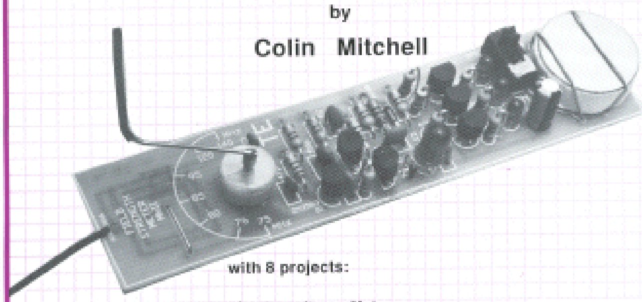
ELECTRONICS NOTEBOOK

6

by

Colin Mitchell



with 8 projects:

- Capacitance Meter
- Transistor Tester
- Continuity Tester
- Field Strength Meter MkI & MkII
- Logic Probe MkIIB
- Phone Ring
- TTL Dice

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A TALKING ELECTRONICS PTY LTD PUBLICATION

INTRODUCTION

WHY IS IT SO?

As Professor Julius Sumner Miller so often said "Why is it so?"

Why are magazines and books filled with so much padding, hype, advertisements and rubbish?

There is so much information to get across to readers in this technological age - it amazes me to see so many magazines with glossy pages of advertising and fiddly articles that don't really say anything at all.

So too with books.

You wonder how a sub-editor could pass some of the manuscripts! Quite often an entire book is nothing but drivel and regurgitated padding.

I know, I have shelves full of them. That's why they call them pulp. They're only good for pulping back into recycled paper. Many don't have a single page of valuable material.

Quite often the only thing that attracts you in the first place is the cover. Once you get the book home and look through the pages you feel like you've been duped. I've spent hundreds of dollars on these worthless dust collectors and now I'm more astute. I look through them before buying. The only reason I keep the junk ones is to stop the others falling over!

But things have now got even worse. Not only are the trashy books staying trashy, but the prices are going up. Have you seen how expensive books and magazines have become?

It seems we are locked into an ever-increasing spiral. As the cost of printing goes up, the cover price increases. This reduces sales and increases the cost of printing. So we see another increase in price.

Where it will end I don't know. Magazines that were a couple of dollars a few years ago are now twice the price and books that were less than ten dollars are now nearly thirty dollars! Some magazines from overseas are around the seven dollar mark!

I wouldn't mind paying seven dollars if the intention of the editor was to provide the reader with good articles. But the main aim is to provide a vehicle for the advertisements and allow the articles to "fill the holes."

Even some of the adverts are annoying. Some are repeated over and over again, month after month while others are so microscopically reduced in size that you need a magnifying glass to read them. How you are expected to read them, I don't know.

And what about the glossy paper. Have you ever tried to read an article under an electric light with the shine of the paper obliterating the text. It's exasperating. It's a typical example of a designer never using or testing his own product.

But the production of glossy magazines and pulp books has a broader ramification.

The natural resources consumed by them is enormous. The amount of timber required to print a run of a single book is astronomical. It's almost equal to the wood required to frame a 14 square house. If you extrapolate this into all the newspapers and books produced in a single day, you can see how many houses are being denied.

The world is consumer-oriented and advertiser driven.

I wouldn't be half as angry if it wasn't for the wastage. More than 25% of all publications are wasted. If a publication doesn't sell within an allotted time is it returned to the distributor for pulping or disposal. Most times it is sent for straight-out disposal.

Out of all the product that is sold, only a small percentage is read completely and only a tiny percentage is shared.

Take the most wasteful product ever invented. The telephone book. Not only is it 6 months out of date when you get it but the number of pages looked at by a household per year is less than ten. The other 99.9% of the book is never used!

The next biggest waster is the local paper and then the daily

CONTENTS

● PROJECT TO BUILD

All the projects in this book are available in kit form from Talking Electronics. See inside front cover for details.

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newspaper.

We have only got ourselves to blame. We laugh at Russia producing 500 copies of a newspaper and pasting them on a billboard for everyone to read. But the time is coming when we should reject the local paper, tear down our newspaper tube for junk mail, stop buying the newspaper and revert to a community attitude of reading the pages of a displayed copy.

This will not only save millions of trees but somewhat restore our global weather balance!

We at Talking Electronics have tried to regress this situation by producing books and magazines that are totally free of wasted pages and unnecessary advertising. The only problem with this is the delay between issues, as it takes a long time to produce 70 pages of concentrated information.

Anyhow we are out again with another Notebook and since all the previous issues have sold out we are convinced they are a needed resource.

In this issue we have combined theory with a number of projects so you can put your understanding into practice with construction.

You will notice we are always guiding you along the practical path in the hope you can turn your studies into a career.

We have always said that electronics is one of the most successful ventures you can enter. The world of electronics is advancing faster than any other field and you can enjoy its rewards if you follow through with at least some of the areas we are covering.

It doesn't matter if you are a designer, promoter or manufacturer of electronic devices or prefer the software side, the scope for new products is enormous.

All it takes is the capability to design the right product at the right price. In this way you can be ahead of the competition and maybe start your own business.

In this regard we try to help you all the way. Lots of our pages have stories and anecdotes to assist you and prevent some of the pitfalls that cripple 50% of new businesses in the first two years.

Even if you are not a whizz at electronics you may be able to excel at the marketing side. Always remember that marketing is 70% of the success of an idea.

It's no good having brilliant ideas if they aren't marketed properly. You must be able to get your idea out to the buyer quickly and cheaply.

But this needn't be an expensive exercise. In fact it must be cost-effective and means you should spend as little as possible on advertising.

Advertising is a compete waste of money. You will make absolutely nothing out of your product if you have to advertise it heavily.

This goes against everything you have been told in the past but that's because you have been fed false figures.

