2. Ammonia Sensor: EC - HX - NH3 Sensor

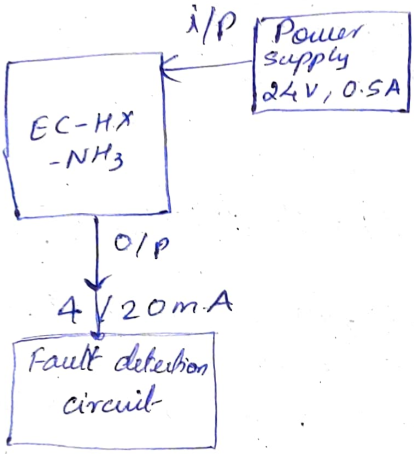
Given specifications in question: Alert when concentration > 100 ppm

For a range of 0 - 100 ppm, 25 ppm is the default alarm level

Here we want alarm at 100 ppm, we'll need 0 - 400 ppm range

EC - HX - NH_3 sensor specifications

Range - 0 - 500 ppm



Fault level < 10 ppm
↓
0.5 mA

Maximum input impedance of monitoring equipment = 700 Ω

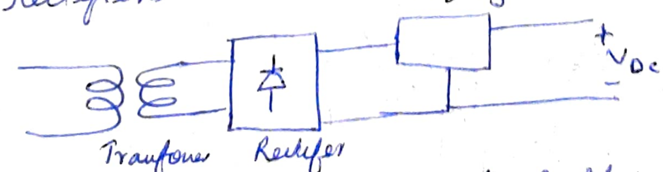
⇒

I	R	V
4 mA	700 Ω	2.8 (Vmin)
20 mA	700 Ω	14 (Vmax)

Requirements:

1) Power supply : An isolated DC power supply of rating 24 V, 0.5 A ⇒ P = 12 W supply

- Implement using DC - DC converter. For DC-DC converter, we have certain disadvantages like they are prone to noise, duty cycle control, switching frequency
- Implement using transformers & voltage regulators and rectifiers



Use of transformers makes it bulkier and can lead to electromagnetic interference issues, makes it costly.

Keeping a transformer inside the product will increase the weight and size of the product

Solution:

Use an isolated AC-DC power supply module which converts 230V (AC) to 24V (DC). It is already available in market

HLK-20M24 ⇒ Isolated AC-DC power supply

Advantages: → compact
→ Easier use
→ No external control
→ Less costly

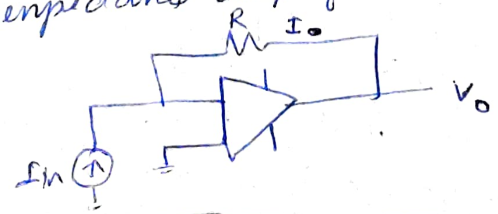
2) Monitoring equipment / Fault detection circuit

Requirement → when atmospheric concentration of ~~equal~~ ammonia is equal to greater than 100ppm, then an alert should be sent

• The ~~an~~ available sensor is is a current sensor, there fore we need to either convert to voltage or current sensors are prone to offsets, negative & positive gains, defects in core of sensors etc. And so, it is easier to convert to voltage and then detect if the obtained voltage is corresponding to a fault concentration above 100ppm

Current to voltage converter

1) Transimpedance amplifier



In the figure shown above, the current I_{in} is the one from sensor which is given an input to an Op-amp. The feedback resistor ~~which~~ will have a drop of $I_{out} \times R$ which will be same as V_0 ($V_0 = -I_{out} R$) (Due to virtual ground concept, $\because I_{in} = I_{out}$)

So now voltage is obtained but the next stage will also be a ~~voltage det~~ detection of fault voltage using Op-amp.

Problem: If we use Op-amps we will need different biasing which will complicate the circuit and making it bulkier.

ii) Current to voltage converter can be simply done using a resistor, but we have to ensure that power loss is minimum.

As per sensor specifications, minimum input impedance is 700Ω. But we want to design this resistor as per the voltage required.

