ELECTRONICS NOTEBOOK 3

by

Colin Mitchell

Including:
An Introduction to COMPUTERS . . .

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CONTENTS

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Introduction

THIS IS THE THIRD NOTEBOOK IN A SERIES.

THESE HAND-DRAWN PAGES ARE GENERATED OVER A PERIOD OF MANY WEEKS & REFLECT ACTUAL SITUATIONS ENCOUNTERED AT OUR WORKBENCH AND ALSO FROM READER QUERIES.

BY COLLECTING & PRESENTING THESE TOPICS WE ARE SUPPLYING ANSWERS TO PROBLEMS WHICH MUST BE TROUBLING MANY EXPERIMENTERS.

THESE NOTES ARE OF COURSE SUPPLEMENTARY TO OUR OTHER BOOKS & MAGAZINES AND AIM TO PROVIDE A COMPLETE COVERAGE OF THE MYSTERIES OF ELECTRONICS.

ALL OUR PUBLICATIONS CONTAIN AN INDEX & THEY SHOULD BE CONSULTED TO CLARIFY ANY UNANSWERED POINTS.

THIS BOOK ADVANCES INTO INTEGRATED CIRCUITS AND COVERS TYPES WHICH FORM THE BASIS TO CMOS CIRCUIT DESIGN.

THE OVER-RIDING AIM OF THESE NOTEBOOKS IS TO SHOW HOW TO COMBINE BUILDING BLOCKS, SIMPLIFY CIRCUITS, LOCATE FAULTS ETC & WHEN TO CHANGE THE DESIGN TO A MICROPROCESSOR DESIGN.

IT MAY TAKE A FEW MORE NOTEBOOKS TO GET THERE BUT OVERALL IT WILL BE WELL WORTH IT.

A MICROPROCESSOR SYSTEM OFFERS VERSATILITY, SIMPLICITY, RELIABILITY & MOST IMPORTANT, ECONOMICS.

YOU WILL BE FASCINATED WITH WHAT WE HAVE TO OFFER, SO STAY WITH US AND TAKE IT ALL IN GRADUALLY.

Colin Mitchell.

FEB 1985.

THE MICRO PAGES IN THE BACK OF THIS BOOK MARK A TURNING POINT IN OUR SCHEDULE. WE HAVE ADVACED FASTER THAN EXPECTED TO THIS WAY OF THINKING.

THE CREATION OF MICROCOMP-1 HAS SHOWN US THE POTENTIAL OF THIS FORM OF DESIGNING.

IF YOU HAVE NOT ALREADY SEEN A MICROPROCESSOR DEVELOPMENT SYSTEM — I HOPE YOU JOIN US WITH THE 'COMP & EXPERIENCE A COMPLETELY NEW WORLD OF PROJECT DESIGN.

Colin. VI 1985.

THERE IS STILL A LOT OF CONFUSION WITH 'n' MARKINGS ON CAPACITORS & READING 1% TOLERANCE RESISTORS:

HERE'S HOW:

'n' MEANS <u>NANO</u> (NAY-NO OR NANNNO)

THIS IS HOW WE REMEMBER NANO: 1n = 1,000 pf = ·001 µF

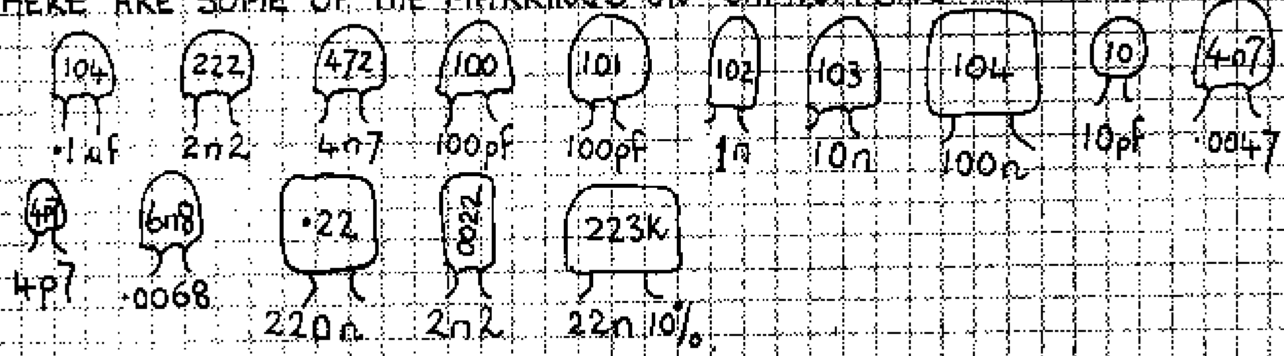
THESE ARE THE CONVERSIONS TO REMEMBER:

