Air pollution and concern about air quality is not something new. Complaints were recorded even in the 13th century when coal was first used for industrial purposes in London. From the middle of the 19th century, the atmosphere of major British cities was regularly polluted by coal smoke in winters, giving rise to the infamous mixture of fog and smoke known as smog. Today the emphasis has shifted from pollution problems caused by the industry to the ones associated with motor vehicle emissions.

Author's Prototype

Air Quality Index

Air Quality Index, or AQI, is a number used by government agencies to communicate to the public how polluted the air currently is, or how polluted it is likely to become. As AQI increases, an increasingly large percentage of the population experiences severe adverse health effects.

Different countries have their own air-quality indices corresponding to different national air-quality standards. Some of these are Air Quality Health Index (Canada), Air Pollution Index (Malaysia) and Pollutant Standards Index (Singapore).

The national AQI was launched in New Delhi on September 17, 2014, under Swachh Bharat Abhiyan. There are six AQI categories (Table I) of the same. The proposed AQI considers eight pollutants (PM10, PM2.5, NO2, SO2, CO, O3, NH3 and Pb) for which short-term (up to 24-hour averaging period) National Ambient Air Quality Standards are prescribed.

For details, you may refer this link: click here

In this project the sensors used are SDS011, MQ-135, DHT11 and DS1307 (as shown in Fig. 1).

A typical PM2.5/10 based meter costs around US$ 200. Here we present a meter for monitoring air particles, gas concentration, temperature, humidity and time, which costs around US$ 45 only. Block diagram of the air-quality meter is shown in Fig. 1.

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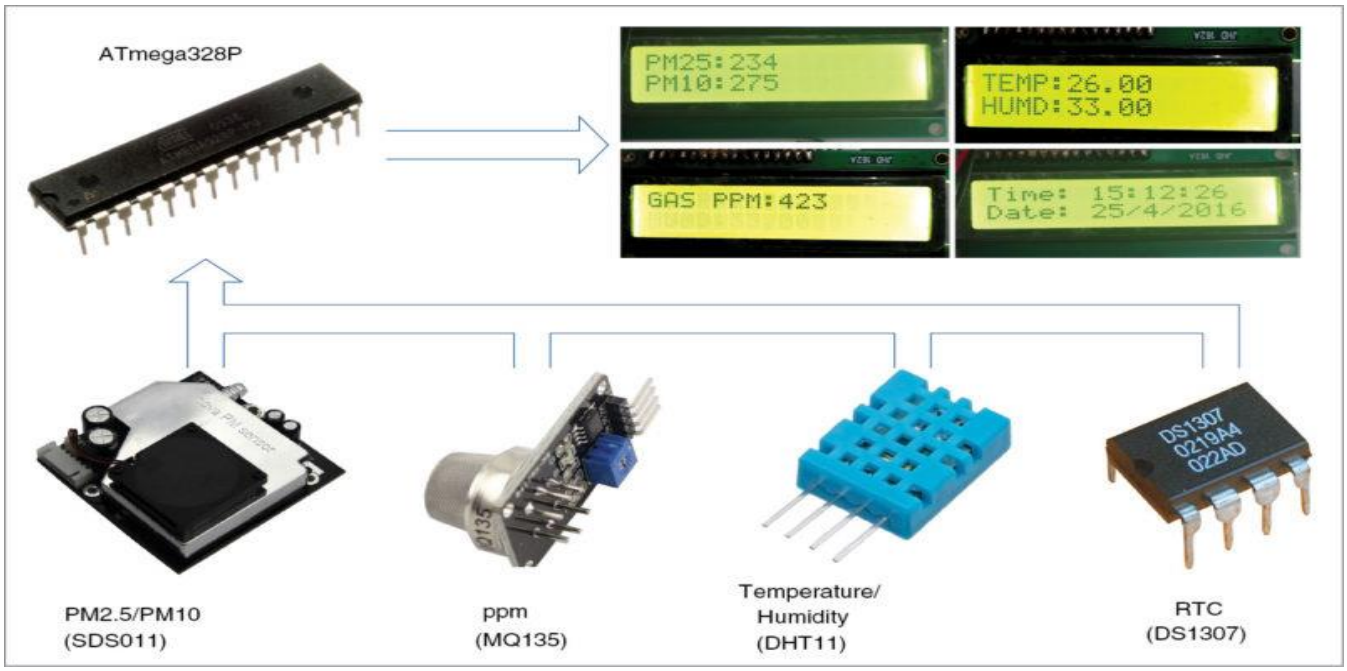

