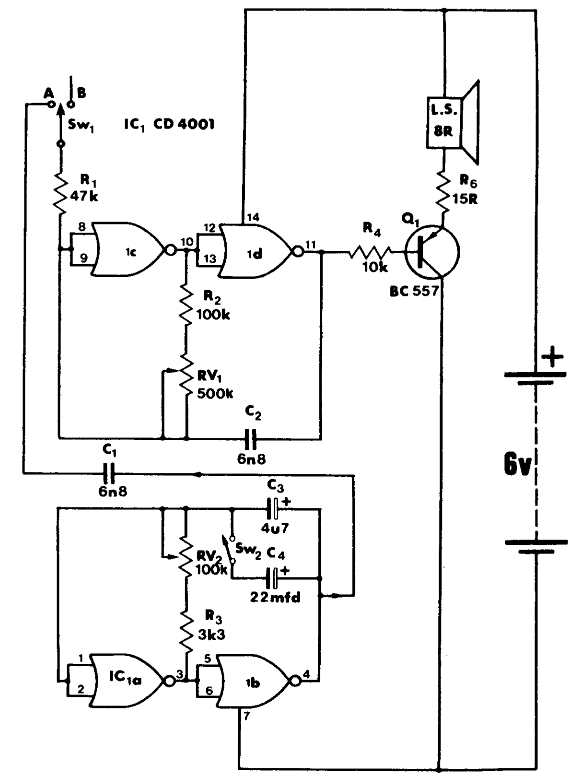
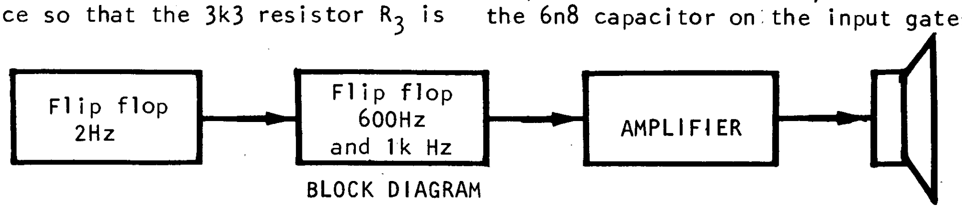


fig.1 HEE HAW SIREN

HOW THE CIRCUIT WORKS:

The circuit consists essentially of two multivibrators. A multivibrator can also be called a FLIP-FLOP. The word flip-flop sounds much better so we'll use it. These two flip-flops are arranged to oscillate at widely differing frequencies. The first oscillator has a frequency of 25Hz when the potentiometer RV2 is at minimum resistance so that the 3k3 resistor R_3 is providing the oscillator frequency. By adjusting RV_2 slightly we obtain the characteristic HEE HAW sound. This frequency is now about 2Hz. Altering the switch Sw_2 will give us a single note which will be sustained for up to 4 secs then change in pitch. The note we hear is actually the frequency of the second flip-flop being modified by the first flip-flop. This is achieved by the effect of the 6n8 capacitor on the input gates 8&9.



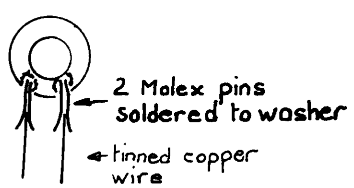
BLOCK DIAGRAM

The 2Hz flip-flop modulates the 2nd flip-flop to give a frequency of 600Hz or 1kHz.

PREPARING THE PRINTED CIRCUIT BOARD:

Before mounting any parts, the PC board requires 10 jumper wires. Refer to the layout diagram for the exact positions of these jumpers. They are made from tinned copper wire or from the leads of resistors. Be sure to locate the correct holes as you will be using them as a guide to positioning the parts in the future. You will notice some of these jumpers are required for the HEE HAW SIREN while others are used in later projects. But it is best to fit them all now.

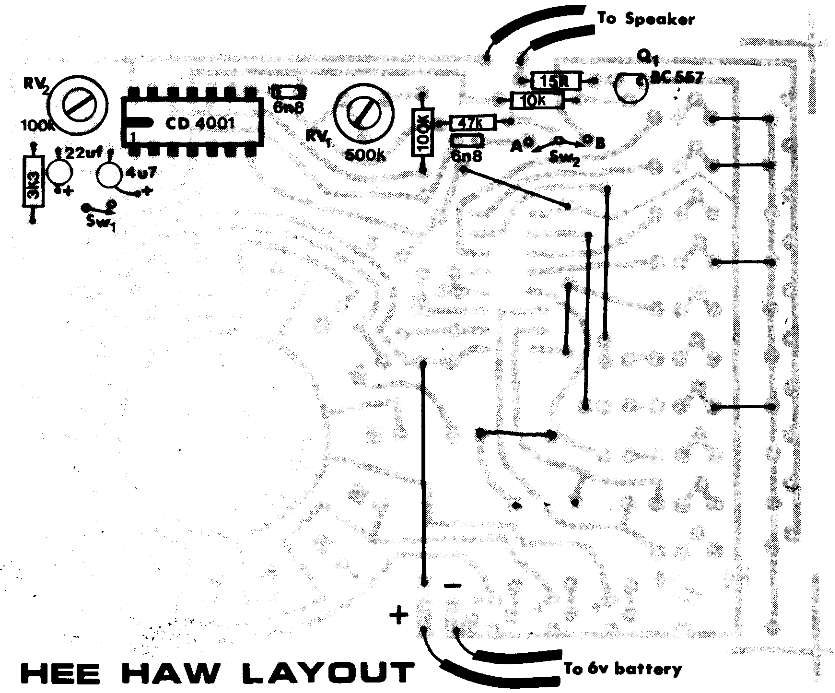
Make two switches as shown here:



They will be needed for the first project. Any type of terminal pin will be suitable and even a full-size switch may be used, connected to 30cm of hook-up wire.

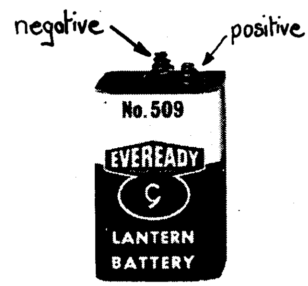
MOUNTING THE PARTS

Fit the two mini trim pots. Cermet trim pots are preferred as you can turn their body with your fingers or use a screwdriver in their slot. Start at the left-hand side of the PC board and fit each component in turn. The CD 4001 IC should be left until last as it is a CMOS IC and requires fast insertion to protect it from static build-up. Once it is soldered in position it is quite robust. Use your fingers to heat-sink the IC so that it does not get too hot. Connect hook-up wire to the places marked for the speaker and battery. No on-off switch is shown in the diagram as the wire can be fitted under the spring terminals of the battery or 2 alligator clips can be connected to the battery terminals.



HEE HAW LAYOUT

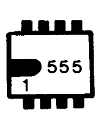
NOTE:



After soldering all the parts onto the PC board, check once more with the layout diagram, then connect the battery. By varying the two trim pots you will be able to get a wide variety of notes which will vary from a HEE HAW SIREN for a toy fire engine to a type of electronic music emitted when a computer goes wrong.

Quiz: What have you learned?

1. How many pins does a CD 4001 have?
2. What type of IC is the CD 4017?
3. What type of gate is inside the CD 4001?
4. Which lead is the cathode? 
5. Identify each pin by referring to the projects and circuit diagrams in this issue:



6. In about 50 words describe what new items you have learnt from this issue:

EXPERIMENTER DECK
HEADS or TAILS?
PROJECT TWO

This project adds a further 9 parts to the HEE HAW SIREN to make our 2-LED readout "HEADS OR TAILS". You must complete the HEE HAW first and have it operating correctly before starting this project. This way you are testing your workmanship in stages...its no good completing a project to find it doesn't work.

THE ORIGIN OF HEADS OR TAILS

In days gone by, players would toss a penny to see who would commence playing a game. This custom is still carried on in cricket. When pennies were in full circulation, one of the simplest games in the world used a penny as the sole betting medium. Although highly illegal, groups or sharp, daring punters would gather behind deserted buildings to play what they called "the fairest game in the world"...TWO-UP. It consisted of tossing a penny in the air and while it is spinning high above their heads, a punter would place a bet on it landing on the ground either heads or tails. A penny was used not only for its large size but because they knew the chances of it landing heads was exactly 50%.

Since there aren't any pennies around today, (and 20c coins are just "not the same") you can make your own heads or tails predictor with the aid of electronics and learn about the laws of chance.

PARTS

R5	Resistor	10K
R7	"	4K7
R8	"	4K7
R9	"	120R
2 -	5mm Red LEDs	
2 -	diodes	IN 4148
IC_2	CD 4017	
5 -	Molex pins	

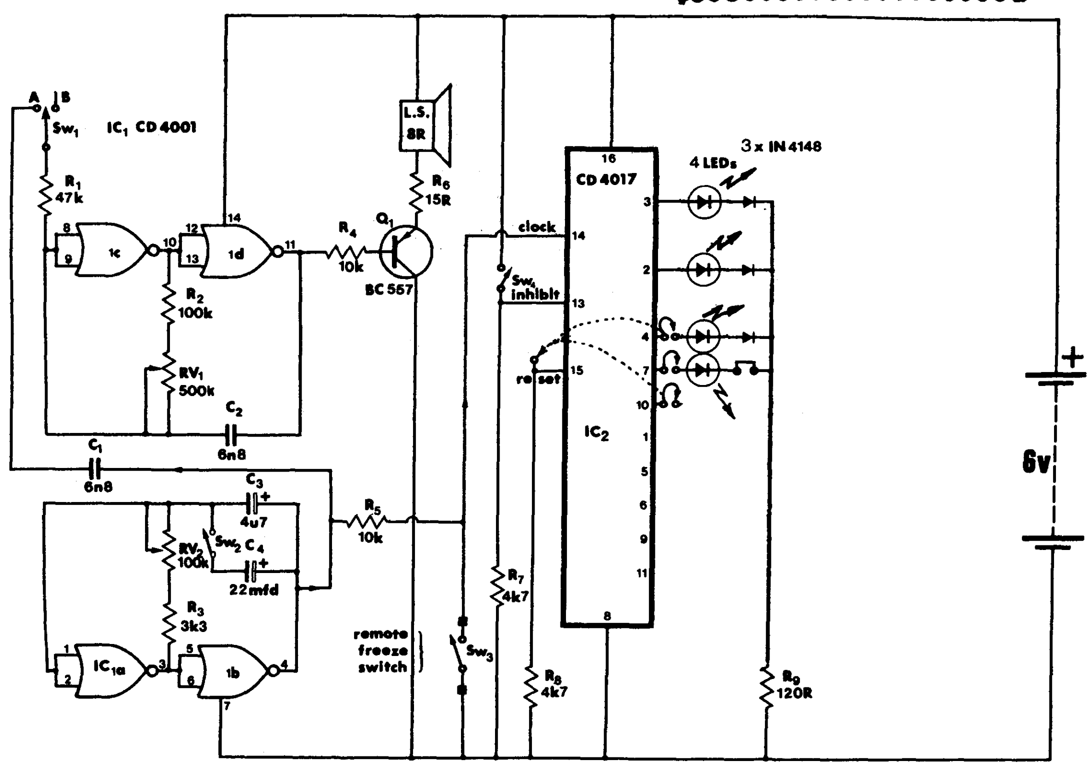


fig.2&3 HEADS or TAILS – use 2 LEDs
DECISION MAKER – use 4 LEDs

This circuit is designed to have no bias, meaning it doesn't tend to favour one LED or the other. This means it can be used with confidence, which is more than could be said about the reliability of a "TWO-UP SCHOOL"...as they used trick pennies, and fluttering instead of spinning the coin!

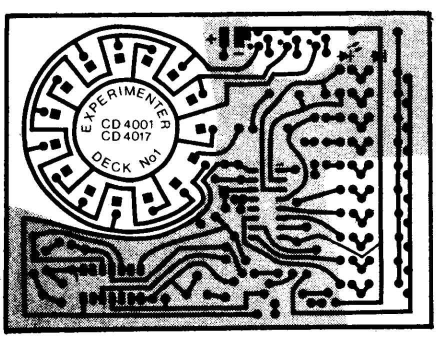
MOUNTING THE PARTS

Solder the CD 4017 carefully onto the board with pin1 passing through the correct hole. Use your fingers as a heat-sink. Follow the layout diagram to locate the positions of the 4 resistors, 2 LEDs and 2 diodes. The LEDs and diodes must be inserted around the correct way or they will not operate. Don't heat up the LEDs excessively while soldering as this will destroy their brightness. Make up 4 jumper leads from 5cm lengths of hook-up flex. Tin both ends of each lead and solder them in positions marked "J". On the jumper lead nearest the CD 4017, solder a flying Molex pin to the lead. Fit a Molex pin to the PC board in the three positions shown. Cut two short resistor leads and insert them into the board in positions marked "W". The flying Molex pin will fit onto either of these wires to form Sw4, the clock inhibit switch. For projects 2 & 3 it is moved from wire W_2 to W_1 to freeze the output.

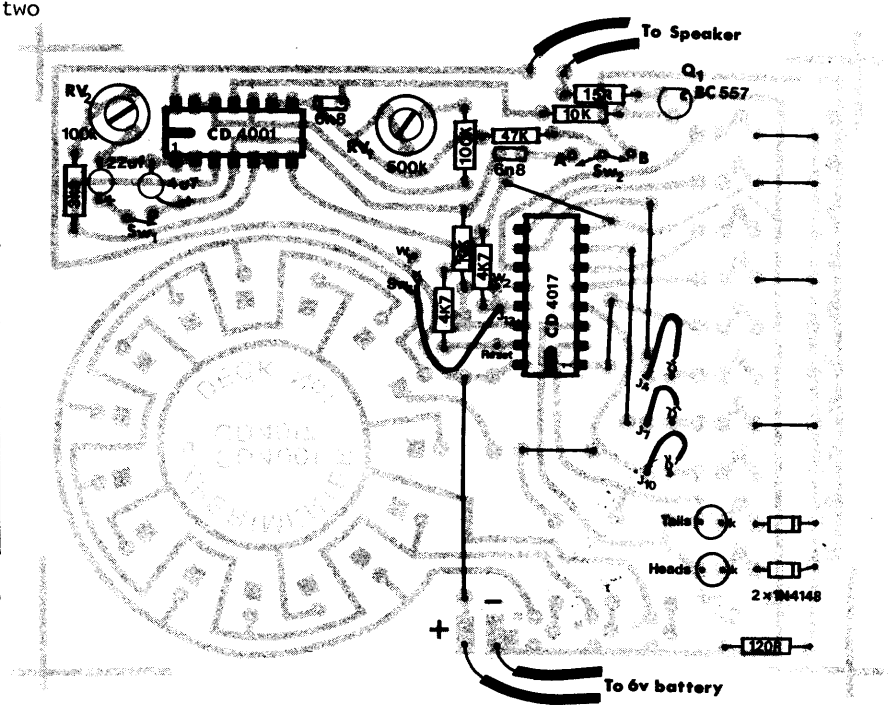
For project 2 the reset jumper J4 is connected onto the Molex pin near IC_2. This will allow only the first two outputs to become activated.

HOW THE CIRCUIT WORKS

The CD 4017 is a counting IC. We are using only two of its outputs in this project. The first output is pin 3 and the second output is pin 2. It has a further 8 outputs which are not used in this project. They are by-passed by using the reset pin number 15 as follows: The third output pin 4 is connected back to the reset pin so that the IC will clock from pin 3 to pin 2 then back to pin 3 again.
The input pin 14 counts the incomming pulses from the flip-flop $IC1_a$ and $IC1_b$. By rotating R2 to minimum resistance the frequency will be about 24Hz. This is the highest frequency obtainable from the flip-flop. Its range starts from one cycle per 9 seconds to 24 cycles per second. The counting IC accepts this and displays the pulses alternately at pins 3 and 2. This means each LED will flash at 12 times per second In fact it will look as if both LEDs are glowing dimly. The IC has another feature built into it at pin 13. This is called the "clock inhibit" pin. Its function is to "freeze" the output at any given instant. It comes into operation when a voltage above about 4v is applied to pin 13.
To obtain positive freezing or clocking we apply either full rail voltage or zero voltage to this pin. In this project we use this "freezing" facility to give us a readout of either heads or tails. At the rate of 12 flashes per second you will be unable to deliberately stop the motion of a particular LED due to the cycling being higher than the Persistence of Vision. (Which is about 5-6Hz). Thus the freezing of either LED will be completely at random and since both LEDs are clocked on and off at an equal rate, (50% duty cycle each), there will be no bias towards either.



Shaded area covers the soldering for projects 1,2&3.

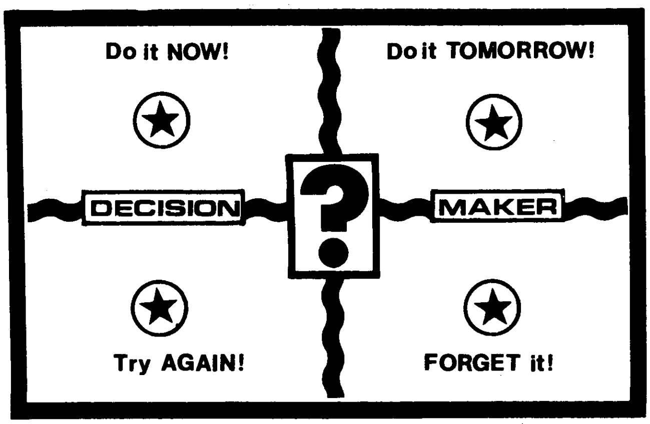


HEADS OR TAILS LAYOUT

DECISION MAKER

PROJECT THREE

This is a simple extension to HEADS or TAILS. It uses the first four outputs of the IC. At the moment this project may not seem very exciting. Mainly because we have not high-lighted it but it must have appeal in the community as 100's of Decision Makers have been sold @ \$29.95. Why would you buy a decision maker? Possibly because we all like decisions to be made for us. Especially when the decision is favourable. That's why you'll like this project. On the surface it looks like an ordinary four-readout display and you would think it gave you a 50/50 chance of arriving at a favourable decision. But on closer inspection you find you have only 25% chance of landing on the LED marked "DO IT NOW". The more alternatives that are provided in the readout will lessen your chance of being stuck with the task.



DISPLAY CARD

Use this DECISION MAKER display card if you intend to build the project permanently in a zippy box. The LEDs fit in the centre of each quadrant. In a future issue a special printed circuit board will be designed to fit below the display to produce a smaller and neater project. An on/off switch would need to be included in the circuit to conserve the battery.

MOUNTING THE PARTS

The three parts are mounted in alignment with the other two LEDs. The reset jumper J_4 is returned "home" and J_{10} is used as the reset jumper.

HOW THE CIRCUIT WORKS

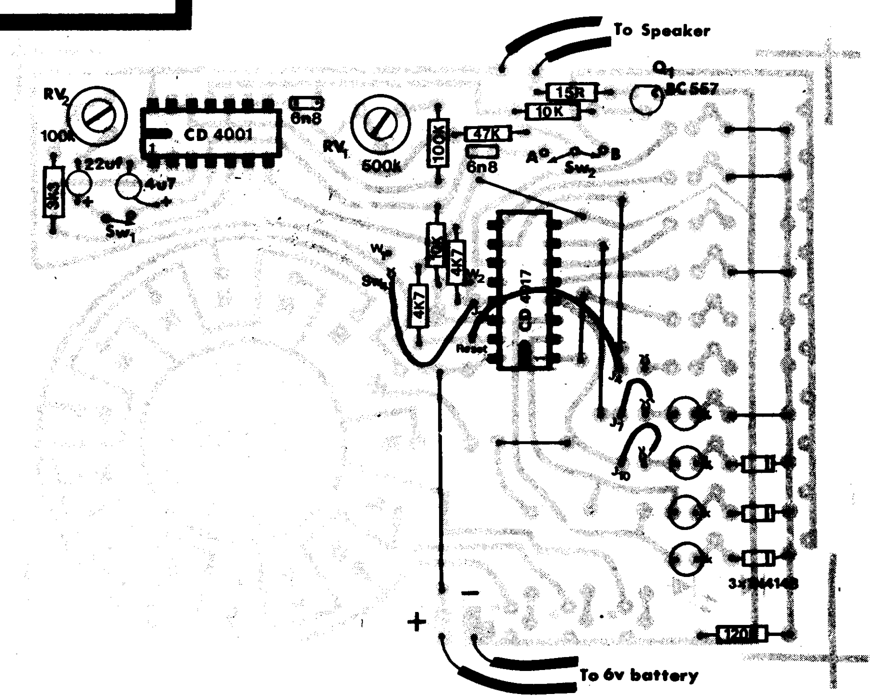
As mentioned before, the CD 4017 is a counting IC. This time we are using four of its outputs. It will clock each of these in turn allowing the 24Hz incomming frequency to be evenly distributed between the outputs to register six cycles per second on each LED. This frequency is sufficiently low enough for you to be able to see slight flickering, however you will not be able to stop the motion on a particular LED. To freeze the LEDs you will need to move the clock inhibit jumper Sw_4 from W_2 to W_1. This will stop the motion instantly. Whether you go by the decision of this game will reflect your acceptance of "things electronic". You will always be able to come back to this game after completing the 10 projects.

DECISION MAKER PARTS

ADDITIONAL PARTS NEEDED

2 5mm LEDs

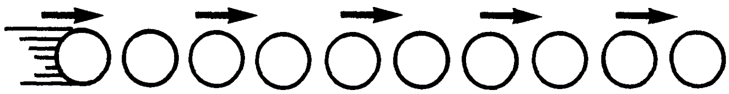
1 diode 1N 4148



DECISION MAKER LAYOUT

RUNNING LIGHT

PROJECT FOUR



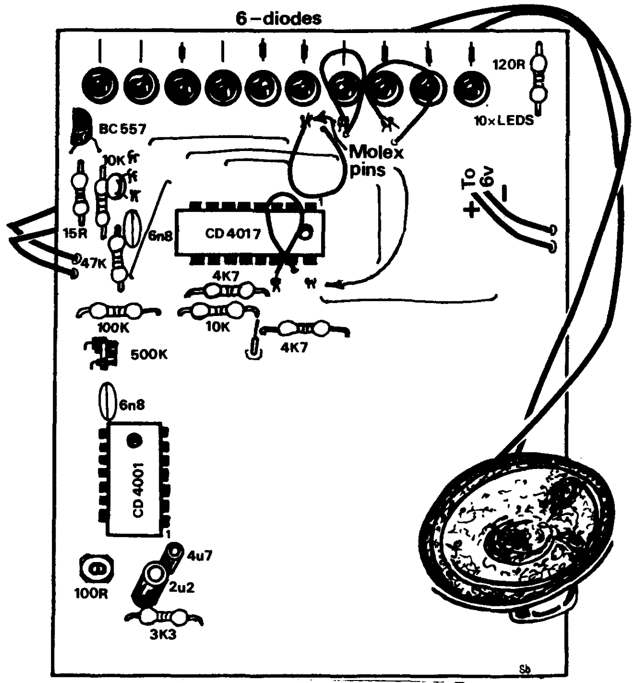
PARTS

5 - 5mm Red LEDs
1 - 5mm Green LED
3 - IN 4148 diodes

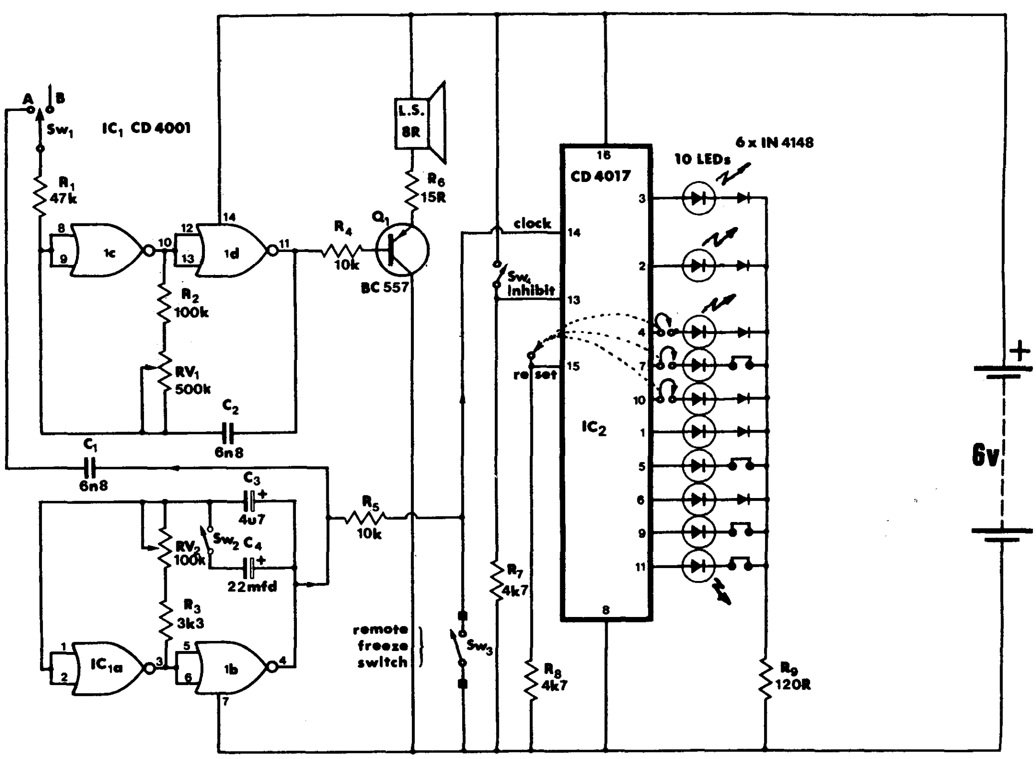
The RUNNING LIGHT project shows the full sequence of the 4017 counter. It uses all the 10 outputs to drive 10 LEDs. The IC turns each output ON and OFF in turn to give the effect of a RUNNING LIGHT.
Depending on the frequency of the incoming signal, the light will seem to travel at varying speeds. In a darkened room, this effect is most interesting. After watching it for some time, you will be quite convinced a single LED is moving across the PC board. Our eyes are wonderful image makes. An old saying goes "Believe nothing of what you hear and only half what you see," holds true for this effect.

MOUNTING THE PARTS

The 6 LEDs and 3 diodes are connected in alignment with the 4 LEDs from the DECISION MAKER project. All the jumper leads should be "home" to allow the IC to clock the full 10 outputs. If you have one green LED, it should be positioned as LED number 9 as the next project uses it to record a score or "hit".

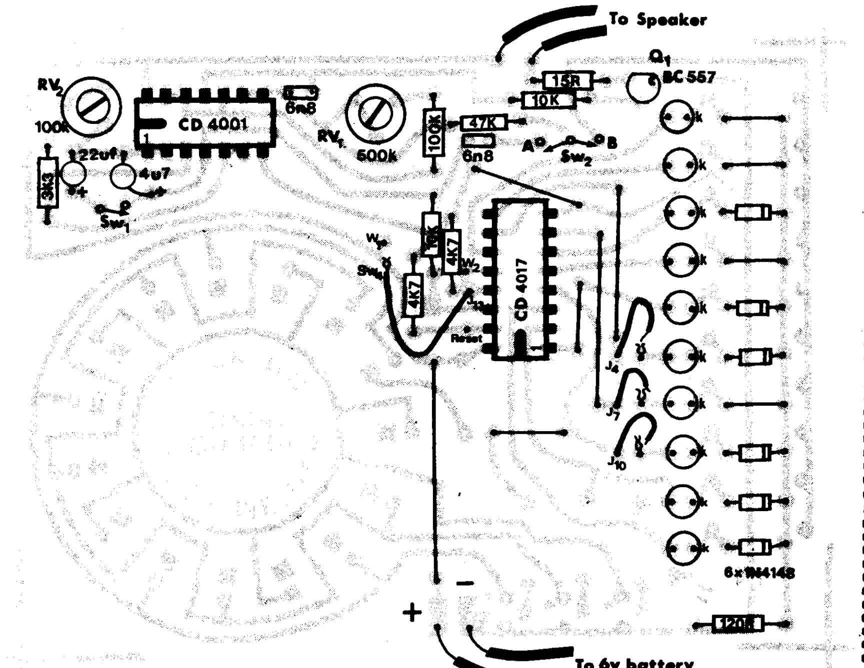


RUNNING LIGHT LAYOUT



The idea behind this project is to give the constructor (that's YOU!) a starting-point for additional experimenting. I wouldn't put the RUNNING LIGHT project away until I had extended its function to say 2 CD 4017's or even putting 40 LEDs in series-parallel to make a square 10 LEDs by 10 LEDs. An even more exciting display combines 2 rows of 10 LEDs wired in opposite directions. The variations are enormous.
Anyone creating a visually exciting or tricky display is invited to send it in for publication. This would fit in ideally with our format. We like to keep extending our projects as this is the most economical approach to circuit construction.

Keep the remainder of the kit of parts for the next episode...to be released next issue.



RUNNING LIGHT LAYOUT

Removing IC's...

One day the time will come when you want an IC for a new project and the only one available will be firmly soldered into a PC board. What do you do? You don't have a desoldering iron or solder sucker or even de-solder wick. It may seem an impossible task but it is possible to remove the IC without completely over-heating it so that it can be re-used.

Unfortunately, in the process, you will ruin the PC board but that's preferable to overheating the chip, or not getting it at all.
Firstly you will need a small piece of ALFOIL to fit tightly over the IC and short all the pins together. This will stop static or leakage from the soldering iron affecting the input gates. It's best to mount the PC board in a clamp or holder because you will need both hands free to work on the de-soldering. Surprisingly enough you will need some solder for the task. I also suggest a constant-heat soldering iron and definitely not a "quick-heat" type as you will tend to over-heat the joint in your enthusiasm to get the job done quickly. Begin at pin one with the soldering iron and small screwdriver or pliers. Carefully lever the solder land off the PC board with driver and heat from the iron leaving the pin free of any obstructions. To avoid overheating the IC, the maximum time allowed for each pin is 4 secs. Actually applying a little fresh solder will aid in lifting the land quickly.

Next select a pin on the other side of the IC to reduce heat build-up. After a great deal of careful prying and lifting you will gain yourself ONE second-hand IC! It may be worth it, it may not. At least you will come to one conclusion. Why didn't I use a socket! My greatest achievement along these lines was to desolder forty-seven 16 pin IC's from a **double-sided** board programming a paper-bag making machine....and replacing them with NEW IC's. After 4 hours solid....it worked!

Quiz:

For the first time, can you see yourself really getting somewhere with electronics?

1. Draw these gates: NAND, OR, NOT, AND, NOR.
2. Explain: V_{SS} V_{DD}
3. The numbers have rubbed off your CD 4017 and CD 4001 IC's. Using only a multimeter, how can you find the CD 4001?
4. A 555 oscillator is running too fast. Would you increase the value of C?
5. What is a "pull-up" resistor?
6. List 4 NEW items learnt from this issue:

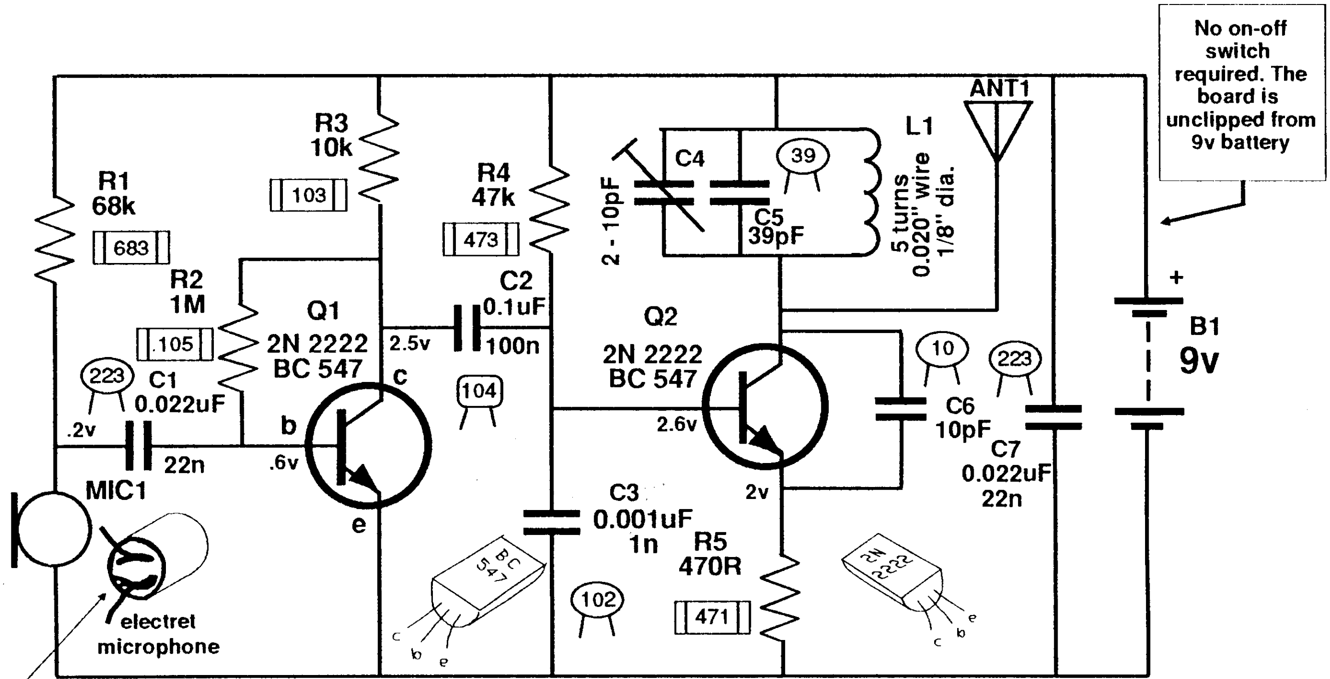
EXPLORER MkII

800m (2400ft) FM transmitter that fits on a 9v battery.

Parts & PC $10.50

PC Board (only) $2.50

The LED Power Meter ($1.10) will help in testing the output of this bug - but it is not essential.



Case of electret mic goes to negative rail

Fig: 1. EXPLORER - MkII CIRCUIT

This is one of the smallest and neatest FM transmitters to be presented as a construction project and it has the advantage of being available as a complete kit of parts. This will save going to a number of suppliers as no single supplier has all the necessary components.

The circuit has been specially designed to demonstrate the techniques of FM transmission and to start you in the world of surface-mount assembly.

FM transmission is the best mode for transmitting a signal as it does not suffer from interference such as electrical noise from car engines or electrical appliances etc. It also achieves the greatest range with the least power.

With just a handful of components and a few milliwatts of output power you can produce an FM transmitter with a very impressive range and perfect clarity.

With the 175cm (5ft 9in) (half-wave antenna supplied in the kit, the range has been conservatively stated as 800 metres (2400ft) under normal working conditions.

To introduce surface-mount technology we have started with the resistors. These are the easiest of the surface-mount components to identify and fit.

Some of the other components such as capacitors and transistors are so small they are almost impossible to solder by hand and the surface-mount capacitors are not marked in any way so they become easily mixed up if you are not very careful.

Surface-mount technology is entirely different to normal through-hole placement and some of the differences are explained in this article.

SUMMARY OF SPECIFICATIONS

Supply: 9v
Current consumption: 7mA
Battery life: 50 hours ZnC
100 hours alkaline
Tuning range: 80 - 110MHz (by stretching or compressing the oscillator coil)
Fine tune by adjusting the air trimmer (2MHz adjustment)
Stability - low. Bug to be left in situ and not to be moved or handled.
Antenna length - 175cm (5ft 9")

The major difference is size and if you are having trouble soldering 1/4 watt resistors, you will have ten times more difficulty with surface mount. SM items are so small it takes the keenest eyesight to read the figures on the component and the nimblest of fingers to pick them up and place them.

But until you buy a kit and see what the parts look like, you will have no idea if

PARTS LIST

SEMICONDUCTORS
Q1, Q2 — 2N 2222 or BC 547 NPN transistors

RESISTORS
(All are surface mount 1/10th watt)
R1 - 68,000-ohm marked as (683)
R2 - 1,000,000-ohm " " (105)
R3 - 10,000-ohm " " (103)
R4 - 47,000-ohm " " (473)
R5 - 470-ohm " " (471)

CAPACITORS
C1, C7 — 0.022uF (22n) ceramic-disc
C2 — 0.1uF (100n)monoblock
C3 — 0.001uF (1n) ceramic-disc
C4 — 2pF to 10pF air trimmer
C5 — 39pF ceramic-disc NPO type
C6 — 10pF ceramic-disc NPO type

ADDITIONAL PARTS AND MATERIALS
L1 — 5 turn coil .020in (0.5mm) enamelled wire 1/8in (3mm) dia
MIC1 — electret mic insert
9v battery snap
B1 — 9v battery
12in (30cm) fine solder
ANT1 — 5ft 9in (175cm) hook-up wire.

Printed circuit board - EXPLORER MkII

Note: The complete kit is available by mail order from Talking Electronics. See Order form on Page 41. Extra PC board $2.50. Spare strip of surface mount resistors: $2.00. LED Power Meter $1.10. Extra notes on this project (14 FM Bugs to Build) $3.50. Please add shipping and handling to all orders as shown on the order form.

you will be able to cope.

Nevertheless surface mount has arrived and is here to stay. Most modern designs already include surface mount components and many are already entirely surface mount. Take pocket cameras, watches, pendant transmitters, toys, video recorders, video cameras and computers for example. Their miniaturisation has been almost entirely due to using smaller componentry.

Surface mount is very easy to implement on a large scale as the components are available in large quantities on reels or in tubes but when it comes to a one-off project, things are different. Few suppliers sell individual surface-mount components and some sell them in lots of 10 or 100. The normal purchase for surface-mount is on a reel of 1,000 to 5,000 pieces.

The only solution is to provide a kit and to make it easy for everyone to put together we have just converted the resistors to surface-mount.

Some of the other components are not available in surface-mount (such as the coil) and there is no real advantage in converting everything to surface mount as the battery cannot be reduced in size without reducing the number of hours of operation.

The main difficulty with surface mount is placing them on the printed circuit board and holding them in place while soldering. There are a number of aids to help you do this, such as solder pastes and solder creams, silicon and infra-red setting glues but most of these come in syringes and cost as much as $20 for a 1oz (30gm) tube. For a simple project, this additional cost is out of the question.

To keep costs down we are going to hand solder each resistor without the aid of glue and the technique we use is called RE-FLOW SOLDERING.

Re-flow soldering only requires two hands. Normal soldering requires three hands - one to hold the component in place, one to hold the soldering iron and one to hold the solder. If you have three hands available, (such as the help of an assistant), you can use the normal soldering method.

Basically re-flow soldering consists of heating up the solder on the board AND THE END OF THE RESISTOR AT THE SAME TIME so that the resistor makes a perfect connection to the board. This is discussed fully in the soldering section.

HOW THE CIRCUIT WORKS

The circuit consists of two stages - an audio amplifier and an RF oscillator.

The electret microphone contains a FET transistor and can be counted as a stage, if you wish. The microphone detects audio in the form of air vibrations that enter the hole (at the end of the mic) and move the diaphragm. This diaphragm is a thin piece of metallised plastic such as mylar and is charged with electrical charges during manufacture.

Next to this is a metal plate containing a number of holes so that the air readily passes through. The relative distance of the mylar diaphragm to the metal plate makes the charges move on the diaphragm (remember static electricity theory: like charges repel and unlike charges attract). Some of the charges pass down a lead that touches the diaphragm and into a FET amplifying device - it looks like a three legged transistor. The FET device amplifies the charges and gives a reading at the output lead.

The output must be connected to a supply via a resistor called the load resistor. The FET draws a varying current during its operation and this creates a varying voltage on the output (across the load resistor).

The reason why a FET has been used is due to it having a very high input impedance and does not have any loading effect on the diaphragm.

