ELECTRONICS NOTEBOOK

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by

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Introduction

I AM PLEASED TO SAY THAT THESE NOTEBOOKS ARE VERY POPULAR. I DON'T MIND WRITING THEM IF YOU DON'T MIND WAITING. SOME PAGES TAKE A DAY TO WRITE, OTHERS COME VERY QUICKLY AND SOME TAKE DAYS OF EXPERIMENTING. LIKE THE PEN WATCH MYSTERY. I HAD TO BUY A WATCH, PULL IT APART AND TRY TO CONNECT C.R.O. PROBES TO PC TRACKS WHILE STILL KEEPING THE WHOLE ASSEMBLY TOGETHER — IT WAS AN ALMOST IMPOSSIBLE TASK.

A PAGE LOOKS VERY SIMPLE BUT IT CONTAINS A LOT MORE THAN FIRST MEETS THE EYE. I REMEMBER LOOKING THROUGH 2 YEARS ISSUES OF A U.S. MAGAZINE AND ONLY FINDING ONE INTERESTING ARTICLE. THE REST WAS FILLED WITH PAGE AFTER PAGE OF ADVERTISEMENTS, AND TEAR-OUT POST-PAID ENQUIRY CARDS.

THESE NOTEBOOKS GIVE YOU A GOOD DEAL OF READABLE INFORMATION, LOTS OF ANSWERS TO THOSE THINGS YOU WANT TO KNOW, AND NO ADVERTISEMENTS.

MANY OF THE PAGES COME FROM TELEPHONE ENQUIRIES & LETTERS ASKING FOR MORE INFORMATION ON THIS OR THAT. THINGS THAT SOME OF US TAKE FOR GRANTED NEED TO BE EXPLAINED TO ANYONE STARTING IN ELECTRONICS — SO THERE'S A SPREAD OF INFORMATION IN EACH ISSUE, FROM SIMPLE TO ADVANCED.

THE CONCEPT OF THE HAND-WRITTEN PAGE MEANS I CAN PRESENT IDEAS THAT COULDN'T BE DONE ANY OTHER WAY. IF YOU NEED ANY MORE INFORMATION ON ANY TOPIC, PLEASE LET ME KNOW. IT WILL GIVE ME IDEAS FOR THE NEXT VOLUME.

SOME READERS ARE ORDERING THEIR SECOND SET OF NOTEBOOKS BECAUSE THE FIRST SET HAS COMPLETELY FALLEN APART WITH USE! I CAN UNDERSTAND IT BECAUSE WE USE THEM A LOT IN OUR WORK ROOM TOO. I HOPE YOU HAVE THE FULL SET BECAUSE NOTEBOOKS 1 & 2 HAVE SOLD OUT. DON'T FORGET THE REGULAR ISSUES OF TALKING ELECTRONICS AS WELL AS OTHER BOOKS THAT COME OUT FROM TIME TO TIME.

WHEN THERE'S ONLY ONE PERSON BEHIND THIS WHOLE VENTURE, ATTENDING TO EVERYTHING FROM THE MAIL TO THE TYPING & PRINTING, YOU HAVE TO BE PATIENT AND APPRECIATE ONLY 2 TO 4 ISSUES CAN COME OUT EACH YEAR.

KEEP YOURSELF BUSY BY MAKING UP SOME OF OUR KITS. WE HAVE OVER 75 RANGING FROM A $4 DIODE TESTER TO A SIMPLE COMPUTER. THE WAY TO LEARN ELECTRONICS IS WITH PRACTICAL EXPERIENCE AND EACH OF OUR KITS IS INTENDED TO GIVE YOU THAT. NOTE: THE DOOR CHIME IC IN THIS ISSUE IS ONLY AVAILABLE FROM TANDY ELECTRONICS.

THE HIKERS EMERGENCY ALARM IS AVAILABLE FROM TALKING ELECTRONICS IN READY-BUILT FORM FOR $33 AND IS ESSENTIAL FOR ANYONE VENTURING INTO THE UNKNOWN.

FOR NOW, KEEP UP THE GOOD WORK, Colin. III 1987

QUIZ #1

HERE'S A QUIZ TO TEST EVEN THE EXPERT. SEE IF YOU CAN GET THEM ALL RIGHT.