3) Matching the sensor specification to monitoring equipment

Sensor characteristics:

⇒ When concentration is less than 10ppm, it is faulty region which means 10ppm is minimum value. Also it is given that 0.5mA is faulty current

⇒ 10ppm ⇒ 0.5mA

Range of operation : 0 - 500 ppm

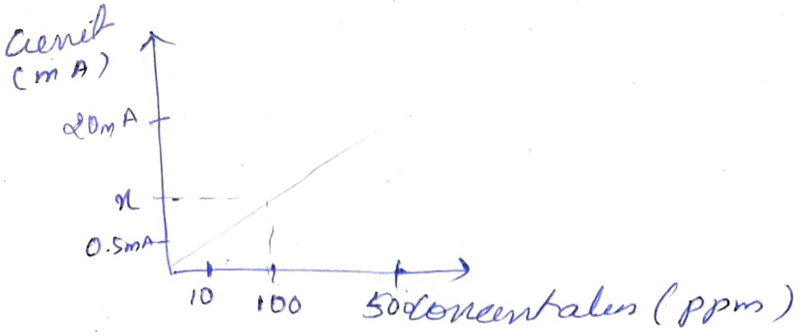
current output : 4 - 20mA

Description: Sensor behaves in a linear fashion

ie for 10ppm ⇒ 0.5mA

500ppm ⇒ 20mA

Then for 100ppm ⇒ it is 4mA



∴ For a concentration of 100ppm ⇒ the current is 4 mA

Resistor selection

Voltage drop across the resistor across the sensor is given as the input to Op-amp Differential amplifier. If 'R' is too low, that mean the reference voltage for differential amplifier should also be same,

In hand : The biasing for the differential amplifier is given through the DC supply used for sensor (24V) using this same 24V, we can generate the reference (-ve terminal of Op-amp) as well as biasing for the Op-amp.

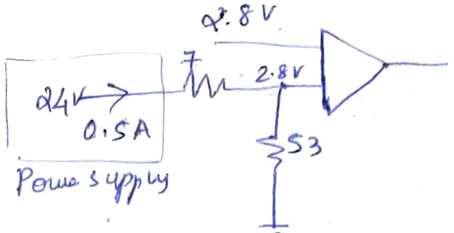
∴ We have to choose an 'R' such that can be generated for the voltage drop across 'R' from the 24 V supply

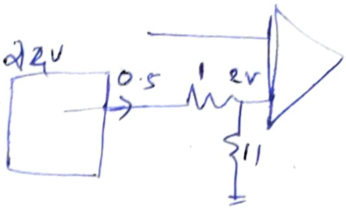
At 100ppm If $R = 700\Omega$, $I = 4mA$ } $V = 2.8V$ $P_{loss} = 11.2mW$

If $R = 500\Omega$, $I = 4mA$ } $V = 2V$ $P_{loss} = 8mW$

This 2V will be the reference for differential amplifier which is generated from 24V

If 2.8V is to be the reference: If 2V is the reference





$P_{(7\Omega)} = 1.75W$ $P_{(1\Omega)} = 0.5W$

$P_{(53\Omega)} = 13.25W$ $P_{(11\Omega)} = 2.75W$

Power loss is more when we choose 2.8V as the reference
∴ 2V will be the reference

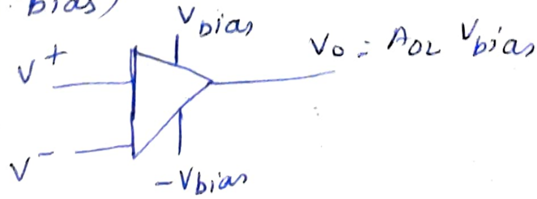
⇒ 2V should come out of sensor which is indicating the 100ppm concentration

$R = 500\Omega$

4) Final circuit

- Sensor will detect the concentration, if the concentration is equal to or greater than 100ppm concentration it sends a current of 4mA and above
- This current will flow through the input resistance of monitoring equipment and the voltage across this resistance will be given to differential amplifier
- The Op-amp input will be a reference voltage at -ve terminal & the output of 'R' will be given at +ve terminal of Op-amp, whenever $V_+ > V_-$

$V_0 = A_{OL}(V_{bias})$ A_{OL} - gain of Op-amp



The Op-amp chosen is LM6211 whose specs as

Input bias voltage: 24 V

Maximum differential voltage: ±0.3V

Circuit diagram:

- The output of Op-amp will be connected to a resistor and LED, Depending of current of Op-amp (taking max. current) – 0.25mA

$V_{out} = 24V$

$\Rightarrow R = \frac{24}{0.25m} = 96k \approx 100k$

Circuit diagram: