ELECTRONICS NOTEBOOK
5

by
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A TALKING ELECTRONICS PUBLICATION

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BEC stands for Basic Electronics Certificate. This is the name for the basic electronics course during the 1980's. It will have changed its name by now but the requirements remain the same. You need a course with an instructor to help you learn electronics, even if it's just to get the name and pronounciation of components such as LEDs, 555's, bezels and CRO's and the understanding of values such as 10n, 104, 223, etc, etc, etc.
For every hour of the course you should allow one hour for construction. That's right - making things! That's the only way you will get anywhere.

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INTRODUCTION

These notebooks have proven their worth, many times over. Newcomers to electronics are constantly asking for information and books that answer their questions in a way that they can understand.

That's the purpose of these notebooks. By preparing a page or two every few days, the whole of electronics will be covered. But that's a huge undertaking. I don't want to cover that already in text books but rather fill in the gaps and explain things in a different way to make them more easily understood.

Even quite complex problems can be broken down and covered at basic level. After all, most circuits consist of many simple 'blocks' and our pages aim to cover these.

Everything I do has a goal and it should be the same with you. One of your first aims should be to get a basic certificate in electronics.

The BEC is just that. The BEC is the BASIC ELECTRONICS CERTIFICATE and since its existence will be unknown to many, I have decided to promote it in this issue.

In the last section of this book you will see details on the BEC including a set of typical exam papers, complete with answers.

The beauty of this course is it comes in many forms: Full-time, part-time, self-paced and correspondence.

To find out more about the content and fees etc, you should contact your local TAFE college and they will put you in contact with the closest participating college.

After looking into the content of the BEC and reading through some past exam papers, I can thoroughly recommend it as a valuable starting point.

Three exams must be taken to cover the content of the course and a series of practical experiments must also be handed in, to gain a pass.

The exams consist of 'objective-type' questions and this allows a large range of topics to be covered. This type of questioning is very tricky as the multi-choice answers can put you off the track very easily.

To perform effectively in the exam you must have had prior experience with this mode of questioning. To this end I have included a set of questions as mentioned above. From the feed-back I get, a complete book on the exam may be produced.

Please let me know if you are doing the course and if more questions are needed.

To assist in the course, don't forget the range of Talking Electronics projects. There is no better way to learn electronics than by construction. We have nearly 100 kits available, ranging from a diode tester to a simple Z-80 based computer. I would suggest building at least 10 to 15 kits to gain the skills necessary for the course.

After the BEC, the choice is yours. At TE we only start you off. Once you climb the first rung, you will be able to see the paths that open up. It's the first, initial stage that's so difficult.

Let's hope we can start you off.

For now,

Colin. VII '82

TRANSISTORS

THERE ARE OVER 20,000 DIFFERENT TYPES OF TRANSISTOR & HUNDREDS OF DIFFERENT CASE STYLES!

