DETECTION OF GAS LEAKAGE USING LPG SENSOR

ISO 9001:2000
Certified

Submitted by
KN.ANURADHA
G.GEETHA
P.KAVITHA

Project Report
2002-2003

Under the guidance of

Mr.M.THIAGARAJAN M.E

In partial fulfillment of the requirements for the award of

BACHELOR OF ENGINEERING IN MECHATRONICS ENGINEERING BRANCH OF BHARATHIAR UNIVERSITY

Department of Mechatronics Engineering

Kumaraguru College of Technology

Coimbatore-641006.

DEPARTMENT OF MECHATRONICS ENGINEERING
KUMARAGURU COLLEGE OF TECHNOLOGY
COIMBATORE-641006.

PROJECT REPORT 2002-2003
CERTIFICATE

This is to certify that the report entitled
DETECTION OF GAS LEAKAGE USING LPG SENSOR
has been submitted by

KN.ANURADHA (99MCE01)
G.GEETHA (99MCE06)
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In partial fulfillment of the requirements for the award of the Degree of **BACHELOR OF ENGINEERING** in **Mechatronics Engineering** branch of Bharathiar University, Coimbatore.

17/3/2003

Guide | Head of Department

The certificate was examined by us in the project work viva-voce examination held on ____________ and her university register number is ____________.

Internal Examiner | External Examiner

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HRD/PROJ/2003
-March-2003

TO WHOMSOEVER IT MAY CONCERN

This is to certify that **Ms. KN. ANURADHA,** final year B.E. (Mechatronics) student of Kumaraguru College of Technology – Coimbatore, has undergone project work in our organisation.

The details are:

- Project Title : DETECTION OF GAS LEAKAGE USING LPG SENSOR
- Period of project : November 2002 to March 2003
- Department : Product Development Engineering (Electronics)

During this period her performance, attendance and conduct were **Good.**

We wish her the very best for a bright future.

ANTHONY THIAGARAJAN
DY. MANAGER – HUMAN RESOURCES

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This is to certify that **Ms. G. GEETHA,** final year B.E. (Mechatronics) student of Kumaraguru College of Technology – Coimbatore, has undergone project work in our organisation.

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This is to certify that **Ms. P. KAVITHA,** final year B.E. (Mechatronics) student of Kumaraguru College of Technology – Coimbatore, has undergone project work in our organisation.

The details are:

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- Period of project : November 2002 to March 2003
- Department : Product Development Engineering (Electronics)

During this period her performance, attendance and conduct were **Good.**

We wish her the very best for a bright future

ANTHONY THIAGARAJAN
DY. MANAGER – HUMAN RESOURCES

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We are highly indebted to our Principal, Dr. K.K.Padmanabhan and our beloved HOD, Dr. V.Gunaraj for providing us with excellent facilities to carry out this project.

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We are very much thankful to Mr. S.DhinakaraRajan, General Manager, PDE(Instruments), PRICOL for granting us the project. We are grateful to Mrs. S.Maheswari, PDE(Instruments), PRICOL for understanding and providing us with valuable suggestions to make this project a success.

We owe our sincere gratitude and heart felt thanks to our parents, our friends and all the staff members of Mechatronics Department for their encouraging support for finishing this project successfully in time.

We also thank our classmate VR.Ramesh for helping us to complete this project.

SYNOPSIS

“ Accidents are not caused but they are created ”. An attempt is made to prevent accidents caused by leakage of LPG and to increase safety of human being. A product is developed to ensure safety of inhabitants of houses, industries and automobiles. This product is “LPG Leak Detector” which detects the leakage of gas from cylinders and provides a warning by means of an alarm.

This product is already existing in the market for domestic as well as industrial purpose, but they are expensive and they have different modules for buzzer, sensor and the main electronic circuit. Our objective is to produce a product with less cost and bring all the modules together in a single unit thereby making it compact.

The Gas Sensor is the core of our project. Various sensors were analyzed and an appropriate sensor was selected. The sensor selection is important, because the final product can only be as good as the sensor. A suitable electronic circuit is designed to meet the requirements. The sensor is connected in the circuit , readings are taken and verified using a gas densitometer.

The performance of the product is good. Sufficient tests are carried out to produce a successful product. Our product finds wide scope for domestic use and industrial usage.

CONTENTS

INTRODUCTION

COMPANY PROFILE

Premier Instruments and Controls Limited was established in 1974 for manufacturing automotive products. Since then PRICOL has grown with its high quality and reliable products and service. PRICOL commenced operations in 1975 in the precision engineering field of automotive instruments. In 1991 it entered into a technical collaboration with Nippan Denso Co limited, Japan.

PRICOL has a co-operative office functioning at Coimbatore city. It has several plants within India for better interactions.

PLANT 1 (Periyanaickenpalayam, TamilNadu)

Manufacturing and servicing of dashboard temperature and pressure sensor, fuel level sensor, ventilation control unit and products of defence, electronic and industrial gauges for automotive vehicles primarily for servicing OEM customers.

PLANT 2 (Gurgaon, Harayana)

Manufacturing and servicing of dashboard instruments for automotive vehicles primarily for servicing OEM customers in and around New Delhi.

PLANT 3 (Chinnamathampalayam, TamilNadu)

Manufacturing and servicing of oil pumps for two wheelers and stationary engines, components of two wheelers, auto fuel clocks, valves, gears and disc system.

PLANT 4 (Karamadai, TamilNadu)

An expert oriented unit setup for manufacturing all types of lubricating oil pumps and valves for two wheelers, stationary engines and machined components.

In 1993 it has been awarded the Prestigious ISO-9001 certificate. It is the first company in Indian automobile instrumentation industry to get ISO-9001.

PRODUCT RANGE:

Instruments and accessories such as electronic speedometer, tachometer, mechanical speedometers, quartz hours counters, fuel gauges and sensors, temperature gauges and sensors, pressure gauges and sensors and panel instruments.

MARKET LEADERSHIP:

Among the eight two wheeler instrument manufacturers in India, PRICOL leads with 55% market in OE and after market.

MAJOR CUSTOMERS:

- Maruthi Udyog Auto Limited
- TVS Suzuki
- Hero Honda
- Kinetic Honda
- Telco
- Mahindra and Mahindra

PRICOL PRODUCTS:

- Odometers
- Temperature, pressure and fuel gauges
- Hub devices
- Speedometer cables

ABOUT THE DEPARTMENT

PRODUCT DEVELOPMENT AND ENGINEERING (INSTRUMENTS)

The Product Development and Engineering (Instruments) department provides strong support base towards new product development, improvement in the existing products, quality enhancement and technology upgradation to suit the products to changing needs and preferences of customers.

A cross-functional team is formed to induct quality into the product. A full-fledged sample making cell for fabricating the parts, tools and prototype samples to lessen the design-to-develop cycle time.

The designs are verified and validated by intensive application of various techniques like FMEA, GD & T, DFA, DFM, DOE etc. Continuous cost-effective programs are carried out through value analysis and value engineering techniques. Sustained and continuous efforts are on for increasing productivity.

ABOUT LIQUIFIED PETROLEUM GAS

LPG stands for liquified petroleum gas. It is called so because these gases can be liquified at normal temperature by the application of moderate pressure increases or at normal pressure by application of cooling using refrigeration i.e, LPG has a special property of becoming liquid at atmospheric temperature if moderately compressed and reverting to gases when pressure is sufficiently reduced. LPG consists of propane(C_3H_8), n-butane(C_4H_{10}), iso-butane, butylenes and with little or no propylene and ethane. More than 90% of LPG contains propane and butane. Propane vaporizes at temperatures above - 42°C and butane at 0°C . One litre of liquid propane will vaporize to about 270 litres of vapour. The expansion ratio is 270:1 at atmospheric pressure. The gas inside the cylinder is in two forms: liquid and vapour. Cylinders are normally filled with 80 to 85% liquid leaving a 15 to 20% vapour space for expansion due to increase in temperature. For LPG the lower explosion limit (LEL) is 1.8% and upper explosion limit (UEL) is 9.6% in air.

COMPOSITION OF LPG:

Propane - 40%

n-butane - 30%

Iso-butane - 30%

Butane and propane are used in combination because they are alkanes and unreactive . Their low level of reactivity increases safety.

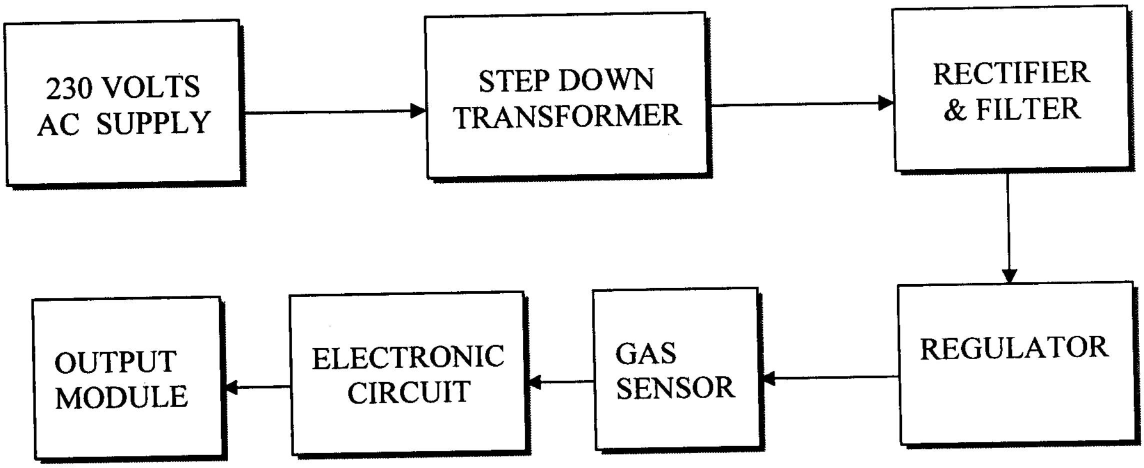
PROPERTIES OF LPG:

- Colourless
- Odourless
- Flammable
- Heavier than air
- Approximately half the weight of water
- Non-toxic but can cause asphyxiation

APPLICATIONS:

LPG is used as fuel for domestic, industrial, horticulture, agriculture, cooking, heating and drying processes. LPG can be used as an automotive fuel or as a propellant for aerosols.

GENERALISED BLOCK DIAGRAM



There are four modules in this block diagram. They are:

1) Power Supply module
2) Sensing Unit
3) Electronic Circuit
4) Output module

POWER SUPPLY MODULE:

230 Volts AC supply is input into a step down transformer, the output of which is an AC signal. This AC is converted into DC by using a rectifier. The rectified DC voltage is fed to a regulator from where constant regulated voltage is obtained. The output from the regulator (7805) can be directly given as an input to the sensor.

SENSING UNIT:

The regulated DC voltage is given as an input to the gas sensor. As the concentration of gas is increased in the sensor environment, the sensor detects the leakage and provides output voltage in volts.

ELECTRONIC CIRCUIT:

Electronic circuit is designed using operational amplifier LM324. It is designed as comparator. Reference voltages are set to the inverting terminal of the three comparators. Sensor output is given to the non-inverting terminal of comparator. The sensor output is compared with the reference voltage in order to provide LOW, MEDIUM and HIGH levels of visual indication (using LED's).

OUTPUT MODULE:

Low level indication - LED 1 (Green)

Medium level indication - LED 2 (Amber)

High level indication - LED 3 (Red)with an audible alarm signal

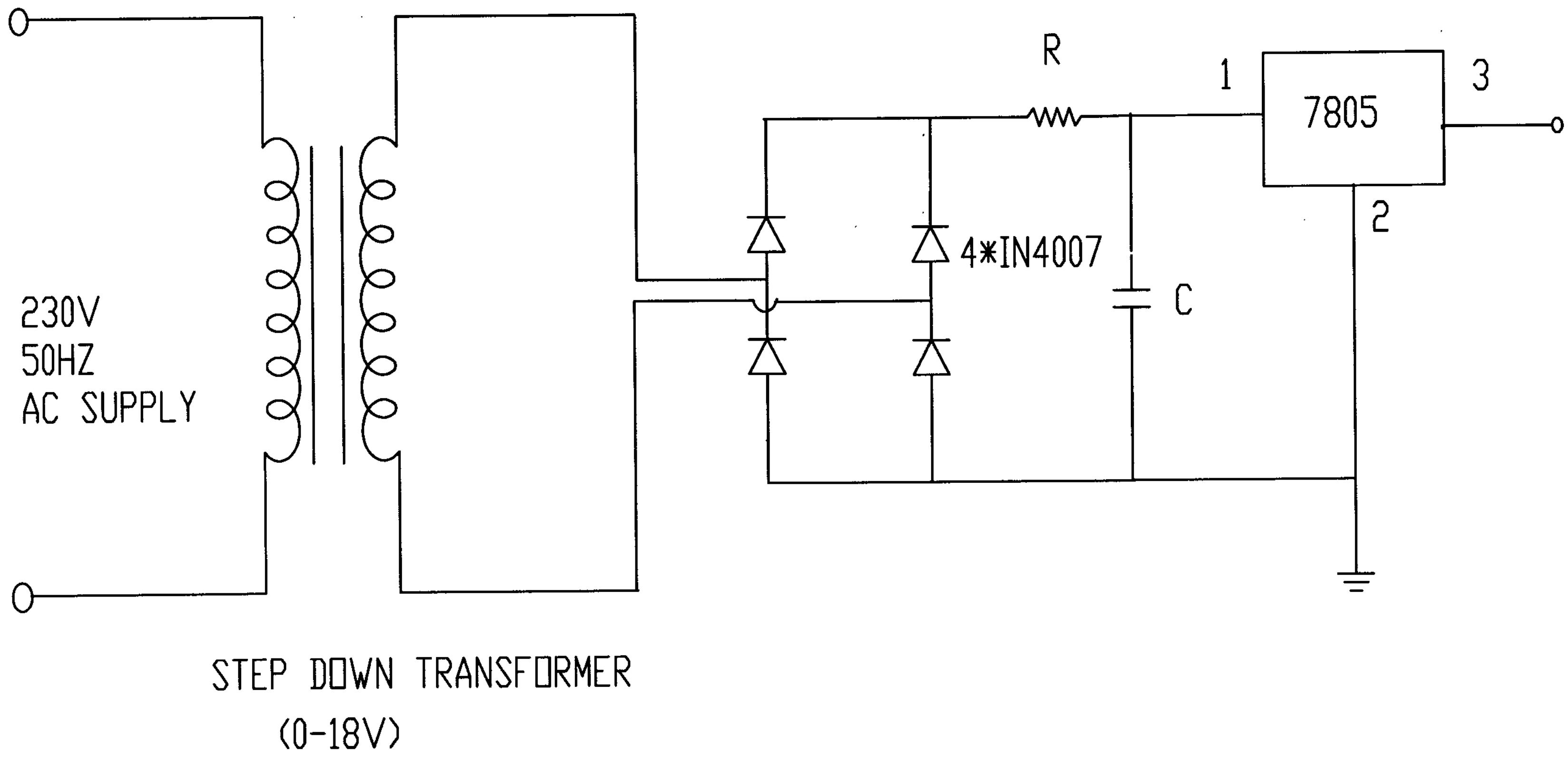
POWER SUPPLY MODULE

TRANSFORMER:

230 Volts AC supply is fed to a step down transformer to reduce it to a safer voltage. Transformer works on the principle of magnetic induction. Transformer consists of two copper coils called primary and secondary wound around an iron core. When AC current is passed through primary coil, it creates changing voltage in primary which induces a changing AC voltage in secondary coil. The ratio of turns in the primary and secondary coils determines the ratio of input and output AC voltages. The transformer used is (9-0-9)Volts.

RECTIFIER:

The output from transformer is still a reduced AC voltage. This alternating voltage is converted to direct voltage by using a full wave bridge rectifier. It uses four diodes. During the positive half cycle, two diodes conduct and one half of the power is obtained at the output. During the negative half cycle, next two diodes conduct and the other half of the power is obtained. Because of conduction of two diodes in each cycle, a voltage drop of 1.4Volts occurs. Since the output is still a changing voltage it must be smoothened. To suppress these ripples, a smoothing capacitor is used. If the value of capacitor is large enough, it will store charge as the voltage rises and give up the charge as the voltage falls. Thus a steadier output voltage can be obtained.



POWER SUPPLY MODULE

REGULATOR:

A regulator is used to provide a constant voltage at the output (without any fluctuations). A 7805 positive voltage regulator having three terminals is used in this circuit. Here 05 represents the output voltage. 7805 positive regulator allows load current upto 1Amp if adequate heat sinking is provided.

Eventhough 78L05 consumes less power compared to 7805, its maximum load current is only 100mA but the our circuit requires 200mA. So, 7805 positive voltage regulator is preferred. This 5V DC supply is given to the sensor to energise it and to the voltage divider network.

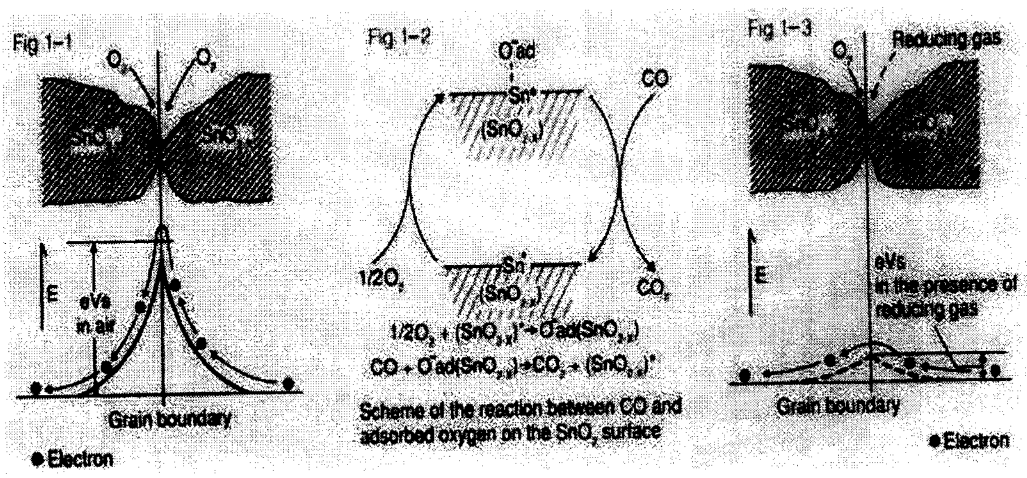
GAS SENSORS

There are two types of Gas sensors:

1. Semi-conductor Gas Sensor
   - Nature Gas Sensor
   - LPG Sensor
   - Air Pollution Sensor
2. Catalytic Gas Sensor.

PRINCIPLE OF OPERATION OF SEMI-CONDUCTOR GAS SENSOR:

A Semi-conductor sensor consists of a semi conducting material applied to a non-conducting substrate between two electrodes. Semi conducting materials include iron oxide, tin oxide and zinc oxide.



