FASCINATING I.C. PROJECTS

P.K. Aggarwal

BUSINESS PROMOTION PUBLICATIONS

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I.C.

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By .

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Foreword

The use of I. Cs in electronic circuits is increasing at a very fast rate and every day more and more I.Cs are being developed and used in entertainment, industrial and medical equipments.

Electronic hobbyist in India is not very much familiar with I. Cs and largely uses discreet components for various circuits. Perhaps he is not 'at home' with ICs. This small book would meet the needs of such creative minds who would like to be initiated in the fascinating world of I. Cs. All the linear and digital I. Cs used in these projects are now commonly available in India and therefore it will help the enthusiasts to expand their interest and activity.

The projects have been described in sufficient details and brief description of every I. C has also been given at proper places.

I hope the book will serve the purpose for which it has been written and will prove helpful to a variety of electronic amateurs and shall also prove to be a reference book to the users of I. Cs. I am particularly happy to note that the book has been written by one of our students and is very inexpensive.

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Head of the Electrical Deptt.
Delhi College of Engg.
Delhi.6
24th April 78

Contents

1. What is an Integrated Circuit

An integrated circuit consists of a single-crystal chip of silicon, typically of 1mm by 1mm area, containing both active (transistors etc.) and passive (resistances, capacitors, diodes etc.) elements and their interconnections. As its name directly indicates, integrated circuit is an integrated or condensed form of an electronic circuit.

Integrated circuits are produced by the same processes used to fabricate individual transistors and diodes i.e. introducing impurities of known amount and type at required points on the p-type or n-type silicon or germanium substrate and interconnecting various points by thin metallic layers or wires. The basic structure of an integrated circuit consists of four distinct layers of materials. Figure 1 shows a p-type substrate.

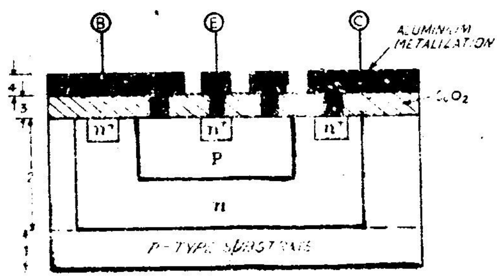


Fig. 1

All the active and passive components are built within the (2) layer, using a series of diffusion steps. The (3) layer is of SiO_2 and it selects where the n-type impurities (2) layer will be injected. Finally (4) layer is added to supply the necessary interconnections between components.

The chips are so small so as to be used as it is and so they are kept in standard packages and connections to them are made by the help of fine metallic wires, as shown in Fig. 2.

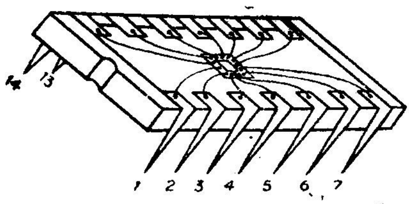


Fig. 2

Let us now see the advantages of the integrated circuit technology. In a general case, the area required for a component (say a transistor) is 50 mils² (50 mili inches x 1 mili inches) 50 sq. I the 1" square substrate will contain about 20x1000=20,000 components. Thus we can see what an amazing number of components a small I.C. chip can contain.

The following are the advantages offered by integrated-circuit technology as compared with discrete components inter-connected by conventional techniques.

1. Low Cost : Due to large quantities processed simultaneously.
2. Small size.
3. High realibility because there are no soldered joints and mechnical and atmospheric disturbances can't affect.
4. Improved performance : because of low cost and small size, much complex circuits can be used with no difficulty.

Although I.Cs have got so many advantages but they can't replace every circuit because of the following limitations:

1. *Power handling capacity* :

As the powers that can be handled by a component depends upon its size, large power components cannot he used in I.Cs

2. *Inductors* : Inductors can't be manufactured inside the I.Cs

3. *New Circuits* : It is possible for an experimenter to design circuits according to his need by using discrete components but in the case of I.Cs,only standard circuits are to be used.

Integrated circuits are now-a-days replacing a large number of discrete components, and I.Cs for almost every field of electrnoics are available in the market. Especially in the digital side there is no place now-a-days where I. Cs are not used.

2. Low Cost Milli-voltmeter

Here is a very simple project which can be of much practical use also. Yes ! this instrument can do the job of a millivoltmeter and can be fabricated for Rs. 35/- or even less. In its simplest form it will measure voltages from 50 mV to 1·5V with an accuracy of at least 10 mV.

The instrument actually does not directly indicate the voltage, that is not possible in such a low cost apparatus, but has got knob to be moved by hand. The scale is actually around this knob, as shown in Fig. 3. There is a bulb which acts as an indicator. To measure a voltage between two points what you have to do is to apply the voltage on the input terminals and move the knob from lowest position till the bulb just goes off. Stop there and note the voltage indicated by pointer of the knob on scale around it.

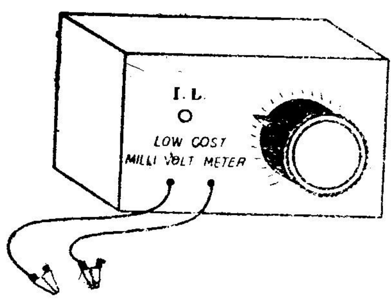


Fig. 3

Principle of Working : The instrument here utilises an operational amplifier I.C. 741C as a comparator.

Operational Amplifier : An operational amplifier is a direct-coupled, high gain amplifier. Direct oupled means that it can amplify d-c voltages also, which is not usually the case with common amplifiers such as audio amplifiers because there a capacitor is used as a coupling between two stages of amplification which restricts d-c signals. Operational amplifiers also have an additional feature that it has two floating input

·terminals and the voltage difference between the two inputs is amplified. The advantage of this is that now we can accurately amplify the difference between two nearly equal voltages like 1.798 and 1.823, or in other words we can have input terminals floating.

An ideal operational amplifier should have the following properties :

1. Input resistance Ri = ∝
2. Output resistance Ro= O
3. Voltage Gain Av= ∝
4 Bandwidth = O to ∝
5. Perfect balance, that is Vo= when $V_1=V_2$ where Vo is output voltage V_1 and V_2 are two input voltages.
6. No temperature dependance.

However in reality such an OP. AMP. is not possible and so all the available OP. AMPS have their properties considerably away from the ideal properties and this sets a criterian for determining the quality of an OP. AMP.

741C : This is a high performance operational amplifier with high open loop gain, internal compensation, high common mode range and short circuit protection.

Following are some typical properties of this OP. AMP.

Input offset voltage	4·0 *m*V*
Input offset Current	60 *n*A *
Input resistance	2·0 MΩ*
Input capacitance	1·4 pF
Large Signal Voltage Gain	200,000*
Output resistance	7·5 Ω
Output S.C Current	25 *m*A
Supply current	2·0 *m*A
Power consumption	50 *m*W

*These properties vary widely from piece to piece.

Pin connections for the I.C. are shown in Fig. 4.

In this instrument, operational amplifier has been used as a voltage comparator. It compares the applied voltage with the standard voltage, that is derived from a standard cell. As we have just seen that OP. AMP. has very high d-c gain so that a very small voltage difference, of the order of 5 *m*V between

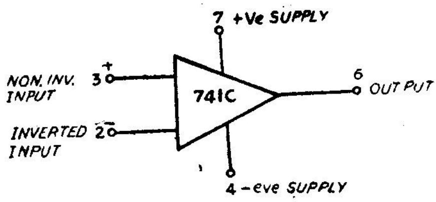


Fig. 4

the input Pins 2 and 3 is sufficient to move the output voltage from zero to supply voltage (nearly). Or in other words we can say that the output will be high (equal to supply voltage approximately) if voltage at pin 3 is more and low otherwise. This is what an voltage comparator has to do.