1. WHAT DOES THE "OFF" POSITION ON A MULTIMETER DO?
2. WHAT IS THE MOST DANGEROUS COMPONENT TO REMOVE FROM A TV? (APART FROM THE PICTURE TUBE)
3. WHAT VALUE OF RESISTANCE IS BROWN – BLACK – SILVER – SILVER ?
4. WHAT VALUE IS 105 ?
5. IF A 120R ¼W RESISTOR IS PLACED ACROSS A 12v BATTERY, WILL IT BURN OUT?
6. WHEN MAKING UP A 9v BATTERY WITH PENLIGHT CELLS, ONE CELL IS ACCIDENTALLY REVERSED. WHAT VOLTAGE WILL BE PRODUCED?
7. IF AN INPUT LINE HAS A VERY HIGH IMPEDANCE, WHAT EFFECT WILL THESE HAVE: (i) A 10M IN SERIES WITH THE LINE
   (ii) A 10M BETWEEN THE LINE & NEGATIVE RAIL.
   (iii) A 100K IN SERIES WITH THE LINE.
8. A REFRIGERATIVE AIR CONDITIONER ON REVERSE CYCLE IS SAID TO BE 300% EFFICIENT. HOW DO YOU EXPLAIN THIS?
9. A 470µ/63V SHOULD NOT BE USED IN A 10V CIRCUIT BECAUSE IT WILL NOT CHARGE UP TO ITS FULL CAPACITY. IS THIS TRUE?
10. A REFRIGERATOR IS PLACED IN THE MIDDLE OF A FULLY INSULATED ROOM. THE UNIT IS LEFT RUNNING WITH THE DOOR OPEN. DOES IT COOL THE ROOM?

ANSWERS:

1. THE OFF POSITION PUTS A SHORT ACROSS THE MOVEMENT OF THE MULTIMETER. WHEN THE METER IS CARRIED THE MOVEMENT PRODUCES A CURRENT THAT FLOWS INTO THE 'SHORT' & THUS THE NEEDLE IS DAMPENED.
2. I CLAIM THE FUSE IS THE MOST DANGEROUS BECAUSE IT IS CONNECTED TO THE MAINS VIA THE ON/OFF SWITCH. ALSO BOTH ACTIVE & NEUTRAL ARE EXPOSED & I ALWAYS REMOVE THE POWER PLUG.
3. 1Ω ONE – ZERO – DIVIDE BY 100 – 10%.
4. 1µ (FOUND ON A TANTALUM)
5. TRY IT. THE RESISTOR GETS VERY HOT AND STARTS TO SMELL BUT IT DOESN'T BURN OUT. THE WATTAGE BEING DISSIPATED IS ABOUT 1·2w & THIS IS A GOOD LESSON IN HEAT DISSIPATION. ¼W RESISTORS WILL DISSIPATE ¼W OF HEAT AND THEIR TEMPERATURE WILL RISE TO ABOUT 70°C. WHEN DISSIPATING ½W THE TEMP WILL RISE TO SAY 110°C AND AT 1·2W THE TEMP WILL BE ABOUT 140°C. BUT IT STILL WONT BURN OUT.
6. 6v. THREE VOLTS WILL BE SUBTRACTED – NOT 1½v !!
7. (i) NO EFFECT.
   (ii) NO APPRECIABLE EFFECT. THE INPUT WILL BE JUST LESS THAN 10M.
   (iii) NO EFFECT.
8. AN AIR CONDITIONER ON REVERSE CYCLE IS A HEAT PUMP. "BUCKETING" HEAT FROM THE OUTSIDE TO THE INSIDE. THE AMOUNT OF HEAT IT CAN BRING IN IS EQUIVALENT TO 3 TIMES THE WATTAGE BEING CONSUMED.
9. **NOT TRUE.** A 470µ/63v WILL CHARGE TO ITS FULL CAPACITY WHEN NEW BUT THE VOLTAGE RATING SHOULD BE CLOSE TO THE VOLTAGE ACROSS IT SO THAT IT KEEPS 'FORMED'. THUS A 63v ELECTRO NEEDS ABOUT 50v – 60v.
10. THIS IS A LAW OF THERMODYNAMICS. THE ANSWER IS SIMPLE. ENERGY IS FLOWING INTO THE ROOM IN THE FORM OF ELECTRICITY. THUS THE ROOM WILL HEAT UP. NO MORE NEED BE SAID.

SOLDERING

This article is based on an excellent text by G Dresser of Moorabbin college of TAFE.

It answers some of the beginners questions on soldering; the necessity for good soldering, and the recent improvements in this technology.

The purpose of soldering in the electronics industry is to provide a reliable, low resistance connection between metals.

There are two approaches to this.

One is to make a mechanical connection first, such as by winding the lead of the component around a solder tag or pin on a PC board, and then complete the connection by soldering it.

This type of connection takes a considerable time to carry out as the mechanical operation requires some sort of twisting or winding mechanism. This is very time consuming and has been found to be unnecessary.

The other approach is to allow the solder to perform both the mechanical connection and also the electrical connection.

This is not only much faster, but it allows the connection to be taken apart very easily if a desoldering operation is required.

Most printed circuit boards are automatically loaded and soldered and surface-mount technology forms a major portion of this production.

There is no way a mechanical connection to be made with surface mount as there are no leads on this type of componentry.

This has lead to the need for vastly improved soldering skills as a failure rate as low as .01% (or one joint in 10,000) means a fail rate of 100% as many computer boards have up to 10,000 solder connections!