1n = 1,000 pf = ·001 = 102
10n = 10,000 pf = ·01 = 103
100n = ·1 = 104

ALL OTHER VALUES CAN BE WORKED OUT USING THE ABOVE AS A GUIDE
EG:

2n2 = 2,200pf = ·0022 = 222
47n = 47,000pf = ·047 = 473
390n = ·39 = (394) = ·39 µf

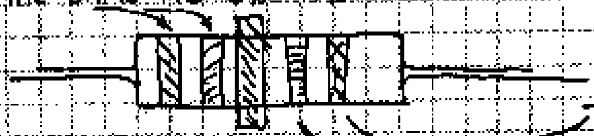
HERE ARE SOME OF THE MARKINGS ON CAPACITORS:



1% TOLERANCE RESISTORS.

1% TOLERANCE RESISTORS HAVE AN EXTRA BAND COMPARED WITH NORMAL 10% & 5% RESISTORS

THE FIRST TWO BANDS ARE READ THE SAME AS 5% & 10% RESISTORS



EG: RED RED BLACK BLACK BROWN = 220 OHMS 1%

THIS BAND ALSO PRODUCES A FIGURE:
EG. BLACK GIVES 0
BROWN = 1
RED = 2
ORANGE = 3
YELLOW = 4
etc

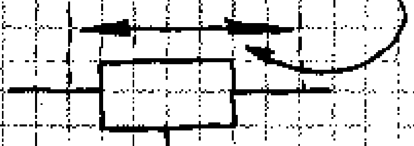
THIS BAND GIVES THE NUMBER OF ZERO'S
E.G: BLACK = OHMS
BROWN = '0'
RED = '00'
ORANGE = '000'
YELLOW = '0,000'
etc

YELLOW, PURPLE, RED, RED, BROWN = 47200 1%
= 47K2

POWER SUPPLY FACTS

QUESTION: IF A TRANSFORMER IS CAPABLE OF DELIVERING 1AMP AC, WHY CAN WE ONLY DRAW ·7AMP DC FROM THE OUTPUT OF A POWER-SUPPLY?

REMEMBER: THE VOLTAGE DROP ACROSS A REGULATOR



MUST BE AT LEAST 3-4 VOLTS, TO KEEP THE REGULATOR FUNCTIONING AT ALL TIMES. IE TO STOP IT "DROPPING OUT"

NOTE: IF THE VOLTAGE ACROSS A REGULATOR IS MORE THAN 5V, IT WILL HEAT UP EXCESSIVELY.