When sensor is heated to a high temperature, e.g.. 400°C, without the presence of oxygen, free electrons flow easily through the grain boundaries of the tin dioxide (SnO2-X) particles. In clear air, oxygen, which traps free electrons by its electron affinity, is adsorbed on to the tin dioxide particle surface forming a potential barrier in the grain boundaries. This potential barrier (eVs in air) restrict the flow of electrons, causing electric resistance to increase (Fig.1-1).

When sensor is exposed to an atmosphere containing reducing gases, Eg : combustible gases, CO, etc.., the tin oxide surface adsorbs the gas molecules and causes oxidation as shown in (Fig. 1-2). This lowers the potential barrier, allowing electrons to flow more easily, thereby reducing the electrical resistance (Fig. 1-3). Reaction between gases and surface oxygen will vary depending upon the sensor element's temperature and the activity of sensor materials.

PRINCIPLE OF OPERATION OF CATALYTIC SENSOR:

Catalytic type gas sensors have a sensing element as shown in figure. When a combustible gas contacts the surface of the element, the gas is oxidized by the action of catalyst on the metal surface, and the combustion heat heats up the core platinum filament. Since platinum's electric resistance is directly proportional to its temperature, Catalytic type sensors can not only detect the presence of a gas, but also measure its concentration. Catalysts used are Noble Metals.

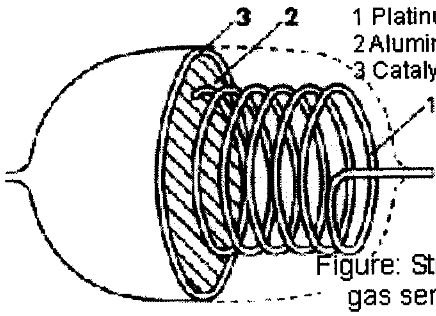


Figure: Structure of gas sensing element

Features:

- Linear outputs in range of 0 – 100% LEL
- Very fast response.
- Hardly affected by ambient temperature and humidity
- Excellent long-term stability
- Excellent reproducibility.

COMPARISON TABLE

Item	Catalytic type	Semiconductor type
Principle of detection	Variation in temperature due to contact oxidation as variation of heater resistance	Variation in electricconductivity of n-type semiconductor due to chemical absorption
Reliability	Very good	Good
Gas selectivity	Good(for smoke) Bad(for combustible)	Good
Response time	Very fast (4 – 10 sec)	Fast (5 – 20sec)
Stability	Very good	Good
Temperature independency	Good	Bad
Humidity independency	Good	Bad
Simplicity	Very simple	Very simple
Cost	Very economical	Most economical
Measuring range	Upto LEL	Upto 10000ppm
Maintenance	Hardly required	Hardly required
Initial stabilization	Very short(1min)	Long (2 hours)

From the above table, it is evident that the accuracy and reliability of semiconductor gas sensor is inferior to Catalytic gas sensor. When detecting the environment of combustible gases, CO etc at a lower concentration, the semiconductor gas sensor has a obvious superiority to the catalytic ones.

SENSOR SELECTION

Since semiconductor sensors provides quick response and high stability when compared to catalytic gas sensor, we started testing semiconductor sensors.

The semiconductor sensors tested are:

HS 131	(Nature gas sensor)
HS 133	(LP gas sensor)
HS 135	(Air pollution sensor)

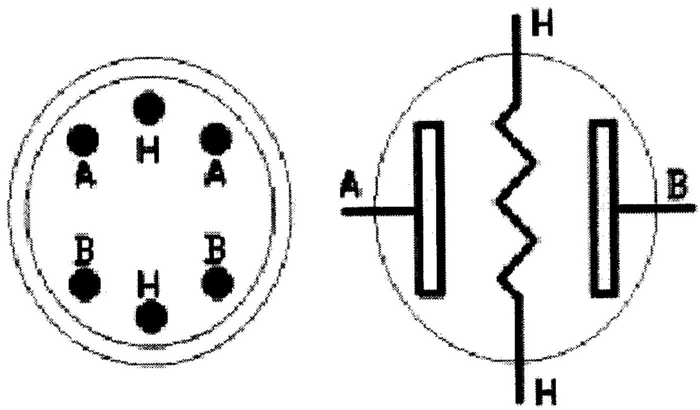
Features of semiconductor sensors:

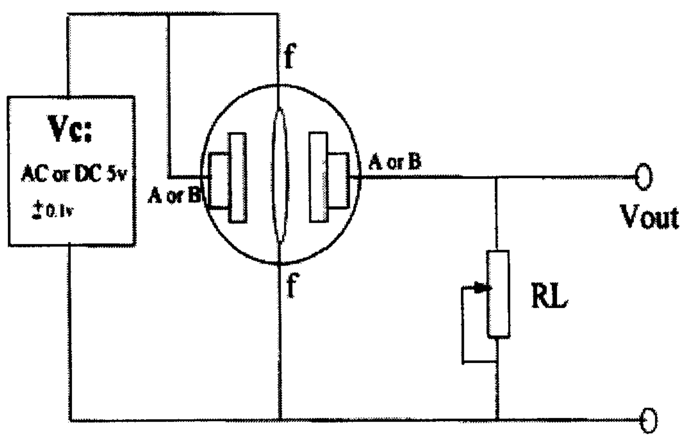
- ➢ High sensitivity in low concentration
- ➢ Fast response
- ➢ Simple and low cost of drive circuit
- ➢ Large output signal without amplifier
- ➢ Stable and long life

Applications:

- ✓ Gas leak detection for restaurants, kitchens, domestic and industry.
- ✓ Air quality control for buildings and offices.
- ✓ Gas detection systems for commercial buildings, Industrial plants.
- ✓ Iso-butane, propane, LPG, methane and alcohol.

Sensor Configuration:



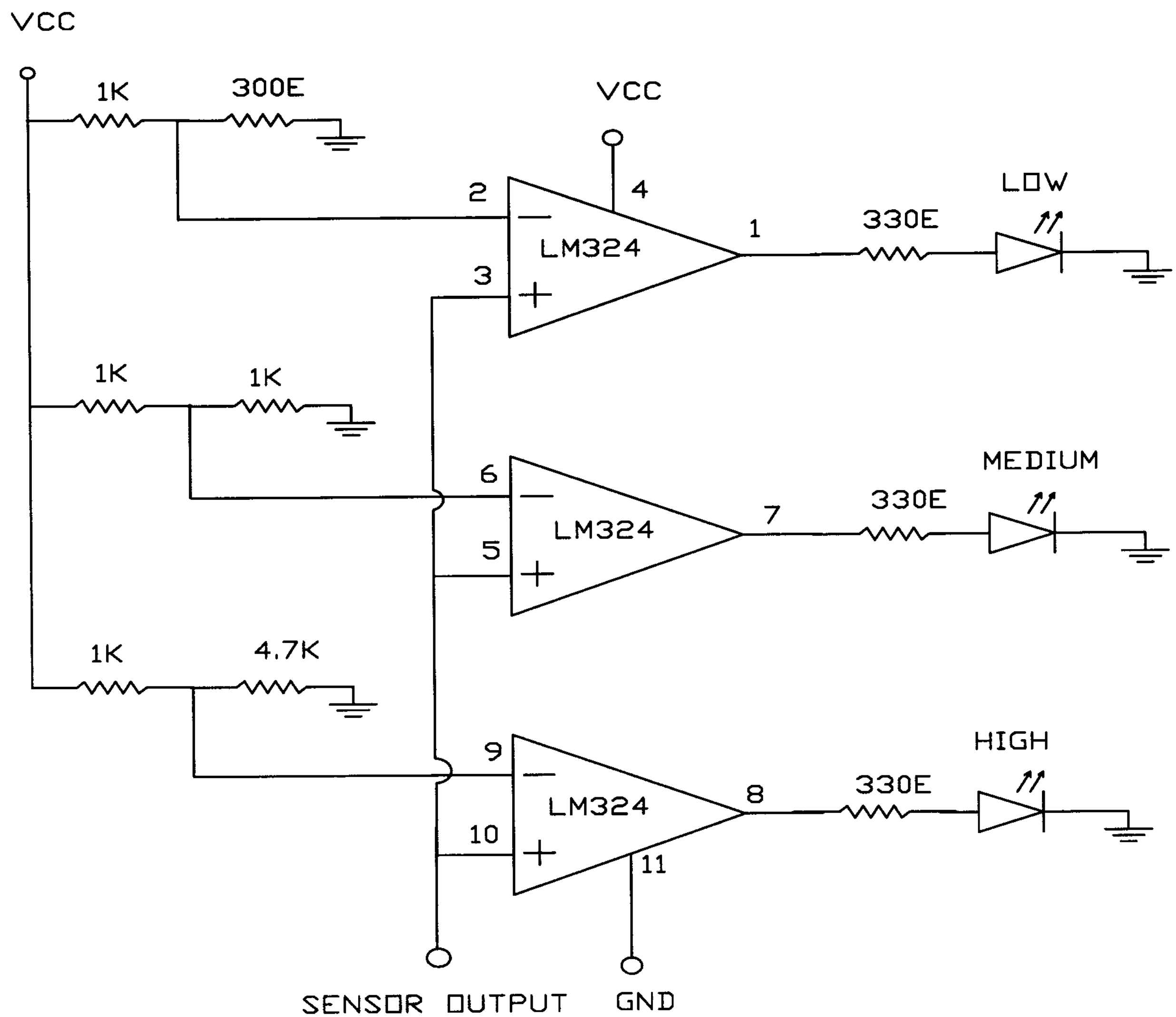


For all the three sensors an input supply of Vin = 5V+/- 0.1V is provided. The same voltage is supplied to one end of heating coil. Other end of heating coil is grounded. Load resistance RL = 5Kohms is connected across the output terminal of the sensor. This load resistance can be varied from 5K – 20K in order to increase the stability. When the sensor is used for the first time, it must be preheated for a minimum of 24 hours.

As per the details given by the manufacturer, the output voltage of the LPG sensor corresponding to various gas concentrations are shown below.

Concentration of gas (ppm)	Output voltage (Volts)
In air	0.25
1000	1.5
2000	2.3
3000	2.9
4000	3.3
5000	3.6
6000	3.9
7000	4.1

In order to provide three levels of visual indications, we have selected three datas from the above table. Since the LEL of LPG is 1.9% or 19000ppm, the third level should be less than 19000ppm. The reference voltage to the comparator are set as follows.



BASIC CIRCUIT

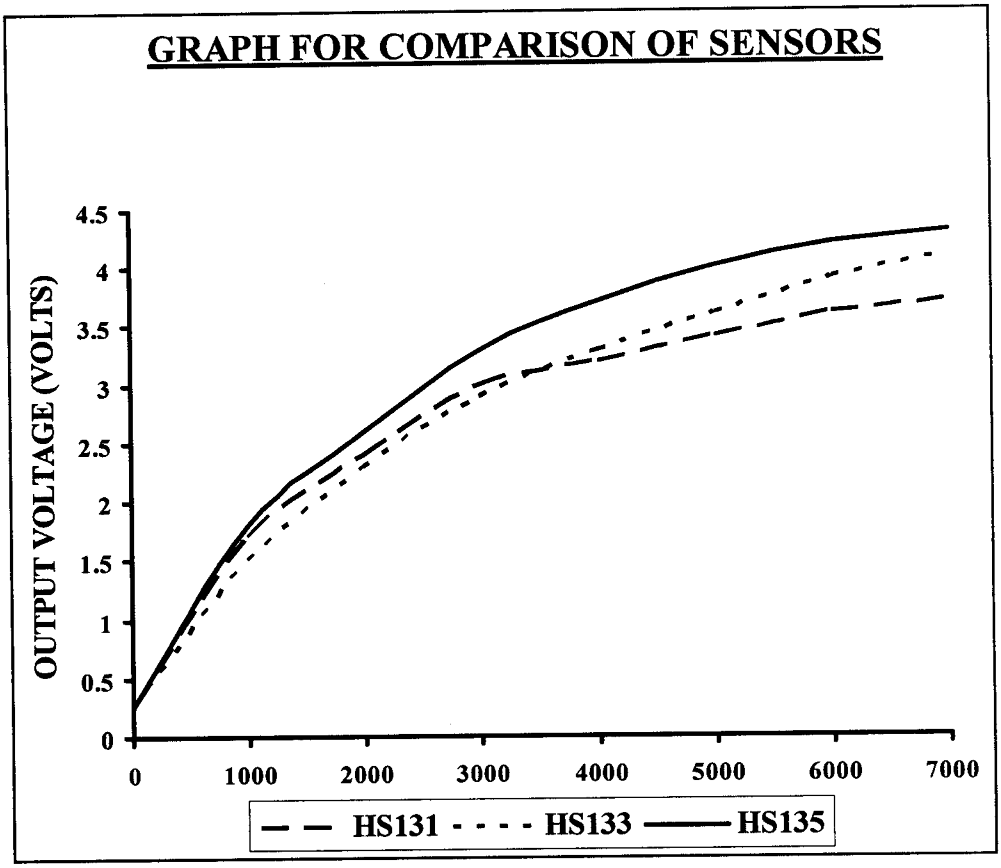
Three reference voltages are set to three comparators using voltage divider network. When the concentration of gas in

Concentration of gas (in ppm)	R1 value (Ohms)	R2 value (Ohms)	Output voltage (Volts)
500	1K	300	1.09
2500	1K	1K	2.5
7000	1K	4.7K	4.1

sensor environment increases the output voltage increases and LED 1 starts glowing when the first preset level is reached showing a LOW level leakage. As soon as the second preset level is reached, LED 2 starts glowing providing MEDIUM level of leakage. LED 3 glows when the third preset level is reached indicating a HIGH level leakage. Readings are taken for different gas concentrations. The readings are tabulated as shown.

Concentration of gas (PPM)	Output Voltage HS 131(Volts)	Output Voltage HS 133(Volts)	Output Voltage HS 135(Volts)
In air	0.25	0.25	0.25
1000	1.7	1.5	1.8
2000	2.4	2.3	2.6
3000	3.0	2.9	3.3
4000	3.2	3.3	3.7
5000	3.4	3.6	4.0
6000	3.6	3.9	4.2
7000	3.7	4.1	4.3

From the graph we infer that HS 135 is more sensitive to iso-butane and alcohol. But HS133 is best suited for domestic purpose whereas HS 135 can be used in automobiles. At present we are developing this product for domestic purpose. So, HS 133 is selected.



Features:

- Output current in excess of 1A.
- No external components required.
- Internal thermal overload protection.
- Internal short circuit current limiting.

DESIGN EVOLUTION PHASE

1. Design using LM324, AND gate and NOT gate
2. Design using LM324 and NAND gate
3. Design using LM324 and EX-OR gate
4. Design using LM324

SETTING THE REFERENCE VOLTAGE:

Reference voltages were set to three comparators using voltage divider network. The values for the voltage divider network were calculated as follows: Formula used to calculate value of resistor in voltage divider network is

Vout = [R2 / (R1+R2)] *Vin

Vin = 5volts. Assuming R1 = 1Kohm, Vout = 1.1volts(500ppm) as per manufacturers data, R2 has to be calculated.