The only way to sell a product is to PROMOTE it. You do this by distributing leaflets and creating displays at outlets that sell your product. This will create "word of mouth" sales and a satisfied customer will tell his friends. But a dissatisfied customer will tell the world! So you have to have a quality product at a realistic price.

To prove my point, we have not spent one cent on advertising Talking Electronics in 12 years and that's the only way we can keep our prices down.

The second tip I can offer is DON'T BORROW! Never take out a loan or borrow any money at all from any loan organisation whatsoever. It's the surest way to go under.

Save up before you start your business and keep within its income. It may be slower but it's guaranteed to work in the long run.

It doesn't matter how inviting a loan may sound on paper, the fact is the lending company becomes a monkey on your back sooner than you think. It finishes up being a "ghost" worker, picking up more than you!

It's enough that credit-cards take 3% - 5% of everything you make, imagine how fast you would go under if every dollar cost you 17%! But that's what a loan costs.

And the loan companies start to dictate - ringing up at the most inconvenient time, demanding the account be pulled into line and strangling your achievements. The answer is to say NO from the start and you won't have to grovel to someone you despise.

The main secret is to keep small. The most efficient business is 3 - 4 workers! Yes, it's a fact. The most efficient business consists of only 3 or 4 workers. Once you get over 5, the return per head decreases. You need bigger premises, a secretary, sandwich boy, accountant, cleaner and the list goes on.

So, keep small but think BIG. Think of ideas that will help in the educational field, the medical field, industrial field and in fact everywhere around you. There are so many devices to be designed and improved that when they come on the market you say "why didn't I think of that!"

Be first, and think of an idea. Look around and see what YOU need. Expand the idea and see if others need it too. Then think of how many in a population of 16 million will need it. Imagine the sales potential for one billion consumers!

Remember, there's a millionaire created every 20 minutes in America. So, someone's succeeding, why can't it be you? It can, but if you are only just starting in electronics you will have to be patient. You have a lot of preliminaries to work on. I suggest you begin by building up your knowledge-base so you will be capable and able to launch a product when the time comes.

Get to it, and read as much as you can and build as many projects as possible. It's only through construction that you will really understand electronics.

TE has produced a range of more than 25 books, of which only about 10 are still available. The rest have completely sold out.

The ones to look for are the Notebook series: 1-6, bugging books such as 14 FM Bugs and Security Devices, Digital Electronics Revealed, and Smart Security Devices.

All the books contain projects and articles specifically designed to help you learn electronics and we can do nothing more than put them out at the lowest price so you can get them all.

We have already had many reports of the success of our readers and I know this will continue during these hard times. The best YOU can do is prepare yourself for the eventual demand for qualified and forward-thinking personnel. I know of three occasions where the mere mention of Talking Electronics has won the person a job and a career - don't forget to try it yourself.

This Notebook contains a lot of things I have been saving up for years and years. Many of them are so old that if I don't put them into print they will be lost forever. They have been put at the back of the book. I hope you like them.

Cheers,

Colin.

Julius Sumner Miller

Julius Sumner Miller is undoubtedly one of the greatest teachers of our time. Not so much for what he taught but his way of teaching. He showed that teaching and learning can be fun. He reduced the most complex mathematical concepts into simple ideas that made even me sit up and think.

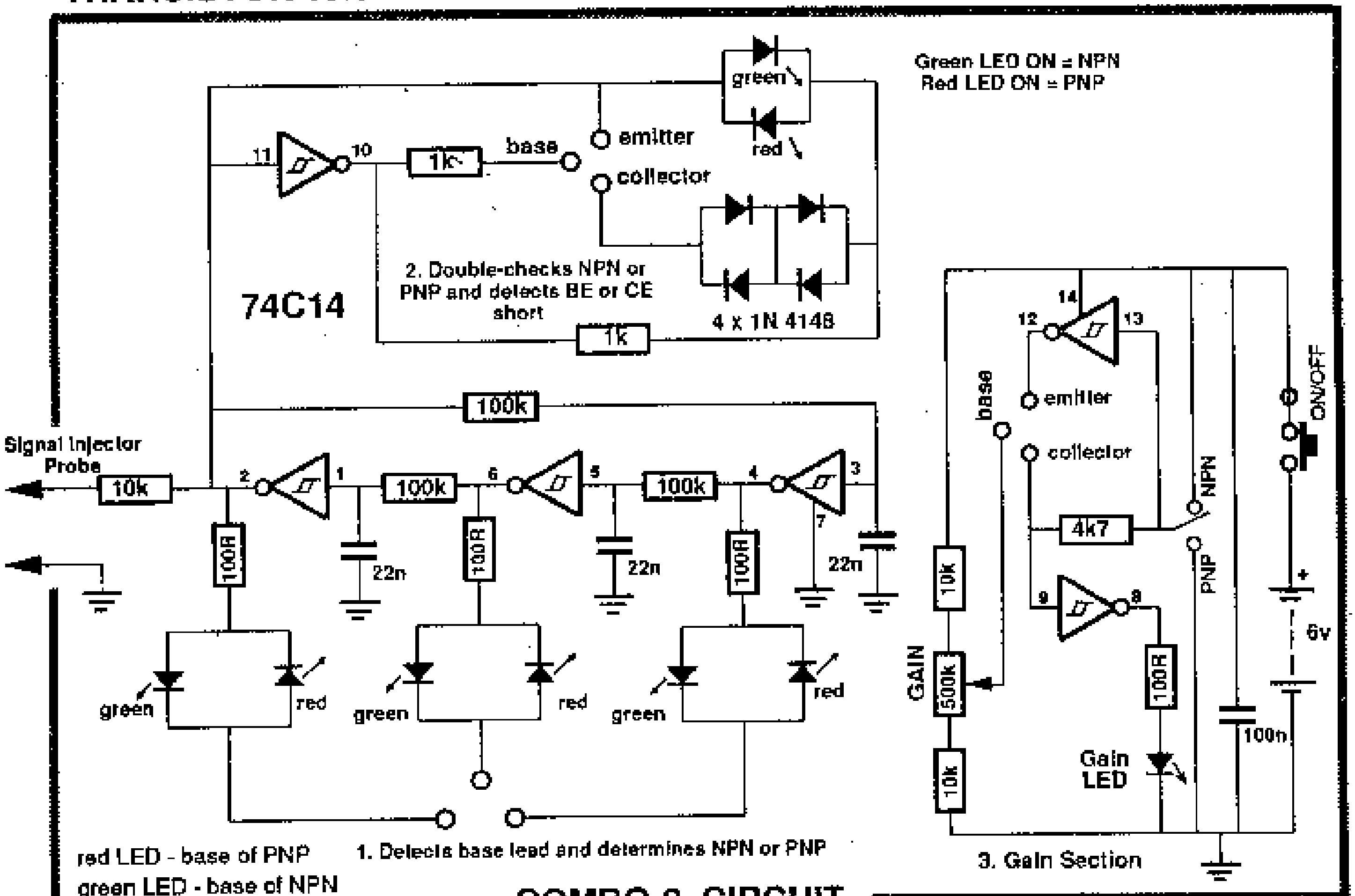
It's unfortunate that he, and the Sydney School of Physics, did not get the recognition they deserve. Relegated to an early morning program on TV they had an enormous struggle to get the concept of teaching the masses Physics and Science, accepted.