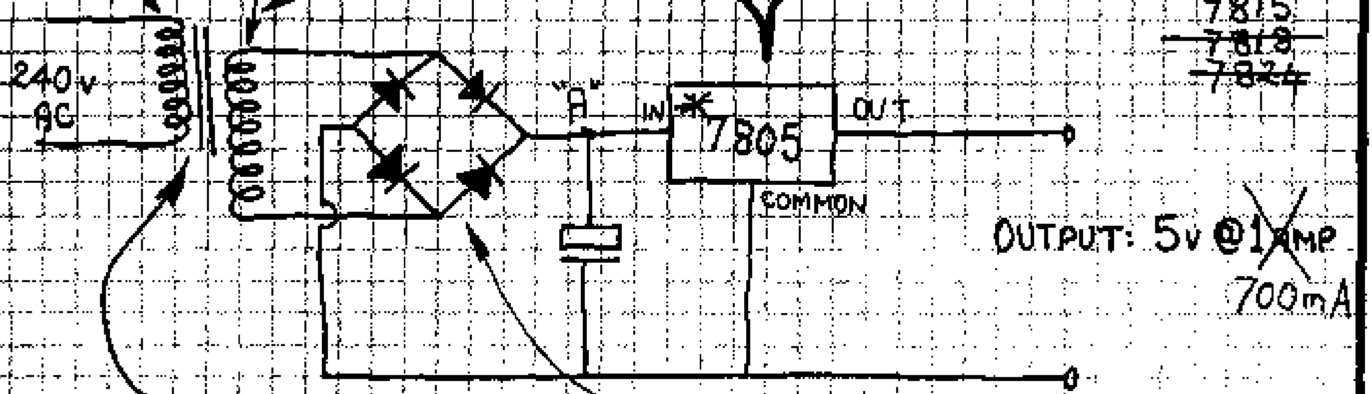
THE SOLUTION IS TO KEEP THE VOLTAGE BETWEEN 3V – 5V

* CAN BE:
7812
7815
~~7818~~
~~7824~~

SECONDARY WINDING.

2155 TRANSFORMER

PRIMARY WINDING



① A 2155 TRANSFORMER WILL DELIVER UP TO 1AMP. THIS IS AN AC VALUE – IN OTHER WORDS THIS IS THE CURRENT WHICH FLOWS BETWEEN TRANSFORMER & BRIDGE.

② A BRIDGE CONVERTS AC VOLTAGE (& CURRENT) TO DC. THIS IS CALLED RECTIFICATION. WHEN COMBINED WITH AN ELECTROLYTIC THE DC VOLTAGE WILL INCREASE 40%!! E.G. 15V AC WILL INCREASE TO 15 × 1·414 = 21·2 VOLTS.

③ WE READILY ACCEPT THE INCREASE IN VOLTAGE AS SHOWN ABOVE BUT MUST PAY THE PRICE OF A REDUCED CURRENT CAPABILITY BECAUSE THE VOLT-AMP RATING OF THE TRANSFORMER IS FIXED AT A MAXIMUM OF 15. [2155 TRANSFORMER]

[VOLT-AMPS IS THE AC WAY OF SAYING WATTS]. THE DC CURRENT WHICH CAN BE SUPPLIED AT POINT 'A' ON THE CIRCUIT CAN BE OBTAINED FROM THE FOLLOWING:

15V AC × 1AMP (AC) = 21·2V DC × ___ AMP DC = ·7 AMPS!!

THE SCHMITT TRIGGER

THE SCHMITT CIRCUIT WAS NAMED AFTER ITS INVENTOR. THE DESIGN IS BASICALLY AN EXPANSION OF THE NATURAL GAP BETWEEN TURN-ON & TURN-OFF OF A NORMAL TRANSISTOR.

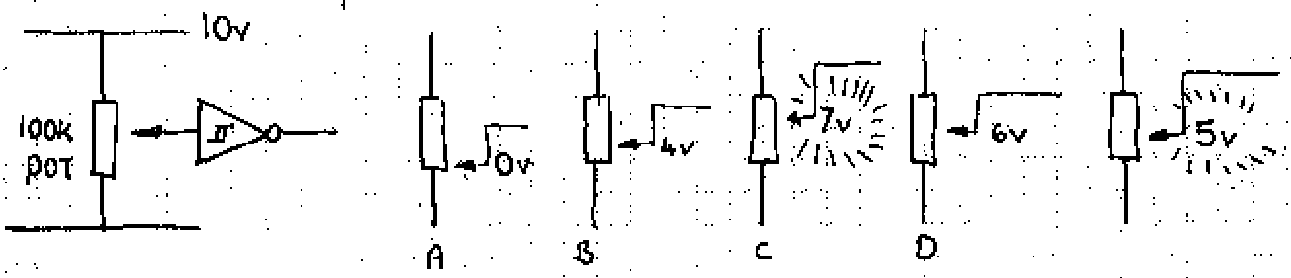
THIS GAP EXISTS BETWEEN ·6V & ·65V (about 50mV) WHERE A TRANSISTOR CHANGES FROM ITS OFF CONDITION TO ITS ON CONDITION.