1.1V = = [R2 / (1K+R2)]*5V

R2 = 282 Ohms

We have used 300 Ohms in our circuit because the nearest standard value available is 300 Ohms. Now R1 = 1K, R2 = 300 Ohms, Vin = 5V. For these values, the output voltage is

Vout = [300E / (1K+300E)]*5V

Vout = 1.154 Volts

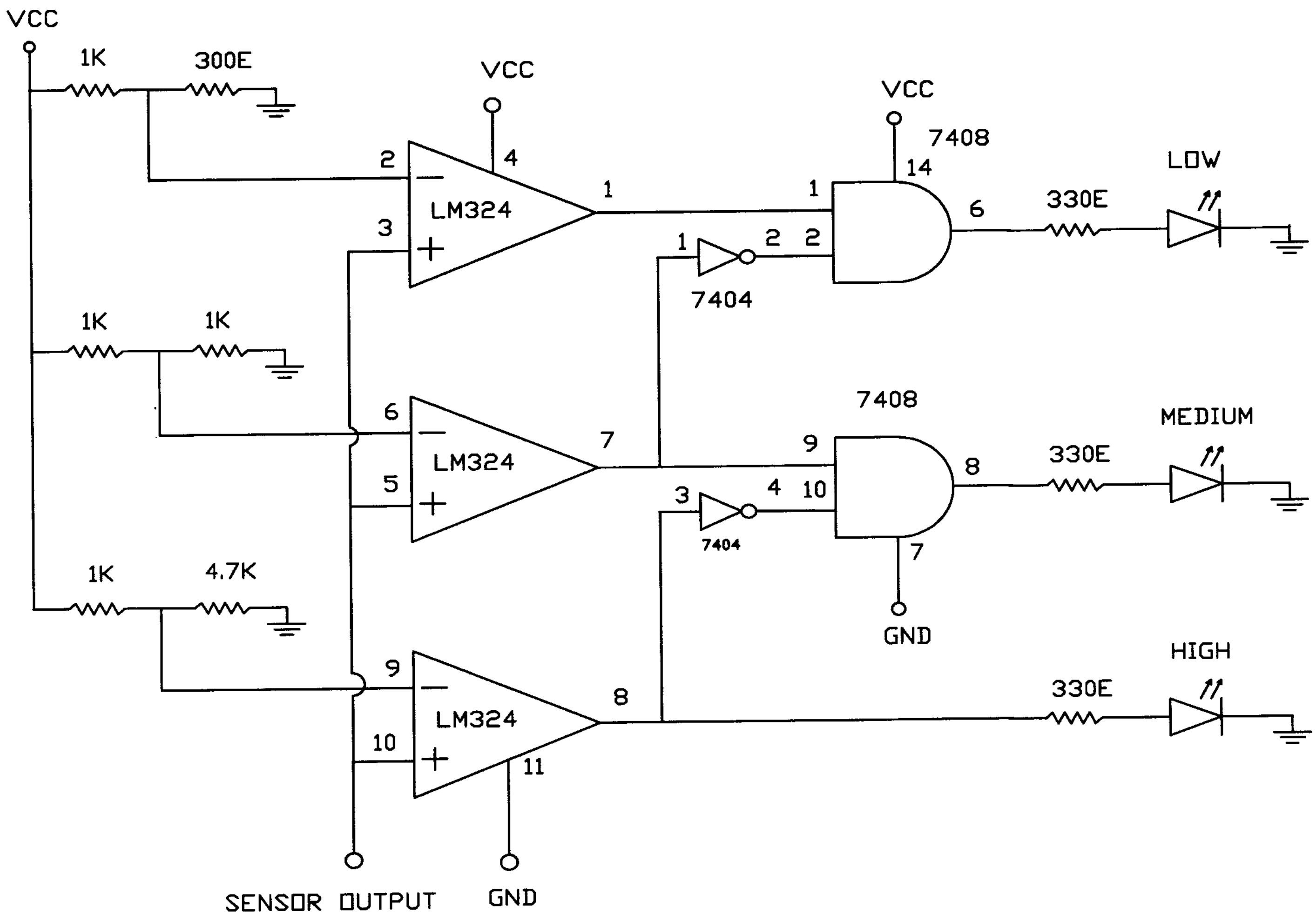
The resistance values used in the voltage divider network for the three reference voltages are tabulated.

Concentration of gas (In ppm)	R1 Ohms	R2 Ohms	Output Voltage (In volts)
500	1K	300	1.15 V
2500	1K	1K	2.5 V
7000	1K	4.7K	4.1 V

1. Design using LM324, AND gate and NOT gate:

Assuming that 5V is given as input to the circuit. Voltage divider networks, supply pins of the gates and LM324 were provided with this input. Reference voltages were set to the pin numbers 2,6,9 of LM324. Sensor output is connected to the pins 3,5,10 of LM324.

Priority encoder consists of AND gate and NOT gate. When the concentration of gas near the sensor environment increases, the voltage at the pins 3,5 and 10 of LM324 simultaneously increase. Just when the voltage at pin 3 exceeds the voltage at pin 2, the output of the first comparator will be high. This voltage is fed to the first pin of AND gate. At this time the output at the pins 7 and 8 of LM324 will be low. If the output of second comparator is directly input to the 2^{nd} pin of AND gate, LOW level indication will not be provided. So, in order to provide the LOW level indication, the low output voltage of second comparator is inverted and input to the AND gate. Now, both the inputs to the AND gate are high and hence the output will be high. This allows the LED1 to glow providing LOW level indication.



CIRCUIT DIAGRAM USING LM324, AND and NOT gate

The MEDIUM level indication will be provided when the leakage increases or just reaches the second preset level of second comparator. When the output of the second comparator is high.

1) Now the second input to the AND gate will be low, so the LED1 will be put off.

2) In order to provide MEDIUM level indication using LED2, the output of third comparator will be low, this can be made high by using an inverter which is fed to the 6th pin of AND gate, also the output from 7th pin of LM324 is input to the 5th pin of AND gate. Now, both the inputs to the AND gate are high and hence the output will also be high. LED2 glows providing MEDIUM level indication.

The HIGH level indication is provided by LED3 which is directly connected to the 8th pin of LM324. Once the third preset level is reached, the HIGH level LED will glow whereas

1) Now the input to the 6th pin of AND gate will be low because of which LED2 will be put off.

2) Once the third preset level is reached, the LED3 will glow providing HIGH level indication.

The circuit works as per requirements but the disadvantage in this circuit is:

a. Cost of overall circuit is high.

b. Number of components increase circuit complexity.

The modified design is constructed using NAND gate which reduces the cost of overall circuit.

INPUT (A)	INPUT (B)	OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

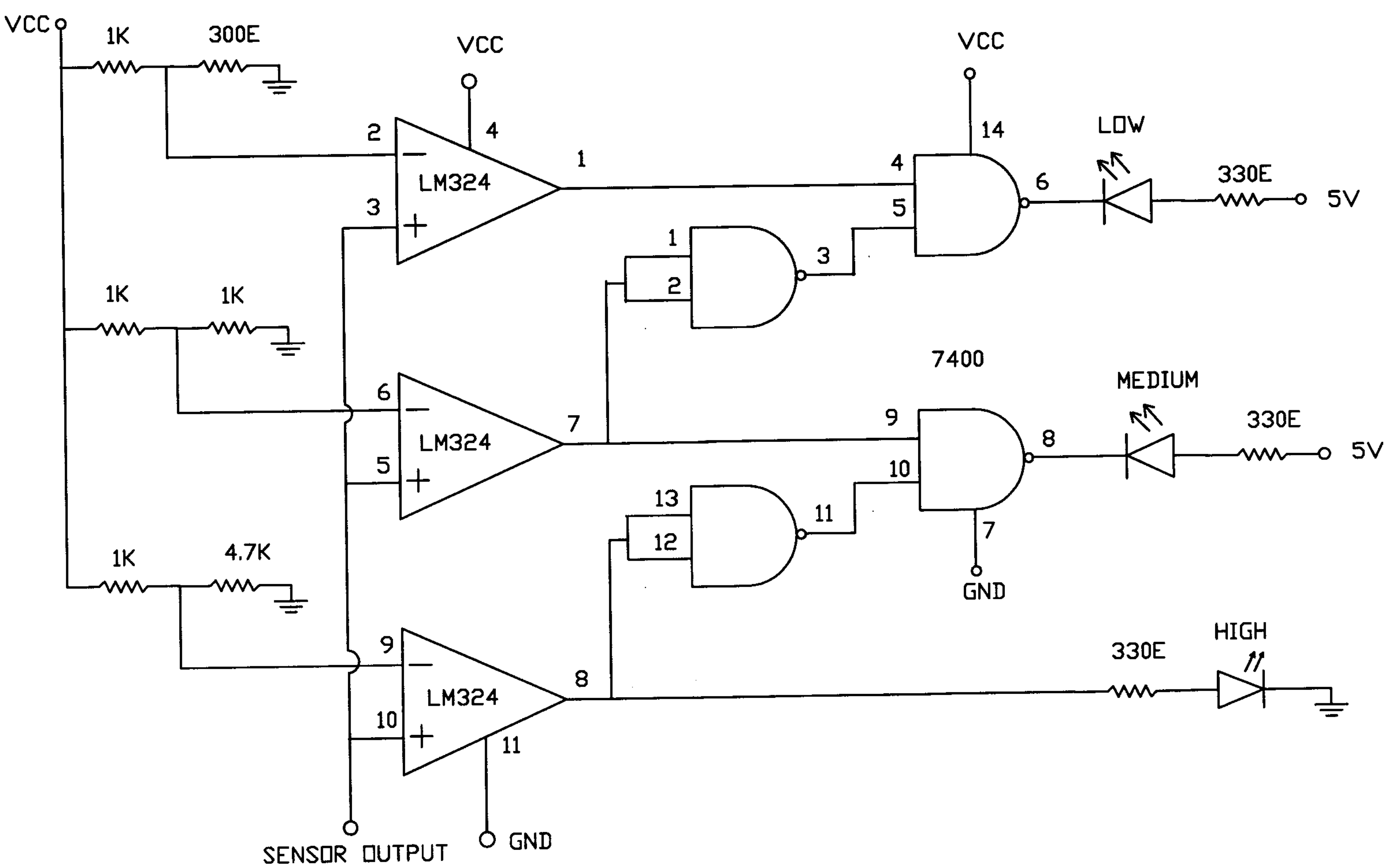
TRUTH TABLE FOR AND GATE (IC7408)

INPUT(A)	OUTPUT
0	1
1	0

TRUTH TABLE OF NOT GATE (IC7404)

2. Design using LM324 and NAND gate:

Similar to the previous circuit , three preset levels are set in order to provide LOW, MEDIUM and HIGH levels of leakage. All the four gates of IC 7400 are used. Reference voltages are same for both the circuits. When the concentration of gas increased near the sensor environment, output voltage of sensor increases. Once it reaches the first preset level, the output at pin1 becomes high which is directly input to the pin1 of IC 7400. Here two NAND gates are configured as Inverters. The input pin of NAND gates are shorted to provide inverted output. After this, the operation of the circuit is more or less same. The only difference here is the LED will be put off



DESIGN USING LM324 and NAND GATE

when the second LED glows. For LOW and MEDIUM levels, the cathode of LED's are connected to the output of NAND gate.

INPUT (A)	INPUT (B)	OUTPUT
0	0	1
0	1	0
1	0	0
1	1	0

TRUTH TABLE OF NAND GATE (IC7400)

The major disadvantage in this circuit is:

1) A time delay of 1 or 2 seconds occurs when switching from one level to another.

2) Number of connections increase circuit complexity.

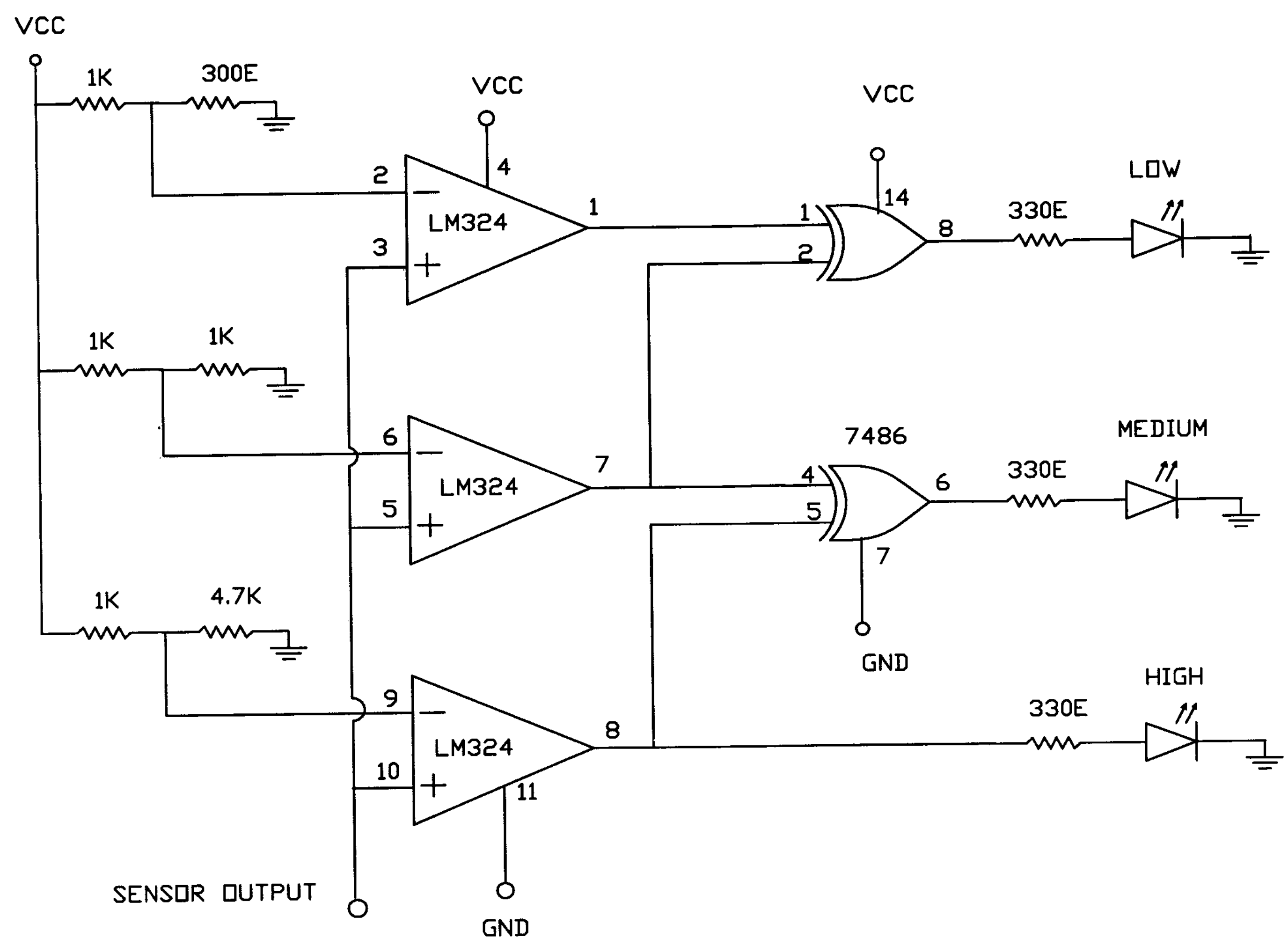
In order to overcome the circuit complexity and to eliminate time delay between switching, the design is modified further using EX-OR gate with number IC 7486.

3. Design using LM324 and EX-OR gate:

Inorder to overcome the circuit complexity and to eliminate time delay between switching, design is modified further by using EX-OR gate. Only two gates of IC 7486 are used in this circuit. The operation is similar to the previous one. Here the complexity of the circuit is reduced only by using two gates. The truth table of EX-OR gate is shown below. The output of EX-OR gate will be high only when any one of its input is high.

INPUT (A)	INPUT (B)	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	0

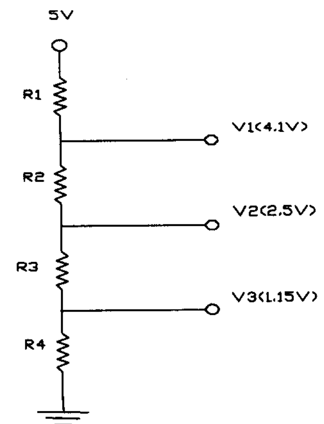
TRUTH TABLE OF EX-OR GATE (IC7486)



DESIGN USING LM324 and EX-OR GATE

4. Design using LM 324:

In order to reduce the number of resistors a series voltage divider network is constructed. To set three reference levels, four resistors are used.



SERIES VOLTAGE DIVIDER NETWORK

The formula used to calculate the resistance value for R1 is given by

$$\mathbf{Vref} = \frac{(R2 + R3 + R4) * Vin}{R1 + R2 + R3 + R4}$$

Initally assume **R1 = 100Ω,**

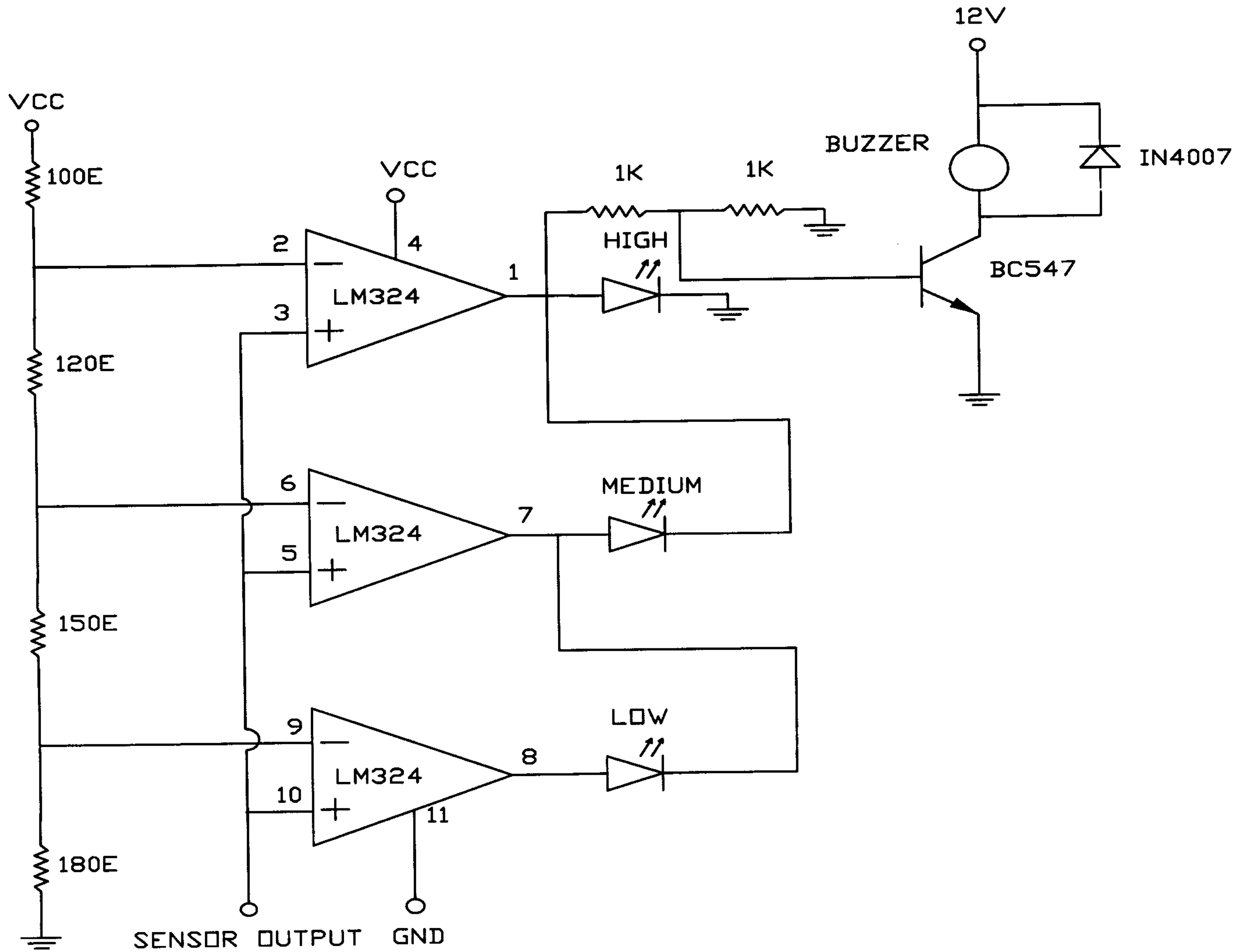
$$4.1 = \frac{(R2 + R3 + R4)*5}{100\Omega + R2 + R3 + R4}$$

$$0.82R1 = 0.18\,(R2 + R3 + R4) \text{ ------------------(1)}$$

Similarly, $$0.5\,R1 = -0.5R2 + 0.5R3 + 0.5R4 \text{ ------------------(2)}$$

$$0.23R1 = -0.23R2 - 0.23R3 + 0.77R4 \text{ ---------------(3)}$$

Substituting for R1 , we get



DESIGN USING LM324

R2 = 177.77 Ω

R3 = 150.00 Ω

R4 = 127.77Ω

The nearest standard values for the above calculated values are R2 = 180 Ω , R3 = 150 Ω , R4 = 120 Ω.For these resistance values, the output voltages and the corresponding gas concentrations are recalculated.

