<u>Autonomous Gas Monitoring System</u>

Subject: Atmospheric Sciences

Duration in Months: 9 months(Sept'09-june'10)

Total Cost: Rs.2,65,000

Foreign Origin: Sensors

Project Category: Applied Research (Sensor technology,wireless data transfer, micro controller)

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Project Summary:

Abstract: Proposal describes the design of Ambient air quality monitoring system that can continuously track certain environmental parameters.

Aspects:

Power consumption: Successful autonomous system must have low power consumption balanced by its capability to scavenge energy from its immediate environment.

Power consumption: 5 sensors(5*400 mW)+ 5 micro controller or micro processors(5*5V*10mA=250 mW)+ motor for sampling tube(1 W) =3.25 W

Power provided by solar cell = 20 watts under winter time solar light

Display unit and other units power will be supplied through power unit nearby.

Robustness: The system will need to be resistant to the elements through encapsulation in a rugged casing that will ensure the system is resistant to shattering, water and vandals.

Data input-output: At the location of sensor, the Gas sensors will measure the concentration of Gas at that point. MCU over there will process the voltage output and return a string containing the information about the concentration of different gases. In the initial phase of our project, we will send this data to base station by using the most useful feature of GSM protocol i.e. Short Message services (SMS) at regular interval. Server will store this data.

Sampling: Samples must be representative and the sampling ideally should not disturb the last sample. High sampling rate results in high consumption of power while low sampling rate can result in missing of event of interest. So ideally 3-4 samples a day can save us from this compromising situation.

Working module:

Work divided into two important phases

Phase 1:

1. Development of sensors monitoring unit and the display unit in laboratory. Following features of sensors used to be taken into account:

1. High sensitivity to the applied gas or environment parameter.
2. Stable and long life.
3. Dimension: Dimension must be small to keep the size of unit under control (gas sensor: diameter~16 mm, hieght~ 10 mm, pressure and humptemp sensor: hieght~ 10mm, length and breadth~ 10 mm)

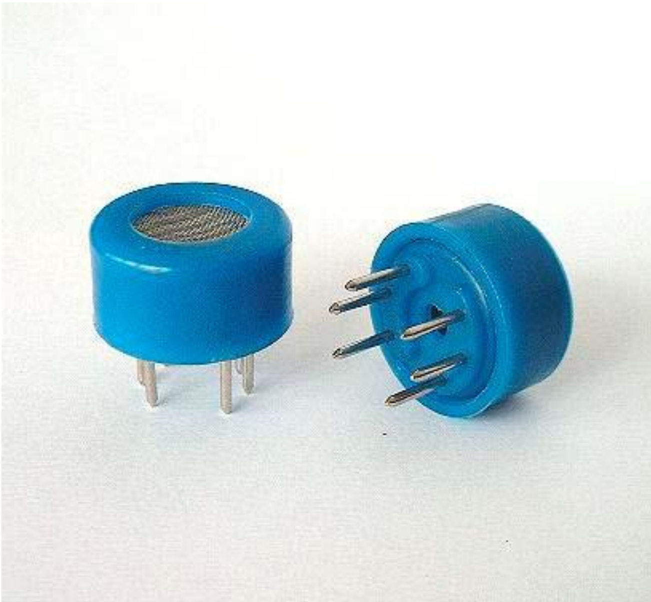
Features of sensors we are using:

<u>OZONE DETECTING SENSOR</u>

For ozone detection we are using **<u>MQ -131</u>** sensor

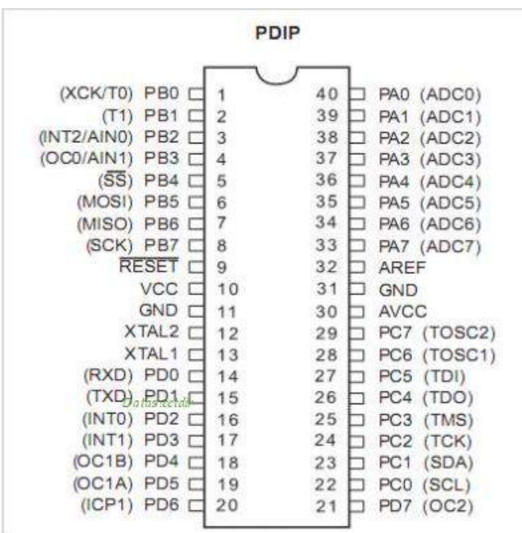
<u>USEFUL LINK</u>

http://www.futurlec.com/Ozone_Gas_Sensor.shtml



This will directly be attached to atmega-32 microcontoller whose base program will be written on CVAVAR using C++ for coding purpose.