If you ever get the opportunity to see an old video of Julius Sumner Miller in action you will see what I mean when I say he is one of the teachers I most admire. That's why I like his quote: "Why is it so?"

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 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.

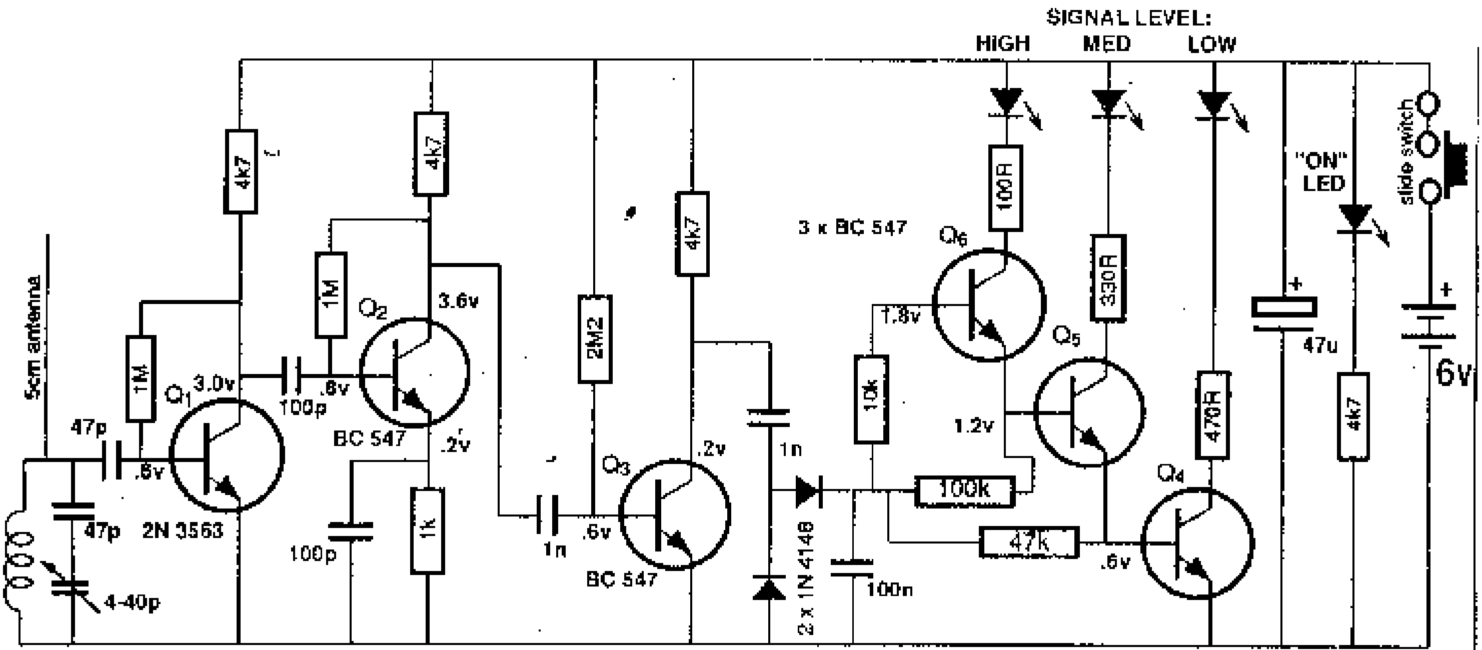
As the frequency of operation of a transistor increases, its gain decreases to unity and this point is called F_T, the cut-off point and determines the maximum frequency at which the transistor will operate. This is usually in the MHz range for small signal transistors and about 1MHz for power transistors. 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.

FIELD STRENGTH METER Mk II

Parts & PC: $13.60
PC board only: $3.00



FIELD STRENGTH METER MkII

Voltages on Q1, Q2 and Q3 measured with no input signal. Voltages on Q4, Q5 and Q6 measured with full input signal.

This project has 3 features. It's ① a Field Strength Meter, ② a Frequency Meter and ③ an aid for testing detuned transmitters.

Its uses will become clear in a moment but firstly let's go over the background of a Field Strength Meter.

A Field Strength Meter is essential when designing and building transmitters. It provides signal strength values and allows us to compare and estimate the efficiency of a transmitter and its expected range.