Reference voltages are:

Gas concentration (PPM)	Reference Voltage (Volts)
1000	1.65
3000	3.00
7000	4.12

Reference values used for design using LM 324

Window detector concept is implemented in this circuit so that EX-OR gate can be eliminated, thus reducing the number of components. In general, when anode potential exceeds cathode potential, the LED emits light. Maximum current taken by LED is 20mA. When the cathode of Low level LED is connected to the anode of Medium level LED and if input to both the LED's are high, that is if output of LM 324 is high, then LOW level LED will be put off and MEDIUM level LED starts glowing. This is because if the voltage at both anode and cathode are equal for an LED, then that LED will be put off. Window detector principle states that there should be a minimum of 1 volt difference between anode and cathode potential.

Advantages of this circuit over the other circuits are:

- ❖ Reduction in number of components.
- ❖ Low cost of the circuit.
- ❖ Circuit complexity is reduced.
- ❖ Design is compact.

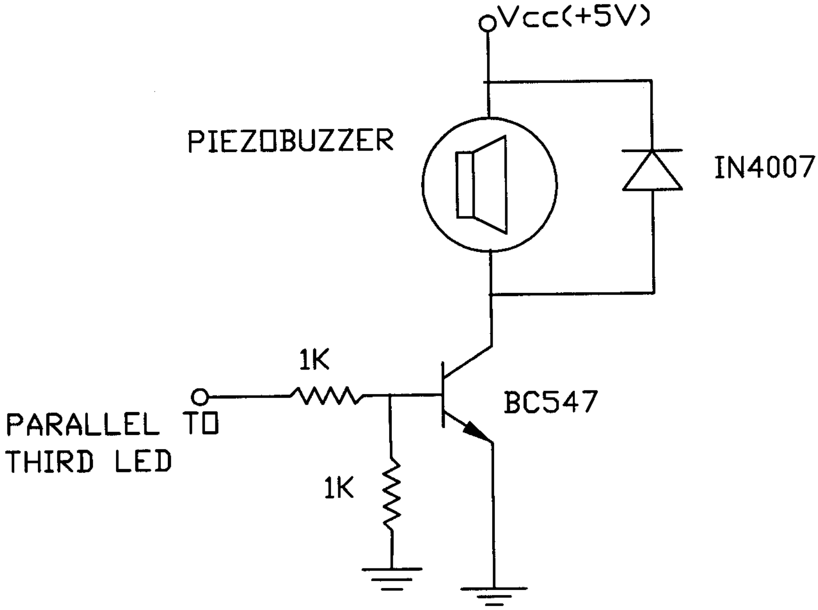
AUXILIARY CIRCUITS

ALARM CIRCUIT:

This circuit is used to provide audible signal when the gas leakage reaches high level. The buzzer used is a piezobuzzer. It works on piezoelectric principle i.e, when electric voltage is applied on two sides of the electrode, the piezo ceramic plate placed between the electrodes undergoes mechanical distortion thereby producing sound.

The buzzer has two terminals one of which is connected to the collector of the transistor BC 547, and the other end is connected to input supply of 12 Volts. When the voltage at 8^{th} pin of LM 324 is low, the transistor BC 547 will not conduct because the base voltage is zero. A pull-down resistor of 1k is used to pull the base of transistor to ground potential. Whereas, when the voltage at 8^{th} pin of LM 324 is high, the voltage at the base of the transistor is high which is at least 0.7 volts greater than emitter voltage, transistor conducts and hence audible signal is produced by buzzer.

Kick back effect diode or free wheeling diode is connected across the buzzer to protect the buzzer. That is the diode will discharge / re-circulate the reverse voltage stored in the buzzer.



ALARM CIRCUIT

MODIFICATION OF BEEP SOUND:

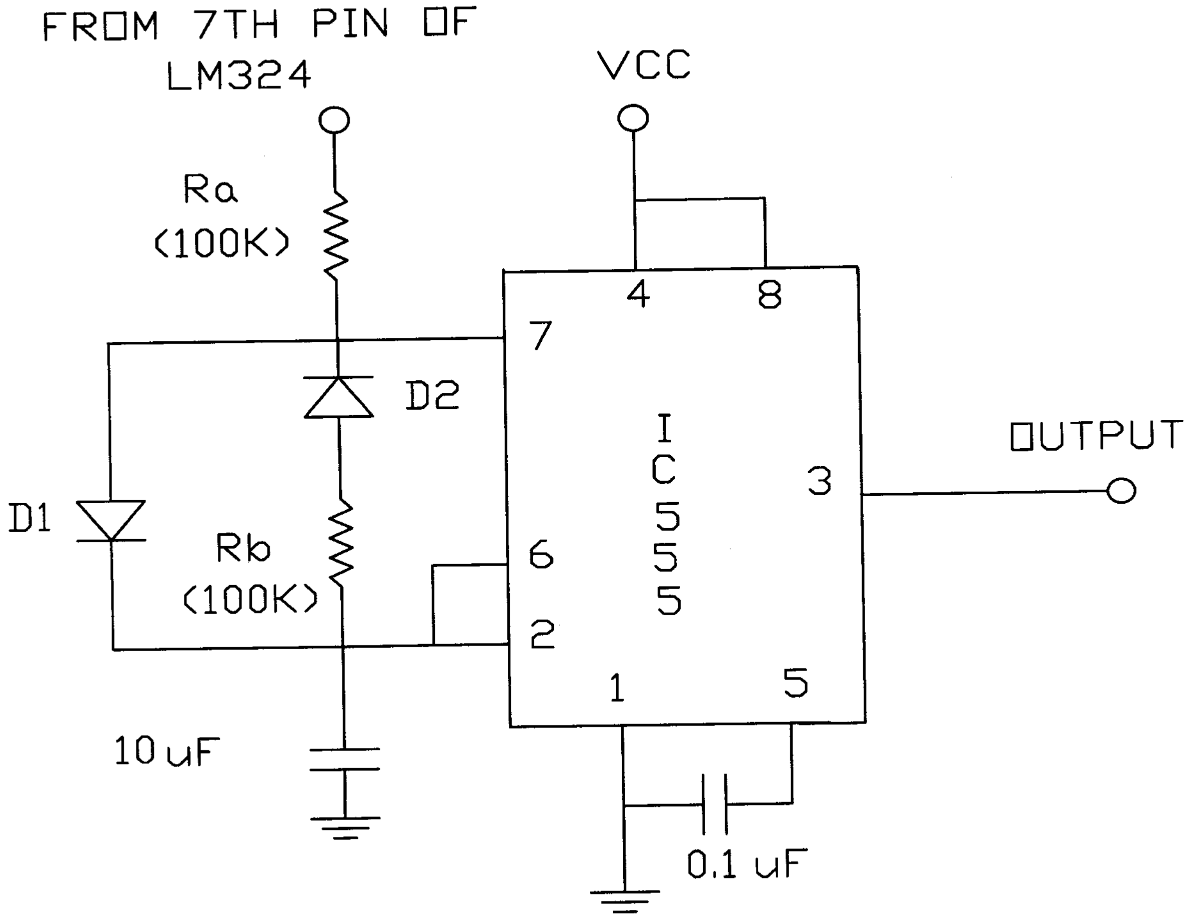
1. USING IC 555 TIMER:

The beep sound can be modified using IC 555 timer. This circuit uses two diodes, two resistors and a capacitor to produce asymmetric waveform. This circuit is connected parallel to the 2^{nd} LED i.e., the 7^{th} pin of LM 324. The resistor Ra determines the ON time whereas Rb determines the OFF time.

When voltage signal is available at the input of the circuit, the capacitor starts charging through Ra and D1. When the capacitor is charging, there will be a drop of 0.7 volts due to diode D1. Therefore, diode D2 is added in the discharge path to compensate the drop. Once the capacitor voltage exceeds 2/3Vcc, the capacitor starts discharging towards ground through Rb and D2 with a time constant RbC. During discharge, when the capacitor voltage reduces to 1/3 Vcc, the capacitor again starts charging.

When the capacitor charges, the output is high. When it discharges, the output goes low. The output of this circuit is connected to the alarm circuit. Thus, the alarm goes ON and OFF for a preset time when there is MEDIUM leakage.

The disadvantage here is that we need an additional IC 555 timer.



ASYMMETRIC WAVEFORM GENERATOR

The ON and OFF times can be calculated using the following formula:

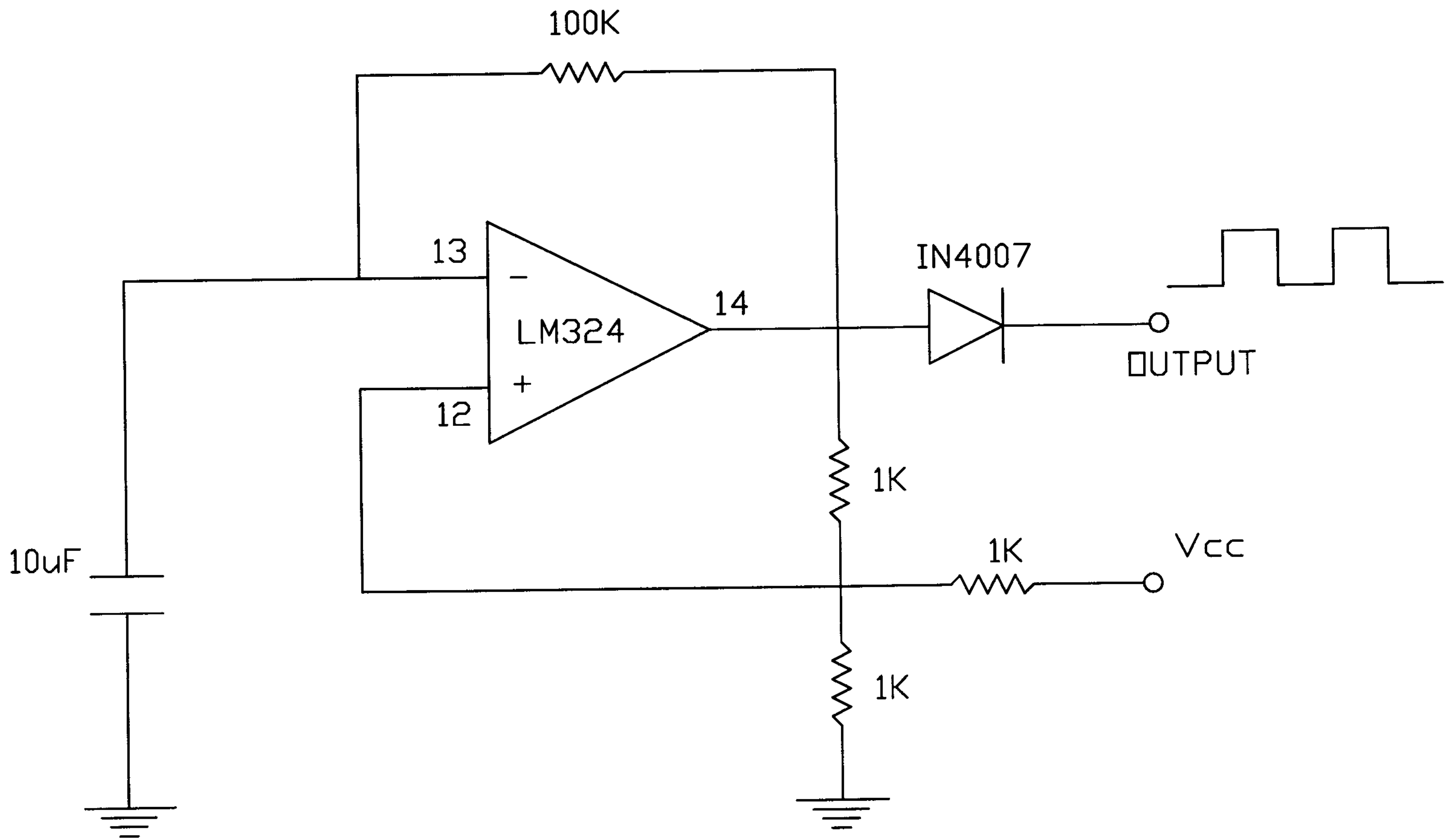
$$T_{ON} = 0.69\,R_a\,C$$

$$T_{OFF} = 0.69\,R_b\,C$$

2. USING LM 324

To modify the beep sound, a square wave generator is used. This uses an operational amplifier, resistors and a capacitor. The circuit is connected parallel to the 2^{nd} LED i.e., to the 7^{th} pin of LM 324. Three resistors R2, R3 and R4 are used to provide a reference voltage at the non-inverting terminal of op-amp. The capacitor charges and discharges in the same path through the resistor R1. Using the formula, R1 can be calculated to determine the ON time and OFF time of the buzzer.

When the leakage is MEDIUM, the voltage is available at the input. Thus the reference is voltage is available at pin 13. The capacitor starts charging through R1 as long as the voltage at the inverting terminal is less than the reference voltage at the non-inverting terminal. When the voltage at pin 12 and pin 13 are equal, the capacitor starts discharging through R1. When capacitor is charging the output voltage is high and it is low when the capacitor is discharging. The output of the circuit is connected to the buzzer



SYMMETRIC WAVEFORM GENERATOR

circuit. So, the buzzer rings for a set ON time and is put off for the same time.

The formula to calculate the ON/OFF time is given:

$$T = RC \ln (1 + \beta / 1 - \beta)$$

$$\beta = R2 / (R1 + R2)$$

$$\text{For } R1 = R2 = 1K,\ \beta = 0.5$$

$$T = RC \ln(3)$$

$$T = 1.1\ RC$$

.

For the corresponding resistor values, the ON/OFF times are calculated and tabulated as shown below.

TIME (Sec)	R VALUE (Ohms)
0.55	50
1.1	100
1.65	150
2.0	182

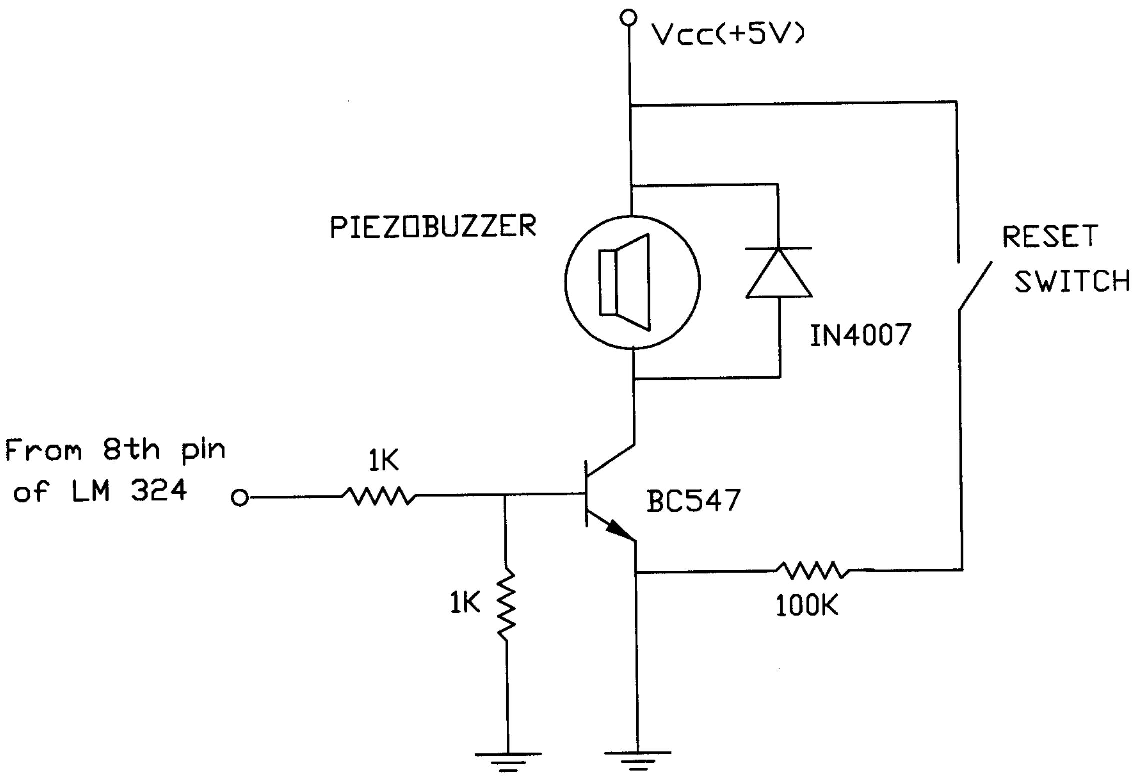
The advantage of this circuit is that is that there is no need for additional IC. The remaining gate available in LM 324 can be used for this purpose.