Fig. 1: Block diagram of the air-quality meter

TABLE I
AQI CATEGORIES

AQI Category (Range)	PM10 (24hr)	PM2.5 (24hr)	NO_2 (24hr)	O_3 (8hr)	CO (8hr)	SO_2 (24hr)	NH_3 (24hr)	Pb (24hr)
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.6-1.0
Moderately polluted (101-200)	101-250	61-90	81-180	101-168	2.1-10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	11-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748	18-34	801-1600	1201-1800	3.1-3.5
Severe (401-500)	430+	250+	400+	748+	34+	1600+	1800+	3.5+

Circuit and working

Circuit diagram of the air-quality meter is shown in Fig. 2. Heart of the circuit is ATmega328P (IC3). Other components used are voltage regulators 7805 (IC1 and IC2), 16×2 LCD display (LCD1), temperature and humidity module DHT11 (connected to CON4), gas sensor MQ135 (connected to CON3), PM2.5/PM10 sensor (connected to CON2) and a few others.

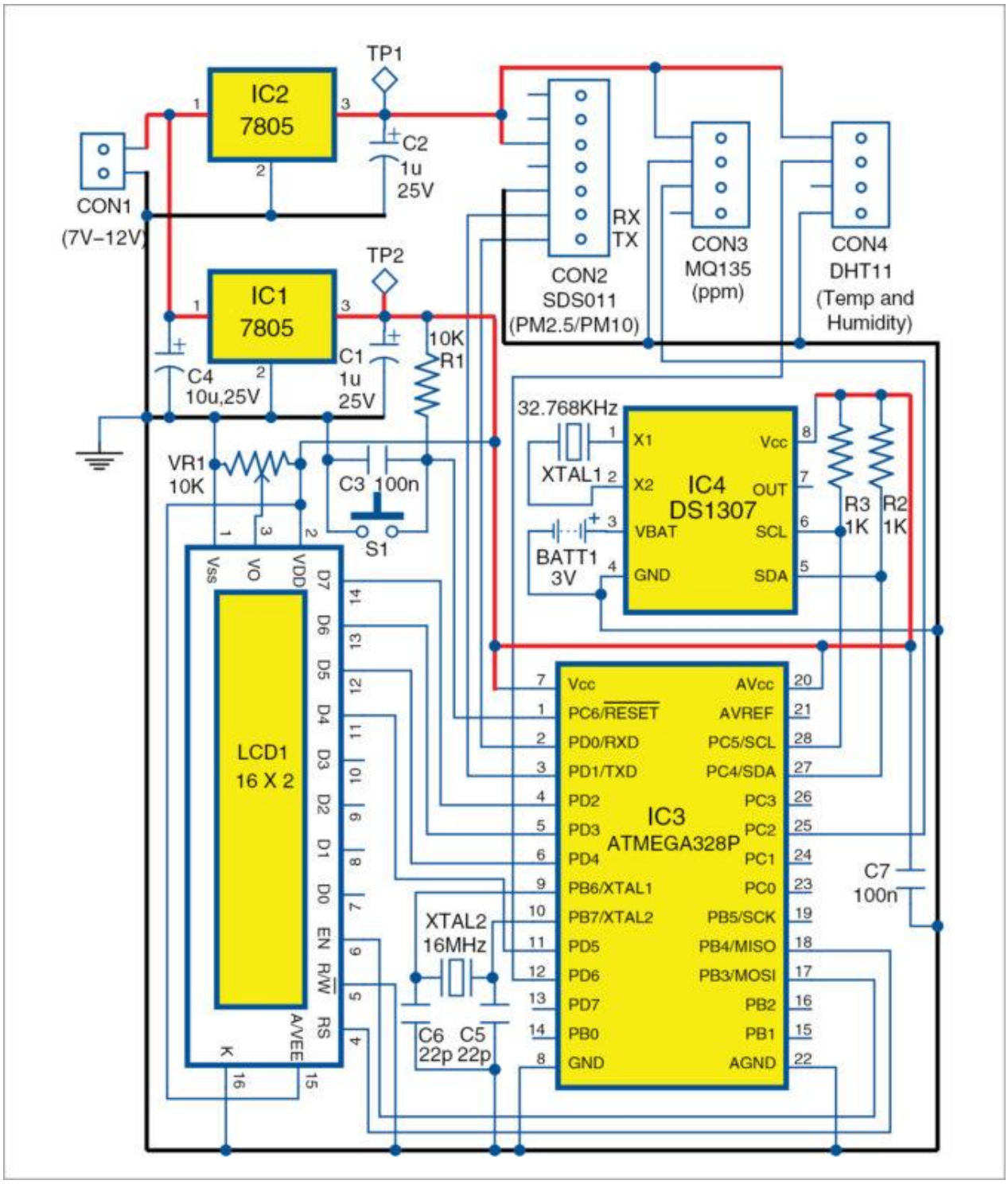

Fig. 2: Circuit diagram of the air-quality meter

PARTS LIST

Semiconductors:

IC1, IC2	- 7805, 5V regulator
IC3	- ATmega328P MCU with Arduino Uno bootloader
IC4	- DS1307 serial, I2C real-time clock

Resistors (all 1/4-watt, ±5% carbon):

R1	- 10-kilo-ohm
R2, R3	- 1-kilo-ohm
VR1	- 10-kilo-ohm potmeter

Capacitors:

C1, C2	- 1µF, 25V electrolytic
C3, C7	- 100nF ceramic disk
C4	- 10µF, 25V electrolytic
C5, C6	- 22pF ceramic disk

Miscellaneous:

XTAL1	- 32.768kHz crystal
XTAL2	- 16MHz crystal
BATT1	- 3V battery
S1	- Tactile switch
LCD1	- 16×2 character module display
SDS011	- PM2.5/PM10 sensor
MQ135	- ppm gas sensor
DHT11	- Temperature/humidity sensor
CON1	- 2-pin connector terminal
CON2	- 7-pin connector
CON3, CON4	- 4-pin connector
	- 12V DC supply/12V battery
	- 7805 heat-sink

ATmega328P. It can be programmed with embedded software using a standard programmer or Arduino IDE. ATmega328P offers 23 input/output functional ports, and a 16MHz crystal oscillator is used to provide timing/clock reference.

Temperature and humidity module (DHT11).This composite sensor contains a calibrated digital signal output of temperature and humidity. The sensor (connected to