Obviously the most accurate way of getting these results is to make a field test but this sometimes requires travelling long distances, so the next best thing is to get results on the bench by using a piece of test equipment such as an RF POWER METER.

An RF power meter is similar to a field strength meter, however the two are used slightly differently.

An RF Power Meter is generally connected directly to the antenna of a transmitter whereas a Field Strength Meter is placed NEAR the antenna without physically touching it.

When you only have 5 - 50 milliwatts available, it is very difficult to place a measuring device (such as a Power Meter) in the antenna circuit without it absorbing and upsetting the energy being radiated.

When you are dealing with frequencies in the 100MHz range, the signal flows over and through any device you place in the antenna circuit. Some of the signal is absorbed in the measuring device so that the reading may not be a true indication of the output. At the same time the performance of the transmitter is reduced so you don't know how to interpret the results.

A much more accurate way of detecting the energy is to place a device NEAR the radiating source (the antenna) so that it does not interfere with the transmission.

> **SUMMARY**
> - Checks the output of low-power transmitters
> - 3 LED readout
> - Detects from 75MHz to 140MHz

This is the advantage of our FSM. It is placed near the radiating source and detects the energy AT A DISTANCE so that the output is not upset.

This project differs from the first FSM described on page 18 in that it is a stand-alone unit and does not require connection to a multimeter.

It contains a set of 3 LEDs, wired in a staircase arrangement, so that they light up progressively as the strength of the signal increases.

A trimmer capacitor at the front end tunes the exact frequency of the trans-

PARTS LIST

1 - 100R
1 - 330R
1 - 470R
1 - 1k
4 - 4k7
1 - 10k
1 - 47k
1 - 100k
2 - 1M
1 - 2M2
2 - 47p ceramics
2 - 100p ceramics
2 - 1n ceramics
1 - 100n monoblock capacitor
1 - 4 - 40p air trimmer
1 - 47u 16v PC mount electrolytic
2 - 1N 4148 diodes
5 - BC 547 transistors
1 - 2N 3563 transistor
4 - 3mm red LEDs
1 - spdt slide switch
1 - paper clip for pointer on trimmer
1 - 5cm enamelled wire for antenna
1 - 10cm tinned wire for batteries
2 - 3v lithium cells
1 - FSM MkII PC board

HOW THE CIRCUIT WORKS

The probe uses 2 IC's and a handful of components to indicate the state of the input on 3 LEDs while the piezo gives an audible indication of the state of the line.

The input is connected to two Inverters in the 4049 IC. The top one is held above mid-rail via the 1M trim pot while the bottom one is held below mid rail by the 1M/220k voltage divider.

The object is to keep these two inverters in a stable state so that they will change state when an Input waveform is detected.

The output of the top inverter passes through another stage of inversion so that the result is equivalent to that of a buffer.

The pulse circuit is taken from the lower inverter and passed through a pulse stretcher made up of two inverters in a monostable mode, to illuminate the pulse LED.

The 3 indicator LEDs (HIGH, LOW, PULSE) must not be illuminated when no signal is present. To achieve this, the output of the 3 driving circuits must be high, and go low when the appropriate LED is to be turned ON.

The 1M trim pot on the Input line sets the voltage on pin 7 of the top inverter so that the LOW LED is illuminated when the probe detects a LOW.

The Inverter between pins 3 and 2 turns on the HIGH LED when the probe detects a HIGH.

The 100p capacitor (between pins 3&7 of the inputs of these two blocks) acts as a speed-up capacitor.

The pulse stretcher is taken from the output of the HIGH inverter via a 100p capacitor and the input of this monostable is high due to the presence of the 2M2 resistor. This makes the output pin 12 low. The 1u electrolytic sits in an uncharged condition and the output is high so that the pulse LED is not illuminated.

The circuit is triggered into operation via the 100p on input pin 9, when output pin 2 goes low. This causes pin 12 to go high and takes pin 14 high with it.

Pin 15 goes low and the latching feature is provided by the diode between pins 12&9. When pin 12 goes low, pin 9 is pulled low and the circuit latches into this state.

The time-delay for the circuit is controlled by the charging of the capacitor, via the 470k resistor.

The voltage on pin 11 gradually falls and at about 40% of rail voltage the inverter changes state and pin 12 goes HIGH. The pulse LED will go out and the low on pin 9 (provided by the diode) will be removed.

The inverter between pins 9&10 will change state and the charge on the 1u will be removed fairly rapidly due to the presence of diodes on the input line (pin 11) of the second inverter.

The remainder of the logic probe is handled by the Schmitt trigger IC.

When a LOW is detected, the low LED turns on and the line also passes to a tone oscillator between pins 3&4 of the 74c14 to produce a low tone. The output of this oscillator is buffered by a pair of Inverters to drive a piezo. These fantastic little devices are effectively a crystal that changes shape (sideways mode) when a voltage is present between its two electrodes.

By wiring it as shown, it sees a voltage that is double rail voltage and this accounts for its loudness (see notebook 4, P 55 for a detailed explanation).

When a HIGH is detected, the high tone comes into operation and the piezo is pulsed with a square wave to give the characteristic piezo sound.

The diodes between input and output of the tone circuits are gating diodes to allow pulses from different blocks to feed into the one circuit.