The art of soldering and making a perfect connection has been improved to a point where dry joints and faulty connections have been almost totally eliminated. The strength of the joint has proven to be adequate, using only solder.

So, the need to make a mechanical connection is no longer necessary.

Soldering has come a long way in the past 20 years. I can remember early colour television sets were riddled with dry joints and the TV serviceman spent half his day looking for intermittents. Even though this was a huge money-earner, sometimes you had to resolder the entire PC board to make sure the fault would not reappear. Some boards were larger than 20cm x 50cm and this could take an hour or more, sometimes you felt like a TV manufacturing company!

As I said, soldering has improved enormously and the processes of soldering produces almost perfect results. The only time when dry joints can occur on a regular basis is when a component gets extremely hot, such as a regulator or output transistor. Even perfect joints will eventually become fractured if the leads of the component are constantly delivering heat to the joint. The only way to eliminate this is to keep hot components on long leads or heatsink the body so that its temperature does not rise more than "touch hot."

If any joint is constantly heated and cooled, and the lead is moved when the joint is passing through the plastic region, the solder will fracture very easily. The end result will be a "dry joint."

Soldering seems like such a simple operation that you may want to pass it over as being non-important. But perfect soldering is the major factor that has made electronics so reliable. Many firms specialise in supplies and equipment just for soldering. It's big business and very specialised.

If computers were still using the soldering skills of 20 years ago, you would have a breakdown every month! That's the measure of the improvement in the art of soldering.

Soldering has made electronics the "Science of Reliability."

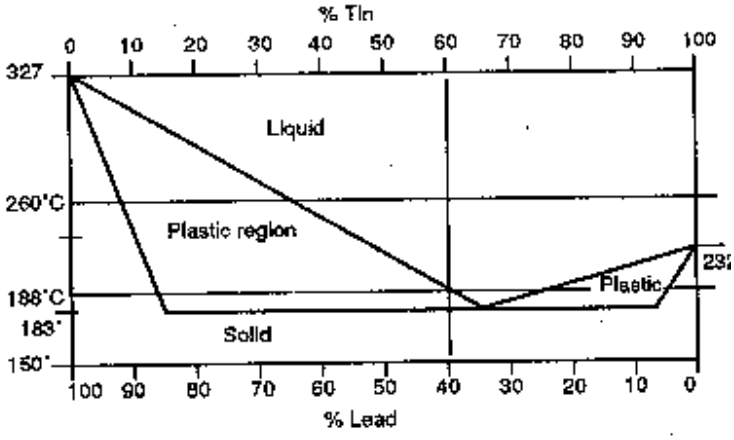
The very first computers consisted of hundreds and even thousands of values and since a valve has a limited life, (due to the glowing filament) these computers, weighing up to 30 tons, would only operate for about 2 hours before a valve failed. Compare that with our modern computer (with 100,000 or more transistors) and a fail rate less than once a year!

Since soldering is so important, we need to study it fully. Firstly let's go through three points: They are:

How does solder work? What are the melting points for solder and how does flux work?

SOLDER

Solder is normally a tin-lead alloy, although other elements such as Copper, Silver, Bismuth, Indium, Antimony and Cadmium can be added to obtain certain characteristics.



The diagram above shows a graph of the tin/lead ratio plotted against temperature. From this it can be seen that the tin/lead alloy has three distinct states:

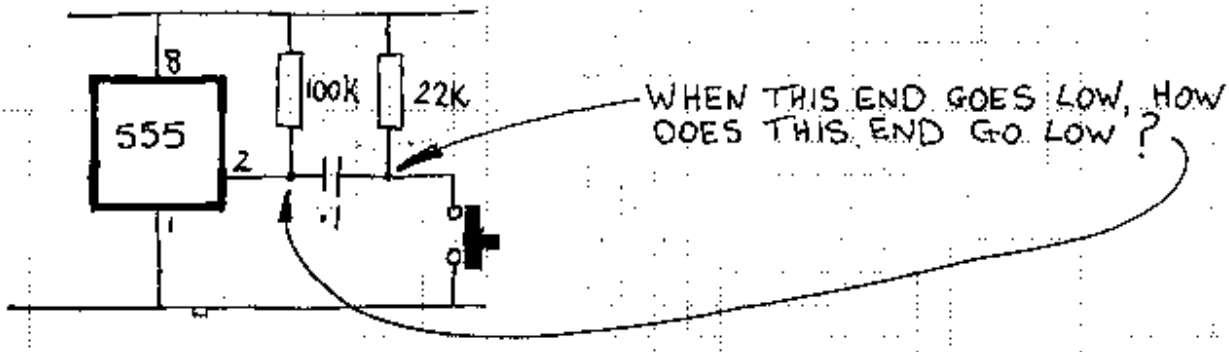
SOLID, PLASTIC and LIQUID

The solid and liquid areas are easy to understand but the plastic region needs a little explanation. This is when the solder is beginning to change from a liquid to a solid. You can see this occurring on a joint when the shiny surface gradually becomes dull. When solder is cooling through this region, the joint must not be moved otherwise the wire or lead forming part of the joint will be very weak when the solder has cooled down. In fact if you wiggle or pull the lead it will easily come away from the joint.