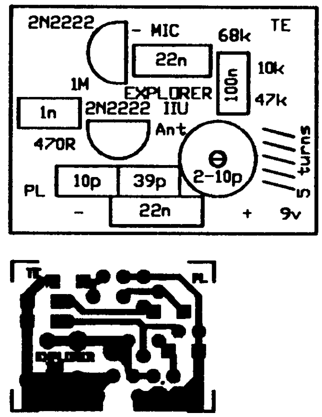


Fig: 3. Enlarged overlay and full-size trackwork for the Explorer MkII.

The output waveform from the microphone will be typically 3 - 30mV in our case, depending on how close it is to the source of the sound. The circuit is capable of detecting a whisper at 10ft (3M) and only very sensitive microphones have been included in the kits.

You can also get medium and low sensitivity devices from suppliers so you have to be careful as they are not labelled.

A 0.022uF (22n) capacitor C1 on the output of the microphone couples the signal to the input of the first audio amplifier stage. This capacitor is designed to separate the DC voltage on the microphone from the base voltage of the transistor.

The first transistor stage consists of transistor Q1 and two biasing components, R2 and R3.

The stage is said to be "AC coupled" as it has a capacitor on both the input and output so the DC voltages of the other stages do not influence the voltage on the stage.

The stage is also said to be "self-biased" with R2 turning the transistor on until the collector voltage drops to about half rail voltage. The value of R2 is chosen so that this occurs.

The value can be chosen by experimentation. If the value is too low, the voltage on the collector will be below half rail.

The AC gain of the stage is about 70 and the signal is amplified 70 times and passed to the oscillator stage via a 0.1uF (100n) capacitor C2.

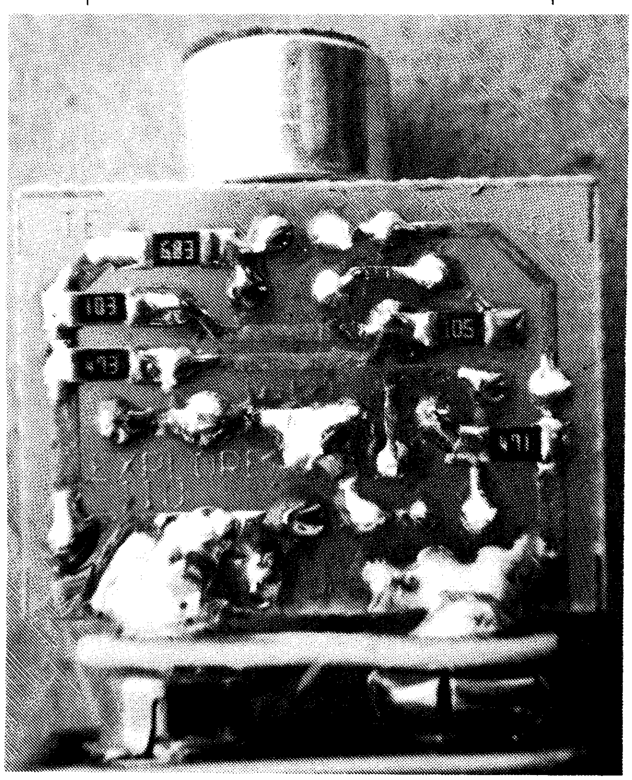


Fig: 2. An enlarged view of the underside of the Explorer

The signal is now typically 200mV to 2,000mV in amplitude and this is adequate for injection into the oscillator stage.

The oscillator stage is designed to operate at about 100MHz and this frequency is set by the value of inductance

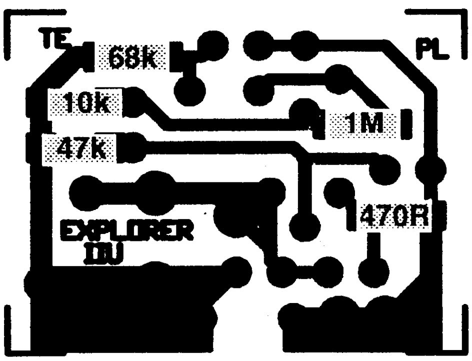


Fig: 4. The resistor values as compared to the circuit diagram. Fig: 5 below shows the resistors with their identification code numbers.

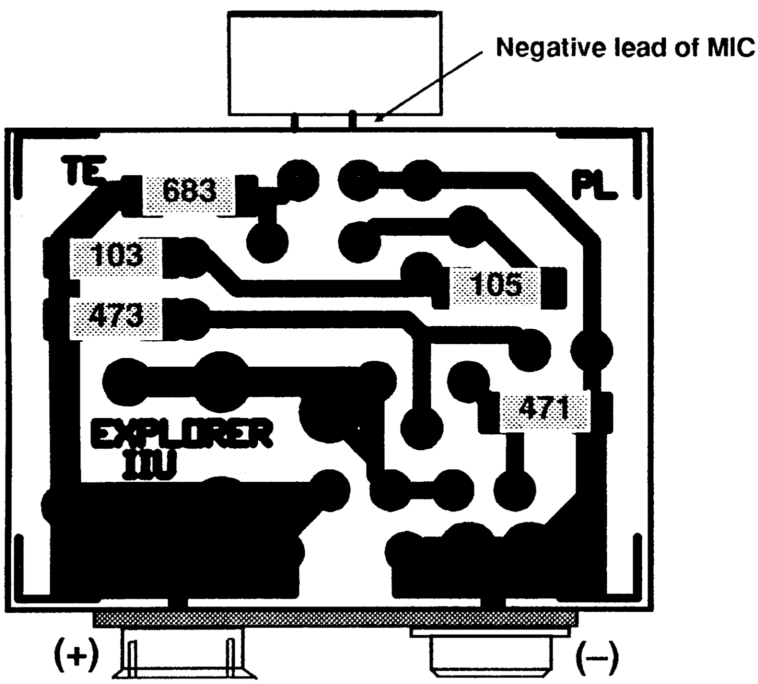


Fig: 5. Fit a length of wire through two holes in the PC board and twist the ends together. Solder it to the positive terminal of the battery snap. Repeat for the negative terminal.

of the 5 turn coil and the capacitor across it (C4 and C5 can be considered as a single capacitor). The frequency is also determined to a lesser extent by transistor Q2, the 10p feedback capacitor C6 and also the biasing components (470R emitter resistor R5 and the 47k base bias resistor R4). The supply voltage also has an effect as the oscillator can be classified as a voltage controlled oscillator.

There are a lot of things that set the frequency and even though the parts have a 5%, 10% or even 20% tolerance, they are STABLE at their present value. The 10pF and 39pF are NPO types and this means they are stable even when the temperature changes a small amount. The frequency is firstly set by pushing the turns of the coil closer together to lower the frequency or pulling them apart to raise the frequency and then the air trimmer is adjusted to obtain the precise frequency required. The air trimmer has a range of about 2MHz.

The circuit will stay at the desired frequency providing the supply voltage remains constant and the temperature of the parts do not rise appreciably (such as when the project is left in the sun etc).

The Explorer is not designed to be handled and is not suitable to be worn on the body. It is designed to be placed on a shelf and left in position.

The most important components in the oscillator stage are the coil L1 and capacitor (C4 and C5), making up the parallel tuned circuit.

They do almost all the work in setting the frequency and generating the waveform. The transistor merely turns on at the correct instant in each cycle to deliver a small amount of energy to the tuned circuit.

How this is done: Transistor Q2 is firstly turned on via base-bias resistor R4 and it injects a small amount of energy into the parallel tuned circuit.

A few low-amplitude cycles now take place and we pick up the operation when the tuned circuit is operating at full amplitude and producing a sinewave at about 100MHz. This frequency is called the CARRIER.

The parallel tuned circuit is also called a TANK CIRCUIT and the name was coined during the development of the earliest transmitters where it was found a coil and capacitor in parallel would smooth out electrical pulses like filling a water tank in bursts so that it delivers an even flow of water.

This name has stayed with us and is an ideal way of describing a coil/capacitor combination.

The waveform from the tank circuit is passed to the 10pF capacitor C6 and this modifies the voltage on the emitter of transistor Q2.

There are two ways of turning on a transistor. One is to raise the voltage on the base while holding the emitter fixed and the other is to hold the base rigid while lowering the voltage on the emitter.

This is the method used in this circuit and the 10pF moves the emitter up and down a very small amount at the rate of 100 million times per second to turn the transistor on and off.

The base is held rigid via a 0.001uF (1n) capacitor and this value is sufficient to hold the base rigid at 100MHz but allows it to move up and down at audio frequencies so that audio being processed by the first transistor can be passed to the oscillator.

The oscillator transistor plays almost no part in determining the waveshape of the signal, it merely delivers a pulse of energy to the tank circuit at the correct instant and the coil and capacitor do all the work. There is one more feature of the tank circuit. Even though it is injected with a pulse of energy of only a few hundred millivolts, it is capable of producing a higher amplitude waveform on its output. In other words the tank circuit is capable of amplifying the voltage supplied to it. This is called its Q-factor.

The other two components in the stage are R4 and R5. R4 turns the transistor on when the power is first applied and sets the operating point for the stage. The 470R emitter resistor R5 acts as a current limiting resistor and allows the transistor to be injected via the emitter.

The voltage produced by the tank circuit is monitored by the 10pF and passed to the emitter of Q2. During a portion of the cycle, the voltage turns the transistor off. This effectively removes the transistor from the circuit and allows the waveform from the tank circuit to be passed to the antenna.

When a waveform at 100MHz is passed into a wire (such as an antenna) the signal is very easily radiated as electromagnetic energy. This is how the signal is radiated to the surroundings.

Capacitor C7 across the battery is designed to tighten up the power rails. The power rails have also been kept tight by connecting the battery directly to the printed circuit board.

Note: The circuit will not operate from a power supply without generating a lot of "mains hum" - the annoying 100 or 120 cycle hum from the mains - you must use a battery to get a crystal clear, hum-free, output.

Test voltages have been provided on the circuit diagram to help with servicing. They are only approximate and apply to our prototype. They show how each transistor has a voltage on the base of about 0.6v, with respect to the emitter, to turn it on.

The voltages around the oscillator stage cannot be measured with an ordinary multimeter when the circuit is operating as the leads of the multimeter will act as an antenna and kill the operation of the circuit. This is certainly the case on the emitter of Q2, where the leads of a multimeter will draw off so much energy that the stage will stop working.

Because you cannot detect the operation with a multimeter, we have developed a piece of test equipment called a LED POWER METER. This is covered on the following pages and shows how the output of the high frequency RF oscillator stage can be measured without loading it too much.

HOW FREQUENCY MODULATION IS ACHIEVED

The audio from the microphone is amplified by the first audio stage and injected into the RF stage via a 0.1uF (100n) capacitor C2.

This waveform increases and decreases the voltage on the base of Q2 by a small amount and modifies the "set point" or "bias point" for the stage.

This has the effect of slightly altering the timing of the stage (the time it takes for one cycle to occur) and the resulting frequency of the stage is altered very slightly by an amount equal to the frequency of the audio.

This is how frequency modulation of the carrier is achieved.

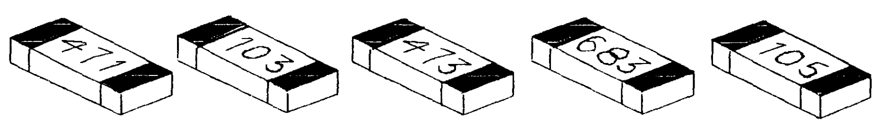


Fig: 6. The 5 chip resistors used in this project are: 470R, 10k, 47k, 68k and 1M.

RESISTOR AND CAPACITOR VALUES

With the size of resistors and capacitors getting smaller and smaller, the space for identifying the value is getting less and less.

To make things simple, a uniform numbering system has been adopted for both resistors and capacitors, consisting of three digits. The first two give the value of the capacitor in pF or the value of resistance in ohms and the third digit is the multiplier.

This brings both capacitors and resistors into the same code and once you can read the code, you can identify everything.

As an example, we will use a 47k resistor. See the third chip in fig: 6. The digits are 4 - 7 - 3. The digit "3" represents the number of zeros to put after the number "47." Thus we get 47,000 ohms.

A 470 ohm resistor is "47" and one zero, thus we get 471 on a chip. A 10k is "10" and three zeros, thus 103 is written on the chip. A 68k is written "68" and three zeros, thus 683 is written on the chip and 1M is written "10" and five zeros. Thus the chip has 105 on it. These are the five values used in the Explorer.

A 10 ohm resistor is "10" and NO ZEROS, so the marking is 100. I know, I don't like it either but 150 on a chip is 15 ohms and not 150 ohms. 150 ohms is "151." Don't ask me what 1 ohm is because surface mount resistors start at 10 ohms and go to about 1M or 2M2.

It's only the range from 10 ohms to 100 ohms that will cause problems. When you see markings such as 120, 180, 470 etc it is best to check the resistance with a multimeter, to make sure the resistances are 12 ohms, 18 ohms and 47 ohms.

Keeping this in mind, we go to the markings for capacitors. The basic unit for surface mount capacitors is pF (sounded 'puff').

Very few surface mount capacitors are marked but those that have identification follow the pF rule. This means 101 is 100pF, and 102 is 1,000 pF. Another name for 1,000pF is 1n (1 nano). 103 is 10n, 104 is 100n and 105 is 1uF.

For those who have to convert from the old system, 1n is 0.001uF, 10n is equal to 0.01uF and 100n is 0.1uF.

For surface mount capacitors, you must think in pF. This will allow you to build any surface mount project in the future.

One point to note: With surface mount capacitors, the size of the chip is no indication of capacitance. The structure of the chip can be single layer or multilayer and this affects the size. Also the voltage rating of the capacitor affects the thickness of the dielectric and thus the size.

ASSEMBLY

Before you do anything, prepare the workbench for a completely different approach to work.

Lay out two sheets of clean white paper and place the kit of parts on one. Don't take the resistors out of the carriers until you are ready - a resistor dropped may be a resistor lost.

Study the board and note that all the components are identified by the printing on the top of the board, called the overlay or legend. You really don't need any instructions at all, but since this may be your first attempt at surface-mount, we will provide some helpful advice.

Note how the board stands on top of a 9v battery, with the battery snap soldered to the edge of the board. The positive and negative lands on the board are large so that the connections to the snap will be strong.

The microphone fits on the top of the board with two short wires and overhangs the board. Some microphones come with wires attached and this makes them easy to fit. Others may need to have wires attached and these can come from the leads of the capacitors.

The only 4 components that have to be fitted around the correct way are the two transistors, the microphone and battery snap. All the other parts, including the capacitors, coil and resistors can be soldered around either way. The air trimmer is best soldered so that the lead going to the screw is connected to the positive rail.

Once you have studied the photos, the PC board and components, you can start.

Here is the order for assembly:
5 surface mount resistors
6 capacitors
2 transistors
air trimmer (variable capacitor)
coil
battery snap
microphone
(test the circuit with LED power meter)
antenna lead.

SOLDERING

Now for the finer points:

The surface mount resistors required a fair degree of skill and you have to be good at soldering if you want to make the board look neat.

Read the notes on resistor identification and make sure you understand the 3 digit code.

Place the strip of resistors on the workbench and take one out of the carrier strip, keeping the code numbers on top. Turn the resistor around so that the numbers make sense (make sure you don't read the numbers around the wrong way!) and place it on the board as shown in the photo, so that it is square with the sides of the board.

Standard soldering:

There are two ways of soldering the chip. One is to sit it in place and heat one end with a soldering iron while applying solder and then repeat with the other end.

The other method is called RE-FLOW.

Re-flow Soldering:

In this method you add a little solder to each land on the board and tin the ends of the chip while holding it in your fingers. Yes! you can actually hold the chip while soldering the other end. If you can't, you are taking too long.

When both the lands on the PC board and the ends of the chip are tinned, it is placed in position and held with a piece of wire such as an opened-out paper clip while touching one end with a soldering iron. This is repeated with the other end.

If you have added enough solder in the pre-tinning stage you will not have to add any more, otherwise a little solder can be added to make the connection neat and shiny.

It is important not to put any force on the chip during the soldering process as the ends can be easily detached from the ceramic substrate and the resistor will go open circuit. A hairline crack will be produced and the only way to check that the resistor has not been damaged is to measure it with a multimeter set to ohms range.

The other 4 chips are placed on the board in exactly the same way, making sure they are covering the lands and sitting flat on the board.

Double check the codes and if everything is correct you have carried out your first surface-mount placement!

The rest of the assembly is a lot easier. It's just a matter of doing things in the correct order.

All the other components are mounted on the top of the board and when two formats are combined like this, the assembly is called HYBRID.

Refer to the layout diagram for the placement of the 6 capacitors. These are soldered in place, one at a time. Some of the leads may have to be bent slightly to allow the component to fit down the holes as it is almost impossible to get all components in either .1" or .2" spacing.

Next, the two transistors are soldered in place. Push them down until they are 1/8" from the board as we want to keep the profile low. In addition, we have designed the circuit with the transistor leads as short as possible. If you place the transistors high off the board, the performance of the oscillator will be different to our prototype.

Solder the leads quickly so that you don't heat up the transistor too much.

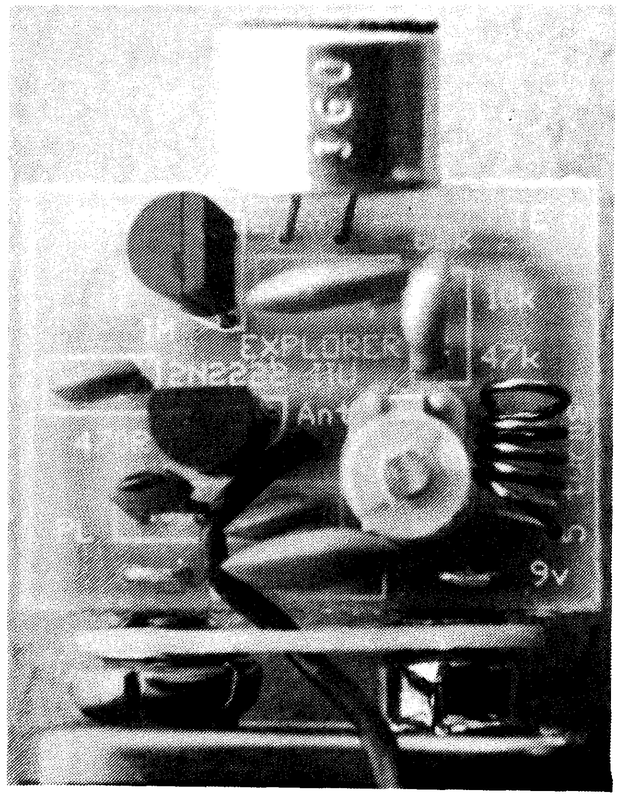


Fig: 7. The completed Explorer project

The air trimmer is next. This must be soldered very quickly otherwise the plastic insulation between the plates will melt or buckle. Keep a finger on the trimmer to act as a heatsink and everything will be ok.

The coil is made from enamel coated wire and this coating must be scraped off with a knife or burnt off with a hot soldering iron so that the two ends are bright and shiny and tinned before fitting the coil to the board.

The kit comes with a pre-wound coil but if you are making it yourself, here are the details:

Wind 5 turns of 24B&S (.020in or 0.5mm) or 21B&S (.028in or 0.7mm) wire on a 1/8" (3mm) diameter shaft such as a small Philips screwdriver and space the turns as shown in the photo.

The coil determines the frequency of the oscillator and the turns will be stretched apart or squashed together after the project is complete. At this stage it does not matter about the spacing, as long as the ends fit neatly down the holes in the board.

Make sure the ends have been tinned as mentioned above. Push the coil up to the board and solder it in place with the turns evenly spaced.

Now the battery snap. If you want this project to produce the highest output power, the battery snap must be fitted directly to the board.

The project does not need an on/off switch as the battery is simply unclipped when not required.

To fit the battery snap, take it out of its plastic jacket and solder it directly to the edge of the board. The crown and cup on the snap will be loose when the plastic is removed and they will have to be tightened by tapping the rivet with a centre-punch. The "crown" terminal is soldered to the positive land on the board by fitting a piece of tinned copper wire through the two holes in the board. The ends are twisted together and fitted through the centre of the crown and cut short so that they don't interfere with the terminal on the battery.

Use plenty of solder as it is necessary to make a good mechanical connection as well as an electrical connection.

The terminals must not be able to be rotated and if they can be turned, they should be soldered again. Use very little solder inside the crown as the positive terminal of the battery must be able to fit inside to make a firm contact. Repeat with the other terminal.

One of the last components to fit is the microphone as its two leads are very fine and any unnecessary bending will cause them to break.

The microphone in the kit comes with two short wires attached and if you look at the solder-lands on the back of the device you will see one goes to the case. This is the negative terminal and must be soldered down the negative hole on the board.

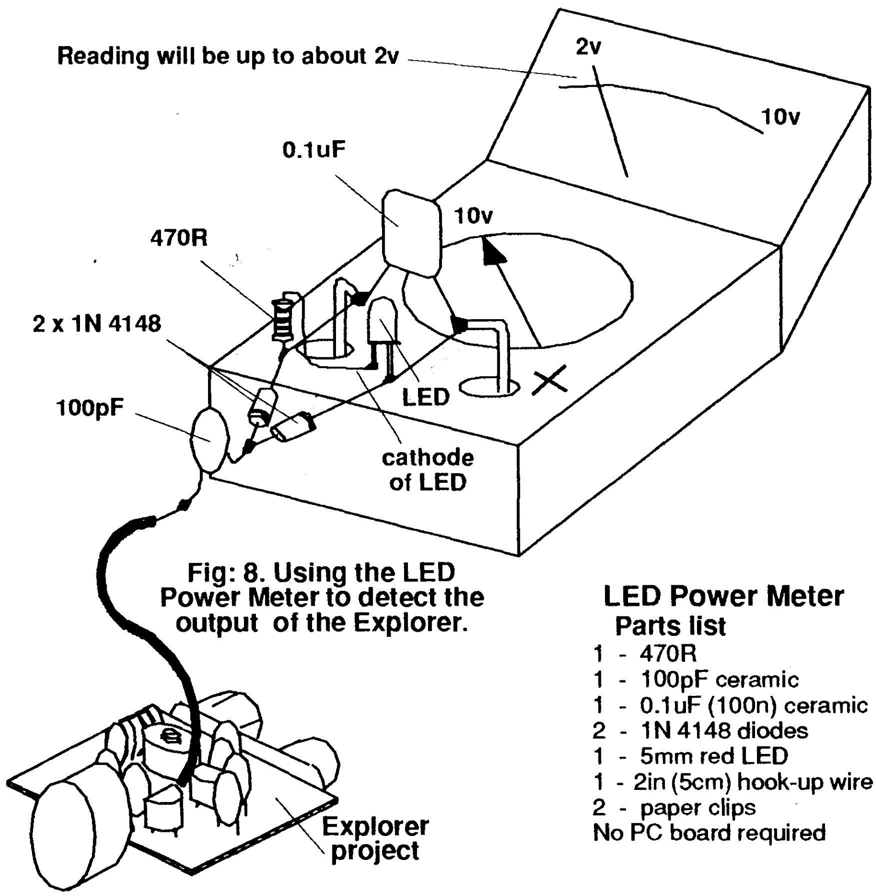


Fig: 8. Using the LED Power Meter to detect the output of the Explorer.

LED Power Meter
Parts list

1 - 470R
1 - 100pF ceramic
1 - 0.1uF (100n) ceramic
2 - 1N 4148 diodes
1 - 5mm red LED
1 - 2in (5cm) hook-up wire
2 - paper clips
No PC board required

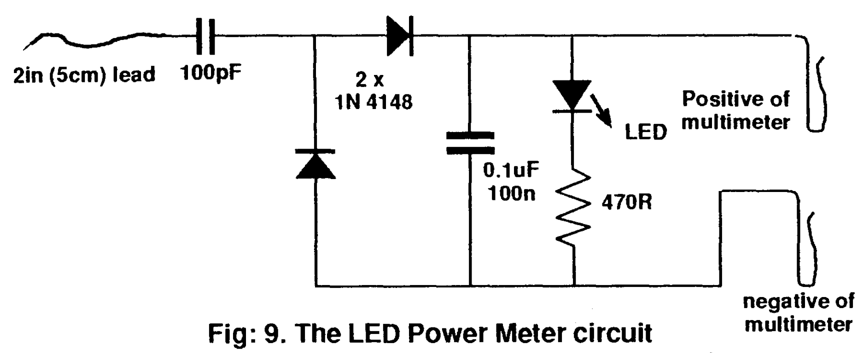


Fig: 9. The LED Power Meter circuit

Finally the antenna. This is soldered down the hole market "ant."

But before fitting the antenna you can check the output of the transmitter with a LED power meter. This is fitted to the antenna point on the board (without the antenna wire connected).

By using this piece of test equipment you can determine if the project is delivering an output. You will also need an FM radio to make sure the output is on the FM band.

THE LED POWER METER

The LED power Meter is a simple RF detector using diodes to charge a capacitor. The voltage developed across the capacitor is shown on a multimeter set to a low voltage range. The circuit is soldered together without the need for a PC board, as can be seen in Fig: 8 and paper clips are used for the positive and negative terminals of the multimeter.

It will only take a few minutes to put this circuit together. The power from the output of the Explorer is indicated by the illumination of a LED and the voltage reading on the multimeter gives a further indication of the output.

The reading is not calibrated and does not represent milliwatts output. It is only a visual indication.

USING THE LED POWER METER

Connect the 2in (5cm)lead to the antenna point on the Explorer board as shown in fig: 8. and turn the project on.

The lead of the LED Power Meter will act as an antenna, so place a radio nearby and tune it to about 88.5MHz or somewhere at the low end of the band. Move the turns of the 5 turn oscillator coil either together or stretch them apart until a feedback whistle is picked up by the radio. This is the frequency of transmission.

When the turns are pushed together the frequency decreases and when moved apart, the frequency increases.

You must not use any metal objects near the coil when moving the turns. If you do, the reading will be upset.

The best item to use is a match or plastic knitting needle as you should keep your fingers and hands away from the coil while adjusting it.

The multimeter will show a reading of about 2v and this voltage will depend on the quality of the transistors. Once you are satisfied the project is working, remove the LED Power Meter and solder the antenna lead to the board.

Move the radio a short distance away and tune across the band to make sure the output is coming through and to make sure you have picked up the main frequency of transmission.

Carry out some experiments yourself and you will be very impressed with the performance.

By moving the Explorer further away you will be able to pick up the sounds it detects. Make sure the frequency of transmission is well away from any radio stations as the signal from a station will swamp the Explorer when you are testing it for range. You can do this by adjusting the air trimmer. You can see the vanes moving in and out of mesh with the stators and the meshing should be mid-way at the start of the test so you can raise or lower the frequency by turning the trimmer.

As the vanes move out of mesh, the capacitance of the trimmer decreases and the frequency of the output increases. When adjusting the trimmer you must use a non-metallic instrument. The best is a plastic knitting needle filed to make it into a flat screwdriver.

If you do not get a squeal from the radio you can assume the frequency is lower than the band (we have designed the output to be very close to the bottom of the band) and it may be just a little too low.

In this case you will have to raise the frequency by expanding the turns of the coil. This will bring the output onto the FM band and you can shift it slightly up or down with the air trimmer to get it away from other stations.

To get the maximum range the antenna should be stretched out straight and placed either horizontally or vertically. The receiving antenna must be in the same plane to get the maximum range and both antennas should be as high as possible.

The signal is generally not affected by brick walls, glass or plaster but it will not pass through metal of any kind such as aluminium foil or metal cladding. Trees can also have an effect due to the amount of moisture they contain.

The signal will also find it difficult to get out of a car and you must place the antenna near a window but away from the metal frame-work as this will almost totally absorb the signal. The range from a car will be a lot less than the 800m we stated at the beginning.

IF IT DOESN'T WORK

If you cannot detect an output on the LED Power Meter, you can safely assume the oscillator stage is not working.

Measure the current for the project. It should be about 7mA. If it is only about 3mA, the oscillator transistor may be damaged or not being turned on.

You cannot measure any of the voltages around the oscillator transistor and expect to get an accurate reading as the leads of a multimeter will upset the operation of the circuit.

However if you measure the voltage on the emitter of Q2 and find it is zero, the transistor is not being turned on and you should check the 47k base-bias resistor. If it is 9v, the transistor may be shorted or the 470R resistor may be open circuit.

But the most likely cause of the project not working will be a soldering fault, such as a bridge between two tracks, poorly soldered joints, or two components that have been swapped - such as the 47k and 470R.

The best thing to do is give the project to someone else to check as it is very difficult to check your own work.

If you have used your own parts to build the project, the fault could be in the markings on the components (or incorrect reading of the values) or the wrong size coil. The only solution is to buy a kit and put it together - you can then compare one project against the other.

If you are picking up a blank spot (called the carrier) on the dial but no audio, the fault will lie in the first stage or the microphone.

Check the voltage on the collector of the audio transistor. It should be about 2.4v, however if it is above 6v or less than 1v, the transistor will not be biased correctly and the 1M base-bias resistor may be at fault.

The electret microphone needs only about 50mV across it to work and the only real way to check it and the audio stage is to use a CRO or audio amplifier (our prototype had 200mV DC across the microphone). By whistling into the microphone at a distance of about one foot (30cm), you will get an output of about 10 - 30mV. The audio transistor will provide a gain of about 70 and produce an output of about 700mV - 2,100mV, as mentioned previously.

If the microphone does not produce at least 10mV, it may be around the wrong way, damaged, or have very low sensitivity. Reducing the 68k load resistor may help if the microphone is a low sensitivity type.

FITTING THE BATTERY

The Explorer is designed to fit on top of a 9v battery and doesn't need any case or potting. The safest thing is not to enclose it at all as heatshrinking can squash the coil and change the frequency of operation.

Fully-assembled devices are available from Talking Electronics for $55.00 plus $5.00 pack and post, for those who are not good at soldering or want a built-up unit. They are covered with heat-shrink so they can be handled and easily fitted to a battery. You can heatshrink your own model by buying a short length of heat-shrink tubing and placing it over the board and shrinking with a candle or gas torch. Crimp the ends with a pair of pointed-nose pliers so they stick together and make a good seal. Cut around the two battery terminals and make a smaller hole for the air trimmer so the frequency can be adjusted, and the project is ready for use.

That's the complete story. I hope you get as much fun out of the Explorer as I did in designing it.

LOCATING A TRANSMITTER

If you are trying to find a transmitter such as the Voyager, when it is transmitting, you can turn on a transistor radio and tune across the dial. You will get a feedback whistle (when you are in close proximity) and this will indicate a transmitter is present.

But the job of actually locating the transmitter with a radio is very difficult.

A radio has no directional ability and it will need two people to do the searching. One will need to hold and listen to the radio while the other searches through the room looking for the bug.

If the searcher makes very low level sounds, the person with the radio will be able to detect when the searcher is getting close to the microphone. The problem with this is most transmitters are so sensitive that it is difficult to know when the searcher is getting really close to the microphone.

Two employees of Talking Electronics tried for 15 minutes to find a hidden bug with this method and failed to locate it, so the chances of tracking it down are slim.

The other method is to use a Bug Detector. Talking Electronics has designed a very simple-to-operate device called **Bug Detector 2000.**

Its operation is fully covered on the following two pages and additional details can be found on the last two pages of this issue, along with a number of other transmitting devices.

The **Bug Detector** is extremely easy to use and only needs to be switched on with the antenna extended and the volume turned up.

It is a broad-band receiver and picks up the whole FM band at the one time so you don't have to tune across any of the frequencies.

This means you can't miss anything and by simply moving around the room with the antenna outstretched like a probe you will get a feedback whistle from the built-in speaker, if a transmitter is present.

By turning the volume down, the meter on the front of the **Bug Detector** will come into operation and register field strength.

It's simply a matter of moving around the room again, this time observing the deflection of the needle on the meter.

The needle will fully deflect at a distance of about 3 metres (10ft) from most transmitters and to get closer you must make the **Bug Detector** less sensitive by reducing the length of the telescopic antenna.

This will allow you to "home-in" and get right up to the bug, which may be hidden under a book or shelf.

Using the radio method described above will get you close to the transmitter but then you will have to do a lot of tapping around to try and find the bug itself.

The **Bug Detector** achieves a result almost silently so that once the bug is located, it can be left in place or removed, according to the circumstances.

MADE-UP DEVICES

The difference between the four transmitters listed at the back of this issue is the range, battery life and size.

They all have the same microphone sensitivity and will pick up a whisper within a room or a discussion in an adjacent room. They can all be bought in made-up form or as a kit and the construction details will be presented in future issues. Look out for them. TE

THE ART OF SWEEPING

These notes will assist you when buying and using some of the currently available bug detecting devices.

It is important to remember that the price you pay for a product is no indication of its capability. We have seen and heard of devices, such as bug detectors, costing up to $14,500 that are not capable of picking up some of our $50 bugs! This is hard to imagine but when you get similar reports from different sources, you have to believe it.

We had a call from a customer who purchased a detector for $1500 from overseas and was trying to use it to detect one of our wall bugs. After half and hour of fiddling with the controls he was convinced the wall bug was not working. We told him to turn on the bug and pick up the transmission on a normal FM radio at about 89MHz and ring us back if he couldn't find it. He didn't return the call so we guess the fault lay with the operation of the detector. It must have been too complex for him to understand!

Most of the failures to locate a bug come from the sheer complexity of the equipment. Some of the designs have so many knobs that you need a manual to work them out. If you have a piece of equipment like this, you need to spend a lot of time familiarising yourself with its operation.

Most of the products in the high-price bracket have been designed by experts FOR EXPERTS and unless you intend to use them constantly, you will very soon forget how to adjust the controls for the best performance. And if you don't adjust them correctly, you will very easily ride over a bug.

In general, expensive equipment requires a lot more expertise to operate and although it may be capable of picking up highly sophisticated devices, such as 1GHz bugs, these are not readily available and in my 13 years in the field, I have never seen one in use.

Since any bug is detectable, you have to consider if anyone is prepared to lose a $1,000 bug on a simple surveillance operation, or use a $50 throw-away model.

BUG DETECTOR 2000

To make meeting areas safe from electronic intrusion, TALKING ELECTRONICS has released a very simple hand-held detector called BUG DETECTOR 2000. It is capable of locating all types of transmitting devices operating in the 20MHz to 200MHz range.

This is the normal range for most types of low-cost bugs and anything above 200MHz costs a lot of money plus it needs a special receiver to pick up the transmission.

Generally, you can feel fairly safe if you sweep the 20 - 200MHz band but you must remember that bugs can be brought in to the area at any time after a sweep and nullify the exercise completely.

The principle of operation of BUG DETECTOR 2000 is "broad-band reception." It is capable of picking up the entire range at the one time. This means there are no adjustments to make during the sweep and it is virtually impossible to miss anything.

The detector is brought into a room with the antenna extended and the volume turned up. With a sweeping motion, the detector is moved around the room and if a transmitting device is active, the Bug Detector 2000 will produce

USING THE BUG DETECTOR 2000

a whistle very similar to the feedback of a public address amplifier. The volume is then turned down completely and this brings the meter into operation.

To "home-in" or pin-point the bug, the operator moves around the edge of the room, going over everything in the room with a continuous sweeping motion. This is done with the antenna extended, allowing it to act as a probe and gaining the maximum sensitivity.

As the detector gets closer to the transmitter, the needle will deflect. By reducing the length of the antenna, the operator will be able to get closer to the bug and finally, its exact location will be found.

BUG DETECTOR 2000 has been designed to provide a rapid means of locating a bug. It ensures that bugs cannot hide and has proven to be much faster and more reliable than using a radio or scanner.

If you are thinking of using a scanner for the job, here are some tips.

Scanners usually jump in steps and even though these steps may be as small as 5kHz, it is possible to jump right over a bug and not detect it.

We have been informed of the case of a promoter at a seminar demonstrating a $20,000 bug detector and being 5cm from a bug without finding it!

This is simply because the detector was scanning another band during the time when the operator was in close proximity to the bug.

Even if the scanner is 50 or 100kHz away from the transmission frequency it will not produce a warning as the scanner is pre-programmed to scan the band and doesn't have any "intelligence."

There are other problems with scanners. Many bugs, even low-cost devices, can have a very narrow bandwidth and since some scanners do not have a "pull-in" feature, (called AFC, Automatic Frequency Control or Automatic Fine Tune), they will not stop on the bug unless the RF energy is above a threshold level.

In addition, scanners set to 5kHz steps will take quite a few minutes to scan through 20MHz - 200MHz and this will make detection a long and tedious operation.

The problem is the scanner stops on every transmission in this 180MHz range. And there are literally thousands of transmissions. Each time it stops, you have to decide if it is a legitimate transmission or a bug! It's not long before your patience wears out!

Those scanners with AFC will carry out the job satisfactorily however at $1,000, their cost is quite high and the size and weight does not lean towards portability.

Once a transmission has been detected, a scanner will not "home-in" on the device and all you will know is a bug is somewhere nearby or up to 100 metres away!

This is one of the problems with a sensitive detector. You may be 20 metres from the bug but you don't know which direction to go! And the search becomes very frustrating.

Voice Activated (VOX) bugs require sound or noise to turn them on and it is necessary to make as much noise as possible when sweeping, to open up them up.

USING A RADIO

A normal FM radio can be used to detect a bug but many of the bugs are now sold in the 110MHz or 86MHz band. This is just above or below the normal FM band and it will absolutely impossible to detect them with a standard radio.

If you are lucky enough to pick up a bug on the FM band, it will produce a squeal when within 2 or 3 metres. All you have to do it get closer and find it.

This is not as easy as is seems. One of the workers had left a bug on a shelf some years ago, when testing it. I picked up the transmission on an FM radio and went into the room to locate it. All I got was a mass of squeals. I spent over half an hour searching the room in a vain attempt to locate it.

That's when I decided to invent the Bug Detector 2000.

One interesting side-light with the bug detector came from a customer in another state.

She rang to say the needle was fully deflected, no matter where she moved around the house. I asked if she had any transmitters in the area and she confirmed this by saying that two of the TV transmitters were only a couple of kilometres away.

I suggested that the RF signal strength in the home was extremely high and it was like living in a microwave oven all day long. She said she was moving as soon as possible.

The Bug Detector will also pick up local Taxis and airport traffic. If you live near any of these transmitters don't worry about any background RF traffic, it merely confirms the bug detector is operating correctly.

DETECTING TRANSMITTING PHONE BUGS

Phone bugs require a little more effort to locate as they can be placed anywhere on the phone line. They are designed to transmit when the handset is lifted and can be placed anywhere in the phone itself, along the line, in a junction box or even external, such as in a phone pit or on a power pole.

BUG DETECTOR 2000 is capable of detecting these bugs via a very clever method.

Simply coil the phone cord about 4 times around the telescopic antenna and place the mouthpiece of the handset to the speaker on the DETECTOR.

If a transmitting bug is present on the line, you will hear a feedback whistle.

Don't worry about any other noises such as motor-boating, radio stations, taxis or CB's as the phone line is increasing the sensitivity of the bug detector enormously and it is acting like a radio, picking up all the transmissions in the area at the one time.

You will only get a feedback whistle if the bug is within about 30 metres of the phone and you will not be able to detect a bug at the exchange or on a pole at the end of the street as the RF signal is too weak for the detector.

To pick up a bug on a pole in the street or in a pit, you will have to keep the phone off the hook and take the detector into the street and scan each of the poles. It is best to dial a recorded service or place a radio near the phone so that you can pick up a known audio signal when it is transmitted by the bug on the pole.

If you have not carried out a scanning procedure before, it is essential to be familiar with the equipment by having someone hide a transmitter and let you locate it.

When you buy the Detector, you should also buy one or two transmitters, such as a room transmitter and a phone transmitter to see how difficult (or easy) it is to locate them.