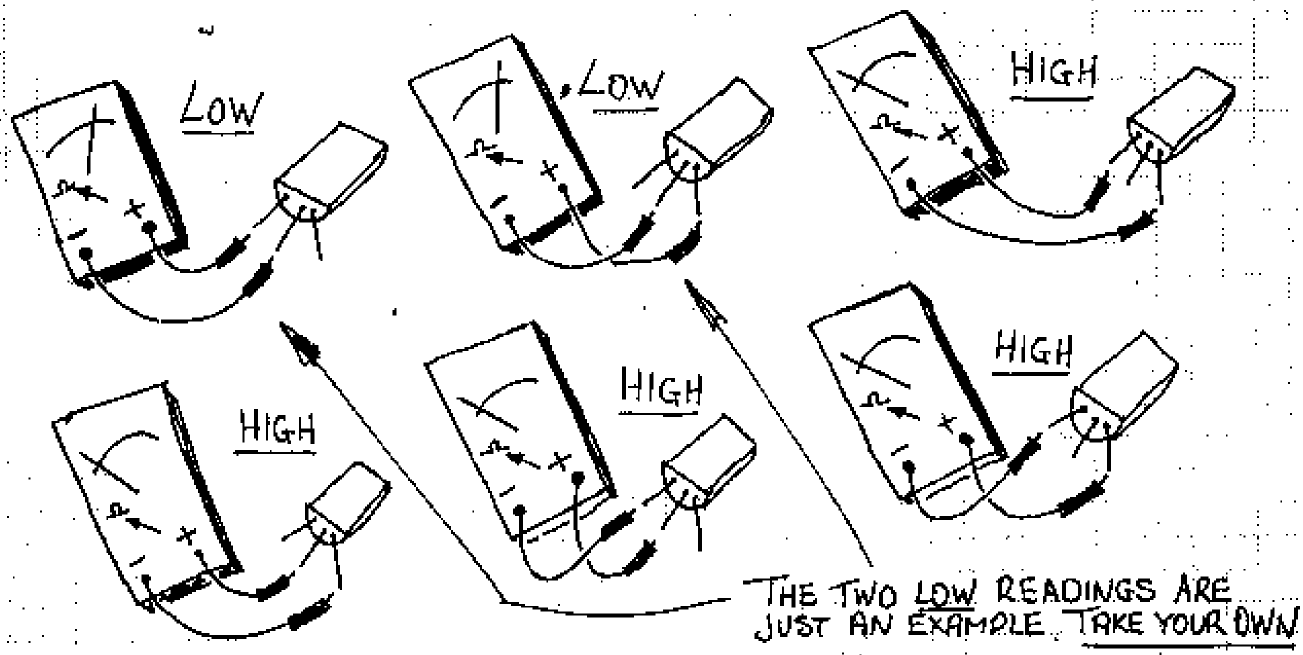
WE COULD NOT BEGIN TO COVER THEM ALL & YOU WILL ONLY COME ACROSS ABOUT 20-50 DIFFERENT TYPES IN YOUR WHOLE ELECTRONICS EXPERIENCE. IN ALL OF OUR PROJECTS WE USE ONE TYPE OF SMALL SIGNAL PNP TRANSISTOR, ONE SMALL-SIGNAL NPN, ONE TYPE OF RF & ONE TYPE OF POWER TRANSISTOR. THIS IS TO KEEP OUR PROJECTS SIMPLE.

IN THIS SECTION WE WILL SHOW HOW TO TEST AN UNKNOWN TRANSISTOR WITH A MULTIMETER AND DETERMINE:

(a) IF IT IS GOOD OR FAULTY.
(b) PNP OR NPN
(c) LOCATE THE BASE, COLLECTOR & EMITTER LEADS.
(d) DETERMINE ITS APPROXIMATE GAIN.

THIS IS HOW IT IS DONE:

1. YOU DO NOT HAVE TO KNOW ANY OF THE TRANSISTOR LEADS TO CARRY OUT THIS TEST. — CARRY OUT THE 6 TESTS AS SHOWN BELOW. PROVE THAT ONLY 2 TESTS SHOW A LOW READING. THE OTHER 4 TESTS ARE 'HIGH'.

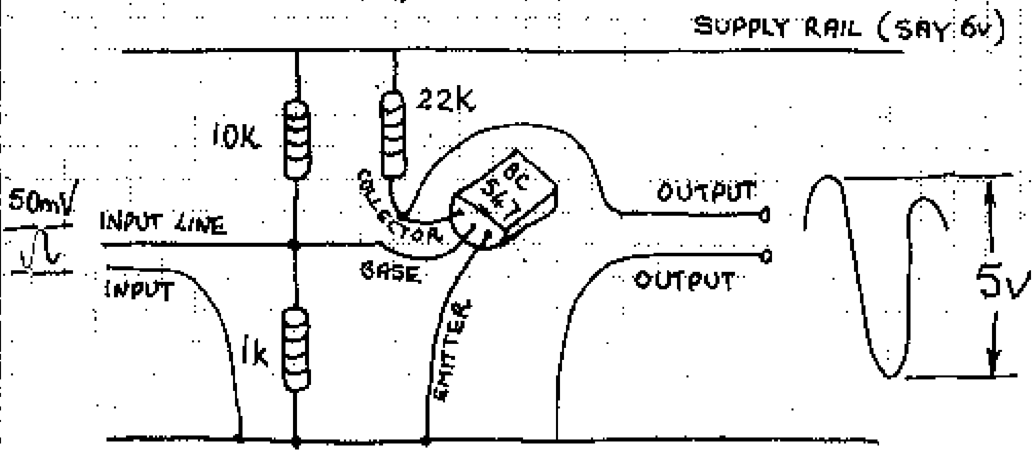


THESE DIAGRAMS SHOW ALL THE 6 WAYS OF PLACING THE LEADS OF A MULTIMETER ON A TRANSISTOR. NOTE: ONLY 2 READINGS ARE LOW.

