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:

Capacitor Discharge Unit - for Model Railways
Car Tracker - tracks a car at 600ft
Transistor Tester - tests NPN & PNP transistors
Two Experimental projects
Explorer MkII - a mini FM Transmitter
LED Flasher - a project for beginners
LED Zeppelin - a game of skill

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.

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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,

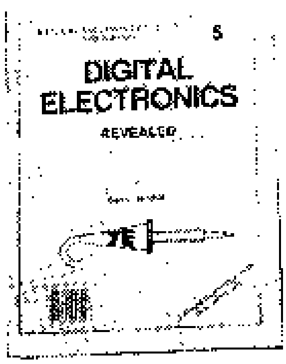
Colin Mitchell.

Colin Mitchell.

Books from Talking Electronics:

LEARNING ELECTRONICS Book 1	$3.50
LEARNING ELECTRONICS Book 2	$3.60
ELECTRONICS NOTEBOOK 1	$5.00
ELECTRONICS NOTEBOOK 2	$4.00
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 Bk 1	$3.30
Electronics for Model Railways Bk 2	$3.80
Six BD 679 Projects to Build	$3.50

See the Order Form on P41 for address and postage details.



DIGITAL ELECTRONICS REVEALED

$5.00

This book contains the full 10 minute digital course. Each issue of Talking Electronics will contain a number of pages from the book until it has been fully covered. But if you can't wait that long, you can get the complete course now by sending for the book.

You will be amazed at how much you learn from its pages. It's in the way it is laid out and the material presented. It's also very handy as a reference book when designing digital circuits. We use it all the time.

SIX BD 679 PROJECTS

$3.50

Learn about the micro-processor.

This book starts you in the world of microprocessors with a simple 3-chip computer called the Micro-comp. It uses a Z-80 micro-processor, a 2732 EPROM containing the MONItor program and an output latch chip to drive two seven-segments displays and two LED displays.

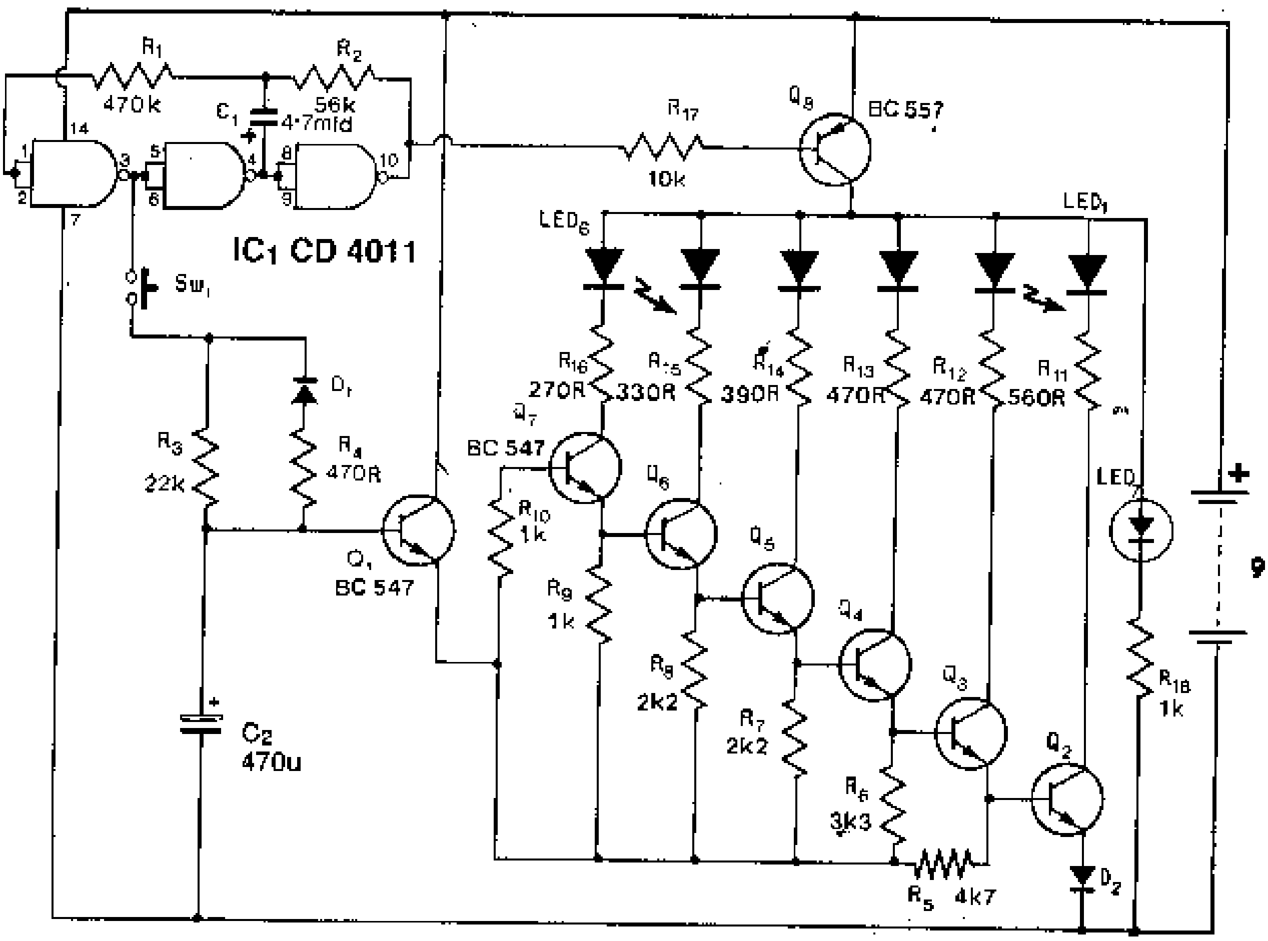
The MONitor chip contains a number of programs that are fully explained in the text so you can learn how to write simple programs yourself. It's the place to start if you want to learn about microprocessors and microcontrollers.