Room and phone transmitters such as those we have described in the catalogue at the end of this book form only a portion of the number of ways of bugging a room. Other devices are more difficult to detect however their use is very limited due to their low effectiveness.

Room intercoms such as those connected to the mains provide a relatively poor means of listening to room conversation and since they must be connected to the power, you should investigate all power outlets, including powerboards and extension leads.

The only remaining listening device you may come across is a "hard wired microphone."

These are microphones and amplifiers placed in the most advantageous position in a room with wires running from the amplifier to a pair of headphones or tape recorder. Because of the long wire, this type of device is not very popular and if you find a loose wire tucked behind a bookcase etc, it may be connected to such a device.

This will be the only way to locate the microphone and stumbling upon the wire will be incredible luck.

One final point.

You can never "guarantee" a room is free of listening devices after a sweep has been carried out as the device may operate on a very low frequency, or very high frequency or be brought into the room in a briefcase during a meeting. The device may be a tape recorder in a briefcase and unless you request to search all personnel, you will never be able to find it.

DETECTING THE TAPE RECORDER

Tape recorder detectors are available on the market that claim to detect an OPERATING TAPE RECORDER at 1 metre. These detectors pick up the radiated RF energy of the erase head operating at a frequency of 40kHz to 150kHz.

Expensive miniature tape recorders use this form of erasure during recording but cheap micro tape-recorders use DC bias when recording and the detectors will not be able to detect them!

Thus cheap tape recorders in a brief case cannot be detected.

THE NON-LINEAR JUNCTION DETECTOR

The only other competition to our BUG DETECTOR 2000 is a non-linear junction detector.

These are expensive devices that claim to detect any piece of equipment that has one or more transistors in its circuit.

They are very easy to defeat, as you will see in a moment and are very expensive to purchase, as well as time-consuming to operate.

Basically they only work in close proximity to the device being detected and thus the sweep must be made very close to every surface in a room.

All bipolar transistors have non-linear junctions (diode junctions) and will radiate harmonics when in the presence of an RF field.

The non-linear junction detector produces RF radiation and the bug being detected has an antenna to receive the energy.

It does not matter if the bug is operating or switched off, the output transistor is connected to the antenna and will receive the RF energy and radiate harmonics. These harmonics are picked up by the non-linear junction detector and passed to a meter or other output device to indicate the presence of a semiconductor.

Non linear junction detectors can be defeated by using Field Effect Transistors (FET's) in the transmitter. FET's do not produce harmonics when in the presence of RF energy and thus the detector does not respond.

Another way to severely reduce the effectiveness of a detector is to shield a bug with copper or aluminium foil, especially around the antenna wire where it emerges from the case. This will act as a short circuit to the RF energy and reduce the effectiveness of the detector.

At the high cost of non-linear junction detectors, and the skill required to achieve results, they still remain in the realm of scientific pieces of equipment.

This leaves almost no competition to the BUG DETECTOR 2000 and with the number of detectors we have sold, we can testify to their capability and success.

It is available for $150 plus $5.00 pack and post, from Talking Electronics at either the Australian or US office.

The addresses are: Talking Electronics, 35 Rosewarne Ave, Cheltenham, Vic. 3192. Tel: (03) 584 2386.

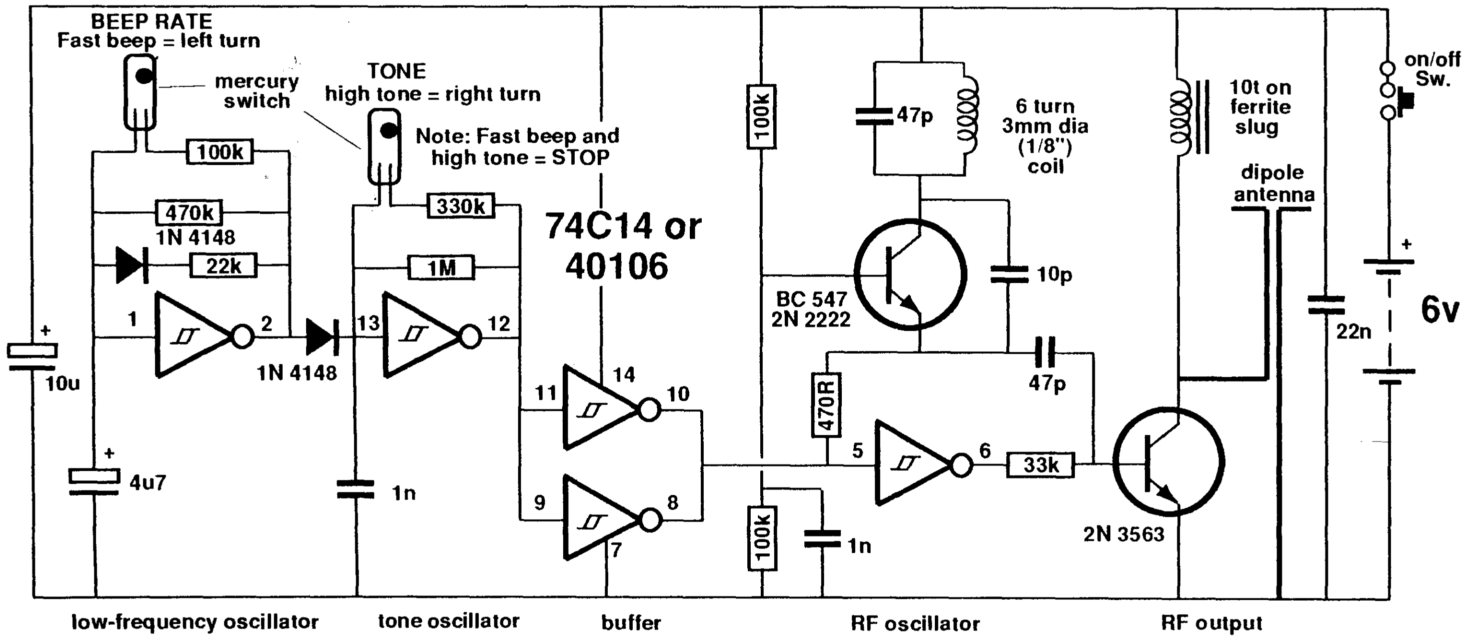
or Talking Electronics, 5042 Wilshire Blvd, Suite 499, Los Angeles, CA 90036

CAR TRACKER

Parts & PC: $17.70
PC board only $3.50

You will also need the LED Power Meter $1.10 and Field Strength Meter MkII $13.60, See Electronics Notebook 6) to fully test this project.

This tracker indicates LEFT and RIGHT turns as well as fast STOPS! (In made-up form we call it CT-03)



CAR TRACKER CIRCUIT

This car tracker has a range of 200-600 metres (600 - 1800ft). It also indicates when the car is turning left, right or stopping. The secret lies in a pair of mercury switches, placed at an incline to each other to act as centrifugal switches.

For those who like transmitter hunts, this project offers a new dimension.

It will enable you to follow a car at a distance and track its stops and turns by listening to the tones on a radio.

The transmitter is placed on the rear shelf of the car to be hunted and the two antennas are outstretched to form a dipole.

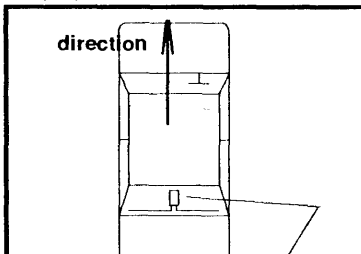
Each antenna is 175cm (5ft 9in) long and should be stretched full length to get the maximum range.

Since the transmission out of the back window of a car is very poor, the antennas must be placed so that the signal passes through the glass, to give the best range. It's no good putting them behind the bodywork as the signal cannot pass through metal.

It's also important to place the Tracker flat on the back ledge facing the direction of travel so that the mercury switches will come into operation when the car turns left, right or stops . . . . more about this later.

This project is not limited to car tracking. It can be used to track any object such as a box, bike, animal or boat. It produces a short beep every 600 milliseconds that will carry up to 3km in a built-up area when a good antenna (such as a dipole) is used.

The actual range is heavily dependent on the effectiveness of the antenna(s) and will vary from 200-600 metres (600-1800ft), when placed in the back of a vehicle, to about 3km (1.5 miles) when placed in the open (or in a room, for example).



For maximum range, Tracker is placed on rear parcel shelf of car

The range improves considerably when the unit is mounted high, such as on the mast of a boat and you can expect to get up to 10km (5 miles) over water. When placed in a box or other small object, the range could be as short as 100 metres (300ft).

The circuit is based on our tried and proven Water Bug design. The same gated oscillator and output arrangement has been used because of the very low current consumption.

The performance specifications are quite spectacular. With an average current consumption of less than .1mA we detected the Car Tracker on our car radio at a distance of more than 3km (1.5 miles), over the tops of houses and into

PARTS LIST

1 - 470R
1 - 22k
1 - 33k
3 - 100k
1 - 330k
1 - 470k
1 - 1M
1 - 10p ceramic
2 - 47p ceramics
2 - 1n ceramics
1 - 22n ceramic
1 - 4u7 16v electrolytic
1 - 10u 16v electrolytic
1 - 2N 2222 or BC 547 transistor
1 - 2N 3563 RF transistor
2 - 1N 4148 diodes
1 - 74c14 Hex Schmitt trigger IC
1 - 6 turn 3mm (1/8") dia coil .5mm (0.02in) enamelled wire
1 - 15cm enamelled wire .5mm (0.02in) for RFC
1 - 6mm x 2.5mm dia (1/4" x 1/10") slug F29 material
1 - 14 pin IC socket
4 - AAA cells
2 - mercury switches
1 - SPDT slide switch
2 - 175cm (5ft 9") antenna wire

1 CAR TRACKER PC BOARD

a shop-lined street. In fact this test was the worst set of conditions we could provide, so we can say the 3km range is a genuine achievement. It's no good talking about a line-of-sight 3km as anything will go 3km if you can see that far!

When a constant tone is produced, (such as when experimenting with the circuit) the current consumption rises to 6 - 7mA and as we will explain in a moment, this represents only the average current, as the oscillator and output stages are being turned on and off at the frequency of the tone.

The main difference between the Water Bug and this project is a brilliant addition.

The circuit can detect when a car turns left, right or stops by a pair of mercury switches.

These act as inertia switches to detect sideways forces and deceleration.

When a car turns a corner, the force that acts on the passengers (to push them to the outside of an imaginary circle) is called centrifugal force. It's the same force that keeps clothes against the side of a washing machine bowl when it is spin drying.

If you study the position of the mercury switches in the photos, you will see that only one switch at a time receives a force to move the mercury onto the contacts when the car turns a corner. When everything is placed correctly on the back shelf of the car, one switch will operate when the car turns left and the other will detect the car turning right. When the car stops, both will make contact.

The right-turn switch alters the tone and the left switch alters the beep rate. This applies when the project is sitting on the work bench and being tested. If the project is turned up-side-down, the opposite will be true. (Don't forget, the angle of the mercury switches will also have to be adjusted according to the positioning of the PC board.)

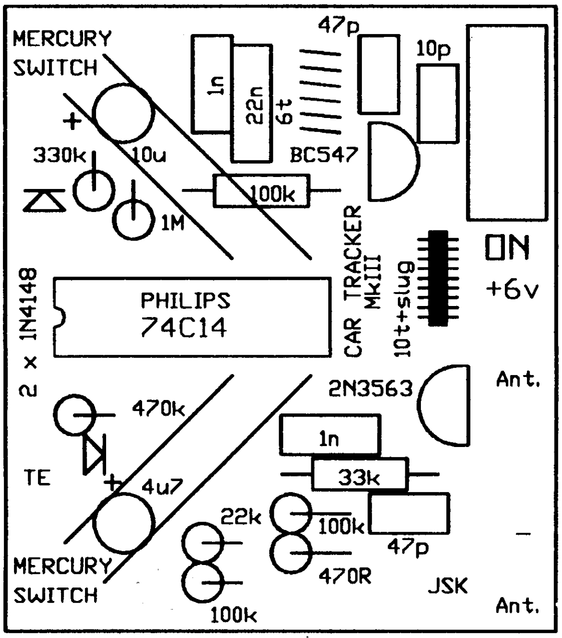
When the car stops, both the tone and beep rate increase and from this you can determine what the car is doing.

When installing the Tracker it is most important to place it on a level surface so that the mercury switches come into contact at the right times.

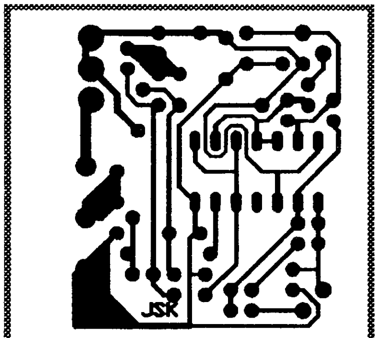
If you are detecting someone stealing a box or potplant for instance, you will only need one mercury switch and the alignment is not so important. But when both switches need to come into operation independently, the alignment must be exact.

HOW THE CIRCUIT WORKS

Most of the circuit has been taken from the Water Bug and only a few minor changes have been made to the output and its interfacing to the oscillator stage.



Enlarged view of Car Tracker



Full-size trackwork for Car Tracker CT-03

In the Car Tracker circuit, the drive for the output has been taken from the emitter of the oscillator transistor where more energy (than the collector circuit) can be picked off without upsetting the amplitude of the oscillator.

This is the last place you would think to connect to, but it works extremely effectively and is one of the features that gives this project such a good range.

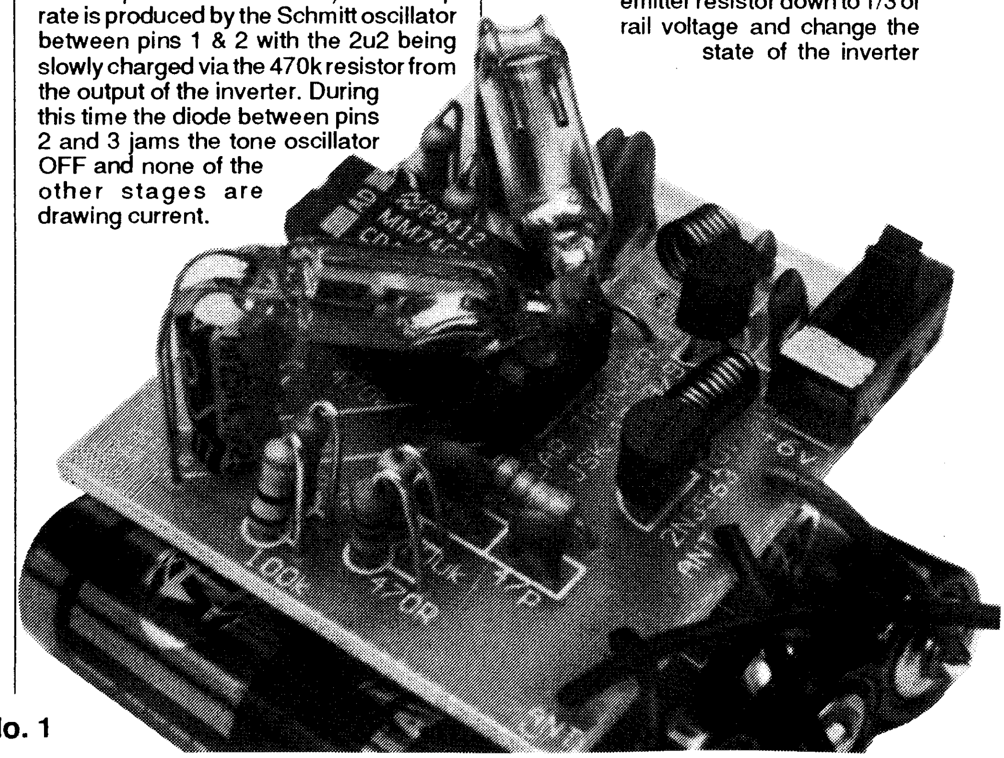
We will start at the left side of the circuit, with the low-frequency oscillator. When the Tracker is turned on, it produces a low beep-rate at a low tone). The beep rate is produced by the Schmitt oscillator between pins 1 & 2 with the 2u2 being slowly charged via the 470k resistor from the output of the inverter. During this time the diode between pins 2 and 3 jams the tone oscillator OFF and none of the other stages are drawing current.

When the 2u2 charges to 2/3 of rail voltage, the tone oscillator is allowed to come into operation and turns on the other stages. The 2u2 is quickly discharged via the 22k (and the diode in series with it) so that the tone is produced for only a very brief period.

When the mercury switch closes the beep-rate is increased as the charge path is now made up of a 100k and 470k in parallel and these charge the 2u2 at a faster rate.

The tone circuit is identical to the beep circuit except the resistance and capacitance values are designed to allow the inverter to operate at a higher frequency.

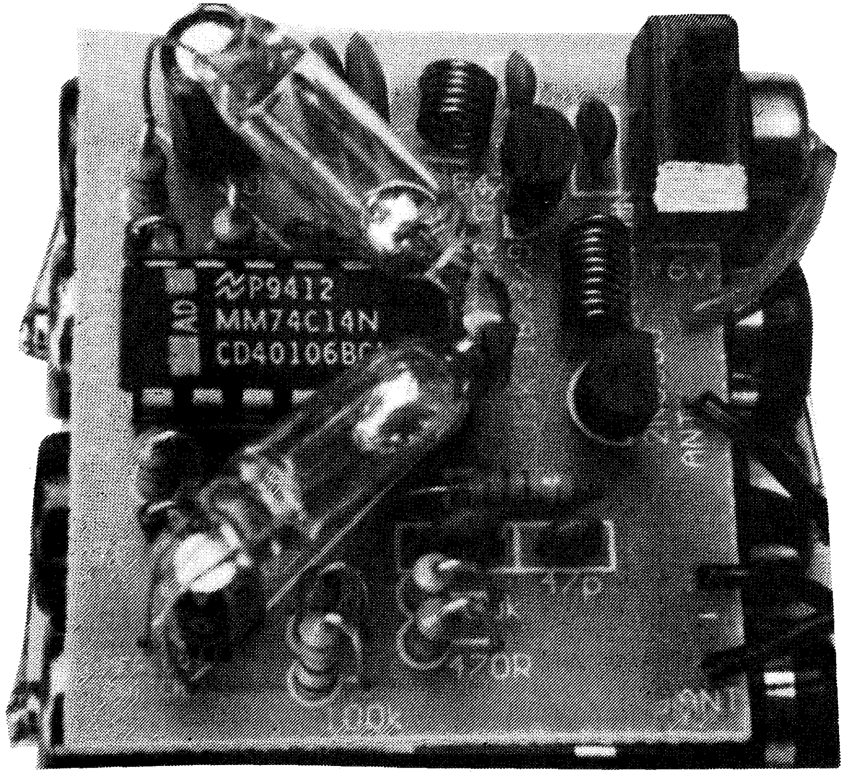
The output of the tone circuit is taken to a pair of inverters. We need two inverters to provide sufficient sinking to pull the 470R emitter resistor down low enough so that the oscillator stage will operate and also change the state of the inverter between pins 9 and 8. If only a single inverter was used, it would not pull the emitter resistor down to 1/3 of rail voltage and change the state of the inverter



(connected to it).

The oscillator and output stages are turned on and off at the frequency equal to the beep tone and this creates the beep we hear in the FM receiver.

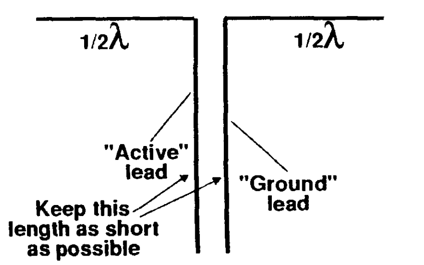
This method of driving the two stages requires very little current as they are only turned on during the high part of the tone waveform and during this time the 88MHz oscillator is able to produce a number of cycles of 88MHz waveform. These cycles are called "carrier" cycles and if the oscillator was to stay on permanently we would pick this up on a radio as a "quiet spot." The fact that the oscillator is turned on and off at a fast rate produces interruptions to the quiet tone and thus an audio tone is produced. It's a very clever way of producing a tone without putting a tone on a carrier.



The oscillator and output stages are turned off during the negative part of the waveform and consume no current at all. The current consumption during the high is about 12 - 14mA and zero during the low, giving an average of 6 - 7mA. But since the beep is very short compared with the period of silence, the reading you will get on a multimeter is only about .1 or .2 mA.

The result is beeps superimposed on background noise and you may think the transmitter is just managing to break through, but in fact the transmitter is being turned ON for very brief periods.

The operation of the 88MHz oscillator is covered in some of the projects in our other books such as 14 FM bugs to build. See P 41 for the list of these books.



A DIPOLE ANTANNA

The Radio Frequency Choke is a new addition and plays an important part in allowing the output to produce a high amplitude. We have wound it on a ferrite slug so that the circuit produces the maximum output while removing some of the harmonics. The actual inductance of this coil is quite critical and the number of turns given must be adhered to. Adding turns or removing them will decrease the output.

HOW THE DIPOLE ANTENNA WORKS

To get the maximum range from the Car Tracker, we have fitted a dipole antenna to the output. The way it works is this: The signal appearing on one half of the dipole is out of phase with that on the other half and the result is very similar to a full wave antenna.

In the circuit diagram we see one of the arms of the dipole comes from the collector of the output stage and we have called this the "Active" lead. The other comes from the negative rail and is called the "ground" lead.

But there is another advantage in splitting the antenna into a dipole arrangement.

The lead connected to the negative rail acts as a ground plane, making the ground plane firmer or more rigid, so that the active lead (connected to the collector) is able to swing higher. We have already explained how this comes about and showed how it is similar to a trampoline with its the legs sitting in rubber. The person on the trampoline will not be able to get a good bounce from the trampoline when it isn't firmly positioned.

Even though we would like to think the ground plane does not rise and fall in a well-designed transmitter, it does see some waveform and this signal is brought out to the other half of the antenna, so it not only tightens up the circuit but it is also radiated.

CONSTRUCTION

The overlay on the PC board should be sufficient to position all the components correctly. Refer to the photos to see how the components are soldered and make sure they are close to the board so that everything is neat and tidy.

Don't forget the IC socket and the correct orientation of the transistors, diodes, electrolytics and chip.

The oscillator coil is pre-wound but the RFC has to be wound on the ferrite slug so that the 10 turns fit neatly and evenly on the centre of the slug. Tin the ends of the wire to remove the enamel and solder them to the board.

The two most important components in the project are the mercury switches. They must be placed so that they are 45° to the direction of travel and inclined at 30° so that the mercury rises up the tube to touch the contacts when the car is changing direction or decelerating.

When positioning the switches, it is advisable to mount them in 'blu tack' or plasticine and adjust the angles until they are just right. Then use hot glue and remove the blu tack.

One of the last items to add to the board are the batteries. Keep the connecting wires as short as possible and solder the switch directly to the cells to prevent any inductive losses.

The whole project can be heatshrunk with 4cm (1.5in) black heatshrink tubing however this is not included in the kit - we have to keep something exclusive for the made-up versions.

OUTPUT

The output power of this project has been pre-set by the design of the output stage and the 10 turn RFC.

During manufacture of our ready-made devices, we found a lot of our time was taken up adjusting the tank circuit for best output, so we decided to look into changing the circuit.

The result was to replace the tank circuit with an RFC wound on a ferrite slug.

This gave us two improvements. Firstly it produced an untuned output that was capable of working at any frequency across the band and thus we did not have to retune if the frequency was altered.

Secondly, the slug prevented harmonics from appearing on the output and gave us a much cleaner signal.

With this design there is no need for peaking and the peaking meter is only needed to determine if a signal is appearing at the various positions on the circuit.

To assist you with testing the circuit we have two pieces of equipment - the LED power meter and the Field Strength Meter MkII.

Both of these should be used to detect the output.

Firstly the LED Power Meter.

This simple piece of test equipment will indicate the presence of RF and should be used firstly on the oscillator stage to set the frequency at which the tracker will operate.

To do this, turn the oscillator ON permanently by connecting pin 1 to pin 14 of the 74c14 Hex Schmitt trigger IC via a piece of tinned copper wire. Then disconnect the coupling capacitor from the output stage so that only the oscillator is operating and connect the lead of the LED power meter to the collector (or emitter) of the oscillator.

This will give a reading of about 1v to 1.5v and also provide a short antenna so that you can pick up the frequency on an FM receiver.

Tune your radio to a quiet spot between 88 and 92MHz and place the radio about 3 metres (10ft) from the transmitter.

Adjust the spacing of the oscillator coil to pick up the tone. Remove the peaker circuit and connect the coupling capacitor.

Now connect the LED Power Meter to the collector of the output transistor and the LED should glow fairly brightly.

This should be done without the antenna connected as we want all the energy to go into the tester.

If you want the frequency to be below the FM band and have a detuned radio, but cannot pick up the transmission, the frequency may be just below the limits of your radio. In this case you can use the Field Strength Meter MkII. It will detect frequencies from 75MHz to 140MHz and help you bring the frequency in line with the capabilities of your radio.

When you are satisfied the frequency is correct, fit one antenna to the collector of the RF output transistor and the other to ground.

The only test left is the one that really matters. It's the field test. Remove the tinned copper wire link from the chip and the tracker will beep. Our prototype created a record by reaching further than any of our previous designs. It went an astonishing 3km, as mentioned in the introduction, over a slight hill and into a shopping centre, on an output power of less than 10 milliwatts!

MOUNTING THE UNIT

As mentioned above, the circuit can be adapted to suit many applications.

It can monitor anything from a car to a box of detergent bottles . . anything that is likely to be taken, removed, "borrowed," shifted or stolen.

To detect when an object gets moved, the mercury switch (or switches) are set on an angle so that movement causes the mercury to touch the contacts.

If you are monitoring a box or similar item, you should fit the project under the lid and try to move the box without setting off the alarm. You will find this very difficult as mercury responds to the slightest movement.

The best way to set the switches is to mount them in a piece of blu-tack and adjust the angle until the correct sensitivity is obtained.

Once you are satisfied with the angles, the whole project should be wrapped in heatshrink.

It can then be attached to any type of surface with blu tack or double-sided foam tape.

If you wish to use it to protect your car, it should be placed either on the rear shelf or under the rear bumper bar. When placed under the car, double-sided foam tape should be placed on the underside of the project so that the mercury switches come into operation when the car turns a corner.

Carry out a few trial runs to determine the angle and position of the unit before attaching it permanently.

In our made-up versions we have a magnetic model using rare earth magnets to provide very strong attachment.

When used on a boat, it can be placed on a mast to give a long range warning.

The mercury switches can be used when mooring to let you know the conditions on the water.

One switch could sense the conditions in the marina and the other could detect the level of water in the bilge. You can connect up to 3 mercury switches to the tone circuit and 3 to the beep circuit to detect up to 6 different conditions. Each mercury switch needs a different value resistor in series with it so that the tone will be distinguishable from the others. You will probably need to produce a list to help you identify the tone or beep rate with its appropriate fault.

You can easily detect water level, rain, wind, invasion (trip switches, pressure mat etc) and battery failure (zener diode) and transmit the result via this circuit to your beach house and save the embarrassment of arriving at your boat and finding it has sunk.

IF IT DOESN'T WORK

If the project doesn't work you need to determine if the fault lies in the audio stages or the RF sections.

Connect the output of the two buffers (pins 8 and 10) to the negative rail. This will permanently turn on the oscillator and output stages.

Measure the current taken by the circuit. It should be about 10 - 15mA. Remove the 47p on the emitter of the 2N 2222 (BC 547) and fit the LED Power Meter to its emitter or collector. You should get a reading on the meter. If not, the oscillator components (100k, 1n, 470R, BC 547, 10p, 47p and 6 turn coil) will be faulty. Try a new transistor first as you may have over-heated it during soldering. Make sure the batteries are providing 6v and the leads to the battery holder are as short as possible. The 22n across the power rails is also important. It keep the rails "tight."

Once you have an output from the oscillator, refit the 47p and connect the LED Power Meter to the collector of the output stage. You should get a higher reading at this point and if not, the most likely cause is a damaged 2N 3563 output transistor.

Remember, the RFC (10 turns on a slug) must be 10 turns or the output will be reduced.

From here we go to the first two stages but firstly the jumper link must be removed.

The output of the low-frequency oscillator can be viewed on a multimeter set to 10v range. The needle will dip briefly each time the Tracker sends out a beep. To detect the output of the tone stage, connect a piezo diaphragm between pin 12 and ground. You will be able to pick up the brief beeps. If not, the tone circuit is faulty and the first thing to do is remove the diode between pins 2 and 13 to detect a constant tone.

If this is not heard, the tone components, 1n, 1M and/or the chip may be faulty.

Next go to the inverter and tie pins 9 and 11 high via a 470R resistor. I know this will overload output pin 12 but it has current limiting to prevent damage.

Measure the voltage on pins 8 and 10. It must be less than 2v otherwise the output stage will not be turned on properly. Measure the voltage on pin 6 to make sure the inverter is turning ON and supplying base drive to the output transistor.

If you are getting a reading on the LED power meter but can't pick up the signal on a radio, the frequency will be outside the FM band. You can use the Field Strength Meter MkII (described in Electronics Notebook 6) to determine the frequency.

I suggest the frequency is too low and by separating the turns of the oscillator coil, it will be increased.

This covers all the simple servicing hints. Remove the resistor on pins 9 and 11 and the project will work. I hope yours goes as well as ours and I know you will be able to put it to good use.

- Colin.

A BRIEF HISTORY OF TE

Talking Electronics didn't just happen. It was the inspiration of Colin Mitchell, a Teacher, TV serviceman and design engineer.
He had a vision of producing an electronics magazine for experimenters; one that included explanations of how things worked, with projects backed by the availability of kits.
The story of the development of TE is very interesting, so let's go back to the beginning.
It started around 1981, when Colin was asked to prepare some technical notes and design a piece of equipment for a client.
He was surprised to find that simple technical information was very difficult to find. Most books looked impressive at first glance, but when he wanted various piece of information, they couldn't be found.
The only solution was to sit down and write the notes himself. After spending many weeks on the project, he decided there was an enormous need for basic electronic instruction so he decided to do something about it.
There were three possible avenues. One was to offer his writings to an existing magazine, another was to write a book and the third was to produce a magazine.

After a brief discussion with two of the largest magazines in Australia it was obvious they were not interested in simple electronics.
They said their sales were flourishing and they couldn't see any gain in adding more pages to their issues.
This rejection did not deter Colin. In fact it reinforced his resolve.
Fortunately he had all the requirements to go ahead and this he did.
Firstly he had to raise the capital, about $120,000 to buy a typesetting machine, typewriters, drafting equipment, parts for prototypes, test equipment and most important of all, an extension to his house in which to produce the magazine.
His experience in electronics was considerable as he knew how to design circuits and how to explain their operation.
He had been a teacher for more than 5 years and had repaired in excess of 35,000 TV sets, including radios and all those fiddly pieces of equipment that come in to a service-center for repair.
He had also written a small magazine for hobbyists and printed his own notes for a correspondence school, so he felt he had all the experience necessary to get a fully-fledged magazine off the ground.
It was about the middle of 1981 and all that had to be done was to think of a name for the venture.
It came suddenly one day, just as all good things do.
The name: TALKING ELECTRONICS. It was perfect. It was a play on words and Colin loved the hidden meaning. Hobbyists are always "talking electronics" and the name fitted perfectly with the way he intended to present his ideas.
To his amazement he found no-one had registered the name before. So, armed with this dynamic title he started preparing the articles for the first issue.
All the start-up costs for nearly six months had to come from his thriving TV service business and fitting them both in meant up to 18-hour days.
After about 6 months the first issue was ready to go to press.
But just before it did, he needed to know how many copies to run. It would be silly to run too few and wasteful to run too many. So, to gauge his print-run he

ORDER FORM:

TALKING ELECTRONICS:
35 Rosewarne Ave,
Cheltenham, Victoria, 3192
Tel: (03) 9584 2386
Fax: (03) 9583 1854

Name: ______________________

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Description of kits and books:		**$**	
Capacitor Discharge Unit	$10.20		
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Combo-2	$18.00		
Experimenter Board	$19.75		
Experimenter Deck	$24.30		
Explorer MkII	$10.50		
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Electronics Notebook 3	4.00		
Electronics Notebook 4	4.00		
Electronics Notebook 5	4.00		
Electronics Notebook 6	4.00		
Digital Electronics REVEALED	5.00		
14 FM Bugs to build	3.50		
Electronics for Model Railways 1	3.30		
Electronics for Model Railways 2	3.80		
Learning Electronics Book 1	3.50		
Learning Electronics book 2	3.60		
Next 6 publications from TE: $18.00 (incl.postage)			
3m of 1mm solder: $1.00			
5m of fine solder: $1.00			

Postage for first kit or book $2.50. Each additional kit or book 70¢ up to a maximum of $9.00. For airmail add $2.00 or for next day delivery add $3.00. For orders over $60.00 add $1.50 for certify.

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Airmail :
Certify:

Signature: **TOTAL $:**

Send credit card number/ Stamps/Cheque/Money Order or Cash. Minimum order $15.00
(No Cheques under $15.00 - send stamps or Money Order ONLY)

Credit card No: We despatch the same day. Allow 3-7 days to receive your order.

Please use the order form

ORDERING INSTRUCTIONS:

The quickest way is to ring up and place your order. Simply quote your credit card number and the goods will be sent the same day. Postal charges are $2.50 for the first kit or book and each additional kit or book is 70¢, up to a maximum of $9.00.

We also send orders COD. (COD costs $7.00 extra). Allow 3-7 days for delivery.

If you want the order sent air mail, add an extra $2.00 or if you want it next day delivery, add $3.00 to the postal charges above.

For orders over $60.00, add $1.50 for certify or for orders over $200 add $3.00 for insurance. For orders under $15.00, please send stamps such as 50¢ or $1.00 or cash.

Minimum cheque or fax orders is $15.00

A $2.40 cheque costs $1.00 to process through a bank and $12.00 if it doesn't go through!!!! No cheques under $15.00 accepted. They cost too much to process.

All enquiries: Please send a large stamped addressed envelope.

I know it all sounds complicated, but do your best. Any excess will be refunded. We need a computer to work out the postage rates and charges, so have pity on us!!

Do not send any enquiries by FAX. We do not have the time to answer any requests or fax you back.

asked for the sales figures of the large magazines, by posing as an advertiser.

The figure of 80,000 wasn't sales figures but readership and this is determined by multiplying sales by 230%. Sales figures are always very misleading. He decided to be on the conservative side and run 25,000 copies.

Then came a problem from the printers. They showed him samples of paper and recommended 55gsm 'shade k'. Without further consultation they ran the text and to Colin's horror, the paper had considerable show-through - you could read the text on the other side of the page!

The printer did not accept responsibility and so another printer had to be engaged and the issue re-run on better stock.

This added to the burden of setting up the magazine, but undaunted, Colin prepared the articles for the second issue and waited for the release of the first issue in the news-stands.

After about 5 days the magazine hit the streets and orders started coming in. The first week was slow but the second week saw interstate orders and very soon half the day was taken up preparing orders and sending them out.

Colin had set a number of ground rules for the mail-order department and the first of these was same day despatch. All kits had to be ready for mailing the same day and this was greatly appreciated by the readers. How often do you see "allow 5-8 weeks for delivery" on a mail-order advertisement - after 8 weeks you have almost forgotten what you ordered!

With a speedy mail order service, TE customers keep coming back again and again. At least 50% of TE business is made up of previous customers, some of which can be traced back to the first issue.

From the second week of the release of issue 1, the small band of workers at TE have never had a quiet day. Apart from assembling the kits and taking phone and fax orders, some of the staff are fully engaged in designing new projects. All our projects are designed entirely at TE. As you know, it is highly dangerous to copy anything from any other source and especially with a magazine that is seen by so many readers.

Apart from the projects, the magazine has many articles on basic electronics and it's the completeness of coverage that has made it a success. Simple questions like "what is a capacitor" or "why do we need this value of resistance" are so obvious to seasoned hobbyists but can be quite puzzling to anyone just starting.

Some of the articles are hand-written on grided note-paper and this form of presentation has proven to be very popular as the reader sees it as similar to a blackboard and teacher.

One of the reasons why we decided to fill the magazine with simple projects as well as complex projects was to enable both newcomers and advanced to find something of interest.

The magazine is aimed at enabling everyone to understand how circuits work and encourage them to learn with a "hands-on" approach by constructing projects.

This has proven to be the most successful way to learn as we have had thousands of readers say they have learnt more from TALKING ELECTRONICS than anything else.

OUR KIT POLICY

One of the major advantages of Talking Electronics is the availability of kits for each of the projects. As you may already be aware, many books and magazines describe wonderful projects, but they don't back up anything with a printed circuit board or a kit of components.

They just present a great idea that falls down simply because one or two of the components cannot be ob-

tained. This results in very little being built and leaves the hobbyist frustrated.
Talking Electronics has changed all this. We can honestly say we have sold more kits than any other small-time hobbyist magazine.
All the projects from each issue are available in kit-form from us and this makes it easy for you to send to one address for everything you need.
With some magazines, each kit has to be ordered from a different supplier and this can be very awkward and expensive.
The other factor you will be pleased to know is the cost of all TE kits are as low as possible. The PC boards are especially low as we order them in a large quantity and pass the savings on to you. This makes our boards cheaper than anything you can produce yourself and even cheaper than you are currently paying.
All boards are fibre-glass (some of the earlier ones are paper-bakelite) and are pre-tinned ready for immediate assembly. All have an overlay (legend) on the top, showing exactly where the parts are located and this makes construction very easy.
The boards are designed on CAD and have a professional look to them. After you fit all the parts, you will get a result that looks really impressive.
The other and most important feature of the magazine is our style of writing. The articles are written directly at the reader, so much so that we get lots of letters where the reader considers he knows us intimately.
I must say it is gratifying to get a reaction like this but it also creates a lot of letters in our mail order department. Lots of readers send in a long letter with their order and we have to read through each of these to make sure they don't contain sections of an order.
To keep the mail-order section running smoothly I must ask you to keep your letters short and not mix them with any orders. In addition, please don't ask for modifications or special designs as we don't have the time to answer personal requests or carry out any individual modifications.
In some instances we will use your requests as a basis for an article or project. I don't want to put you off but please don't expect a personal reply to your letter, simply because you have written 3 or 4 pages.
If you want the magazine to come out regularly it is imperative we stick to the task of getting the pages ready. You can imagine, a two-page reply to a reader takes almost as long as getting two pages ready for the magazine. If we can kill two birds with the one stone, that's great.
In some of the issues we will be including a "LETTERS PAGE," in which we will answer your letters and at the same time share the reply with the readers.
Many of the requests are certainly in this category and that's how some of the hand written pages came about. These hand-written pages can be found in our Electronics Notebook series. These books are available from us and the list of titles can be found near the order form.

ONE FINAL POINT

We have come on the market to complement and supplement all the other electronics magazines and electronics stores.
Our aim is to explain electronics thoroughly so you will become more interested and more involved in this dynamic field.
This will not only increase the sales of our magazine and kits but also those of other suppliers as well as other magazines.

ORDER FORM:

TALKING ELECTRONICS:

35 Rosewarne Ave,
Cheltenham, Victoria, 3192
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Fax: (03) 9583 1854

Name: ________________________

Address: ________________________

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Description of kits and books:	$	
Electronics Notebook 1 with Starting in TTL 5.00		
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5m of fine solder: $1.00		
Postage for first kit or book $2.50. Each additional kit or book 70¢ up to a maximum of $9.00. For airmail add $2.00 or for next day delivery add $3.00. For orders over $60.00 add $1.50 for certify. — **Postage:**		
Airmail :		
Certify:		
Signature: — **TOTAL $:**		

Send credit card number/ Stamps/Cheque/Money Order or Cash. Minimum order $15.00
(No Cheques under $15.00 - send stamps or Money Order ONLY)

Credit card No: We despatch the same day. Allow 3-7 days to receive your order.

Please use the order form

We believe in the theory of everyone helping each another and by encouraging newcomers into the fascinating field of electronics, we will be generating increased demand from all sectors.

This is the situation we have found so far proven by the letters from readers who have said their interest in electronics has been revitalised by the appearance of the magazine.

In some of our comments we will be talking about the content of other magazines and books; suggesting we would like to see their editorial content improve. We are not saying you cease buying any of these publications but rather add our publication to your shopping list and see how our approach compares with theirs.

Ours is a "hands-on" approach with each of the projects backed up by a kit. Each project has been designed around one or more "building blocks" and you will very soon see how everything fits together.

Our commitment is to teach you electronics at the lowest possible cost and that's why our kits are priced so reasonably.

In return, your obligation is to buy as many kits as you can on a regular basis.

Many of the kits are "do-nothing" devices or toys, but don't worry. They have been included for a purpose and form an important part of the learning process.

It is essential you carry out a "building program" and not expect to learn by a vicarious (simply looking on) approach. Only by building will you gain the finer points such as measuring voltages, reading waveforms, modifying a design, and best of all: locating a fault and fixing it.

All the equipment you will need to start can be purchased from any electronics store. These include: a soldering iron, side cutters, and a multimeter (more about this later).

Now that we've started together, let's stick together.

Take a look through this issue and see what we have presented. I'm sure you will agree it's a new approach and you will find plenty of things of interest.

Next to this write-up you will find our mail-order form. We have also included some of the other items we have available, such as books and made-up products. We despatch everything the same day so when you send in it will only take a few days to get them back and you will have them by the weekend! We send everything to you immediately and trust the credit card number you supply is honoured. We have had almost no trouble so far and expect the same to apply now. So don't let us down.

Don't forget to buy a hank of solder when you buy a kit - especially the fine solder (see the order form) as it will improve the finish of your project considerably.

We will have a lot to say about the art of soldering in the next few issues as the greatest cause of a project failing to work is due to poor soldering.

Before I go, I would like to ask you to show your support for the magazine.

Please choose one or two kits from the list and send for them on the order-form in the centre pages. And at the same time why not get a 6 issue subscription.

This way we will get an instant feedback on how you feel and be encouraged to get the next issue out as soon as possible.

We intend coming out every 3 months but this will change to every 2 months as we get settled in. Who knows, we may even come out every month in the future, but I am not committing myself to such an enormous endeavour until we get everything running smoothly.

I will close now as I have a lot of preparation to do. I wish you all the best and know you will be excited at the prospect of learning something really beneficial. We have succeeded in helping thousands of readers take up or improve in electronics and I am sure you will benefit too.

SERVICING Part I

These servicing notes are quite a few years old and come from a TV servicemen who worked in the field for more than 15 years, repairing nearly 35,000 TV sets.

Some of the things he talks about are no longer applicable but his approach to servicing is quite unique and worth retelling.

The art of servicing has not changed in 50 years - it still takes skill, patience and determination.

Even if you are just beginning in electronics, one of the areas you can consider is servicing.

We will always need servicemen and without this dedicated band of trouble-shooters, all our electronic appliances would be destined for the rubbish bin, the first time they broke down.

The art of servicing has never been documented before. so let's see what he says.

The first of his stories is about the multimeter. He then goes on to talk about the dry joint. So, over to the serviceman:

The first concern for anyone wishing to start in the field of servicing is "What multimeter should I buy?" I will answer this with 3 true stories.

I'm going back to the first day I spent in a TV service work-shop. There I met the head technician, Graham. As you will see, he must be the most capable technician ever. In the two years I knew him, he never used a piece of test equipment.

The reason was simple. The owner of the workshop didn't supply anything. The only tools lying around were junky side cutters and a few screwdrivers. The multimeters were always broken and a CRO was not even heard of.

It was under these conditions that Graham was expected to work. The owner knew very little about servicing and that's probably why he provided no equipment.

Anyway, Graham was prepared to work and he was classified as a bench technician. The other technicians were road technicians.

The way it worked was this: Any of the sets that could not be fixed by the road technicians would be brought to the workshop.

I was then Graham's job to fix them. He was a very quick and efficient. The first thing he would do is take the back off the set, lift out the chassis and put it on test leads.

Everything that was given to him had gone through a number of hands. At least one of the road technicians had tried all the valves, searched for any obviously burnt out parts and generally tried to find the fault without success.

But with Graham it was different. He would put his fingers across various parts and after a few seconds the fault would be found.

His secret was to use his fingers! Depending on the problem, he would feel around the appropriate section of the set and place his fingers across resistors and capacitors. If the fault was in the boost section for instance, he would locate the high voltage resistors and bridge each of them with his fingers to create approximately the same resistance as the burnt out resistor. In this way the height would be restored.

If the fault was in the sync section or vertical linearity he would locate the leaky capacitors and say "replace this one, this one and this one . . . "

Invariably the set was fixed.

I used this method for nearly 10 years. It does work. You can adjust the resistance of your fingers from 500k down to less than 50k and simulate a leaky capacitor. If the picture fault worsens when you place them across a particular capacitor it should be replaced. If the picture develops another fault, the capacitor is possibly ok.

I have never been quite as game with the high voltage side. I prefer to use a 2M2 resistor on test leads.

This is obviously a case of what to do when you don't have a multimeter.

The second story comes from Bert...a TV technician living some 10 miles from me. He had just recently bought a 100k ohms per volt FET multimeter and was using it on a Thorn valve TV which had a fault in the EHT section.

He applied the meter to the grid of the 6CM5 horizontal output valve and got a high positive reading. Naturally he thought the oscillator or output stages were at fault and spent many hours replacing every part in the two sections.

Still the high positive reading persisted.

At this stage he came to me with the set and proudly displayed his new meter. My first test was to check the grid voltage with my 20k ohms per volt meter. Sure enough it was correct at -35v. The fault was in a boost capacitor and the set was fixed in 5 minutes.

Bert had learnt a very important lesson. He returned the meter the same day and bought a cheap $25 special! The leads of the meter were picking up stray emissions from the EHT transformer. The meter was far too sensitive for the application. This is a rare occurrence but can happen when working around high voltage, high-frequency transformers.

The third is a story of economics. The first meter I ever bought had a sensitivity of 1k ohms per volt. It lasted through two years of rough use, and 100's of TV's, before the needle began to stick.

My next two meters were 10k ohms per volt. They lasted a few years too. I recently bought a taut-spring multimeter of 30k ohms/volt - it lasted one week and the movement siezed up. The core shifted and jammed the movement. It always happens. The expensive items get damaged first. I remember buying an expensive multimeter last year and dropped it within a month. This all leads me to one conclusion. For repair work you only need two fingers - I mean a cheap multimeter in the price range of $25 to $35. Sensitivities of 10k ohms/volt to 30k ohms/volt are quite satisfactory but the movements are very delicate and the slightest knock will put them out of alignment..

DRY JOINTS

Don't be mistaken, dry joints are one of the most prevalent single faults in colour TV servicing. They account for between 20-30% of all calls. Some TV sets ONLY suffer from dry joints. To back this I can say I have never put a replacement part into at least two brands of colour sets. Their only fault has been poorly designed double sided PC boards that suffer from dry joints.

In the days before plate-though printed circuit boards, a pin was used to connect the top track to the underside of the board. These pins tend to expand and contract during the operation of the set and eventually produce a dry joint.

There are five types of dry joints and five different ways to diagnosing them.

A competent TV serviceman can be recognised by his approach to locating troublesome intermittent faults.

Here is a brief outline of how these dry joints occur and a proven method for locating them.

Some dry joints are classified as thermal faults. By this we mean the set will operate for a certain length of time then fail. This is due to the heat build-up in the set, expanding the components and their leads a few thousandths of an inch (or even millionths of an inch) to create an opening or crack between the component lead and the PC board.

This may result in the sound dying away or the picture closing to a line across the middle or both the sound and picture going off together. A bang on the back of the set generally restores full operation or alternately, turning the set off for half an hour will bring it back to life.

Believe me, finding intermittent faults is very time consuming and after many years on the road I have simplified the problem considerably. I let the customer do all the watching and testing.

For two reasons I never take a TV out of the house. Apart from the damage caused to large sets in the transportation and the heavy lugging required, the real reason is that movement will generally heal the intermittent fault and it may take weeks for the fault to re-appear in the workshop. "Soak Testing" a TV (watching the set with the back on) is very expensive and the sets generally do not fault in my work-shop!

The second point against removing a TV is the customer resistance. Most customers do not like their set removed from the house.

So, where do you start? The following 5 points will help you diagnose intermittents on-the-spot but in most cases you will be guided 99% by your own experience.

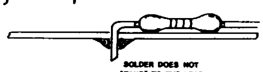
5 TYPES OF DRY JOINTS

1. The unsoldered joint.

This is easy to spot. A component lead which has never been soldered on a PC board or tag strip is obvious (I once fixed an unsoldered resistor attached to a tag strip on a 15 year old B&W set. It had faulted only after 15 years!)

Use a hot iron when soldering the component to the board. Look for any other un-soldered connections.

2. Dirty Component Lead.

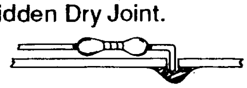


SOLDER DOES NOT "TAKE" TO THE LEAD

The diagram shows a component which has not been pre-tinned and the solder does not "take" to the lead. The component should be removed, cleaned, tinned and re-soldered.

If in doubt about the solderability of the lead, use a new component.

3 The Hidden Dry Joint.



HIDDEN DRY JOINT

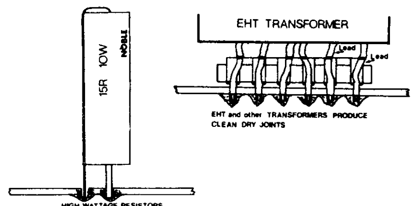
In the diagram, the component does not pass through the board sufficiently to pick up the dip soldering process or the lead is dirty - creating a hidden dry joint UNDER a perfectly good external soldering connection. Moving the component will make it come away from the board.

4. Heat or Excessive Current Failure.

In this case the lead has been cut too close to the body of the resistor, allowing heat to flow into the solder connection, thus gradually destroying it and the surrounding PC board.

If a fairly high current flows through the connection, the joint can develop heating troubles within itself, gradually failing and accelerating the process until finally burning itself out.

5. Expansion and Vibration Failure. Leads from transformers or coils can create very clean dry joints due to the high-frequency vibration of the trans-



HIGH WATTAGE RESISTORS CAUSE HEAT FAILURE

EHT and other TRANSFORMERS PRODUCE CLEAN DRY JOINTS

former along with slight expansions and contractions, creating a pushing and pulling effect on the joint or joints until finally they become open. This can also be due to insufficient solder forming the original connection during dip soldering. Use plenty of solder when re-soldering and make sure the iron is hot.

Dry joint problems are so complex that the same faulty joint may create six different effects in six similar sets. Their location requires extreme skill and patience. I once waited 45 minutes in a customers home for a fault to occur.

When it did occur, I walked over to the set. This created enough vibration through the floor to fix the set for three days. (no, I'm not an elephant!) So how do you go about locating these faults? As I said, 99% is prior skill combined with lots and lots of LUCK.

This is the skill part:

1. Inform the customer to turn the set on and have it faulting when you arrive at his home. You need to be promptly on the scene as some faults create excessive heating or even picture tube burn lines. Being on mobile 2-way is a great advantage.

If a light tap on the cabinet remedies the problem - ask which side of the set responds best. A very light tap will mean the vibration created when taking the back off will heal it - so ask as many details as possible before leaving your workshop.

2. With the set still on, remove the back. If the set comes on, bad luck. Stop immediately and wait.

3. When the set does have a positive fault - place a large mirror a short distance in front of the screen so that it can be viewed from behind the set. When making any tests on the chassis such as tapping or freezing, you will need to look in the mirror constantly as it will be your guide to locating the problem.

4. Turn up all controls, including the colour, to maximum. This may produce a dull picture on the screen and help with diagnosis.

The above is greatly simplified however you will need to ask yourself whether it is a power supply fault, sound fault, high voltage fault or tuner fault and concentrate on this particular section.

Each set differs as to fault locating and it would take 100 pages to list all the methods of attack. As a general rule, I use this method:

1. With the set still on, remove the back carefully. Use a can of "FREEZE" (compressed carbon dioxide) to spray accurately all over the PC board starting at one end of the soldered side and working systematically over the board. Cover every board in the set. Next spray each and every component with the CO_2. (I have never had it damage any components, even when it freezes them to almost absolute zero - but I keep the nozzle a little distant from the parts all the same.

2. Obviously you have been inspecting the soldering a while spraying. This time I suggest taking a closer inspection - especially around the pins of EHT transformers, switch-mode-power-supply transformers and high wattage resistors.

Look for any burn marks, unusual or poor soldering and re-solder any suspect connections. It is best to solder with the set off, so before making any repairs, switch the set off for 30 seconds then on again to see if the fault is self-healing. Once you are satisfied the set remains faulting, you can re-solder a few connections at a time, then turn the set on.

3. Some faults do not respond to freezing or inspection. For these intermittent joints you will need low-level illumination and a plastic handled screwdriver.

If the PC board is large and mounted on a thin frame it can be twisted by holding the upper and lower corners of the board. This is extremely dangerous because you are using two hands for this operation. Make sure you are just touching the blank PC board or the metal frame-work as the grip you are applying will allow any voltage over 100v to become quite lethal.

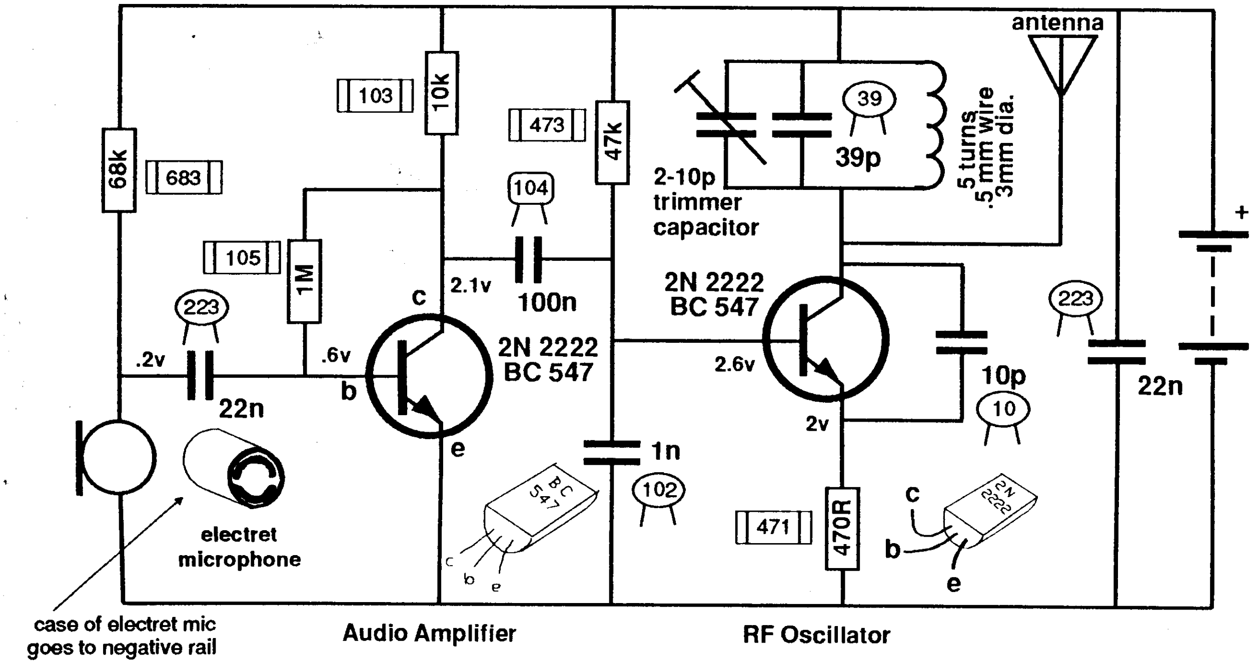
Twist the board and wait for any reaction. Quite often you will see a spark from the faulty joint and the set springs into life. The other approach is to tap the board with the plastic handle of the screwdriver and gradually home-in on the fault.

There is no other magic to finding dry joints. These are the general basic rules and provided you keep a mental record of each and every dry joint as you find it, you will build up a *skill* equal to any expert.

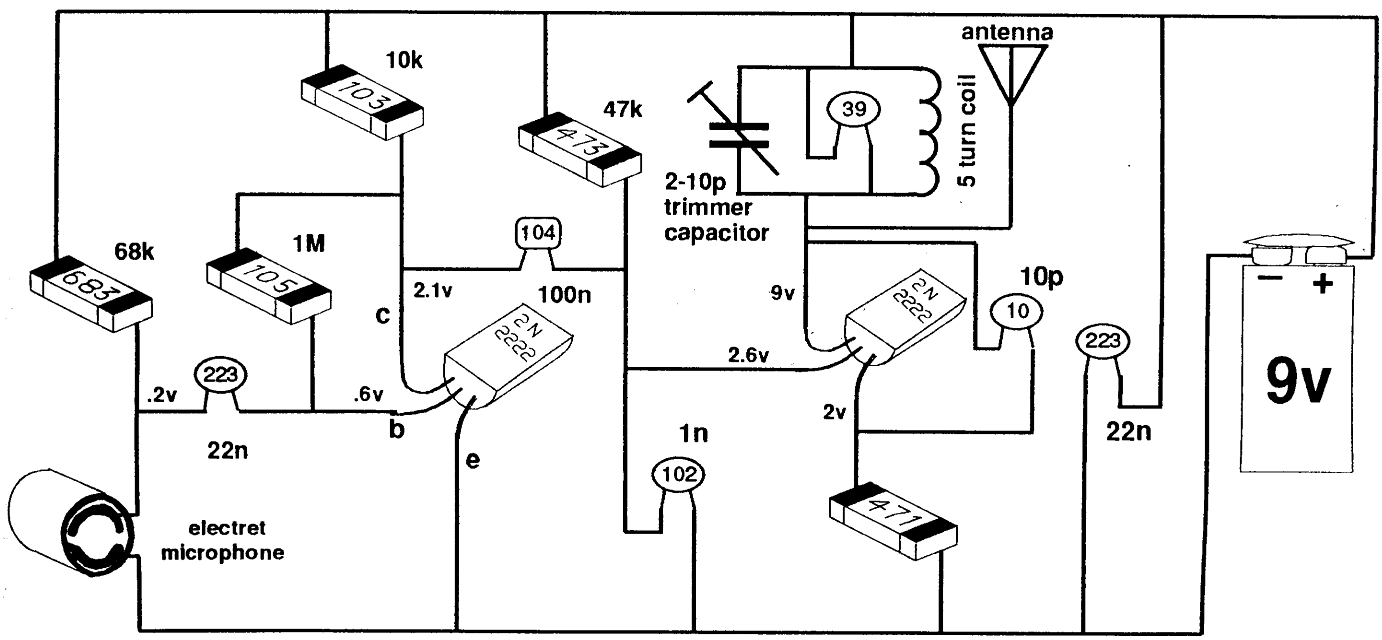
UNDERSTANDING A CIRCUIT DIAGRAM

– Comparing a schematic with a Printed Circuit Board Layout

These two pages will help you understand the Explorer circuit on page 28.



EXPLORER MkII CIRCUIT



EXPLORER Mk II CIRCUIT

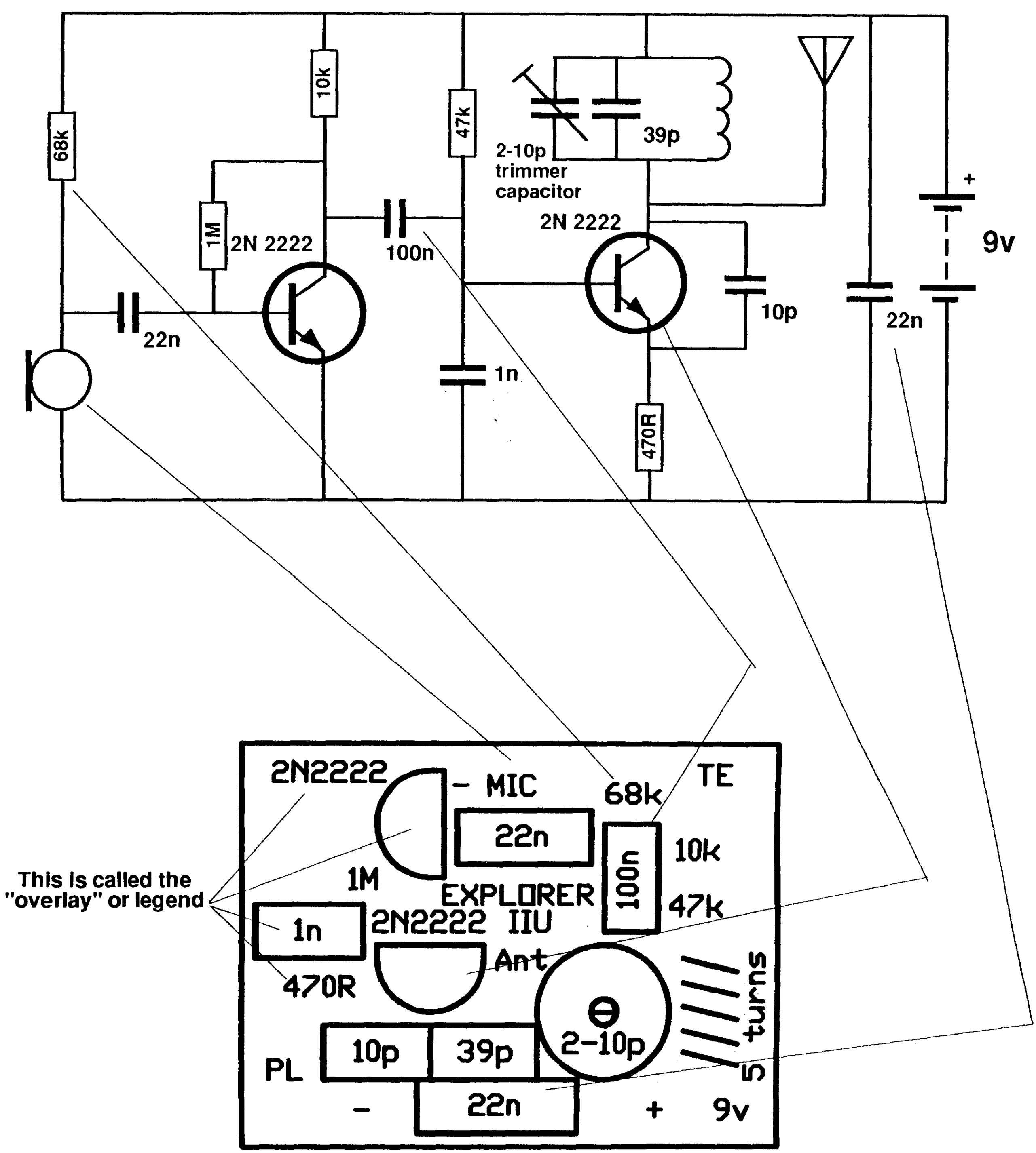
The 4 diagrams on this page and the next show the Explorer MkII circuit. This project can be found on page 28 of this issue.

The top diagram is called a CIRCUIT DIAGRAM or SCHEMATIC. It shows how the components are connected together. Each item is shown as a symbol. But sometimes the symbol does not tell you what the component looks like.

The lower diagram shows this better - especially the transistors, electret microphone and surface mount resistors. The third diagram, on the following page, shows the symbols without any line-diagrams, as you would find in most books, and the fourth diagram shows the PC board with the OVERLAY on top of the board to show where the components are placed.

You are required to complete the matching of the symbols with the overlay on the next page.

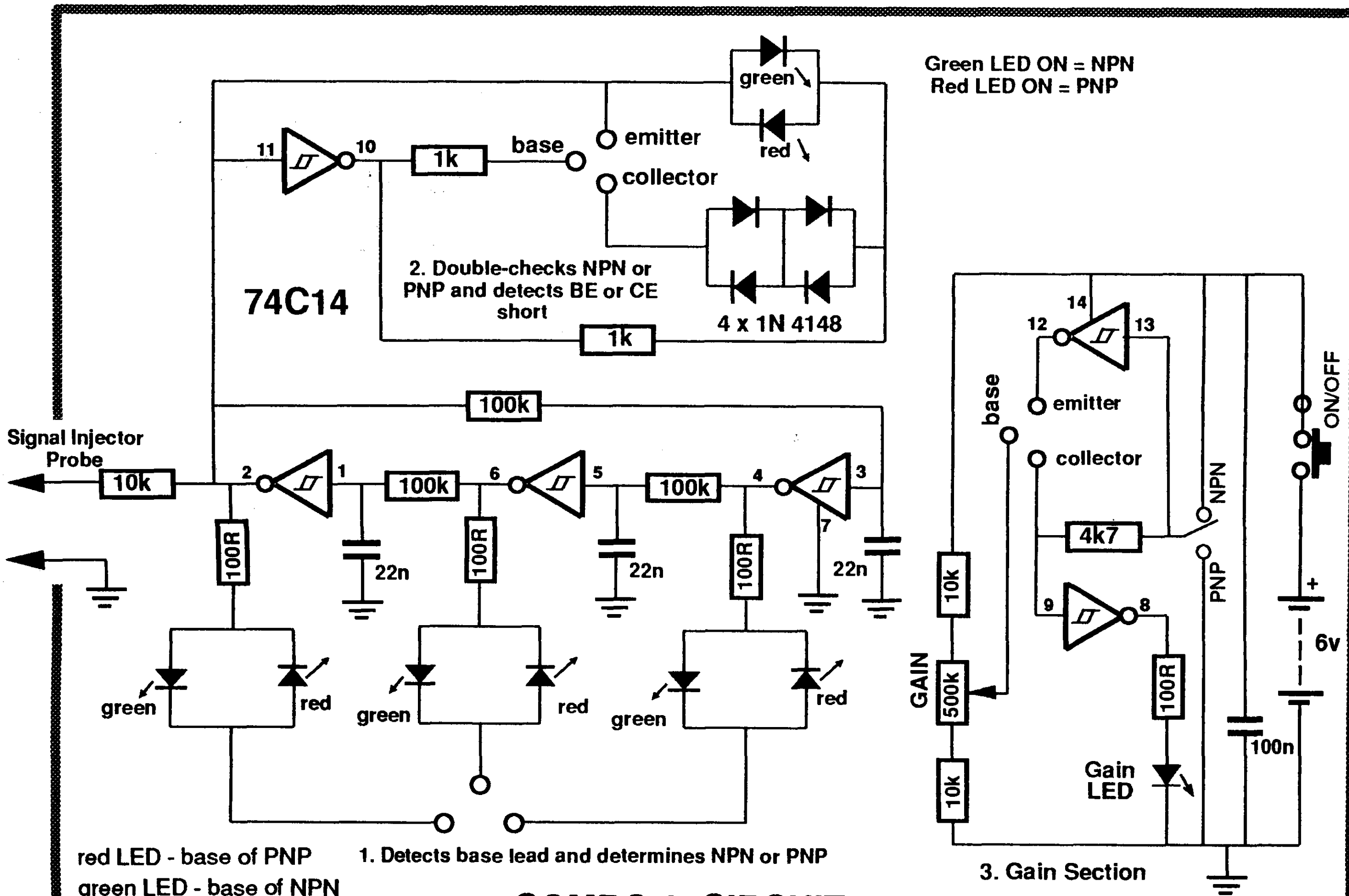
Some of the components on the circuit diagram have been matched up with the outlines on the overlay. Match up the remaining components.



COMBO-2

Parts & PC: $18.00
PC board only $3.20

TRANSISTOR TESTER & SIGNAL INJECTOR



COMBO-2 CIRCUIT

There have been a lot of transistor tester circuits presented over the years in electronics magazines, but this one is different. It has more features than the others and includes a signal injector so you can test audio sections of radios and the front end of FM transmitters etc.

The major advantage with this design is its automatic operation. All you have to do is fit the three leads of the transistor to the tester in any order and the LEDs will let you know the base and if the transistor is NPN or PNP. This is section 1 at the bottom left-hand side.

The base is indicated by a single illuminated LED out of a pair.

If the LED is green, the transistor is NPN. If the LED is red, the transistor is PNP.

This saves fiddling around, swapping the leads until the base is determined. Many of the other testers do not identify any of the leads and its very frustrating if you don't know the pin-out of a transistor.

From there you go to section 2 at the top where the polarity of the transistor is further proven and a check is made to see if the transistor has a collector-emitter short or base-emitter short.

All you have to do is fit the transistor to the three leads so that the base goes to

FEATURES:

- Tests transistors - locates base lead and finds CE or BE shorts.
- Determines transistor gain
- Produces a signal for testing audio circuits

OPERATION

Use section 1 to detect the base lead and determine PNP or NPN.

Go to section 2 to determine open or shorted collector-emitter or base-emitter junction.

Go to section 3 to determine gain of transistor.

PARTS LIST

4 - 100R
2 - 1k
1 - 4k7
3 - 10k
3 - 100k
1 - 500k mini trim pot with shaft
3 - 22n ceramic
1 - 100n monoblock
4 - 1N 4148 diodes
5 - 3mm red LEDs
4 - 3mm green LEDs
1 - 74c14 Hex Schmitt trigger IC
1 - 14 pin IC socket
2 - SPDT slide switches
4 - 15cm hook-up flex
1 - black alligator clip
3 - coloured ezy clips
11 - machine pins on strip & 1 pin
1 - 2cm heatshrink to fit over socket
1 - paper clip or nail for probe
4 - AAA cells & 2cm double sided tape
1 - 10cm tinned copper wire

1 - COMBO-2 PC BOARD

the correct ezy clip and the two LEDs at section 2 will indicate if the transistor has a short in one or more of the junctions or if any are open circuit.

The transistor can then be taken to section 3 where the gain is determined.

The PNP/NPN switch is set, since you already know this fact from the previous sections.

Turn the gain knob fully clockwise then anticlockwise. If the red LED illuminates or goes out at a low gain value, the collector and emitter leads must be swapped.

You now know the pin-out for the transistor and are ready to determine the gain.

The gain is given the parameter H_{fe}. This is a value determined by measuring the base current and comparing it to the collector current.

Our tester does not provide an extremely accurate measurement as the scale is very compressed at one end but it does provide a good indication that the transistor is amplifying or if it has a low gain due to a fault.

The gain pot is rotated until the LED just goes out for a PNP transistor. The value is read from the scale around the pot.

For an NPN transistor, the reading is made when the LED just illuminates.

HOW THE CIRCUIT WORKS

The circuit consists of three sections. Section 1 is a run-of-three oscillator. Section 2 is a phase inverter and section 3 is a current gain section.

1. BASE DETECTOR

The run-of-three oscillator consists of three schmitt inverters connected in a ring with 100k and 22n components in the timing circuit.

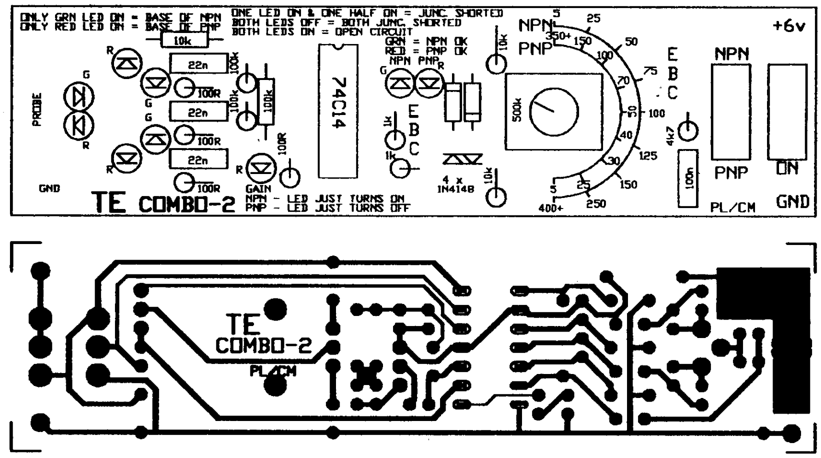
When the project is first turned on, the three 22n capacitors are not charged and the input to each inverter is LOW. This makes the outputs HIGH and causes the three 22n's to charge up at the same time via the three 100k resistors.

A race will occur and the first to charge to about 70% of rail voltage will make the input of its schmitt trigger HIGH. The output of the trigger will go LOW and the 22n on the following gate will begin to discharge via the 100k.

This LOW will cause the output of the second schmitt trigger to be HIGH and apart from charging the next 22n capacitor, it feeds into a red and green LED via a 100R resistor. We will talk about these LEDs in a moment.

When the second gate charges the 22n to 70% of rail voltage, the gate changes state and its output goes LOW.

This LOW is transferred around to the first gate where it begins to discharge the



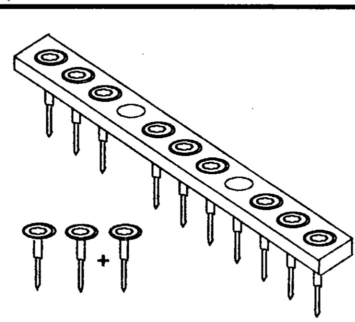
Artwork for Combo-2 Transistor Tester

first 22n in the discussion.

The circuit runs around with one output high, then two outputs high. When an output is HIGH, a green LED is illuminated via a 100R and the current passes through a junction of a transistor placed in the set of three hollow pins. If the junction is forward biased, the current will flow through the junction and through a red LED and 100R to the negative rail. Both the green and red LEDs will turn on.

The way the circuit works is to automatically produce a voltage at every pin in turn and have each of the other two pins at zero. It then produces a voltage at TWO PINS in turn and a low at the third.

This provides all the 6 possibilities for testing the leads of a transistor and because the circuit runs around so fast, there is only one junction that will not conduct. This is the base-collector junction. You have to remember that this method of testing a transistor is not the same as testing it with a multimeter as



The 4th and 8th hollow pins are removed from the strip and used as separate pins at the front-end of the board. The strip is then cut into 3 sections of 3 pins and the ends neatly filed.

we are "actively testing it" by suppling the base with a turn-on voltage and causing the collector-emitter junction to conduct.

2. THE COLLECTOR-EMITTER SECTION

This section detects shorts or open junctions between the collector-emitter leads as well as double-checking the NPN or PNP polarity of the transistor.

When an NPN transistor is fitted, only the green LED will illuminate.

The circuit is being fed a voltage that is constantly reversing. When output pin 10 of the inverter is HIGH, the NPN transistor is biased on and the voltage drop across the two lower signal diodes (1.2v) as well as the voltage across the collector-emitter junction (.3v) is too low to allow the red LED to turn ON. The green LED is presently reverse biased and does not turn on.

When the output of the Schmitt trigger goes low, the transistor is reverse biased and the green LED will illuminate.

If a PNP device is fitted, the opposite occurs and the red LED illuminates.

If a faulty device is connected, both LEDs will illuminate if the device has an open collector-emitter junction as the transistor will not be turned on during the forward part of the cycle.

If the device has a short between collector and emitter, neither LED will illuminate as only the forward voltage drop of the two diodes (1.3v) will be present and this is not enough to turn on either LED. (You need at least 1.7v).

3. THE GAIN SECTION

The gain section uses the circuit in figure 1 (in the H_{FE} article on page 9). The transistor is placed in the circuit around the correct way and the base current is adjusted via the pot until a pre-determined current flows through the 4k7 load resistor.

When this exact current flows, the voltage across the load resistor is detected by the Schmitt gate and the LED is illuminated (or extinguished) according to the polarity of the transistor.

A slide switch allows the circuit to test

THE GAIN OF A TRANSISTOR

The gain of a transistor varies enormously from one type to another and also within the same type. It also varies according to the frequency at which the transistor is operating and the circuit components surrounding it.

Putting it into a nutshell, the gain is very hard to predict as it is affected by so many factors. We will discuss some of these.

The first transistor to be invented had a very small gain and in fact it was so small the inventors were not sure if the device had a gain of not! The noise produced by the transistor was over-riding the gain they were getting.

Early transistors were germanium devices. They were noisy, low gain, and with characteristics that depended on the temperature of the day! They were extremely temperature sensitive, so much so that early transistor radios could not be left in the sun without the sound distorting!

As transistors were improved, their whole structure changed.

One of the first things to change was the material from which they were made. It changed from germanium to silicon. With this came higher voltage capability, higher current and temperature of operation, better stability and higher gain values.

Let me qualify this.

The gain of a transistor (in the category in which it is placed), is very high or at least sufficient for the intended application.

For any transistor, there is a connection between gain and current handling capability. In most cases it is not possible to produce a transistor with high gain AND high current handing ability.

That's why small signal transistors have a high gain and power transistors have a low gain.

When designing a circuit you have to take this into account. All the amplification (voltage amplification) must be done in the early stages of the circuit so that the current amplification can be achieved in the final stages.

To overcome the problem of high-power, low-gain; manufacturers have introduced a special type of transistor called a Darlington. It combines two transistors in the one package so that very high amplification can be achieved as well as high current handing.

But Darlington transistors form a very small portion of the overall transistors types. The most common types are low current, medium current and high current varieties. These are available in both PNP and NPN. Each of these groups can be divided further into low frequency and high frequency.

Let's stop there before we get too involved with groupings.

CURRENT GAIN

The main element of this discussion is the gain of a transistor.

There are 4 different current gains. These are:

1. The DC current gain (as measured by the Combo-2 tester),
2. The AC current gain when the transistor is operating as an oscillator in a test circuit,
3. The gain when the transistor is placed in a normal circuit, and
4. The current gain at the maximum frequency of operation (for the transistor).

These are different values and we will see why.

1. THE DC CURRENT GAIN

This is determined by measuring the current in the collector circuit and dividing it by the current in the base circuit.

The highest result obtained from a number of determinations is selected and used as the value for the transistor. It is the value supplied in the specification sheets. This value is quite often completely different from what you get when using the transistor in practice as it is generated under ideal conditions.

It is determined under very low current conditions. When a higher current is required to be controlled by the transistor, the gain drops considerably.

For example, a transistor may be capable of handling 500mA, but the best gain factor may be determined at 10mA! The gain at 10mA may be 300 but at 500mA it may be only 70.

This applies to all transistors and that's why the gain values you will be getting on the Combo-2 are the highest the transistor will produce. When the transistor is placed in a normal circuit the gain factor will fall according to the current required by the circuit.

2. THE AC CURRENT GAIN.

The AC Current gain is the gain you get when the transistor is operating as an amplifier in oscillator mode, but again under very favourable conditions. Instead of taking static conditions as in the DC gain above, the SLOPE OF A GRAPH is measured and a value obtained. The result is less than the DC current gain but not very much less.

3. THE GAIN IN A CIRCUIT

When a transistor is placed in a circuit, things change completely. All the components around the transistor have a loading effect that reduces the gain.

The result is called STAGE GAIN and this is the MOST IMPORTANT GAIN as it is the gain you REALLY get.

For instance, a transistor with a gain of 300 may only produce a gain of 50-70 when fitted into a stage. It's the effect of all the components around the transistor that reduce the gain.

Such things as output capacitors, coils, loudspeakers and stages that follow, all require to be driven and/or have losses and when the transistor has to drive these components, its gain suffers.

There are also components called self-biasing components and negative feed-back components that reduce the gain so you can see why a transistor has to have a high gain in itself to end up providing a gain when fitted to a circuit.

4. THE FREQUENCY

The third factor is frequency. As the frequency of operation of a transistor increases, its gain decreases. This is a characteristic of the transistor itself. It is due to the way the transistor is made and the size of the chip making up the device. It is something that cannot be altered after the transistor is made. It's only by improved technology that transistor frequencies have increased from the first audio transistors to the modern gigahertz devices.

