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AN ELECTRONIC LABORATORY WORKBENCH

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ABSTRACT

The need to compliment the theoretical knowledge of basic electronics with practical work in the study of electrical and electronics engineering is well accepted. Its importance stems from the fact that it enhances the students understanding of the subject matter.

This idea necessitated the design and construction of electronic work station which can be used to demonstrate the many applications and characteristics of diodes and operational amplifiers in basic electronic circuits. This no doubt will aid the students in their course of study. This paper presents the work stations and its use for demonstrating some electronic theories (characteristics and applications of diodes and op amps) in electrical and electronics engineering.

INTRODUCTION

In the early days of engineering education in Nigeria, laboratory facilities were provided for testing theories that were taught in class. Because the number of students were few (less than thirties) the few facilities that were usually available were able to go round, As a result, there were two or three students to a laboratory set up. Over the years, the number of students have grown (over 200) but no new equipment have been purchased. Besides, the few equipment that were used by fewer students when the equipment were new are now being used by the large number of students now. And these equipment are now old, with most of them having broken down.

Besides, due to paucity of funds, the institutions have not been able to purchase additional equipment to replace the broken down ones or augment the available ones. Also because most of the newly recruited lecturers themselves did not have adequate laboratory exposure due to reasons stated above, they are not usually in a position to mount experiments of their own.

1. The result of this is that many students now crowd on the few laboratory setup that are available. In most cases, some of the students do not get access to the equipment to be able to know or see what is going on. They just copy the results from their colleagues. Quite often some of the students do not bother to attend the practical sessions as they

can always get the results from their friends. This situation exists in most universities and polytechnics in the country to-day.

The objective of the work presented in this submission is to try and address this problem and proffer a solution to it. The paper presents electronic workstation, which can be used to demonstrate some basic electronic theories and topics effectively. The package is such that most of these theories are easily demonstrated by means of the work station. The unit is cheap, simple. It was designed and built in our department, and can be easily replicated by other departments.

2. The Electronic Work Station

The workstation consists of a power supply, functions generator, and experimental benches, as indicated in block form in Figure 1.

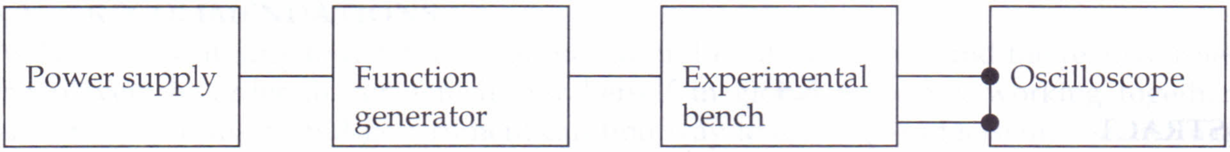


Figure 1. The Work Station

The only additional equipment that is needed to effectively perform an experiment on the work station is a double beam Oscilloscope for measuring signal levels, frequencies e.t.c

2.1 The Power Supply

This is a simple stabilised power supply. It uses a bridge rectifier together with the usual components to provide a stabilised output. It provides a supply to both the function generator and the workbenches.

Figure 2. shows the circuit of the power supply, which is incorporated within the unit.

2.2 The Function Generator.

This uses the I C to produce the various waveforms that are needed for the experimentation. It generates sine, square and triangular waveforms.

Figure 3. Shows its circuit diagram.

2.3 Experimental Workstations

The unit is designed to have several experimental workstations to be used to perform experiments to demonstrate various aspects of electronics. At the moment, three of the works stations have been constructed. These are stations for the junction diodes, characteristics and applications transistors characteristics and applications and operational amplifiers characteristics and applications. Two of these are shown pictorially in Figure 4 and 8.

2.3.1The junction diode Workstation

The multipurpose diode workstaion is used to perform experiments on the characteristics and various applications of the junction diode. The schematic layout of the workstaion is shown in Figure 5. The waveforms are obtained from a step-down transformer. The experiments that can be performed with this workstation are

Experiment 1 Junction diode characteristics
Experiment 2 Half and full wave rectifications
Experiment 3 Filtering
Experiment 4 Clipping and clamping circuits.
Experiment 5 Limiting circuits.

The circuits for the various experiments are shown in Figure 6

APPLICATIONS OF P-N JUNCTION DIODE

1. HALF WAVE RECTIFICATION

The basic circuit for half wave rectification is shown in figure 6(a). In the first half cycle of the input (i e $0 < \theta < \pi$), the diode D is forward bias and thus allow the flow of current while at the second half cycle of the input (i.e. $0 < \theta < 2\pi$), diode is reversed bias and disallows the flow of current.

2. FULL WAVE RECTIFICATION USING A CENTRE TAP TRANSFORMER

The circuit of figure 6b shows how transformer T is connected in a full wave rectifier circuit. When power is supplied to the primary of T closed D_1 and D_2 operate as a full wave rectifier. Each diode sees only half the voltage appearing across the secondary and each diode conducts alternately.

Full wave rectification can also be attained by using four diodes without a centre tap transformer. See figure 6(c) (the bridge rectifier circuit).In the first half cycle ($0 < \theta < \pi$), terminal T_1 (in figure 6c) is positive with respect to terminal T_2, thus the diodes D_1 and D_2 conduct. (This gives rise to the output waveform in the range $0 < \theta < \pi$. In the second half cycle ($0 < \theta < 2\pi$), terminal T_2 is positive with respect to terminal T_1 and diodes D_2 and D_4 conducts, this gives rise to the output waveform in the range $0 < \theta < 2\pi$. For both half circles the voltage drop across R_L is unidirectional which results in a positive half circle output waveform. The input is said to be rectified by the bridge circuit.

(3) CAPACITOR FILTER

Half-wave rectification

A capacitor may be added to a rectifying circuit to obtain capacitor filter. The capacitor stores energy during the conduction period and delivers this energy to the load during the non-conducting period. The half wave rectifier with capacitor filter circuit is shown in 6d. the capacitor charges until V_c is maximum i. e $V_c = V_i$, this occurs at wt = π / 2 radian and neglecting diode drop, the capacitor voltage

$V_c = V_m$. between $\frac{\pi}{2w} < + < \frac{2\pi}{w}$, the input voltage V_1 decreases below the capacitor voltage, V_c (i.e. $V_1 < V_c$) thus making the diode to be reversed biased and consequently, the diode discharges through R_L until $V_i = V_i$.

4. FULL-WAVE RECTIFICATION

Full-wave capacitor filter circuit is shown in figure 6e.i). The principle of the full-wave rectifier with capacitor filter is similar to that of the half-wave except that ripple is smaller.

5. THE SHUNT RECTIFIER

Shunt rectifier is used where low output is demanded. A simple shunt rectifier circuit is shown in figure 6 f. When the diode D is forward biased, the voltage applied is directly across R_1 and $V_0 = 0$. at the time the diode is reversed biased

$V_0 = V_{in}$ since.

$$V_0 = \left(\frac{R_2}{R_1 + R_2}\right) V_{in} \qquad R_2 >> R_1$$

For forward bias R_1 is large.

For reverse bias R_2 is far greater than R_1. R_1 is small. Thus shunt rectifier is suitable for application where the output current required is small.

6. CLIPPING CIRCUIT

This is also referred to as voltage limited or slicer. It is mostly used in comparator circuits. When in operation in comparator circuit it selects the part of the waveform to be transmitted. An example of a clipping circuit is shown in fig 6 h

7. CLAMPING CIRCUIT

Another application of the p-n diode is in clamping circuit. A typical example is the peak clamping circuit show is figure 6j

In operation, assuming initial capacitor change equal to zero, the diode is reversed biased until $V_{in} = V_b$, at which stage the capacitor begins to charge with current i. as long as $V_{in} > V_b$, the output voltage remains at V_b (i.e. $V_0 = V_b$)

2.3.2 The Operational Amplifier Workstation

This bench or unit uses 741 ics, resistors and capacitors mounted on a panel as shown in figure 7. It can be used to demonstrate the many applications and characteristics of op amps. Such applications include; the voltage follower, the inverting and non-inverting op amp, the inverting op amp as a summer, as a difference amplifier, as an integrator and as a differentiator. Some of the many characteristics that it can verify are the input bias current, open and closed loop gains offset voltage, slew rate, bandwidth effect etc.

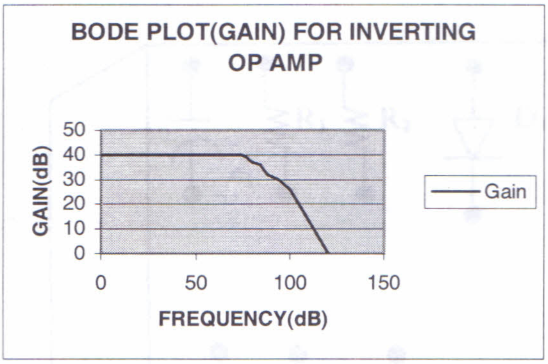
The power supply of ± 15V is internally or externally derived. The case is made of wood and aluminum sheet as shown in figure 8. Terminal plugs are fitted on the aluminum sheet to provide internal connections to the components mounted on the panel, and external connections for the various application example of the op amp circuit.

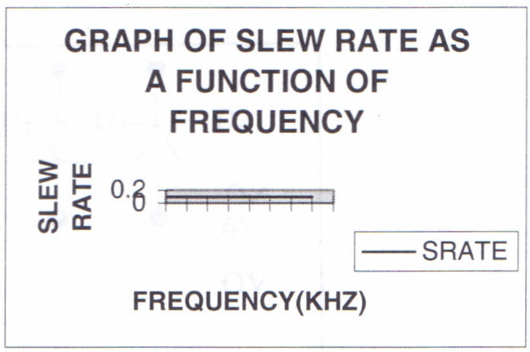
Figure 6 shows a set up for performing various experiments on the op amp i.e. some of the experiments that can be performed on the op amp are:

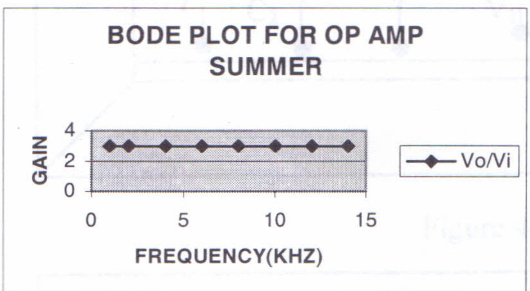
EXPERIMENT1

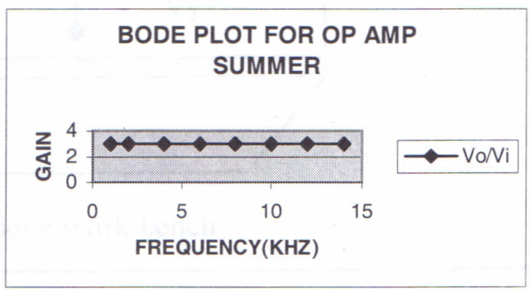
Experiment 1.	Closed loop gain of an inverting and non-inverting op amp at various frequencies.
Experiment 2.	Gain of a voltage follower at various frequencies.
Experiment 3.	The op amp as a summer at various frequencies.
Experiment 4.	The op amp as integrator and differentiator.
Experiment 5.	Slew rate measurement at various frequencies.
Experiment 6.	Input bias current.
Experiment 7.	Offset voltage measurement.

Results obtained for some these experiments are shown.









CONCLUSION

This paper has shown that the work benches presented performed satisfactorily as seen from the results obtained from the various set up for the many application and characteristics of diode and op amp in basic electronics. The use of locally made laboratory work station in high schools and institution of higher learning is therefore encouraged to enhance students understanding of some basic electronic theories.

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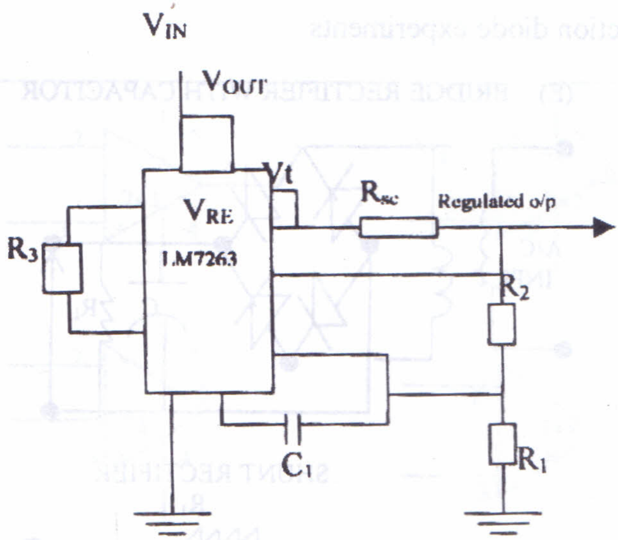
Ife, Julius : A multipurpose operational amplifier circuit board for demonstrating the many applications and characteristics of operational amplifier. An Msc mini Project Report. Electrical and Electronics Engineering Department. University of Lagos. Akoka. Lagos. May 2002.



$V_{OUT} = V_{REF}\ (R_2)/(R_1 + R_2)$

Fig. 2 Regulated Power Supply

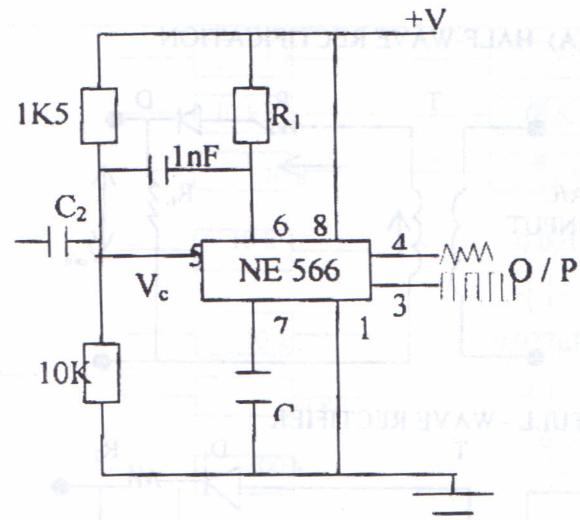


Fig. 3 Waveform Generator

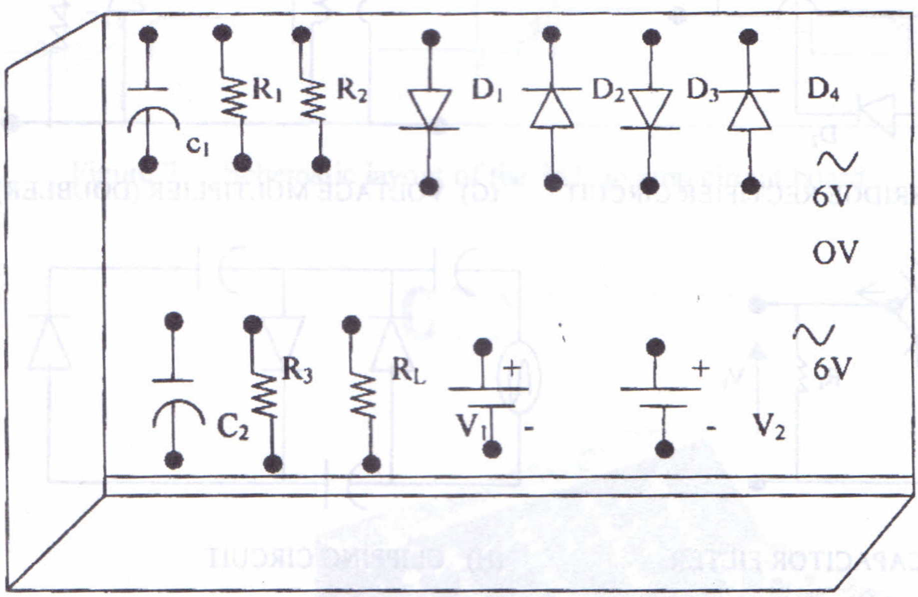


Figure 4 The diode work bench

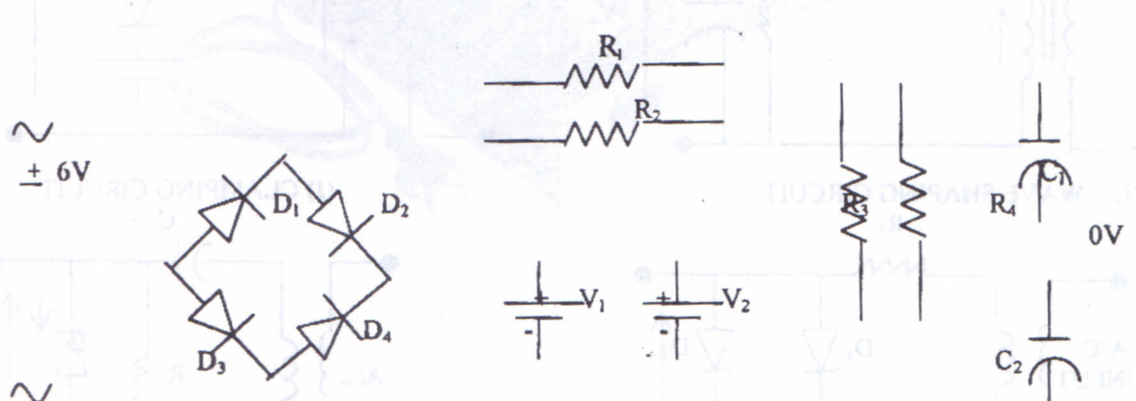
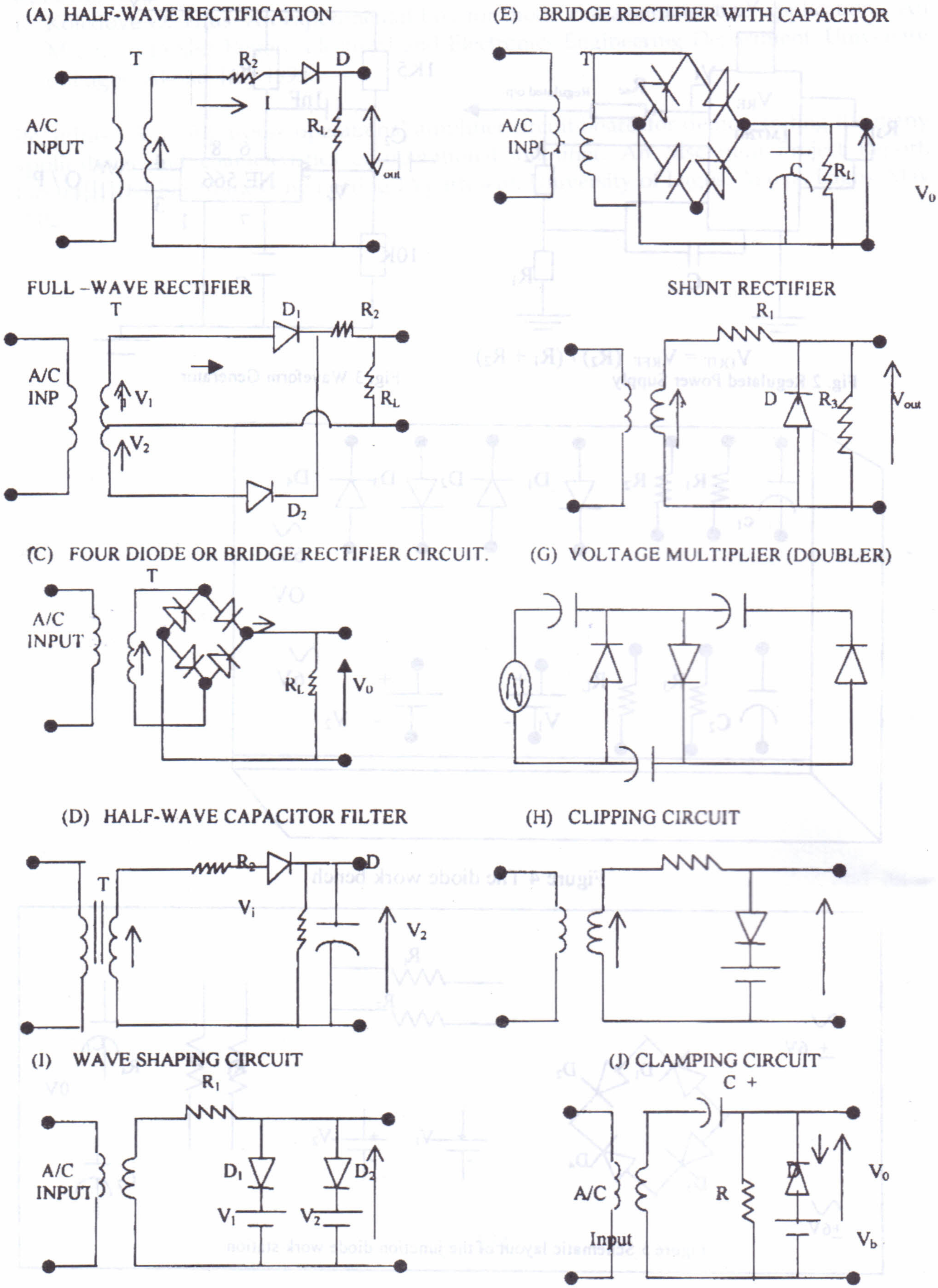


Figure 5 Schematic layout of the junction diode work station

Figure 6 The circuit for the various junction diode experiments



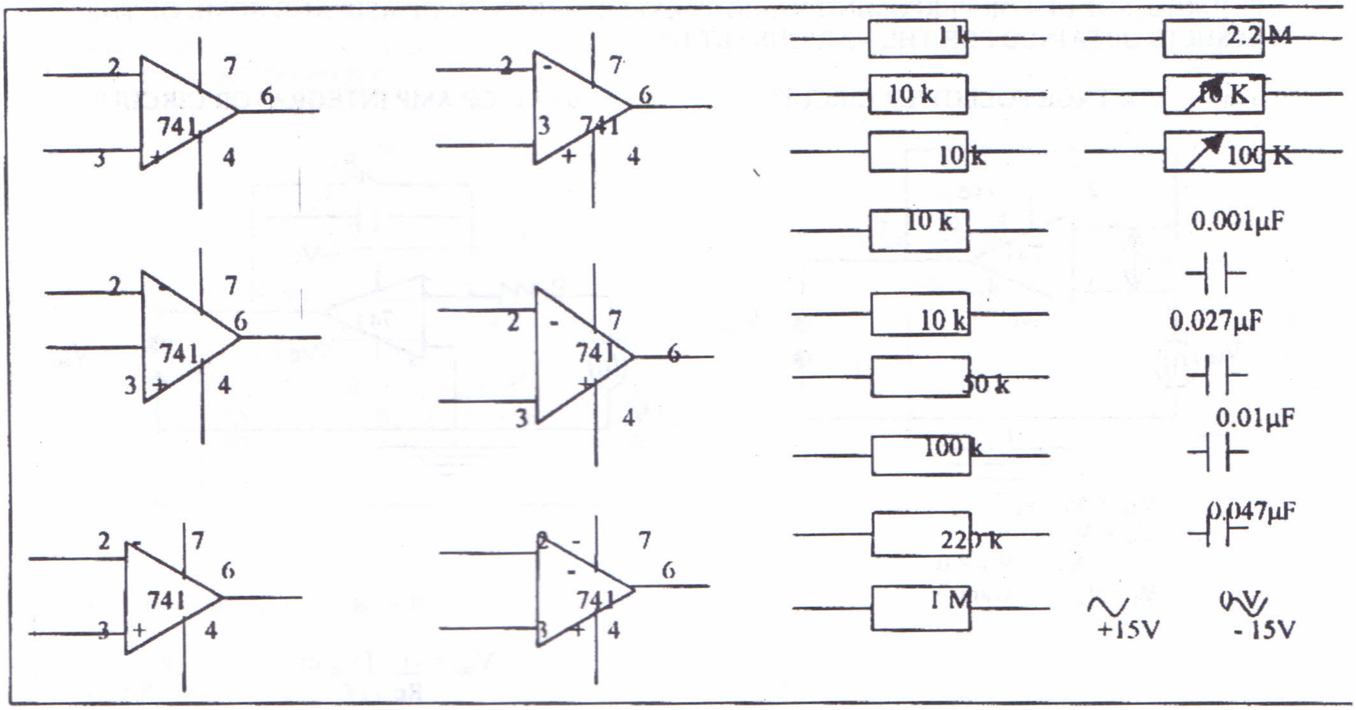


Figure 7 : Schematic layout of the 741 op amp circuit board

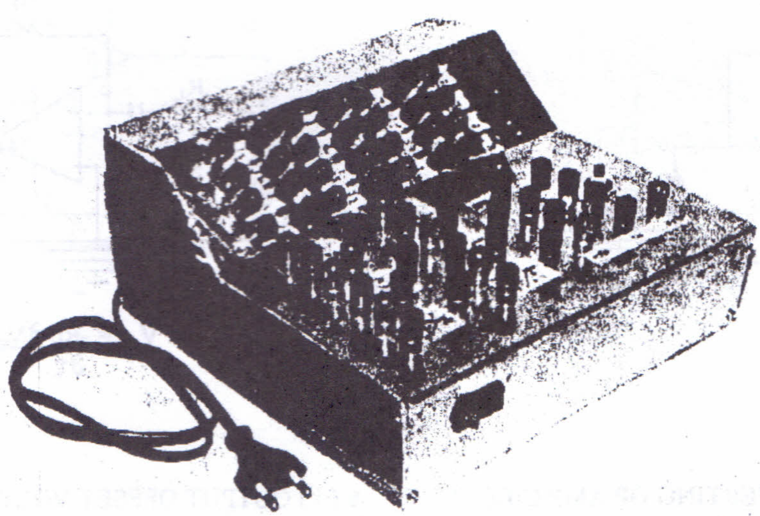
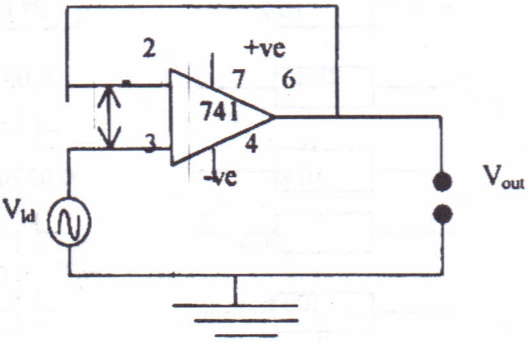


Figure 8: The op amp workbench

FIGURE 6: SET UP FOR PERFOMING VARIOUS EXPERIMENTS ON OP AMP AND SOME OF THE RESULTS OBTAINED FOR THE VARIOUS SET UP.

6 (a) VOLTAGE FOLLOWER CIRCUIT

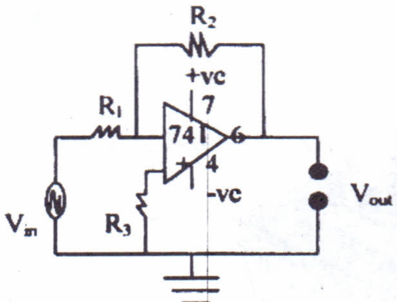


$V_{Id} = V_i - V_o$

$V_{Id} = \frac{V_o}{K}$, $V_{Id} = 0$

$V_I = V_o$ Gain =

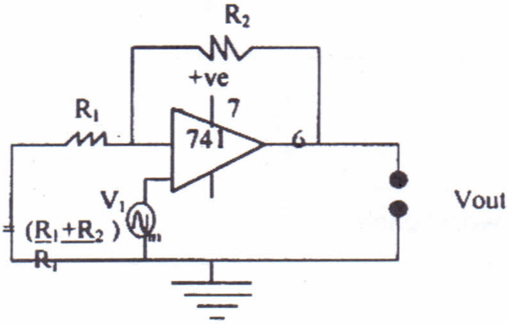
6 (b) INVERTING OP AMP CIRCUIT



$V_{out} = -\frac{R_1}{R_1} V_{in}$

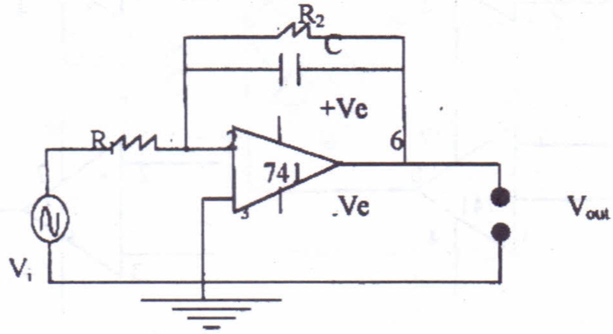
Gain = $\frac{R_2}{R_2}$

6 (c) NON-INVERTING OP AMP CIRCUIT



$V_{out} = \frac{(R_1+R_2)}{R_1} V_{in}$

6 (f) OP AMP INTEGRATOR CIRCUIT

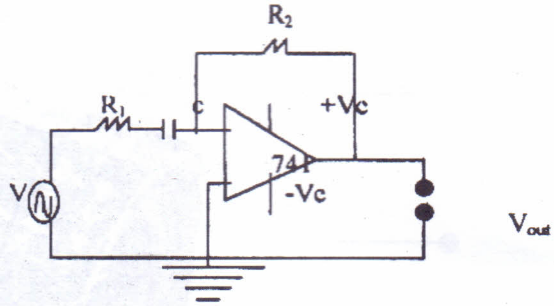


$V_{out} = \frac{-1}{Rc} \int V_{in}\, dt$

$V_{out} = \frac{-1}{Rc} V_{in}\, t$

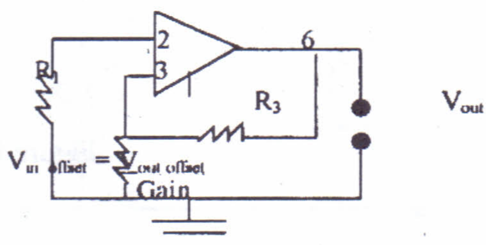
Gain = $\frac{-1}{Rc}$

6 (g) OP AMP DIFFERENTIATOR CIRCUIT



$V_{out} = \frac{-Rc\, \partial V_{in}}{\partial t}$

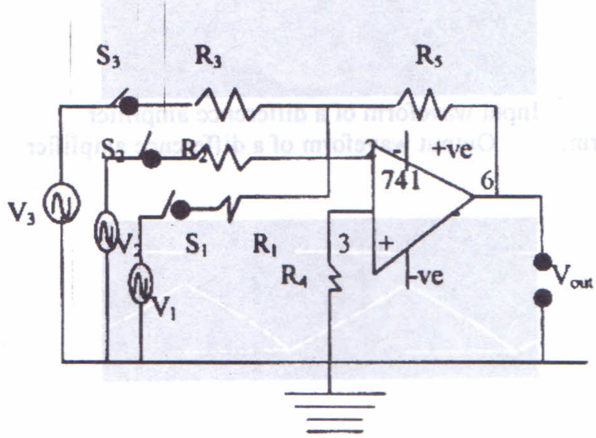
6 (i) OUTPUT OFFSET VOLTAGE MEASUREMENT.



$V_{in\ offset} = \frac{V_{out\ offset}}{Gain}$

$$\text{Gain} = 1 + \frac{R_2}{R_1}$$

6(d) INVERTING OP AMP SUMMER CIRCUIT MEASUREMENT



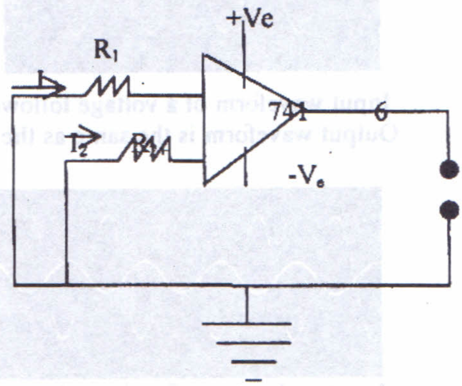
$$V_o = \frac{R_5 V_1}{R_1} + \frac{R_5 V_2}{R_2} + \frac{R_5 V_n}{R_n} \quad R_1 = R_2$$