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.

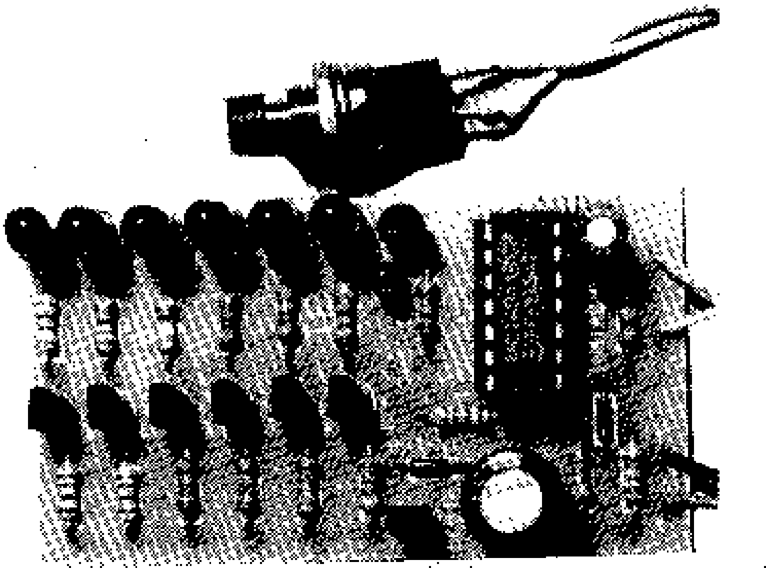
HOW THE CIRCUIT WORKS

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.

EXPERIMENTER DECK

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

BUILD THESE 10 EXPERIMENTS ON ONE PC BOARD:

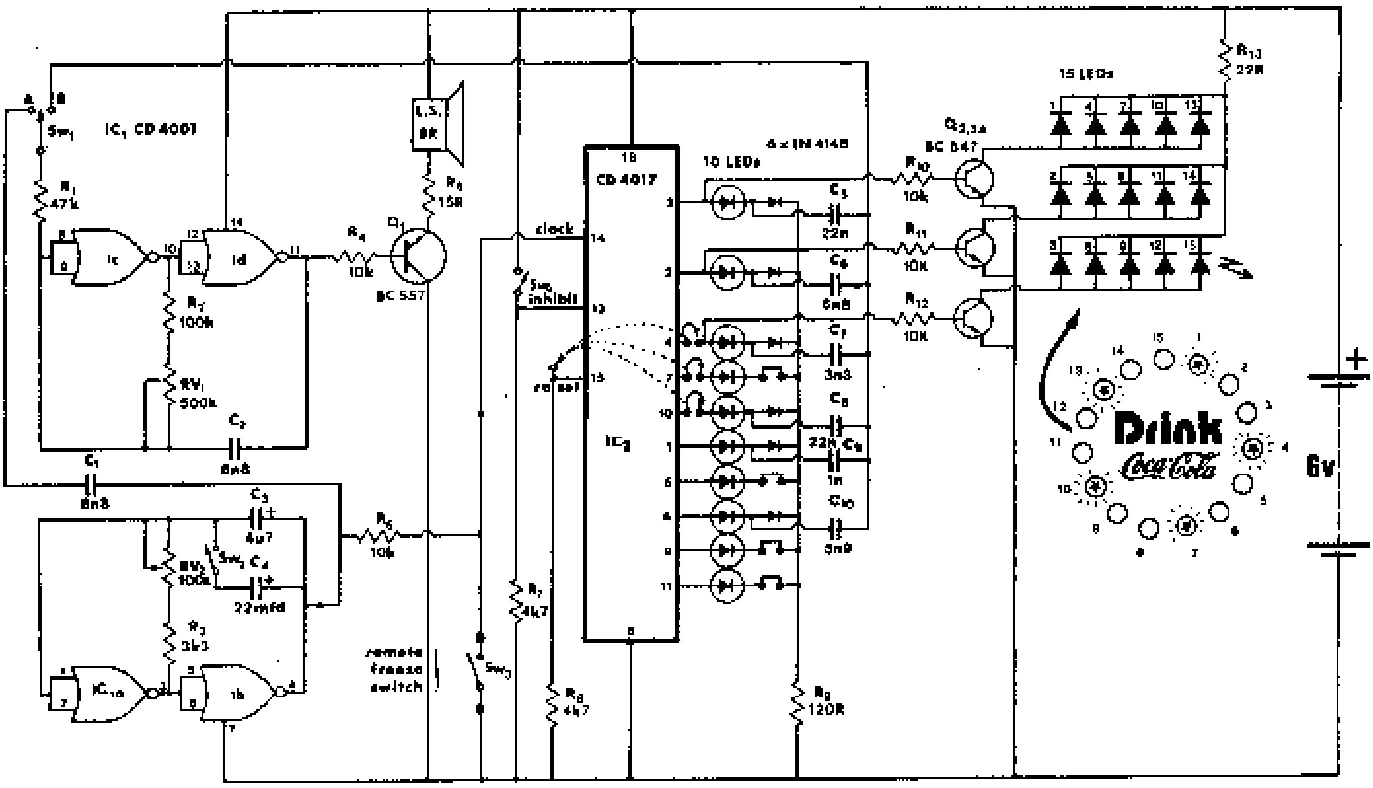
1. HEE HAW SIREN
2. HEADS or TAILS?
3. DECISION MAKER
4. RUNNING LIGHT
5. CRICKET GAME
6. TIMER
7. TEST YOU REFLEX TIME
8. TUNE
9. MAKING MUSIC
10. ADVERTISING SIGN

'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 safe place. The complete circuit may look complex but each individual project is simple.

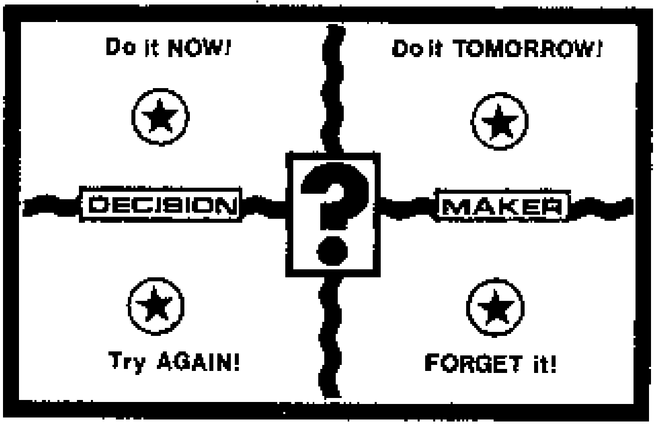


COMPLETE "10 EXPERIMENT" CIRCUIT

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.