The principle of the instrument should now be clear from the circuit diagram, Fig. 5. The potantiometer here divides the standard voltage of the cell according to our choice, *i.e.*, setting of the knob. This voltage is compared with the voltage to be measured. Till the standard voltage is less than the voltage to be measured, the output of the OP. AMP. is low and so the transistor TI is in saturation, the bulb is glowing. As soon as the standard voltage exceeds the voltage to be measured the OP. AMP. output goes high, transistor comes in cut off and bulb goes off.

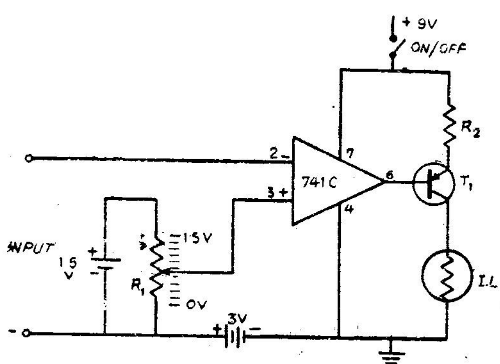


Fig. 5

Choice of potentiometer (linear or logarithmic) is purely yours. Logarithmic scale has the advantage of broadened scale at low voltages but the disadvantage is of difficulty in marking out the scale.

Marking of scale

After assembling the meter has to be standardised, i.e. scale has to be put. This can be done as follows :

Apply some voltage at the input, which can be derived from an another cell and potentiometer and use an another milli-voltmeter to find the value of this voltage. Move the knob of the instrument assembled by you, till the bulb just goes off. Stop at that point and mark the voltage there.

For a linear potentiometer only four points of 1.5 V, 1.0 V, .5 V and 0.V may be marked directly and remaining points can be achieved by dividing the scale equally whereas for logarithmic scale, a large number of points have to be marked directly.

List of Components

Semiconductors :

T_1	A C 128
I. C.	741 C.

Resistances :—

R_1 , 0-10 K Ohm. Potentiometer.
R_2 , 56Ω, 1/2 watt.

Miscellaneous :—

6 Indicating lamp, 1.5 V cell, 9 V battery, Single Pole ON/OFF switch.

3. ·I. C. Regulated Power Supply

Every electronic hobbyist should have a good power supply and specially when dealing with I.C's; a highly regulated power supply is a must. So here is given an 1.5 to 10.5 V, contineously variable; 0-300mA, I C regulated power supply as a project to be made by readers. This power supply will have extra features like short circuit protection, very good regulation and low hum, and can be made under Rs. 60/- only.

Circuit Description: The heart of the supply is a voltage regulator integrated circuit, 723. The unregulated D.C. voltage obtained by transformer TFI, rectifier bridge B1, capacitor C_1 and C_2 and resistance R_1 in usual way, is regulated by the I. C 723, transistor T_1 and asscociated components. (see *Figure 6*)

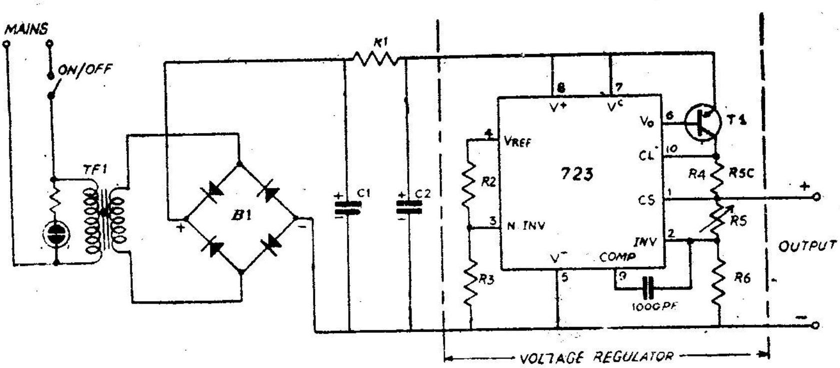


Fig. 6

The integrated circuit 723 is a monolithic precision voltage regulator capable of operation in positive or negative supplies as a series, shunt, switching or floating regulator. It contains a temperature compensated reference amplifier, error amplifier, series pass transistor and current limiter.

Specifications of 723 :

Vref. = 7.15 V
Input Voltage range=9.5/40 V
Output Voltage range=2/37 V
Load regulation=.03/.15 %
Line regulation=.01/.1 %
Ripple rejection=74 db
Output current=150 *mA*
Temp. stability=.002%/°c
Internal power dissipation=800 *m*W
Sense Voltage=.65 V
Internal block diagram of I.C. 723 (See Figure 7)

Principle of Working of Voltage regulator :

All the voltage regulators works on one priniciple, that is an reference voltage is produced in some way and is compared with the output voltage, or its fraction. The error voltage is amplified by high-gain d-c amplifier and is used to control the output voltage such that it remains constant.

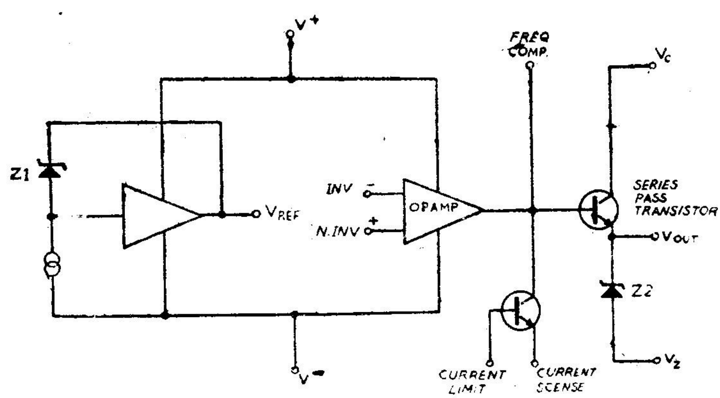


Fig. 7

The reference voltage in this I.C. is obtained by zener diode and an temperature compensating amplifier (see figure 7). This reference voltage is devided by resistance R_2 and R_3 to obtain 1.5 V at the junction of R_1 and R_2 and is applied at pin No. 3,

noninverting input of the error amplifier (OPAMP). The inverting input, at pin 2 is equal to

$$V\ output \times \frac{R_6}{R_5+R_6}$$

The output of this OP. AMP. at Pin 9 is applied to the base of a series pass transistor, inside the I.C. The final output of the I.C. is at the emitter of this transistor, which is given to the base of a power transistor because of the power dissipation limitations of the internally fabricated transistor. The second transistor in the I.C. is for the purpose of short circuit protection.

The output voltage is given by

$$V\ output = V\ ref \times \frac{R_3}{R_2+R_3} \times \frac{R_5+R_6}{R_6}$$

In this circuit

$$V ref = 7.15\ V$$
$$R_2 = 5.60\ K\ \Omega$$
$$R_3 = 1.0\ K\ \Omega$$
$$R_5 = 0\text{—}10\ K\ \Omega$$
$$R_6 = 1.0\ K\ \Omega$$

so

$$\text{Max. } V\ output = \frac{7.15 \times 1.0}{5.60+1.0} \times \frac{11.0}{1.0}$$
$$= 11.88\ V$$

$$\text{Min } V\ output = 7.15 \times \frac{1.0}{5\text{-}60+1.0} \times \frac{1.0}{1.0}$$
$$= 1.08\ V$$

So the circuit will work well with 10% tolerence resistances.