THE SCHMITT CIRCUIT MAKES 2 IMPROVEMENTS. NOT ONLY DOES IT INCREASE THE GAP TO ABOUT 2V BUT ALSO CAUSES THE CHANGE TO TAKE PLACE AT THE VERY END OF THE GAP. AND IT CHANGES ALMOST INSTANTLY.

THIS MEANS THE 2V WIDE GAP IS COMPLETELY DEAD TO SIGNALS OR NOISE. ONLY THOSE PULSES WHICH EXTEND ABOVE & BELOW THE GAP HAVE ANY EFFECT ON THE CIRCUIT.

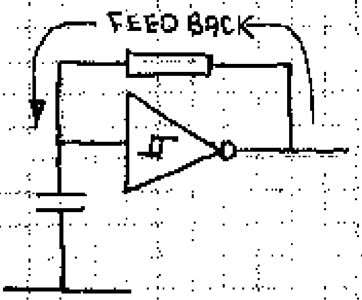
NOISE IS ONE OF THE MOST DIFFICULT COMPONENTS TO REMOVE. IT COMES FROM ELECTRICAL APPLIANCES SUCH AS MOTORS, NOISY CIRCUITS (EG. 555 TIMERS) MAINS SPIKES & FLUCTUATIONS & MANY OTHER HIDDEN EMITTERS.

THE SECRET OF THE SCHMITT TRIGGERS' NOISE REJECTION IS THE GAP CALLED THE 'HYSTERESIS' GAP & THIS CAN BE CLEARLY DEMONSTRATED BY PERFORMING THIS EXPERIMENT:



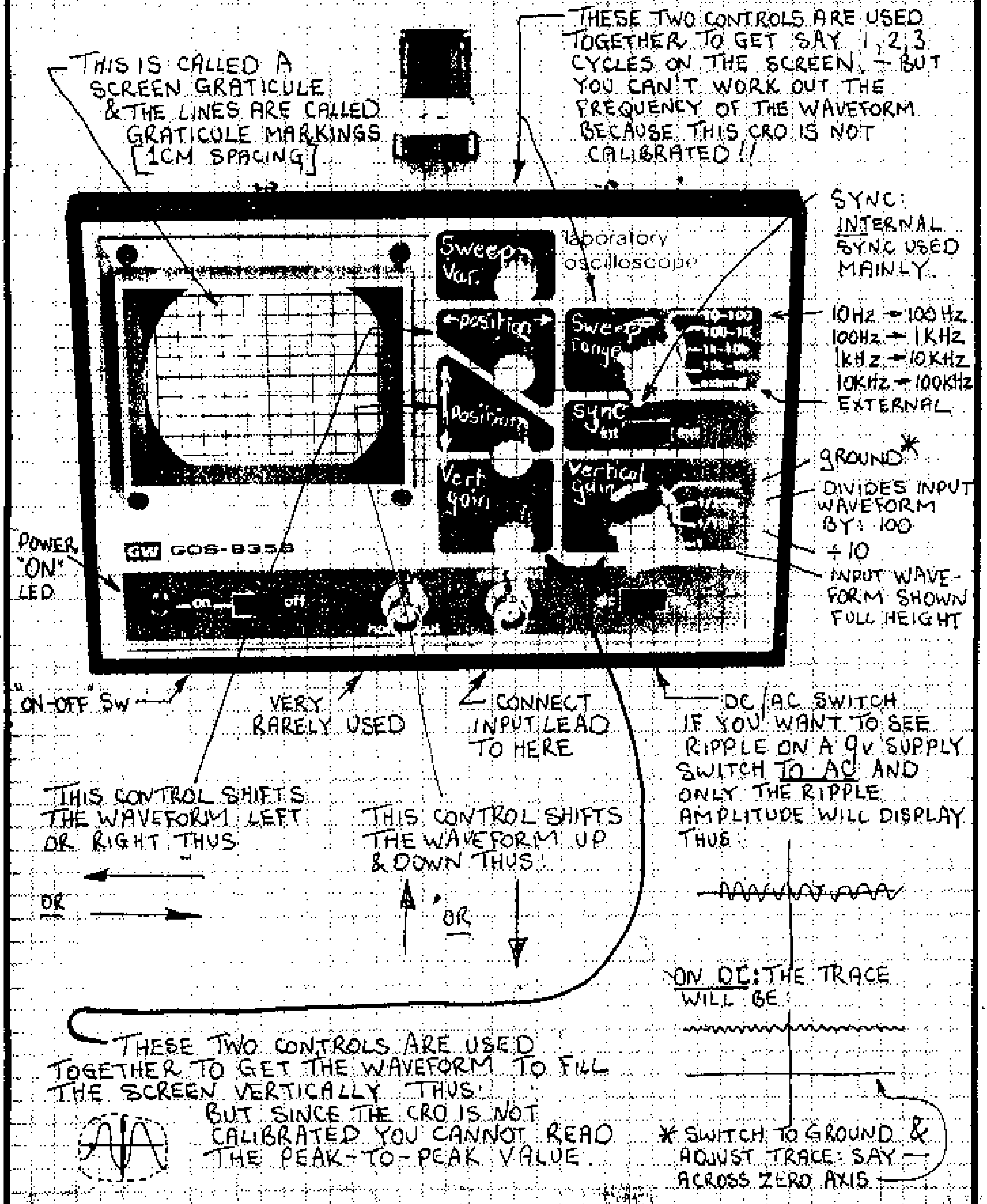
THE SLIDING ARM OF THE 100K POT STARTS AT 0V AS SHOWN IN DIAG 'A'. THE OUTPUT IS HIGH. AS THE POT IS INCREASED TO 7V, THE OUTPUT IMMEDIATELY GOES LOW. AS THE POT IS REDUCED, THE OUTPUT DOES NOT GO LOW UNTIL 5V IS REACHED.

USE CAN BE MADE OF THIS FEATURE TO PRODUCE AN OSCILLATOR WITH A SINGLE SCHMITT GATE.



THE CIRCUIT CAN BE SEEN TO BE A FEED-BACK ARRANGEMENT WITH THE CAPACITOR CREATING THE TIME DELAY AS IT CHARGES & DISCHARGES. THE 2V GAP GIVES THE CAPACITOR HIGH & LOW VOLTAGE LEVELS TO WORK TO.

A SIMPLE CRO:


THIS IS CALLED A SCREEN GRATICULE & THE LINES ARE CALLED GRATICULE MARKINGS [1CM SPACING]
THESE TWO CONTROLS ARE USED TOGETHER TO GET SAY 1, 2, 3 CYCLES ON THE SCREEN — BUT YOU CAN'T WORK OUT THE FREQUENCY OF THE WAVEFORM BECAUSE THIS CRO IS NOT CALIBRATED!!
laboratory oscilloscope
Sweep Var.
←position→
Position
Sweep range
Sync
Vert gain
Vertical gain
GW GOS-835B
on
off
SYNC: INTERNAL SYNC USED MAINLY.
10Hz → 100Hz
100Hz → 1KHz
1KHz → 10KHz
10KHz → 100KHz
EXTERNAL
GROUND*
DIVIDES INPUT WAVEFORM BY: 100
÷10
INPUT WAVE-FORM SHOWN FULL HEIGHT
POWER "ON" LED
"ON-OFF" SW
VERY RARELY USED
CONNECT INPUT LEAD TO HERE
DC/AC SWITCH
IF YOU WANT TO SEE RIPPLE ON A 9V SUPPLY SWITCH TO AC AND ONLY THE RIPPLE AMPLITUDE WILL DISPLAY THUS:
ON DC: THE TRACE WILL BE:
* SWITCH TO GROUND & ADJUST TRACE: SAY ACROSS ZERO AXIS
THIS CONTROL SHIFTS THE WAVEFORM LEFT OR RIGHT THUS
OR
THIS CONTROL SHIFTS THE WAVEFORM UP & DOWN THUS:
OR
THESE TWO CONTROLS ARE USED TOGETHER TO GET THE WAVEFORM TO FILL THE SCREEN VERTICALLY THUS:
BUT SINCE THE CRO IS NOT CALIBRATED YOU CANNOT READ THE PEAK-TO-PEAK VALUE.