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.

DECISION MAKER PARTS

ADDITIONAL PARTS NEEDED

2 5mm LEDs

1 diode 1N 4148

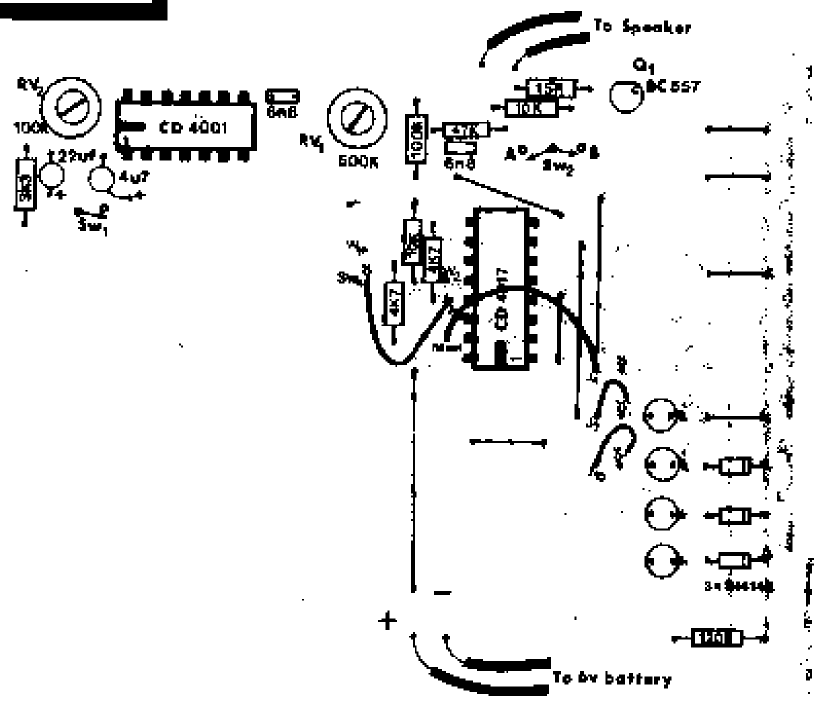
MOUNTING THE PARTS

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.

⇦ DISPLAY CARD



DECISION MAKER LAYOUT

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 troubleshooters, 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.

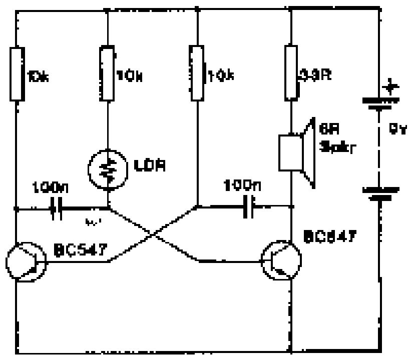
Some dry joints are classified as thermal faults. By this we mean the set will operate for a certain length of time then fail. This is due to the heat build-up in the set, expanding the components and their leads a few thousandths of an inch (or even millionths of an inch) to create an opening or crack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

...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.

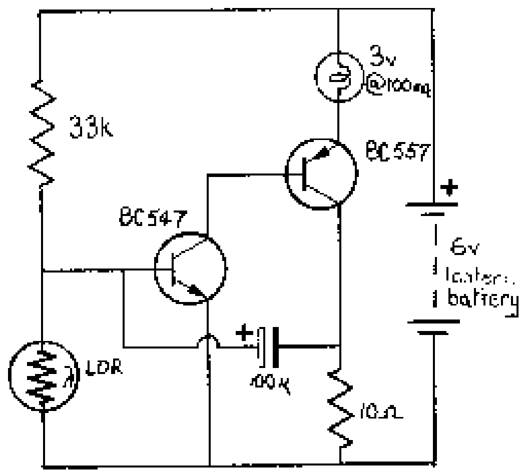
A piece of veroboard 12 holes long will accommodate all the parts making it a very compact project which can be disguised as a packet of pills by using a suitable empty container.