Few Comments :— The circuit can be assembled in the box of very commonly used 1.5–12 V battery elliminator. The multithrow switch can be here replaced by a 10 K ohm potenicmeter.

If you are already having a power supply, you can make a separate voltage regulator and use it externally or fit inside.

If it is required to have a supply for high voltage and

currents, the values of R_2, R_3, R_5 and R_6 can be found out on the basis of calculations shown above. The value of short circuit resistance, Rs. can be found from the fact that at short circuit the drop across it should be .7 V. So for the above circuit assuming
I s.c=.3 Amp,

$$Rs.c \times .3 = .7$$

$$\text{or } Rs.c = \frac{.7}{.3} = 2.3\ \Omega$$

The transistor to be used should be able to withstand max voltage and max current, and both at a time.

For example transistor 2N 3055 can be used upto 30 V and 3 A with sufficient heat sink.

Component list :—

Semiconductors

T_1 AC 187
I. C :— 723
Rectrifier bridge =12 V, 500 *mA.*

Transformer :—

Input 230 V, 50 c/s
Output 12 V, 500 *mA.*

Capacitors :—

C_1, C_2=1000 μF 12 V, electroytic.
C_3 :—1000 pF.

Resistances :—

R_1=2 Ω, 5W, Wire wound.
R_2=5.65 K Ω 1/2 watt.
R_3=1.0 K Ω 1/2 watt.
R_4=2 2 Ω, 5W, wire wound.
R_6=1.5 K Ω 1/2 watt.
R_5 0—10 K Ω, linear potentiometer.

Miscelleneous :—230 V Neon indicator; ON/OFF switch.

4. Electronic Staircase Switch

Now follows a very simple, enjoying and useful project from digital electronics. You must have seen staircase switches where a bulb can be controlled from two points and might have noted the complexity of circuit that is involved there. Now if it is required to control a bulb from more than two points, there is no answer for that till you make this project. Yes with this project you can control an electrical equipment from any No. of points without highly complicated wiring.

Here push buttons are used instead of on-off switches. To make equipment OFF or ON you are to just press any push-button for a moment. Next time when you again want to change that state, you can again press the same or any other push button.

Circuit description:-

The heart of the circuit is a bistable multivibrator which is a most basic element of the digital electromics and is also known as Flip-Flop, binary, scale of -2 toggle circuit, trigger circuit.

Bistable Multivibrator:

A bistable multivibrator has got two stable states. The two state concept is very popular in digital electronics and these stages are known by various names like high and low, 1 and zero, OFF and ON, yes and no. The two stable states actually corresponds to two possible voltage levels at a point in the circuit. In bistable multivibrator we have two output points, opposite with respect to each other, and one input point from where we can change the output states, by just giving a pulse of voltage at the input. In principle, the Flip-Flop (most common name of bistable multivibrator) resembles the 'ball pen' that is made in or out by just pressing the knob behind the pen.

I.C. 7493 :

This is a 4- bit counter consisting of four master/slave flip-flops which are internally interconnected to produce a divide by two counter and a divide-by-six counter.

Specifications and characteristics :—

Supply voltage	4.75—5.25V
Operating Temp. range	0—70° C
Min. Input high voltage	2.0 V
Max. Input low voltage	.8 V
Min. Output high voltage	2.4 V
Max. Output low voltage	.4 V
Max. Supply Current	53 mA
Output short circuit current	57 mA

Pin Configuration :-

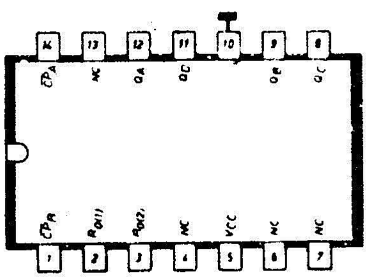


Fig. 8

Here only first flip-flop portion has been used for our purpose. (see figure 9) However if it is required to make two such circuits, the second flip-flop can also be used independently because clock pulse of the second flip-flop has also been brought out.

In the circuit 9 V supply has been obtained by TFI, B_1, C_1, R_1 and C_2 in the usual way. As the output of I.C. may not be sufficient to drive the relay, an transistor T_1 is used to drive it.

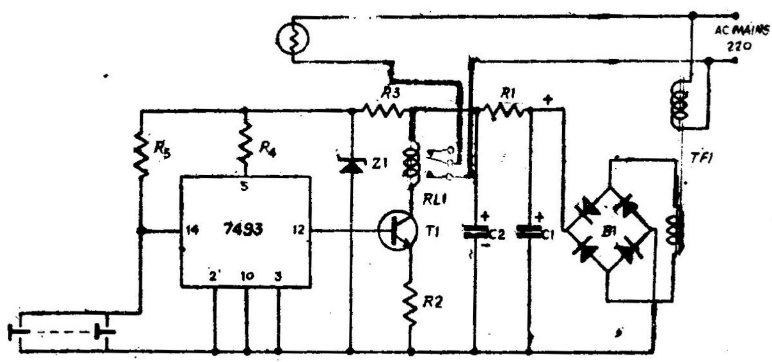


Fig. 9

Component list :

Semiconductors :

I C 7493
T I AC 187
B 1 Rectifier bridge, 12V, 500mA
Z 2 Zener Diodi 5V, 300mW

Transformer:-

TFI	220 V AC, 50c/s to 9 V

Capacitors:-

C 1, C_2 1000 MF, 12 V

Resistances:-

R1	5Ω	2W
R2	10.0Ω	1W
R3	7 8Ω	1/2W
R5	1.5 KΩ	1/4W

Miscelleneous:-

Relay	I V, 225Ω

[R4 may be used if 5 V zener in not available, such that voltage at Pin 5 of the I.C. is within 4.8V ana 5.2 V]

5. Electronic Multiplier

Here is an interesting and useful project using operational amplifier. This gadget can make multiple multiplications and divisions by the use of four knobs. Here again the result is not directly indicated but has to be found out in the same manner as in project No. 1.

There are four scales (around the four knobs) and one indicator which will be used for calculations. The calculations will be made by the fact that the bulb will be just changing its state or will be in half glow stage if and only if

$$ab=cd \text{ or } \frac{a\times b}{c}=d$$

where a, b, c and d are the valves indicated by the four knobs A, B, C and D respectively. So the calculations can be done as the following example shows:

Example :-

Let us find $2{\cdot}3\times\frac{4{\cdot}9}{6{\cdot}3}$

Set $a=2{\cdot}3$

$b=4{\cdot}9$

$c=6{\cdot}3$

move the D knob till the bulb just changes the state. The value d shown on D scale is the required result.

If It is required to make further calculations set b and c to get the value of a according to the relation

$$a=d\times\frac{c}{b}$$

So the process can be continued for multiple calculations.

The gadget can't directly calculate large or small numbers like 2340 or ·0029 and they have to be first converted into numbers like 2.34×10^3 and $2{\cdot}9\times10^{-3}$ and the powers of ten's have to be made use in the result to shift the decimal points.

Circuit description : The circuit is based on well known wheatstone's bridge. This bridge consists of four arms of resistances, shown in figure 10 by a, b, c, d.

