Indian Institute of Technology Guwahati

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CS321 : Peripheral Lab

Under the guidance of : Prof. S.B. Nair

Hazard Detection System

Project Report

Batch : G (Group : 1)

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Contents

1. Overview

- The hazard detection system developed consists of 2 units, the sensing and alerting unit and the main control unit. Currently only one unit of each type was made. The idea was to have several control and sensing units configured to a control unit so that multiple parts of a home/building can be monitored.

- This system covers detection of gas leakage, earthquake, and fire.

- The control and sensing unit consist of Arduino Mega 2560 microcontroller, to which MQ5 gas sensor, Temperature and humidity sensor and vibration sensors are attached along with Xbee S1.

- This unit sends the data sensed by the sensors wirelessly to the control unit using Xbee.

- In case of a hazard, relevant action/buzzer is turned on by the alerting unit.

- The whole system is wireless, each unit can be appropriately placed at different locations.

- The user has the functionality to turn OFF any specific type of hazard detection from his smartphone (like turning off gas detection when user knows some gas will leak while changing gas cylinder).

- The user can also monitor the behaviour of each sensor on his smartphone as live graph of data coming from sensing units is plotted against time and shown to user on his smartphone.

2. Components Used

- Arduino Mega 2560
- Raspberry pi
- MQ5 gas sensor
- Temperature and humidity sensor
- Piezo Vibration sensor
- 2 S1 Xbee
- Grove sensor shield
- Xbee Shield
- Xbee explorer
- DC Motor

3. Description about sensors

3.1 Gas Sensor

1. Why we used this sensor?
   - High sensitivity to LPG, natural gas
   - Low sensitivity to alcohol, smoke (noise of alcohol and cooking fumes are avoided)
   - Fast Response
   - Stable and long life
   - Simple drive circuit

2. Specifications
   - Standard work condition

Symbol	Parameter Name	Technical Condition	Remark
VC	Circuit Voltage	5V +/- 0.1	AC or DC
VH	Heating voltage	5V +/- 0.1	AC or DC
PL	Load resistance	20K	–
RH	Heater resistance	31 +/- 10%	Room Temp
PH	Heating consumption	Less than 800mW	–

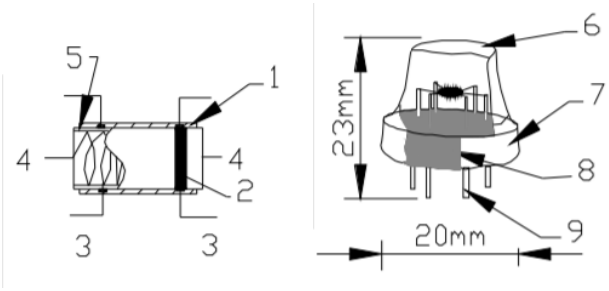
   - Environment condition

Symbol	Parameter Name	Technical Condition	Remark
Tao	Using Temp	$-10°C$ - $50°C$	–
Tas	Storage Temp	$-20°C$ - $70°C$	–
Rh	Relative humidity	Less than 95% Rh	–
O2	Oxygen concentration	21%(standard condition)	Min value is over 2%

   - Sensitivity characteristic

Symbol	Parameter Name	Technical Condition	Remark
Rs	Sensing Resistance	$-10°C$ - $50°C$	–
	Concentraton Slope rate	$-20°C$ - $70°C$	–
Standard detecting cond.	–	$200°C$ +/- $2°C$,65% +/- 5%	–

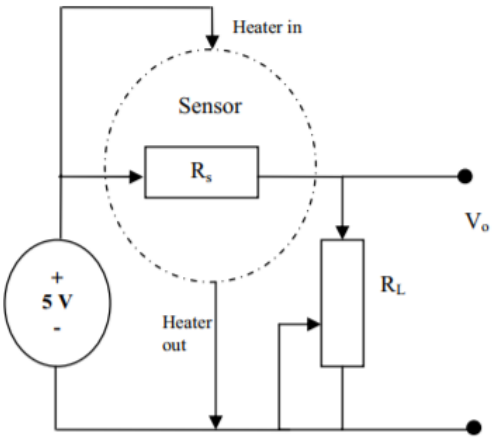
3. Structure and configuration



No.	Parts	Material
1	Gas sensing Layer	SnO2
2	Electrode	Au
3	Electrode line	Pt
4	Heater coil	Ni-Cr Alloy
5	Tubular ceramic	Al2O3
6	Anti-explosion network	Stainless Steel Gauze
7	Clamp ring	Copper plating Ni
8	Resin base	Bakelite
9	Tube Pin	Copper plating Ni

Sensor composed by micro AL2O3 ceramic tube, Tin Dioxide (SnO2) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for work of sensitive components. The enveloped MQ-5 have 6 pin ,4 of them are used to fetch signals, and other 2 are used for providing heating current.