The is basically how dry joints occur. A very hot

THE CAPACITOR

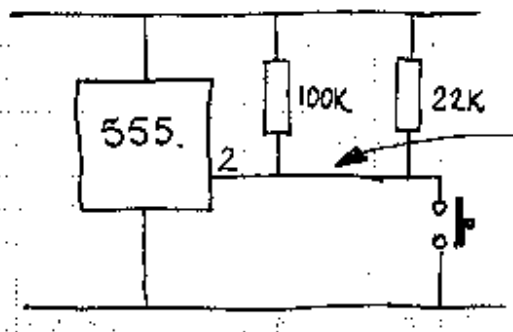
MANY READERS DON'T UNDERSTAND HOW A CAPACITOR WORKS. HERE'S A LETTER FROM A READER: "IF ONE PRESSES THE BUTTON, THE CAPACITOR CHARGES. INITIALLY IT HAS NO CHARGE SINCE BOTH SIDES ARE CONNECTED TO THE POSITIVE RAIL. WHEN THE BUTTON IS PRESSED, THE RIGHT-HAND SIDE OF THE CAPACITOR GOES LOW BUT THE LEFT-HAND SIDE IS STILL CONNECTED TO THE HIGH RAIL. SO HOW CAN PIN 2 BE DRIVEN LOW TO PRODUCE A "ONE-SHOT?".



THE ANSWER IS TO THINK OF THE CAPACITOR AS A RECHARGEABLE BATTERY. IF YOU MEASURE A FLAT BATTERY IT WILL HAVE NO VOLTAGE ACROSS ITS TERMINALS - THIS IS OBVIOUS. WHEN YOU START TO CHARGE IT, THE VOLTAGE ACROSS THE TERMINALS STARTS TO RISE.

CONSIDER THE CAPACITOR IN THE CIRCUIT ABOVE TO BE A SMALL BATTERY. AT THE MOMENT THE BATTERY IS UNCHARGED AS BOTH ENDS ARE CONNECTED TO THE POSITIVE RAIL VIA RESISTORS. WHEN THE BUTTON IS PRESSED THE RIGHT-HAND END IS TAKEN TO THE NEGATIVE RAIL. WHAT HAPPENS TO THE LEFT-HAND END? IT COMES DOWN TOO BECAUSE THE BATTERY IS NOT CHARGED — IT HAS NO VOLTAGE ACROSS ITS TERMINALS & THUS THE LEFT-HAND SIDE MUST COME DOWN. THIS MAKES PIN 2 LOW & STARTS THE 555 TO PRODUCE A "ONE-SHOT".

THE BATTERY (THE CAPACITOR) NOW STARTS TO CHARGE VIA THE 100K RESISTOR AND IF WE THINK OF THE BATTERY AS BEING VERY SMALL, IT WILL ONLY TAKE A SECOND OR TWO TO CHARGE & THUS PIN 2 WILL START TO RISE EVEN THOUGH THE SWITCH IS STILL PRESSED. WHEN THE BUTTON IS RELEASED WE HAVE A SITUATION WHERE A FULLY CHARGED BATTERY IS CONNECTED VIA A 100K & 22K IN SERIES & IT WILL GRADUALLY DISCHARGE THROUGH THESE TWO RESISTORS.



USING A CRO

MANY EXPERIMENTERS THINK A CRO (CATHODE-RAY OSCILLOSCOPE) WILL SOLVE THEIR PROBLEMS. IN MANY CASES IT DOES BUT IT CAN ALSO COMPOUND THE PROBLEM BY DISPLAYING ALL THE IMPERFECTIONS IN THE WAVEFORM AND MAKING YOU MORE CONFUSED THAN BEFORE.

WHEN YOU DISPLAY A WAVEFORM YOU NEED TO INTERPRET IT AND "READ" THOSE PARTS THAT ARE IMPORTANT.

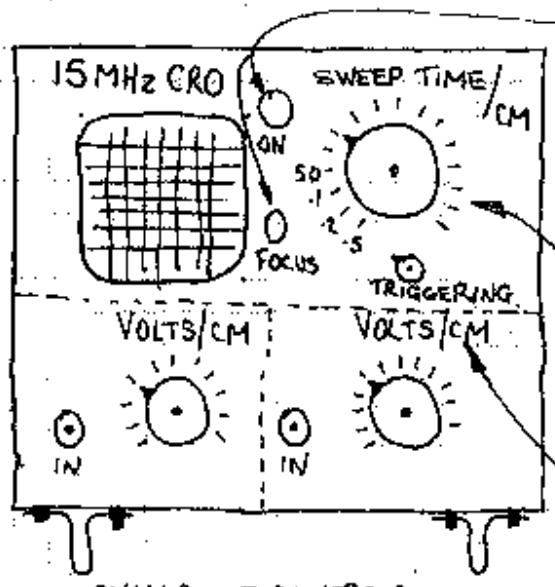
IF YOU ARE ABOUT TO BUY A CRO YOU SHOULD LOOK AT ONE WITH AT LEAST 15 MHz RESOLUTION. 20MHz IS BETTER & 30MHz WILL DO EVERY SITUATION. YOU NEED RESOLUTION OF THIS MAGNITUDE TO PICK UP SPIKES, GLITCHES AND OTHER IRREGULARITIES AS THEY ARE GENERALLY HIGH FREQUENCY.