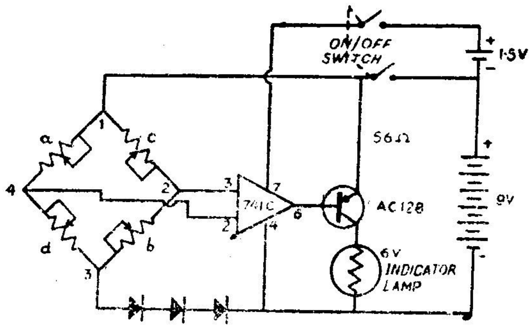


Fig. 10

At two opposite corners (1, 3) d.c. voltage is applied and according to the bridge theorm there will be no voltage difference on the remaining two corners (2,4), if and only if the condition,

$$\frac{a}{c} = \frac{d}{b}$$

is satisfied.

Detecting the position of zero voltage between two corners (2, 4) is a problem in commonly used electric systems. Here a high gain operational amplifier is used for this purpose, which can detect very small voltage differences of the order of 5 *m*V. This fact, how an operational amplifier can be used as comparator has been already discussed in detail in Project No. 1.

Marking the scales. Marking of the scales has to be done before making connections. Use a good resistance meter for this purpose. Mark each of the scale independently by measuring the resistance across the corresponding potentiometer by

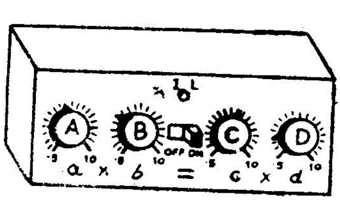


Fig. 11

measuring the resistance across it. Mark .5 for 50Ω, 1 for 100Ω, 10 for 1000Ω and similarly for other values. Mark all the scales by one meter only and in one range only as far as possible.

List of components

Semiconductors : I.C. 741C. Transistor AC 128.

Resistances :

One 56Ω, ½ watt.

Four potentiometers a, b, c, d each of 1kΩ, linear.

Miscellaneous :-

9 V small battery, 6V indicator lamp, single pole switch, 3 diodes of any type, etc.

6. Touch Switch

Just a finger touch on a metallic portion will make a bulb on and the next touch will make it off, if you make this simple project.

Circuit description:— The circuit employs two I.C's. One is a linear IC, OP. AMP, 741 C which has been already described in Project No. 1 and the second is a 4 bit binary counter, 7493 used as a simple flip-flop, described in Project No. 3.

The OP. AMP. has been used here as touch sensor. Let us see how it works.

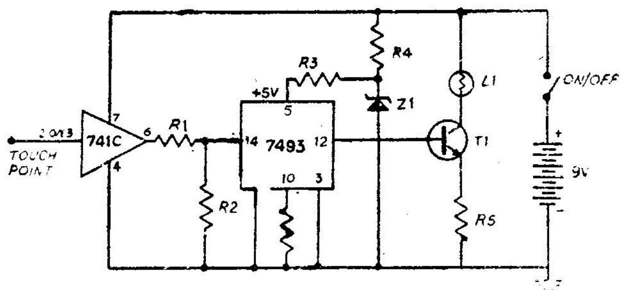


Fig. 12

As we know that OP AMP's are very high gain d-c amplifiers. However, most of the OP AMP's have a certain offset voltage present initially at the input terminals. This gives generally a high or low level at the output terminal without any input. Now when we touch on input terminal, we introduce a small + ve voltage at that point which may make output voltage to change. In most of the cases only one input terminal will give the desired effect. However, sometimes it may happen that offset voltage may be too high to be operated by fingure touch. For this difficulty, most of the OP AMP's available have offset balancing arrangement in them. If the reader finds himself in such a situation he can try it with offset arrangement as shown in Figure 13. The arrangenment can also be used to change the normal output level if required.

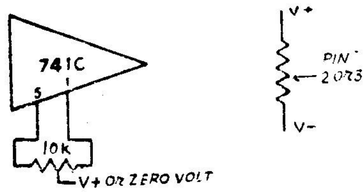


Fig. 13

Component list

Semiconductors :

I.C	7493
I.C	731c
T1	AC187
Z1	zener diode, 5V/5.25V/5.6V*, 300mW

Resistances :-

R1	1KΩ
R2	1KΩ
R3	0-100Ω
R4	100Ω
R5	22Ω

Miscellaneous :-

6V torch lamp, P.C.B, ON/OFF switch etc.

*R3 has to be adjusted such that voltage at pin 5 of the 7493 is between 4.8 and 5.2 V

7. Sensitive Doll

Here you can make a doll's eyes glow in a life-like fashion. It is a touch sensitive toy, which, by your fingure touch, opens her eyes (open means the tiny bulbs in eyes will glow) quickly in a sec., keep open them for about 5 secs. and then closes them slowly, in about 5 seconds.

Circuit description

The first part of the circuit (see Figure 14) is a touch switch using OP. AMP. 741. This switch is so adjusted that generally output remains at high (about 9 V) and goes down by fingure touch by off set balancing, if required, as described in Project No. 5.

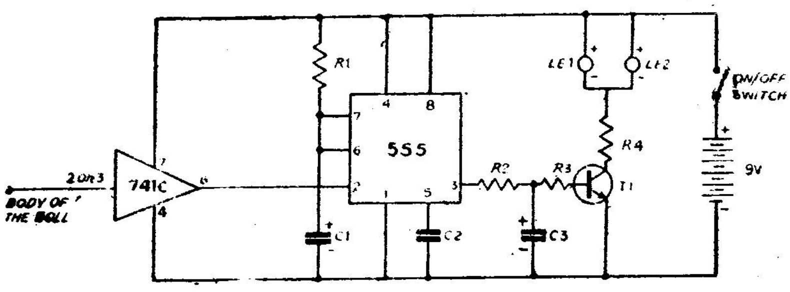


Fig. 14

The pulse obtained by the OP. AMP. is then given to a monostable circuit which consists of an I C, 555 known as Timer.

I.C. 555 :— This is a highly stable multipurpose timing circuit and can be used for many purposes like producing accurate time delays, oscillation, triggered pulse generator etc. It can give timing from microseconds through hours.

Max. Ratings.

Supply Voltage = +18 V
Power dissip. 600 *m*W

Operating temp. range 0-70°C
Lead temp. (soldering 60 seconds) 300°C

Pin Configuration

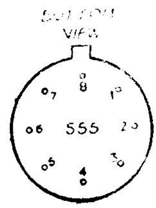


Fig. 15

1. Ground
2. Trigger
3. Output
4. Reset
5. Control Voltage
6. The r should
7. Discharge
8. V c c

In the present circuit I.C. 555 has been used as monostable multivibrator with pulse width of about 5 secs. This pulse width can be controlled by Cl and R1.

The output of the monostable is of rectangular shape which has been shaped to our requirement by R_2, R_3 and C_3. The rate of glowing of LEDS (Light Emitting diodes) is controlled by R_2 and rate with which they will go off is proportional to R_3.

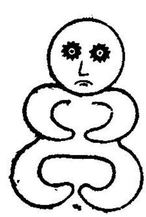


Fig. 16

Component list

I.C.	741 C
I.C.	555
T1	AC 187
LED'S, 2 No.	
C_1	1000 μF 12 V
C_2	.01 μF
C_3	1000μF 12 V

R_1	15 K	All 1/4 watt.
R_2	33 K	
R_3	330Ω	
R_4	10^Ω	

ON OFF switch, 9 V battery, Double 8 pin I.C. P.C.B. etc.