RESET CIRCUIT:

The purpose of this circuit is to switch off the buzzer sound manually by using a toggle switch. Once the gas concentration reaches high level, the buzzer starts blowing. This concentration continuously increases until one turns the regulator knob of the cylinder to the OFF position (in case of domestic purpose). Even after the knob is turned to the OFF position, the buzzer blows until the sensor output reduces below the third preset level.

One end of the buzzer is connected to the supply voltage (5V). A toggle switch is connected to the 5V supply or buzzer. A 100K resistor is connected between toggle switch and emitter of the transistor. This resistor is connected in order to limit the current value. Now, even though the output at 8th pin of LM 324 is high, the buzzer will not blow because emitter potential is higher than the base potential since the_toggle switch is kept in ON position._Hence the transistor will not conduct and there will not be any voltage available at the collector of the transistor.

❖ When the toggle switch is kept in ON position, 5V is passed through the resistor to emitter of transistor BC 547. Now, the buzzer will be reset.



RESET CIRCUIT

❖ After the reduction of gas in that environment, this toggle switch must be switched to the OFF position so that the circuit will produce Alarm signal when it reaches high level.

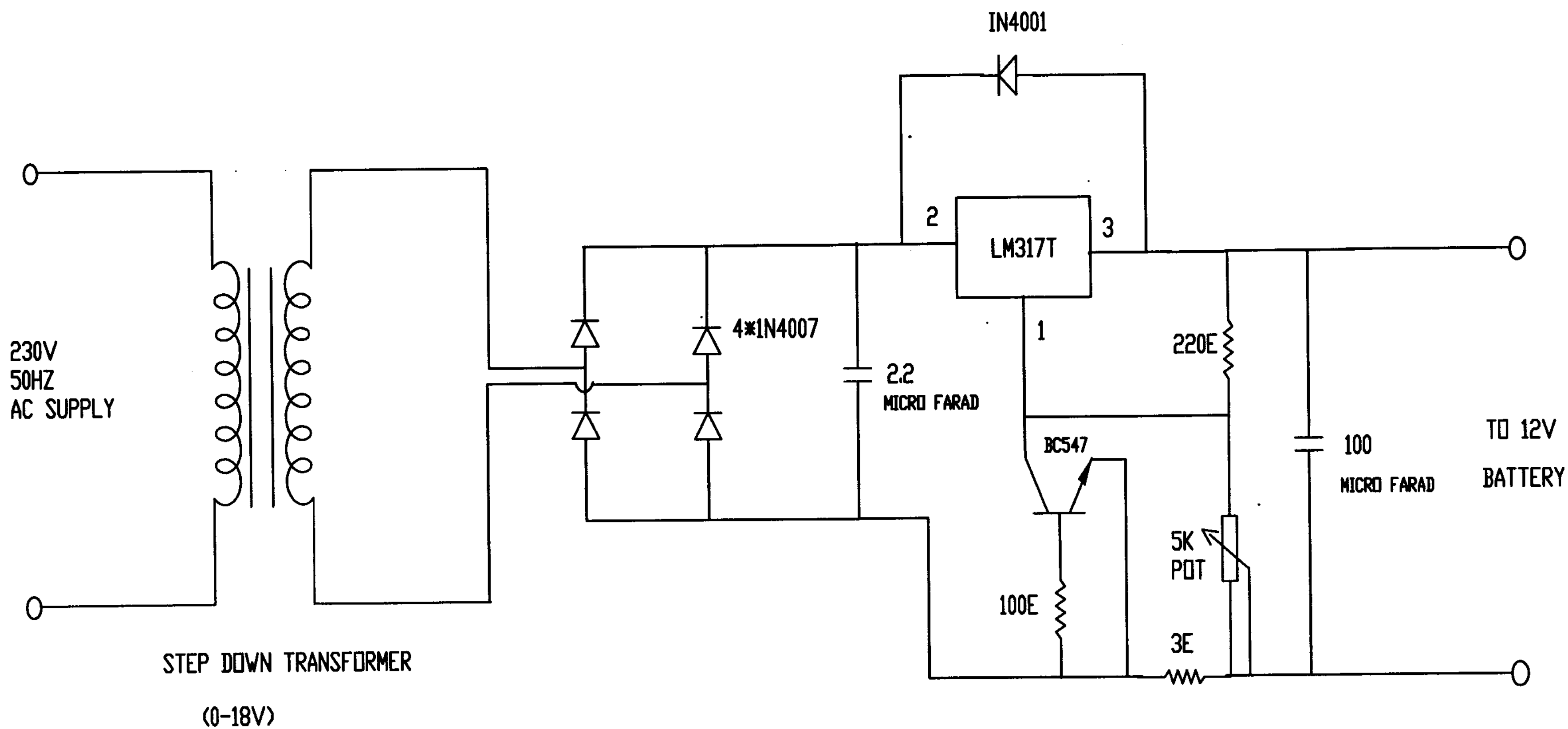
❖ If this switching is not done, then the base voltage will never exceed the emitter voltage and hence the buzzer will not blow.

BATTERY CHARGING CIRCUIT:

Battery charger is used to drive the circuit in case of power shut down. This circuit is used to charge the battery when the supply is ON. The charging current should be kept to around 0.1 times the capacity of the battery. So, charging current must be 0.25A. The charging voltage should be set to 2.3 to 2.4 volts per 2V cell. So, a 12V battery should be charged at

Charging Voltage	=	13.8 Volts
Regulator drop	=	3.0 Volts
Rectifier drop	=	1.4 Volts
		18.2 Volts
10% safety	=	1.82 Volts
		20 Volts

The standard value of transformer available is (0 - 18)V. Drop across LM317T is 3 Volts. During every cycle, drop across rectifier is 1.4 Volts. The charging current is limited by a small resistor.



BATTERY CHARGING CIRCUIT

Resistance is given by 0.6V/0.25A which is approximately equal to 3 Ohms. This 0.6Volts is the voltage required to go fully into conduction. Between 0V and 0.6V, the transistor will adjust the regulator to increase or decrease voltage depending on the current it is passing. The charging voltage is set by using a potentiometer. This value is 5K potentiometer for 12V batteries. An extra fuse is used on the charger about two times the maximum current we are charging with. A battery can deliver more than 100Amps during short circuit. In order to protect other components, a fuse is introduced at the input of the adjustable regulator LM317T. This is in case of power shut down. A fuse is added at the primary winding of the transformer, to protect the circuit from short circuits in the main supply.

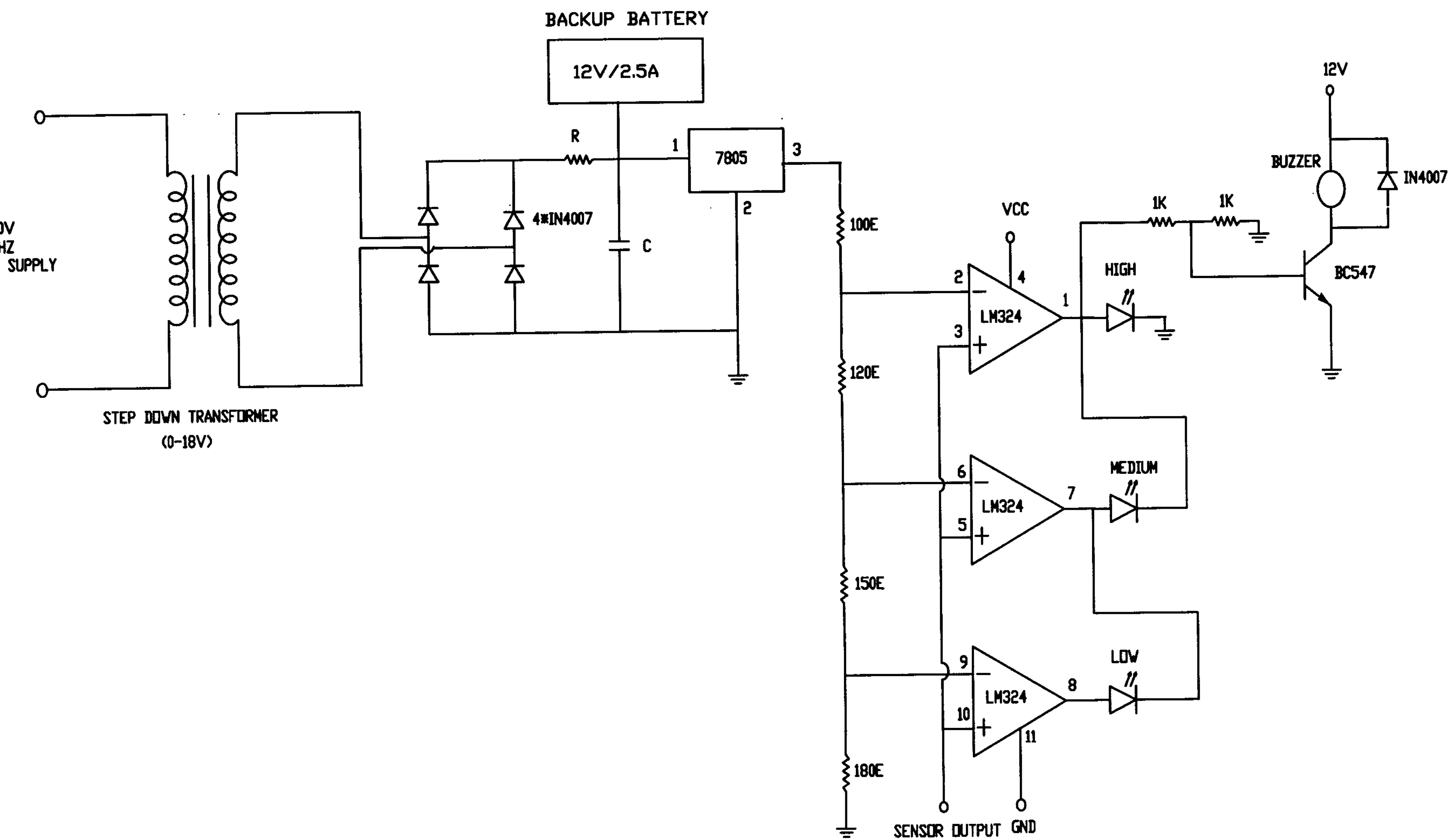
FINAL DESIGN CIRCUIT

Our final circuit is designed to detect gas leakage in

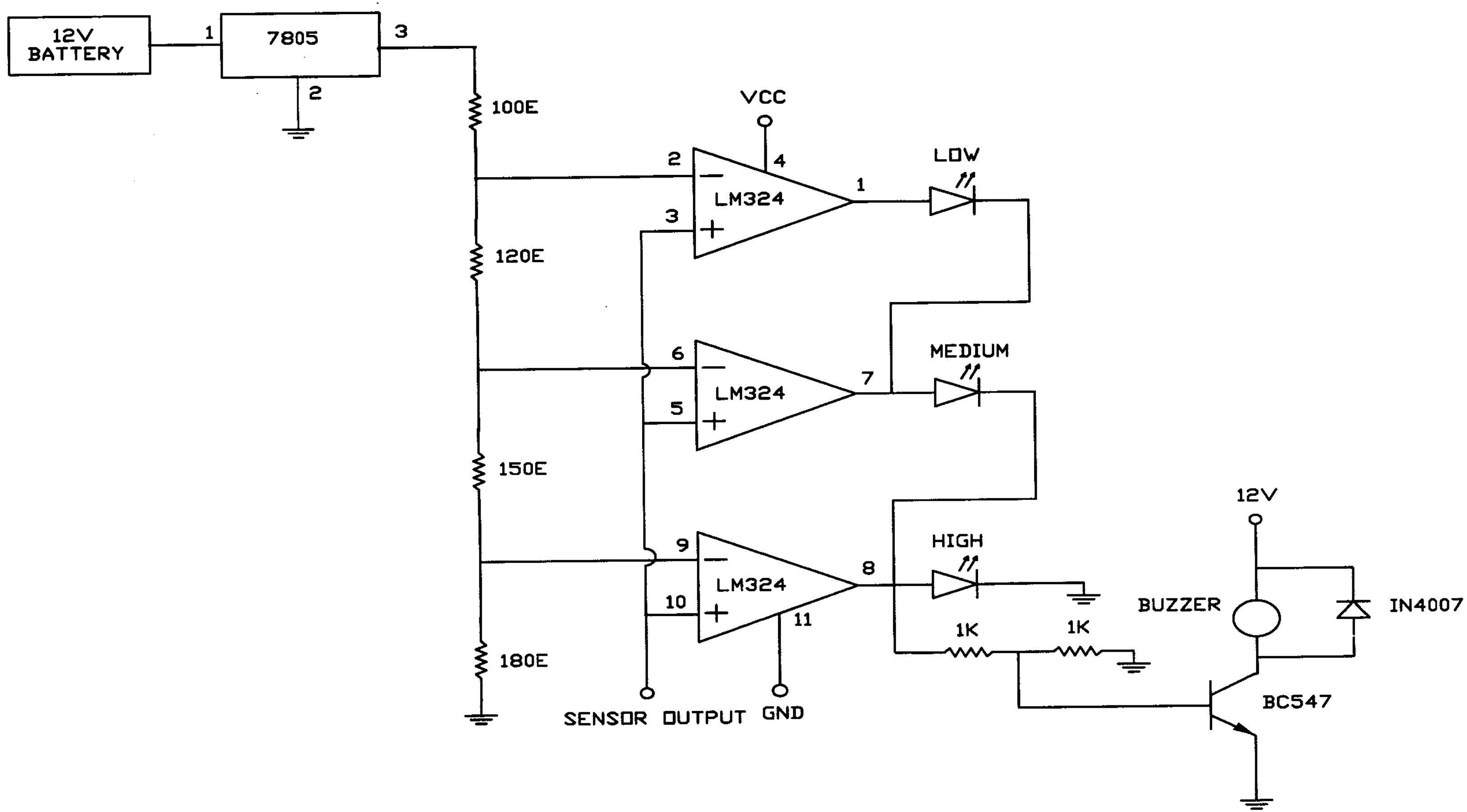
1) Houses.
2) Automobiles.

To detect the gas leakage in houses, power supply unit is added to the previous circuit. This unit consists of Transformer, Rectifier, Filter and Regulator. 230 volts ac supply is given as input to the step-down transformer. This ac voltage is converted to dc voltage using a bridge rectifier circuit. This dc voltage is filtered in order to reduce the ripples. The output voltage from filter is input is 7805 positive regulator, the output obtained here is regulated 5V dc supply. After this, the operation of the circuit is same.

Whereas in Automobiles, the previous circuit is added with a battery and 7805 positive regulator. Here, the 12V DC supply from car battery is directly input to the 7805 regulator, from where the output obtained is 5V DC supply. The previous circuit is added to this 5V and the operation is similar to the previous circuit.



FINAL DESIGN CIRCUIT (DOMESTIC PURPOSE)



FINAL DESIGN CRCUIT(AUTOMOBILES)

CONCLUSION

The "LPG Leak Detector" used for detecting leakage of gas has been developed. This product can be used in houses, industries and automobiles. Use of this product minimizes accidents that are caused due to high level leakage of LPG and hence safety is assured. Various tests were carried out inorder to select a suitable sensor for our application. Consequently, a sensor with high sensitivity to LPG was selected.

The design for application circuit was evolved in a step by step process. Several logics were used and eventually a circuit which works on a simple logic was selected. This reduces the complexity and cost of the overall design. The sensor was connected in the application circuit and its working was verified using a Gas Densitometer.

Finally, we achieved our aim of producing a product with compact size and reduced cost.

FUTURE ENHANCEMENTS

The product developed offers much scope for improvement and enhancement. Our product detects gas leakage and provides three levels of visual indication along with audible alarm signal for HIGH level leakage. For expansion in future, wireless communication can be implemented. The sensor can be kept near the source of leakage and the alarm can be kept at a remote place.

A digital display can be provided to indicate the concentration of gas leakage in ppm. This can be done by programming with a microcontroller.

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APPENDIX

Sencera Co. Ltd. Data Sheet

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HS-131 Nature gas sensor specification

1. Characteristics

1. 1 High sensitive and good selectivity to fume and alcohol.

1. 2 Long life and reliable stability.