SETTING UP THE CRO

THE FIRST THING TO DO IS GET A TRACE ON THE SCREEN — THEN YOU CAN ADJUST THE CONTROLS TO SUIT THE WAVEFORM.

THESE ARE THE STEPS:

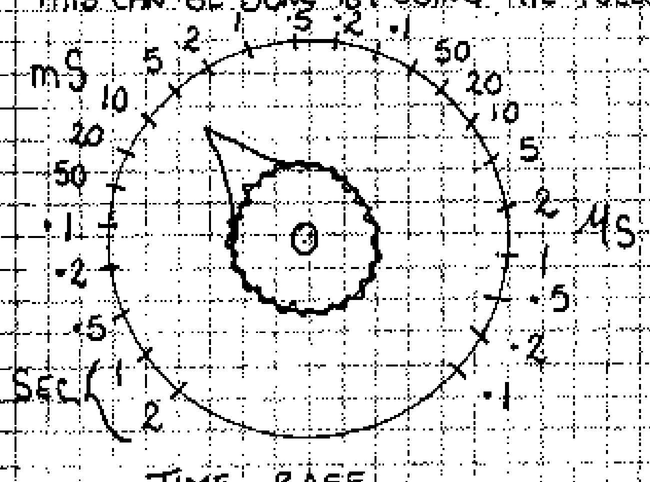
1. TURN ON THE POWER.
2. TURN UP THE BRIGHTNESS (INTENSITY) AND WAIT A FEW SECONDS FOR THE TUBE TO WARM UP.
3. TURN THE HORIZONTAL SWEEP (ALSO CALLED THE TIME-BASE CONTROL) TO A MEDIUM RATE (SAY 1mS/CM) SO THAT A LINE WILL BE PRODUCED ACROSS THE SCREEN.
4. TURN THE HORIZONTAL SHIFT CONTROL TO MID POSITION.
5. TURN THE VERTICAL CONTROL (VOLTS/CM CONTROL) TO SAY 20 VOLTS/CM SO THAT THE TRACE WILL BE WITHIN THE RANGE OF THE SCREEN.
6. TURN THE VERTICAL SHIFT CONTROL TO MID POSITION.
7. SWITCH TO AUTO TRIGGERING & INTERNAL TRIGGER TO ENSURE THAT THE TRACE WILL APPEAR AND NOT BE "BLANKED OUT".

ONCE THE TRACE IS ON THE SCREEN, ADJUST THE BRIGHTNESS AND FOCUS TO PRODUCE A SHARP TRACE & THEN THE SWITCHES CAN BE RE-SET TO SUIT THE WAVEFORM UNDER TEST.

CONVERTING HORIZONTAL SWEEP TO FREQUENCY

THE SWEEP CONTROL (HORIZONTAL CONTROL) IS USUALLY MARKED IN TIME (SEC, mS, μS) FOR THE SWEEP TO TRAVEL 1 CM ACROSS THE SCREEN. — BUT WE OFTEN NEED TO KNOW THE FREQUENCY OF THE WAVEFORM.