4. Driving Circuit



The sensing part is made from Tin Dioxide (SnO2) layer, which is a resistive element with a resistance (Rs) that changes with the change of concentration of gases like LPG, CH4, CO, and alcohol. The sensor can detect small concentrations of the above mentioned gases as small as 0.1 mg/L , which makes it suitable for gas leak detection. It is worth mentioning that the sensor is also sensitive to room temperature and humidity.

The driving circuit of the gas sensor, which is shown in Figure above, requires a DC power supply of 5 Volts and a load resistance (RL).

The sensor needs to be heated to function properly, which is done through a heating element of a fixed resistance (RH). This means that the sensor should be switched on for a specific period of time before measurements are made. The heating power supply is done through the same power supply of the sensing circuit. The output voltage Vo from the sensing circuit is given by, and is fed into a microcontroller where it is digitized using an 8-bit analogue to digital converter (ADC). The microcontroller reads the voltage from the sensor and uses it to calculate change in concentration.

5. Characteristic graph

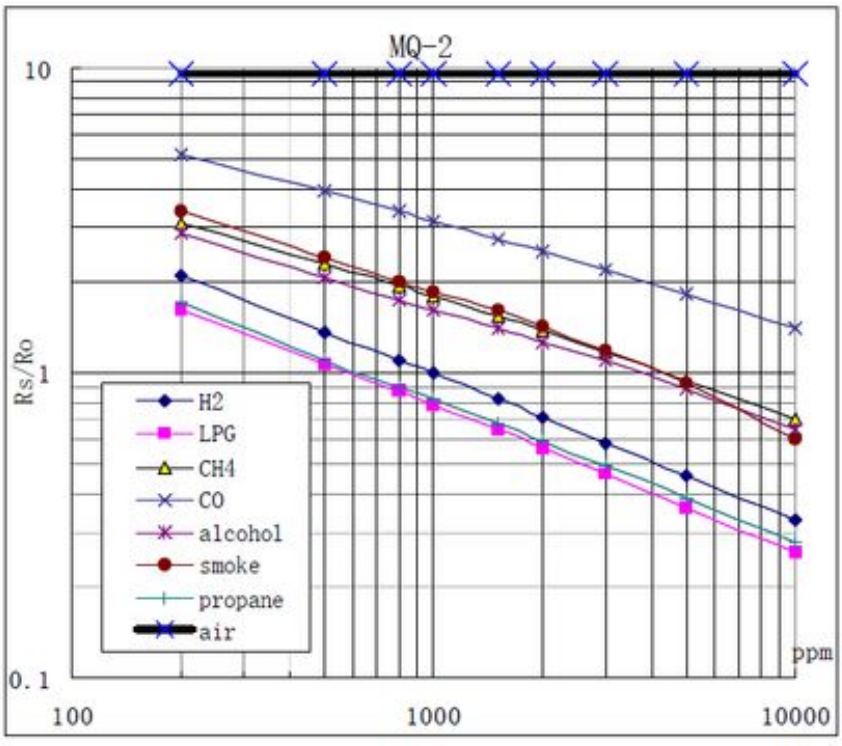


Fig.2 sensitivity characteristics of the MQ-2

Fig.3 is shows the typical sensitivity characteristics of the MQ-2 for several gases.
in their: Temp: 20℃、
Humidity: 65%、
O_2 concentration 21%
RL=5kΩ
Ro: sensor resistance at 1000ppm of H_2 in the clean air.
Rs:sensor resistance at various concentrations of gases.

6. Conventional Gas leakage detection vs Our product
   - Gas Leak detectors typically just indicates the leak of gases. They are kind of useless in cases when there is no one present to deal with the situation (like when there is no one at home and gas cylinder starts leaking).
   - Our product not only alerts gas leakage but also handles it by spreading the gas out through an exhaust fan.
   - It is ensured that the switching on of exhaust fan is spark free so that no fire is caused as the sensing unit is air-tight.
   - The user can get notified of the leak even when he is not at home so that any further necessary measures can be taken.