THESE DIAGRAMS SHOW A MULTIMETER SET TO "OHMS" (IT'S BEST TO USE 'HIGH OHMS'). WHEN A MULTIMETER IS SET TO OHMS, THE BATTERY INSIDE THE METER IS WIRED TO GIVE NEGATIVE OUT THE POSITIVE LEAD & POSITIVE OUT THE NEGATIVE LEAD! THAT'S WHY YOU MUST FOLLOW THESE TESTS EXACTLY AND DON'T START TO LOOK AT THE POLARITY SITUATION.

HOW A TRANSISTOR WORKS.

— WE WILL COVER 7 POINTS.



1. A TRANSISTOR DOES NOT BEGIN TO OPERATE UNTIL THE BASE IS ·55V HIGHER THAN THE EMITTER. IN THE CIRCUIT ABOVE, TWO RESISTORS (10K & 1K) FORM A VOLTAGE DIVIDER TO PUT ·55V ON THE BASE. AT ·65V THE TRANSISTOR IS FULLY TURNED ON, SO WE HAVE ONLY 100mV (·65 - ·55V) FOR THE INPUT SIGNAL TO CHANGE THE TRANSISTOR BETWEEN THE STATES OFF & ON.

2. A FULLY TURNED ON TRANSISTOR IS CALLED SATURATED & A FULLY TURNED OFF TRANSISTOR IS CALLED CUT-OFF.

3. BETWEEN THESE TWO EXTREMES THE TRANSISTOR IS IN ITS OPERATING RANGE & AS THE INPUT SIGNAL CHANGES BY 1mV, THE OUTPUT WILL CHANGE BY ABOUT 100mV. IF WE DELIVER A 50mV INPUT SIGNAL AS SHOWN ON THE DIAGRAM ABOVE, THE OUTPUT WILL BE 100×50 mV = 5V.

4. ONE OF THE CHARACTERISTICS OF THE ABOVE CIRCUIT IS IT INVERTS THE SIGNAL. WHEN THE INPUT IS RISING, THE OUTPUT IS FALLING AND VICE VERSA.

5. YOU WILL NOTICE ONE OF THE INPUT TERMINALS IS CONNECTED TO THE EMITTER AS IS ONE OF THE OUTPUT TERMINALS. THIS IS WHY THE STAGE IS CALLED A "COMMON EMITTER STAGE".

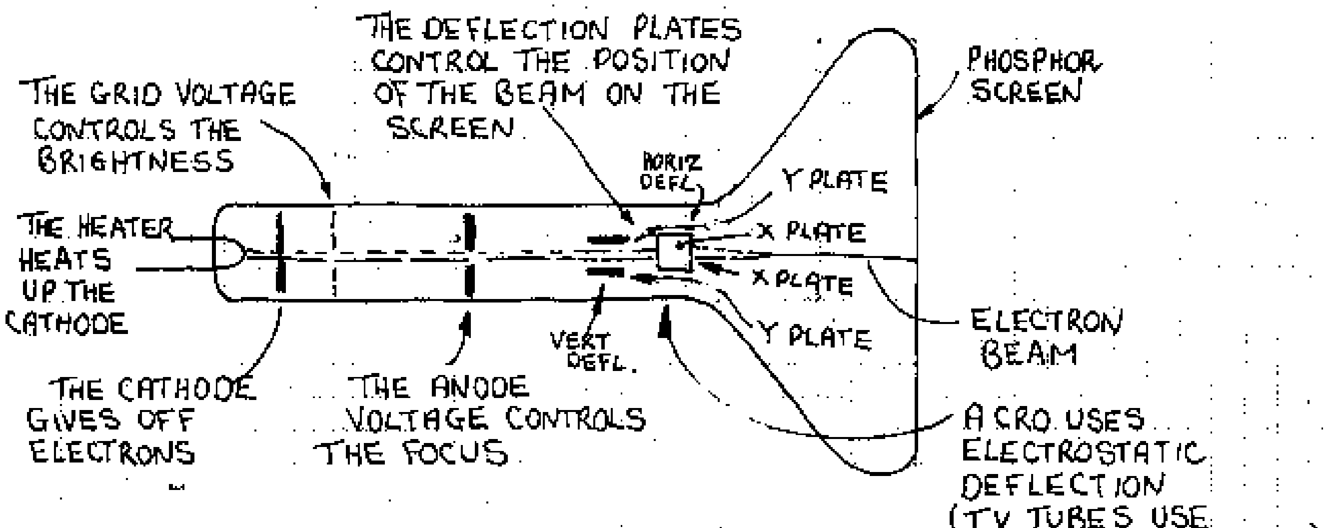
6. TO BE MORE TECHNICAL, THE BASE SHOULD BE SITTING MIDWAY BETWEEN ·55V & ·65V SO THAT IT WILL AMPLIFY BOTH THE POSITIVE EXCURSIONS OF THE INPUT SIGNAL AS WELL AS THE NEGATIVE EXCURSIONS. THUS THE BASE SHOULD BE AT ·6V.