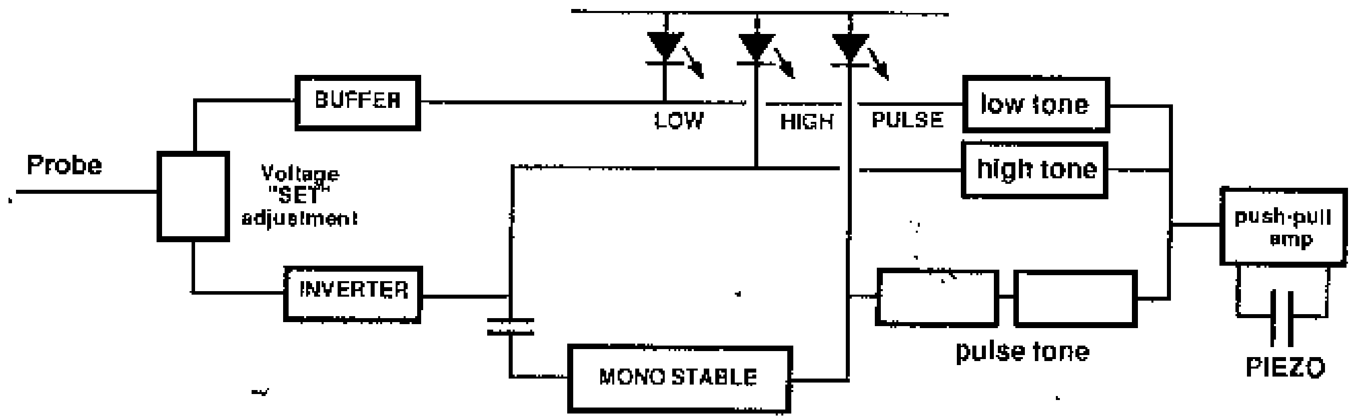
The diode between pins 6&9 turns on the Schmitt oscillator between pins 9&8 when the anode of the diode is low. This allows the 22n to discharge via the 68k resistor and the circuit will start to produce a tone. When the anode is high the 22n remains charged and the oscillator is prevented from operating. This is a simple way of "gating" or turning the oscillator on and off.

The output from the pulse stretcher circuit is taken from an inverter between pins 14 &15 and passed to a pulsed-tone circuit made up of a Schmitt Inverter between pins 5 & 6 and 9 & 8. At the same time both high and low tone sections are disabled.

A power diode is provided in the positive rail to prevent damaging the probe with reverse voltage if connected to the power around the wrong way.

The 1u and 10n capacitor across the rails help remove spikes from the power rails and prevent false triggering. The 10k input resistor prevents the circuit being tested, from overload or damage.

BLOCK DIAGRAM



The input block is a "voltage set" control to turn the HIGH/LOW indicator LEDs off when no input is present.

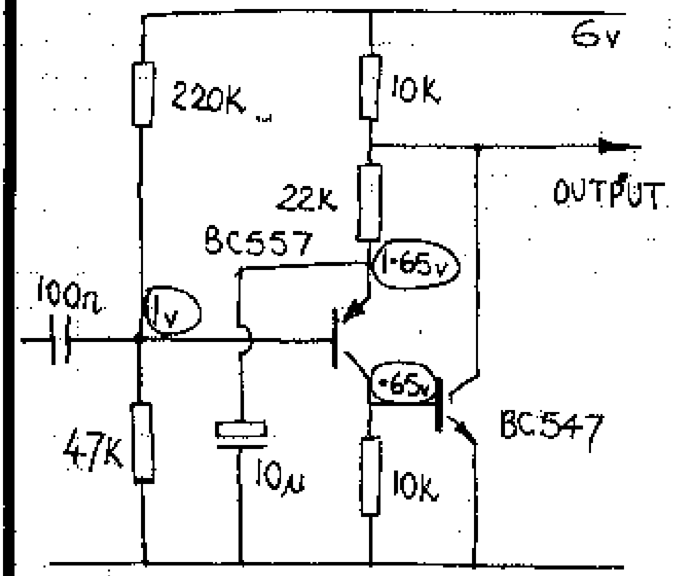
The incoming signal is passed through a non-inverting buffer (two inverting buffers in series) and also one inverting buffer. The output of these gives the HIGH/LOW indication.

A pulse-stretcher circuit provides an indication of a pulse as short as 1 microsecond. The outputs of the HIGH/LOW drivers are passed to tone circuits to drive a piezo. The pulse circuit is fed to a pulse-tone pair of oscillators to provide a beep tone for the piezo.

The result is 3 different tones to make it easy to differentiate between HIGH, LOW and PULSE.

A HIGH GAIN STAGE

THIS CIRCUIT OFFERS HIGH GAIN, GOOD STABILITY AND NEEDS FEW COMPONENTS.



A HIGH-GAIN DC COUPLED AMPLIFIER

THE FIRST FACTOR TO UNDERSTAND IS THE 'QUIESCENT STATE' — IN OTHER WORDS 'HOW THE CIRCUIT TURNS ON', & MAINTAINS AN EQUILIBRIUM OR 'REST STATE' — IN WHICH THE TRANSISTORS ARE JUST AT THE POINT OF 'TURN ON'.

THE CIRCUIT STARTS UP THIS WAY:

THE 220K/47K FORMS A VOLTAGE DIVIDER WITH THE MID-POINT AT 1v $\left(V = \frac{47}{220} \times 6 = 1v\right)$

THIS IS THE STARTING POINT FOR THE BIASING OF THE CIRCUIT & IS THE VOLTAGE FOR THE BASE OF THE FIRST TRANSISTOR.

THE 220K/47K COMBINATION SET THE POTENTIAL FOR THE CIRCUIT. — THE BASE OF THE FIRST TRANSISTOR DOES NOT SET THIS VALUE.

NEXT WE GO TO THE EMITTER OF THE FIRST TRANSISTOR. THE VOLTAGE BETWEEN THE BASE & EMITTER MUST BE VERY CLOSE TO ·65v (SINCE THE TRANSISTOR IS AT THE POINT OF JUST BEING TURNED ON.) THIS MEANS THE EMITTER MUST BE 1·65v.