3.2 Piezo Vibration Sensor

1. Why we used this sensor?
   - Solder Tab Connection
   - Withstands High Impact)
   - Operating temperature: $0°$C to $85°$C
   - Low cost vibration sensing
   - Wide dynamic range: 0.1Hz to 180Hz
   - Adjustable sensitivity

2. Specifications and Working

   - Working

     The sensor comprises of a flexible component comprising a 28 m thick piezoelectric PVDF polymer film with screen-printed Ag-ink electrodes, laminated to a 0.125 mm polyester substrate, and fitted with two crimped contacts.
     As the piezo film is displaced from the mechanical neutral axis, bending creates very high strain within the piezo polymer and therefore high voltages are generated.
     When the assembly is deflected by direct contact, the device acts as a flexible ”switch”, and the generated output is sufficient to trigger MOSFET or CMOS stages directly. If the assembly is supported by its contacts and left to vibrate ”in free space” (with the inertia of the clamped/free beam creating bending stress), the device will behave as an accelerometer or vibration sensor.

Adding mass, or altering the free length of the element by clamping, can change the resonant frequency and sensitivity of the sensor to suit specific applications. Multi-axis response can be achieved by positioning the mass off center.

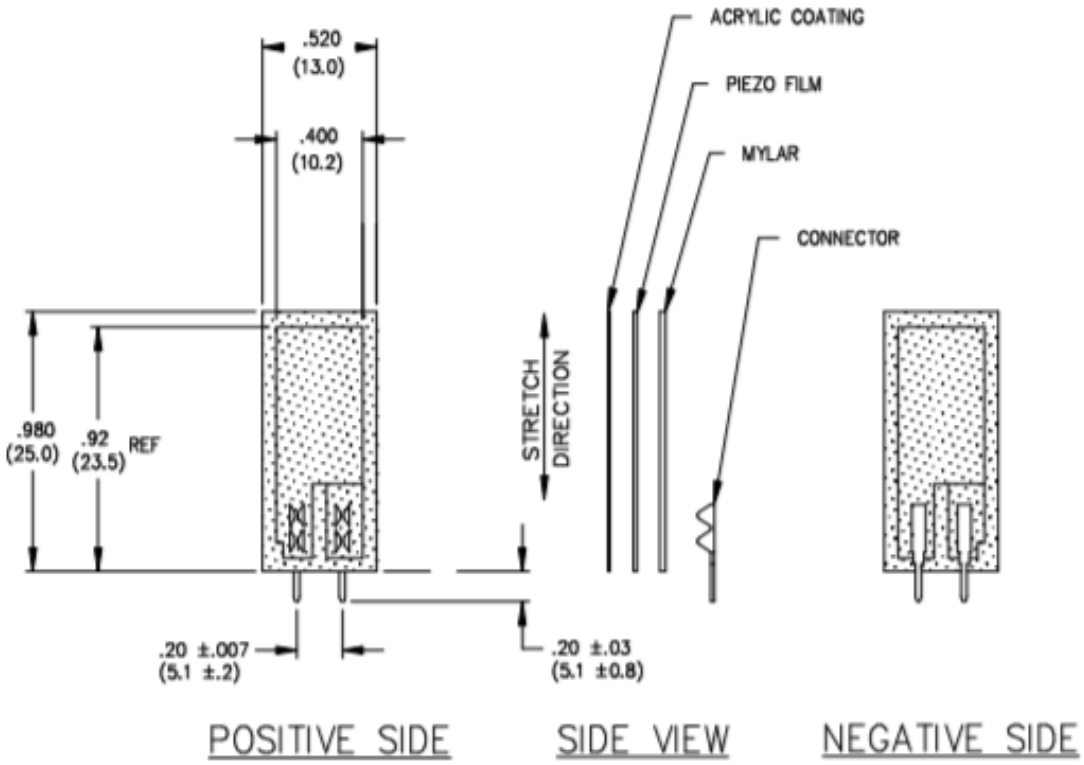
- Typical Properties

S.No.	Parameter	Value	Units
1	Voltage Sensitivity	1.1	V/g
2	Charge Sensitivity	260	pC/g
3	Resonance frequency	75	Hz
4	Voltage Sensitivity(at reso)	6	V/g
5	Upper Limiting Frequency	42	Hz
6	Linearity	+/-1	%
7	Capacitance	244	pF
8	Inertial mass	0.3	Gram
9	Dissipation Factor	0.018	(none)