AtMEGA-32 datasheet



ALOGORITHM

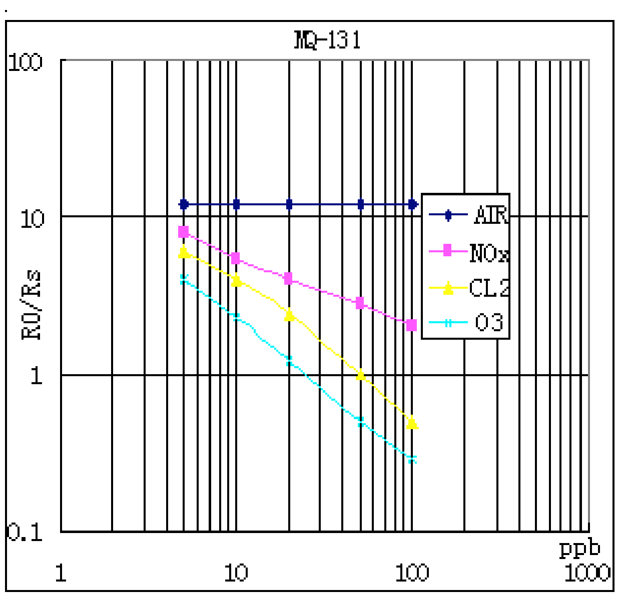
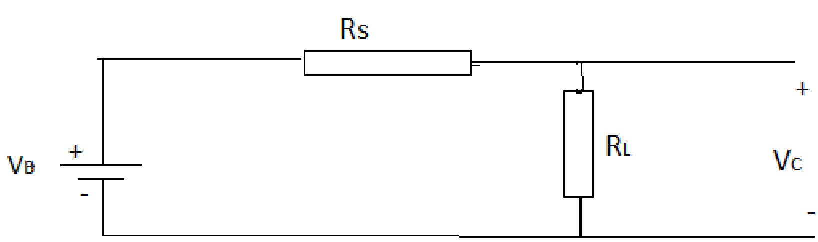


Figure shows the typical sensitivity characteristics of the MQ-131 for several gases. in their:
Temp: 20^o
Humidity: 65%
O_2 concentration 21%
R_L=20kΩ
Ro: sensor resistance in the clean air.
Rs: sensor resistance at various concentrations of gases.

<u>Equation used:-</u>

<u>CIRCUIT DIAGRAM</u>



$(V_B-V_C)/Rs= V_C/R_L$

$Rs=(V_B/ V_C -1) \; *R_L$

$Rs/Ro=(V_B/ V_C - 1) \; *R_L/Ro$

As there is a linear Equation of the graph log (Rs/Ro) = m log(ppb) + c

now the **required equation**,

$ppb = (Rs/Ro*10^{-c})^{1/m}$

$$ppb = ((V_B/V_C - 1) * R_L/Ro * 10^{-c})^{1/m}$$

where,
V_B :- voltage of the battery.
V_C :- output voltage given by the sensor.
R_L :- 20kΩ.
Ro :- sensor resistance in the clean air.

We can know the value of m and c by using any two points on the graph

We will send the ppb value through GSM

RESULT

Input that will be given by the sensor to the microcontroller is Vc.

Output that will be given by the microcontroller will be ppb.

2. Microcontroller unit: Each sensors might need its individual microcontroller unit or it can be adjusted with the no. of pins. We will be using Atmega-16 as our microcontroller. We have a gas sensor circuit diagram according to the figure:

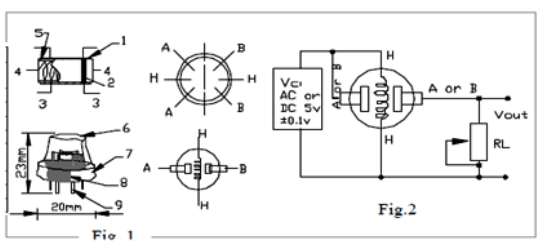


Fig 1 Fig.2

In the figure we will connect 'Vout' to input of adc into the microcontroller where we will keep the adc into free running whre it will take the input continuously according to its frequency. We can monitor output of 8 gas sensors using a single mcu (Atmega 16).