CON4) includes a resistive-type humidity measurement component and an NTC temperature-measurement device. Its output pin is connected to pin 12 of IC3.

Serial real-time clock (RTC) IC (DS1307). It is a low-power, full binary-coded decimal (BCD) clock/calendar with 56 bytes of NV SRAM. Addresses and data are transferred serially through an I2C, bi-directional bus. The clock/calendar provides information about seconds, minutes, hours, days, dates, months and years. SCL and SDA pins of IC4 are connected toSCL (pin 28) and SDA (pin 27) pins of IC3, respectively.

TABLE II
TEST POINTS

Test point	Details
TP1, TP2	5V

(Voltage measured with respect to ground)

Air-quality sensor (MQ135). The sensitive material of the sensor is tin-dioxide (SnO2), whose conductivity increases with concentration of gas. Change in conductivity is converted into output voltage signal, which varies corresponding to the concentration of the combustible gas. MQ135 is highly sensitive to ammonia, sulphide and benzene steam, smoke and other harmful gases. It is a low-cost sensor, suitable for different applications. Output of the gas sensor (CON3) is connected to analogue input pin 25 of IC3.

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PM2.5/PM10 sensor (SDS011). SDS011 is an air-quality sensor developed by Inovafit, a spin-off from University of Jinan (Shandong). Because of its size, it is probably one of the best sensors in terms of accuracy. While other sensors tend to focus on shrinking the sensor size, SDS011 has opted for a size tradeoff, allowing it to be used as a larger fan—larger the fan, better the quality.

SDS011 uses the principle of laser scattering in the air, which can be obtained from 0.3 microns to 10 microns suspended particulate matter concentration. Data is stable and reliable, and there is a built-in fan, digital output and a high degree of integration. UART port of SDS011 (CON2) is connected with IC3 UART port.