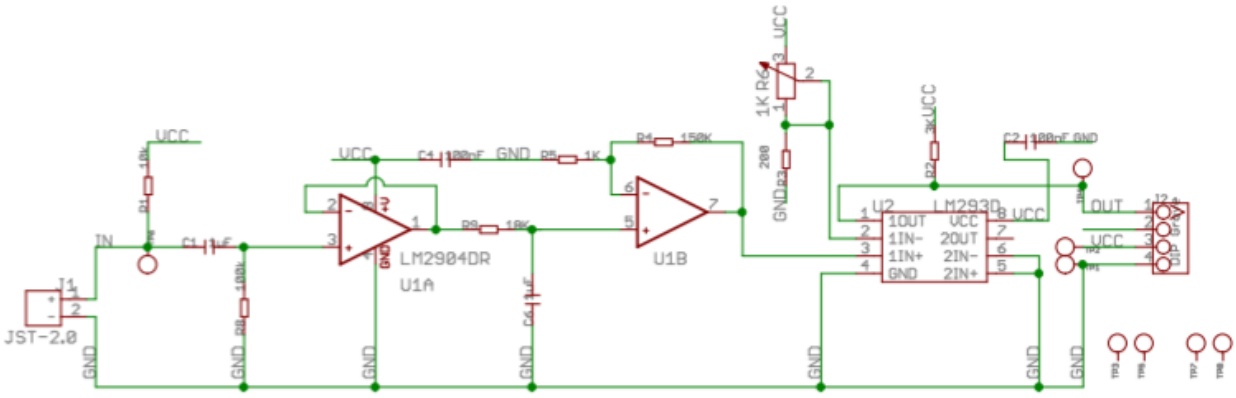
- Environmental Specifications

Storage Temperature	$-40°$C - $80°$C
Operating Temperature	$-20°$C - $60°$C

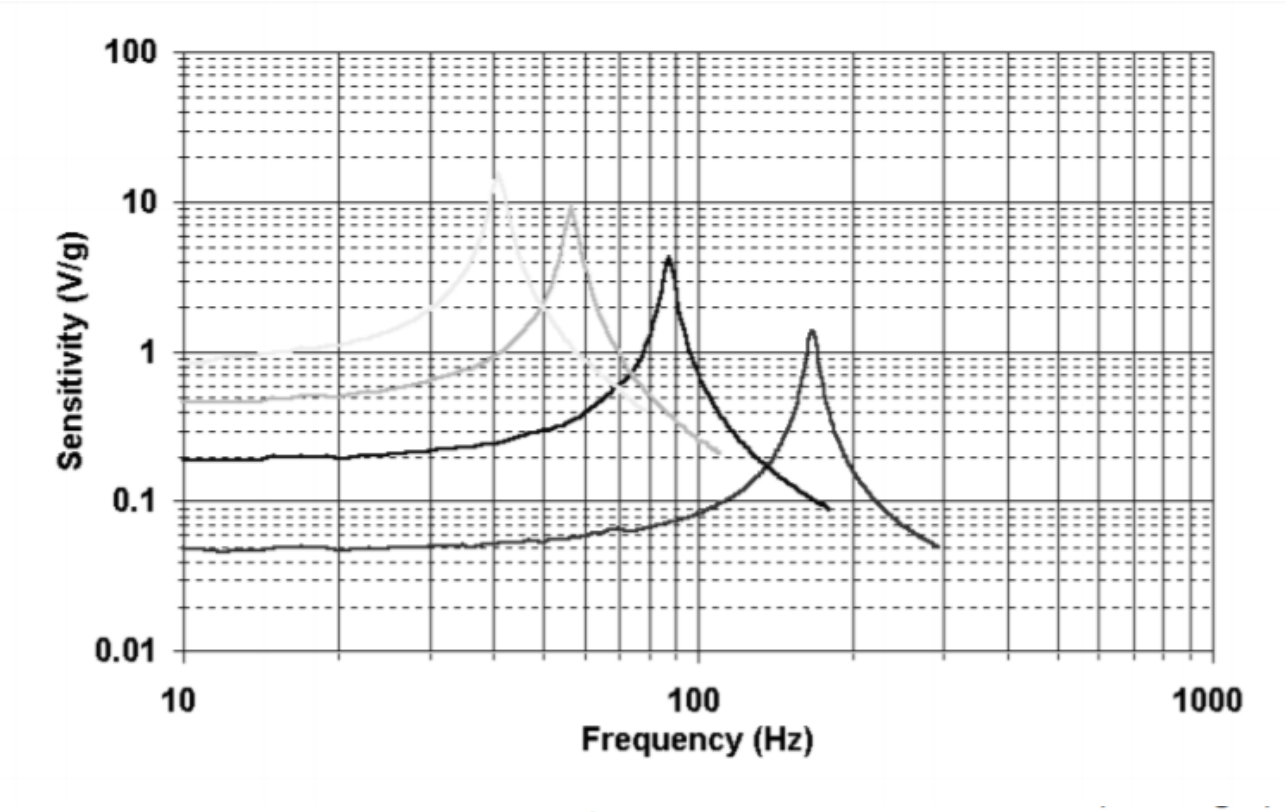
3. Structure



4. Circuit



5. Sensitivity Graph



Added Mass	Baseline Sensitivity	Sensitivity at Resonance	Resonant Frequency	+3 Db Frequency
0	50 mV/g	1.4 V/g	180 Hz	90 Hz
1	200 mV/g	4 V/g	90 Hz	45 Hz
2	400 mV/g	8 V/g	60 Hz	30 Hz
3	800 mV/g	16 V/g	40 Hz	20 Hz

6. Conventional Earthquake detection vs Our product

- Earthquake prediction is still a mind boggling problem for scientists around the world. We can't predict earthquake, but can immediately alert so that evacuation can be fast.