Algorithm (

Variable a;

a=read_adc (pin x); // if we are using a 8 bit microcontroller a will be a value between 1 to 256 depending upon Vref

Voltage 'v'= (a/256)*Vref;

According to this data of 'v' we will calculate the value of gas concentration using relation of electrolytic oxidation/reduction.

We will take average of such values during an hour maybe.

Then this average value of gas concentration will be transmitted for further analysis using wireless transmitter.

)

Note: here adc will take approximate values of the voltage (according to its least count) which might result in variation in actual results but we will average out the error. Also I am thinking to use something else for reading the analog value of voltage directly and using it for much accurate results.

For such a large averaging time we might have to use microprocessor, we will see it later.

3. Data Transmission: As for our plan, we will be installing the gas sensors at suitable locations, but will have a single base station with a server to collect data, process and store them and accordingly send appropriate command to a particular unit if needed. To accomplish this, here comes the role of Data communication. In this section we will be mainly using two modules: GSM Modem and Transceivers.

0B**GSM MODEM**

GSM (**Global System for Mobile Communications**) is the most popular standard for mobile telephone systems in the world. 80% of the global mobile market uses GSM standard. GSM also pioneered low-cost implementation of the short message services (SMS), also called text messaging, which has since been supported on other mobile phone standards as well. We will be using this feature of GSM protocol to transfer the data to and fro from sensor location to the server.

At the location of sensor, the Gas sensors will measure the concentration of Gas at that point. MCU over there will process the voltage output and return a string containing the information about the concentration of different gases. In the initial phase of our project, we will send this data to base station by using the most useful feature of GSM protocol i.e. Short Message services (SMS) at regular interval. Server will store this data.

This service can also be used by server to command any one of the unit to do work, other than their normal work. In general there is not much fluctuation in the concentration of the air at anyplace, unless something goes wrong in the surrounding. So, in normal condition we will take the sample of gas at larger intervals to save the energy used. In case the server finds a large change in concentration of the gas from the normal value, it can send overriding command to the sensor to take samples at lower interval of time.

We will also provide the facility of providing this valuable information to the general public, so that they can be aware of degrading environment and take step to minimize the pollution at their level. A little contribution from all can help in improving the current or the more worst coming environmental condition. For this they need to send a SMS to a particular number in a particular format, defining the location for which they want the data. Server will look for the data at that location and send back the SMS containing the information about the Gas condition over there.

1B**TRANSCEIVER**

In India, there are still places where there is no GSM connectivity. Other than those remotely inaccessible villages, we may also want to install the Gas sensor in the areas such as mining locations. How to transfer data at these places? For this we have thought of using Transceiver. A Transceiver has a transmit side (Tx) and a receive side (Rx), which are connected to the antenna. This operates on a frequency of 2.4 Ghz. One of the transceiver will be located at the sensor site and the other on the nearest site, where there is a good GSM network signal strength (let's call it sub-station). This will constitute its own network. Instead of SMS now data from the MCU can be sent through this pair of Transreceivers. Depending upon the distance between the sub-station and the Gas sensor; and the range of transreceiver used there may be a chance of deporting additional transceiver. Transceiver used by us is: 24XStream, 50mW transceiver, w/MMCX, 19200 bps part number X24-019NMC. Now at sub-station, we will also have a GSM modem. Data received through transceiver will be sent to server through SMS by GSM modem. Rest all will be the same. In this fashion we can cover the whole terrain.

2B**Why GSM is preferred over Transreceiver**

This is entirely to reduce the project cost. In GSM system we are using the already network of GSM service provider, in lieu of a very small charge. If we use the transreceiver, whole the way, we will have a very large establishment cost and also we will have to incur maintenance cost.

4. Display Unit: Following factors to be kept in mind while with LED display:

- Outdoor display
- The placement of the led display will affect the minimum and mega mum viewing distance.
- Contents on the display in running mode and the type of content to be displayed, in our case its mostly text or numerical type.