8. Accurate LED Flicker

Here is again a very simple and interesting application of IC 555, Timer. Here an LED (light emitting diode) will flicker at a previously determined, variable rate from 200 to 5 glow per second. It has got application like finding the persistance of eye, measuring the r.p m of an rotating object by sterboscopic method etc.

Circuit description

The circuit (figure 17) uses the IC 555 as a accurate astable multivibrator. The timings of the astable multivibrator are given by

High output time=.693 (R_1+R_2) C_1 msecs.

Low output time=.693 (R_2) C_1 msecs.

Where R_1 and R_2 are in KΩ

and C_1 is in μF (m f d)

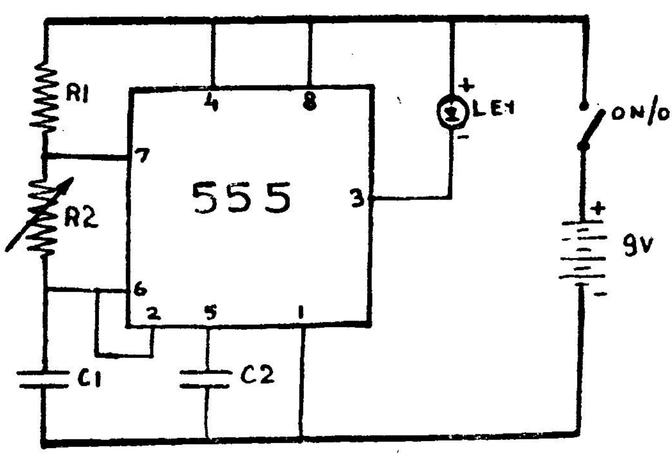


Fig. 17

In the circuit R_1=330 Ω and R_2 is a variable resistance from 0—10 KΩ. The output of the I.C. is directly given to the LED in a way such that it glows when output is low. This been done to have a low value of glow period at high frequencies, which is favourable for measuring speed by sterboscopic method whereas at low frequencies the glow period and off periods are nearly same.

Component list.

Semiconductors

IC 555
LED

Capacitors

C_1	20 μF
C_2	.01 μF

Resistances

R_1	330 Ω 1/4 watt.
R_2	0—10 K Ω, linear.
R_3	56 Ω 1/2 watt

Miscellaneous

Single 8 Pin I. C., PCB, 9 V battery.

9. Electronic Game

Here is a very interesting application of I.C. 7493, a four-bit binary counter. This electronic Game will count your scoring automatically and display them visually by the help of four LED'S.

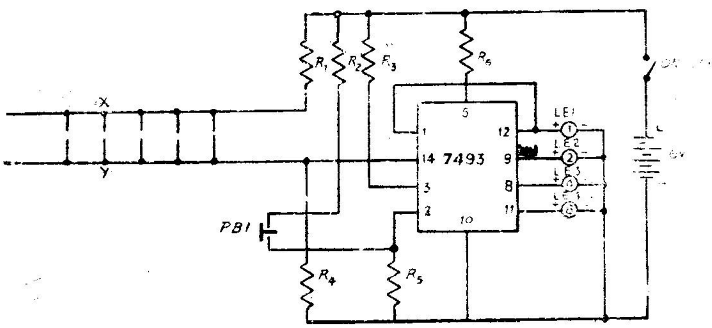


Fig. 18

The circuit (figure 18) is nothing but a 4 bit binary counter using 7493. Let us see in brief how the counting action is performed.

Principle of Counting

This counter actually consists of 4 flip-flops. An flip flop changes its stage only when the input voltage is falling. So if we connect 4 flip flops serially (output of one is connected to the input of next) and give a train of pulses at input, we will get wave shapes at four outputs as shown in figure (19). Now note one thing that if we give value numbers 1, 2, 4 and 8 to four outputs, then at any instant if we add up the value numbers of those who are at high we get the No. of pulses that passed before that instant. This is what as counter has to do.

So we see how four flip flops can count the No. of pulses up to 15.

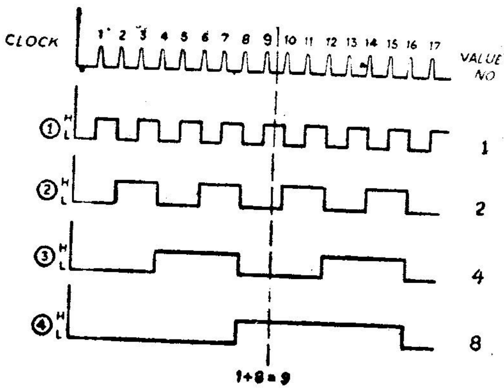


Fig. 19

For setting all the outputs to zero a reset point is provided in I.C. 7493, which is given a high voltage whenever zero has to be set, by PB 1.

This game will be slightly different. Here the number of touches will be counted which may be taken as grade or a fowl. The nails in the board should be (see figure. 20) either such that they are shorted to board (preferably an P.C.B.) whenever an metallic ball touches it or nails should be divided into two groups, X and Y, each nail given an X or Y line and then whenever the ball touches X and Y simultaneously, the counting will occur. The complexity can further be increased by making some nails which will set the whole score zero and

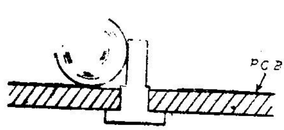


Fig. 20

connecting some nails to PIN 1 directly such they add 2 in the scoring and many other such things can also be added.

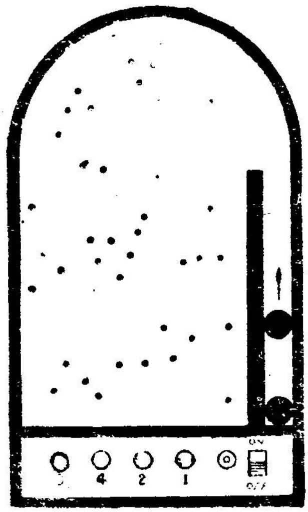


Fig. 20A

List of Components.

I C 7493	
LE1—LE4	Four LEDs
R_1, R_2, R_3	$47\Omega\frac{1}{4}$ watt each
R_4, R_5	$470\Omega\frac{1}{4}$ watt each
R_6	82Ω—22Ω*

ON/OFF slide switch, Push button, nails, P.C.B. etc.

10. Cheap Electronic Stop Watch

It is a model type stop watch to measure small times, costing about Rs. 70/-. It can be used for races, measuring typing speed, photographic applications etc.

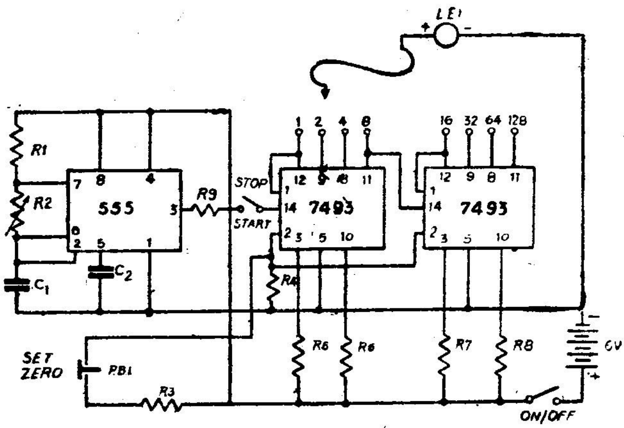


Fig. 21

Circuit description

Timer has been used in astable mode to give time reference and it oscillates at 1 Hz. Two, 4 bit counters 7493 counts the output of the oscillator and gives output in the binary form on 8 output points. Only one LED has been used (to minimise the cost) for the visible display.