As the frequency of operation of a transistor increases, its gain decreases to unity and this point is called F_T, the cut-off point and determines the maximum frequency at which the transistor will operate. This is usually in the MHz range for small signal transistors and about 1MHz for power transistors. For high frequency transistors F_T will be 500MHz and higher. We generally do not have to worry about the maximum frequency capability unless we are designing high frequency circuits.

This leaves the question "What is the gain of a transistor?" unanswered, but you can see how complicated it is.

THE GAIN is what you get when the transistor is fitted to a circuit. If you are designing a circuit it is always a wise idea to take CRO measurements of the input and output of each stage to determine the gain as well as view the waveforms and also see if any high frequency noise is present.

both PNP and NPN transistors.

CONSTRUCTION

All the components fit on a PC board 107mm x 28mm.

Refer to the photo below to see how the machine pins are used as a 3-pin plug for the test leads so that they can be moved from section 2 to section 3.

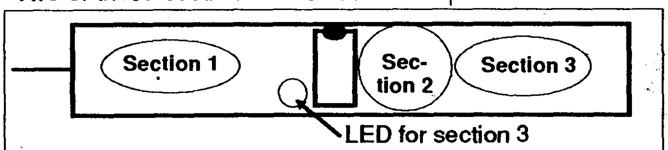
PREPARING THE 3-PIN PLUG AND TWO 3-PIN SOCKETS

Supplied in the kit is a strip of 11 machine pins to make the plug and sockets for the test leads.

From this strip three 3-pin sections are made and two individual pins are removed (plus 1 pin) for the test pins for section 1.

Remove pins 4 and 8 from the strip and cut it into three pieces making three 3-pin sections.

Two of these sections are soldered to the board as 3-pin sockets and the other is turned into a 3-pin plug for the three test leads.



The three sections on the Combo-2.

Cut three pieces of hook-up wire to equal length and solder them to the top of the three machine pins.

Place heat-shrink over both the leads and plug and shrink into place.

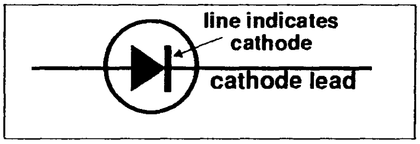
Solder 3 ezy clips to the other ends of the leads and label them collector, base and emitter with an adhesive label wrapped around the clip.

Mark one end of the 3-pin plug so that it can be fitted the correct way into the socket on the board.

Start assembling the board by fitting the IC socket and the two 3-pin sockets.

Then start at one end and fit each component as you come to it.

Each LED is identified on the board with a diode symbol and the cathode lead is the line on the symbol.



The cathode of the LED is identified by a flat on the side of the body of the LED and it is also the shorter of the two leads.

The 3 individual machine pins at the end of the board are the next to be fitted.

These are designed to take the leads of the transistor under test.

The rest of the components are easy to fit as everything is identified on the board.

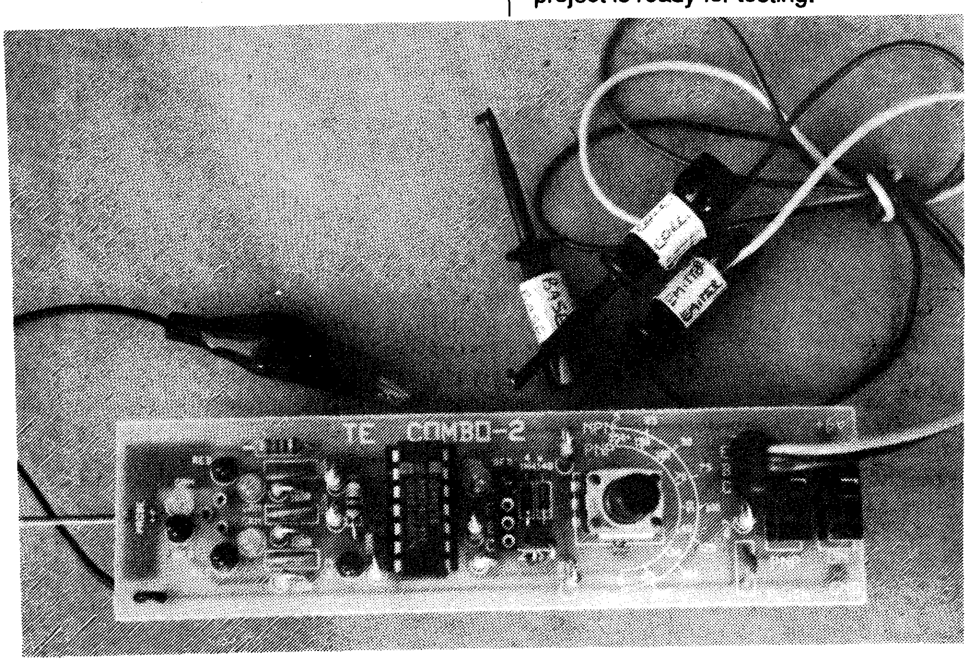
The earth lead for the signal injector is soldered to the board at the point marked GND and an alligator is fitted to the other end.

The probe is made from a nail soldered to the underside of the board at the position marked "probe."

Solder the 4 AAA cells together with short pieces of tinned copper wire and fit them under the board with double sided tape.

Don't forget to mark the ON/OFF switch with red nail polish to identify the ON position.

Fit the IC to the socket so that pin 1 is towards the top of the board and the project is ready for testing.



TESTING THE CIRCUIT

To test the Combo-2 you will need a number of good transistors, preferably both PNP and NPN types.

Section 1 finds BASE lead:	
NPN	Only green LED of pair comes on
PNP	Only red LED of pair comes on
Section 2 double-checks for PNP and NPN and checks for shorts between COLLECTOR and EMITTER leads:	
Both LEDs off, both junctions shorted	
Both LEDs on - open circuit	
Green LED ON - NPN, ok	
Red LED ON - PNP, ok	
Section 3 determines gain:	
NPN	LED just turns on
PNP	LED just turns off

Place them in the first section and make sure that only the green LED comes on for the NPN type next to the base lead.

Swap the leads around to check that all the LEDs work. Repeat with one or more PNP types.

USING THE COMBO-2

When the Combo-2 is turned on, only the two LEDs in Section 2 will come ON. This indicates power is applied to the circuit.

Place the leads of the TRANSISTOR UNDER TEST (sometimes called TUT) in the three machine pins at section 1. If the transistor is "good", five LEDs will come on. The base lead is identified by only one LED of the pair coming on.

If this LED is green, the transistor is NPN. If this LED is red, the transistor is PNP.

Sometimes, if the transistor has shorts between some of its leads, 5 LEDs will come on and so we need section 2 to determine if the transistor is "good."

Connect the transistor to section 2 via the jumper leads and read the LEDs as shown in the table above.

Take the jumper plug to section 3 and determine the gain of the transistor. Turn the gain pot and read the scale from the pointer on the shaft.

CONCLUSION

This project should solve a lot of your problems with identifying transistors, especially when using transistors with odd pin-outs. Add it to your collection of test equipment and most of all, don't loan it as you will never get it back!

Hfe

The need for measuring the gain of a transistor goes back to the early days when the gain was fairly low and to get a good device for a particular application you had to go through a whole batch and pick the best.

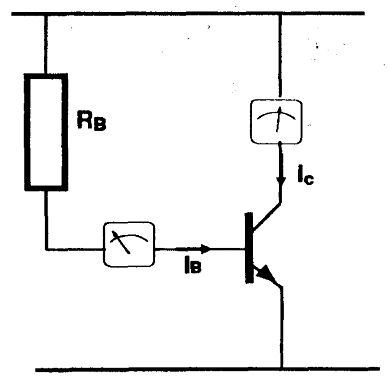


Fig: 1. Measuring the current gain of a transistor

The DC current gain H_{fe}, for a transistor is:

$$\beta = \frac{I_C}{I_B}$$

Today's transistors are much better and almost all have more gain than you need.

This means we don't really need to know the gain but it is interesting to find out the value for those transistors you have in the junk-box or for a transistor you may have damaged during soldering. For this and other reasons we have designed a tester to give you the answers.

It has been designed to give you the gain for small signal devices, medium power devices and high power devices.

We mentioned in the main article that small signal devices have a gain in the range 70 - 450, medium power devices have a gain of 50 - 200 and high power devices a gain of 10 - 110.

These are only approximate values and you could get a device with a value totally outside this range. For instance, some medium- to high-power devices are available in darlington versions and have a gain of 1,000 to 30,000 - way outside the range of our Tester.

BUT if the device is BELOW the range specified above, I would suggest the transistor is faulty and damaged in some way.

This can quite often happen due to over-heating, if you don't use a heatsink when soldering, or overheating when in use.

But this is getting away from our topic. Let's get on with the theory.

THEORY

The gain of a transistor is a very variable thing. Even from a single batch of transistors, the gain can vary from less than 70 to more than 400.

GAIN is one of the factors used to grade transistors and is one of the reasons why we have so many thousands of different types. You may have noticed the suffix 'A,' 'B,' or 'C' after a transistor type. These letters denote the gain category and although none of the transistors are faulty, the numbering and lettering combines with other factors that mean the transistor can only be used in a certain location such as low voltage, low gain or low frequency application.

Since the gain of a transistor varies according to many things such as manufacturing technique, the voltage of the supply (in which the transistor is placed), the frequency of operation of the circuit and the current passing through it, an infinite number of values can be created from a single type, so it is quite often difficult to know which to use and what to expect.

The only way we can cover this complexity is to discuss the three values commonly quoted in specification sheets.

What happens to a transistor, and how it behaves in a particular circuit is another matter and cannot be predicted in any way so we will content ourself with values that can be determined.

The most often quoted gain for a transistor is the optimum value - the one that is determined under ideal conditions. It is called the DC gain or β_{DC} or H_{FE}.

This is obtained from a circuit such as shown in figure 1. The circuit is set up and a graph drawn for the collector current when varying base currents are applied. The maximum gain is read from the graph.

This value is generally about 20% higher than the "AC" or "working" gain (to be discussed later) and that's why it is most commonly used.

But some purists don't think the above method is realistic as a transistor is not a static device but a dynamic amplifier such as when used in an audio situation. They want an "operating" value of gain. In other words they want an AC gain value.

In this case an amplifier is set up and varying signals are applied to the base for varying rail voltages.

Once again, the best gain is picked off the graph and used as the AC value or BETA or H_{fe}.

The third value of gain is the value that applies at the upper operating frequency of the transistor and does not concern us in this discussion. It is the highest operating frequency for the transistor and occurs when the gain falls to unity.

For most requirements, the difference between h_{fe} and h_{FE} can be ignored if you are working within the limits of the transistor.

Data sheets generally supply h_{FE} or d.c. current gain and this is the value we obtain from the tester.

The current gain can be written as:

$$\beta = \frac{I_C}{I_B}$$

and this is exactly what the tester is doing, but in a reverse mode. It is reading off the base current for a particular collector current.

It does this in a very clever way. It knows that when a certain current flows through the 4k7 collector load resistor in the gain section, a voltage will be produced across this resistor to cause the detecting gate between pins 9 and 8 to change state and turn on the "gain LED."

By turning the "gain pot," the base current is increased until the transistor produces the required collector current and the value of gain is read off the scale around the pot.

In other words all the mathematics has been done by the project designer and any transistor fitted to the test socket will duplicate the values already worked out.

THE BJT

In most discussions, transistors are referred to as "transistors," but in effect the writer is referring to the first type of transistor to be invented (in simple terms), namely the bipolar junction transistor, or BJT.

They should be referred to as BJT's, but since this is such a mouthful, they are simply called "transistors."

Since the introduction of this type of transistor there have been a number of other developments such as the Field Effect transistor (the FET), the darlington transistor and others that can be lumped into the transistor group.

Unfortunately our tester is not capable of testing these devices and you will get a false reading if you try to test them, so it is advisable to know the device you are testing is actually a "common" or "garden" transistor.

Most of the devices in your junk-box will be common NPN or PNP transistors and the tester will identify the base lead and provide a value of gain as well as an indication that the transistor does not have an obvious short between any of the junctions - so you shouldn't have any problems.

STAGE GAIN

The gain we talk about in our projects, under the heading "HOW A CIRCUIT WORKS," is the OPERATING GAIN or STAGE GAIN. It is not the gain of the transistor.

For example, the first audio stage in our FM transmitters, such as the FM Bug, Ant, Amoeba, Cube of Sugar, VOX etc. has a STAGE GAIN of between 50 - 70.

This is the highest gain you will get, even if you are using a transistor with a gain (H_{FE}) of 250 to 450.

If you are using a transistor with a gain below 250, the stage gain may drop to 30 - 50.

The problem is the gain of a transistor is almost totally "killed" when it is fitted into a circuit.

Why is this so?

The reason for the drop in gain is due to biasing and coupling.

Figure 1 is a typical example. It is a

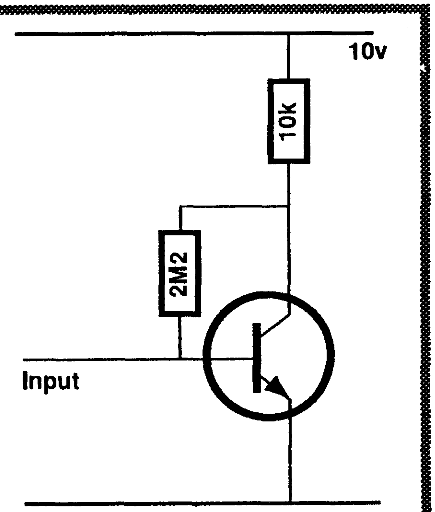


Fig.1: A self-biased transistor stage

self-biased stage with a 2M2 as the base bias resistor. We will see how this resistor reduces the gain of the transistor.

BIASING

Let us assume the transistor has a gain of 250. When power is first applied, current flows in the 2M2 to turn the transistor ON. As the transistor turns on, the voltage across the 2M2 reduces because the voltage across it becomes less and this reduces the current to the base. A point is reached where the current through the 2M2 cannot turn the transistor ON any more. This is called the equilibrium point or quiescent point or balance point and the voltage on the collector is about 5v. The current through the 2M2 will be about 2uA.

The transistor cannot turn on any more due to the value of the 2M2 and the gain of the transistor.

If we supply 1uA into the base of the transistor via the input line, the transistor will turn on more and produce a further 250uA in the collector circuit and drop the collector voltage another 2.5v.

But something else will happen at the same time to prevent the collector voltage dropping.

It's the current flowing through the 2M2 resistor. As the voltage on the collector drops, the current through the 2M2 will reduce and if the collector voltage drops to 2.5v, the current through the 2M2 will fall from 2uA to 1uA and so the collector will not fall to 2.5v but something between 2.5v and 5v.

The actual final voltage does not matter but you can see that the current flowing into the base is partially reduced (or cancelled) by the base bias resistor, due to the fall in collector voltage. Thus the transistor does not produce the 250 gain you expect.

In reality the gain is about 125.

Further losses are encountered by coupling capacitors between the stages.

We will see how this occurs.

COUPLING

Figure 2 shows a coupling capacitor between two stages.

When a sinewave is processed by the first stage it is passed to the second stage via the capacitor.

The second stage will amplify this to produce a larger output but we want to investigate how and why the waveform on the collector of the first stage is reduced when the second stage is added.

The best way to see this is to remove the second stage.

With the second stage removed we will assume the waveform on the collector of the first stage is 8v.

When the second stage is reconnected, the waveform will fall to about 6v.

The reason for this is the second stage puts a LOAD on the first stage. After all, the energy to drive the second stage must come from somewhere and it comes from the first stage.

The "reduced swing, or reduced amplitude, on the collector" decreases the gain of the stage even further and the gain may fall from 125 to between 50 and 70.

This brings us to our conclusion. The gain of a transistor has almost no bearing on the gain you will get when it is connected to a stage.

The only way to determine the gain of a stage is to take measurements with a CRO.

To do this you must inject the input with a low-level signal from a sinewave generator and record the amplitude. Then read the output of the stage.

Sometimes you will get quite a shock at the low gain. It can be as low as 10 - 50

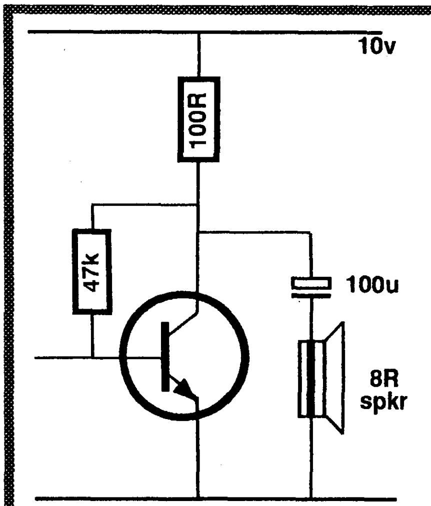


Fig.3: An output stage

for a stage you are expecting to be 100. The main reason will be due to poor design.

Figure 3 shows a transistor driving an 8 ohm speaker. This is where the problem lies. The transistor is NOT driving the speaker. It is merely discharging the 100u during the second half of the cycle. The 100 ohm resistor is DRIVING THE SPEAKER and since this resistor is such a high value, the speaker cannot expect to be driven very hard.

It is being driven at less than 10% of full output (due to the ratio of the 100R:8R) and this means the waveform will be less than 10% of rail voltage. It will appear that the transistor is not providing a good driving force but the fault lies in the poorly designed circuit.

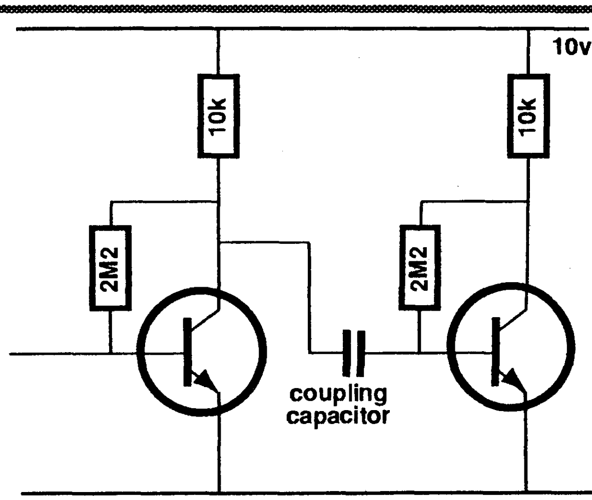


Fig.2: Two stages coupled via a capacitor

THE TRANSISTOR PAGE

A SERIES OF PROJECTS USING PARTS FROM YOUR JUNK-BOX.

NO — WE HAVEN'T FORGOTTEN THE TRANSISTOR!

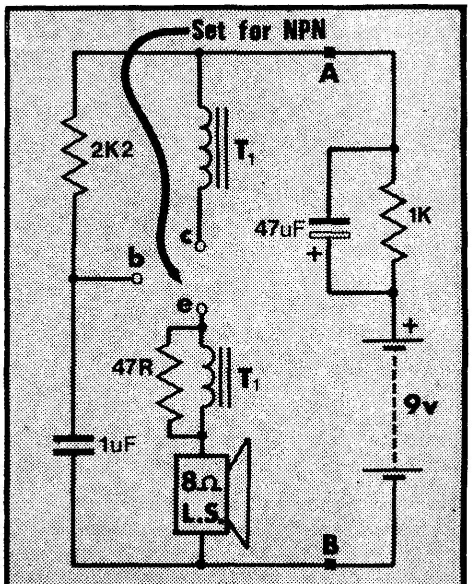
Here are 5 novel circuits you can build with any small-signal silicon transistors. You may use any odd transistors you have in the junk-box or take advantage of the special offer of 20 transistors for $2.40 Any transistors salvaged from computer boards or having an odd type number can be identified as either PNP or NPN by testing it with the SIMPLE TRANSISTOR TESTER described in this article. It does not give any other characteristics however,as these circuits are so simple that you can use any of them as a tester in themselves. The TICKING BOMB, for instance, is ideal as it uses both an NPN and a PNP transistor so that either one can be substituted with an unknown type. As a precaution against reverse voltage you should include a 1k resistor in series with one lead of the battery. This will limit the reverse current to 10ma while the electrolytic reduces the impedance of the supply to enable the circuit to operate.

The transistor offer contains 20 NEW and fully guaranteed transistors. They are not rejects or seconds. This offer has been made available by this magazine at almost cost-price to encourage new experimenters into the field of MAKING rather than looking and thinking. Some electronics shops are also participating in this offer so ask the manager of your local shop first, before sending for the offer.

The whole 5 circuits can be constructed on one piece of veroboard strip, 81 holes long by 15 holes wide. The cost of this is less than $2.
The board can be cut into lengths for each project to make a neat and thoroughly presentable finish. The 81 copper strips run across the board and have been cut in the middle by the manufacturer, making over 160 useful contact pads.

A SIMPLE TRANSISTOR TESTER

Do you have a number of transistors which have their numbers rubbed off or odd transistors of an un-identified type?
This circuit will test them and find out if they are PNP or NPN. It is short-circuit proof so putting a transistor round the wrong way will not damage it. The diagram is set for NPN types. The terminals marked C B and E can be alligator clips on short lengths of hook-up wire. The transformer T_1 is a speaker transformer salvaged from a transistor radio. It can have any impedance such as 400:8 ohm and must be inserted so that the primary winding gives a feed-back to the secondary winding. When this occurs, you will hear a whistle in the speaker. Now you are ready to try all your odd types. Those that do not oscillate should be put aside and re-tested when the battery with its current limiter is reversed at terminals A and B.



TRANSISTOR TESTER

EQUIVALENTS FOR THIS PROJECT:

PNP TYPES		
BC 157	BC 158	BC 159
BC 177	BC 327	BC 557
BC 558		

NPN TYPES		
BC 107	BC 108	BC 207
BC 208	BC 337	BC 547
BC 548	BC 635	

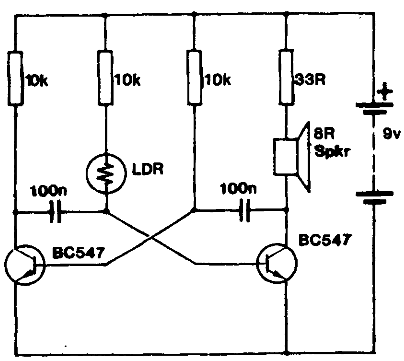
...the transistor page

LIGHT ALARM

This project has a number of uses. Essentially it is a light alarm that is triggered into oscillation by a Light-Dependent-Resistor. Under dark conditions the LDR has a very high resistance and thus the second transistor has no bias on its base. This prevents the multivibrator from functioning and in this contition it draws only about 1mA. As the light intensity increases, the resistance of the photocell decreases and the multivibrator starts up.

Its frequency gradually rises to a high pitched whistle and is limited by the 10k limiting resistor in series with it.

Now, the possibilities for an alarm like this are endless. It will give an audible indication of the intensity of a light source or compare two illuminations. As an alarm it is useful as a theft indicator. It can be put into a cupboard or drawer to protect it from prying fingers. It can used as an alarm for the medicine chest or money drawer. In any case its advantage lies in the fact that it doesn't have to be wired to any switches and can be easily moved around.



LIGHT ALARM

Circuit activated when light falls on Light dependent resistor.

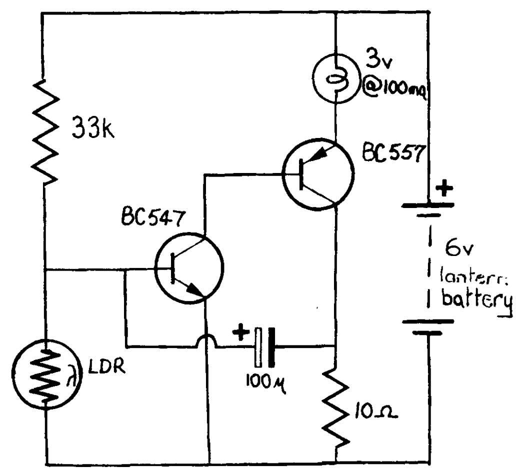
A piece of veroboard 12 holes long will accommodate all the parts making it a very compact project which can be disguised as a packet of pills by using a suitable empty container.

Parts

2 transistors BC 547
3 resistors 10k
1 resistor 33 ohm
2 capacitors .1mfd
1 LDR type ORP12
1 2¼" speaker 8 ohm
1 9volt battery
1 battery clip
1 piece of veroboard

BLINKER

Have you seen the blinking lights at the road-side to warn motorists of roadworks or an excavation? These lights turn off during the day and begin to operate only at dusk. They contain 1 or 2 lantern batteries, a Light-Dependent-Resistor and a 2-transistor flasher. The main requirement for a circuit to operate this type of warning device (apart from creating the flashes) is for its daytime current to be as low as possible to conserve battery. Since the flash of the globe is extremely short, the average current drawn from the battery will be quite small. This circuit achieves both of these requirements.



"BLINKER"

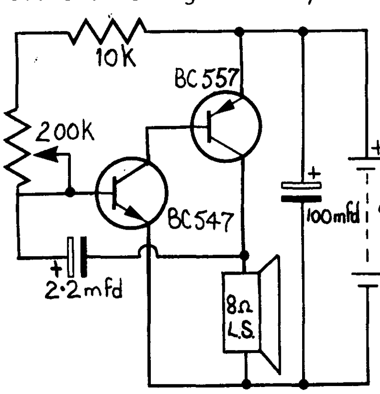
The stand-by current is only 100microamp and the average operating current is less than 25 milli-amps. The only two critical components in the circuit are the 10 ohm resistor and globe. The resistor must be 10 ohms. A 5 ohm or 15 ohm resistor will not work. The lamp must be a low current type. A miniature model railway globe of about 3v - 4v is ideal. It must be rated at .05 to .1 amp to operate successfully. Ordinary torch globes of 2.5v @ 300ma will not work at all. Use a light dependent resistor type ORP12 or similar which has a dark resistance of 10M and a light resistance of 300 ohms.

Parts

1 transistor BC 547
1 transistor BC 557
1 resistor .33k
1 resistor 10 ohm
1 LDR type ORP12
1 electro 100mfd 16v
1 globe 3v 100ma
1 6v lantern battery
1 piece of veroboard

TICKING BOMB

When you build this circuit you will see what we mean. The effect from the speaker is very similar to a loud ticking clock. The 100mfd electrolytic is very important. It reduces the internal impedance of the battery (especially if it is low) and changes the tone from a soft tick to a very loud sharp click. It also reduces the current from 25ma to about 2ma. The circuit operation is very simple. On connecting the battery the 10k resistor, 200k pot, 2.2mfd capacitor and 8 ohm speaker are the only parts drawing current. As the capacitor begins to charge the base voltage on the NPN transistor rises to about .6v This turns the transistor on and in turn switches the second transistor to a conducting state. This results in a click from the speaker. At the same time the negative lead of the electrolytic is brought nearer the positive rail and thus the charge on the electrolytic is reduced. This turns off the first and second transistors to begin the cycle over again.



"TICKING BOMB"

The rate of charge of the electrolytic is dependent upon the value of the resistors in series with it. Thus the rate of ticking can be altered by the trim pot. Almost any NPN and PNP transistors can be used in this circuit. In fact this circuit is an ideal simple test for transistors. It will determine if they are NPN or PNP. All the parts are mounted on a small piece of veroboard 15 holes by 15 holes.

Parts

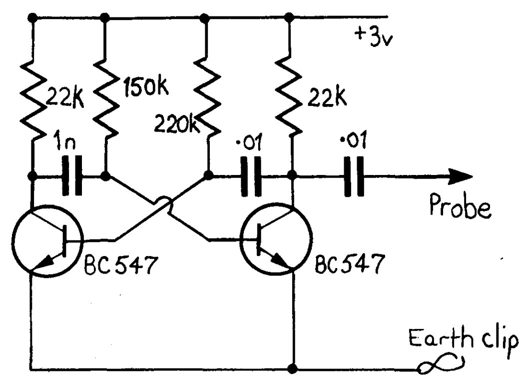
1 transistor BC 547
1 transistor BC 557
1 resistor 10k
1 electro 2.2mfd 16v
1 mini-trim pot 200k
1 electro 100mfd 16v
1 2¼" speaker 8 ohm
1 9v battery
1 battery clip
1 piece of veroboard

SIGNAL INJECTOR

This circuits produces a very handy signal injector. It is a free-running multivibrator with an output of square wave form at a fundamental frequency of about 2kHz and thus is rich in harmonics and can provide a continuous note when injected into any receiver, up to about 20MHz.

The signal injector can be fitted into a plastic tube about 10 to 15 cm long so before cutting the veroboard it is best to find a container. A small plastic pill bottle is ideal and the veroboard can be cut to size. The probe can merely be a long thin bolt mounted in the centre of the lid.

To find a fault in an amplifier or superhet radio, simply connect the earth lead to the chassis of the amp and move through each stage starting at the speaker. Obviously an increase in volume should be heard at each preceeding stage. This injector will also go through the IF stages of radios and FM sound sections in TV's. Use 2 mercury button batteries for the supply and fabricate a switch into the screw-on lid. The first use for this injector will be to test the operation of the next project...The MINI AMPLIFIER.



SIGNAL INJECTOR

Parts

2 transistors BC 547
2 resistors 22k
1 resistor 150k
1 resistor 220k
1 capacitor 1000pf
2 capacitors 10n
1 earth clip
1 probe tip
2 button cells
1 plastic container
1 piece of veroboard

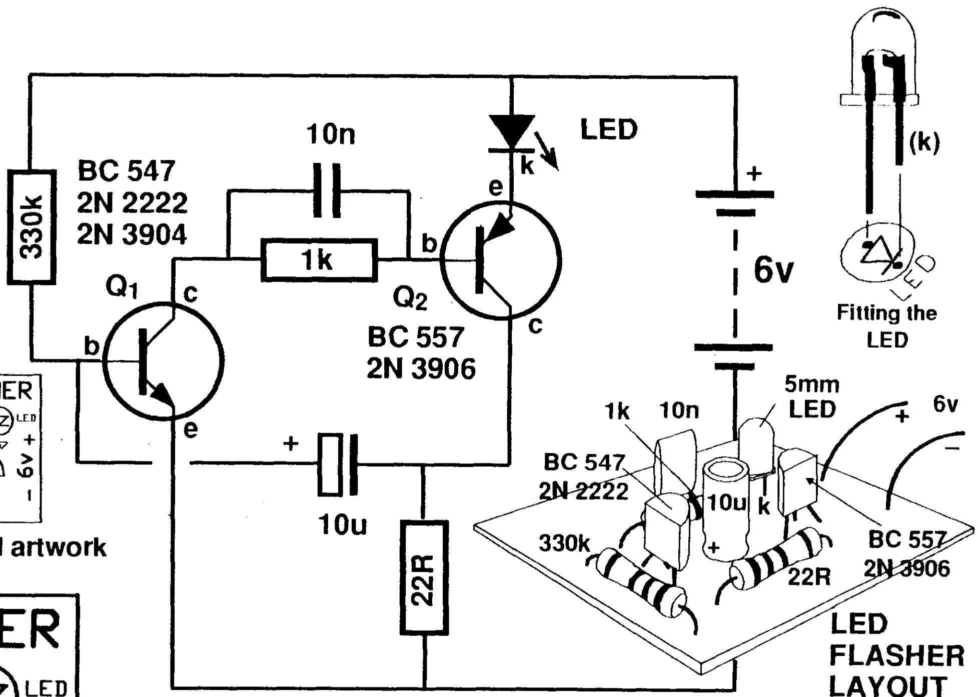
MAKE YOUR OWN FLASHING LED

LED FLASHER

Parts & PC board: $2.20
PC board only: $1.00

PARTS LIST

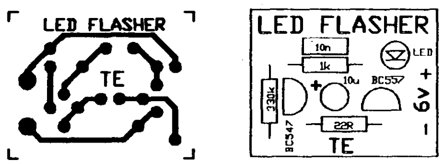
1 - 22R
1 - 1k
1 - 330k
1 - 10n
1 - 10u 16v electrolytic
1 - 2N 2222, or BC 547
1 - 2N 3906 or BC 557
1 - 1/4" (5mm red) LED
1 - red lead (5cm long)
1 - black lead (5cm long)
1 - **LED FLASHER PC**



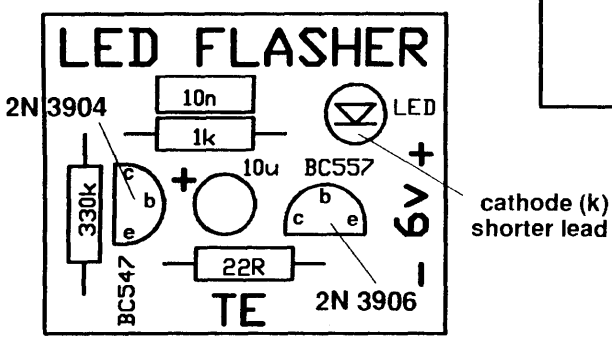
Fitting the LED

LED FLASHER LAYOUT

LED FLASHER CIRCUIT



Full-size LED Flasher PC board artwork



Enlarged view of LED Flasher overlay

You can make your own flashing LED with 7 components, an ordinary 3mm or 5mm (1/8" or 1/4") LED and a small PC board. This circuit has a couple of advantages over the flashing LED you can buy as a discrete item. It pulses the LED with a higher peak current to give a brighter illumination and consumes less average current than a flashing LED. This means it will work for a long time on an almost flat battery and cost nothing to run. It can be used for battery equipment to indicate the power is ON or as an ALARM ON indicator.

You can use a superbright LED and get a really bright flash, or an ordinary green, orange or yellow LED to get something better than a flashing red LED.

THE CIRCUIT

The operation of the circuit is as follows: When the battery is connected, both transistors are off and the electrolytic charges via the 330k resistor. The 22R completes the charge path.

When the voltage on the base of Q1 rises to about .6v, the transistor turns on and its collector-emitter voltage drops. This turns on Q2 via the 1k resistor. The 10n reduces the effect (the resistance) of the 1k resistor and Q2 conducts and the LED is illuminated. The current through the LED is limited by the 22R resistor and at this part of the cycle a voltage is developed across the 22R. The negative end of the electrolytic is 'jacked up' by this voltage and the positive end of the electro pushes its charge into the base of Q1 to turn it on even harder.

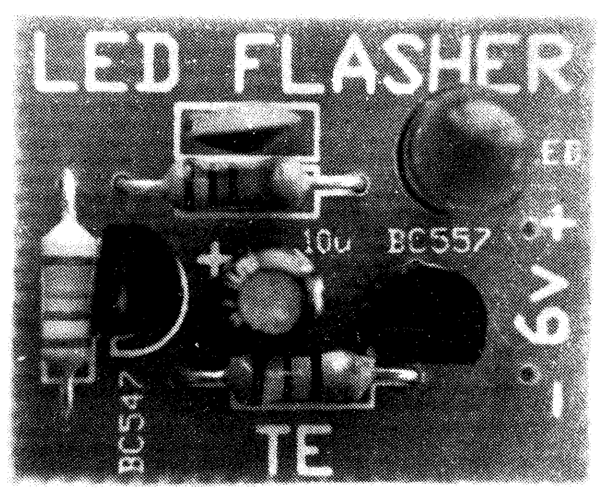
In a very short time all the energy in the electro has been delivered to Q1 and it cannot hold Q1 on any longer. The transistor turns off slightly and this has the effect of turning off Q2. The LED turns off and the voltage across the 22R disappears. The negative lead of the electro drops and so does the positive lead.

Q1 is turned off and this turns off Q2 and the LED is extinguished. The cycle starts again by the 10u electro charging. The charge time is considerably longer than the discharge time and this gives the LED a very brief flash.

CONSTRUCTION

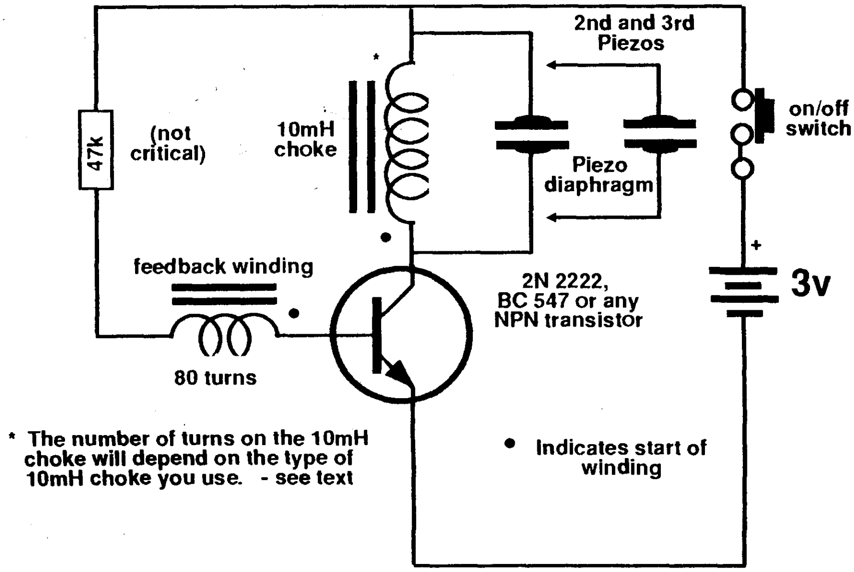
All the parts mount on a small PC board and because the board has an overlay (all Talking Electronics boards have overlays), you need no further instruction on where the parts go. That's why we have overlays on all our boards - so everyone can build the projects.

This project is a good place to start and you can use almost any set of old cells for the supply and let the flasher use them up. See how long they last!



Learn about the transformer feedback oscillator with the:

MINI PIEZO SIREN



Piezo Siren Circuit

The Piezo Siren circuit is a simple arrangement driving a piezo diaphragm.

No kit is available for this as we are mainly interested in describing how the circuit works. But to get the most out of the article you should put it together using parts from your junk box.

The piezo diaphragm can come from a music card and if you have two or three diaphragms, they can be added in parallel as shown on the diagram to see how they affect the frequency of the output.

The only component you will have to make is the "transformer." This is a standard 10mH inductor with 80 turns of enamelled wire wound around it to create the feedback winding. The inductor can be found in a number of our kits such as the light alarm, battery backed piezo siren or purchased as a separate component from a large electronics store.

Even though the circuit is very simple, it introduces a number of important features and that's why we have decided to cover every aspect in detail.

THE CIRCUIT

The circuit uses a transistor to drive a piezo and when we discuss the operation of a transistor we are describing TRANSISTOR ACTION. This is the action of a transistor amplifying the current entering the base and allowing a larger current to flow through the collector-emitter circuit. TRANSISTOR ACTION is simply another name for TRANSISTOR AMPLIFICATION.

The circuit also demonstrates TRANSFORMER ACTION (the component across the piezo diaphragm is essentially an inductor with an over-wind to supply positive feedback to the base of the transistor.

A very simple circuit to show how a transformer feedback oscillator works.

Getting the circuit to work will depend on a number of factors including selecting the correct 10mH choke and piezo. You may have to try various types and swap the feedback winding to achieve oscillation. Read the article before doing anything.

These two windings demonstrate TRANSFORMER ACTION (the action of a waveform in one winding being passed to another winding. The waveform is passed via electro-magnetism - a magnetic field - and this is magnetism produced by electrical current.)

The inductor and piezo diaphragm in parallel form an arrangement called a PARALLEL RESONANT CIRCUIT.

The overall circuit forms an oscillator called a TRANSFORMER FEEDBACK OSCILLATOR.

This gives us four topics to discuss. We will discuss them in a non-technical way so you don't get lost in technicalities.

Parts you will need:

1 - 47k (yellow-purple-orange-gold)
1 - 2N 2222 or BC 547 transistor
1 - 10mH choke
1, 2 or 3 piezo diaphragms
2 - AA cells
1 - SPDT slide switch
2.5 metres winding wire (gauge not critical for 80 turn feedback winding)

1. TRANSISTOR ACTION

Transistor action is simply the amplifying action of the transistor. A transistor amplifies the current entering the base and causes a higher current to flow in the collector-emitter circuit. The ratio of these two is the gain of the transistor and is generally about 100, however the gain can range from 20 to 400 or more, depending on the type of transistor and the value of the surrounding circuit components.