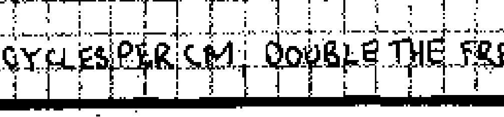
THIS CAN BE DONE BY USING THE FOLLOWING TABLE:



TIME - BASE

SWEEP SPEED	FREQUENCY
50mS	20 Hz
20 mS	50 Hz
10 mS	100 Hz
5 mS	200 Hz
2 mS	500 Hz
1 mS	1k Hz
·5 mS	2 kHz
·1 mS	10 kHz
50 μS	20k Hz
20 μS	50k Hz
10 μS	100 kHz
5 μS	200 kHz
2 μS	500kHz
1 μS	1MHz
·5 μS	2 MHz
·2 μS	5MHz
·1 μS	10 MHz

THIS TABLE ONLY APPLIES WHEN 1 CYCLE IS DISPLAYED PER CM THUS:



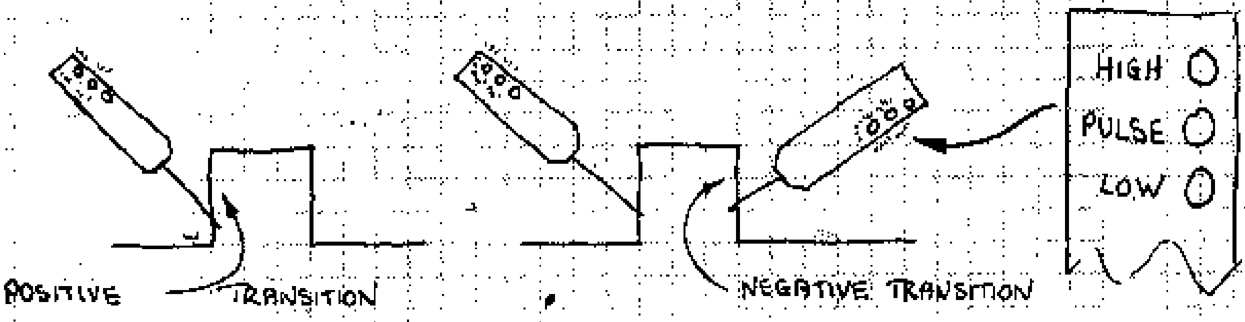
[IF 2 CYCLES PER CM DOUBLE THE FREQ.]

USING A LOGIC PROBE

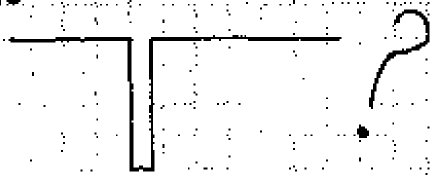
THERE ARE A NUMBER OF LOGIC PROBES ON THE MARKET — ALL (MOST) HAVE 3 LEDS TO INDICATE THE STATE OF THE CIRCUIT. ONE LED INDICATES STEADY HIGH STATE, ONE DETECTS STEADY LOW STATE AND ONE DETECTS TRANSITION FROM ONE STATE TO THE OTHER.

THIS IS CALLED THE PULSE LED

SOME DESIGNS DETECT ONLY A POSITIVE-GOING PULSE WHILE OTHERS DETECT BOTH POSITIVE & NEGATIVE-GOING PULSES, THUS:

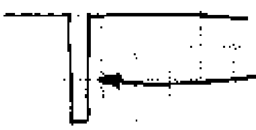


IT IS HANDY TO BE ABLE TO DETECT BOTH THE POSITIVE TRANSITION AS WELL AS THE NEGATIVE TRANSITION. BUT IF A PROBE DETECTS ONLY THE POSITIVE-GOING WAVEFORM HOW CAN YOU DETECT AN ISOLATED NEGATIVE PULSE SUCH AS:

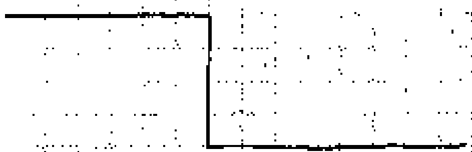


ANSWER:

THE POSITIVE-GOING PART OF THE WAVEFORM WILL BE DETECTED.