12V power/battery supply (CON1) is regulated to 5V using IC1 and IC2 and applied to the circuit. When the system is powered on, the device takes one minute to preheat the gas sensor before it is ready for operation. LCD1 displays proximate values of the four sensors connected to IC3. All these parameters are displayed on LCD1 at an interval of one second.

Software

Board menu in Arduino IDE and burn the program (sketch) through the standard USB port in the computer.→The software is written in Arduino programming language. ATmega328P is programmed using Arduino IDE software. ATmega328P comes with a bootloader that allows to upload a new code to it without the use of an external hardware programmer. Select the correct board from Tools

Various operations are implemented in the code as follows:
RTC library is easy to use and can get the date, time and day of the week accurately.

READ

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DHT.temperature and DHT.humidity read temperature and humidity, respectively.

PM_CAL() function calibrates PM2.5/PM10 value.

The arrangement given below gives a rough approximation of the parts per million (ppm) levels of gas or pollutants. These values are calculated as:

```
count=analogRead(GasSensorPin);
Vout=(count*4.88)/1000.0;
Rs=((5.0*Rl)-(Rl*Vout))/Vout;
ratio=Rs/approx;
GasConc=146.15*(2.868-ratio)+10;
ppm=GasConc;
```

Download source code: click here

Construction and testing

An actual-size, single-side PCB for the air-quality meter is shown in Fig. 3 and its component layout in Fig. 4. Suitable connectors are provided on the PCB for input and output.