Our circuit turns on when the transistor receives current into the base via the 47k base-bias resistor.

The transistor amplifies the current about 100 times and allows the higher current to flow in the collector-emitter circuit. This is called TRANSISTOR ACTION or TRANSISTOR AMPLIFICATION.

The base-bias resistor is designed to partially turn the transistor ON and this causes a medium amount of current to flow through the collector-emitter circuit.

2. TRANSFORMER ACTION

Connected to the collector is a coil of wire called an inductor. The wire is wound on a ferrite core. Ferrite is an iron material in which the particles of iron are surrounded by an insulating material so that the iron particles are magnetically separate.

This allows each particle to form very small magnetic dipoles and prevents currents called EDDY CURRENTS from passing through the material.

When current passes through the winding it produces EXPANDING MAGNETIC FLUX and this flux cuts the turns of the winding we have added, called the feedback winding.

This feedback winding is connected to

THE DIFFERENCE BETWEEN PIEZO DIAPHRAGMS AND PIEZO BUZZERS.

There is a lot of misunderstanding when describing a piezo diaphragm and a piezo buzzer.
I never use the word piezo buzzer.
A piezo diaphragm is a passive component. It needs a driving circuit to create an output. A piezo diaphragm does not produce any sound when connected to a DC supply.
A piezo buzzer on the other hand produces a tone when connected to a DC supply.

To prevent any ambiguity I prefer to describe the buzzer as a piezo diaphragm with an active or driving circuit.

We have quite often ordered piezo buzzers from the manufacturer and received piezo diaphragms so that's why we make a clear distinction.
Sometimes an active tone generating circuit is enclosed in the same housing as the diaphragm. If you are not sure, ask if a tone generating circuit is present. This tone circuit can give a constant tone, a warbling tone, a two-tone output or a beeb-beeb-beeb output such as a truck reversing indicator.

the base of the transistor so that the current it produces is ADDED to the current supplied by the base-bias resistor and this causes a greater current to flow in the base of the transistor.

This causes the transistor to turn on more with the result that a higher current flows through the inductor.

The current continues to increase until the transistor is fully turned on and at this point in the cycle the flux is a maximum but it is NOT EXPANDING. Only expanding flux cuts the turns of the feedback winding and produces a current in it. Stationary magnetic flux does not produce (induce) a current in the overwind and thus the current produced by the feedback winding ceases.

This causes less current to flow in the base of the transistor and the transistor turns off a slight amount (don't forget, the base-bias resistor is still providing a small amount of turn-on current).

The current through the inductor reduces and the flux begins to reduce. This causes a collapsing magnetic field to be present and this flux cuts the feedback winding to produce a current in it of opposite polarity.

The feedback current opposes the current supplied by the base-bias resistor and the base sees a lower current.

This causes less current to flow in the base and the transistor turns off more.

This action continues to run around the circuit until the transistor is fully turned off.

At this point the current supplied by the base bias resistor takes over to start the cycle over again.

The number of turns on the feedback winding is worked out by winding sufficient turns to get the circuit to work then removing a few at a time until the circuit fails to work. A few turns are then added to guarantee operation. The energy from the feedback winding must be enough to maintain oscillation.

3. THE PARALLEL RESONANT CIRCUIT

As far as the circuit is concerned, a piezo is a capacitor of about 10n to 20n. The inductor and capacitor form a tuned circuit or PARALLEL RESONANT CIRCUIT and if the piezo is removed, the circuit will not operate (see below for the waveform produced when the capacitor is removed). A tuned circuit consisting of a coil and capacitor produces a waveform very similar to a sinewave when energy is supplied to them. The transistor plays no part in the shape of the waveform, it merely turns on at the correct instant to supply the pulse of energy.

Piezo diaphragms give the loudest output at about 3kHz to 5kHz and two or three can be added in parallel across the inductor to alter the frequency and bring it near the 3-5kHz range. This will give the loudest output from all the piezos.

4. THE TRANSFORMER FEEDBACK OSCILLATOR

A circuit oscillates when its input receives an IN PHASE signal from the output. That is: a signal that ADDS to the input signal. This is called a positive feedback signal.

Oscillation is sometimes called instability and this always occurs when positive feedback is present.

The feedback winding in our circuit must be wired so that positive feedback occurs. If the circuit does not oscillate when first switched on. simply reverse the feedback winding and oscillation will occur.

This type of circuit is called an Armstrong oscillator (ref: Understanding Oscillators by Barry Davis P 94.)

The values that set the frequency of oscillation are the inductance of the inductor and the type of piezo diaphragm.

THE 10mH CHOKE

We said we were not going to get into any complex discussions in this article and I hope you have followed us up to now.

If I said you can buy hundreds of different 10mH chokes, you may start to wonder if you will ever get this project working.

Fortunately most of the chokes will work in this circuit but just in case you get an unusual one, I want to mention why some may not work.

THE PIEZO DIAPHRAGM

One of the most annoying components in electronics is the piezo diaphragm.

We find it everywhere. In musical cards, watches, sirens, and even as shock sensors.

It comes in various shapes and sizes according to the job it does, however they are all almost identical in design.

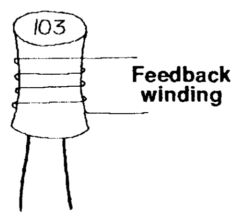
It consists of a sheet of metal (such as brass) with a thin layer of ceramic on one side. On top of the ceramic is a conducting layer. This becomes one plate of a capacitor. The other plate is the brass sheet.

When a voltage is present across the two plates, the ceramic material shrinks. When the voltage is reversed, the ceramic stretches. Since the ceramic is only on one side of the brass plate, the plate bends in the centre like a "dish" then bends "out." This movement vibrates the air and gives us the very annoying high frequency sound.

The piezo diaphragm is called a transducer because it is capable of converting electrical signals into sound waves.

It is a passive device (a transistor is an active device) as it does not have any amplifying capability and requires a driving circuit (such as a transistor), to provide it with a waveform so that it can produce an output.

Some piezo diaphragms have a transistor and other components contained in the same housing. These are sometimes called piezo buzzers but this name can be misleading as they don't sound like a buzzer at all. Sometimes they call a piezo diaphragm a "buzzer" and this makes it even more confusing. If a piezo diaphragm is connected to a DC voltage it will only give a very weak click and not buzz at all so you must be very clear when you specify the difference between a diaphragm and a device with an active circuit enclosed in the same case.



Winding the 80 turns around the 10mH choke to make the feedback winding.

The two we tried had a DC resistance of 4 ohms and 180 ohms and it would be reasonable to assume anything in between will be suitable. However you can get some 10mH chokes outside this range and their operation will be unknown. Especially chokes with very low resistances.

Why can the resistance vary so much and how is the value of inductance determined?

A particular value of inductance such as 10mH can be obtained by winding a few turns of very thick wire around a large core or many turns of thinner wire around a smaller core or lots of turns of very thin wire around a very small core. Each of these will create a 10mH choke and give the same result in a "test circuit."

What do we mean by the same result? Each will create the same amount of magnetic flux in the core of the inductor when a known current flows.

But when these inductors are used in our circuit they will behave differently because of the different DC resistances. (In the laboratory, a different voltage will be applied to each to achieve the same current flow due to the different resistance values). We have a fixed voltage of 3v for our circuit and so a medium resistance coil is required.

If the resistance is too low, the transistor will have difficulty passing sufficient current to generate the necessary flux. If the coil resistance is too high, the supply voltage will be insufficient to pass the required current.

THINGS WE HAVE COVERED

Firstly, the waveform appearing across the piezo diaphragm is generated by the parallel combination of the coil and piezo. We have learnt that the piezo is seen by the circuit as a capacitor and this means the coil and piezo form a parallel tuned circuit.

The transistor plays no part in the generation of this waveform.

The transistor merely delivers a small amount of energy to the resonant circuit. The coil and capacitor will then continue to create a waveform for a number of cycles by passing energy from the coil to the capacitor and back again. But each time a small amount of the energy is lost by the piezo when it distorts the diaphragm in the process of making a sound and the waveform would eventually die away.

Some of the energy is also lost when it is passed to the feedback winding and injected into the base of the transistor to turn it on.

The job of the transistor is to inject a small amount of energy into the inductor/capacitor combination at the correct portion of each cycle so that the waveform is maintained.

The frequency of the waveform is determined by the value of the coil and capacitor (piezo). The transistor or the 47k base-bias resistor has no effect on determining the frequency. If the capacitor (the piezo) is removed, the frequency will increase and change shape into a very spiky waveform.

The timing-effect or "controlling effect" of the capacitor has been lost and the frequency is now determined by the speed with which the coil can produce magnetic flux and the time for the transistor to turn on.

The amplitude of the waveform will also increase from 3v to 60v and this could

TURNING ON A TRANSISTOR

There are two ways to describe how a transistor turns on. One is to discuss the voltage on the base and the other is to talk about the current on the base. In fact the turning on is a combination of both.

Exactly what happens is this: The transistor does not turn on until the voltage on the base reaches 0.6v.

At this voltage you can deliver a very small current to the transistor. As you increase the current, the voltage on the base rises. This is something you have no control over. It is called a CHARACTERISTIC of the transistor. At medium current the base voltage will be about 0.65v and at maximum current the voltage will be about 0.7v.

The transistor creates this voltage between the base and emitter terminals and is called the "base-emitter junction voltage."

When measuring the base voltage, a value of less than 0.6v will indicate the transistor is not turned on at all, at 0.6v the transistor is at the point of being turned on; 0.65v will indicate the transistor is turned on and 0.7v will indicate the transistor is fully turned on.

THE FEEDBACK WINDING

The secret behind the circuit working (oscillating) is the feedback winding. It must be connected to the base around the correct way so that it provides positive feedback.

The circuit shows how to connect the transformer with the start of one winding going to the base of the transistor and start of the other winding to the collector. You can only use this information if you have wound the transformer yourself as then you will know the start of each winding and also know that the two windings are wound IN THE SAME DIRECTION.

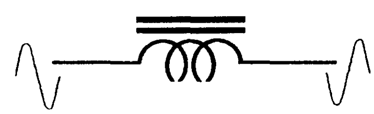
The transistor provides the initial 180° phase shift and the feedback winding provides a further 180° to bring the output signal into phase with the signal on the base.

When we study the circuit, we see the voltage on the base increases when the transistor is turned on and this causes the voltage on the collector to decrease. This means the two signals are out-of-phase by 180°. The feedback winding is then connected so that the two signals are in phase and the circuit becomes a feedback oscillator.

WHAT WE MEAN BY PHASE-SHIFT

In the article, we talk about the phase shift provided by the feedback winding and the phase shift produced by the transistor.

Each phase-shift is 180° and this means the combination of the two produces a 360° phase shift. This brings the output in phase with the input and creates positive feedback. It is easy to see how the feedback winding creates 180° phase shift.



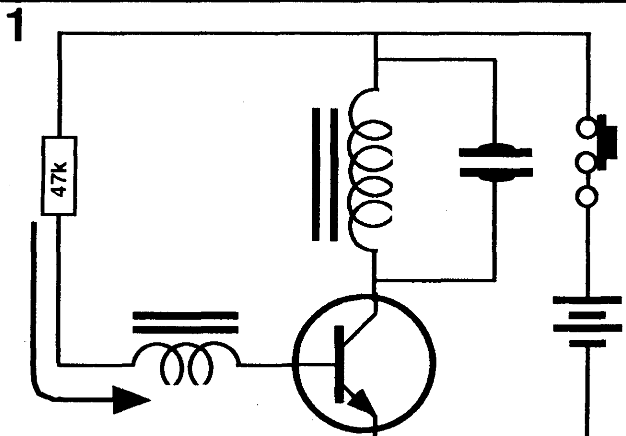
The signal appearing on the ends of the feedback winding

The signal appearing on the feedback winding is shown in the diagram above. At the beginning of the cycle it is increasing on one line while decreasing on the other. If the winding is connected around the correct way the increasing voltage will add to the voltage supplied by the 47k base-bias resistor and the transistor will turn on more. If the winding is connected incorrectly the output of the feed-back winding will subtract from the voltage supplied by the 47k resistor and the transistor will fail to maintain oscillation.

The transistor also creates 180° phase-shift and this phase-shift is shown by taking the rising voltage on the base and comparing it to the voltage on the collector. When the voltage is rising on the base the transistor is being turned on and this causes the voltage on the collector to fall. This means the two waveforms are out-of-phase and this is how we arrive at a 180° phase-shift.

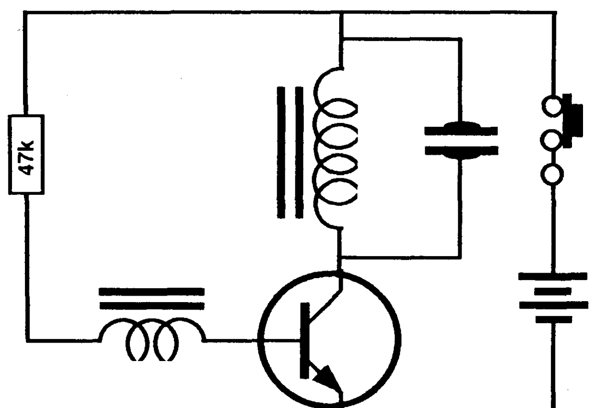
How the circuit works: A Step-by-Step analysis.

1



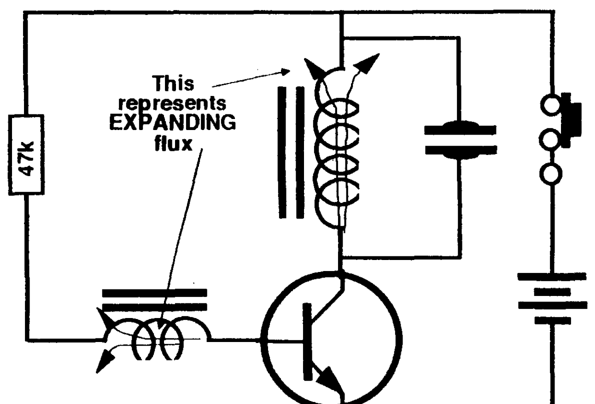
The circuit starts when current flows through the 47k resistor and into the base of the transistor.

2



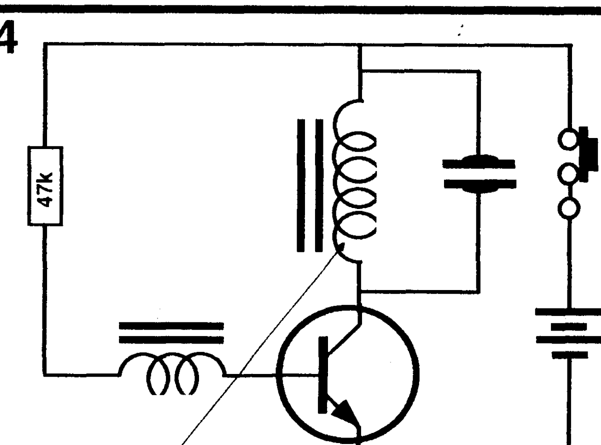
The transistor turns on and passes current through the coil on the collector. The coil produces magnetic flux.

3



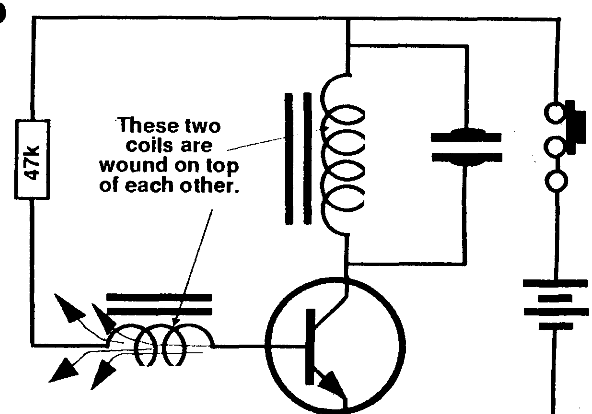
The magnetic flux cuts the turns of the feedback winding and produces a voltage and current in it to turn the transistor on harder.

4



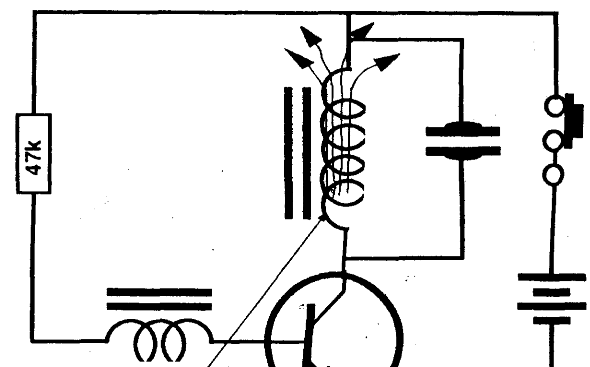
More current flows through the coil and the magnetic flux increases.

5



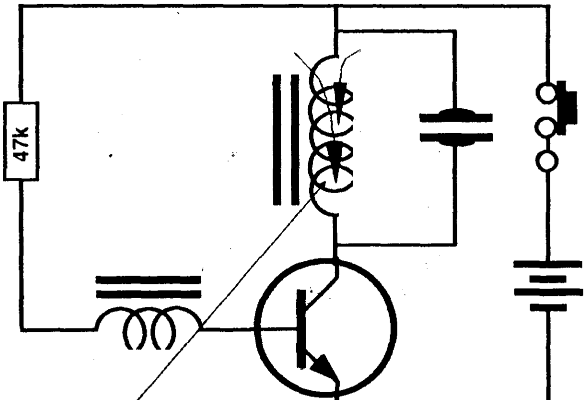
The voltage and current in the feedback winding increases and turns the transistor fully ON..

6



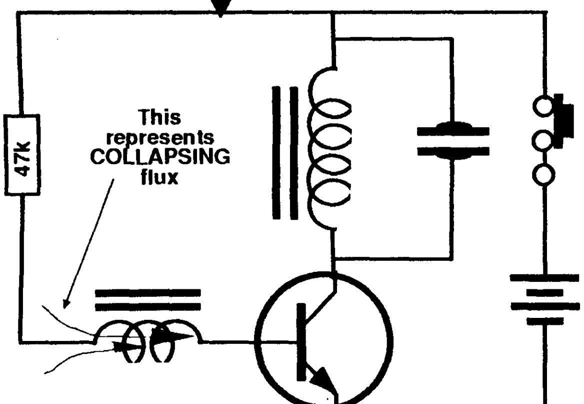
The magnetic flux increases to a maximum and remains stationary AT A MAXIMUM. This means flux is produced by the main coil but nothing cuts the feedback winding.

7



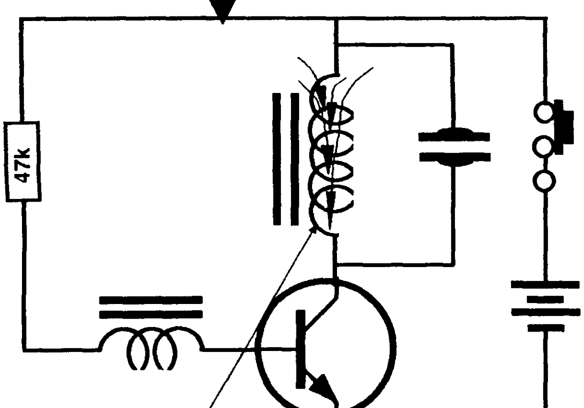
This makes the transistor turn off a small amount and the flux in the main coil becomes a COLLAPSING MAGNETIC FLUX.

8



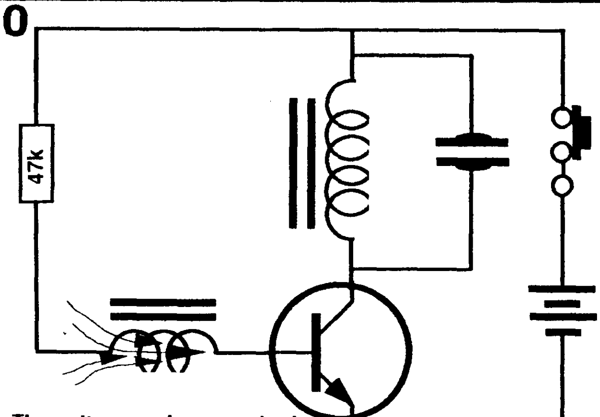
The flux is now in the OPPOSITE DIRECTION and cuts the turns of the feedback winding to produce a REVERSE VOLTAGE.

9



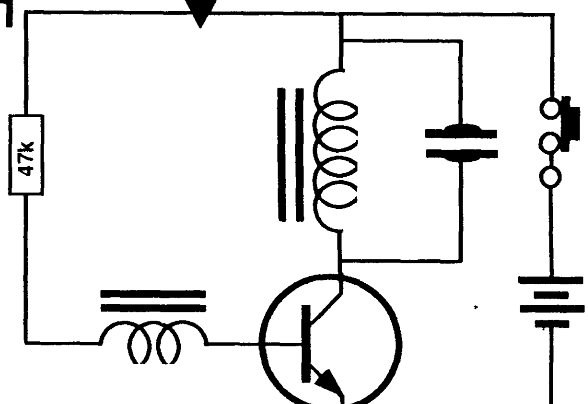
This turns the transistor off more and the collapsing magnetic field continues to collapse until all the field has been converted to voltage.

10



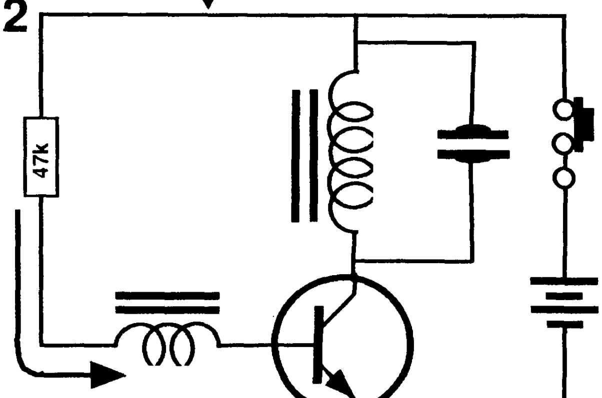
The voltage and current in the feedback winding turns the transistor off completely and the voltage from the main winding is passed to the capacitor.

11



The magnetic flux in the main coil collapses completely and the voltage and current in the feedback winding ceases.

12



The transistor gets turned ON again via the 47k base resistor to start the next cycle.

damage the transistor. In fact the 60v we measured across the coil represents the zener voltage of the transistor as the transistor is zenering when the capacitor is removed. That's why a simple circuit such as this can damage a transistor when the piezo is removed.

This is a completely different set of conditions and will not be covered in this discussion.

One of the important features of the capacitor (the piezo) is the "controlling effect" on the frequency. The capacitor takes time to charge and discharge and this determine the frequency of the waveform.

As more piezos are added in parallel across the coil, the frequency reduces and as it comes into the range 3kHz to 5kHz, the output of each piezo increases.

Before leaving this discussion we will go over the twelve step-by-step diagrams on the previous pages. They explain a very important concept called TRANSFORMER ACTION and if you have built the circuit you will be able to carry out a simple experiment to show the effect of removing turns from the feedback winding.

Simply loosen the turns and slip some of them off the top of the inductor. A point will be reached when the circuit ceases to operate. This is the CRITICAL VALUE and by adding a few turns onto the inductor the oscillator will start up again.

When designing a circuit like this, you must add a few extra turns so that the circuit is guaranteed to start-up every time.

As you remove the turns you are supplying the transistor with less energy and a point is reached where the transistor does not have sufficient gain to allow enough current to flow through the coil and create the required amount of magnetic flux for the feedback winding.

THE STEP-BY-STEP DIAGRAMS

FRAME 1

The first frame shows the transistor turns on when current enters the base via the 47k resistor.

The transistor amplifies this current and allows about 100-200 times the current to flow in the collector-emitter circuit.

FRAME 2

This current also flows through the coil and produces magnetic flux. The flux lines are shown on the diagram as upward lines but this is only diagrammatical.

We have shown upwards lines to represent expanding flux and downwards lines to represent collapsing flux. The lines are actually imaginary but the important point is the strength of the magnetic field is INCREASING.

FRAME 3

The turns of the feedback winding are wound over the main coil and the expanding flux cuts the turns to produce a voltage. It also produces a current but the size of the voltage and current is not important at this stage. The thing that is important is the POLARITY OF THE VOLTAGE.

The feedback winding must be wired so that the voltage ADDs to the voltage from the 47k resistor. When the voltage ADDS, more current will flow into the base of the transistor. This causes the transistor to turn ON more.

FRAME 4

When the transistor turns on more, a higher current flows through the coil and this produces more flux.

FRAME 5

The higher flux produces more voltage (and current) in the feedback winding and a cyclic-action results with the transistor turning on more and more.

FRAME 6

A point is reached where the transistor is turned on FULLY and the magnetic flux produced by the coil is a MAXIMUM but it is NOT EXPANDING and the feedback winding does not see any moving flux. Therefore it does not produce any voltage or current AT ALL.

FRAME 7

This causes the transistor to turn off almost completely - to the level provided by the 47k resistor.

The current in the coil falls to almost zero and the magnetic flux cannot be maintained.

The result is the magnetic flux collapses. In other words it becomes REDUCING MAGNETIC FLUX and this flux cuts the turns of the feedback winding. (The flux we are talking about is in the ferrite core of the inductor.)

FRAME 8

We can consider this reducing magnetic flux to be REVERSE MAGNETIC FLUX as it produces a voltage and current in the feedback winding that is of opposite polarity to that in frame 3. The current produced by the feedback winding is opposite to that supplied by the 47k resistor and thus the transistor turns OFF completely.

FRAME 9

The magnetic field continues to collapse until all the magneitic energy from the core has been converted to electrical energy in both windings.

FRAME 10

At this point in the cycle two things happen.

1. The electrical energy produced by the main winding produces a very high voltage (with very low current) and this voltage is passed to the capacitor (the piezo) where it distorts the diaphragm - see Piezo Diaphragm notes on page 60.

2. The energy produced by the feedback winding keeps the transistor OFF.

FRAME 11

The magnetic flux contained in the ferrite core of the inductor is completely converted to electrical energy in the two windings.

FRAME 12

When all the magnetic flux is converted to electrical energy, the reverse voltage produced by the feedback winding ceases and the transistor gets turned on again via the 47k resistor to start the next cycle.

This action repeats 5,000 times per second and the piezo diaphragm bends and "dishes" to produce the annoying sound we know as a "piezo."

CONCLUSION

This simple circuit highlights the complex nature of a transformer. Whenever you see a transformer in a circuit you will not be able to work out what it is doing unless you know the parameters of the components driving it.

The only way to get these parameters is to see the waveforms on a CRO (Cathode Ray Oscilloscope).

The size and shape of the waveform will depend on many factors: The size of the transformer, the number of turns, the core material, the number of windings, the loading on the transformer, the frequency of operation, and many other things.

Transformers are very handy devices and will always find their place in modern circuits as they can convert a voltage to a higher or lower value, transform current to a higher or lower value, modify waveforms, invert pulses and a dozen other things.

Three things we have covered in this discussion are:

1. A waveform (or signal or voltage or current) is passed from one winding to another via magnetic flux. In other words the signal in one winding produces magnetic flux and this flux cuts the turns of the other winding and produces a waveform (or signal) in that winding.

2. The transfer of a waveform only occurs when the signal in the first winding is changing.

There is one thing that changes the waveform considerably. If the driving circuit is switched off abruptly, the magnetic flux contained in the core of the transformer collapses and cuts the turns of each winding and produces a waveform that can be very high in value. This is sometimes called the FLYBACK EFFECT such as used in a flyback circuit with a flyback transformer.

This is why transformers are such fascinating devices.

TEST YOURSELF No1

How good are you at identifying resistors? This quick test will give you a rating.

The most common component in electronics is the resistor. You see it so often you may take it for granted that you know a lot about resistors. But do you? Actually you could spend a whole lifetime studying resistor characteristics and insulating materials and still only know a fraction. This simple test should bring out your knowledge of resistors.

Can you name any other component which is made to exacting standards yet sells for just 2 cents? No, possibly not. Automation has made this possible as quarter and half watt resistors have reduced in price dramatically in the past decade and yet their quality has risen dramatically.

This test is graded into two sections: Beginners should attempt questions 1 to 10 while more advanced hobbyists can work right through. The answers appear at the end of the test.

1. Write down all the resistors between 10ohms and 270ohms: (use the E12 series or common series) (16 marks)

2. Draw the symbol for:
   (a) A fixed resistor (1 mark)
   (b) A potentiometer (1 mark)

3. What is the difference in appearance between a 47ohm resistor and a 4k7 resistor? (1 mark)

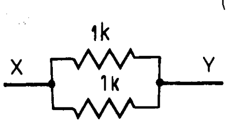
4. Write down the value of these resistors:
   (a) red–red–orange: (4 marks)
   (b) yellow–purple-brown: (4 marks)
   (c) blue–grey–orange: (4 marks)
   (d) red–purple–green: (4 marks)
   (e) green–blue–red: (4 marks)

5. What are the colours of these resistors?
   (a) 2.2M (4 marks)
   (b) 470ohm (4 marks)
   (c) 56k (4 marks)
   (d) 220ohm (4 marks)
   (e) 3k3 (4 marks)

6. What is the value between A&B? (1 mark)

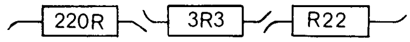
7. If two resistors have the same colours but are of different size; what does this tell us? (1 mark)

8. What is the value between X&Y? (1 mark)



9. What is the value of these resistors?
   (a) Silver–green–orange–orange: (4 marks)
   (b) Gold–brown–purple–red: (4 marks)

10. Explain the value of these resistors: (3 marks)



Total 73 Marks

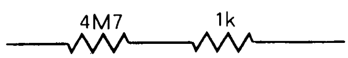
SECTION 2: More Advanced

11. With 2 resistors in series, why should the value of each be nearly the same: (4 marks)

12. Choose ½ watt resistors to make each of these values:
    (a) 1k 1 watt: (2 marks)
    (b) 3k3 2watt (2 marks)
    (c) 4M7 1 watt: (2 marks)

13. Give 2 situations where question 12 may arise in practice:
    (i)
    (ii) (2 marks)

14. Explain why this is unnecessary (Hint: tolerance) (1 mark)



15. A 2k2 ½ watt resistor is getting too hot. What should you do? (1 mark)

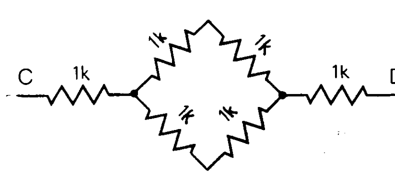
16. Four resistors, all consisting entirely of red bands, are paralleled. What is the combined resistance? (4 marks)

17. How can you detect, without instruments, if a wire-wound resistor is not functioning? (1 mark)

18. What is the value of these?
    (a) yellow–purple–gold–silver: (4 marks)
    (b) red–red–gold–gold: (4 marks)
    (c) yellow–purple–silver–gold: (4 marks)

19. What are the colours of these resistors?
    (a) R27 10% (4 marks)
    (b) 1R5 10% (4 marks)
    (c) 3R3 5% (4 marks)
    (d) 1R0 5% (4 marks)

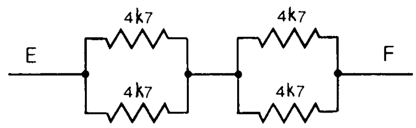
20. What is the value across the terminals C&D? (5 marks)



21. From a sample of 50 different resistors, which colour appears most often? (2 marks)

22. A black bag contains 10 1k resistors and 10 3k3 resistors. How many resistors must you choose to be guaranteed a resistance of:
    (a) 1k (5 marks)
    (b) 10k (5 marks)
    (c) 4k3 exactly (5 marks)

23. What is the resistance between E&F? (5 marks)



Total 74 Marks

Answers:

1. 12ohms, 15ohms, 18ohms, 22ohms, 27ohms, 33ohms, 39ohms, 47ohms, 56ohms, 68ohms, 82ohms, 100ohms, 120ohms, 150ohms, 180ohms, 220ohms. 2. (a) (b) 3. The third colour band: black, red. 4. (a) 22k (b) 470ohms (c) 68k (d) 2M7 (e) 5k6 5. (a) red–red–green (b) yellow–purple–brown (c) green–blue–orange (d) red–red–brown (e) orange–orange–red 6. 2k 7. Their wattage is different 8. 500ohms 9. They were read around the wrong way! (a) 3M3 10% (b) 270ohms 5% 10. 22ohms; 3point3 ohms; point 22 ohms 11. So the heat dissipated by each will be nearly the same. So that the voltage across each will be nearly the same. 12. (a) Two 2k2 resistors in parallel or two 470ohm resistors in series (b) Four 12k resistors in parallel or four 820ohm resistors in series (c) A 2M2 and 2M7 resistor in series or two 10M resistors in parallel. 13. When no 1 watt resistor is available, when a high voltage is present two resistors are put in series. 14. The tolerance of the 4M7 resistor will swamp the small effect of the 1k resistor. 15. Check the circuit for leaky or shorted transistors. If the voltage across the resistor is correct it may need a higher wattage. 16. 550ohms 17. Touch it with a wet finger, it should be hot. 18. (a) 4R7 10% (b) 2R2 5% (c) R47 5% 19. red–purple–silver–silver (b) brown–green–gold–silver (c) orange–orange–gold–gold (d) brown–black–gold–gold 20. 3k 21. red 22. This is a trick question. (a) you must choose 3 resistors which can be paralleled up to give 1k1 or 1k. (b) 12 resistors, at worst you may be choosing nine 1k resistors then you need three at 3k3. (c) 11 resistors. 23. 4k7.

Score:

For each section:

Over 65 marks	– Excellent
Over 50	– Very Good
Over 40	– Good
Below 40	– Not a Pass

TEST YOURSELF... No 2

How good are you at identifying capacitors?
This quick test will give you a rating.

CAPACITORS ..

Capacitors come in so many shapes and sizes. They have at least 3 different identification codes and sorting them out can be quite difficult. This can be a problem as their size bears no relationship to their value, rating or type of constructional material. So let's see how much you know....try this test and give yourself a rating. The marks for each question do not relate to their difficulty.

1. Name 5 types of capacitors:
   A: (No cheating now)
   B:
   C:
   D:
   E: (10)

2. Draw the symbol for:
   (a) A capacitor:
   (b) An electrolytic:
   (c) A variable capacitor:
   (d) A non-polar 10mfd electro: (8)

3. Explain with words or a drawing:
   (a) green cap:
   (b) PC mounting:
   (c) RT or PT leads:
   (d) "styro":
   (e) 

   (f) "poly": (8)

4. Arrange these capacitors in approx order of size: small,med,large:
   (a) 1mfd 63v ceramic.......( )
   (b) 1mfd 63v electrolytic..( )
   (c) 1mfd 63v paper.........( )
   (d) 1 mfd 63v polyester....( )
   (e) 1mfd 63v tantalum......( ) (3)

5. List all the values of capacitors between .001mfd and .027mfd: (16)

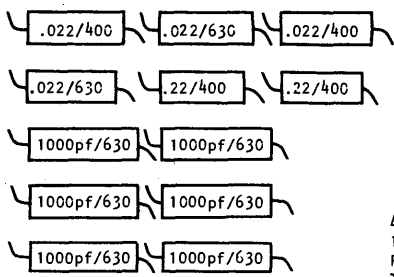
6. Can you give a simple explanation why these three electrolytics will be about the same physical size:

   1mfd 350v
   10mfd 35v
   100mfd 3.5v (2)

7. An electrolytic can suffer from at least 3 main faults. Can you name them:
   (a)
   (b)
   (c) (3)

8. Draw:
   (a) 2 capacitors in series:
   (b) 2 capacitors in parallel: (2)

9. Almost any value of capacitance can be created by joining caps in series or parallel or a combination of both. In addition, high-voltage ratings can be achieved with this method.



With the above set of capacitors, create these values:
   (a) .47mfd/400v
   (b) 500pf/400v or higher
   (c) 100pf/1Kv or higher
   (d) .01mfd/1Kv or higher (8)

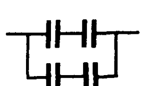
10. When choosing an electrolytic, why should its rated voltage be close to its working voltage? (2)

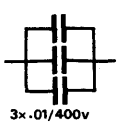
11. What is the advantage of a tantalum (and the new tantalum equivalent) over ordinary electrolytics? (4)

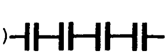
12. Would you use a ceramic capacitor as a timing capacitor? (the frequency setting capacitor in an oscillator circuit) (2)

13. What is the value of these combinations:

(a) 

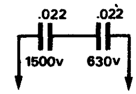
(b) 

(c) 

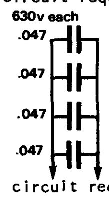
(d) 

(8)

14. Explain the fault with these arrangements:

(a) 

circuit requires .01/2Kv

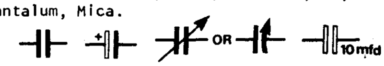
(b) 

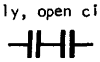
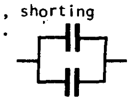
circuit requires .22/2Kv

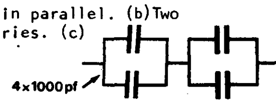
(4)

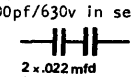
Total: 80marks.

Answers:

1. Paper, Ceramic, Polystyrene, air, Polycarbonate, Polyester, Electrolytic, Tantalum, Mica.
2. 

3.(a)the name given to a style of polyester capacitor using green resin coating. (b)Printed Circuit Mounting with both leads at one end.(c)Rat Tail, PT=Pig Tail - where one lead emerges from each end. (d)Polystyrene (e)N:style number which does not involve us. 630:the working voltage .68:the capacitance in mfd K:tolerance which is ±10% (f) Polypropylene or polyester. 4.Approximately the paper will be the largest,then polyester,ceramic,electrolytic and tantalum the smallest. 5..0012,.0015, .0018,.0022, .0027, .0033, .0039, .0047, .0056, .0068, .0082, .01, .012, .015, .018, .022. 6. A factor obtained by multiplying the capacitance and the voltage will give the size of an electrolytic. 7. Drying out and losing capacitance, intermittent connections to the leads, shorting internally, open circuit.
8. (a)  (b) 

9. (a)Two .22mfd in parallel. (b)Two 1000pf/630v in series. (c) 

(d) 

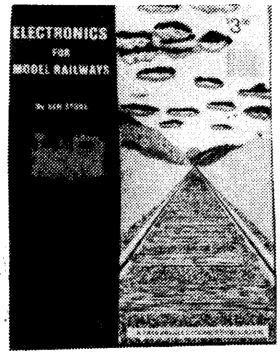
10. To keep the electrolytic "formed" 11.smaller size, lower leakage current. 12.No,never. 13.(a)4n7/1kv (b)2n2/ 3kv (c)33n/400v (d)12n/2.5kv 14.The capacitance is correct but the voltage will be equal across each capacitor so that 1kv will appear across the 630v cap. (b)The cap. is correct but the voltage rating of the combination is still 630v. Thus 2kv will appear across the 630v capacitors.

score:

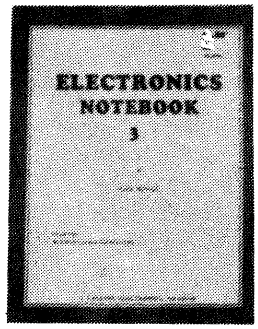
Over 70 marks - Excellent
over 60 - Very Good
over 50 - Good
below 60 - Not a pass

Book Section

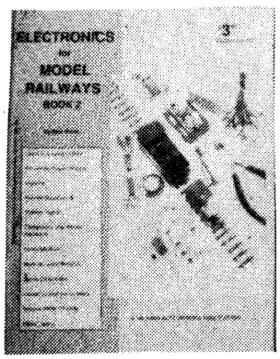
The following pages have been taken from Electronics Notebooks 1-6 and the 10 Minute Digital Course has been taken from Digital Electronics REVEALED. These books are available from Talking Electronics and are listed in the Order Form on page 41 in the centre of this issue. These pages give you some idea of the information in the books. Each issue will include a few more pages of the 10 Minute Digital Course. It will take more than 10 issues to fully cover the book and if you can't wait this long, you can send for the book. It only costs $5.00 plus postage and you can read it from cover to cover in an evening or so and keep it along side your other books, for easy reference.