7. THE GAIN OF A TRANSISTOR IS A CHARACTERISTIC OF THE MANUFACTURING PROCESS. SOME TRANSISTORS HAVE A GAIN OF 20, OTHERS 50-150 & HIGH GAIN TRANSISTORS HAVE A GAIN OF 250-450. WHEN A TRANSISTOR IS PLACED IN A CIRCUIT, THESE GAIN FIGURES DROP APPRECIABLY DUE TO THE EFFECT OF BIASING COMPONENTS (STABILISING COMPONENTS) & COUPLING CAPACITORS ETC. A SMALL SIGNAL TRANSISTOR WITH A SPECIFIED GAIN OF 250 WILL HAVE A GAIN OF 50-70 WHEN PUT IN A CIRCUIT.

THE CRO – THE BASICS.

A CRO LOOKS COMPLICATED – MAINLY BECAUSE THE CONTROLS DON'T GIVE A DIRECT READING IN HERTZ, KHz OR MHz. ONCE YOU LEARN TO "READ THE SCREEN" & CONVERT THE SWEEP TO HERTZ, YOUR FEAR WILL VANISH.

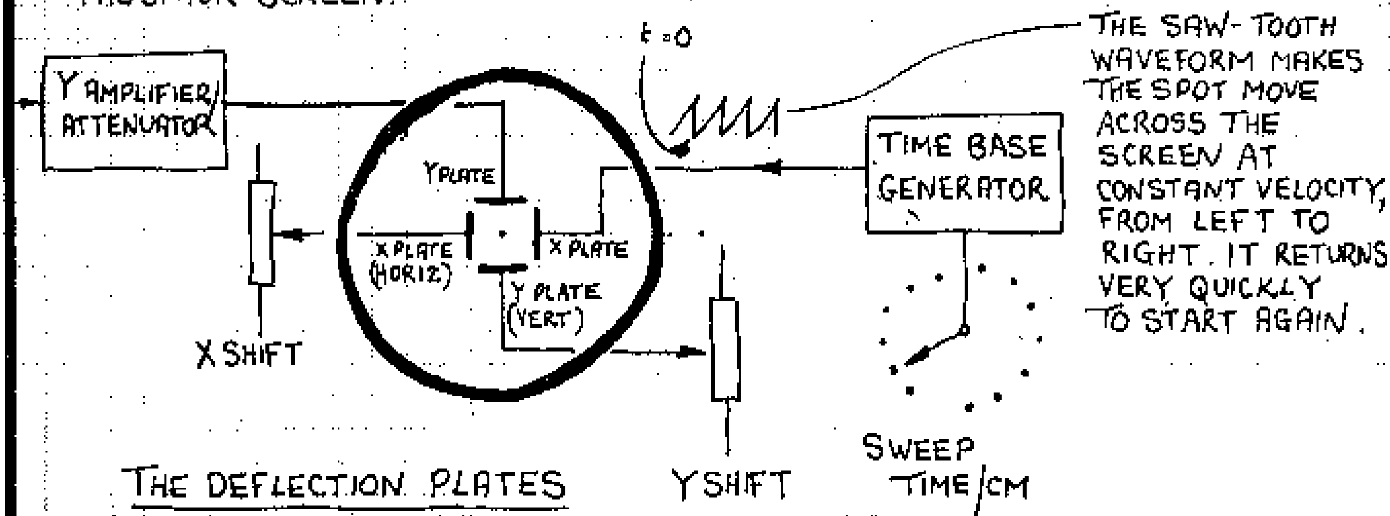
ALTHOUGH A CRO IS NOT USED VERY MUCH IN "SIMPLE ELECTRONICS" IT IS IMPORTANT TO KNOW HOW IT WORKS. HERE ARE THE BASICS:



THE ELECTRODE ARRANGEMENT

THE ELECTRONS ARE GIVEN OFF BY THE CATHODE (THE HEATER HEATS THE CATHODE & CAUSES THE ELECTRONS TO "JUMP OFF".) THEY ARE ATTRACTED TO THE ANODE AND PASS THROUGH A SMALL HOLE CALLED THE GRID.

THIS CREATES A NARROW BEAM CALLED THE ELECTRON BEAM. THE ANODE ACCELERATES THE ELECTRONS & THE BEAM PASSES BETWEEN TWO SETS OF PLATES CALLED THE DEFLECTION PLATES, BEFORE HITTING THE PHOSPHOR SCREEN.

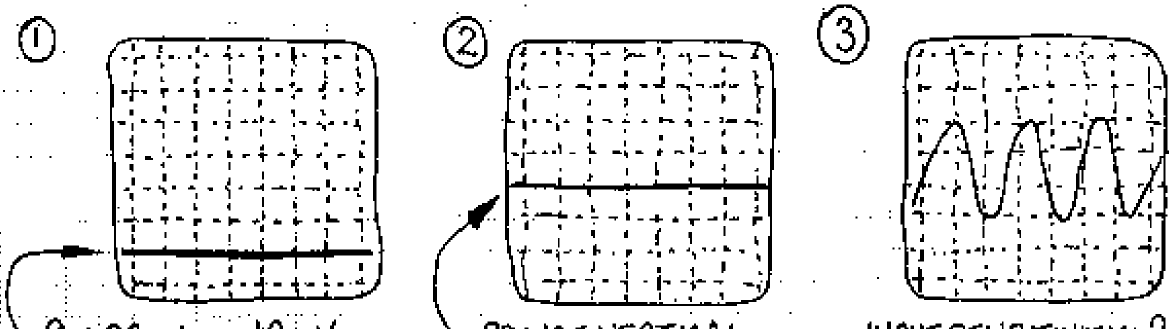


THE DEFLECTION PLATES

ACCURACY

IN ALL CASES, THE OBJECT OF CHANGING THE VOLTS/CM SETTING IS TO GET THE LARGEST WAVEFORM THAT WILL FIT ONTO THE SCREEN. IN THE EXAMPLE MENTIONED PREVIOUSLY, SUPPOSE THE 9v DC HAD A 10mV RIPPLE PRESENT. TO VIEW THE RIPPLE, THIS IS THE PROCEDURE:

(1) SWITCH THE INPUT TO 'AC'. (THE OTHER SETTINGS ON THE SWITCH ARE "DC" & "GND" - GROUND)
THIS WILL CAUSE THE TRACE TO JUMP DOWN TO THE LOWEST MARKING ON THE SCREEN (OR ACROSS THE MIDDLE - DEPENDING WHERE THE TRACE WAS SET). AT THIS STAGE YOU WILL NOT BE ABLE TO SEE THE RIPPLE AS THE CRO SETTING IS NOT SENSITIVE ENOUGH.



(1) 9V DC WITH 10mV RIPPLE. INPUT SET TO "AC". SENSITIVITY 2v/CM

(2) ADJUST VERTICAL SHIFT TO CENTRE TRACE

(3) INPUT SENSITIVITY: 2 OR 5 mV/CM TO VIEW THE "10mV" RIPPLE

(2) SHIFT THE TRACE TO THE MIDDLE OF THE SCREEN SO THAT READINGS CAN BE TAKEN - SO THAT BOTH POSITIVE & NEGATIVE EXCURSIONS CAN BE VIEWED & SO THAT BEST SENSITIVITY CAN BE SELECTED.

(3) ADJUST THE INPUT SENSITIVITY SO THAT THE TRACE FILLS THE SCREEN. YOU MAY NEED 2mV/DIV (SAME AS 2mV/CM) OR 5mV/CM. READ THE WAVEFORM AND DETERMINE IF IT IS 8mV, 9mV, 10mV OR 12mV. MAKE A RECORD OF THE VALUE & NOTE THE RIPPLE WILL BE 100 Hz.