A SINGLE TRACE IS OK BUT A DUAL TRACE HAS THE ADVANTAGE OF BEING ABLE TO COMPARE ONE SIGNAL AGAINST ANOTHER FOR SUCH THINGS AS DELAY VALUES, DISTORTION, GLITCHES ETC.

BUT BEFORE YOU BUY ANYTHING, IT'S NICE TO KNOW A LITTLE ABOUT HOW TO SET IT UP, AND WHAT TO EXPECT. THESE NOTES WILL START YOU OFF.

SETTING UP A CRO

HERE IS A SIMPLIFIED SET-UP PROCEDURE:



ONLY SOME CONTROLS ARE SHOWN.

[A] TURN THE CRO ON AND ADJUST BRIGHTNESS & FOCUS TO GET A THIN TRACE ACROSS THE SCREEN PREFERABLY ACROSS THE MIDDLE.

[B] TURN THE VOLTS/CM KNOB SO THAT THE WAVEFORM NEARLY FILLS THE SCREEN. (ABOUT 6-8CM FROM TOP TO BOTTOM)

[C] CLICK THE "SWEEP TIME" KNOB UNTIL YOU GET ABOUT 3-4 CYCLES ON THE SCREEN.

[D] TURN THE TRIGGERING KNOB UNTIL YOU GET A STEADY WAVEFORM. THIS WILL CAUSE THE TRACE TO "LOCK-IN". YOU CAN ALSO USE THE 'AUTO' MODE.

"SWEEP TIME" ALTERS THE HORIZONTAL OR X TIME BASE. THE UNITS ARE SEC/CM, mS/CM OR µS/CM.

THE "VOLTS PER CM" IS THE VERTICAL OR Y SENSITIVITY AND THE UNITS ARE VOLTS/CM OR mV/CM.

WITH NO INPUT SIGNAL THE TRACE SHOULD SWEEP ACROSS THE CENTRE OF THE SCREEN. THIS IS REFERRED TO AS THE 'ZERO AXIS' AND GIVES A REFERENCE FOR POSITIVE AS WELL AS NEGATIVE AMPLITUDES.

IF THE WAVEFORM CONSISTS OF ONLY POSITIVE VALUES, YOU CAN ADJUST THE VERTICAL-SHIFT KNOB TO MOVE THE TRACE TO THE LOWEST LEVEL ON THE SCREEN. THIS WILL ENABLE THE LARGEST WAVEFORM TO BE DISPLAYED & WILL GIVE THE GREATEST ACCURACY WHEN READING VALUES.

ALLOWS FOR POSITIVE AND NEGATIVE WAVEFORMS.

THIS SWEEP ALLOWS FOR POSITIVE WAVEFORMS ONLY.

THIS SWEEP ALLOWS FOR NEGATIVE WAVEFORMS ONLY.

THE OBJECT IS TO GET THE WAVEFORM TO FILL THE SCREEN. BUT JUST BEFORE YOU TAKE ANY READINGS, CLICK THE VERTICAL SENSITIVITY SWITCH (VOLTS/CM SWITCH) TO REDUCE THE WAVEFORM APPRECIABLY SO THAT NO SPIKES OR PARTS OF THE WAVEFORM HAVE BEEN MISSED DUE TO THEM BEING TOO LARGE FOR THE SCREEN.

CREATING A STEADY WAVEFORM

WAVEFORMS CAN BE SIMPLE OR COMPLEX. SIMPLE WAVEFORMS ARE EASY TO DISPLAY. THE SIZE AND SHAPE OF EACH CYCLE IS REGULAR AND THE CRO CAN 'LATCH' OR TRIGGER ON EACH CYCLE AND PRODUCE A STEADY TRACE. THIS IS CALLED AUTO TRIGGERING.

IF THE WAVEFORM IS IRREGULAR, IT WILL BE DIFFICULT FOR THE CRO TO LATCH AND THE TRACE WILL JUMP AROUND AND APPEAR AS A JUMBLE OF WAVEFORMS.