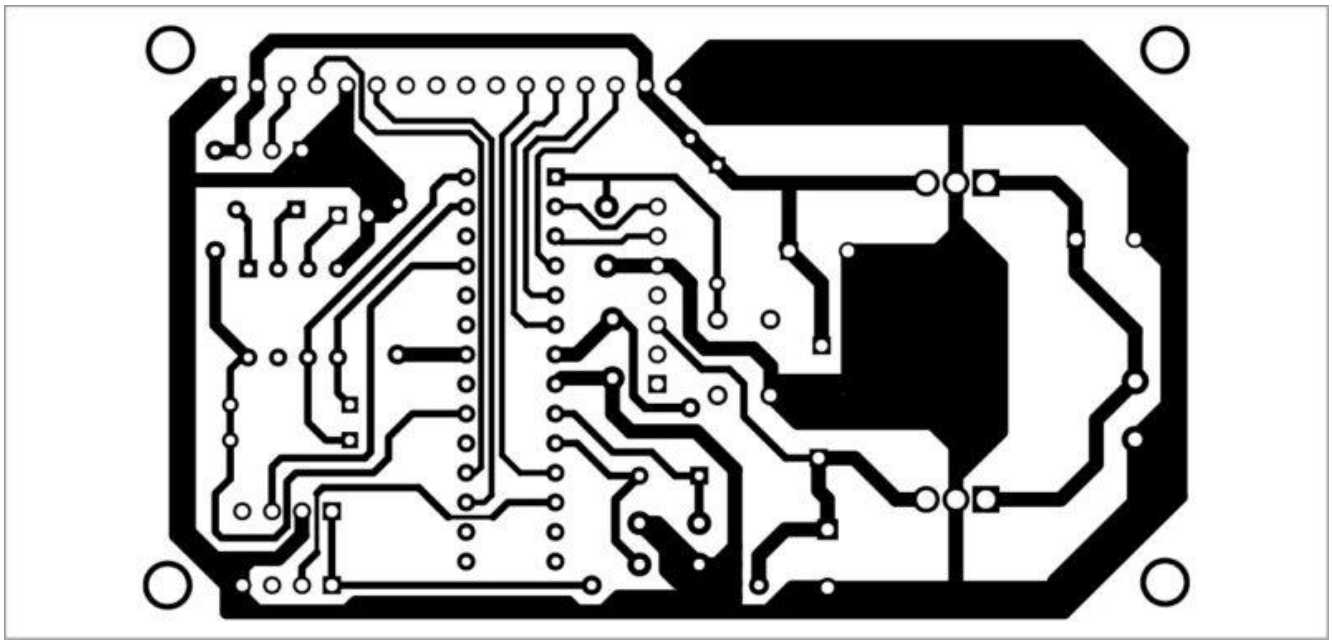

Fig. 3: Actual-size PCB pattern of the low-cost air-quality meter

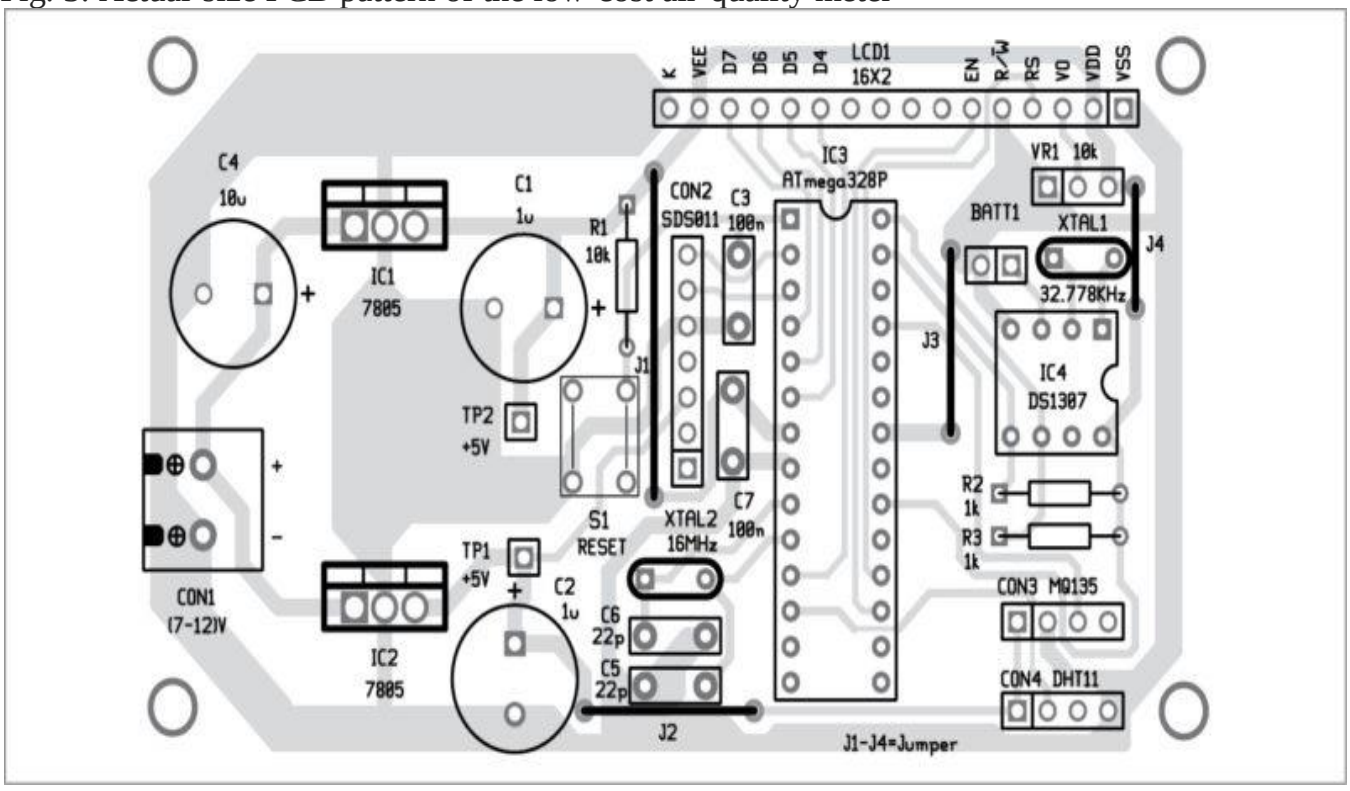

Fig. 4: Component layout of the PCB

Download PCB and Component layouts: click here

Assemble the circuit on the PCB to minimise errors. Carefully assemble the components and double-check for overlooked errors. Connect the power supply through 12V DC jack/battery and provide power supply to the circuit by connecting its Vcc and GND to CON1 on the PCB.
To test the circuit for proper functioning, check the power supply at TP1 and TP2 with respect to GND and ensure it is 5V.

All the mentioned parameters (PM2.5/PM10, temperature/humidity, ppm and time/date) are displayed on LCD1 at an interval of one second. In case the text is not visible on LCD1, adjust the potentiometer (VR1) connected with LCD1.

You may use cigarette smoke as polluted air for testing. PM value can reach up to 999 within five seconds when smoke is generated. The ppm value increases with smoke density, and temperature and humidity change as per the environment.