THE 10:1 PROBE

— THIS SETTING ACTUALLY <u>DIVIDES</u> THE SIGNAL BY 10!

MOST CRO'S COME WITH A PROBE HAVING A 10:1 FEATURE. THIS IS A SWITCH ON THE PROBE INDICATING "10:1" OR "NORM."

FIRSTLY YOU MUST BE VERY CAREFUL NEVER TO LEAVE THE PROBE IN THE 10:1 POSITION AS THIS WILL MAKE THE READINGS ON THE SCREEN ONLY 1/10th THEIR NORMAL HEIGHT.

YOU CAN IMAGINE THE TROUBLE THIS WOULD CREATE. WAVEFORMS WOULD APPEAR SMALLER THAN EXPECTED & YOU MAY THINK THE CIRCUIT UNDER TEST IS NOT AMPLIFYING SUFFICIENTLY. WHEN MEASURING DC VOLTAGES, THE 10:1 POSITION CAN BE USED FOR VOLTAGES ABOVE 200V & THE SCALE ON THE VOLTS/CM CONTROL IS MULTIPLIED BY 10. FOR INSTANCE THE SETTING "10 VOLTS/CM" BECOMES 100 VOLTS/CM.

MAX FREQUENCY

THE ONE FACTOR THAT DETERMINS THE COST OF A CRO IS THE MAXIMUM FREQUENCY THAT THE Y AMPLIFIER (THE AMPLIFIER THAT PROCESSES THE SIGNAL) CAN HANDLE. IN TECHNICAL TERMS THE MAXIMUM FREQUENCY IS THE POINT WHERE THE TRACE SHOWS ONLY 71% OF THE TRUE AMPLITUDE OF THE SIGNAL (CALLED THE −3dB POINT).

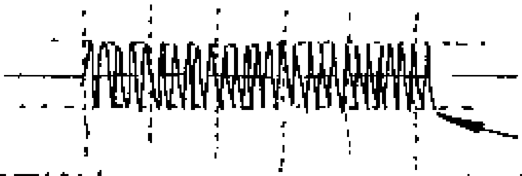
BUT THIS IS NOT THE ONLY FACTOR TO LOOK FOR.

WHEN YOU ARE READING HIGH FREQUENCIES, NOT ONLY WILL THE WAVEFORM BE REDUCED BY THE LIMITATIONS OF THE Y AMPLIFIER BUT THE LOADING EFFECT OF THE CRO WILL REDUCE THE OUTPUT OF THE CIRCUIT UNDER TEST. SO HEIGHT OF WAVEFORM IS NOT A MAJOR CONSIDERATION.

THE MORE-IMPORTANT FACTOR — AND THIS HAS NEVER BEEN MENTIONED BEFORE — IS THE NUMBER OF CYCLES PER DIVISION THAT WILL BE DISPLAYED AT MAXIMUM FREQUENCY.

FOR INSTANCE, A 15MHz CRO WITH MAX SWEEP TIME OF ·5µS/CM WILL SHOW 7½ COMPLETE CYCLES PER CM FOR A 15MHz SIGNAL.

IT WILL BE ALMOST IMPOSSIBLE TO COUNT THIS MANY CYCLES PER DIVISION AS THE SCREEN WILL BE FILLED WITH THE WAVEFORM. LIKE THIS:



THIS WAVEFORM IS SO COMPACT YOU CAN'T READ IT.

X5 MAGNIFICATION

MANY CRO's HAVE A X5 MAGNIFICATION KNOB THAT INCREASES THE SWEEP SPEED BY 5. IN THE EXAMPLE ABOVE, THE ·5µS/CM IS EXTENDED TO ·1µS/CM (100nS/CM) SO THAT ABOUT 1 CYCLE IS DISPLAYED PER DIVISION.

WHAT IS THE MAXIMUM FREQUENCY OF A CRO?

THE ANSWER IS COMPLEX AND INVOLVES A NUMBER OF FACTORS. THESE ARE: 1. THE BANDWIDTH OF THE Y AMPLIFIER. 2. THE MAXIMUM SWEEP SPEED — THE PRESENCE OF A X5 MAGNIFICATION KNOB. & 3. THE NUMBER OF CYCLES YOU ARE PREPARED TO ACCEPT, PER DIVISION.