If $R_1 = R_2 = R_5 = R_n$

$$V_o = \frac{R_5}{R_1}(V_1 + V_2 + \ldots V_n)$$

$$V_o = (V_1 + V_2 + \ldots V_n)$$

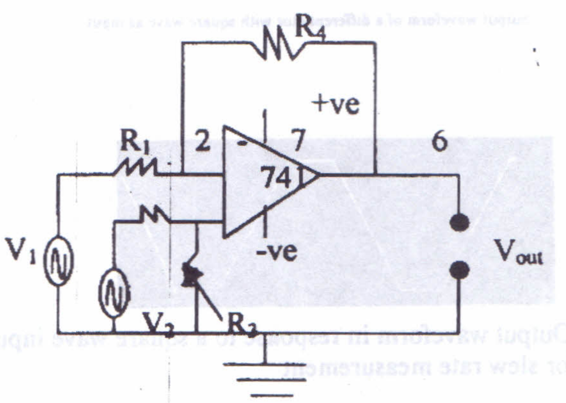
6 (h) CIRCUIT FOR INPUT BIAS CURRENT



$R_1 = R_2$

$$I_B = \frac{I_1 + I_2}{2}$$

6 (e) DIFFERENCE AMPLIFIER CIRCUIT

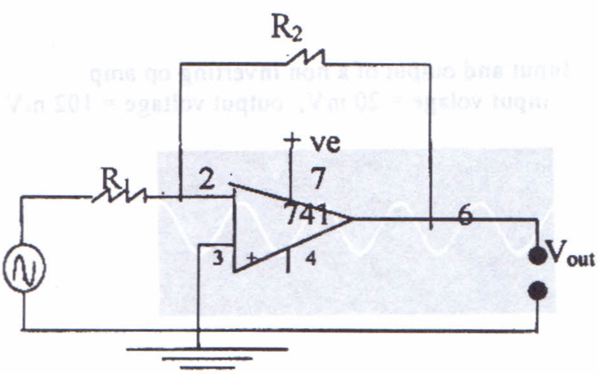


$$\frac{R_4}{R_1}(V_2 - V_1)$$

$$\text{Gain} = \frac{R_4}{R_1}$$

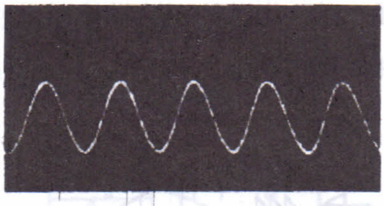
$$\text{Gain} = \frac{-1}{Rc}$$

6 (j) CIRCUIT FOR SLEW RATE MEASUREMENT

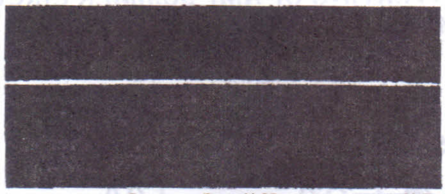


$$\text{Slew rate} = \frac{\Delta V}{\Delta T}$$

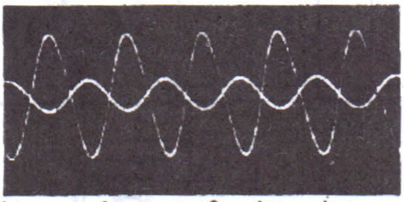
Figure 6: Results for various op amp applications and characteristics.



Input waveform of a voltage follower
Output waveform is the same as the input waveform.



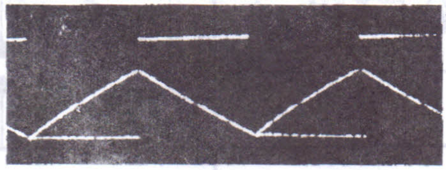
Input waveform of a difference amplifier
Output waveform of a difference amplifier



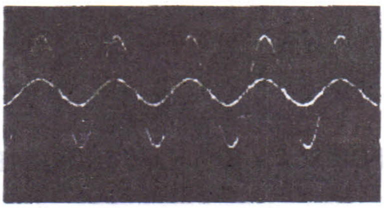
Input and output of an inverting op amp.

INOUT VOLTAGE = 20Mv

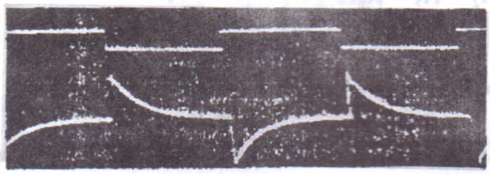
Output voltage = 1oomV



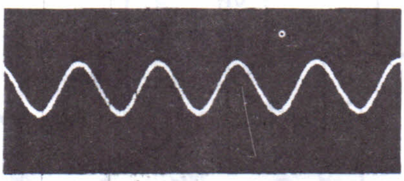
Input square wave produces a triangular waveform at the output of the integrator.



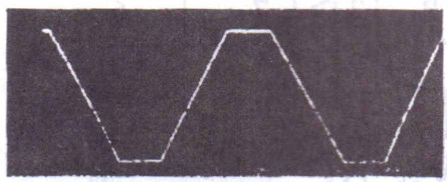
Input and output of a non inverting op amp
input volage = 20 mV, output voltage = 102 mV



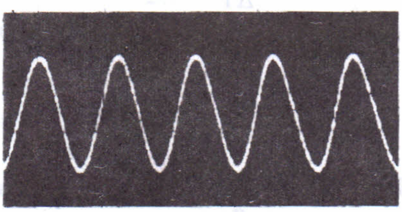
output waveform of a differentiator with square wave as input



Input voltages to summer = 20mV



Output waveform in response to a square wave input for slew rate measurement



Output voltage of summer =60mV