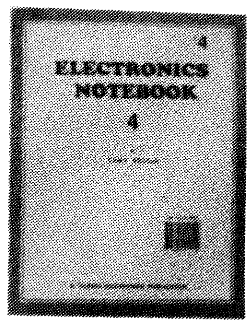
Electronics for Model Railways Book 1: $3.30
Air Horn
Capacitor Discharge
Crossing projects
Train Sensors
Light Chaser
Power Supply
Throttle
Warning Lamp
and more . .



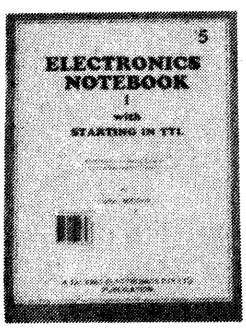
Notebook 3: $4
n values for capacitors
The Transistor
Surface mounting
The Zener
The Schmitt Trigger
The CRO
Using a logic probe
The Z-80 microprocessor



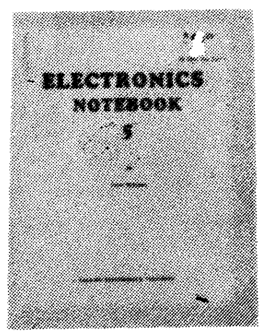
Electronics for Model Railways Book 2: $3.80
More projects for your layout including:
A Simple Power Supply,
Signals Module
Tunnel Stretcher
Walk-around Throttle
Delay Module
Diesel Sound
PWM Throttle
Fibre Optics



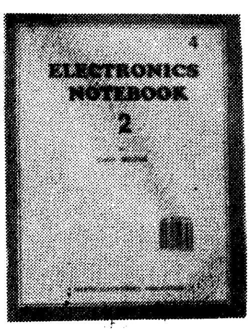
Notebook 4: $4
Identifying symbols
Soldering
Using a CRO
Ohms Law
Constant current circuit
The Thyristor
The Triac
Zener diode
5v regulator
D Flip Flop
Motor controller
Boolean Algebra
and more



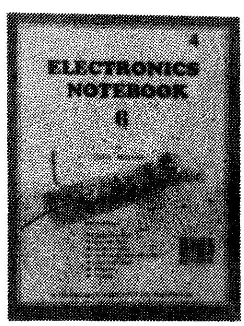
Notebook 1: $5
List of abbreviations
circuit symbols
electrical circuits
Ohms Law
The Antenna
Inductance
The diode
The Transistor
CRO waveshapes
The LED, and:
Starting in TTL. Including 20 experiments.



Notebook 5: $4
Resistors
Capacitors
Surface Mount
The Electrolytic
The Transistor
The CRO
Getting your BEC - a full set of questions with answers



Notebook 2: $4
Making PC boards
Super Alpha pair
Phase Shift oscillator
Motor boating
Push pull
Battery decoupling
Zener diode
Gating with diodes
The electret microphone
The Tank circuit
and more



Notebook 6: $4
Transistor tester project
Capacitance meter project
2 Field Strength meter projects
Logic Probe MkIIB project
Components in series and parallel
Surface-mount project
TTL project
IQ test
Glossary of terms
Index to notebooks 1-6

See the Order Form on page 41

THE PIEZO DIAPHRAGM

THE PIEZO DIAPHRAGM IS ANOTHER MIRACLE OF TECHNOLOGY AND IT IS APPEARING IN SO MANY APPLICATIONS, FROM MUSICAL XMAS CARDS TO WHISTLING KEY RINGS. BUT IN THIS FRAME WE ARE GOING TO HIGHLIGHT ITS USE AS A MICROPHONE.

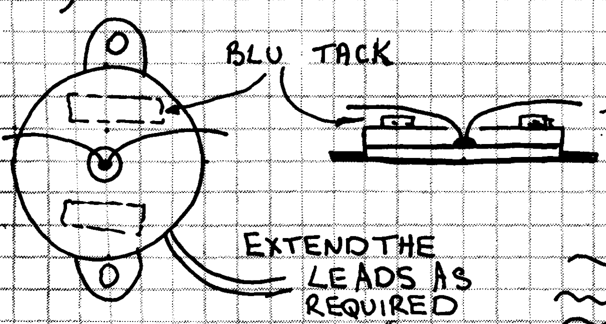
TO ACT AS A MIC THE DIAPHRAGM MUST BE SUPPORTED AT ITS EDGE SO THAT WHEN SOUND WAVES HIT THE DIAPHRAGM, IT WILL PRODUCE A HIGH OUTPUT. WE FOUND THE OUTPUT TO BE VERY CLEAN AND ALTHOUGH IT IS NOT NEARLY AS SENSITIVE AS AN ELECTRET MICROPHONE, IT CAN BE USED IN EXCITING NEW APPLICATIONS.

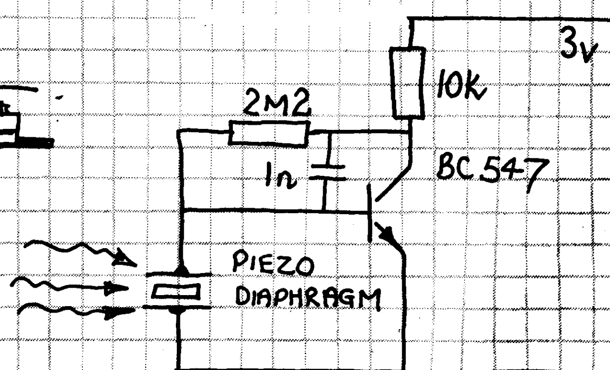
NORMAL SPEECH AT 30cm PRODUCES ABOUT 1mV AND A WHISTLE AT 30cm PRODUCES ABOUT 10mV. TOUCHING OR STRIKING THE DIAPHRAGM WILL PRODUCE A MUCH HIGHER OUTPUT AND IT CAN BE USED AS A GLASS BREAKAGE DETECTOR, A LOUD-NOISE DETECTOR OR A SHOCK DETECTOR.

BUT MORE INTERESTING IS ITS USE AS A WALL BUG. PICKING UP CONVERSATIONS THROUGH WALLS. WHEN MOUNTED ON A WALL, DOOR OR WINDOW, THE ACOUSTIC PROPERTIES OF THESE MATERIALS MEANS THEY ARE ACTING LIKE A HUGE SOUNDING BOARD & IT ONLY REQUIRES THE DETECTOR TO BE PLACED ON THE WALL & THE SOUNDS CAN BE AMPLIFIED SUFFICIENTLY TO HEAR CONVERSATIONS YOU NEVER THOUGHT EXISTED!

PIEZO DIAPHRAGMS VARY ENOURMOUSLY IN THEIR SENSITIVITY & WE FOUND MUSICAL CARDS TO BE AN EXCELLENT SOURCE OF HIGH SENSITIVITY UNITS. A SUITABLE TYPE IS SOLD BY DICK SMITH ELECTRONICS CAT. № L 7022 WHILE A 3-LEAD TYPE SOLD BY ANOTHER STORE WAS QUITE INSENSITIVE.

TO USE THE DICK SMITH UNIT ON A WINDOW, TWO PIECES OF TINNED COPPER WIRE ARE SOLDERED TO THE DIAPHRAGM (WITHOUT TAKING IT APART) THUS:





A SIMPLE PRE-AMP

BLUE TAC IS ATTACHED TO THE TRANSDUCER AND THE WIRES BENT SO THAT THEY TOUCH THE GLASS. THE BLUE TACK WILL KEEP PRESSURE ON THE WIRES AND HOLD THE UNIT IN PLACE. A SIMPLE AMPLIFIER FOR THE PIEZO IS SHOWN & THE 1n KEEPS THE STAGE STABLE & KEEPS UNWANTED SELF-INDUCED HUM TO A MINIMUM.

THE FUSIBLE RESISTOR

THE FUSIBLE RESISTOR IS A VERY SUCCESSFUL WAY OF PROVIDING CIRCUIT PROTECTION. TO DETERMINE WHERE IT CAN BE USED, A NUMER OF POINTS MUST BE UNDERSTOOD.

1. A FUSIBLE RESISTOR WILL DROP A SMALL VOLTAGE (IN OTHER WORDS A SMALL VOLTAGE WILL BE PRODUCED ACROSS IT). THIS MAY BE $1/10^{th}$ V to 1V, UNDER NORMAL CONDITIONS & WILL RISE WHEN A FAULT OCCURS.

2. A FUSIBLE RESISTOR MAY GET WARM OR HOT UNDER NORMAL OPERATION & WILL GET VERY HOT & BURN OUT WHEN A HEAVY LOAD OCCURS. — FOR THIS REASON IT MUST NOT BE PLACED NEAR FLAMMABLE COMPONENTS, TEMP SENSITIVE COMPONENTS OR AGAINST THE PC BOARD.

A FUSIBLE RESISTOR IS SIMPLY A NORMAL (LOW OHM) RESISTOR PLACED IN A CIRCUIT SO THAT A HIGH CURRENT WILL BURN IT OUT. THE PRINCIPLE OF OPERATION IS THE FACT THAT THE POWER (ENERGY) LOST IN A RESISTOR RISES VERY FAST WHEN THE CURRENT INCREASES. IN FACT IT RISES AS THE SQUARE OF THE CURRENT AS SHOWN IN THE FOLLOWING EQUATION:

$$P_{POWER} = I^2 R$$

[WE SAY: "I SQUARED R LOSSES"]

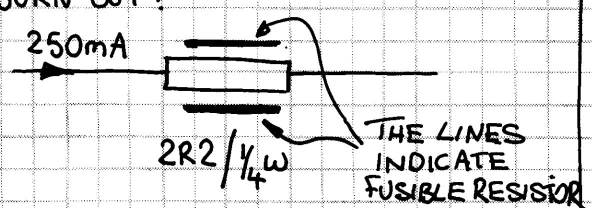
FOR EXAMPLE: IF THE CURRENT DOUBLES, THE POWER DISSIPATED INCREASES FOUR TIMES. ALSO: IF THE CURRENT IS HALVED, THE I^2R LOSSES ARE REDUCED TO ONE-QUARTER.

IF A FUSIBLE RESISTOR OPERATES JUST BELOW ITS RATED DISSIPATION UNDER NORMAL CONDITIONS, AN INCREASE IN CURRENT WILL OVER-TAX IT CONSIDERABLY. — A POINT WILL OCCUR WHEN IT BURNS OUT.

THE ADVANTAGE OF A FUSIBLE RESISTOR IS IT WILL WITHSTAND SURGES AND IS EQUIVALENT TO A '<u>DELAY FUSE</u>'.

HERE ARE SOME EXAMPLES:

1. WHEN WILL THIS FUSIBLE RESISTOR BURN OUT?



$P = I^2 R$

$= .25 \times .25 \times 2.2$

$\simeq 1/8$ WATT.

AT 250mA, THE DISSIPATION IS $\frac{1}{8}$ WATT. YOU WILL NOTICE THE TERM 'VOLTAGE' DOES NOT COME INTO THE EQUATION.

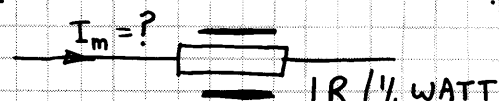
IF THE CURRENT INCREASES TO 500mA, THE POWER DISSIPATION IS:

$= .5 \times .5 \times 2.2$

$= .55$ WATTS.

AT 500mA THE RESISTOR WILL BURN OUT.

2. WHAT IS THE MAX CURRENT?



(THE RESISTOR WILL BURN OUT WHEN ½W IS BEING DISSIPATED)

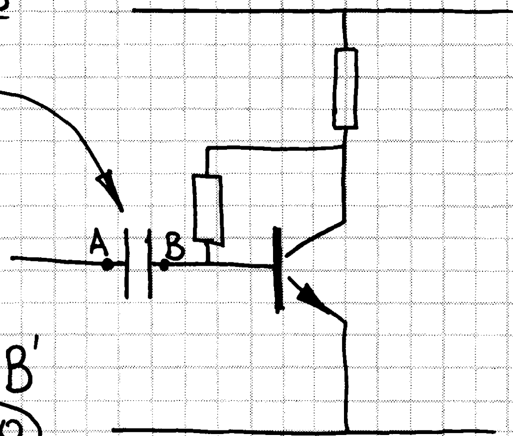
$P = I^2 R$

$.5 = I^2 \times 1$

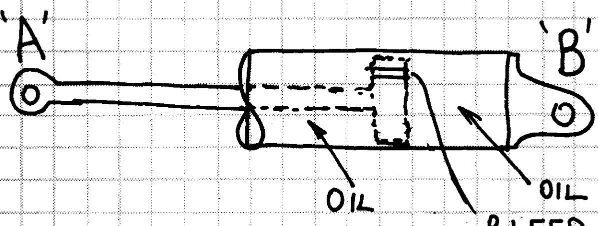
$I = .7$ AMPS

HOW A CAPACITOR WORKS

THIS DISCUSSION WILL HELP YOU UNDERSTAND HOW A COUPLING CAPACITOR WORKS.



THE ANALOGY:



A DOOR CLOSER

WE HAVE ALL SEEN A DOOR CLOSER (OR SHOCK ABSORBER). IT CONSISTS OF AN OIL FILLED CYLINDER & PLUNGER. A SMALL BLEED HOLE IN THE END OF THE PLUNGER ALLOWS OIL TO PASS FROM ONE END OF THE CYLINDER TO THE OTHER AS THE PLUNGER IS WITHDRAWN OR PUSHED IN.

IF A PERSON HOLDS END 'A' & ANOTHER HOLDS END 'B', THE ASSISTANT 'B' WILL FEEL VERY LITTLE REACTION IF 'A' PULLS THE PLUNGER SLOWLY.

BUT IF 'A' PUSHES & PULLS VERY QUICKLY, 'B' WILL FEEL THE FULL EFFECT.

THE CAPACITOR IN THE CIRCUIT ABOVE BEHAVES EXACTLY LIKE THE SHOCK ABSORBER. — IF THE VOLTAGE ON END 'A' IS ALLOWED TO RISE SLOWLY, THE CAPACITOR WILL CHARGE & END 'B' WILL NOT MOVE. (THIS MEANS THE TRANSISTOR WILL NOT SEE THE CHANGE IN VOLTAGE).

IF THE VOLTAGE ON END 'A' RISES & FALLS QUICKLY, END 'B' WILL FOLLOW EXACTLY & THE TRANSISTOR WILL SEE THE CHANGING WAVEFORM.

IF THE WAVEFORM RISES AT A 'MEDIUM' SPEED, THE CAPACITOR WILL PARTLY CHARGE & SOME OF THE REACTION WILL BE PASSED TO THE OTHER END.

THE TRANSISTOR MAY SEE 10% OF THE WAVEFORM, 50% OR 90% & THIS IS WHAT HAPPENS IN PRACTICE. — THE COUPLING CAPACITOR PASSES SOME OR MOST OR NEARLY ALL OF THE WAVEFORM & ANY LOSSES ARE CALLED "STAGE COUPLING LOSSES."

NOTES:

— INCREASING THE SIZE OF THE CAPACITOR IS EQUIVALENT TO USING A LARGER SHOCK ABSORBER.

— A DC VOLTAGE ACROSS THE CAPACITOR IS EQUIVALENT TO EXTENDING THE ARM OF THE SHOCK ABSORBER.

— FREQUENCY IS EQUIVALENT TO PUSHING & PULLING THE ARM 'A'.

10-MINUTE DIGITAL COURSE

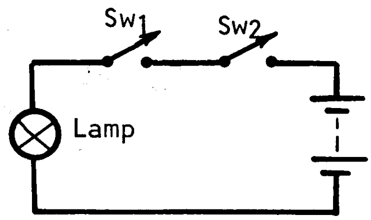
SIMPLIFIED FOR BEGINNERS

There are 5 basic logic elements: AND, OR, NOT, NAND, NOR.
This is how they operate:

SYMBOLS

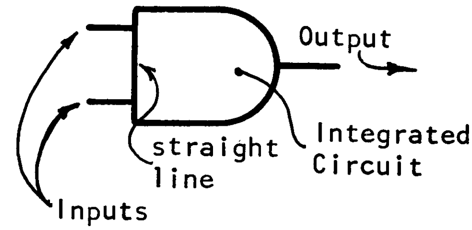
1

AND



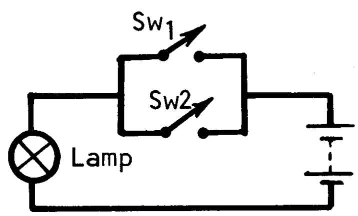
Close both Sw_1 and Sw_2 to light lamp.

An AND element is called an AND GATE.



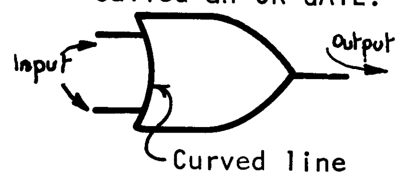
2

OR



Close Sw1 OR Sw2 to light Lamp.

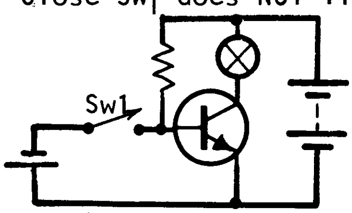
An OR element is called an OR GATE.



3

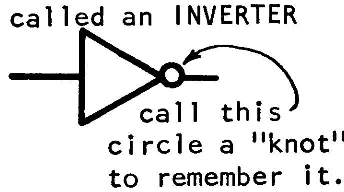
NOT

Close Sw_1 does NOT light lamp



ie: close Sw_1 to turn lamp off.

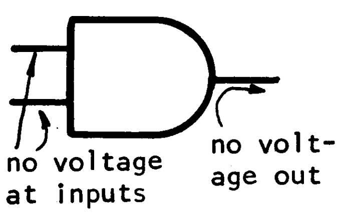
A NOT function is called an INVERTER

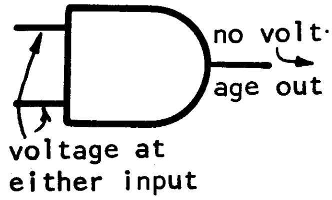


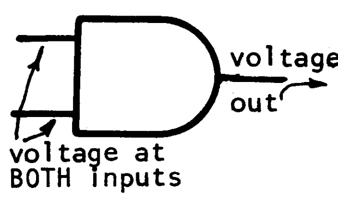
How AND, OR and NOT GATES work:

4

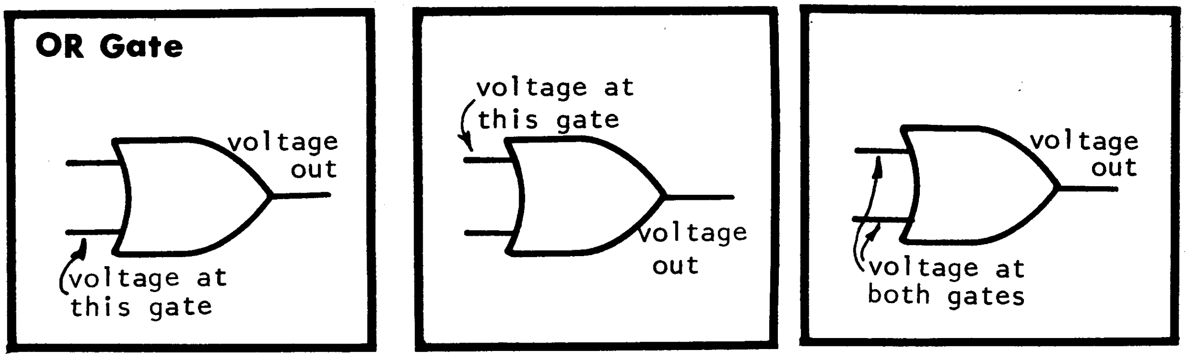
AND Gate:



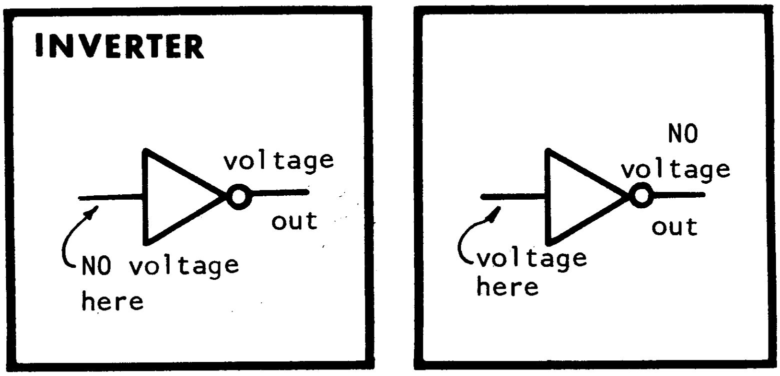




5



6



CALL THIS AN INVERTER

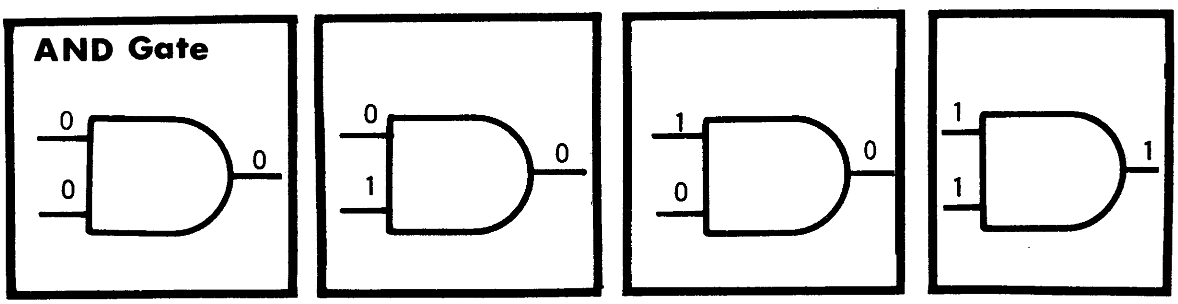
The 2 LOGIC NUMBERS:

0 = no voltage
1 = voltage

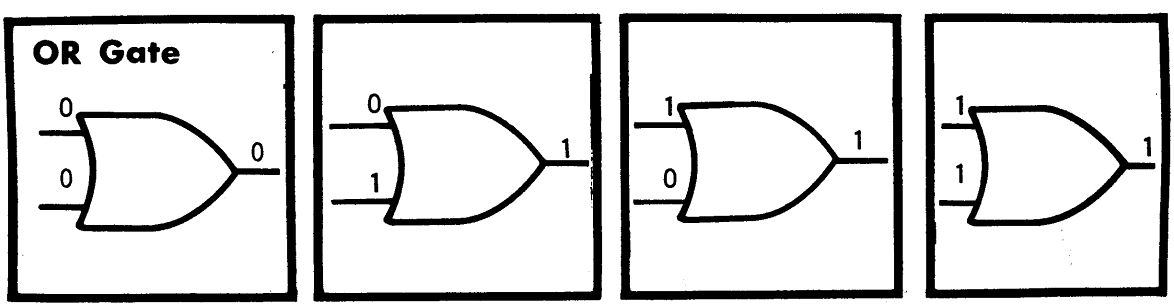
7

The Function of the 3 gates can be expressed in logic numbers

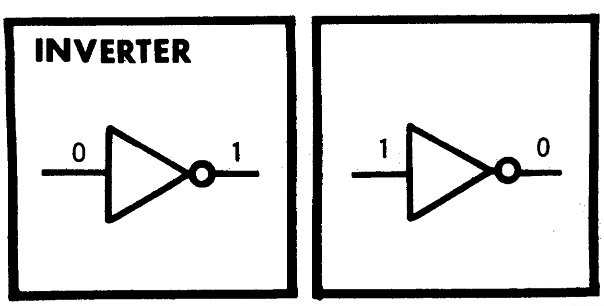
8



9



10



11

The numbers 0 and 1 are called logic values. Each gate can have 2 possible values. TRUE for logic level 1 and FALSE for logic level 0. Thus we can make a TRUTH TABLE for each of the gates.

AND Gate

INPUTS		OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

➡

INPUTS	OUTPUT
*any combination	0
1 1	1

* means any combination except 1 1

OR

INPUTS		OUTPUT
0	0	0
0	1	1
1	0	1 1
1	1	1

➡

INPUTS	OUTPUT
0 .0	0
any other combination	1

NOT

INPUT	OUTPUT
1	0
0	1

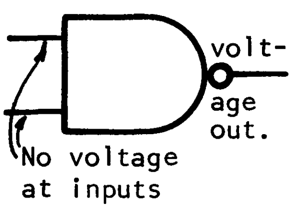
➡

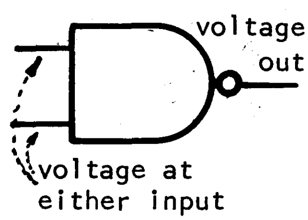
cannot be simplified except to say it's an inverter

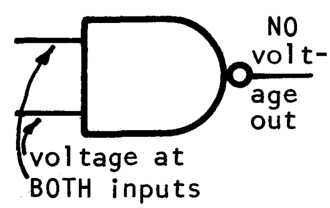
Two further gates are:
NAND– the complement of a normal AND gate
NOR – the complement of a normal OR gate

12

NAND

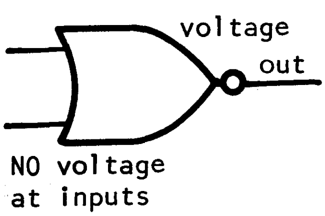


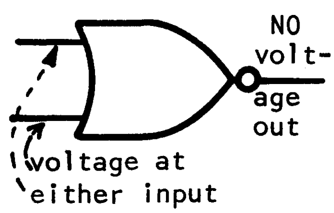


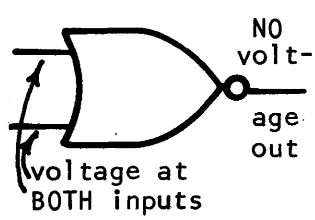


13

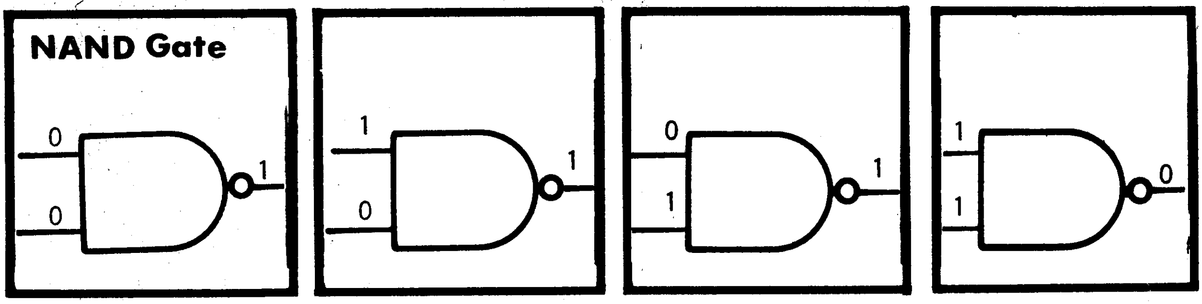
NOR



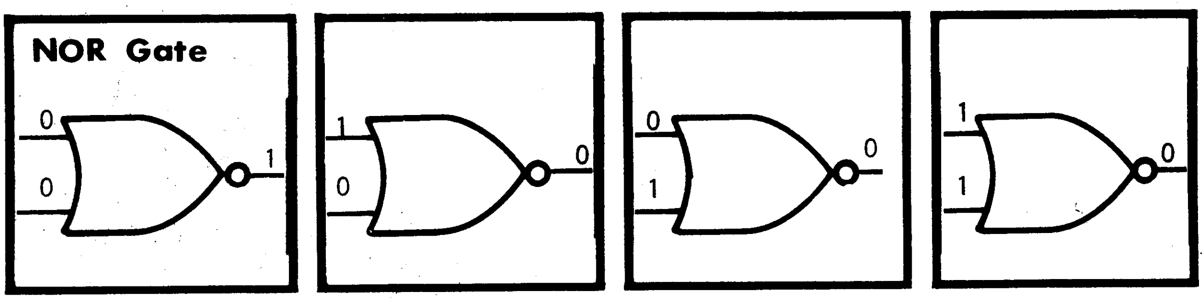




14



15



16

NAND Gate

INPUTS		OUTPUT
0	0	1
0	1	1
1	0	1
1	1	0

INPUTS	OUTPUT
1 1	0
any other combination	1

NOR Gate

INPUTS		OUTPUT
0	0	1
0	1	0
1	0	0
1	1	0

INPUTS	OUTPUT
0 0	1
any other combination	0

SUMMARY

For an AND gate:
A voltage at one input will have no effect but a voltage at both inputs will change the state of the output.

For an OR gate:
A voltage at one input will change the output and the other input will have no effect.

For an INVERTER
The output is of opposite logic level to the input.

For A NAND gate:
A voltage on one input will have no effect but a voltage at both inputs will change the state of the output.

For a NOR gate:
A voltage at either input will change the output.

TEST

Answer these questions:

1. Name the 4 commonly used types of gates:
2. What is the common name for a NOT gate?
3. What are the two TRUTH values?
4. Look at the four TRUTH tables to answer these:
   - A: With one gate of an AND GATE at logic 1 will the other gate alter the output?
   - B: With one gate of an OR GATE at logic 1 will the other gate alter the output?
   - C: With one gate or a NAND GATE at logic level 1 will the other gate alter the output?
   - D: With one gate of a NOR GATE at logic level 1 will the other gate alter the output?

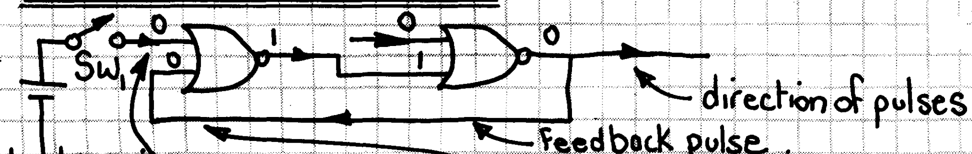
In blocks 1 → 16 we saw how AND OR NOT, NAND & NOR gates function.

This section shows how NAND & NOR gates can be used in FLIP FLOP circuits.

17. THE FLIP FLOP

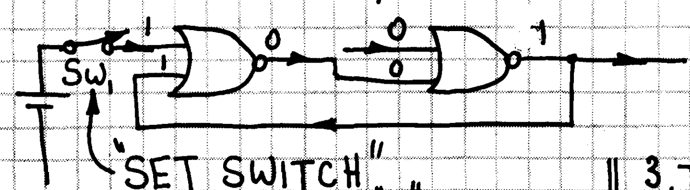
* HAS 2 STATES: "0" & "1" OR "LOW" & "HIGH".
* CHANGES STATE VERY RAPIDLY.
* CAN HOLD "A PIECE OF INFORMATION".

A SIMPLE FLIP FLOP – CONNECT 2 NOR GATES:



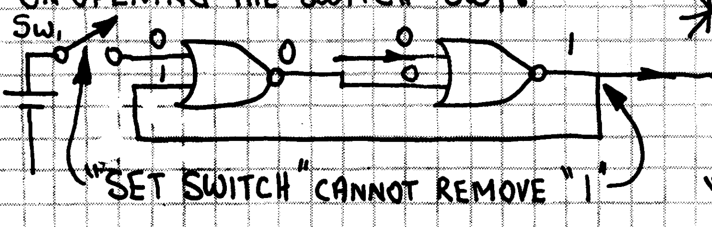
1. INITIALLY THIS GATE HAS "0" ON IT.
2. LET US ASSUME THE BOTTOM INPUT IS ALSO "0".
3. THE OUTPUT OF FIRST NOR GATE WILL BE "1".
4. THE INPUTS TO THE SECOND NOR GATE WILL BE "0" & "1".
5. THE OUTPUT OF THE SECOND NOR GATE WILL BE "0"
6. THIS OUTPUT FEEDS BACK TO THE FIRST NOR GATE.

ON CLOSING SWITCH SW1:



1. THE SWITCH GIVES A "1" TO THE TOP INPUT GATE.
2. A "0" & "1" ON THE INPUTS MAKES THE OUTPUT CHANGE TO "0"
3. THE SECOND NOR GATE HAS "0" & "0" ON ITS INPUTS, MAKING THE OUTPUT CHANGE TO "1".
4. THIS "1" FEEDS BACK TO THE FIRST NOR GATE.

ON OPENING THE SWITCH SW1:

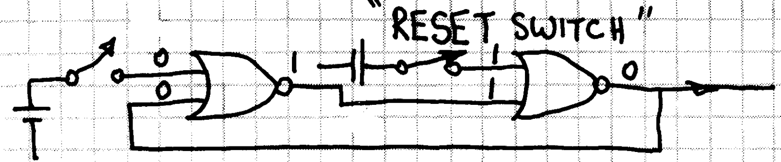


* WHEN SWITCH SW1 IS OPENED THE FIRST NOR HAS "0" & "1" ON ITS INPUTS. THE OUTPUT DOES <u>NOT CHANGE</u>.

THUS WE HAVE REGISTERED:

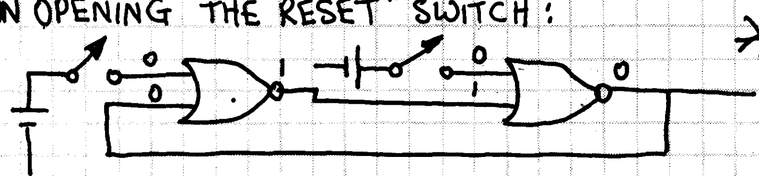
"A PIECE OF INFORMATION".

18 TO "RESET" THE SIMPLE FLIP FLOP BACK TO ITS ORIGINAL STATE WE NEED A SWITCH AT THE SECOND NOR GATE.



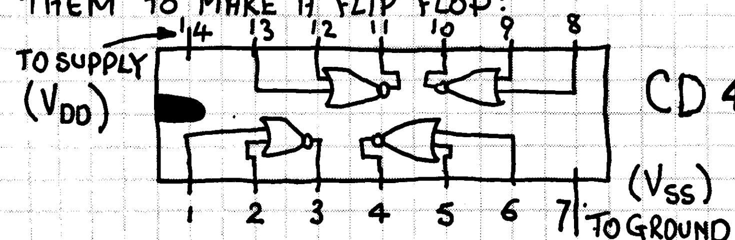
THE "RESET" SWITCH PUTS A "1" ON THE TOP INPUT OF THE SECOND NOR GATE. THIS CHANGES THE OUTPUT TO "0". THIS FEEDS DIRECTLY TO THE INPUT OF THE FIRST NOR GATE, AND CAUSES ITS OUTPUT TO CHANGE TO "1". THIS CREATES A HIGH ON BOTH INPUTS OF THE SECOND NOR GATE.

ON OPENING THE "RESET" SWITCH:



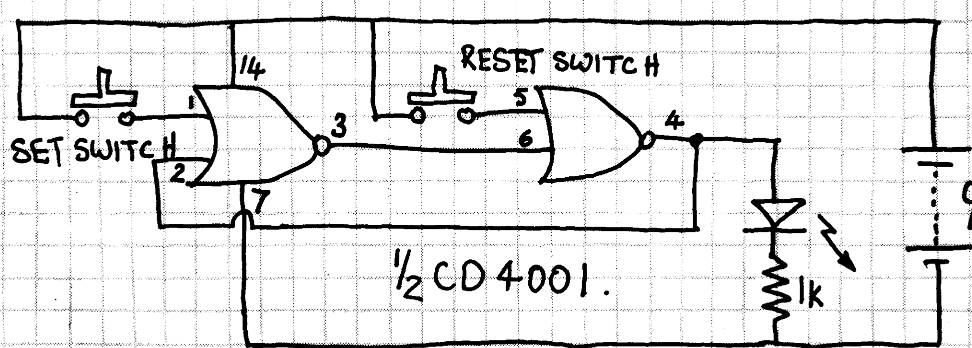
* WHEN THE "RESET" SWITCH IS OPENED THE OUTPUT DOES NOT ALTER & THE RESET SWITCH HAS NO FURTHER EFFECT.

A CMOS CD4001 IC CONTAINS 4 NOR GATES. WE CAN USE ANY TWO OF THEM TO MAKE A FLIP FLOP:



CD 4001 IS A QUAD 2-INPUT NOR GATE.

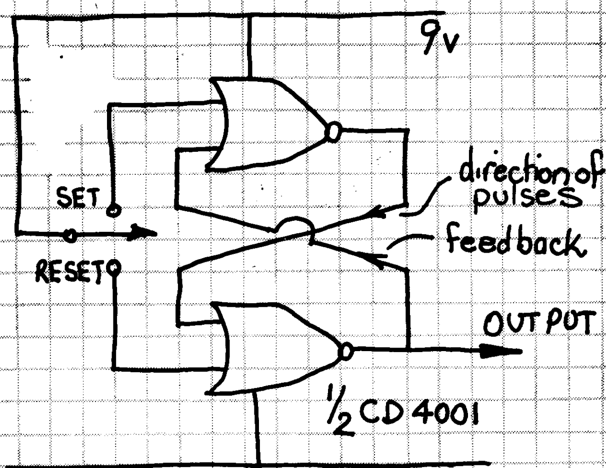
IT CAN BE ARRANGED AS A FLIP FLOP:



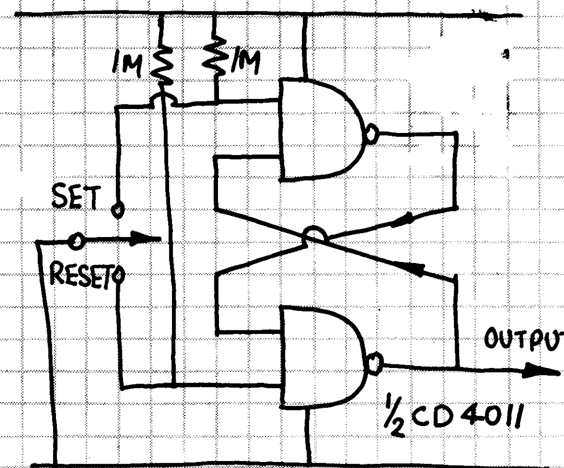
CLOSING THE "SET SWITCH" WILL TURN THE LED ON AND THE "RESET" SWITCH WILL TURN THE LED OFF

A FLIP FLOP CIRCUIT IS A BASIC BUILDING BLOCK. IT IS REDRAWN IN #19 WITH A SINGLE SWITCH. THE NEW LAYOUT WILL BE EASIER TO UNDERSTAND & FOLLOW.

19 NOR GATE FLIP FLOP:



NAND GATE FLIP FLOP

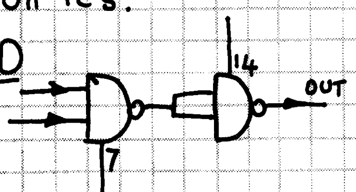


THE FIVE LOGIC FUNCTIONS:

AND
OR
NOT
NAND
NOR

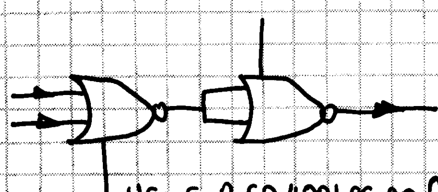
CAN BE PERFORMED BY CD 4001 & CD4011 IC's.