IF YOU ARE PREPARED TO ACCEPT 4 COMPLETE CYCLES PER DIVISION, THE CRO IN THE EXAMPLE ABOVE IS DISPLAYING A 40MHz SIGNAL. IF YOU COUNT 10 COMPLETE CYCLES PER DIVISION, THE CRO IS DISPLAYING 100MHz!!

YOU CAN SEE HOW THE BANDWIDTH HAS LITTLE OR NOTHING TO DO WITH THE MAX FREQUENCY THAT CAN BE DISPLAYED. FOR INSTANCE, THE COMPARASON BETWEEN 2 CRO'S, SUCH AS 15MHz & 30MHz, MAY MEAN BOTH INSTRUMENTS SHOW THE SAME NUMBER OF COMPLETE CYCLES PER DIVISION AT MAX FREQUENCY BUT THE 30MHz CRO WILL HAVE A HIGHER (BETTER) WAVEFORM.

GETTING YOUR B.E.C.

(BASIC ELECTRONICS CERTIFICATE)

THIS SECTION IS AIMED AT GETTING YOUR BEC.

THIS CERTIFICATE IS A 'FEATHER IN YOUR CAP' AND IS THE STARTING POINT TO FURTHER LEARNING. ALTHOUGH THE EXAM IS SIMPLE (TO SOME) IT CERTAINLY COVERS A LOT OF TOPICS AND TO GAIN A CREDIT (OR PASS) YOU WILL HAVE TO BE ALERT TO A GOOD DEAL OF BASIC ELECTRONIC KNOWLEDGE.

EXAMS FRIGHTEN EVERYONE AND QUITE OFTEN YOU DON'T DO AS WELL AS EXPECTED BECAUSE YOU ARE NOT FAMILIAR WITH THE REQUIREMENTS, APPROACH OR CONTENT OF THE EXAM.

IN THE PAGES THAT FOLLOW, WE COVER SOME TYPICAL QUESTIONS AND SHOW YOU HOW TO DO YOUR BEST. THERE ARE LOTS OF TRICKS AND TRAPS IN THE QUESTIONS & WE WILL POINT THESE OUT ALONG THE WAY.

NO MATTER WHEATHER YOU WANT TO GO FOR YOUR BEC THIS YEAR OR NEXT, THESE PAGES WILL HELP YOU ENORMOUSLY. WORK THROUGH THEM AT YOUR LEISURE & ATTEMPT THE FINAL PAPER UNDER TEST CONDITIONS.

I HOPE YOU LEARN A LOT.

MANY OF THE QUESTIONS ARE MULTI-CHOICE. THIS IS CALLED "OBJECTIVE TESTING" AND YOU MUST PICK THE CORRECT ANSWER FROM 3 OR 4 POSSIBILITIES.

WHEN ANSWERING THIS TYPE OF QUESTION YOU MUST DECIDE ON THE ANSWER <u>BEFORE</u> LOOKING AT THE CHOICES. PUT YOUR ANSWER IN THE MARGIN <u>THEN</u> LOOK AT THE CHOICES.

THIS TYPE OF QUESTION LOOKS EASY BUT IS THE MOST DIFFICULT OF ALL TO ANSWER AS THE CHOICES WILL MUCK YOU UP VERY EASILY.

IT IS ESSENTIAL TO WRITE YOUR "GUESSES" FIRST TO PREVENT BEING DISTRACTED.

<u>SECONDLY</u>

MULTI-CHOICE QUESTIONS TAKE A LONG TIME TO READ, STUDY & ANSWER. BUT EACH IS WORTH ONLY ONE OR TWO MARKS SO DON'T SPEND TOO LONG ON ANY ONE QUESTION.

45. Refer to diagram 14. Determine the supply voltage E.

(a) 70v AC,
(b) 110v AC,
(c) 50v AC,
(d) 14.7v AC.

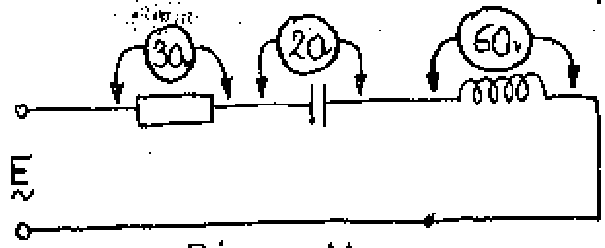


Diagram 14.