2. Application

2.1 Gas leakage detecting in family and industry

2.2 Suitable for detecting of methane, isobutane, propane.

3. Structure of components.

3.1 Structure of HS-131 shown as Fig.1

Fig.1

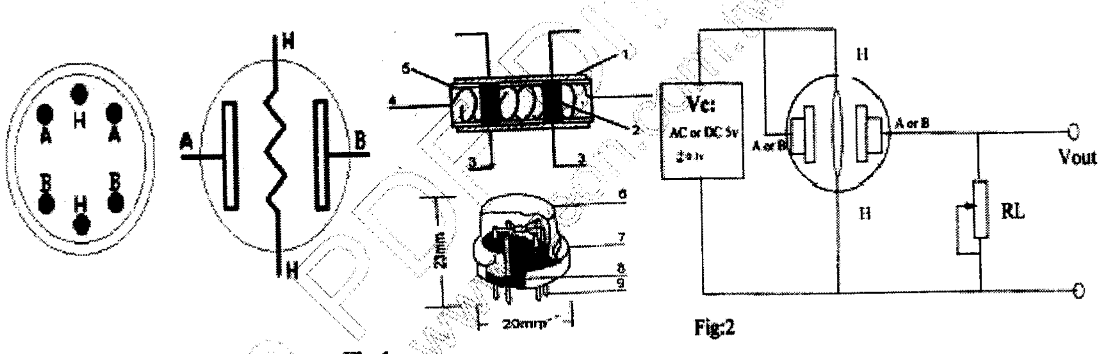


Fig.1

Fig:2

3.2 HS-131 have 6 pins, 4 of them are used to detect signals, and other 2 are used for providing heating current. Measurement circuit is shown as (Fig.2)

4. Property

4.1 Standard operating condition

Symbol	Descriptions	Rated	remarks
Vc	circuit voltage	5V	AC OR DC
VH	Heating voltage	5V	ACOR DC
PL	load resistance	can be adjustable	Ps <25mW
RH	Heater resistance	33Ω±5%	At 21 ℃
PH	Heating consumption	less than 800mw	

4.2 Environment condition

Symbol	Descriptions	Rated	Remarks
Tao	Using Tem	-20℃-50℃	
Tas	Storage Tem	-20℃-70℃	
RH	Related humidity	less than 95%Rh	
O2	Oxygen concentration	21%(standard condition) Oxygen concentration can affect sensitivity	Minimum value is over 2%

4.3 Sensitivity characteristic

Symbol	Descriptions	Rated	Remark 1	Remark 2
Rs	sensing body resistance	2kΩ-20kΩ (5000ppm methane)		Detecting concentration scope
α (5000/1000) isobutane	concentration slope rate	≤0.6		1000ppm-20000ppm methane
standard detecting condition	Temp: 20℃±2℃ Vc:5V±0.1 Humidity: 65%±5% Vh: 5V±0.1			
preheat time	over 24 hour			

4.4 Mechanical characteristic

Project	Condition	property
Vibration	frequency 100cpm	should be conformed to given sensitivity characteristic
	vertical vibrating amplitude	
	time 1 hour	
Punch	acceleration 100G	
	punch times 5	

5. Sensitivity curve of HS-131

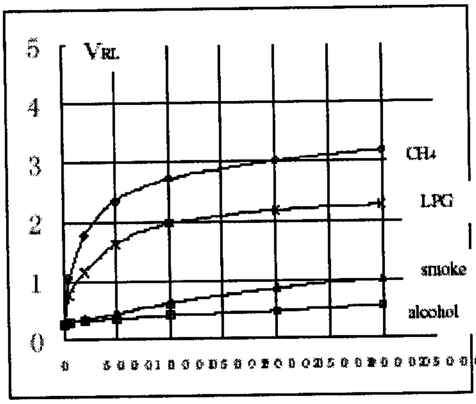


Fig. 3

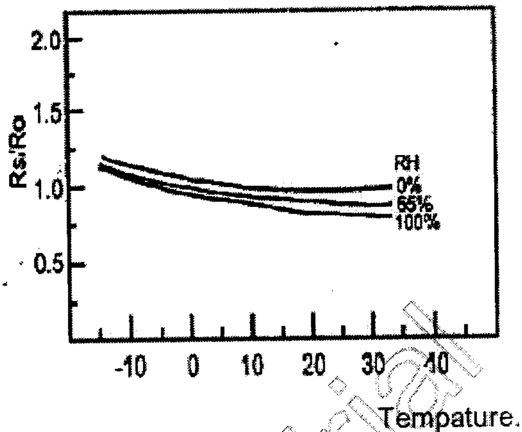


Fig. 4

Fig 3. is relation curve of VRL and gas concentration. At Temperature : 20℃、Humidity: 65%、O2 concentration: 21% RL=5kΩ. Fig 4. is relation between surface resistance of HS-131 and environment related humidity.Test environment : Ro is resistance value at 20℃,0%RH and in the 5000ppm CH4, Rs is resistance value of components in other Temperature and humidity.

6. Sensitivity adjustment

HS-131 resistance value will be changing with different spices and gas concentrations.Before operating the components, sensitivity adjustment is necessary.We suggest use 3000-10000ppm methane(CH4) or 300ppm-1000ppm .Isobutane <i-C4H10 > is standard gas concentration.

Adjustment process:

a. Put HS131 components to application circuits.

b. If use the sensor is Long time storage, suggest the preheating time must over than 24 hours in order to guarantee components property can reach stability completely.

c. In the standard gas concentration, adjust load resistance RL until you get the output signal.

d. Due to environment conditions will cause different sensitivity.

So, please check Fig. 4 drawing to modify the sensitivity character.

Sencera Co. Ltd. Data Sheet

Tel:02-27046595 Fax:886-2-27041279 Email:justinel@ms14.hinet.net

HS-133 LPG sensor

1. Characteristics

1. 1 High sensitive and good selectivity to fume and alcohol.

2. 2 Long life and reliable stability.

2. Application

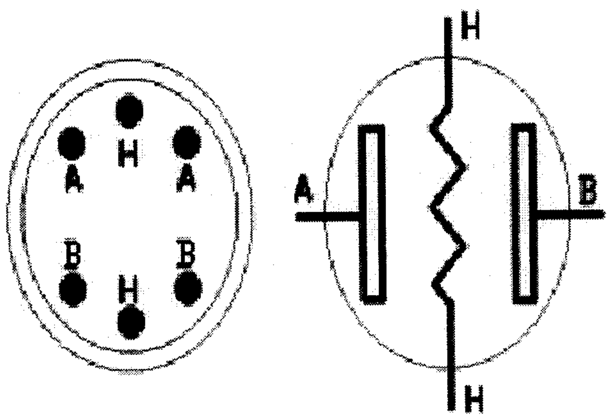
2.1 Gas leakage detecting in family and industry

2.2 Suitable for detecting of LPG , isobutane , propane and methane.

3. Structure of components.

3.1 Structure of HS-133 shown as Fig.1

Fig.1



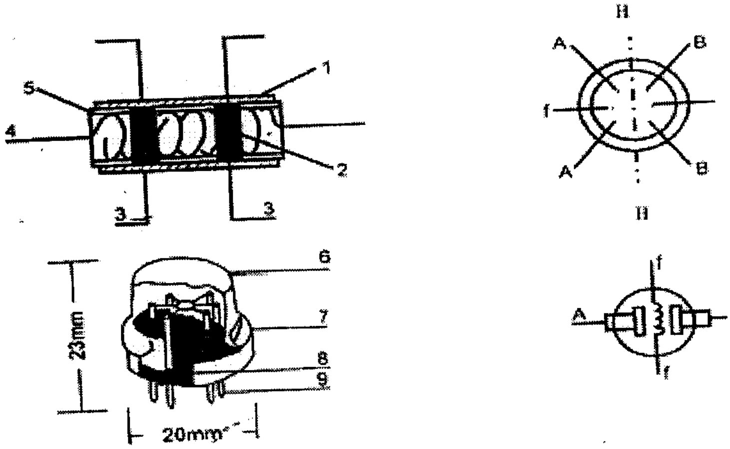


Fig.1

Items	Descriptions	Materials
1	gas sensing layer	SnO2
2	measurement electrode	Au
3	measurement electrode ignited line	Pt
4	heater	Ni-Cr alloy
5	tubular ceramic basic body	Al2 O3
6	anti-explosion network	100 dual layer stainless steel
7	clamp ring	Ni plated
8	basic seat	Bakelite
9	tube foot	Ni plated

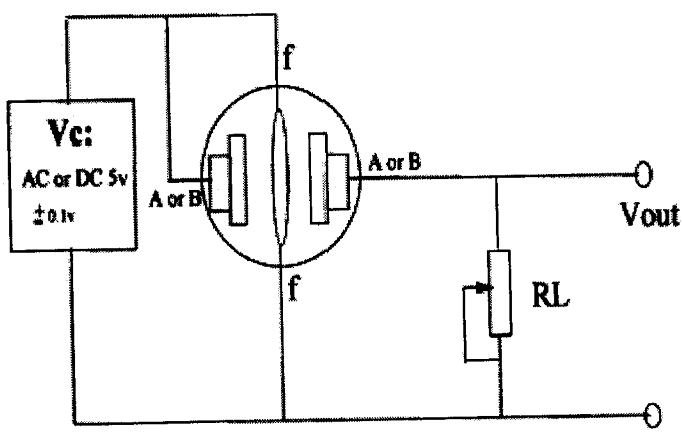


Fig:2

3.2 HS-131 have 6 pins, 4 of them are used to detect signals, and other 2 are used for providing heating current. Measurement circuit is shown as (Fig.2)

4. Property

4.1 Standard operating condition

Symbol	Descriptions	Rated	remarks
Vc	circuit voltage	5V	AC OR DC
VH	Heating voltage	5V	ACOR DC
PL	load resistance	can be adjustable	Ps <25mW
RH	Heater resistance	33Ω ±5%	At 21 ℃
PH	Heating consumption	less than 800mw	

4.2 Environment condition

Symbol	Descriptions	Rated	Remarks
Tao	Using Tem	-20℃-50℃	
Tas	Storage Tem	-20℃-70℃	
RH	Related humidity	less than 95%Rh	
O2	Oxygen concentration	21%(standard condition) Oxygen concentration can affect sensitivity	Minimum value is over 2%

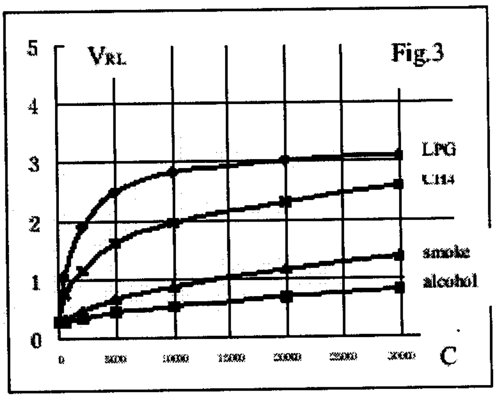
4.3 Sensitivity characteristic

Symbol	Parameter name	Technical parameter		Remark
Rs	sensing body resistance	2kΩ-20kΩ (2000ppm isobutane)		Detecting concentration scope: 300ppm-10000ppm isobutane or LPG
α (5000/1000) isobutane	concentration slope rate	≤0.6		
standard detecting condition	Temp: 20℃±2℃ Vc:5V±0.1 Humidity: 65%±5% Vh: 5V±0.1			
preheat time	over 24 hour			

4.4 Mechanical characteristic

Project	Condition	property
Vibration	frequency 100cpm	should be conformed to given sensitivity characteristic
	vertical vibrating amplitude	
	time 1 hour	
Punch	acceleration 100G	
	punch times 5	

5. Sensitivity curve of HS-133



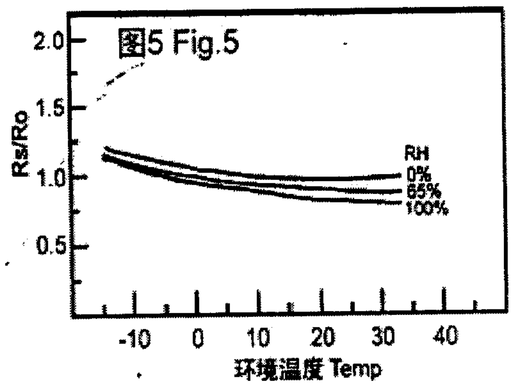


Fig 3 is relation curve of V_{RL} and gas concentration.
in their: Temp: 20℃、 Humidity: 65%、 O_2 concentration 21% RL=5kΩ

Fig 3. is relation curve of VRL and gas concentration. At Temperature : 20℃、Humidity: 65%、O2 concentration: 21% RL=5kΩ. Fig 4. is relation between surface resistance of HS-133 and environment related humidity. Test environment : Ro is resistance value at 20℃,0%RH and in the 5000ppm CH4, Rs is resistance value of components in other Temperature and humidity.

6. Sensitivity adjustment

HS-133 resistance value will be changing with different spices and gas concentrations. Before operating the components, sensitivity adjustment is necessary. We suggest use 3000-10000ppm methane(CH_4) or 300ppm-2000ppm .Isobutane <i-C_4H_{10} > is standard gas concentration.

Adjustment process:

a. Put HS133 components to application circuits.

b. If use the sensor is Long time storage, suggest the preheating time must over than 24 hours in order to guarantee components property can reach stability completely.

c. In the standard gas concentration, adjust load resistance RL until you get the output signal.

Sencera Co. Ltd. **Data Sheet**

HS-135 Air pollution sensor specification

1. Characteristics:

    1.1 Long period stability.

    1.2 Widely detecting scope.

2. Application

    Family and industry use

    Suitable for detecting of Smoke、SO2、CO2 、isobutane、alcohol...etc.

3. Property

A. Standard work condition

symbol	parameter name	Technical condition	remarks
Vc	circuit voltage	5V	AC OR DC
VH	Heating voltage	5V	AC OR DC
PL	load resistance	can adjust	Ps
RH	heater resistance	33Ω ±5%	room Temp
PH	heating consumption	less than 800mw	

B. Environment condition

symbol	parameter name	technical condition	remarks
Tao	Operating Temp	-20℃-50℃	
Tas	storage Temp	-20℃-70℃	
RH	Operating humidity range	less than 95%Rh	
O2	oxygen concentration	21%(standard condition) Oxygen concentration affect sensitivity	minimum value is over 2%

C. Sensitivity characteristic

Symbol	parameter name	technical parameter	remark 1	ramark 2
Rs	sensing body resistance	1KΩ-10KΩ (1000ppm isobutane)	suitable for 3000ppm LPG and propane	detecting concentration scope: 1%~10% smoke 0.3~20% CO2 300ppm-5000ppm isobutane
α (3000/1000) isobutane	concentration slope rate	≤0.6		
standard detecting condition	Temp: 20℃±2℃ Humidity: 65%±5%RH	Vc:5V±0.1 Vh: 5V±0.1		
preheat time	over 24 hours			

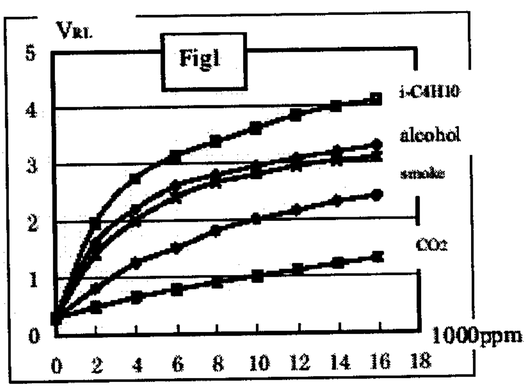
D. Machinary characteristic

project	condition	property
vibration	ferquency 100Hz	should be conformed to given sensitivity characteristic
	vertical vibrating amplitude	
	time 1 hour	
punch	acceleration 100G	
	punch times 5	

4. Sensitivity characteristic curve of HS-135 air pollution sensor as follow:

Fig 1 is relation curve of VRL and gas concentration.

At:Temp: 20℃ 、 Humidity: 65%RH、 O2=concentration 21% RL=5kΩ



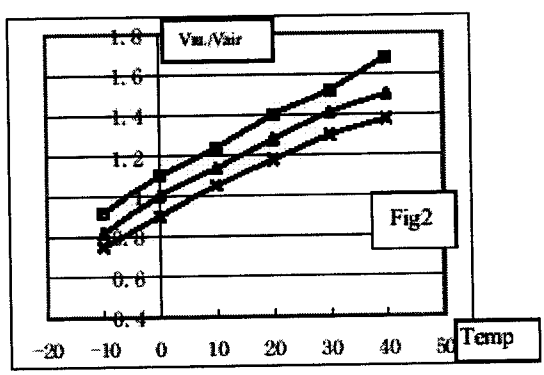


Fig 2 is relation between surface resistance of HS-135 with environment related humidity.

5. HS-135 structure and circuit symbols(Fig 3).

series	parts	materials
1	sensing layer	SnO_2
2	measurement electrode	Au
3	measurement electrode ignited wire	Pt
4	heater	N1-Cr alloy
5	tubular ceramic basic body	Al_2O_3 ceramic
6	anti-explosion network	100 dual layer stainless steel (SUS316)
7	clamp ring	Ni plating
8	basic seat	bakelite
9	tube foot	CP wire

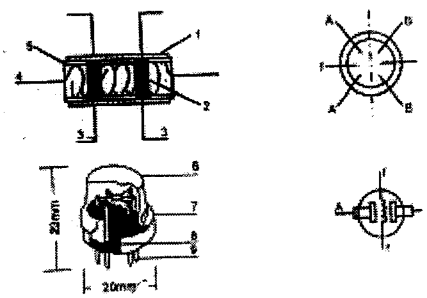


Fig3

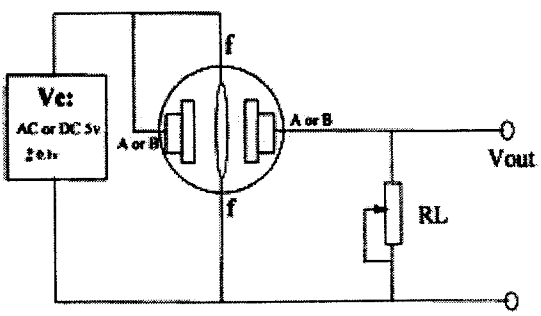


Fig4

6. Electric parameter measurement circuit

Fig 4 is standard test circuit of HS135.

As environment temperature and humidity will effect to sensor sensitivity.

So. when accurately measuring, must consider environment factor.

7. Sensitivity adjustment

Resistance value changing of HS-135 will be exist in every pieces and difference gas environment. So, when check the sensor sensitivity, we suggest that use 300ppm-1000ppm isobutane <i-C_4H_{10} > as sensitivity adjustment standard gas.

Adjustment steps:

a. Input sensor to application circuits.

b. If the sensor is first time to be use, we suggest the preheating time will not be less than 24 hours. In order to guarantee sensitive can reach stability completely.

c. In the detecting gas concentration, adjusting load resistance RL until the suitable signal output.

Low Power Quad Operational Amplifiers

General Description

The LM124 series consists of four independent, high gain, internally frequency compensated operational amplifiers which were designed specifically to operate from a single power supply over a wide range of voltages. Operation from split power supplies is also possible and the low power supply current drain is independent of the magnitude of the power supply voltage. Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuits which now can be more easily implemented in single power supply systems. For example, the LM124 series can be directly operated off of the standard +5V power supply voltage which is used in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies.

Unique Characteristics

- In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage.
- The unity gain cross frequency is temperature compensated.
- The input bias current is also temperature compensated.