IF YOU REQUIRE TO DETECT AN ISOLATED NEGATIVE PULSE SUCH AS:



YOU CAN DETECT IT ON THE HIGH-LOW LEDS!

THIS MEANS DETECTING THE POSITIVE TRANSITION IS SUFFICIENT.

TEST

1. WHAT DOES 'n' MEAN? WHAT ARE THE VALUE OF THESE IN 'n': ·0022, ·047, ·1, ·001, 22, ·01,

2. WHAT IS THE VALUE OF THESE 1% RESISTORS: BROWN - BLACK - BLACK - BLACK - BROWN, RED - RED - RED - RED - BROWN, YELLOW - YELLOW - RED - RED - BROWN.

3. WHICH WILL DESTROY A DIODE MORE QUICKLY: OVER-VOLTAGE OR OVER-CURRENT?

4. WHAT IS THE WATTAGE RATING OF SMALL GLASS ZENERS?

5. HOW MUCH CURRENT DO THE INPUTS OF A CMOS CHIP DRAW?

6. IN A SCHMITT TRIGGER OSCILLATOR WHICH COMPONENT(S) DETERMINE THE FREQUENCY OF THE OUTPUT.

7. HORIZONTAL SWEEP ON A CRO IS MARKED IN: TIME/CM; CM/SEC, CYCLES/SEC; SEC/CYCLE?

8. CHIPS CAN BE EDGE TRIGGERED OR ________ TRIGGERED.

9. ON A LOGIC PROBE WHICH LEDS WILL BE ILLUMINATED FOR: (a) A STEADY HIGH (b) A SQUARE WAVE (c) A STEADY LOW

10. WHAT DO THESE MEAN: 4V5, 4n7, 4M7, 4u7, 4p7.

11. NAME 2 BUSES IN A COMPUTER

12. IN A FEW WORDS, DESCRIBE THE ROLE PLAYED BY: Z-80, 2716, 74LS 273, THE EPROM, THE CPU.

13. WHAT DOES $\overline{IORQ}$, $\overline{MREQ}$, $\overline{CE}$ MEAN?

14. WHICH BUS IS A 2-WAY BUS: DATA OR ADDRESS?

15. WHICH CPU REGISTER IS CAPABLE OF THE GREATEST NUMBER OF FUNCTIONS?

16. A MICRO OPERATES ON: (a) BINARY VALUES (b) HEX VALUES or (c) NORMAL NUMBERS?

17. DESCRIBE THE CONNECTION BETWEEN BITS BYTES & NIBBLES.

18. WHICH REGISTER DOES DJNZ USE?

ANSWERS: 1. n = NANO = ·001 MICROFARAD. 2n2, 47n, 100n, 1n, 22n, 10n. 2. 100R 1%, 22K2 1%, 44K2 1%. 3. OVER-VOLTAGE. 4. 400mW. 5. ALMOST ZERO - 1/1,000th OF A MICROAMP. 6. 'R' AND 'C'. 7. TIME/CM. 8. LEVEL-TRIGGERED. 9. A RED LED, B. ALL LEDS, C GREEN LED. 10. 4·5 VOLTS, ·0047 MICROFARAD, 4MEG7, 4·7 MICROFARAD, 4·7 PICOFARAD. 11. THE ADDRESS BUS & DATA BUS. 12. Z-80 IS THE CPU, THE BRAINS OF THE MICRO. 2716 IS THE EPROM OR PRE-PROGRAMMED CHIP. 74LS273 IS A LATCH. THE EPROM IS A PROGRAMMED ROM. THE Z-80 IS THE CPU. 13. IN/OUT REQUEST IS ACTIVE LOW. MEMORY REQUEST IS ACTIVE LOW. CHIP ENABLE IS ACTIVE LOW. 14. DATA BUS. 15. THE ACCUMULATOR. 16. BINARY VALUES. 17. BIT = 1 BYTE = 8 NIBBLE = 4. 18. 'B' REGISTER.