46. Refer to diagram 15. Determine the value of current I:

(a) 30mA,
(b) 14.1mA,
(c) 20mA,
(d) 10mA.

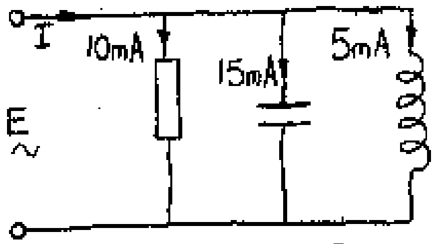


Diagram 15

47. Two 100uF/25v electrolytics are connected in parallel. The resulting capacitance of the combination is:

(a) 200uF/50v,
(b) 100uF/50v,
(c) 200uF/25v,
(d) 50uF/50v.

48. Removing the iron core from an inductor will:

(a) reduce the inductance,
(b) increase the voltage across the coil,
(c) reduce the current flow,
(d) change the circuit characteristics.

PART B

Short answer section.

49. What is the combined value of these five resistors connected in series: 2M2, 220k, 4k7, 470R, 3R3.
1 mark

50. Describe what you know about the minimum voltage and current that will kill you.
3 marks

51. Describe how to wire up a 3-pin plug.
3 marks

52. Why is a radiator and toaster earthed but an electric drill is not.
1 mark.

53. What will happen if a radiator is connected to an extension lead that has the earth and active leads reversed?
2 marks.

BASIC ELECTRONICS CERTIFICATE
(ANALOGUE ELECTRONICS)

This paper carries 60 marks. Section A: 25 x 2 mark questions. Section B: 10 marks as allocated.

1. Refer to diagram 1. Identify the following FET symbols:

(a) 1. n channel E MOSFET 2. p channel J FET
3. n channel J FET 4. p channel D MOSFET

(b) 1. p channel J FET 2. n channel E MOSFET
3. p channel D MOSFET 4. n channel J FET

(c) 1. n channel J FET 2. n channel D MOSFET
3. P channel E MOSFET 4. p channel J FET

(d) 1. n channel D MOSFET 2. p channel J FET
3. n channel J FET 4. p channel E MOSFET

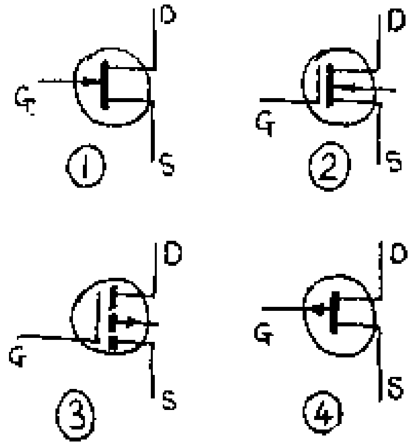


Diagram 1

2. When testing an NPN transistor with a multimeter, the readings on an ohms scale for a good device should be:

(a) base-collector high/low, collector-emitter high/low, base-emitter high/low
(b) base-collector high/low, collector-emitter high/high, base-emitter high/low
(c) base-collector high/low, collector emitter high/high, base-emitter high/high
(d) base-collector high/high, collector-emitter high/low, base-emitter high/high

3. The transistor in diagram 2 is replaced with one having a higher gain. To maintain the same operating point, the resistor R_1 must be:

(a) increased,
(b) decreased,
(c) remain the same,
(d) decreased in resistance but increased in wattage rating.

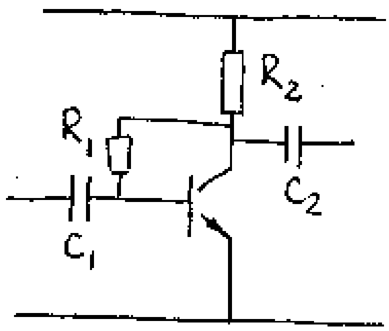


Diagram 2.

4. An emitter resistor added to the circuit in diagram 2 will:

(a) increase the gain of the stage,
(b) decrease the gain of the stage,
(c) improve the low frequency response,
(d) convert the stage to an emitter follower.

5. A 1,000uF / 25v electrolytic is always larger than a 1,000uF / 16v type:

(a) true,
(b) false.