Specification of display unit given below:

LED DISPLAY (DOT-MATRIX DISPLAY)

A dot matrix display is a display device used to display information on machines, clocks, railway departure indicators and many and other devices requiring a simple display device of limited resolution. The display consists of a matrix of lights or mechanical indicators arranged in a rectangular configuration (other shapes are also possible, although not common) such that by switching on or off selected lights, text or graphics can be displayed. A dot matrix controller converts instructions from a processor into signals which turns on or off lights in the matrix so that the required display is produced. We are using Dot-matrix display to display the current composition of gases, day's max & min content of certain gases and certain informative texts.

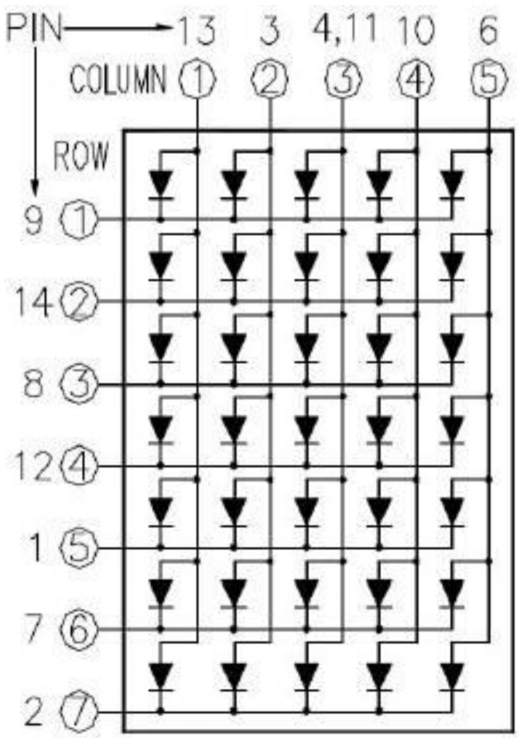
We are using 120*8 matrix display.

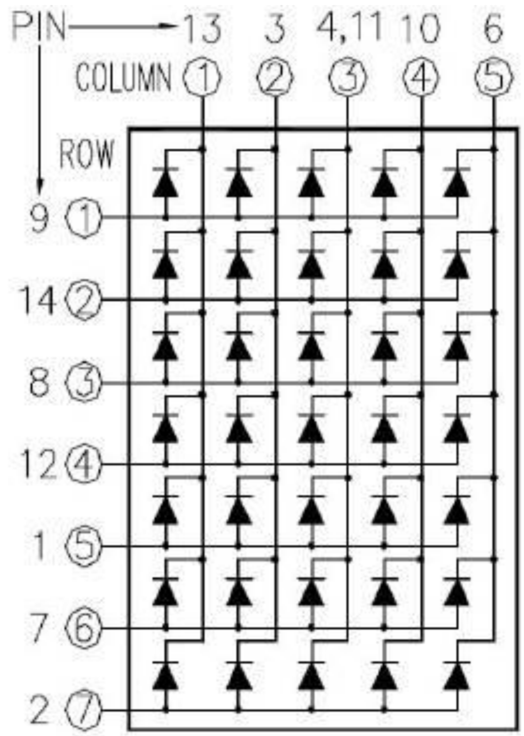
One or more dot matrix display is multiplexed to form a display panel. A set of hex values define a character which are send to the dot matrix display. To minimize the pin usage led matrix is formed having certain number of rows and columns. The concept is to refresh each display unit with a frequency at which human eye cannot perceive changes.

Dot matrix displays are available with common cathodes as the columns and common anodes as the columns. The led’s may be single color, bi-color or RGB.

Example of how dot matrix circuit looks like

Here we are interfacing 5x7 dot matrix display with common cathode columns and having bright red led’s. The cathodes are shorted along the column and anodes shorted along the row.5x7 dot matrix display needs 7 Row drivers and 5 Column drivers.