Advantages

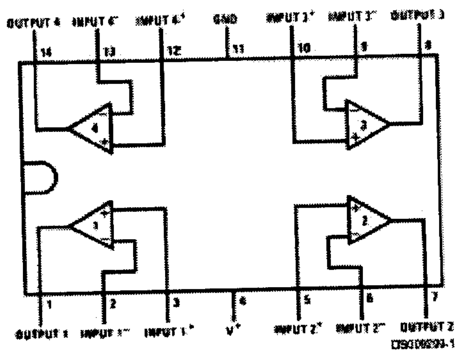
- Eliminates need for dual supplies
- Four internally compensated op amps in a single package
- Allows directly sensing near GND and VOUT also goes to GND, Compatible with all forms of logic
- Power drain suitable for battery operation

Features

- Internally frequency compensated for unity gain
- Large DC voltage gain 100 dB
- Wide bandwidth (unity gain) 1MHz (temperature compensated)
- Wide power supply range : Single supply 3V to 32V
  or dual supplies ±1.5V to ±16V
- Very low supply current drain (700 μA)—essentially
  independent of supply voltage
- Low input biasing current 45 nA (temperature compensated)
- Low input offset voltage 2 mV and offset current: 5 nA
- Input common-mode voltage range includes ground
- Differential input voltage range equal to the power
  supply voltage
- Large output voltage swing 0V to V+ - 1.5V

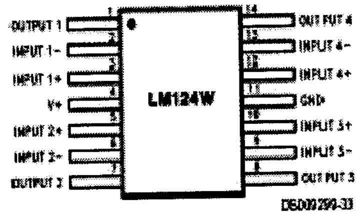
Connection Diagram

Dual-In-Line Package



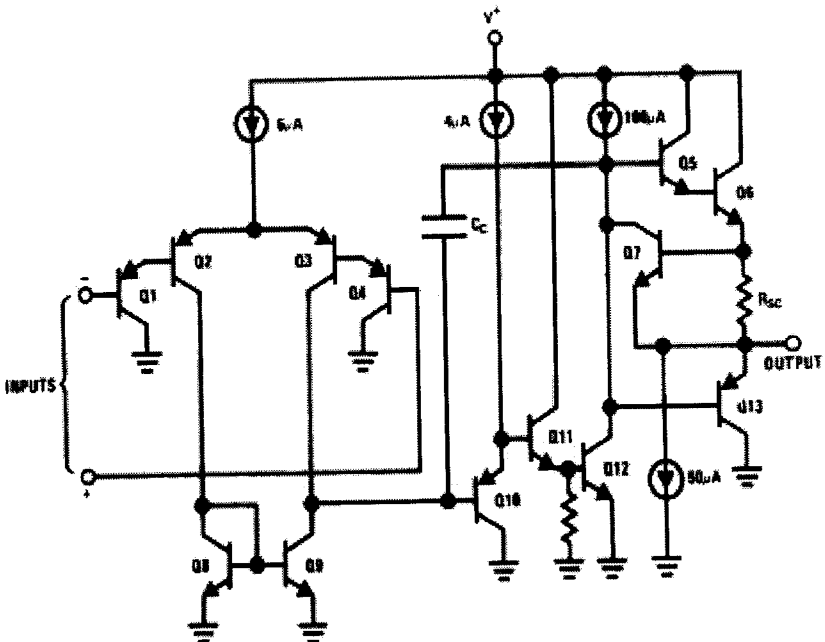
Connection Diagram (Continued)

Note 3: See STD Mil DWG 5962R99504 for Radiation Tolerant Device



DS009299-33

Schematic Diagram (Each Amplifier)



DS009299-2

Absolute Maximum Ratings (Note 12)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.

	LM124/LM224/LM324 LM124A/LM224A/LM324A	LM2902
Supply Voltage, V^+	32V	26V
Differential Input Voltage	32V	26V
Input Voltage	−0.3V to +32V	−0.3V to +26V
Input Current		
(V_{IN} < −0.3V) (Note 6)	50 mA	50 mA
Power Dissipation (Note 4)		
Molded DIP	1130 mW	1130 mW
Cavity DIP	1260 mW	1260 mW
Small Outline Package	800 mW	800 mW
Output Short-Circuit to GND		
(One Amplifier) (Note 5)		
$V^+ \leq 15V$ and $T_A = 25°C$	Continuous	Continuous
Operating Temperature Range		−40°C to +85°C
LM324/LM324A	0°C to +70°C	
LM224/LM224A	−25°C to +85°C	
LM124/LM124A	−55°C to +125°C	
Storage Temperature Range	−65°C to +150°C	−65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	260°C	260°C
Soldering Information		
Dual-In-Line Package		
Soldering (10 seconds)	260°C	260°C
Small Outline Package		
Vapor Phase (60 seconds)	215°C	215°C
Infrared (15 seconds)	220°C	220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

ESD Tolerance (Note 13)	250V	250V

Electrical Characteristics

$V_+ = +5.0V$, (Note 7), unless otherwise stated

Parameter	Conditions	LM124A			LM224A			LM324A			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	(Note 8) $T_A = 25°C$		1	2		1	3		2	3	mV
Input Bias Current (Note 9)	$I_{IN(+)}$ or $I_{IN(-)}$, $V_{CM} = 0V$, $T_A = 25°C$		20	50		40	80		45	100	nA
Input Offset Current	$I_{IN(+)}$ or $I_{IN(-)}$, $V_{CM} = 0V$, $T_A = 25°C$		2	10		2	15		5	30	nA
Input Common-Mode Voltage Range (Note 10)	$V^+ = 30V$, (LM2902, $V^+ = 26V$), $T_A = 25°C$	0		$V^+-1.5$	0		$V^+-1.5$	0		$V^+-1.5$	V
Supply Current	Over Full Temperature Range $R_L = \infty$ On All Op Amps $V^+ = 30V$ (LM2902 $V^+ = 26V$) $V^+ = 5V$		 1.5 0.7	 3 1.2		 1.5 0.7	 3 1.2		 1.5 0.7	 3 1.2	mA
Large Signal Voltage Gain	$V^+ = 15V$, $R_L \geq 2k\Omega$, (V_O = 1V to 11V), $T_A = 25°C$	50	100		50	100		25	100		V/mV
Common-Mode Rejection Ratio	DC, V_{CM} = 0V to $V^+ - 1.5V$, $T_A = 25°C$	70	85		70	85		65	85		dB

Electrical Characteristics (Continued)

$V^+ = +5.0V$, (Note 7), unless otherwise stated

Parameter		Conditions		LM124A			LM224A			LM324A			Units
				Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Power Supply Rejection Ratio		$V^+ = 5V$ to $30V$ (LM2902, $V^+ = 5V$ to $26V$), $T_A = 25°C$		65	100		65	100		65	100		dB
Amplifier-to-Amplifier Coupling (Note 11)		f = 1 kHz to 20 kHz, $T_A = 25°C$ (Input Referred)			−120			−120			−120		dB
Output Current	Source	$V_{IN}^+ = 1V$, $V_{IN}^- = 0V$, $V^+ = 15V$, $V_O = 2V$, $T_A = 25°C$		20	40		20	40		20	40		mA
	Sink	$V_{IN}^- = 1V$, $V_{IN}^+ = 0V$, $V^+ = 15V$, $V_O = 2V$, $T_A = 25°C$		10	20		10	20		10	20		mA
		$V_{IN}^- = 1V$, $V_{IN}^+ = 0V$, $V^+ = 15V$, $V_O = 200$ mV, $T_A = 25°C$		12	50		12	50		12	50		μA
Short Circuit to Ground		(Note 5) $V^+ = 15V$, $T_A = 25°C$			40	60		40	60		40	60	mA
Input Offset Voltage		(Note 8)				4			4			5	mV
V_{OS} Drift		$R_S = 0Ω$			7	20		7	20		7	30	μV/°C
Input Offset Current		$I_{IN(+)} - I_{IN(-)}$, $V_{CM} = 0V$				30			30			75	nA
I_{OS} Drift		$R_S = 0Ω$			10	200		10	200		10	300	pA/°C
Input Bias Current		$I_{IN(+)}$ or $I_{IN(-)}$			40	100		40	100		40	200	nA
Input Common-Mode Voltage Range (Note 10)		$V^+ = +30V$ (LM2902, $V^+ = 26V$)		0		V^+-2	0		V^+-2	0		V^+-2	V
Large Signal Voltage Gain		$V^+ = +15V$ (V_OSwing = 1V to 11V) $R_L \geq 2$ kΩ		25			25			15			V/mV
Output Voltage Swing	V_{OH}	$V^+ = 30V$ (LM2902, $V^+ = 26V$)	$R_L = 2$ kΩ	26			26			26			V
			$R_L = 10$ kΩ	27	28		27	28		27	28		
	V_{OL}	$V^+ = 5V$, $R_L = 10$ kΩ			5	20		5	20		5	20	mV
Output Current	Source	$V_O = 2V$	$V_{IN}^+ = +1V$, $V_{IN}^- = 0V$, $V^+ = 15V$	10	20		10	20		10	20		mA
	Sink		$V_{IN}^- = +1V$, $V_{IN}^+ = 0V$, $V^+ = 15V$	10	15		5	8		5	8		

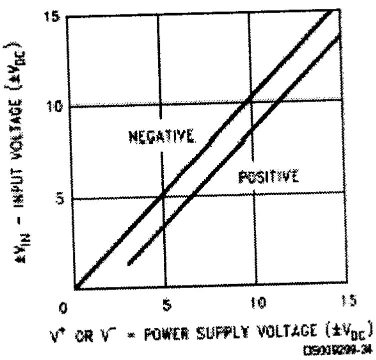
Electrical Characteristics

$V^+ = +5.0V$, (Note 7), unless otherwise stated

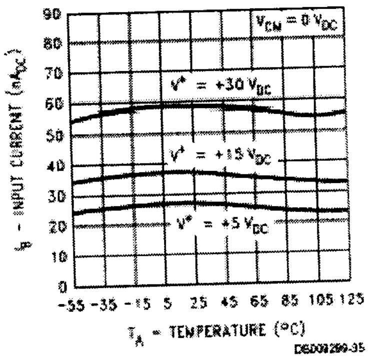
Parameter	Conditions	LM124/LM224			LM324			LM2902			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	(Note 8) $T_A = 25°C$		2	5		2	7		2	7	mV
Input Bias Current (Note 9)	$I_{IN(+)}$ or $I_{IN(-)}$, $V_{CM} = 0V$, $T_A = 25°C$		45	150		45	250		45	250	nA
Input Offset Current	$I_{IN(+)}$ or $I_{IN(-)}$, $V_{CM} = 0V$, $T_A = 25°C$		3	30		5	50		5	50	nA
Input Common-Mode Voltage Range (Note 10)	$V^+ = 30V$, (LM2902, $V^+ = 26V$), $T_A = 25°C$	0		$V^+-1.5$	0		$V^+-1.5$	0		$V^+-1.5$	V
Supply Current	Over Full Temperature Range $R_L = \infty$ On All Op Amps										mA
	$V^+ = 30V$ (LM2902 $V^+ = 26V$)		1.5	3		1.5	3		1.5	3	
	$V^+ = 5V$		0.7	1.2		0.7	1.2		0.7	1.2	
Large Signal Voltage Gain	$V^+ = 15V$, $R_L \geq 2$kΩ, ($V_O = 1V$ to $11V$), $T_A = 25°C$	50	100		25	100		25	100		V/mV
Common-Mode Rejection Ratio	DC, $V_{CM} = 0V$ to $V^+ - 1.5V$, $T_A = 25°C$	70	85		65	85		50	70		dB
Power Supply Rejection Ratio	$V^+ = 5V$ to $30V$ (LM2902, $V^+ = 5V$ to $26V$),	65	100		65	100		50	100		dB

Typical Performance Characteristics

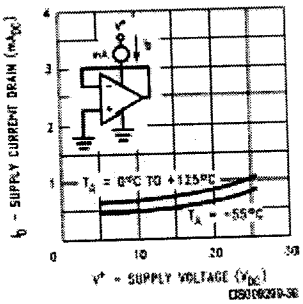
Input Voltage Range



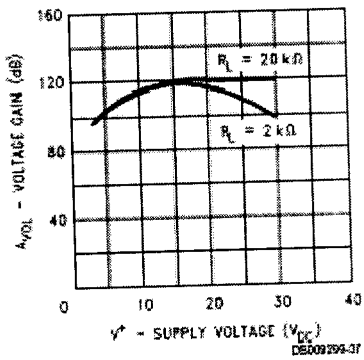
Input Current



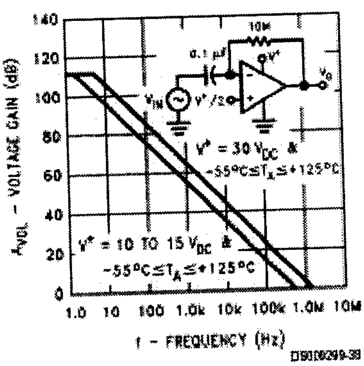
Supply Current



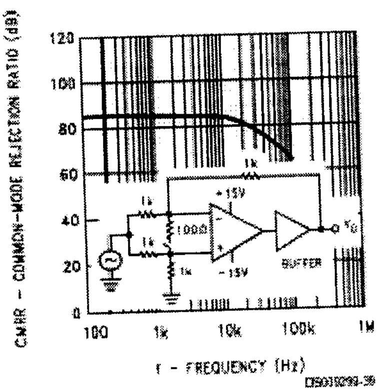
Voltage Gain

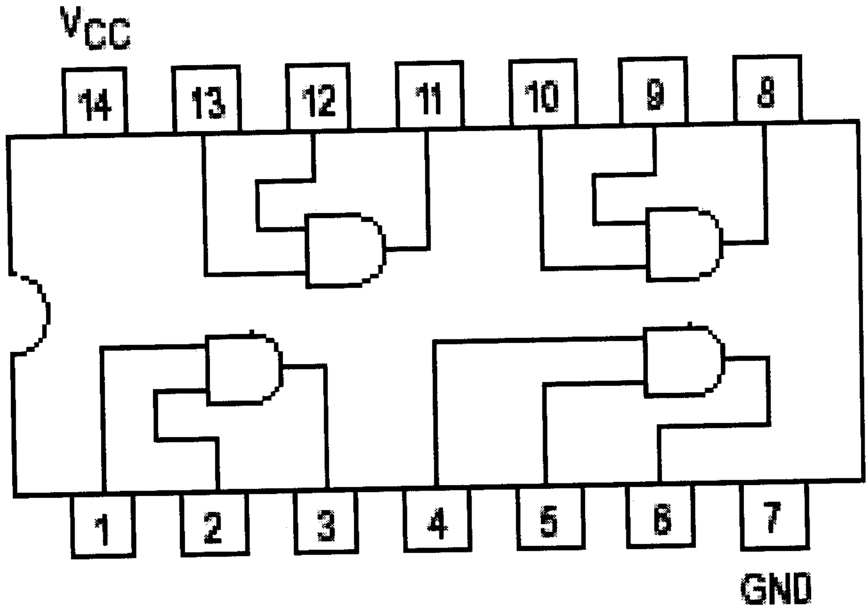


Open Loop Frequency Response

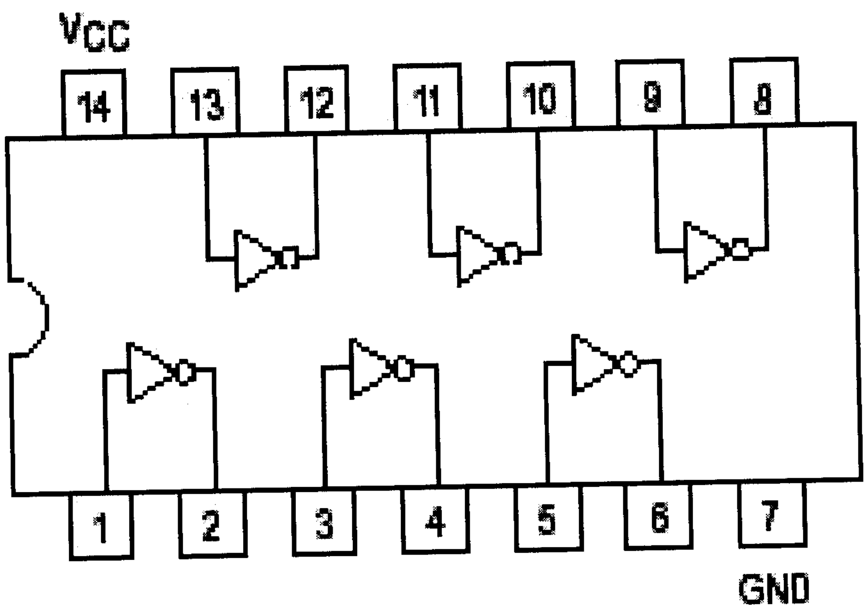


Common Mode Rejection Ratio

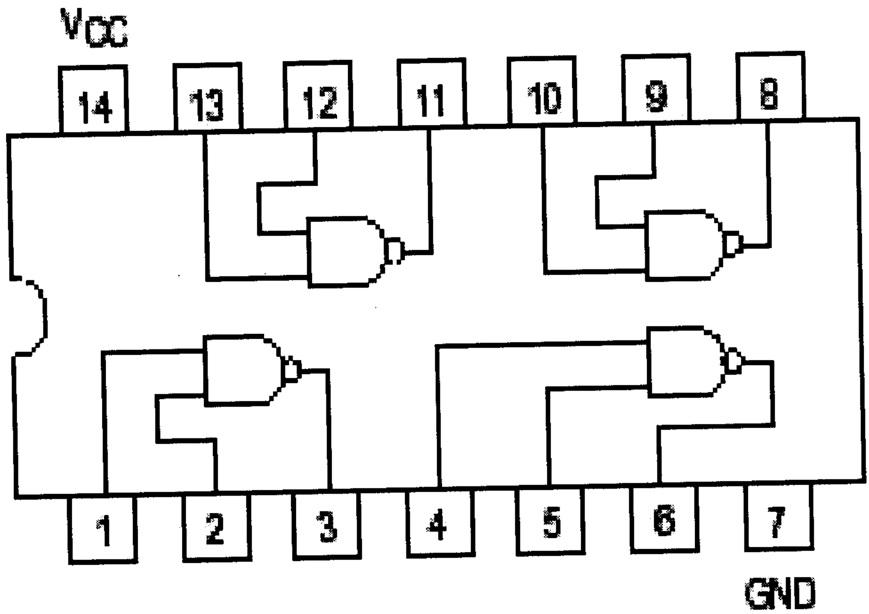




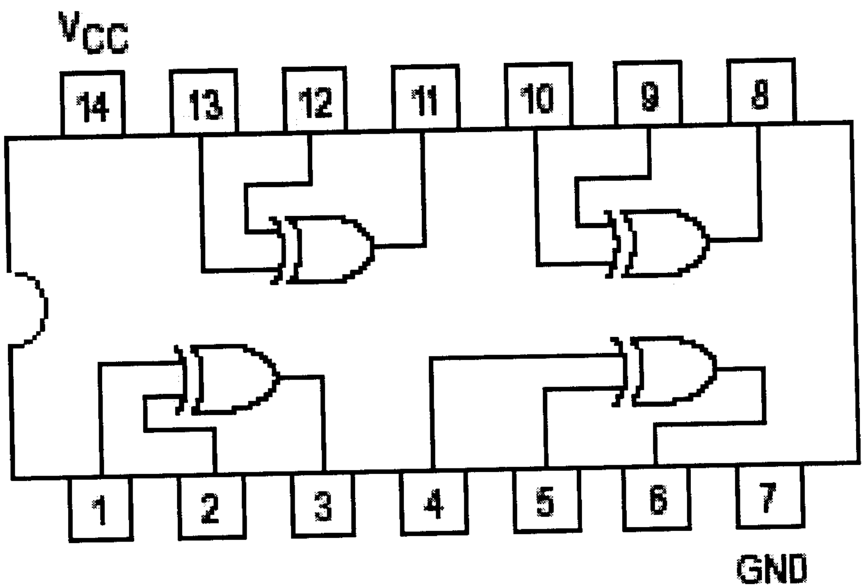
PIN CONFIGURATION OF AND GATE (IC 7408)