Using the Stopwatch

Press P.B.I. (Push button) for a second to set zero. Make S1 in start position to start the counting and return to stop after the time to be measured. Now connect the LED wire to the 8 points (1 to 8) one by one, noting down whether LED glows or not and add up the values of all the points where the bulb is glowing. This will give the time in seconds. If the time is more then 255 seconds, estimations has to be used as to how many times 256 seconds has to be added in the previous sum to get the correct time.

Component list

Semiconductors

I.C	555	
I.C	7493	2 No. s.
LE_1	LED	

Capacitors.

C1	50.0 μF
C2	.01 μF

Resistances

R_1	15K	¼ watt
R_2	10K Pot, log.	
R_3, R_5, R_7, R_6	47Ω each, ¼ watt	
R_4	470Ω ¼ watt	
R_6, R_7	82Ω—22Ω*, 1/4 watt.	

Miscellaneous

Two single pole slide switches, one push button, 4 penlight cells etc.

* These have to be adjusted such that, voltages at pin 10 of 7493 are in between 4.8—5.2V.

11. Electrician's Companion

This gadget can prove very useful for an electrician to check the wiring with mains off. It will check the continuity between two points on any wiring and can also detect any leakage between lines. Thus it can replace the widely used "Meggar"

The circuit produces about 100-300 V from a 9V battery which is sufficient to derive a few neon lamps. For testing the wiring, the instrument is fixed in any plug of the wiring. The continuity of a line can now be checked by using a neon tester. There is a switch on the instrument to connect the earth line to left or right pin. However if no earth line is there, only one pin need to be inserted and other can be touched by another person.

Circuit description :—

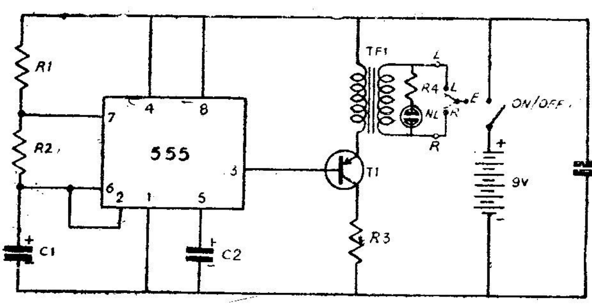


Fig. 22.

The circuit utilises an IC, 555 Timer as an astable multivibrator to give rectangular waveshape at about 20 Hz. The times of the vibrator depends upon R_1, R_2 and C_1, and are given by

High output time $= .693\ (R_1+R_2)\ C_1$ mili secs.
Low output time $= .693\ (R_2)\ C_1$ mili secs.
where R_1 and R_2 are in $K\Omega$, C_1 is in mfd.

The output of the vibrator is given to the base of a transistor. It interupts the current in the primary of a step up transformer which results in high voltage at the secondary of this transformer which is given to the output lines. To minimise the current consumption, the resistances R_1 and R_2 have been so chosen so as to load the battery for only one tergth of the total time. The gadget is shown in figure 23.

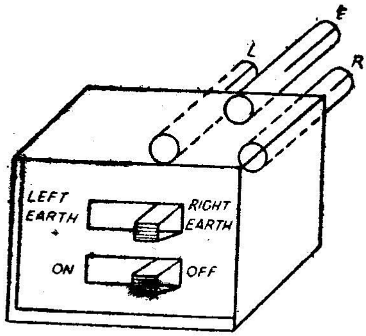


Fig. 23

List of components

Semiconductors

I. C 555
T_1 AC 128

Transformer :—

TFI Any low freq. transformer with step up ratio of about 100. preferably 6-9 V transformer for battery elliminator. [Here secondary has to be used as primary and vice versa]

Capacitors

C_1 10 μF, 12 V, electrolytic
C_2 .01 μF
C_3 1000 μF, 12 V electrolytic

all 1/2 watt.

Resistances

R_1 10 K
R_2 1 K
R_3 100Ω
R_4 150 K

Miscellaneous :—

Neon lamp, 2 single pole switches, battery (either 9 V or pencil cells)

12. Electronic Puzzle

Here is a project which will give lot of entertainment as well as help in understanding the logic circuits.

There are 20 single pole slide switches which has to be set by the candidate so as to make the indicator ON. The logic diagram should be printed on switch board so that candidate can apply his mind and just don't presses the key's in arbitrary manner. The game can be played in a number of ways e. g. one person will set the switches from S_1 to S_{14} and the candidate has to touch the switches from S^{15} to S^{20} only 4 times to make the LED glow. The game is purely intellectual and does not depend on luck at all, and there are millions of possible combinations to make the LED glow.

The complete circuit (Fig. 24) employs only 4 I.C's. Let us first study these I.C's.

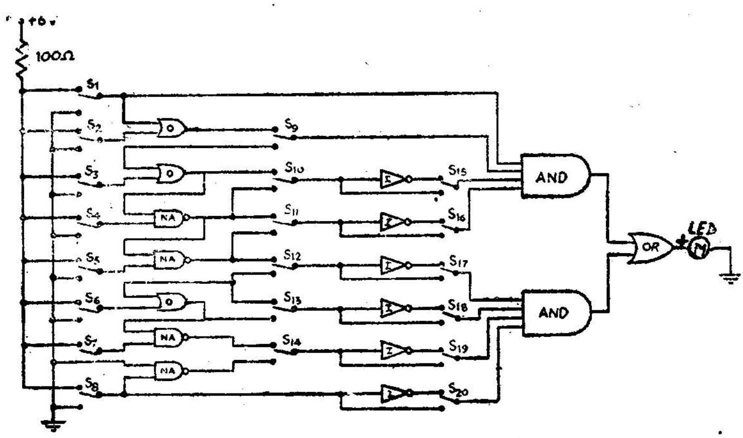


Fig. 24

1. IC 7404 (Hex Invertors)

This I.C consists of 6 invertors. An invertor gives the output opposite to the input i.e. if input is LOW the output will be HIGH and vice-versa.

Pin confriguration

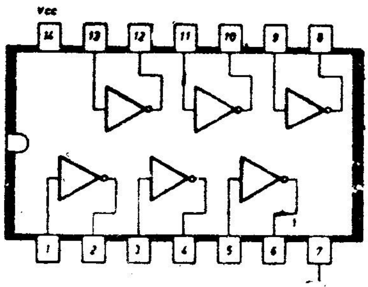


Fig. 25

2. **IC 7408** (Quadruple 2-Input AND gates)
It consists of 4, 2 input AND gates.

An AND gate gives HIGH output if and only if all the inputs are at HIGH level.

Pin Confriguration

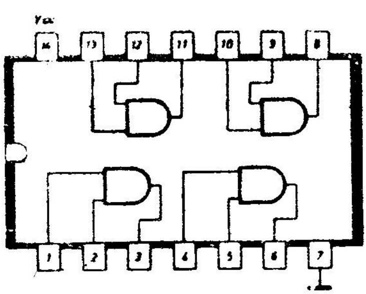


Fig. 26

3. **IC 7400** (Quadruple 2-Input NAND gates)
It consists of 4, 2 input NAND gates.