HERE ARE TWO WAYS TO TRY AND STEADY THE TRACE:

1. SWITCH TO MANUAL TRIGGER AND ADJUST THE CONTROL UNTIL THE TRACE BECOMES AS STEADY AS POSSIBLE.
2. ADJUST THE 'VARIABLE SWEEP TIME' (LOCATED IN THE CENTRE OF THE MAIN HORIZONTAL TIME BASE CONTROL) UNTIL THE TRACE BECOMES STEADY. YOU WILL NOT BE ABLE TO ACCURATELY DETERMINE THE FREQUENCY OF THE SIGNAL BECAUSE THE SWEEP TIME WILL NOT BE AS PER THE TIME BASE CONTROL.

DETERMINING THE FREQUENCY.

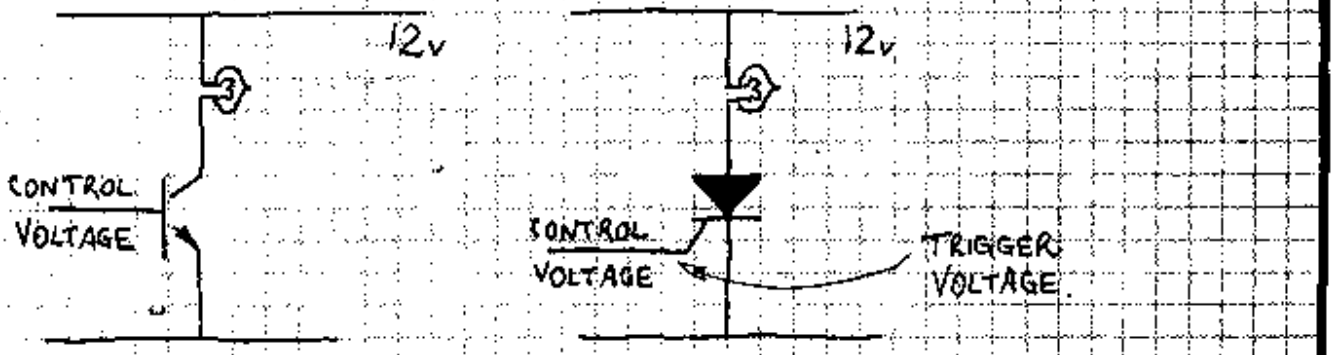
WHEN THE WAVEFORM IS STEADY YOU WILL BE ABLE TO MAKE SOME OBSERVATIONS, INCLUDING THE FREQUENCY OF THE SIGNAL. THE CRO DOESN'T GIVE YOU THE FREQUENCY DIRECTLY, YOU HAVE TO WORK IT OUT USING THE TABLE ON THE FOLLOWING PAGE.....

THE THYRISTOR

THERE ARE TWO FAMILIES OF THYRISTORS — SCR's & TRIAC's. SILICON CONTROLLED RECTIFIERS (SCR'S) CONTROL DIRECT CURRENT & TRIAC'S CONTROL ALTERNATING CURRENT. THESE NOTES WILL HELP YOU UNDERSTAND WHEN & WHERE THEY CAN BE USED.

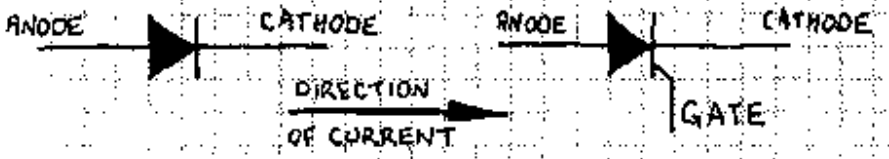
1. THE SCR

THE SILICON CONTROLLED RECTIFIER IS SIMILAR TO A TRANSISTOR WITH AN INBUILT LATCH.
SUPPOSE A TRANSISTOR IS REPLACED WITH AN SCR.



IN BOTH CIRCUITS, THE CONTROL VOLTAGE WILL TURN THE LAMP ON. BUT WITH THE SCR CIRCUIT THE LAMP WILL STAY ON! TO TURN THE LAMP OFF, THE POWER MUST BE TURNED OFF. THIS WILL UNLATCH THE SCR. THIS MAY SEEM INCONVENIENT BUT SCR'S ARE USED WHERE THIS CHARACTERISTIC IS AN ADVANTAGE.

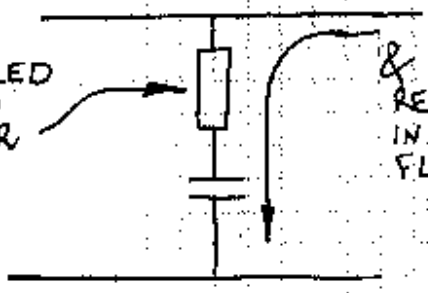
SCR'S DO NOT AMPLIFY BUT ARE EITHER ON OR OFF. THEY ACT AS A SWITCH. THEY CAN ALSO BE LIKENED TO A DIODE IN THAT THEY CONDUCT IN ONLY ONE DIRECTION. BUT THE DIFFERENCE IS THEY MUST BE SWITCHED ON VIA THE GATE EACH TIME THEY ARE REQUIRED TO PASS CURRENT:

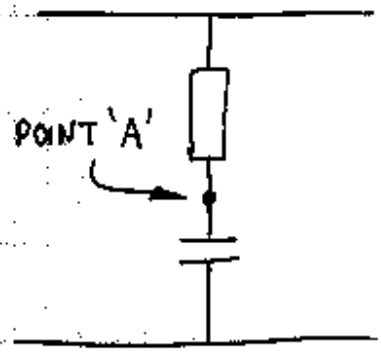


FOR A DIODE, AS SOON AS THE ANODE IS .6v HIGHER THAN THE CATHODE, CURRENT BEGINS TO FLOW.