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 da 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 lo as possible to conserve battery. Since the flas 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"

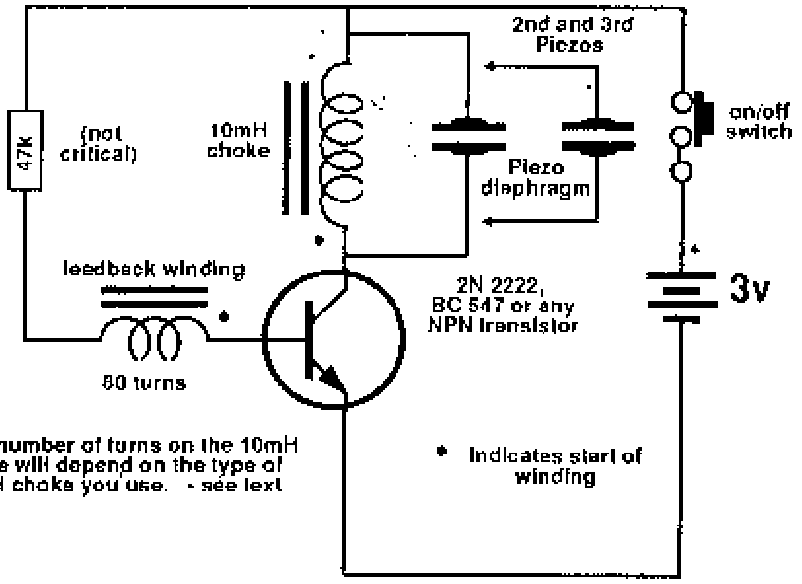
The stand-by current is only 100microamp and th average operating current is less than 25 milli amps. The only two critical components in the circuit are the 10 ohm resistor and globe. The resistor must be 10 ohms. A 5 ohm or 15 ohm resistor will not work. The lamp must be a low current type. A miniature model railway globe o 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

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.

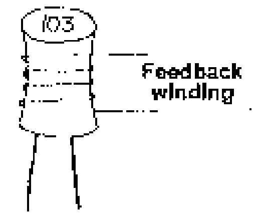
2. TRANSFORMER ACTION

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



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."

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.

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

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 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

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.

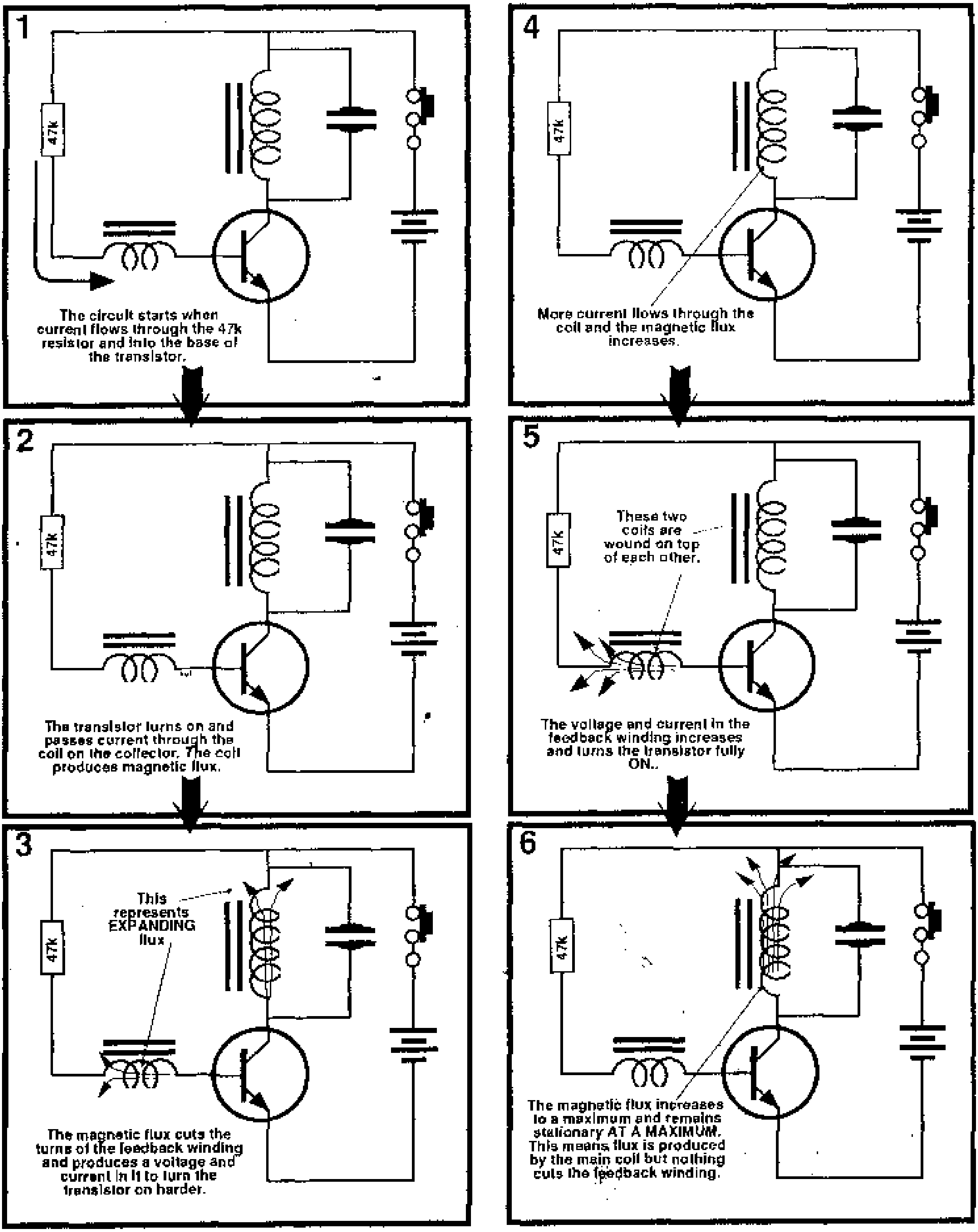
Each phase-shift is 180° and this means the combination of the two produces a 360° phase shift. This brings the output in phase with the input and creates positive feedback. It is easy to see how the feedback winding creates 180° phase shift.