THE 'TURN-ON' OF THE FIRST TRANSISTOR PRODUCES A VOLTAGE DROP ACROSS THE 10K COLLECTOR LOAD RESISTOR AND THIS IS ·65v DUE TO THE BASE-EMITTER JUNCTION OF THE SECOND TRANSISTOR. THIS VOLTAGE IS ENOUGH TO BEGIN TO TURN ON THE SECOND TRANSISTOR.

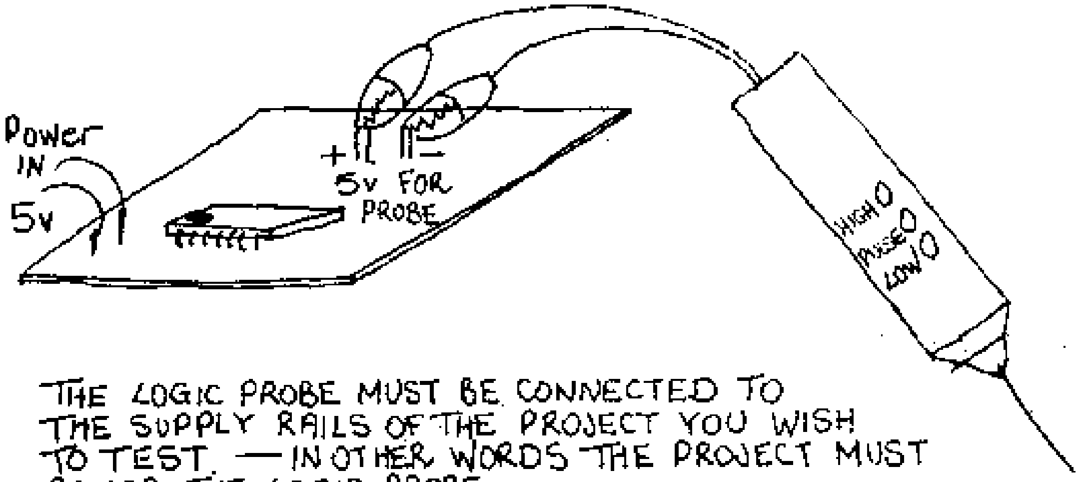
THE VOLTAGE ON THE COLLECTOR OF THE SECOND TRANSISTOR FALLS. THIS PUTS A REDUCED VOLTAGE ON THE JOIN OF THE 10K & 22K RESISTORS AND THE CURRENT FLOW THROUGH THE 22K RESISTOR CONTROLS THE 'TURN ON' OF THE FIRST TRANSISTOR.

THIS CREATES A STABLE CONDITION CALLED THE 'REST STATE', 'EQUILIBRIUM', QUIESCENT STATE' OR 'DC STATE.'

HOW DOES THE CIRCUIT AMPLIFY?

WHEN CONSIDERING THE AC OR AMPLIFYING STATE, THERE IS ONE IMPORTANT POINT TO REMEMBER. THE EMITTER OF THE FIRST TRANSISTOR IS EFFECTIVELY 'FIXED' OR 'RIGID' AS FAR AS THE SIGNAL IS CONCERNED. IN OTHER WORDS THE EMITTER DOES NOT SEE ANY AC SIGNAL — YOU WILL SEE HOW & WHY ON THE NEXT PAGE.

USING A LOGIC PROBE



THE LOGIC PROBE MUST BE CONNECTED TO THE SUPPLY RAILS OF THE PROJECT YOU WISH TO TEST. — IN OTHER WORDS THE PROJECT MUST POWER THE LOGIC PROBE.

THERE ARE TWO REASONS FOR THIS.

FIRSTLY IT BRINGS THE DETECTING VOLTAGES (THE HIGHS & LOWS) OF THE PROBE IN LINE WITH THOSE OF THE PROJECT.

FOR INSTANCE, IF THE PROJECT OPERATES ON 5V, THE PROBE WILL BE POWERED BY A 5V SOURCE & THUS IT WILL REGISTER A 'HIGH' WHEN IT SEES A VOLTAGE BETWEEN 3·5 – 5V.

IF THE PROJECT OPERATES ON 12V, (FOR CMOS CHIPS) THE PROBE WILL REGISTER A 'HIGH' WHEN IT SEES A VOLTAGE BETWEEN 8 – 12V. OBVIOUSLY YOU DO NOT WANT THE PROBE TO REGISTER A HIGH WHEN IT SEES 3·5V – 5V (IN THE EXAMPLE ABOVE) AS THIS IS A LOW FOR 12V CMOS OPERATION.

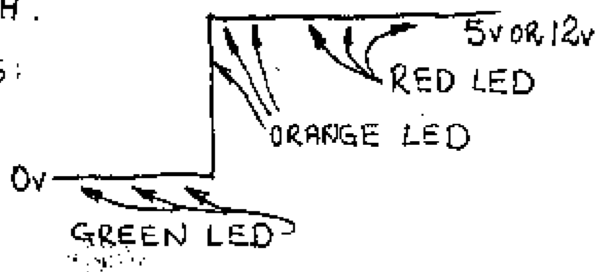
THE SECOND REASON FOR POWERING THE PROBE FROM THE PROJECT, IS TO CREATE AN EARTH RAIL FOR A "LOW" & A POWER RAIL FOR A "HIGH." IF A PROJECT HAS BOTH 5V & 12V RAILS, YOU MUST CHANGE THE PROBE VOLTAGE TO MATCH THE CHIPS (OR LINES) YOU ARE TESTING.

SETTING UP

WHEN THE PROBE IS CONNECTED TO THE POWER RAILS, NO INDICATOR LEDS SHOULD COME ON, — THE TIP IS "FLOATING". BY PROBING THE NEGATIVE RAIL (ZERO RAIL) THE GREEN LED WILL COME ON. BY PROBING THE POSITIVE RAIL, BOTH THE PULSE LED (ORANGE) AND RED LED WILL COME ON. THIS WILL INDICATE THE INPUT OF THE PROBE IS GOING FROM "ZERO" TO 'HIGH'.