PIN CONFIGURATION OF NOT GATE (IC 7404)



PIN CONFIGURATION OF NAND GATE (IC 7400)



PIN CONFIGURATION OF EX-OR GATE (IC 7486)

COST CALCULATION

COST OF COMPONENTS COMMON TO ALL CIRCUITS

SNo.	Component list	Type	Quantity	Make	Cost(Rs.)
1.	Transformer	(6-0-6)V	1		36.00
2.	Diode	IN4007	4	MIC	1.04
3.	Capacitor	100Uf 10uF	1 1	INCAP	2.70 0.80
4.	Regulator	7805	1	ST	4.93
5.	HS133 Sensor		1	Sencera	145.00
6.	2 pin connector		1	Molex	2.60
7.	6 pin connector		1	Molex	5.70
8.	Heat sink		1		4.0
9.	LED		3		5.10

Total = Rs. 207.87

COST OF BUZZER CIRCUIT

SNo.	Component list	Type	Quantity	Cost(Rs.)
1.	Buzzer	TDB-12PN	1	13.65
2.	Diode	IN4007	1	0.26
3.	Resistors	MFR	2	0.30
4.	Transistors	BC547	1	0.73

Total = Rs. 14.94

Cost of common components = Rs. 207.87

Cost of buzzer circuit = Rs.14.94

PCB cost = Rs.15.125

General cost = Rs.237.935

COST OF CIRCUIT USING LM324, AND GATE AND NOT GATE

SNo.	Component list	Type	Quantity	Cost(Rs.)
1.	Resistors	MFR	9	1.35
2.	Op-amp	LM324N	1	3.90
3.	And gate	IC 7408	1	8.00
4.	Not gate	IC 7404	1	8.00
5.	IC Base		3	6.24
				39.97

General cost =Rs. 237.935

Total = Rs. 277.905

COST OF CIRCUIT USING LM324 AND NAND GATE

SNo.	Component list	Type	Quantity	Cost(Rs.)
1.	Resistors	MFR	9	1.35
2.	Op-amp	LM324N	1	3.90
3.	Nand gate	IC 7400	1	10.00
4.	IC Base		2	12.48
				27.73

General cost =Rs. 237.935

Total = Rs. 265.665

COST OF CIRCUIT USING LM324 AND EX-OR GATE

SNo.	Component list	Type	Quantity	Cost(Rs.)
1.	Resistors	MFR	9	1.35
2.	Op-amp	LM324N	1	3.90
3.	Ex-Or gate	IC 7486	1	8.00
4.	IC Base		2	12.48
				25.73

General cost =Rs. 237.935

Total = Rs. 263.665

COST OF CIRCUIT USING LM324

SNo.	Component list	Type	Quantity	Cost
1.	Resistors	MFR	4	0.60
2.	Op-amp	LM324N	1	3.90
3.	IC Base		1	6.24
				10.74

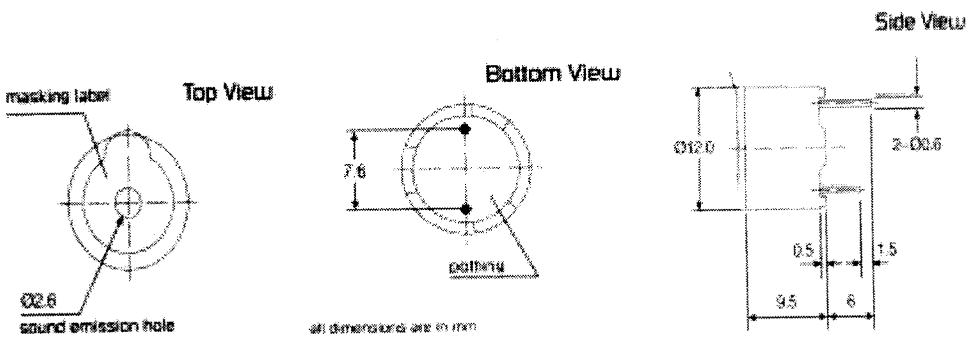
General cost =Rs. 237.935

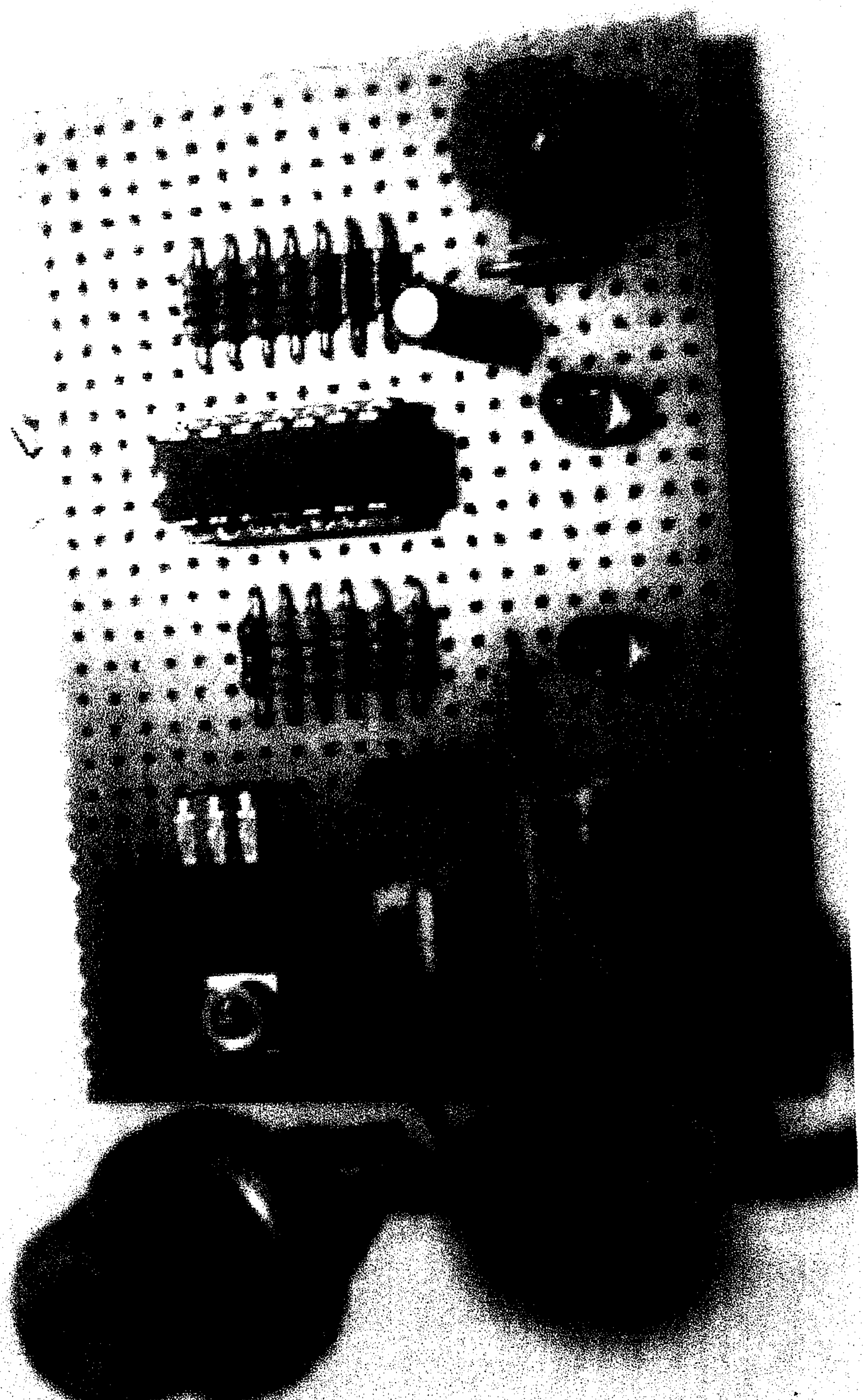
Total = Rs. 248.675

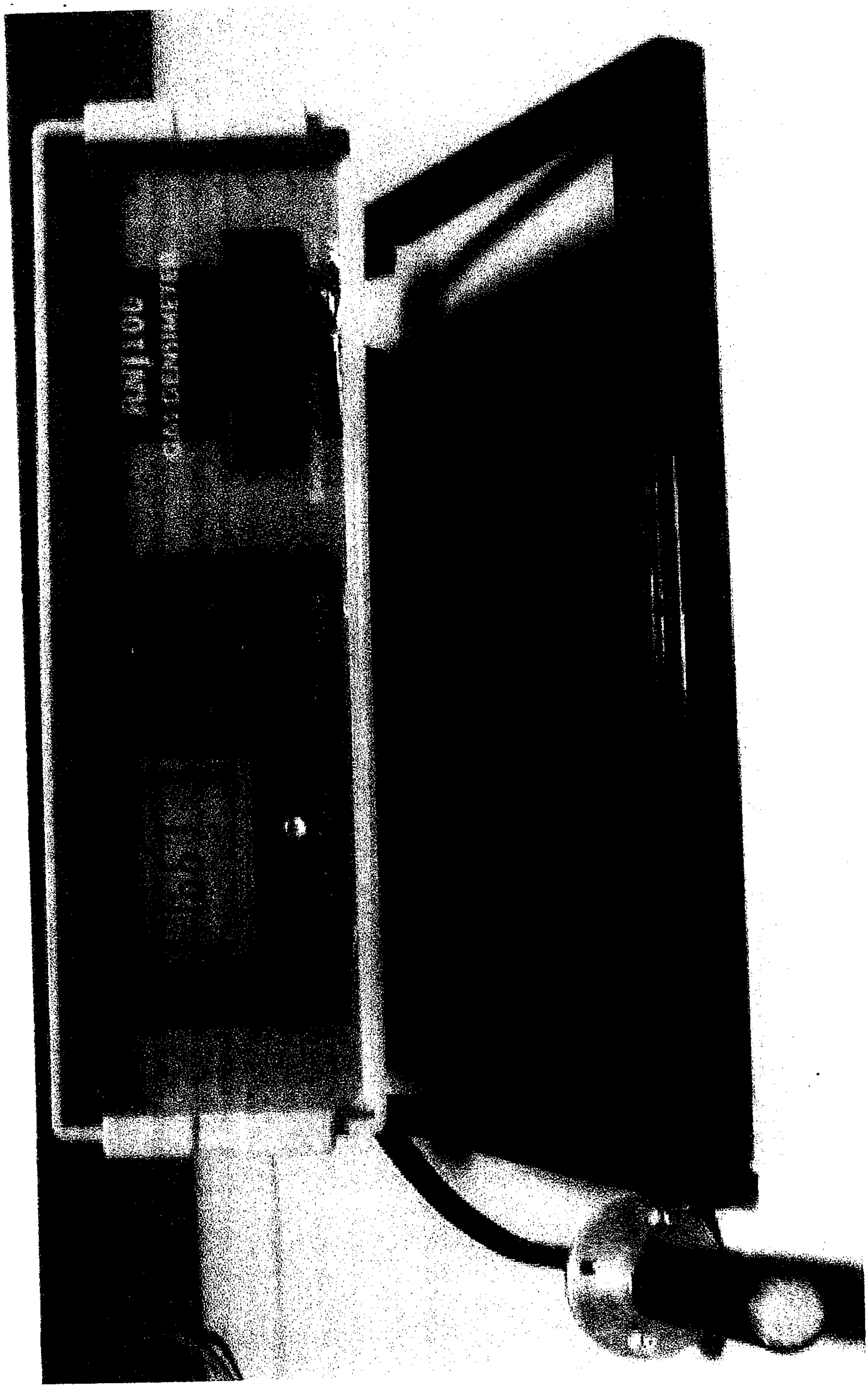
TDB series Magnetic Buzzers

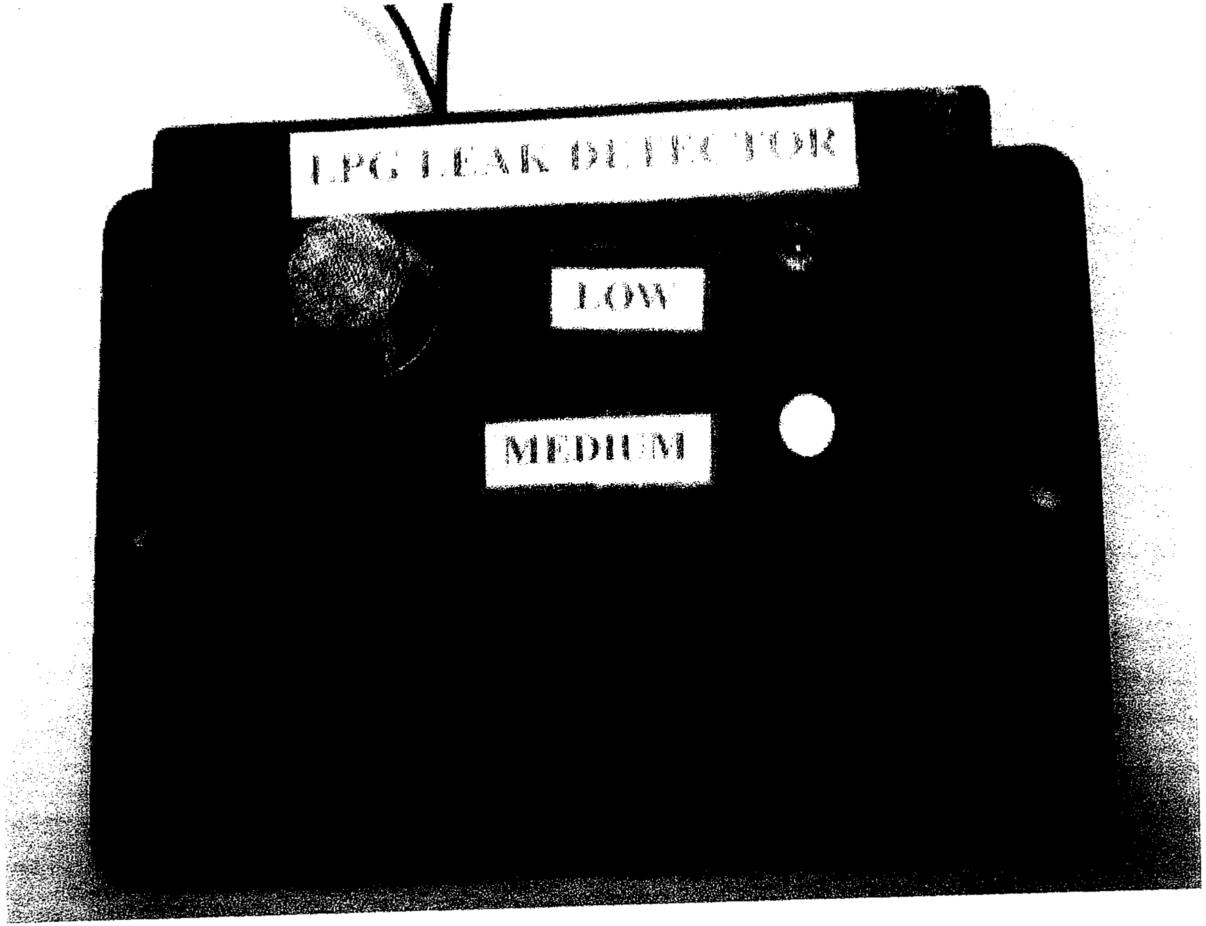
ELECTRICAL SPECIFICATIONS

MODEL NUMBER	TDB 12
Operating Voltage(Vdc)	8 – 15
Rated Voltage (Vdc)	12
Max. Rated Current (mA)	30
Min. Sound Output (dBA/10cm)	85
Frequency (Hz)	2300+/-300
Tone Nature	Single
Operating Temperature	- 40 to + 85
Weight (gm)	2








LPG LEAK DETECTOR
LOW
MEDIUM