- Seismic sensor (very expensive) isn't used given the cost factor, instead it is tried to accomplish the task using cheap vibration sensor.
- Vibration sensor has been calibrated to be very sensitive and detect any minor vibrations in wall. The unit will immediately sound buzzer after detecting vibration.
- Since during earthquake all walls shake at around the same frequency, all units will sound buzzer immediately as earthquake strikes and evacuation can be done immediately.

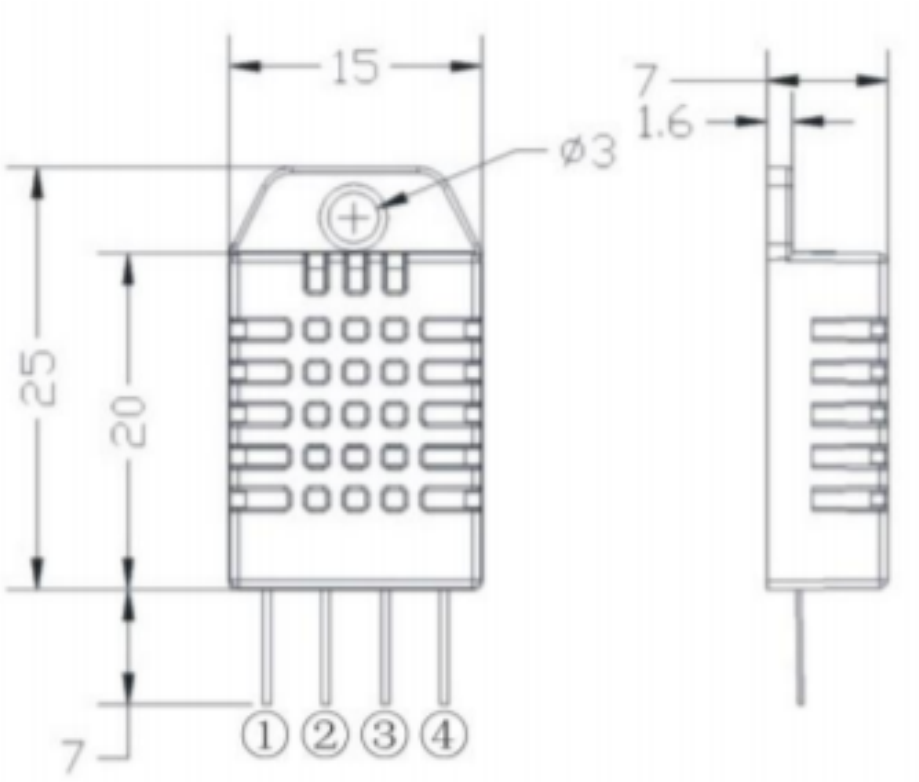
3.3 Temperature and Humidity Sensor

1. Why we used this sensor?
   - Ultra-low power
   - Fully automated calibration)
   - Excellent long-term stability
   - High accuracy temperature measurement