1. AND



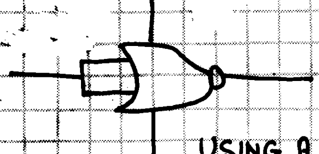
Using a CD4011 as an AND gate

2. OR



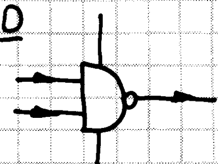
USING A CD 4001 as an OR gate

3. NOT



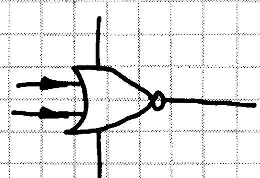
USING A CD 4001 AS A NOT.

4. NAND



A CD4011 IS A NAND GATE

5. NOR



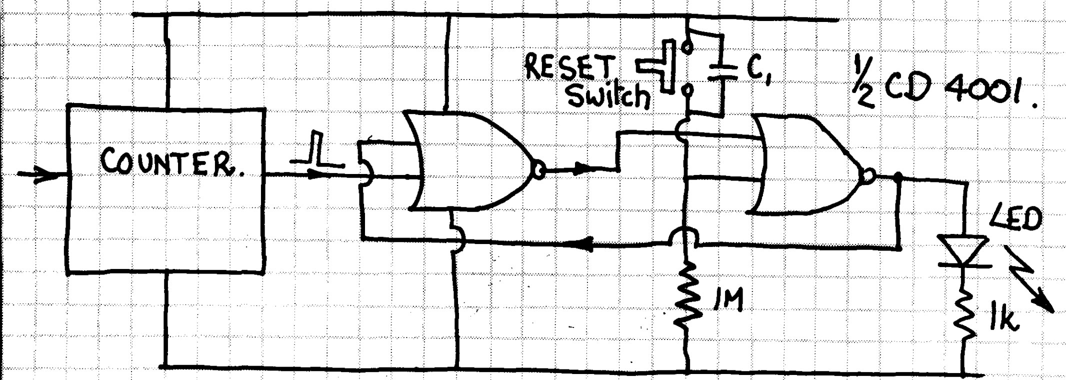
A CD 4001 IS A NOR GATE

The most useful IC's are NAND & NOR gates. They can arranged to perform all the five basic functions.

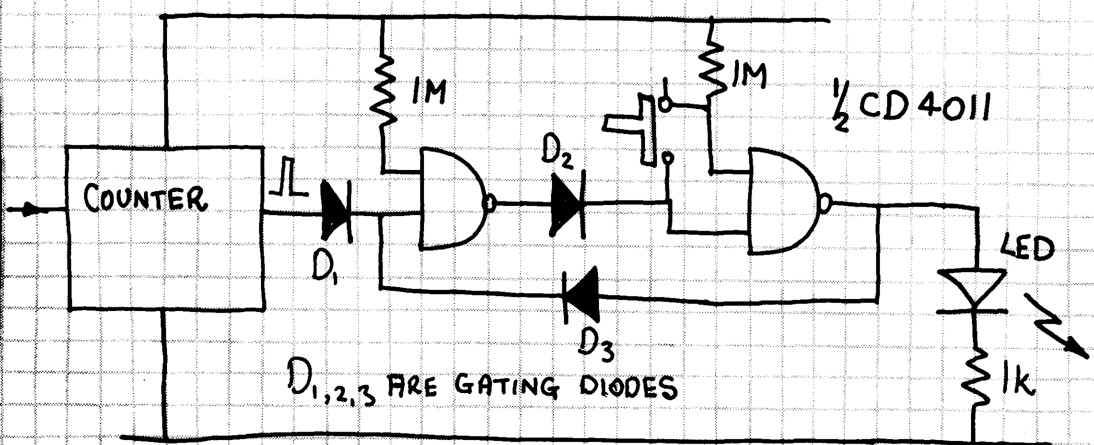
With their inverting outputs we can build them into a number of clever switching and latching circuits. These will be described in the next sections.

20 SINCE SOME PULSES IN ELECTRONICS ARE ONLY PRESENT FOR VERY SHORT PERIODS OF TIME, WE MUST HAVE SOME WAY OF STORING AND RECORDING THEM. THE ANSWER IS.......

.... A LATCH — A CD 4001 OR CD 4011 CAN BE USED AS A LATCH.



THE OUTPUT OF THE COUNTER IS NORMALLY "LOW". IT GOES "HIGH" FOR 1 PULSE THEN LOW. THE LED WILL LIGHT & STAY LIT. IT WILL "LATCH ON". THE RESET SWITCH WILL TURN LED OFF.
THE CIRCUIT HAS INDETERMINATE START-UP. BUT WITH C_1 THE CIRCUIT WILL START UP WITH THE LED OFF.



$D_{1,2,3}$ ARE GATING DIODES

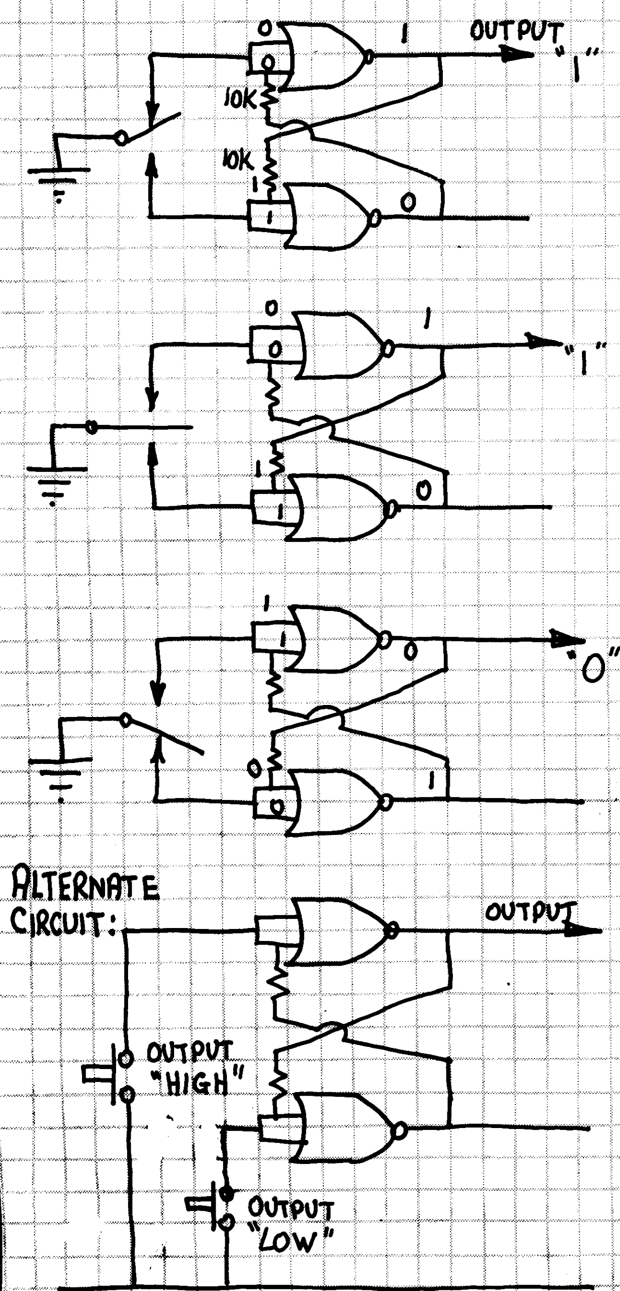
DEBOUNCE SWITCH:

Whenever a mechanical switch is included in a digital circuit there will be problems of "SWITCH BOUNCE". This is due to the contacts striking each other several times before finally closing. Since ICs such as counters and flip flops will record frequencies up to many MHz they will register the opening and closing of a normal switch as several pulses and produce a false reading. To eliminate this problem we can use two NAND gates to form a DEBOUNCING CIRCUIT. In this type of circuit, the states are unaffected by noise, since the states are changed by the first noise pulse from the switch and cross-coupling causes the circuit to self-latch and be immune to further pulses.

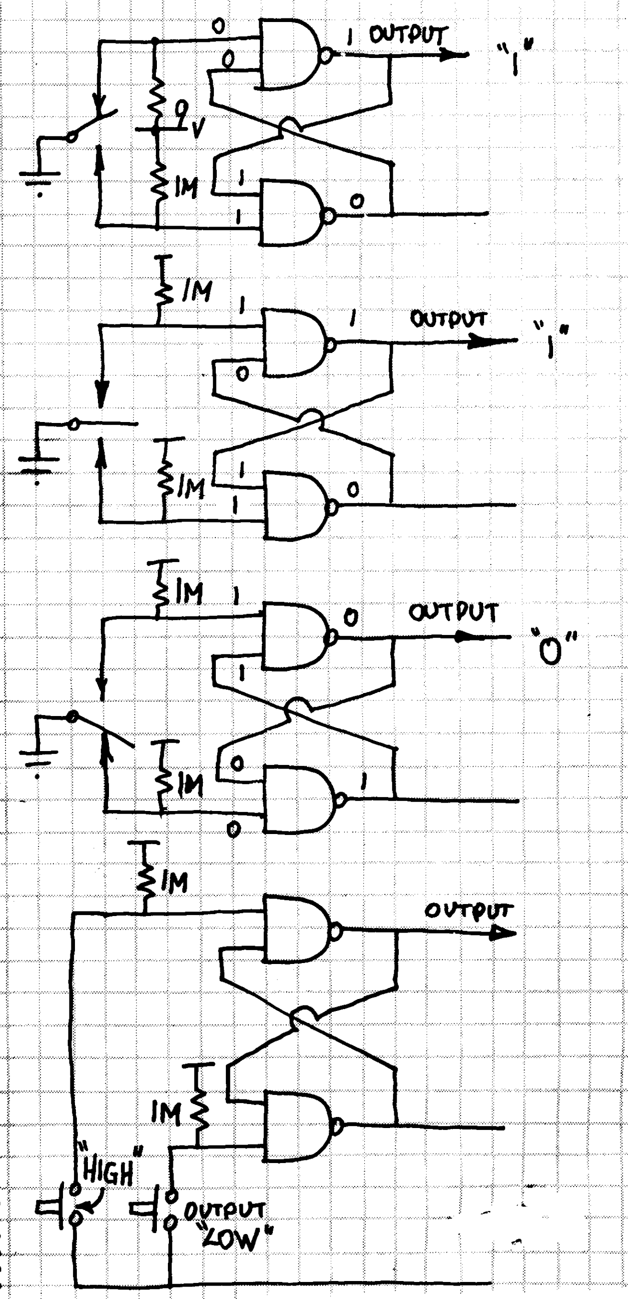
21 ...... DEBOUNCE SWITCH.

THE IMPORTANT POINT TO NOTE IS THE IC DOES NOT CHANGE STATE ON OPENING THE SWITCH CONTACTS, NOR DOES IT CHANGE STATE ON RE-CLOSING THE CONTACTS BACK TO THE SAME GATE.

USING A CD 4001 NOR GATE:

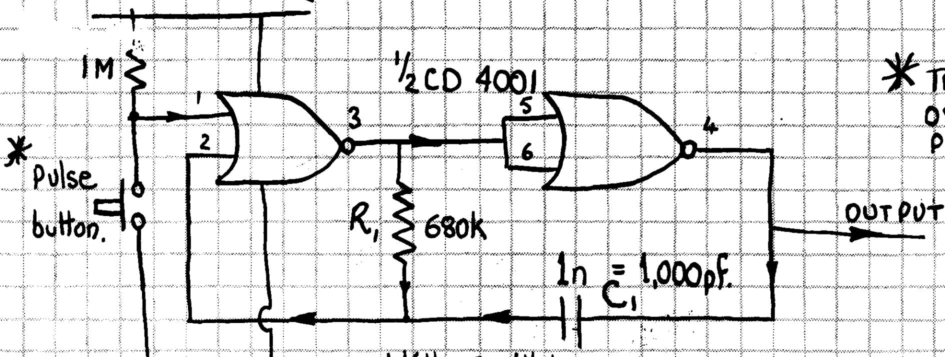


USING A CD 4011 NAND GATE:



22 MULTIVIBRATORS:

THE MOST USEFUL MULTIVIBRATOR IS THE ASTABLE OR SQUARE-WAVE GENERATOR. THE CIRCUIT SHOWS ½ CD4001 IC USED TO MAKE A 1KHz ASTABLE MULTIVIBRATOR.



1 KHz Oscillator

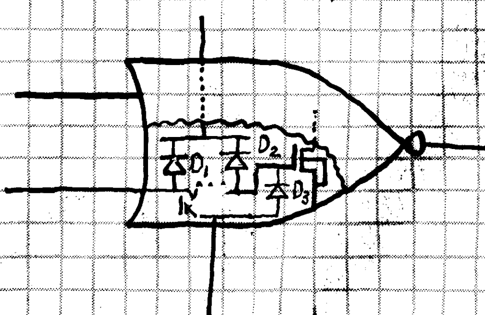
* THE CIRCUIT ONLY OSCILLATES WHILE THE PULSE BUTTON IS PRESSED

HOW THE CIRCUIT WORKS:

THE CIRCUIT IS SHOWN GATED OFF DUE TO PIN 1 BEING BIASED HIGH VIA THE UPPER 1M RESISTOR. [A HIGH ON EITHER INPUT GATE WILL CAUSE THE OUTPUT TO GO LOW]. THUS PINS 3, 5 & 6 ARE LOW. PINS 5 & 6 ARE THE INPUT GATES OF THE SECOND NOR GATE AND WILL CAUSE THE OUTPUT PIN 4 TO BE IN A HIGH STATE UNTIL PIN 1 GOES LOW MOMENTARILY.

WHEN A PULSE OF SHORT DURATION IS DETECTED ON PIN 1 IT WILL CAUSE PIN 3 TO GO HIGH AND THE OUTPUT PIN 4 TO GO LOW. SEE TRUTH TABLE FOR NOR GATES TO VERIFY THIS. CAPACITOR C_1 BEING FULLY CHARGED, WILL ATTEMPT TO MAKE PIN 2 SWING NEGATIVE WITH RESPECT TO THE 0v RAIL. LET ME EXPLAIN THIS IN ANOTHER WAY WHICH MAY BE EASIER TO UNDERSTAND. SUPPOSE WE CONSIDER THE CAPACITOR TO BE A 9v RECHARGEABLE BATTERY. INITIALLY THE BATTERY IS IN A STATE OF FULL CHARGE. WHEN A TRIGGER PULSE IS RECEIVED AT PIN 1 THE FIRST NOR GATE WILL GO HIGH AND SINCE IT IS DIRECTLY COUPLED TO THE SECOND NOR GATE IT CAUSES THE OUTPUT PIN 4 TO GO TO 0v. THIS IS EQUIVALENT TO UNPLUGGING THE FULLY CHARGED BATTERY AND PLACING ITS POSITIVE TERMINAL ON THE 0v RAIL.

IN BUILT INTO EACH GATE OF THE IC ARE 3 DIODES, ONE OF WHICH PREVENTS THE INPUT SIGNAL GOING BELOW 0v (the other two are discussed later). SO WHEN THIS −9v IS PRESENTED AT INPUT GATE 2, DIODE D_3 CONDUCTS VIA THE 1k RESISTOR AND QUICKLY REMOVES THE CHARGE ON THE CAPACITOR (OR BATTERY ANALOGY). WITH THE CAPACITOR FULLY DISCHARGED, IT BEGINS TO RECHARGE IN THE REVERSE DIRECTION FROM THE HIGH ON PIN 3, VIA R_1 AND THE VOLTAGE ON PIN 2 STARTS TO RISE EXPONENTIALLY TOWARDS THE POSITIVE RAIL. DURING THIS RISE THE TRANSFER VOLTAGE IS ATTAINED AND CAUSES THE OUTPUT PIN 3 TO GO LOW AND PIN 4 TO GO HIGH.

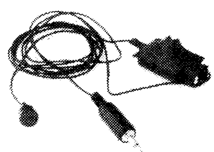


PARTLY BROKEN AWAY SECTION SHOWING THE 3 INPUT PROTECTION DIODES CONNECTED TO EACH GATE.

SECURITY DEVICES

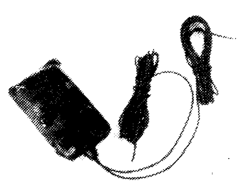
The following is a list of security devices from Talking Electronics. All items are professional quality and guaranteed to perform as described. If you are not certain about your requirements, please phone for advice.
Don't let the low prices put you off. All devices are as good as or better than anything else on the market as they have been designed and made by us. We make what we sell.
Here is our product range:

ACTIVE MICROPHONE $45 (plus $5.00 post). This device can be used with any tape recorder to improve the sound pick-up. Most micro-cassette recorders are useless when left in your pocket or in a room. They don't pick up voices very well at all. This active microphone turns them into superb performers.

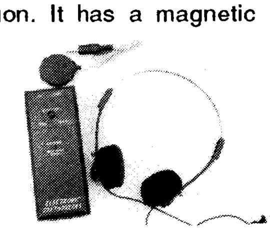


BUG DETECTOR 2000 BD-2000 $150 (plus $5.00 post). Detects transmitting bugs in a room, car, office or telephone. The unit works on the wide-band principle of RF detection. It is switched on & the antenna extended. With a sweeping motion the antenna is probed into all parts of the room. The unit will give a feedback whistle when a bug is detected. The volume control is turned down and a meter on the detector indicates the relative strength of the bug. In this way you can 'home in' on the exact location of any transmitting device.
For phone use: Wind the telephone cord about 4 times around the antenna and place the mouthpiece of the phone to the speaker of the detector. A feedback whistle will indicate any RF bug that is on the line within 20 metres. Be sure to test every phone as some bugs are designed to operate on one specific extension only.

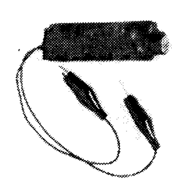
CAR TRACKING TRANSMITTER CT-03 $85.00 & $95 (plus $5.00 post). Has centrifual switches to indicate when the car is turning left, right or stopping. Comes with very strong magnets so you can clamp it to any metal object. or with double-sided sticky tape: Standard model $85.00. Magnetic model: $95.00



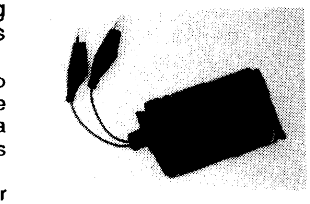
ELECTRONIC STETHOSCOPE $120 (plus $5.00 post). This unit has been designed for locksmiths who are constantly required to open combination-lock safes after the owner has forgotten the combination. It has a magnetic transducer that attaches to the safe so that you can hear the slightest click of the mechanism. It also has a number of other uses such as detecting noises in engines, the rushing of water in leaky pipes and you can even hear your heart-beat.



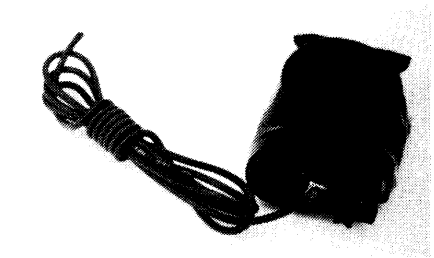
INFINITY BUG (SIMPLE TYPE) IBR-00 $150 (plus $5.00 post). This is the simplest version of our popular infinity bug. It is small enough to be placed in the base of the phone and works like this:
After making a call the other party hangs up. Instead of hanging up, you whistle down the line and the bug will 'open up.' You will then be able to hear everything that is being said at the other end. Note: This model requires someone at the other end (or a FAX machine) to answer the phone, every time you wish to use the bug. Size: 2cm x 3cm x 6cm. Also, all infinity devices must be connected to the line in the room you wish to listen to. You cannot place it on your own phone then dial someone else. The bug MUST be at the other end.



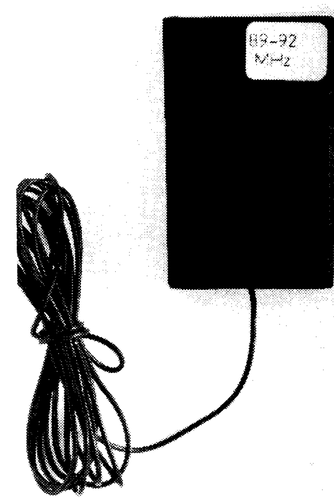
INFINITY BUG RING VERSION IBR-01 $250 (plus $5.00 pack and post). This unit is connected to the phone line and has a super-sensitive microphone and a complex circuit to detect a coded phone ring. It can be installed in a home, office or factory and is ideal for checking on the presence of staff or burglars etc.
It works like this: The unit is connected to the number to be monitored as per the instruction sheet accompanying it and a special note is made of the time intervals required to activate the device.
When you ring the monitored number you must let the phone ring for only one or two rings. At the receiving end, this will sound like the beginning of two rings. You then hang up and wait an exact number of seconds (as supplied on the instruction sheet), before calling the bug again. This time, when the phone starts to ring, the bug switches on and the bell does not sound at all.
Again you wait until you hear a click on the line. When you hear the click, whistle down the line and this will open up the bug and let you hear whatever is happening in the room being monitored. The sounds are clearer than if you were in the room and if someone picks up the phone, the bug automatically hangs up. The bug times-out after 5 minutes and can be immediately re-activated by whistling to keep the line open. You can hang up at any time. The bug works on both decadic and DTMF (rotary dial and tone phone systems).
The bug also works in the Simple Infinity Bug mode (see above).



SPY BUG 100 SB-100 $85 (plus $5.00 pack and post). The bug is the size of two 20c coins (quarters). Comes with 60cm (24in) antenna and is capable of transmitting about 100 metres (300ft).



SPY BUG 400 SB-400 $50 (plus $5.00 pack and post). A super sensitive FM bug capable of transmitting 400 metres (1200ft) in a built up area and is fixed at a frequency about 88 - 90MHz. It can pick up sounds such as the ticking of clocks, whispers etc up to 3 metres (10ft) from the microphone. It is the size of a Tic tac box and is powered by two AAA cells and will transmit for 200 hours. The batteries are soldered in place for reliability and the unit is returned to us for battery replacement ($7.00) after 200 hours use.

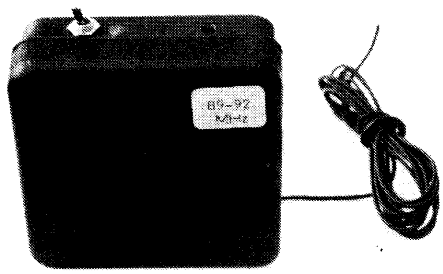


SPY BUG 800

SB-800 $55 (plus $5.00 pack and post). A very small bug that fits on top of a 9v battery and transmits up to 800 metres (2500ft). Has air trimmer adjustment to get between the FM stations on the dial.

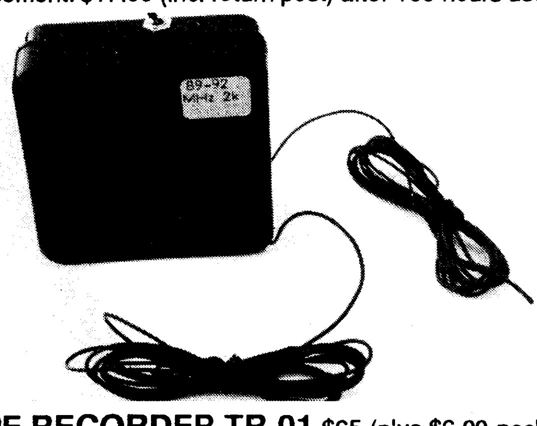
SPY BUG 1000 SB-1000

$65 (plus $5.00 pack and post). This bug is capable of transmitting 1km (1/2 mile) in a built up area (Several kilometres in open country) it is suitable unit for long distance transmission. This unit is the size of a pack of 20 cigarettes and uses 4 AAA cells for power. Battery replacement: $14.00 (incl return post) after 100 hours use.



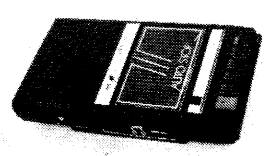
SPY BUG 2000 SB-2000

$120 (plus $5.00 pack and post). This is our most powerful bug. It is capable of transmitting 2km (1 mile) in a built up area (more in open country) and is suitable for long distance transmission. This unit is the size of a pack of 20 cigarettes and uses 8 AAA cells for power. Battery replacement: $17.00 (incl return post) after 100 hours use.



TAPE RECORDER TR-01

$65 (plus $6.00 pack and post). This is a specially modified tape recorder with zero standby current for long battery life. Designed for use with Phone Tapes, the unit features AC or DC operation and uses normal tapes. Size 5cm high x 14cm wide x 27cm long (2in x 5½ x 10½).

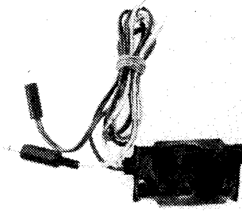


TAPE RECORDER TR-02S

$125 (plus $6.00 pack and post). This is a palm-sized Sanyo tape recorder that takes standard tapes. It has a control so that you can slow down the tape to 3 hours 15 min per side for a 120 tape.

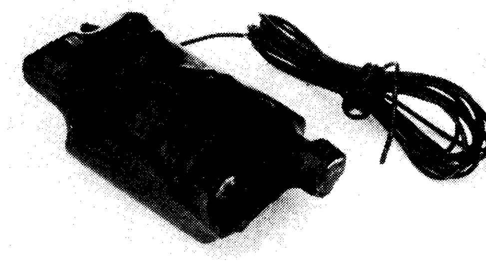
VOX MK II VOX-02

$55 (plus $5.00 pack and post). This is a non-transmitting device to switch a tape recorder ON and OFF. It also has a microphone output for the MIC input of a tape recorder to improve the pick-up of the tape recorder, like the Active Microphone.



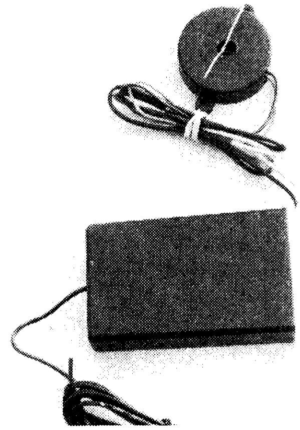
VOX MK IV VOX-04

$80 (plus $5.00 pack and post). This is a voice operated bug that only transmits when it picks up sounds. When no sounds are present the bug shuts down to the 'monitoring mode' and sends out a homing beep to let you know you are monitoring the correct frequency. The battery life is increased 300% as it only transmits when sounds are present. It has a very sensitive microphone and an adjustable level control to set the noise level at which the bug turns on.



WALL BUG WB-01

$50 (plus $5.00 pack and post). This unit has 400metre (1200ft) range and is fitted with a vibration detector instead of a microphone. It is designed to be attached to a window with Blu Tack and will listen right through the glass. Also called a SPIKE MIC or CONCRETE BUG it will also listen through walls and doors but the quality is not as good as the Spy Bug-400, for example.



This completes our range. All units are fully assembled and tested.

All products are sold on the understanding that they be used for your own personal safety and surveillance. On no account do we sell these devices for the purposes of breaking any laws etc. All devices are guaranteed and we can modify certain units for specific requirements.

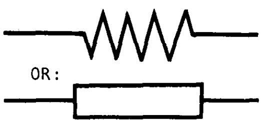
Send: Check, Money Order, or Credit card details to your local office:

Contact: US Office:
Talking Electronics
626 S. Euclid St, (Cnr Alomar Ave,)
Anaheim, CA 92802
Tel: (714) 533 4252

Australian Office:
Talking Electronics,
35 Rosewarne Ave,
Cheltenham, Vic 3192 Australia
Tel: (03) 584 2386

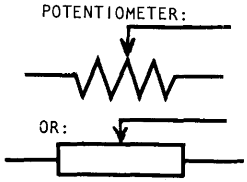
DATA Sheet No.1.

RESISTOR:



OR:

POTENTIOMETER:



OR:

Ω = ohms
R = ohms
k = 1,000 ohms
M = 1,000,000 ohms

103 = 10k ohms
104 = 100k "
105 = 1M ohms

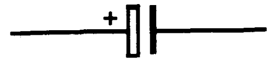
CAPACITOR:

mfd = microfarad
pf = picofarad
n = nanofarad

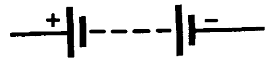
1000pf = 1n
1n = .001mfd
1000n = 1 mfd
2n2 = .0022 mfd
22n = .022 mfd

102 = 1,000pf
103 = 10,000pf
= .01 mfd
104 = .1 mfd
105 = 1 mfd

ELECTROLYTIC:

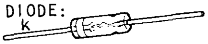


BATTERY:



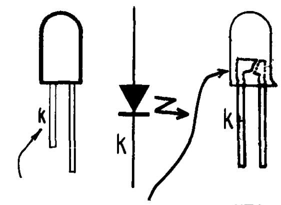
DIODE:

SIGNAL DIODE:



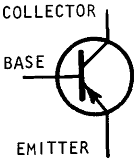
POWER DIODE:

LED:

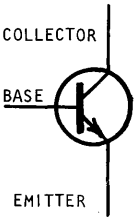


Cathode lead is SHORT

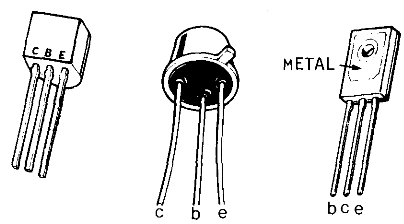
LOOKING INTO LED. Cathode is LARGER.



COLLECTOR
BASE
EMITTER
PNP TRANSISTOR



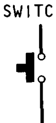
COLLECTOR
BASE
EMITTER
NPN TRANSISTOR



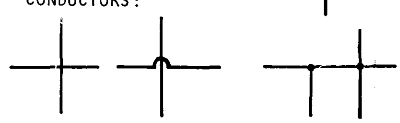
Any transistor CASE may be PNP or NPN.

SWITCH:

PUSH-ON SWITCH:



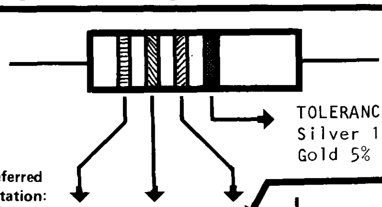
CONDUCTORS:



NOT CONNECTED

CONNECTED

COLOUR CODE FOR RESISTORS



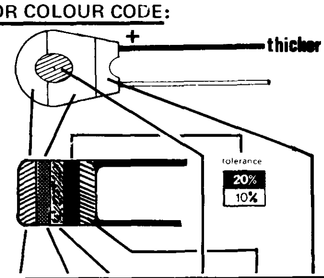
Silver or gold here is a divisor, NOT tolerance.
Silver: DIVIDE by 100
Gold: DIVIDE by 10

TOLERANCE:
Silver 10%
Gold 5%

Resistance:	Preferred Notation:			
.22ohm	R22	red	red	silver
.27ohm	R27	red	purple	silver
.33ohm	R33	orange	orange	silver
.39ohm	R39	orange	white	silver
.47ohm	R47	yellow	purple	silver
.56ohm	R56	green	blue	silver
.68ohm	R68	blue	grey	silver
.82ohm	R82	grey	red	silver
1.0ohm	1R0	brown	black	gold
1.2ohm	1R2	brown	red	gold
1.5ohm	1R5	brown	green	gold
1.8ohm	1R8	brown	grey	gold
2.2ohm	2R2	red	red	gold
2.7ohm	2R7	red	purple	gold
3.3ohm	3R3	orange	orange	gold
3.9ohm	3R9	orange	white	gold
4.7ohm	4R7	yellow	purple	gold
5.6ohm	5R6	green	blue	gold
6.8ohm	6R8	blue	grey	gold
8.2ohm	8R2	grey	red	gold
10ohm	10R	brown	black	black
12ohm	12R	brown	red	black
15ohm	15R	brown	green	black
18ohm	18R	brown	grey	black
22ohm	22R	red	red	black
27ohm	27R	red	purple	black
33ohm	33R	orange	orange	black
39ohm	39R	orange	white	black
47ohm	47R	yellow	purple	black
56ohm	56R	green	blue	black
68ohm	68R	blue	grey	black
82ohm	82R	grey	red	black
100ohm	100R	brown	black	brown
120ohm	120R	brown	red	brown
150ohm	150R	brown	green	brown
180ohm	180R	brown	grey	brown
220ohm	220R	red	red	brown
270ohm	270R	red	purple	brown
330ohm	330R	orange	orange	brown
390ohm	390R	orange	white	brown
470ohm	470R	yellow	purple	brown
560ohm	560R	green	blue	brown
680ohm	680R	blue	grey	brown
820ohm	820R	grey	red	brown
1k	1k	brown	black	red

1.2k	1k2	brown	red	red
1.5k	1k5	brown	green	red
1.8k	1k8	brown	grey	red
2.2k	2k2	red	red	red
2.7k	2k7	red	purple	red
3.3k	3k3	orange	orange	red
3.9k	3k9	orange	white	red
4.7k	4k7	yellow	purple	red
5.6k	5k6	green	blue	red
6.8k	6k8	blue	grey	red
8.2k	8k2	grey	red	red
10k	10k	brown	black	orange
12k	12k	brown	red	orange
15k	15k	brown	green	orange
18k	18k	brown	grey	orange
22k	22k	red	red	orange
27k	27k	red	purple	orange
33k	33k	orange	orange	orange
39k	39k	orange	white	orange
47k	47k	yellow	purple	orange
56k	56k	green	blue	orange
68k	68k	blue	grey	orange
82k	82k	grey	red	orange
100k	100k	brown	black	yellow
120k	120k	brown	red	yellow
150k	150k	brown	green	yellow
180k	180k	brown	grey	yellow
220k	200k	red	red	yellow
270k	270k	red	purple	yellow
330k	330k	orange	orange	yellow
390k	390k	orange	white	yellow
470k	470k	yellow	purple	yellow
560k	560k	green	blue	yellow
680k	680k	blue	grey	yellow
820k	820k	grey	red	yellow
1M	1M	brown	black	green
1.2M	1M2	brown	red	green
1.5M	1M5	brown	green	green
1.8M	1M8	brown	grey	green
2.2M	2M2	red	red	green
2.7M	2M7	red	purple	green
3.3M	3M3	orange	orange	green
3.9M	3M9	orange	white	green
4.7M	4M7	yellow	purple	green
5.6M	5M6	green	blue	green

CAPACITOR COLOUR CODE:



BLACK	0	0	x1pF x1uF		10v
BROWN	1	1	x10pF x10uF		
RED	2	2	x100pf	250v	
ORANGE	3	3	x1000pF		
YELLOW	4	4	x0.01mfd	400v	6.3v
GREEN	5	5	x0.1mfd	100v	16v
BLUE	6	6		630v	
VIOLET	7	7			
GREY	8	8	x0.01mfd		25v
WHITE	9	9	x0.1mfd		3v
PINK					35v

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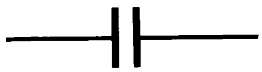
DATA Sheet No.2.

CAPACITOR:



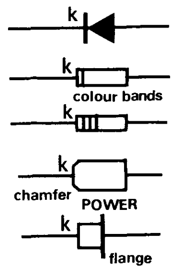
mfd = microfarad
pf = picofarad
n = nanofarad

1000pf = 1n
1n = .001 mfd
1000n = 1 mfd
2n2 = .0022 mfd
22n = .022 mfd
220n = .22 mfd

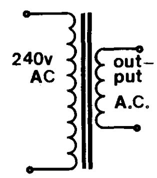
102 = 1,000pf
103 = 10,000pf
= .01 mfd
104 = .1 mfd
105 = 1 mfd

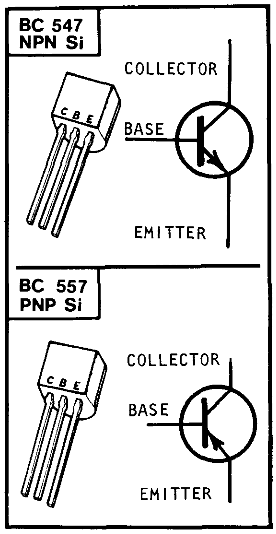
472 = .0047 = 4n7
473 = .047 = 47n
474 = .47 = 470n

DIODE:

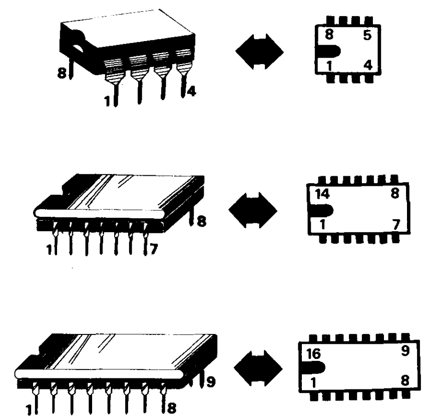


TRANSFORMER:





IC PIN NUMBERS:

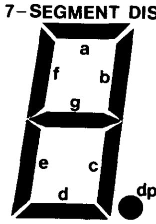


USING A MULTIMETER TO FIND PNP or NPN:

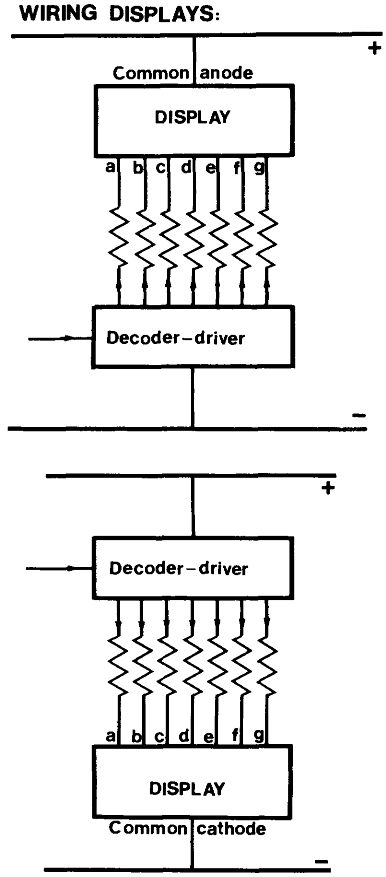
1. Clip meter -ve lead onto centre lead of transistor.
2. Set multimeter to high ohms (x1k range)
3. Positive lead to outer pins reads:
   HIGH-HIGH IT's PNP
   LOW-LOW IT's NPN

If "B" unknown - use transistor tester on Page 27 of issue No1.

7-SEGMENT DISPLAY

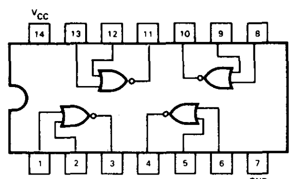


WIRING DISPLAYS:

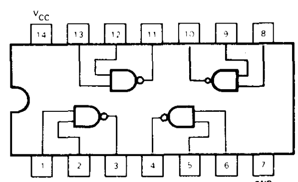


PIN OUTS:

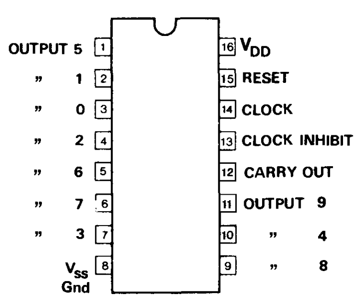
CD 4001



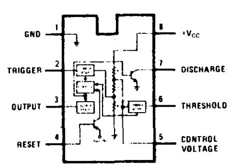
CD 4011



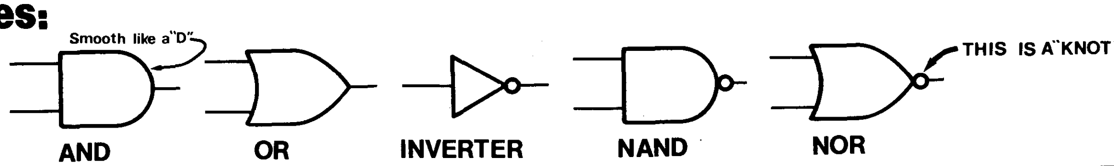
CD 4017



555



Gates:



CPW