FOR AN SCR, IT DOES NOT ALLOW CURRENT TO FLOW UNTIL THE GATE IS SUPPLIED WITH A TRIGGER VOLTAGE. WHEN USED WITH AN AC WAVEFORM (AS SHOWN IN THE NEXT FRAME) THE TRIGGER PULSE CAN BE DELAYED & THUS WE CAN CONTROL WHEN WE WANT THE CURRENT TO FLOW. THIS CHARACTERISTIC GIVES US THE NAME CONTROLLED RECTIFIER & SINCE THE JUNCTION IS MADE OF SILICON, WE GET SCR.

THE DELAY CIRCUIT:





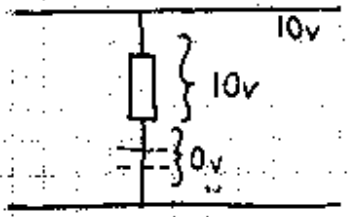
THE IDEA OF A DELAY CIRCUIT IS TO CREATE A POINT AT WHICH WE CAN DETECT A GRADUALLY INCREASING VOLTAGE. POINT 'A' WILL DO THIS. IT STARTS AT ZERO WHEN THE CAPACITOR IS UNCHARGED AND IT WILL GRADUALLY RISE AS THE CAPACITOR BECOMES CHARGED.
IF WE ATTACH A DETECTOR (SUCH AS THE BASE OF A TRANSISTOR OR THE INPUT OF A LOGIC GATE) TO THIS POINT WE WILL BE ABLE TO DETECT WHEN A PARTICULAR VOLTAGE LEVEL HAS BEEN REACHED.

IT'S OBVIOUS THAT THE CAPACITOR STARTS WITH ZERO VOLTAGE (AS IT IS IN AN UNCHARGED STATE WHEN THE POWER IS APPLIED). THE RESISTANCE OF THE RESISTOR DETERMINES THE CURRENT FLOW AND THIS PLACES A CHARGE PLACES A CHARGE ON THE PLATES OF THE CAPACITOR. THUS THE VOLTAGE ACROSS THE CAPACITOR INCREASES.

WE KNOW THE VOLTAGE RISE IS NOT LINEAR, BUT WHY NOT? WHEN THE CAPACITOR IS UNCHARGED THE VOLTAGE RISES QUICKLY BUT WHEN IT IS NEARLY FULLY CHARGED THE VOLTAGE INCREASES VERY SLOWLY.

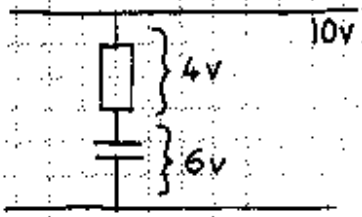
IF WE TAKE 3 POINTS IN TIME WE CAN SEE WHY:

AT THE START:



THE CAP HAS ZERO VOLTS ACROSS IT & THE RESISTOR SEES 10V.
CURRENT FLOW = $\frac{V}{R}$
$= \frac{10}{R}$

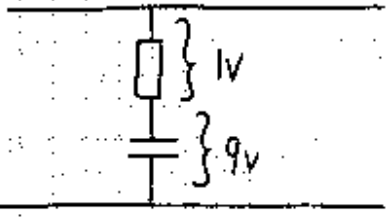
AT ABOUT ½ TIME:



THE CAP HAS 6v ACROSS IT & THE RESISTOR 4V

CURRENT FLOW = $\frac{4}{R}$

AT THE END:

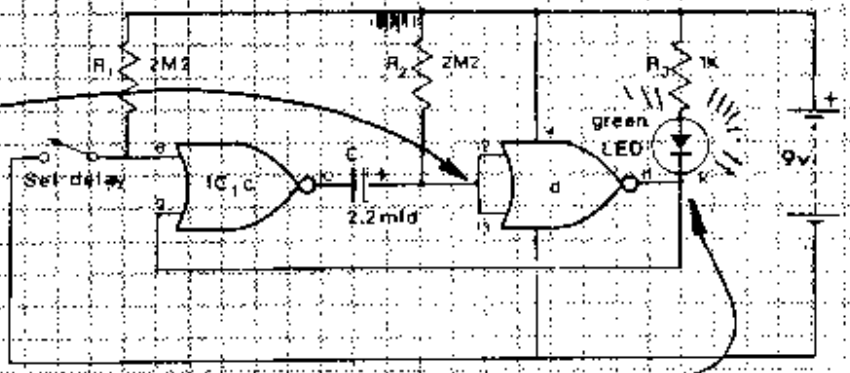


THE CAPACITOR HAS 9v ACROSS IT AND THE RESISTOR 1V.