PIN
13
3
4,11
10
6
COLUMN
1
2
3
4
5
ROW
9
1
14
2
8
3
12
4
1
5
7
6
2
7


PIN
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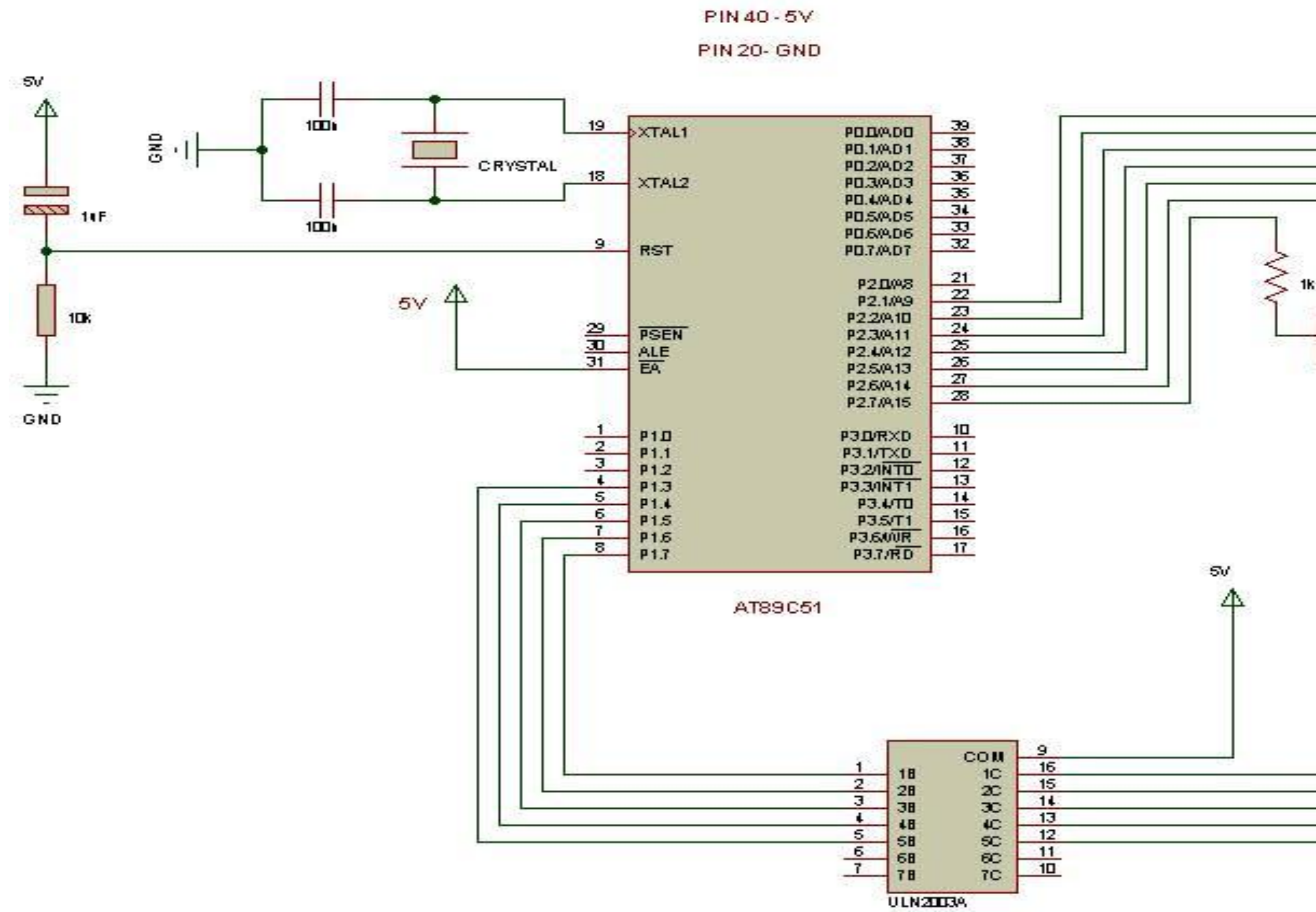


The transistors are turned on by the TTL voltages applied by the Port 2 of MCU to their bases through 1-kilo ohm resistors. To make any led segment glow just make the respective row and column bits on. We send the hex value of character to be displayed in first column to Port2 and send columns selection byte to Port1.Then we send another hex value to row and select the respective column. This process is done very fast and it seems that the whole character is displayed at the same time.

We are making a 120*8 resolution dot matrix, so it is impossible to build such display with having address to each LED individually, which would be near impossible for a display with more than just a few LEDs. One of the first ways we might have thought of to do this is to put enough shift registers on display to hold a bit for every LED. Then, connect the cathodes to the appropriate bit of the right register, and also connect all the anodes to positive voltage. To display something on dot-matrix display, we'd just shift in the data one bit at a time for the entire sign.

