DESIGN OF A SOLAR-POWERED INCUBATOR

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ABSTRACT

The development of an egg into a normal chick is influenced principally by temperature, humidity and incubation period. These requirements are achieved by temperature control of incubation chamber at 37.75 $\pm 0.26^0$C for 22 days, a maximum of 60% relative humidity and turning the eggs every one and a half hours. The paper presents and investigation on the potential of solar energy as power supply system to achieve these objectives for the purpose of efficient cheap and mass production of chicks. The minimum hatchability obtained was 70%.

1.0 INTRODUCTION

In any ordering of basic human needs, food heads the list and lack of it is the most painful form of poverty. Majority of the poor are found geographically in Asia and African continents. It is in these continents that malnutrition occurs more than elsewhere as a result of very low standard of living. In advanced nations, the growing of crops and breeding of animals are strongly supported by a highly diverse industry, research and development of superior breeds, chemicals, equipment, credit and advisory facilities (1).

In contrast, the poor nations lack support and depend much on traditional and inefficient methods of production. Several types of incubators have been designed and constructed. They are powered from energy sources such as coal, kerosine and electricity. Electricity types are most popular because of the nature of electricity supply.

A significant feature of the current agricultural expansion of the developing nations is the demand for increase in quantity and quality of supply of poultry products. Majority of the problems associated with these needs include lack of initial capital and infrastructure. It is on this background that the paper presents an investigation into the use of solar power supply for an incubator.

1.1 PERFORMANCE OF AN INCUBATOR UNDER SOLAR-POWER SUPPLY

In Afica, most of its populace are rural dwellers, living in poor conditions without basic necessities like eleotricity and portable drinking water. About 80% of its active population is engaged in farming, only for subsistence. The reasc ack of capital or basic infrastructure and researc is un-improved traditional methods of farming are expected to feed the larger populace. It is for this r ason that hunger and malnutrition continues to re n despite the Government efforts since independenc e. Several types of incubators have been designed and constructed. They are powered from energy sour es such as kerosine and electricity. Electricity types are most popular because of the nature of the electricity supply.

The objectives of the solar-powered bird incubator is to enable this machine to be used efficiently and cheaply in rural areas as well as urban sectors for small scale production. The system involves the use of solar energy from the sun, converted into electrical voltage and used to charge a pile of batteries for storage and simultaneously drive the incubator directly.

A switching network is incorporated to take solar energy or battery source when the luminous intensity of the solar falls. By this means, the incubator is powered un-interruptedly for the purpose of optimum operation and mass production of birds at reduced cost.

2.1 SYSTEM SPECIFICATIONS

The solar-powered incubator consists of the following components:

(a) Solar energy power supply source
(b) Standby source
(c) Power source switching system

(d) Temperature control system
(e) Egg turning system

The design criteria to meet these specifications are as follows:

(a) Use of solar as the main source of energy supply to run the system.
(b) Application of digital techniques to process and control a desired temperature.
(c) Regulation of temperature at a desired value
(d) Use of LEDS and alarm to indicate the operational state of the machine.

2.2 POWER SUPPLY

The block diagram of the power supply is shown in fig. 1. The photovoltaic modules convert the light energy falling on its surface into a d. c voltage which is used to charge a pile of batteries. The modules consist of bank of solar cells which produce a voltage of 12V at a sensitivity of 1mW/cm^2, and a better charging unit.

The output of the inverter is an alternating voltage at 220V, 60Hz that powers the incubator directly.

3.0 SWITCHING NETWORK

This connects the system to the photovoltaic modules when luminous intensity is sufficient to produce at least 6V or changes over to the battery source. The circuit diagram is shown in figure 2. The switch over time lag is improved by the 6800 μf capacitor.

We have $Q = CV = It$ ...1

This gives a time of:

$$\therefore t = \frac{CV}{I} \quad ...2$$

Considering a design current of 10A and supply voltage of 12V,

$$\text{delay time is } t = \frac{6800 \times 10^{-6} \times 12}{10}$$

$$t = 8.16\text{ms}$$

3.1 AUTOMATIC SHUT-OFF BATTERY CHARGING UNIT

The circuit diagram of this unit is shown in fig. 3. incorporates short circuit protection and current booster.