A GRAPH FOR THIS CAN BE SHOWN THUS:

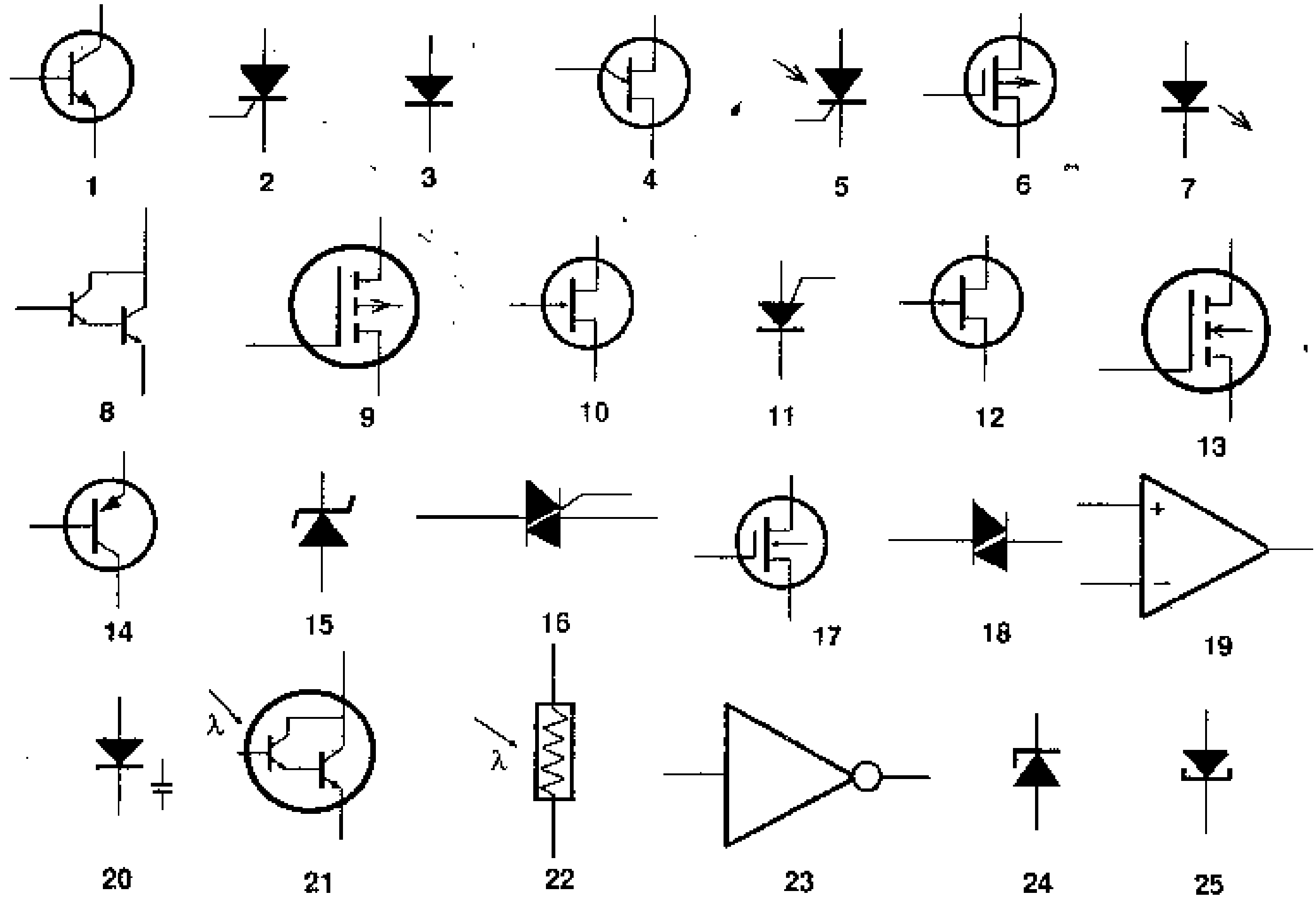
THE ORANGE WILL ONLY STAY ON FOR A MOMENT AS IT IS A 'PULSE LED'.



SYMBOLS QUIZ

See Learning Electronics-2 Page 70 for assistance.

Match each symbol with its correct name:



Select from these:
(a) LASCR (Light Activated SCR)
(b) N-channel JFET (Junction-field-effect transistor)
(c) P-channel JFET (Junction field-effect transistor)
(d) Inverter
(e) NPN transistor
(f) PNP transistor
(g) tunnel diode
(h) N-channel enhancement-type MOSFET
(i) P-channel enhancement-type MOSFET
(j) PUT (programmable unijunction transistor)
(k) diode
(l) TRIAC
(m) OP AMP (operational amplifier)
(n) Varicap Diode
(o) NPN Darlington Transistor
(p) LED (Light Emitting Diode)
(q) SCR (Silicon Controlled Rectifier)
(r) UJT (Unijunction Transistor)
(s) Zener diode
(t) LDR (Light Dependent Resistor)
(u) Photo Darlington Transistor
(v) Zener Diode (Alternate Symbol)
(w) P-channel depletion-type MOSFET
(x) N-channel depletion-type MOSFET
(y) DIAC (Diode AC Semiconductor)

ANSWERS:
1. (e) NPN transistor
2. (q) SCR
3. (k) diode
4. (r) UJT
5. (a) LASCR
6. (i) P-channel depletion-type MOSFET
7. (p) LED
8. (o) NPN Darlington transistor
9. (w) P-channel enhancement-type MOSFET
10. (b) N-channel JFET
11. (j) PUT
12. (c) P-channel JFET
13. (h) N-channel enhancement-type MOSFET
14. (f) PNP transistor
15. (s or v) Zener diode
16. (l) TRIAC
17. (x) N-channel depletion-type MOSFET
18. (y) DIAC
19. (m) OP AMP
20. (n) Varicap diode
21. (u) Photo Darlington Transistor
22. (t) LDR
23. (d) Inverter
24. (s or v) Zener diode
25. (g) tunnel diode