This would work, and it might even do a decent job at it. But there are a few problems with it. First, it requires a chip for every four or eight LEDs. Second, it probably won't be very bright since our register might only be able to sink of few mA of current per pin.

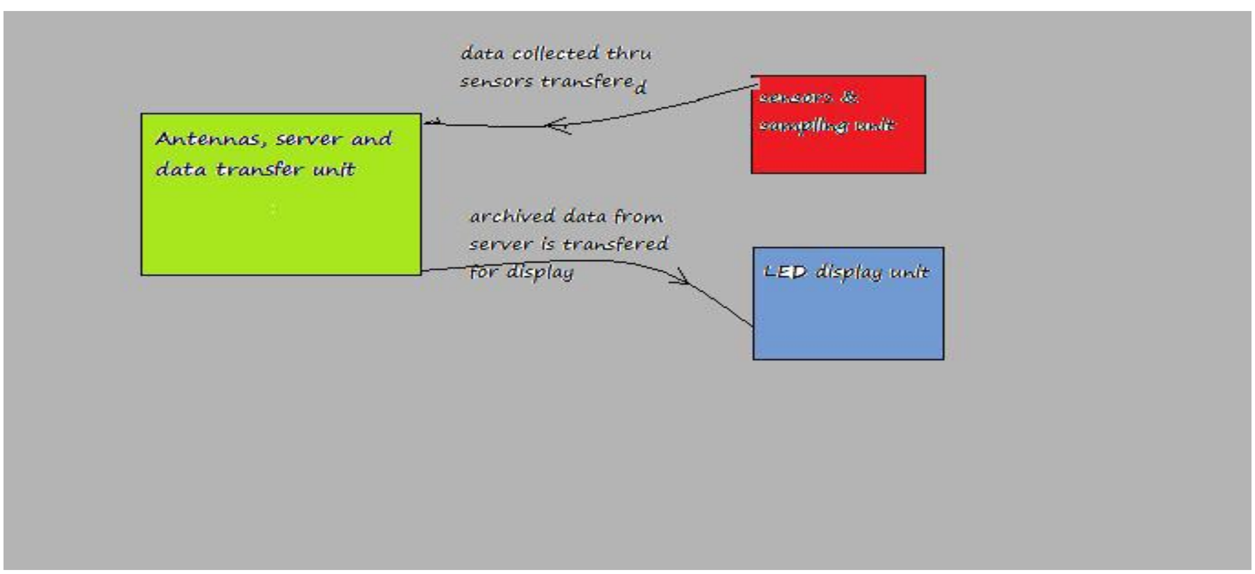
The solution to both of these problems is quite simple. We can take advantage of "persistence of vision," which means that if you display several things very quickly, your eye will act as if they all were displayed simultaneously. This is how televisions appear to be displaying an entire picture when it's really only an electron beam displaying a single point at a time.

Instead of every row always displaying its data, we can display the data only for a single row at a time, but cycle through all the rows very quickly. We connect a single shift register output to all the cathodes in a column. Then, to display the row we want, only one row is connected to +5V at any time. We can accomplish this with a ring counter, so that only one row is logic "1" at any given time.

We've made a simple schematic for running an 8x8 grid of LEDs using a de-multiplexer, some inverters, and a shift register. The two input lines to the de-multiplexer decide which row will be illuminated. Then, we use the clock and shift register input to move your data into the shift register. The transistors allow more brightness, and they also invert the shift register outputs.

Phase 2:

1. Sensor fixed at certain location inside the campus.



2. Data retrieved from sensor unit will be transferred to the main server through gsm or transreceiver.

3. Server will analyze and archive the data and would relay the processed data back to the respective displays.
4. Archived data would be processed to keep record of the maximum and minimum amount of the various gas parameters and will display it.

Design:

System consists of three parts:

1. ***Sensing chamber***: It consist of :

I. Sampling Cell: Basically it will be plastic tube connected to a motor which will take the air sample in it and it will be closed at both ends with a valve which will open only while taking the samples. Sample will be taken such that two consecutive samples will not disturb the reading of each other. We will take each sample after one or two hour and will turn off the motor so it will not affect next reading. In the figure 2 is sampling tube and 3 is the motor driving it.