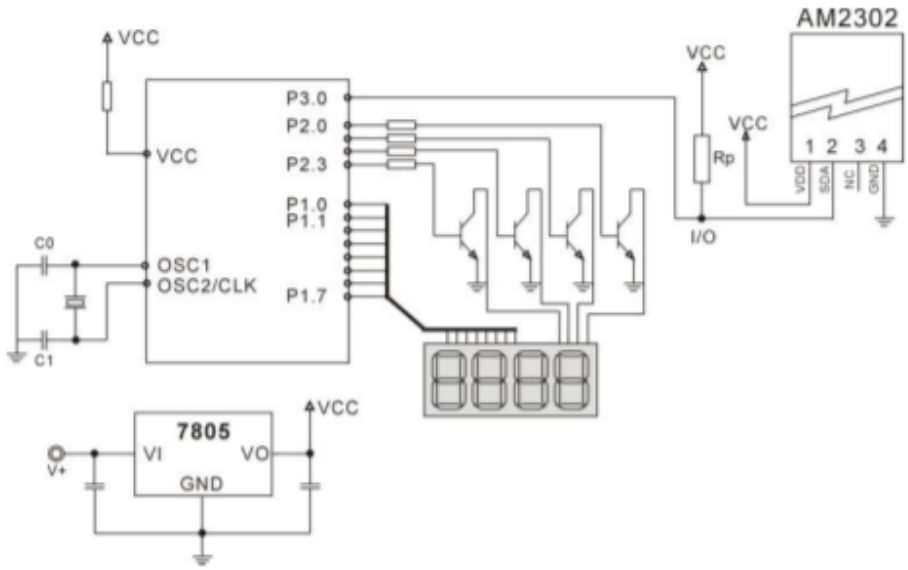
2. Specifications

Item	Min	Norm	Max	Unit
VCC	3.3	-	6	V
Measuring Current Supply	1	-	1.5	mA
Standby Current Supply	40	-	50	uA
Measuring range (Humidity)	5%	-	99%	RH
Measuring range (Temperature)	-40	-	80	°C
Accuracy (Humidity)	-	-	±2%	RH
Accuracy (Temperature)	-	-	±0.5	°C
Resolution (Humidity)	-	-	0.1%	RH
Resolution (Temperature)	-	-	0.1	°C
Repeatability (Humidity)	-	-	±0.3%	RH
Repeatability (Temperature)	-	-	±0.2	°C
Long-term Stability	-	-	±0.5%	RH/year
Signal Collecting Period	-	2	-	S
Respond Time 1/e(63%)	6	-	20	S