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.



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)

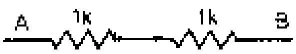
2. Draw the symbol for:
   (a) A fixed resistor (1 mark)
   (b) A potentiometer (1 mark)

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)

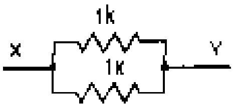
5. What are the colours of these resistors?
   (a) 2.2M (4 marks)
   (b) 470ohm (4 marks)
   (c) 56k (4 marks)
   (d) 220ohm (4 marks)
   (e) 3k3 (4 marks)

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

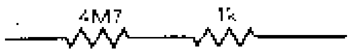
SECTION 2: More Advanced

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)

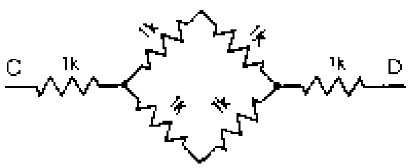
16. Four resistors, all consisting entirely of red bands, are paralleled. What is the combined resistance? (4 marks)

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)

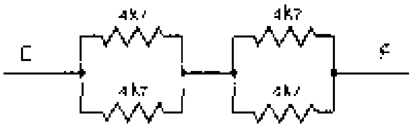
20. What is the value across the terminals C&D? (5 marks)



21. From a sample of 50 different resistors, which colour appears most often? (2 marks)

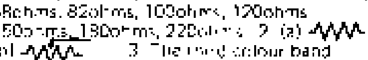
22. A black bag contains 10 1k resistors and 10 3k3 resistors. How many resistors must you choose to be guaranteed a resistance of:
    (a) 1k (5 marks)
    (b) 10k (5 marks)
    (c) 4k3 exactly (5 marks)

23. What is the resistance between E&F? (5 marks)



Total 74 Marks

Answers:

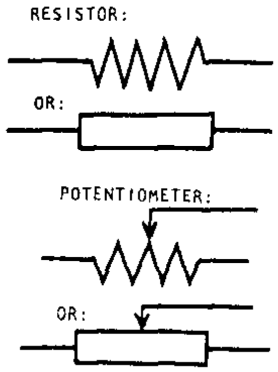
1. 12ohms, 15ohms, 18ohms, 22ohms, 27ohms, 33ohms, 39ohms, 47ohms, 56ohms, 68ohms, 82ohms, 100ohms, 120ohms, 150ohms, 180ohms, 220ohms. 2. (a)  3. The third colour band black, red. 4. (a) 22k (b) 470ohms (c) 68k (d) 2M7 (e) 5k6. 5. (a) red—red—green (b) yellow—purple—brown (c) green—blue—orange (d) red—red—brown (e) orange—orange—red. 6. 2k. 7. Their wattage is different. 8. 500ohms. 9. They were read around the wrong way. (a) 3V3 10% (b) 270ohms 5%. 10. 220ohms, 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 1k 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:

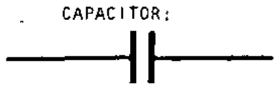
Over 65 marks — Excellent
Over 50 — Very Good
Over 40 — Good
Below 40 — Not a ...