II. Sensors: Electrochemical sensors detect gases by producing a chemical reaction between the gas being measured and oxygen contained in the sensor. This reaction produces a small current, which is proportional or substantially proportional to the concentration of the polluting gas present. The sensor is, in effect, a type of fuel cell. In our design sensors will be embedded in the sampling tube. In figure, 1 and 4 are sensors and there electrical units. Parameters for the gases to be detected are taken according to the recommendation of CPCB:

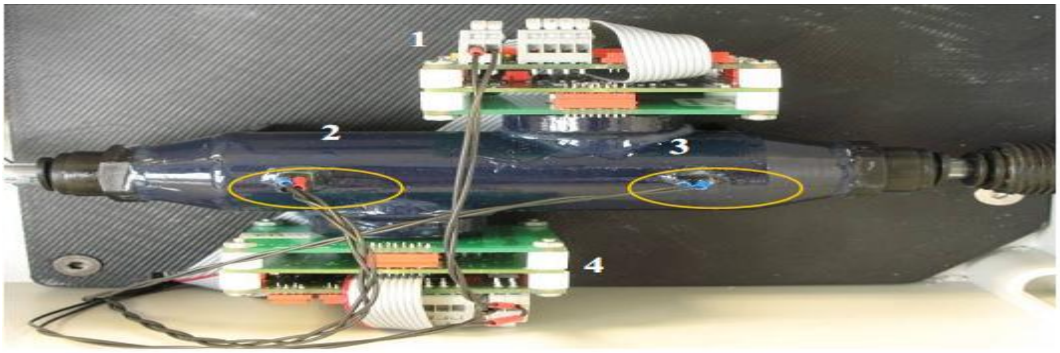
Parameters	Least count of Instruments(in ppm)
CO	10
SO2	5
NOx	10
NH3	10
Pressure	300-1100hpa

III. Integrated Chip's: These are designed to convert output from sensor(i.e, in the form of the current produce on the electrodes of the sensors which will be collected by the IC's) to some form(such as digital signal) that is easy to transfer through transmitter.

IV. Battery: Batteries are used for the working of the sensors. We will use solar cell to charge the batteries. We are using 20V batteries and one 20W solar panels for a single unit.

V. GSM OR Transreciever: It can transfer data at 1kbps within range of 10 km for transreceiver and anywhere with network connection through GSM. Transmitter will transfer the data after each sampling to the display unit where it will be received by the receiver antenna and will be displayed on the board.

VI. Box: The above all part will be tightly packed in a box which is water resistant thermal resistance to some extent. All the above procedure is automated.



2. Data Retrieving Unit: Data transmitted by the transreciever will be collected by the antenna connected to server which will manipulate it and store the important data.

3. Display unit: This unit consists of LED's display board(to display the conc. of gases samplised), MCU(to convert the signal received by the receiver antenna to able to display on LED's board) and a antenna(which will receive the data transfer by retrieving unit and this data will be converted by the MCU to digital unit).

Specifications:

Ad hoc network (self-organized): No any human interference between data collection and the
No any human interference between data collection and the between Environment-to-person communication.
Sensing capability: sensing capability will be a compromise between market price and need of
Accuracy.
Communication, processing, memory capabilities
Energy- constraints:
Unconstrained (if connected to the power grid)
Mobile/immobile: It can be set anywhere at some higher altitude and sufficient sunlight.
Base station: main base station with server and required hardwares energy

Origin of the proposal
India being the 4th largest emitter of Greenhouse gases, niggling environment makes its high time to make peoples aware of the situation.
Gas Sensing and Monitoring refers to the process of continuously tracking the changes in concentration of different air component.

Definition of the problem
Growing urbanization and no. of Industrial towns make it a requirement to have a close concern of the environment.
Hard to keep monitoring continuously certain sites such as industries,busy traffic signals,villages prone to soil erosion & high ammonia concentration etc.

Objectives

1. To develop device able to monitor certain atmospheric components and transfer the datas continuously for the display.
2. To determine status and trends of ambient air quality.
3. We can share certain details with agencies like Town and Country Planning Department,

Kanpur Development Authority etc engaged in pollution control in Kanpur.