The supply from the modules charges the batteries cascaded to produce 12V, 10A. The batteries supply the system when the luminous intensity is weak. The batteries are connected as shown in fig. 4.

3.2 OSCILLATOR CIRCUIT

Figure 5 shows the oscillator.

D.C from the batteries is used to drive an astable oscillator at high frequency so that a 120KHz square wave is produced.

3.3 D. C - to - A. C INVERTER

Figure 6 shows the D. C - to - A. C Inverter.

Decade counters, 4017 are used to divide the high frequency down to 60Hz for inversion by a high current step-up transformer.

3.4 A. C - to - D. C CONVERTER

The d.c power supply levels used to run the system are ±12V and +5V regulated.

The circuit used to obtain these voltages is shown in fig 7.

To enable the system run without hitches, the output current is boosted to about 5A

4.0 INCUBATOR

This incubator comprises the temperature control system, egg turning system and a means of displaying the desired set and incubating temperatures. (2).

The aim of this is to maintain the temperature at a desired set value for as long as needed. Feedback digital control system technique is employed for its numerous benefits such as stability, response time and sensitivity. The block diagram is shown in fig. 8.

4.1 INPUT PRESET SWITCHES

Used to set desired temperature in binary (0000 0000_2 to 1111 1111_2). This is shown in fig. 9.

4.2 SENSOR BIASING

Sensor is biased as shown in fig 10 to produce an output signal of 10mV/^{0}C.

4.3 SIGNAL AMPLIFIER

Buffer and differential amplifiers are used to amplify the small signal from the sensor to 5V at desired set temperature. This is shown in fig. 11.

At 37.5°C, the output of amplifier is 5V (digital level), so that its voltage gain, A is calculated from fig. 11 (differential amplifier) as:

$$A_F = \frac{V_{in}}{V_o - V_r} \quad .....3$$

The initial temperature of the incubator was 30°C and the set point was 37.5°C. These corresponds to 0.3V and 0.375V respectively. Substituting these in equation 3 gives:

$$A_f = \frac{5}{0.375 - .30} = 66.67V/V$$

But the gain of the inverting amplifier is:

$$A_F = \frac{R_f}{R_1} \quad .....4$$

$$\text{Thus } R_F = R_1 A_F \quad .....5$$

Choosing $R_1 = 10k\Omega$, then $R_F = 66.7k\Omega$.

Hence, a 100KΩ pot was selected. It was then adjusted to 66.67KΩ and it produced 5V at 37.5°C.

4.4 A/D CONVERTER

The analog-to-digital converter chip ZN 427 is designed to convert the amplified analogue signal to digital word (byte). This circuit is shown in fig. 12.

4.5 ERROR TEMPERATURE DETECTOR

It consists of 2 digital comparators which compare the digital word from the A/D converter with present digital word equivalent to the desired temperature. It issues a decision which either drives ON the heating system or puts it OFF.

4.6 SIGNIFICANT COMPONENTS

Other components of significance are

(a) Current buffer
(b) Heating element control
(c) Fan delayed turn-off operation
(d) Egg turning and timer control
(e) Present/incubating temperature display.

CONCLUSION

The results of the test carried out on the model bird incubator constructed shows the viability of the project. However, limitation of electricity supply in villages, high cost of diesel and frequent power interruptions often discourage the local population from engaging in this sector. These limitations amongst others spur up the investigation of solar energy as an alternative power source.

Meanwhile it has been shown that the raw material solar energy is abundantly available in most parts of sub-Sahara Africa (3). Hence photovoltaic modules shown in the design are employed to convert the radiant solar energy into a significant electric signal which is stored by a battery and simultaneously powers the machine.

It is hoped that with this alternative source, the incubator will be used effectively in rural areas for the purpose of mass produc of birds at cheap cost.