GLOSSARY OF TERMS

Rev Jan '94

AC Alternating Current. The "mains" or "AC" is electrical current that constantly varies in amplitude sinusoidally. The voltage of the mains also changes direction but in this case we refer to the current changing direction.
AC Voltage A voltage that is constantly changing direction.
A/D Converter Circuit that converts analogue signals into a digital equivalent.
Access Time The time required to send or receive data from a specific memory location.
Accumulator Central register of a processing chip where arithmetic or logical operation can be performed. Also the name given to a rechargeable battery such as a car battery.
Active Component. A component that provides gain or amplification such as transistor, integrated circuit, valve - such as a triode value, See Passive for opposite.
Adder Circuit that can add binary numbers.
Address A specific location within a system's memory map.
Address Bus Bus that carries the value of the location in memory.
Address Decoder Circuit that detects the presence of a particular address.
Aerial (Antenna) A length of wire designed to transmit or receive radio waves.
AF Audio Frequency. Generally the range 20Hz to 20kHz.
AFC Automatic Frequency Control. Similar to Automatic Fine Tune (AFT) A circuit that keeps a receiver in tune with the wanted transmission.
AGC Automatic Gain Control. A circuit that adjusts the gain of a stage so that the volume is constant even though the input signal may vary over a wide range.
Alternating Current (AC) An electric current whose direction changes direction with a frequency independent of circuit components.
ALU Arithmetic Logic Unit. The section of a microprocessor that carries out all arithmetic and logic operations.
AM Amplitude Modulation. Where audio signals increase and decrease the amplitude of the "carrier wave."
Ammeter Instrument for measuring the current in amps, milliamps or microamps. Milliammeter. Microammeter.
Amp The unit of electrical current. Also milliamp (1/1,000amp and microamp 1/1,000,000amp i.e. one thousandth of an amp and one millionth of an amp). One amp corresponding to the flow of about 6×10^{18} electrons per second.
Ampere-hour Corresponding to the flow of 1 amp for 1 hour i.e. 2.2×10^{22} electrons.
Amplify A circuit that increases the amplitude of a signal.
Amplitude The highest value reached by voltage, current or power during a complete cycle.
Analogue A system in which data is represented as a continuously varying voltage.
AND gate Gate that produces a logic 1 when all of its inputs are 1. In all other cases the output is 0.
Antenna A length of wire or similar that radiates (such as a transmitting antenna) or absorbs (such as a radio antenna) radio waves.
Artificial Intelligence The capability of machine to learn and correct itself and adapt to new situations
ASCII American Standard Code for Information Interchange. The most widely used code that assigns a specific sequence of binary digits to alphanumeric and control codes.
Assembly Language Next step up from machine code it consists of letter codes called mnemonics that stand for machine code instructions
Astable A circuit that has no stable state and thus oscillates at a frequency dependent on component values.
Asynchronous A form of data transmission (parallel or serial) that is not synchronised.
Audio A signal that can be heard with the ears.
Automatic Frequency Control (AFC) A circuit that automatically maintains the frequency of any source.
Automatic Gain Control (AGC) A circuit that automatically controls the gain of another circuit to maintain a constant output during variation in input waveform.
Autotransformer A transformer that has a single winding with tappings, rather than two separate windings. Transformer action still applies and the only difference is the transformer does not provide isolation as with a true primary and secondary situation.
AVC abbreviation for automatic volume control.

Back Electromotive Force Back emf. The emf that opposes the normal flow of current in a circuit.
Balun Comes from Balance/Unbalanced transformer. Used for example to connect a balanced antenna to an unbalanced (coaxial) transmission line.
Base One terminal of a transistor. Generally the input lead. It separates the collector and emitter regions.
BASIC Beginners All-Purpose Symbolic Instruction Code.
Battery A device for supplying DC voltage. A group of cells is called a battery.
BAUD Measure of serial transmission speed - bits per second. 1 baud is one bit per second.
BFO Beat Frequency Oscillator. An adjustable frequency oscillator with an output that can be mixed with the final intermediate frequency signal to produce audio.
Bias A Voltage whose main function is to set the operating characteristics of an electronic device. e.g. bias resistor.
Bimetallic Strip A strip consisting of two metals with different coefficients of expansion bonded together. When the strip is heated it bends and this can be used to open or close contacts.
Binary Number System based on the number 2. The binary digits are 0 and 1.
Bipolar transistor The most common form of transistor.
Bistable Circuit that has two stable states.
Bit Binary digit - the smallest unit of binary data.
Blocking Oscillator An oscillator in which blocking occurs at the end of a cycle., This type of circuit usually employs a transformer.
Bootstrapping A technique used to provide 100% positive feedback in a circuit to improve the output.
Bottoming A transistor in the fully conducting state.
BPS Bits Per Second - the number of bits transmitted over a serial link in one second.
Breadboard A board for holding components that make a circuit. The components can be removed an reused without being damaged. Also called a proto-typing board.
Bridge - generally a short-circuit on a PC board caused by solder joining two adjacent tracks.
Bridge rectifier a full-wave rectifier in which there are four arms - each containing a diode.
Bubble Memory Serial memory in which small magnetic bubbles are used as the storage medium.
Buffer A temporary memory location in which data is stored prior to use. In analogue use it is a circuit that isolates the driving circuit from the driven circuit.
Bug Fault or error in software or hardware. Also a transmitting device.
Bus A group of lines to convey information from a source to