Q2.) ammonia sensor works at typically cold storage, refrigerators, ammonia processing planets etc

Usually, this are at normal temperature.

=) This design can have less concentration on temperature effects.

assumption on sensors:

base current = 0.2mA

sensitivity = (100 ± 40) nA/ppm = (60 to 140) nA/ppm

input voltage = 15V

∴ for, 100 ppm, current = (60 to 140) $\frac{nA}{ppm}$ × 100 ppm

Current change for 100 ppm = (6 to 14) μA

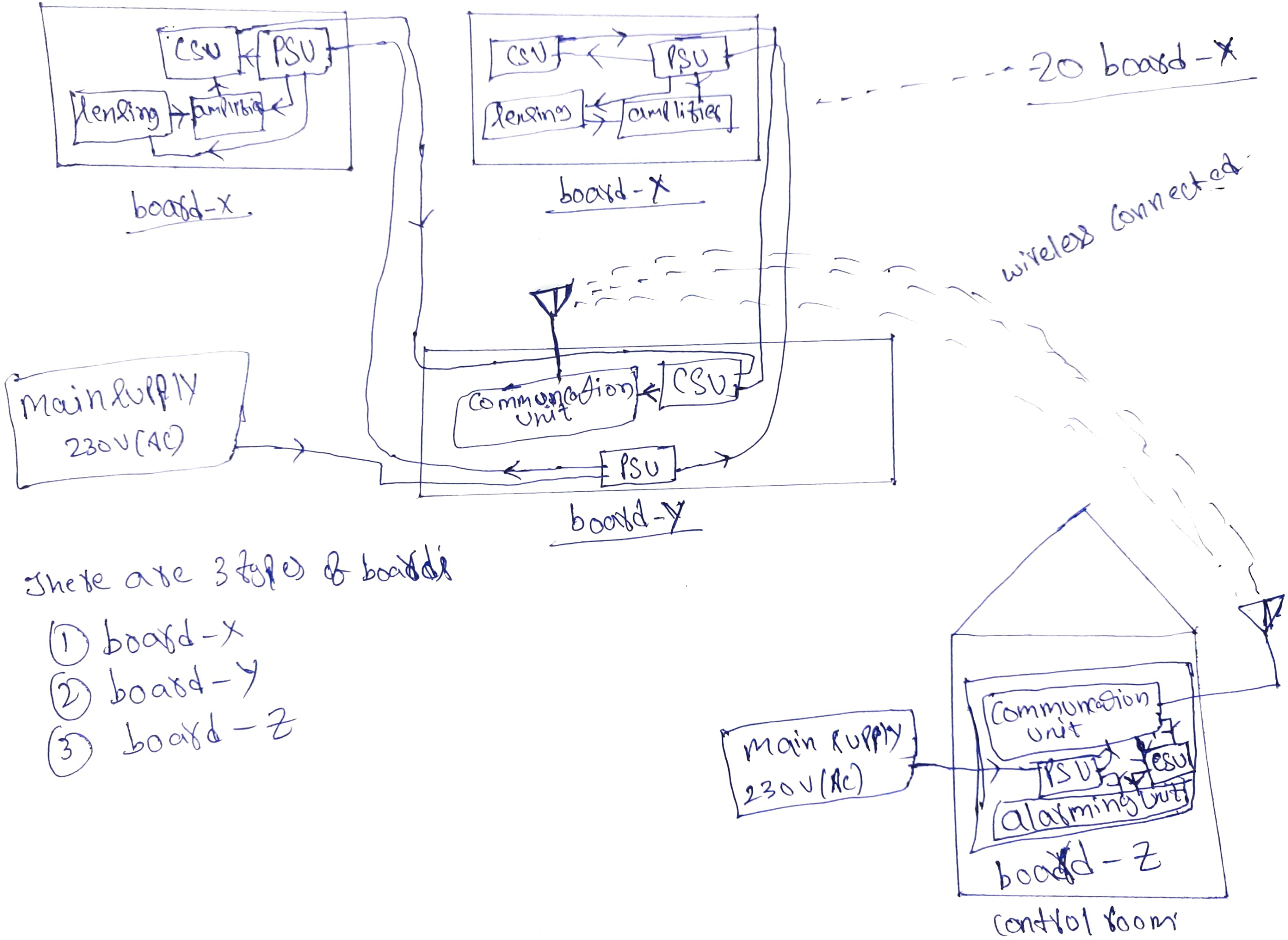
Summary of design:

In this design, sensor is conneted to a board which contain a PSU and CSU (control system unit)

=) we have large no. of this type boards (~20)

all this boards are connected to one large board which contain one PSU, one CSU and one communication unit. Then, in control room which is 100m far from the plant will have a CSU, alarming unit, communcation unit and power supply unit

PSU: Power supply unit ; CSU: Control system unit



There are 3 types of boards

1. board-X
2. board-Y
3. board-Z

Power to board-x is supplied by board-y, board-y power is supplied by main supply;

control unit unit of board-y is connected to control units of All 20 board-x

Control unit of board-y is connected to communication unit of board-y, this communication unit is connected to communication unit of control room.