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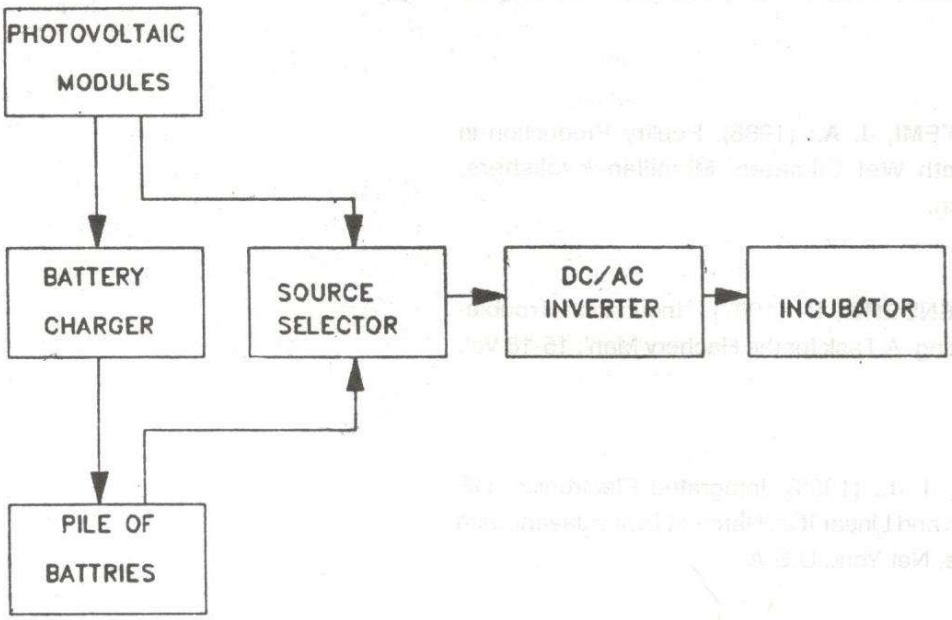