3. Structure

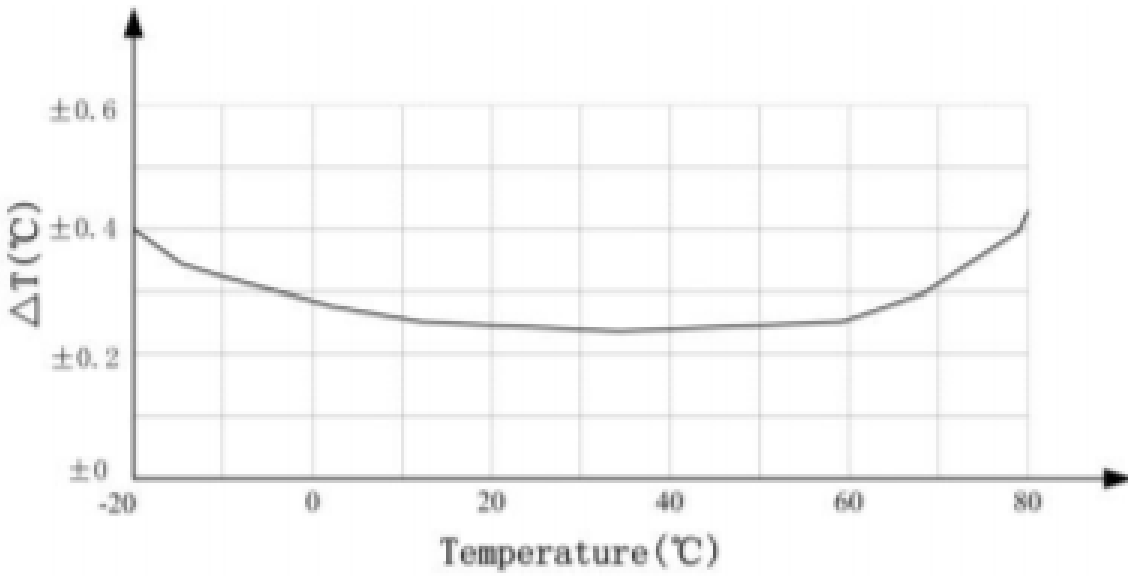


4. Circuit



5. Temperature measurement performance

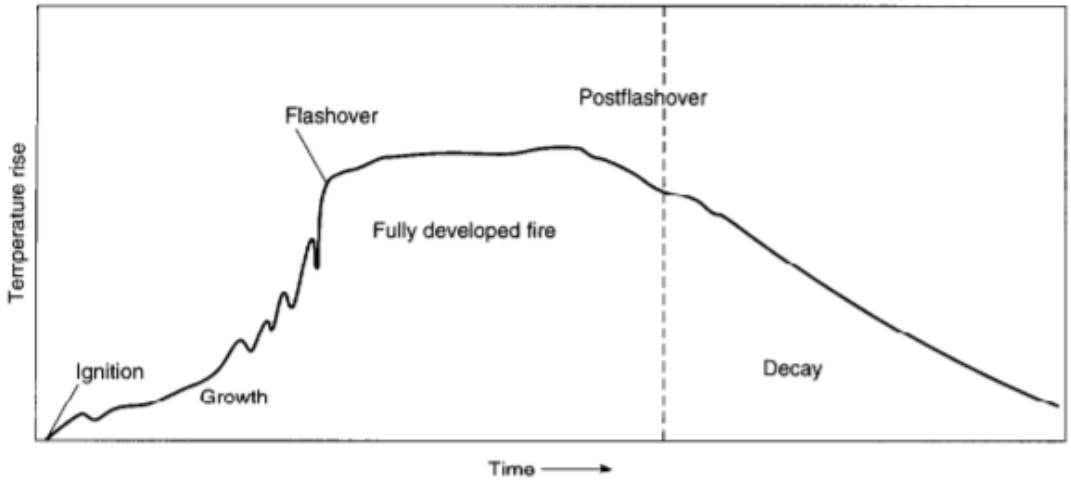
Parameter	Condition	min	typ	max	Unit
Resolution			0.1		℃
			16		bit
Accuracy			±0.5	±1	℃
Range		−40		80	℃
Repeat			±0.2		℃
Exchange		Completely interchangeable			
Response	1/e(63%)		<10		S
Drift			±0.3		℃/yr



6. Conventional Fire detection vs Our product

- Fire detection systems typically consist of heat detectors, CO2 detectors, flame detectors, smoke detectors etc. most of which are very expensive (like CO2 detector). Our product aims at providing efficient detection system at minimal cost.
- Temperature sensor used typically aims at warning at early

stages of fire so that it can be avoided at early stages when temperature rises very fast with time.



Since response time of temperature sensor is very fast, it can identify temperature changes very fast and alert when temperature has crossed the threshold temperature.

- Sprinklers are avoided as they can worsen the situation in case of fire caused due to some kind of electrical failure.
- Location of fire can be identified as the admin can observe which unit is showing sudden temperature increase by live graph monitoring, which is not the case with traditional fire detection systems.

4. Innovative Feature

- The whole system is wireless. The detection box xan be placed remotely anywhere as per need and it will send the data to the central server operating on Raspberri Pi wirelessly, and the Pi will send instructions after processing the data.
- Special feature to turn the detection off for each hazard individually is provided so that unwanted alarms can be avoided. For example, when gas cylinder at home is changed, there is some gas leakage. The user can therefore turn off gas detection using his smartphone, before changing the cylinder. User might be using some fire in the room for his need. SO he can just turn of the fire detection with his smartphone.

5. Use of Mqtt

- The whole reading of the sensors are published directly on the mqtt server so that the user can monitor everything live.
- Live Graphing has also been included on the mqtt server for a better analysis of data for the admin user.
- The enable-disable feature (talked above) can be used from the mqtt app directly on user's android device.