An NAND gate gives LOW output if and only if all the inputs are at HIGH level.

Pin confriguration.

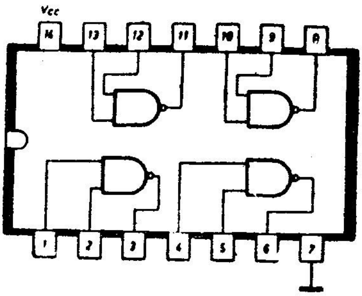


Fig. 27

4. **IC 7421** (Dual 4-Input AND gates)

It consists of 2, 4 input AND gates.

Pin Configuration

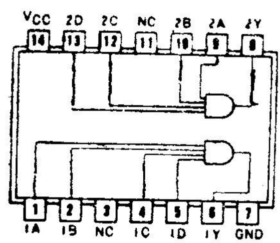


Fig. 28

Only logic diagram has been shown to avoid the unnecessary complexity. The actual circuit has to be assembled keeping in mind this logic diagram and pin configurations of each I. C.

The reader can very well expand or reduce the complexity by using more or less logics and can develop a number of such games himself.

6 V battery (4 pen light cells) should be used as supply and a resistance (22-82 Ω) should be used between supply points of I C'S (Vcc) and the +6 V point such that Vcc for every IC is within 4.8—5.2 V.

13. Electronic Quiz

This is a project for passing the spare hours and enjoying the time either alone or with your friends. It will also judge the intelligence of any one.

The candidate has to set up a number of wires using his mind and then press a push button (P.B.1.) ten times to know his scoring. There are three indicators for indicating the scoring, with a number (3 or 2 or 5) alotted to each of them. Every time a push button is pressed, the indicators change their states, resulting in a new sum. The scoring of a candidate is the total sum of 10 sums. The rules of the games can be, however, changed by readers according to their choice and thus the single game can be played in a number of ways. Not only this, the permanent wiring of the logic circuits can be altered in many ways to make the game according to your choice.

Circuit description:-

There is a 4 bit counter in the circuit which results in 16 possible states on its 4 outputs by giving pulses at the input, which is done by pressing the push button. The outputs of the counter are now applied to logic gate I.C.s through loose wires (which are set by the condidate) and the output of those are used to derive the three LED's (Light Emitting Diodes).

Note:—P.B. 2 sets all the counter outputs at low level and may be pressed before a candidate starts the game.

List of Components

I.C	7493
I.C	7404
I.C	7411
LED	3 Nos

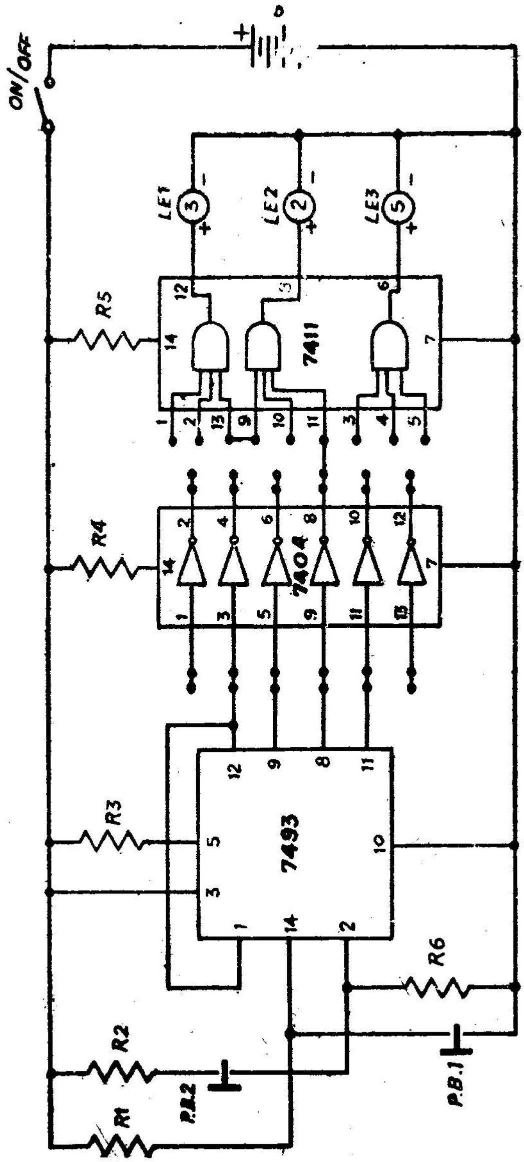


Fig. 29

R1,	1KΩ, ¼watt
R3,R4,R5	82—22—Ω* ¼watt each
R2	47Ω
R6	470Ω

ON/OFF Switch, 2 Push buttons, banana clips and sockets, battery etc.

* These have to be adjusted such that supply available to all the ICs is between 4.8 V and 5.2 V.

14. Magic Switch

This single switch will be controlling 4 bulbs independently with your own hand, but if your friend tries, he will not be able to do so.

The switch actually has got effect on a particular bulb at some intervals while on others at other intervals. While pressing the push button you have to keep an account of the glowing of a LED in the bulb box which you may place in such a way that it is visible to you and not to your friends. If the P.B. (Push button) ts pressed when LED is glowing, the first bulb (these may be LED's) will change its situation whereas if it is pressed just after the LED goes off (actually this period is from the time LED just goes off to 1/4 the time of the total time period) the second bulb will be effected. Similarly the 3rd will be effected if P.B. is pressed mid way of the LED off period and fourth will be effected just before the LED is going to be ON.

The frequency of glowing can be adjusted by R2 depending on the practice you have acquired.

Circuit description (See Figure 30)

I.C. 555 works as a astable multivibrator, and its output is fed to a 4 bit counter 7493. Only two bit output of the counter has been used and they are inverted by an hex-Invertor 7404.

Four, two input AND gates (I.C. 7408) now decode this two bit information on four lines. These 4 lines now drive four JK master/slave flip flop's. These flip flop's have property that the output changes state if and only if its both J and K inputs are high. Two 7473 I.C's, (dual JK master/slave flip-flop) have been used for this purpose.

7473 :- The device is a Dual JK Master/Slave flip-flop with a separate clear and a separate clock for each flip-flop.