Fig. 1: Block Diagram of Solar Power Supply

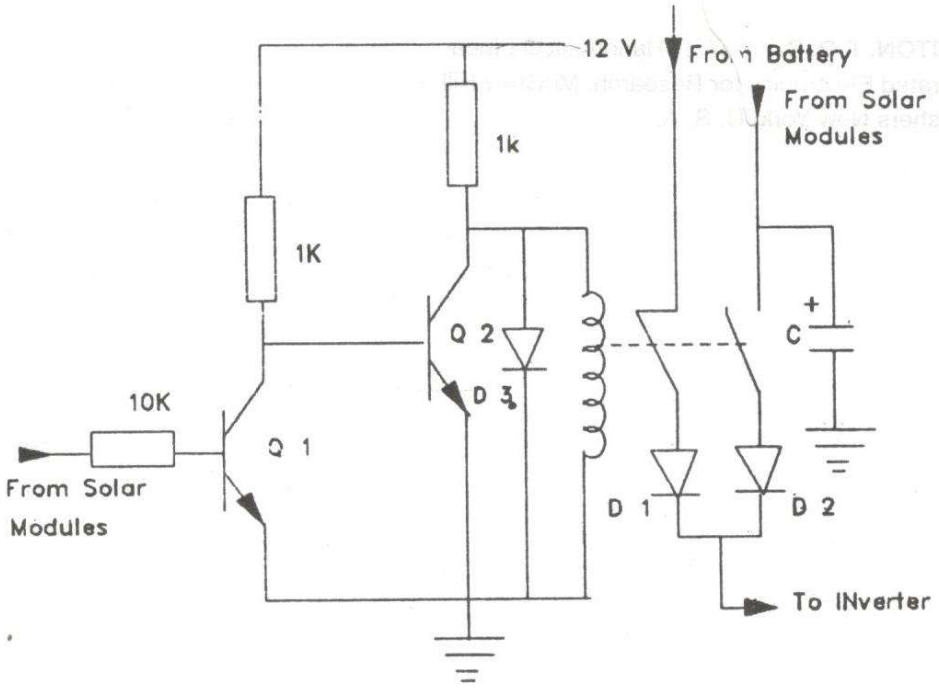


Fig. 2: Source Switching Network

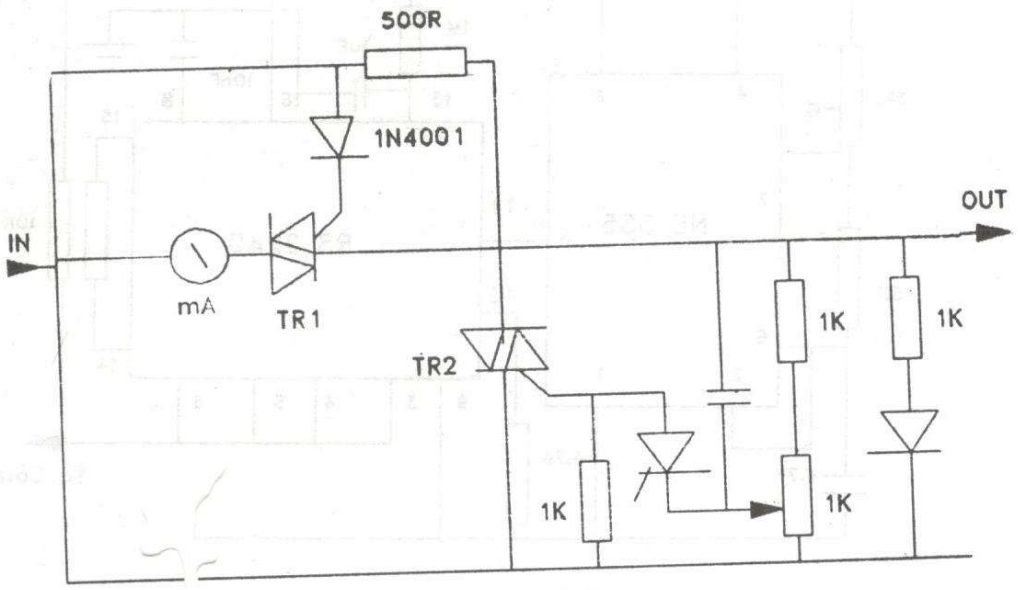


Fig. 3: Automatic Shut-off Battery Charger

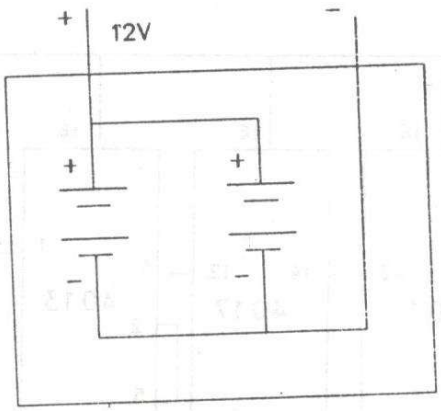


Fig. 4: File of Batterise

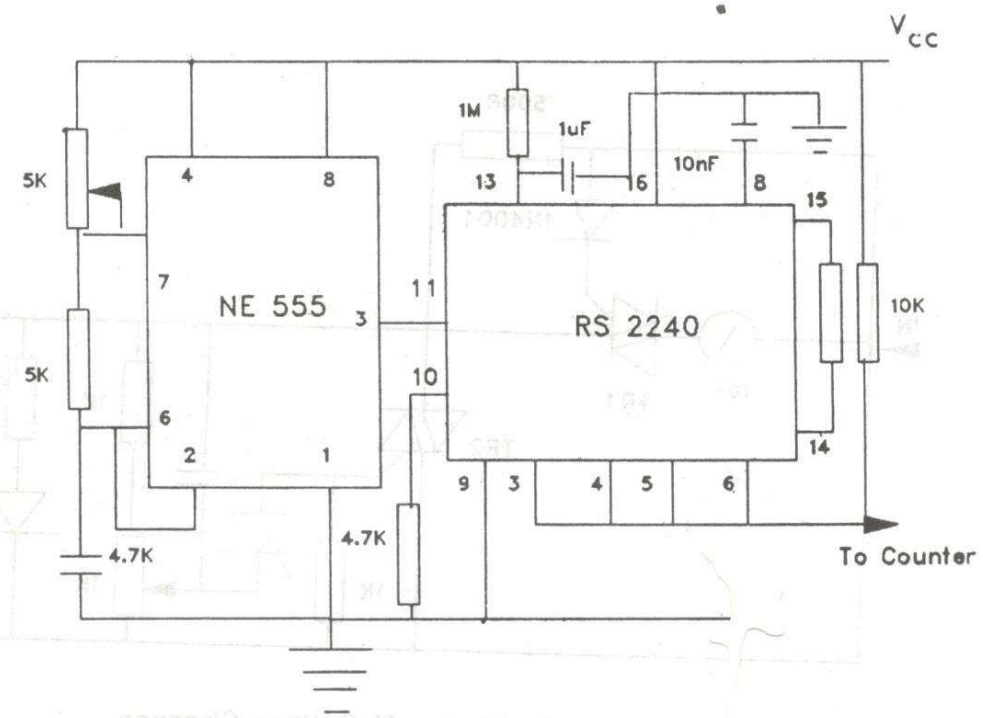


Fig. 5: Clock Generator

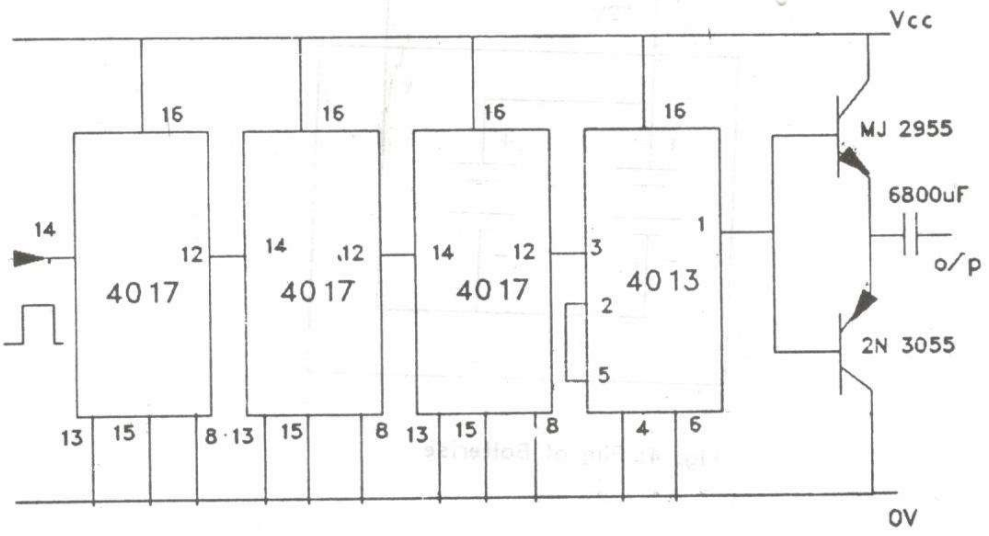


Fig. 6: DC/AC Inverter

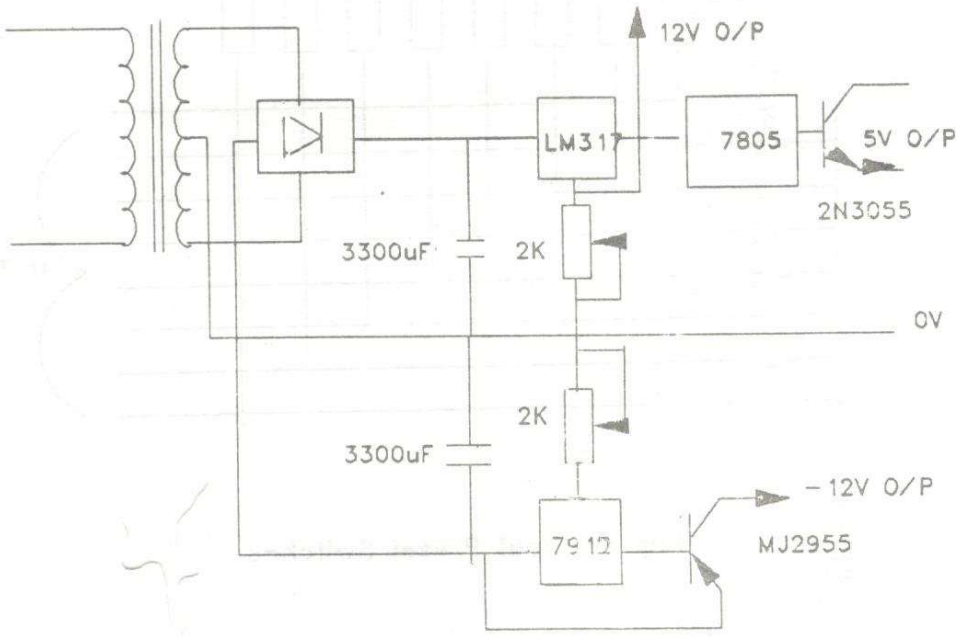


Fig. 7: Dual Rail Regulated Power Supply

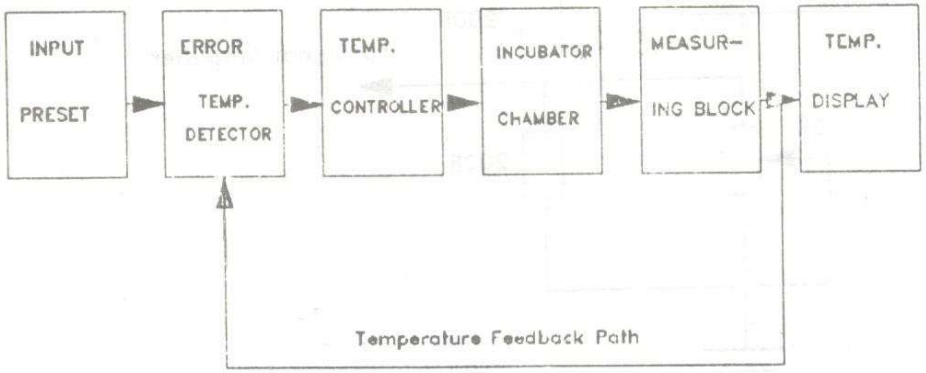


Fig. 8: Block Diagram of temperature Control System

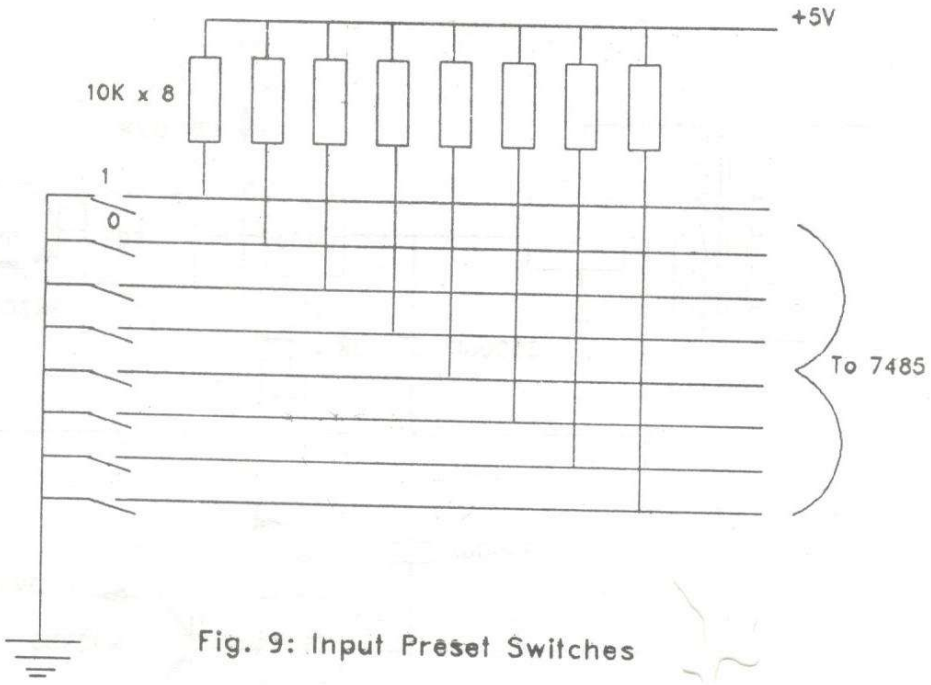


Fig. 9: Input Preset Switches

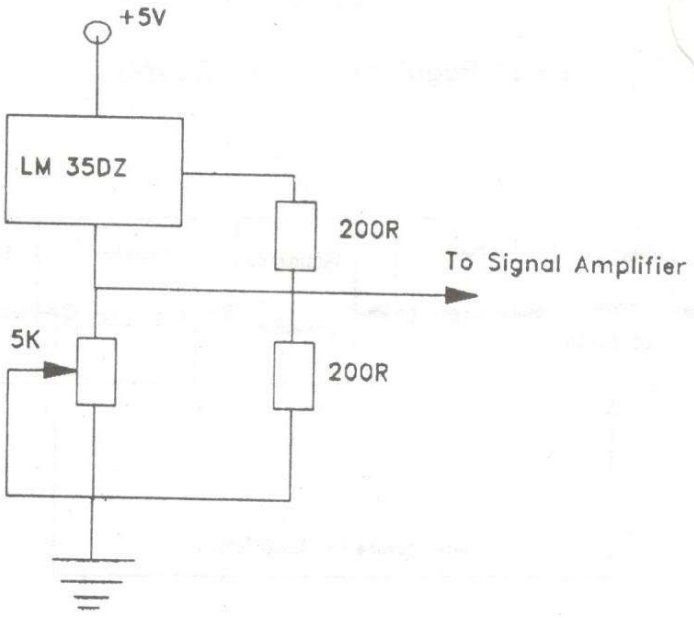


Fig. 10: Sensor Baising

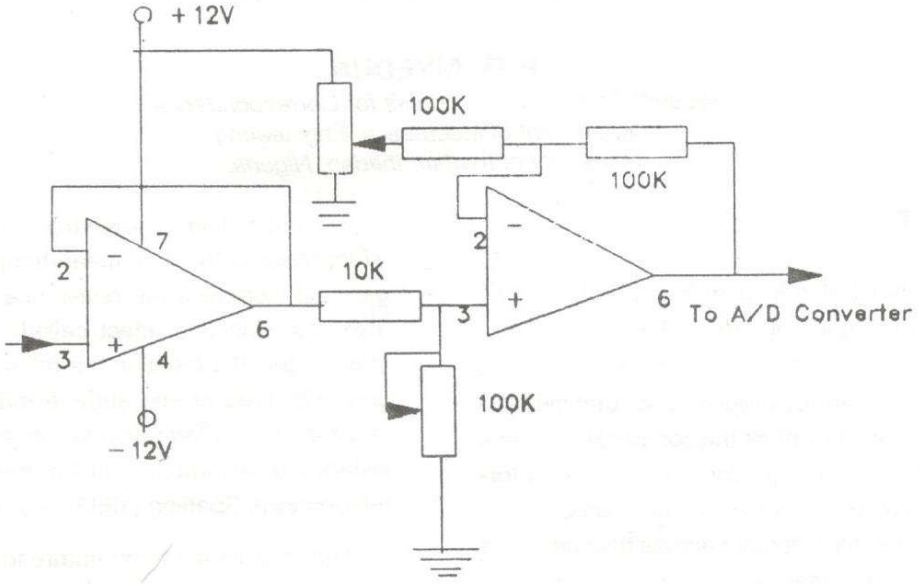


Fig. 11: Signal Amplifier