Review of status of Research and Development in the subject:

National Status

In Kanpur, monitoring of PM10 is being conducted with the objective to determine status of PM in ambient air of Kanpur and to assess the content of sulphate in PM under the World Bank Assisted Program.The monitoring was started at 6 locations in Kanpur in July 2000 by CPCB and in September 2000 by the National Environmental Engineering Research Institute (NEERI) at three locations.

Many companies and research laboratories giving latest development in the field of gas monitoring and sensing. eg- Pollution protection systems Mumbai Pvt.Ltd.,India Big Patent etc.

Central Pollution Control Board is executing a nation-wide program of ambient air quality monitoring known as National Air Quality Monitoring Programme (NAMP). The network consist of 342 operating stations covering 127 cities/towns in 26 States and 4 Union Territories of the country.

International Status

1. Safegas is the favored human machine interface for mine gas monitoring systems in Australia and New Zealand because it provides a user friendly, Windows based front end that is compatible with a range of tube bundle and real-time telemetric hardware and is scalable to cater for future system expansion. Features include alarms raised on gas values, explosibility, gas ratios, rates of change and hardware faults. The Safegas system has various security levels, audit trails, automated calibration and is highly user customizable.

2. Monitoring landfill gas migration. Landfill **gas monitoring** is the process by which gases that are released from by decomposition of biodegradable waste in anaerobic environment are electronically monitored.

3. **Dr.R Kumar of University of Cambridge** intended to develop a solid state electrolyte using software with fuzy logic and neural network properties such that the system capable of learning gas profiles & overcome problems of cross sensitivity.

4. **Uni. of California: Developing** mass spectrometer for gas monitoring.

5. **World Academy of Science: Development** of autonomous gas monitoring system with the help of GSM and Blue tooth services. Infrared sensing technology is being used for monitor of greenhouse gases like CH_4 and CO_2 at point sources.

- **<u>Importance of the proposed project in the context of current status:</u>**

. India lagging far behind in gas monitoring technologies. Municipalities and Govt. authorities not working as par as expectation, making people aware might pressurized them to work.

. Providing such a device at affordable prices so that factories, municipals, researchers etc can easily have access to certain datas of their interest.
. "The UK Government's chief scientist now says climate change is a far worse danger than international terrorism" (BBC News, 10 Jan 04)
. Environmental phenomena are a major scientific and societal concern:
–Pollution
–Water
–Climate
. Information technology, communications and sensing are enabling technologies
. Due to current technological changes, there will be a watershed phenomenon in
–Ability to monitor
–Price point
–Infrastructure
–Data processing

Future Prospects:

- Gas sensing and Monitoring device may be available in the market at affordable prices so that factories, municipals, researchers etc can easily have access to certain datas of their interest.
- Can be developed for monitoring of **Landfill Gas Monitoring** with a very little advancement.
- Can be developed for volcanic prediction using gas chemistry in a safer way by modifying the design and robustness of device.
- Wireless sensor networks can be used to measure and monitor the water levels within all ground wells in the landfill site and monitor leachate accumulation and removal. A wireless device and submersible pressure transmitter monitors the leachate level.
- Using wireless sensor networks within the agricultural industry is increasingly common. Gravity fed water systems can be monitored using pressure transmitters to monitor water tank levels, pumps can be controlled using wireless I/O devices, and water use can be measured and wirelessly transmitted back to a central control center for billing.
- **Cost Analysis(a single device):**
- Projected cost including :
- sensors(8 pieces: 5 gas sensors + 3 other sensors) ~ Rs 6,000
- microcontroller unit + transmitter-receiver system ~ Rs15,000
- + solar cell +sampling chamber + 2 batteries
- server ~ Rs 20,000
-
- LED display ~ Rs 5,000
- Total cost ~ Rs 46,000

Problems to be tackled:

- Working of sampling tube: For each sample to be representative valve should be automatically working and pump should be working all time.

- Data transmission: difficulty will rise in transmission of data if transmitter put inside the sealed box.
- Data losses: Information losses might occur during transmission ; can be corrected by putting a microchip of certain which can store data and transmit it a while later.

Sampling chamber: polycarbonate chamber can be used for our requirement

Progress in the project:

1. Purchasing has been done for one unit of the device
2. Data transmission working and solar cell working has been checked.
3. One display unit board has been in progress.
4. Trying to apply for Tepp funding for our project
5. Programs have already been written for few of the sensors.