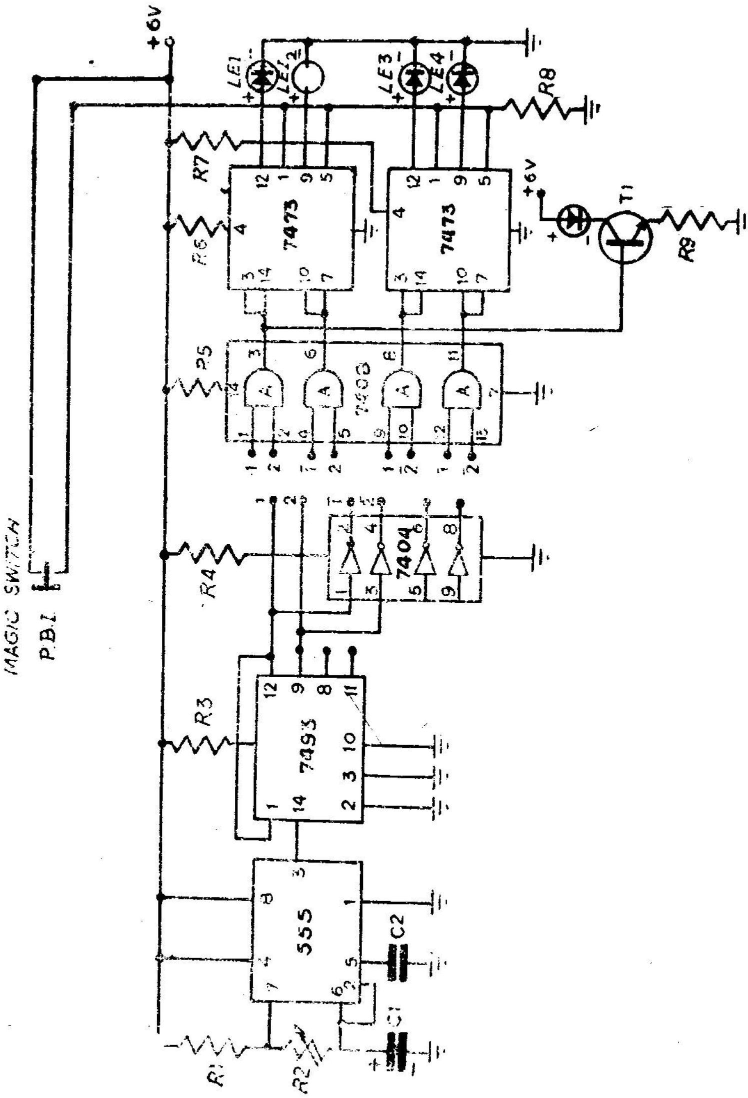
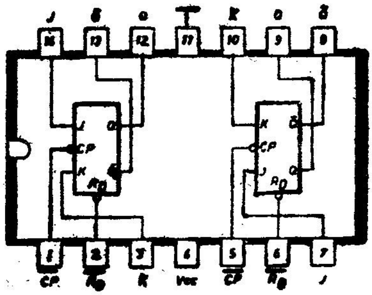

+6V
LE1
LE2
LE3
LE4
R8
R7
R6
7473
7473
+6V
T1
R9
R5
7408
MAGIC SWITCH
P.B.1
R4
7404
R3
7493
555
C2
C1
R1
R2

Fig. 30

Pin Configuration :-



Base diagram
of IC 7473
Fig. 31

Some important specifications :-

Supply voltage range	4.75—5.25 V
Supply Current	up to 40 *m*A.
Min Input HIGH Voltage	2.0 V
Max Input LOW Voltage	.8 V
Min. Output HIGH Voltage	2.4 V
Max. Output LOW voltage	.4 V
Output S.C. Current	(—18)—(—57) *m*A
Max Clock freq	15 MHz.

The outputs of these four flip-flops directly drive four LED's.

The switch capacity can be increased to 8 bulbs or 16 bulbs by taking 3 outputs and 4 outputs respectively instead of 2 from the I.C. 7493. It is also possible to use relays instead of LEDs and thus control whole of your electrical appliances by a single switch.

List of Components.

I C	555	
I C	7493	
I C	7404	
I C	7408	
I C	7473	2 Nos
LED		5 Nos
T1	AC 187	
C1	100 μF	

C2 .01 μF

R1 2.2k, 1/4 Watt

R2 10k variable

R3, R4, R5, R6, R7, 82—22Ω each.

R8, R9 330*, 1/4 watt each.

Push button, ON/OFF switch, battery, P.C.B. etc.

15. Temperature Controlled Oscillator

This gadget produces a sound, the tone of which changes with temperature. At room temperature the instrument keeps quiet. As the temperature is increased, at about 50°C, the sound starts coming and with more temperature the tone changes. The device can be very well used as fire alarm.

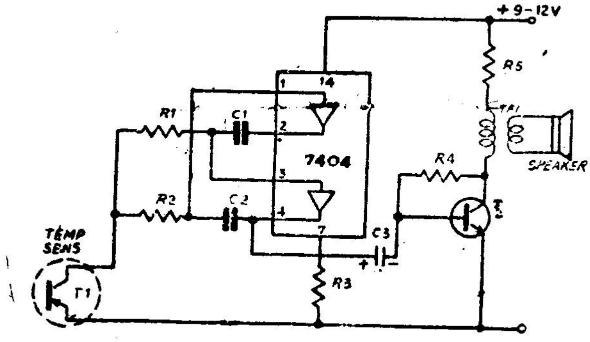


Fig. 32

Citcuit description : (see figure 32)

The circuit employs two invertors (a part of 7404, Hex Invertors) to work as audio oscillator. Capacitor C1 and C2 provide positive feedback. The frequency of oscillation depends upon these capacitors as well as on the resistance that are in series with them. The T1 also comes in this circuit and resistance offered by this transistor effects the frequency of oscillation. Now this resistance offered by T1 depends upon the temperature because T1 is in cut off position and only the Icbo is flowing which depends largely on temperature.

The output of the oscillator is amplified by a n-P-n transistor T2 and is fed to a speaker through step down transformer.

List of components

IC	7404
TI	AC 188
T2	AC 187
TFI	Output transformer of a Push Pull stage for transistor set.
CI, C2	I μF, ceramic 2 Nos
C3	10 μF
RI, R2	4.7K, ¼ watt each.
R3	330Ω, ½ watt.
R4	
R5	100Ω, ½ watt.

16. Revolving Display

Press a push button and see how quickly the display rotates by one element. Continuous pressing and releasing will give a rotating effect. You can use it as a game, to know how fast one can press the push button.

Circuit description : (See. Fig. 33)

The circuit employs an I C 7473 (dual J K master/slave flip-flop with separate clears and clocks) to work as a 2 bit binary counters. The inverted outputs (1 and 2) are also brought out so as to eliminate the need of invertors as was done in Project No. 13. Four, two input NAND gates decode this 2 bit code on four lines such that at one time only one line is at low level. For this purpose I C 7401 (Quad 2 input NAND gates with open collector output) has been choosen because in this I. C. output stages consists of a transistor with its collector open and brought out, so that it can drive loads of 100 mA directly.

Display can be either two LED's in series as shown or two 6 V miniature indicating lamps in parallel (with precaution that total current in one line is not more than 100 mA).

Display can be made self revoling by using a low frequency (1—10H_z) astable multivibrator (as used in Project No. 13 by 555 timer).

List of Components

I.C	7473	
I.C	7401	
LED's	9 Nos	
R1	1KΩ	¼Watt.
R2, R3	22—82* KΩ each,	¼Watt.
R4	100Ω	¼Watt.
R5	330Ω	¼Watt.

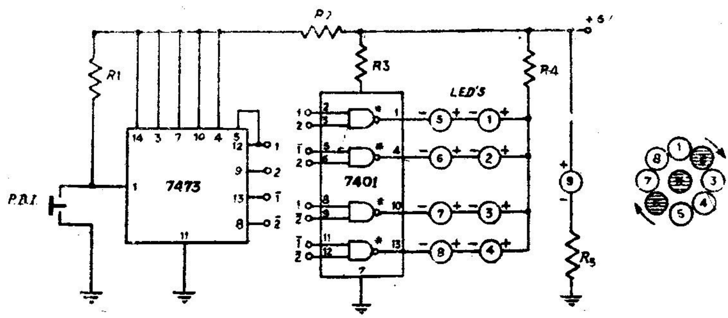


Fig. 33

Push button, Double 14 Pin rectangular I C P.C.B, 4 Pen light cells etc.

* These should be adjusted such that voltages at Pin No. 14 of I C s are in between 4.8 and 5.2 V.