DATA Sheet No.1.

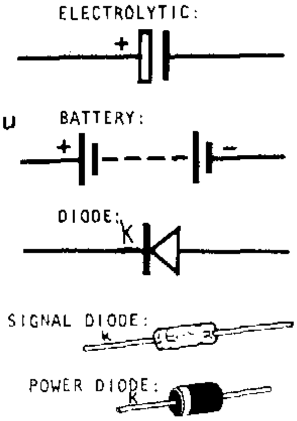


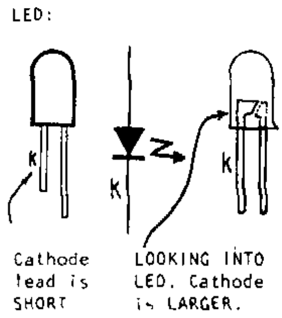
Ω = ohms
R = ohms
k = 1,000 ohms
M = 1,000,000 ohms

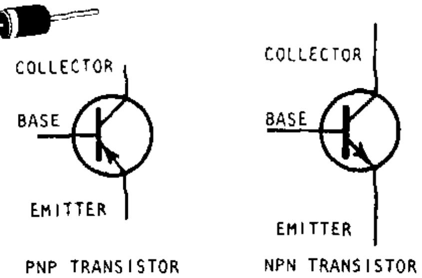
103 = 10k ohms
104 = 100k ''
105 = 1M ohms

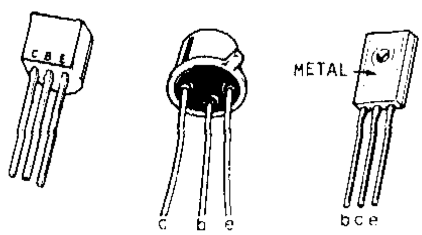


mfd = microfarad = u
pF = picofarad
n = nanofarad
1000pF = 1n
1n = 0.001u
1,000n = 1u
2n2 = 0.0022u
22n = 0.022u
102 = 1,000pF
103 = 10,000pF = 0.01u
104 = 0.1u
105 = 1u

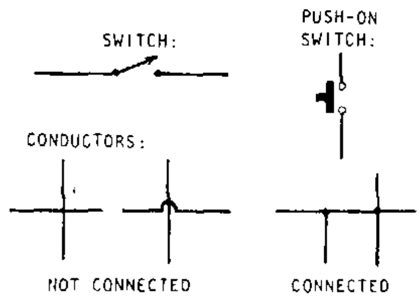




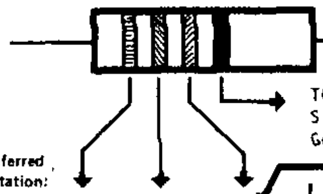




Any transistor CASE may be PNP or NPN.



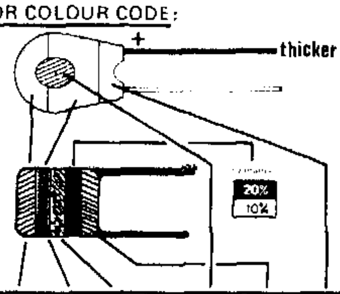
COLOUR CODE FOR RESISTORS



Silver or gold here is a divisor, NOT tolerance.
Silver: DIVIDE by 100
Gold: DIVIDE by 10

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	[illegible]	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	[illegible]	[illegible]
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
[illegible]	[illegible]	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	x1,000pF		
YELLOW	4	4	x0.01u	400v	6.3v
GREEN	5	5	x0.1u	100v	16v
BLUE	6	6		630v	
VIOLET	7	7			
GREY	8	8	x0.01u		25v
WHITE	9	9	x0.1u		3v
PINK					35v