CURRENT FLOW = $\frac{1}{R}$

THUS THE CURRENT FLOW CHANGES FROM $\frac{10}{R}$ to $\frac{1}{R}$ OR A 10:1 RATIO INCREASE

HOW THE DELAY CIRCUIT WORKS:

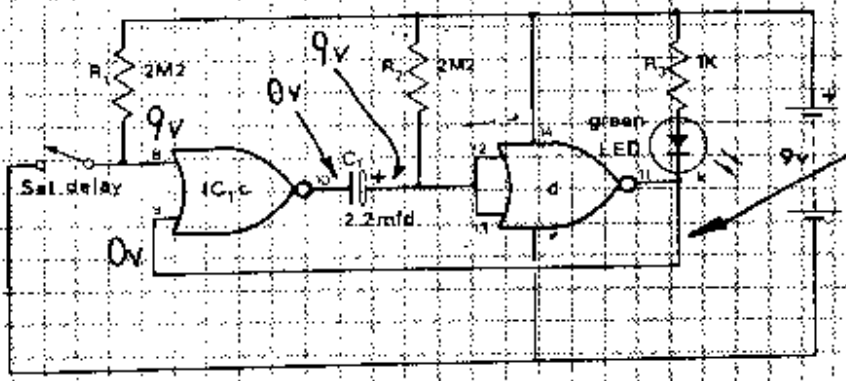


① START HERE

WHEN THE CIRCUIT HAS BEEN ON FOR A PERIOD OF TIME, PINS 12 & 13 WILL BE HIGH DUE TO THE 2M2 CHARGING C_1 TO 9v.

OUTPUT PIN 11 WILL BE LOW & THE LED WILL BE ILLUMINATED

SEE A TRUTH TABLE



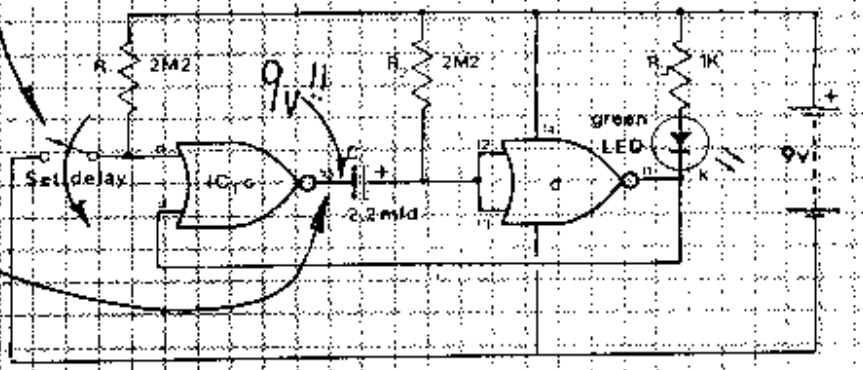
② THIS LINE WILL BE LOW.

PIN 8 IS HIGH, PIN 9 IS LOW & THUS PIN 10 WILL BE LOW.

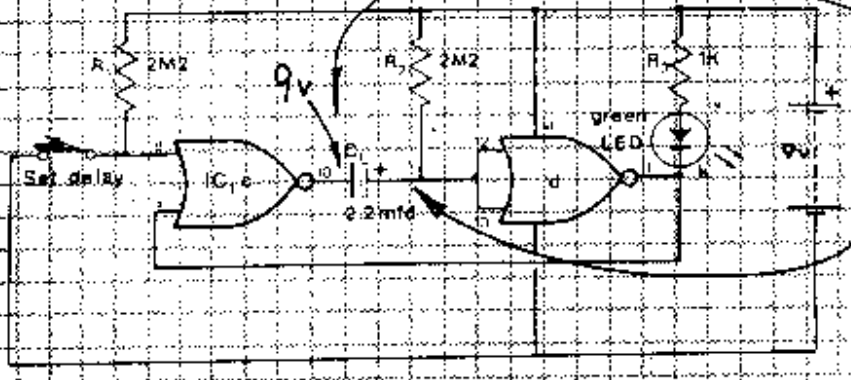
C_1 WILL BE CHARGED VIA R_2.

③ CLOSE THE SWITCH.

PIN 8 WILL GO LOW & FROM DIAGRAM ②, PIN 9 IS LOW. THE OUTPUT PIN 10 WILL GO HIGH



④ THIS END WILL HAVE 9v ON IT.



WHAT WILL HAPPEN TO THIS END??