The communication unit of control room is connected to alarming unit, whenever suspicious happens this communication unit triggers alarm unit

here, communication happens completely wireless which saves, 100 meters wire and power.

summary of amplifier:

we amplifier the sensor signal using MOSFET, common source stage with active load amplifier

summary of CSU of board-x:

CSU of board-x contain a bi-stable multivibrator which will trigger CSU of board-y when suscipious happens

summary of PSU of board-x: PSU of board-x contain linear regulator which outputs 15 volts

PSU of board-Y: it will contain a step-down 230V to 18V transformer and full bridge and capacitor

CSU of board-Y: This CSU will take signal from CSU of board-X and triggers the communcation unit

Communcation Unit of board-Y: This is a industrail IoT wireless expansion HAT, used to trigger Communcation unit of control Room

Communcation unit of control room: This is the receiver part of industrial IOT wireless expansion HAT

CSU of board-Z: it take signal from communcation Receiver and triggers alarm system

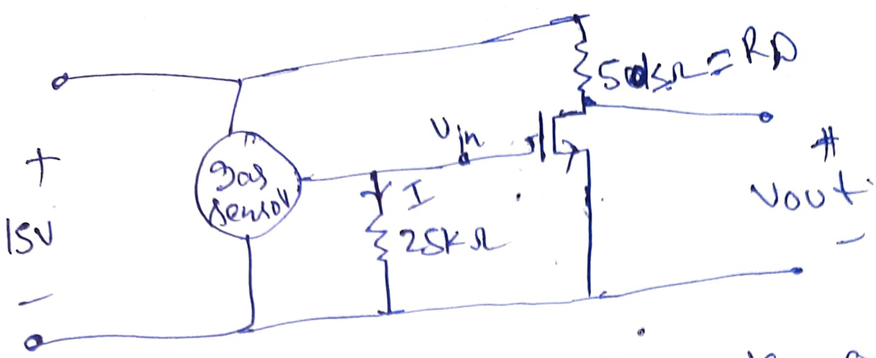
alarm unit: buzzer, siren and flash lights

Trade offs: The power of board-X is connected by PSU of board-Y, which saves cost

communication between board-Y and control room happens completely wireless which saves 100 meters of wire

in amplifier, we use mosfets instead of amps which save power.

Design of amplifier



at free air, ~~base~~ current, is 0.2mA

$\Rightarrow V_{in} = (25k\Omega)(0.2mA) = 5V$

for 100pm, $\Delta I = 6\mu A$ to $14\mu A$ $= (25k\Omega)(6\mu A)$ to $(25k\Omega)(14\mu A)$

$\Rightarrow \Delta V_{in} = (25k\Omega)(6\mu A)$

$\Rightarrow \Delta V_{in} = 0.15V$ to $0.35V$

voltage gain of amplifier is A_V

$A_V = -g_m \cdot R_D$

$\mu_n C_{ox} = 50\mu A/V^2$; $\frac{W}{L} = \frac{10}{4}$; $V_T = 1V$

$\Rightarrow g_m = \mu_n C_{ox} \frac{W}{L}(V_{gs} - V_T) = 50 \times 10^{-6} \times \frac{10}{4}(5-1)^2$

$\Rightarrow g_m = 2mS$

$\Rightarrow A_V = -g_m \cdot R_D = -2mS(5k\Omega)$

$\Rightarrow A_V = 10$

$\Delta V_{out} = A_V \cdot \Delta V_{in}$

$\Delta V_{out} = 10 \cdot (0.15V)$

$\Delta V_{out} = 1.5V$

~~Before~~ Vout at free air:

$15 - (5k)\frac{(50 \times 10^{-6})}{2}\left(\frac{10}{4}\right)(4)^2$

$V_{out} = 15 - (5k)10^{-3}$

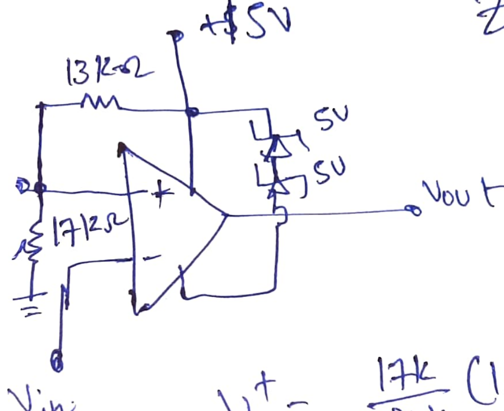
$V_{out} = 10V$

∴ In free air, Vout = 10V

at 100ppm, Vout ≤ 8.5V

Design of CSU of board-X:

Zener diode with 5V drop



$V^+ = \frac{17k}{30k}(15) = 8.5V$

$V^- = V_{in}$

if, $V_{in} > 8.5V$, then $V_{out} = 5V$

$V_{in} < 8.5$, then $V_{out} = 15V$

Design of CSU and Communication unit of board-Y:

CSU of board-Y is just safety element it check's the signal is not greater than 15V

after clearing safety check, signal goes to Communication unit which is Industrial IoT wireless expansion HAT which has embedded software, which signals receiver if Vout > 10V to control room.

Design of control room alarm and CSU:

The receiver of Industrial IOT automatical starts alarm if it recives signal from sender