- **Lab 6: iterative approach:**

- signal conditioning circuit.

- Product dev. cycle (:
  - → include Eng'g design process.

Estimated Annual Usage EAU

Estimated turn around = Formula

1. ideas (Brainstorm)
   ↓
2. market survey
   ↓
3. Formulate pb statement
   + define CTQ (critical to quality constraints)
4. check CBA: Cost Benefit Analysis
   (expenditures + gain revenues).
5. Upper mgt
6. Design team
7. Eng'g design Process: end product is a prototype
   ↓
   we need to test it
8. First technical Review

Prototype ≠ 9. Pilot:
near endproducts closer to actual finished product

10. 2nd technical Review
11. manufacturing line dev. → marketing training; → inventory build up
    ↓
    2 types of testing → Normal testing; → Acc. testing

- **Gantt Chart:** timeline
  - → to check milestones + Book resources.
  - → maybe run tasks that might run in parallel

Introd.:

- slow: response time too big.
- accurate and precise or cannot now because not repeated experiment

N.B: lets take scenario:

RTD — we want to take resistance of RTD by DAQ

take voltage in → DAQ In → [DAQ]

since DAQ analog: we need A/D: quantization.

ex: 0 → 4V

2 bits:

00	0→1V
01	1→2V
10	2→3V
11	3→4V

any RTD gives voltage 1→2V → (01)

no such precision

⇒ we need Signal Conditioning Circuit

any interface between Sensor and DAQ

Fn:

1. amplifie Range.
2. change from resistance to voltage.
3. Filtering noise at a sensor.
4. cold junction for thermocouple
5. excitation circuit for LM335 (the biasing)
6. for RTD: signal conditioning circuit that make the curve linear
7. Electrical isolation

NB: thermocouple need cold junction compensation

- Requirements:
- 0 to 10V
- RTD between Room t° → 40-45°C

- Signal Conditioning.
  1. output from Resistance to voltage (0→10V) since at DAQ.

1. Must:

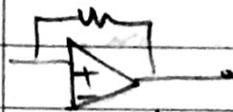
2. Fn decomposition

1. Resistance to voltage: → Transducer Conversion Circuit
2. Range of V from 0 to 10V: Voltage translat op amp circuit

v div.

→ what # designs possible?

A- Transducer Conversion:
- check op amp. ✓ voltage divider
- RC circuit
- whitston Bridge



put R on feedback and read output

?

B- Voltage translation Circuit:

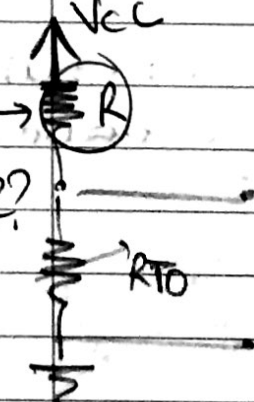
→ use op amp

NB:

Rmin at 25°C
Rmax at 45°C

→ then use voltage divider to get original range before Amplification.

How to choose value of this R?



measure voltage here ✓

→ R:

our goal is to max V_{min} and V_{max}.

- $V_{min} = V_{CC} \times \frac{R_{RTD\,min}}{R + R_{TD\,min}}$

- $V_{max} = V_{CC} \times \frac{R_{RTD\,max}}{R + R_{TD\,max}}$

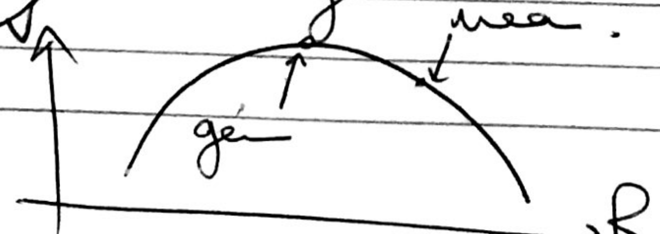
→ we want $V_{max} - V_{min}$ be largest.

$\frac{d(V_{max} - V_{min})}{dR} \Rightarrow R = \sqrt{R_{RTD\,min} \times R_{RTD\,max}}$

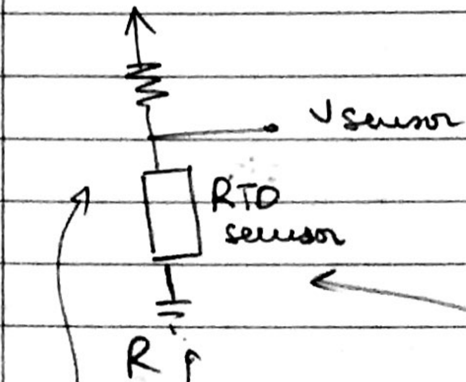
↳ geom average

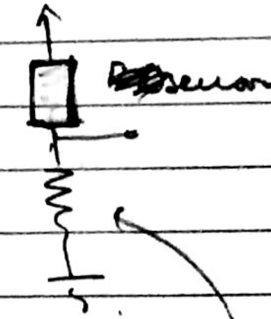
N.B: Some may use arithmetic mean $\frac{R + R_{RTD}}{2}$

↳ this chosen R can have a drastic change

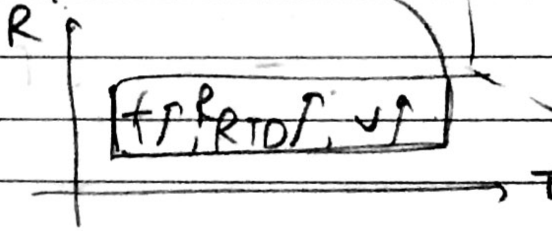


- what V. divider:





curve of RTD.



RTD is a PTC: positive temp. coefficient

NTC just like Thermistor: T↑, R_ther↓, V↑

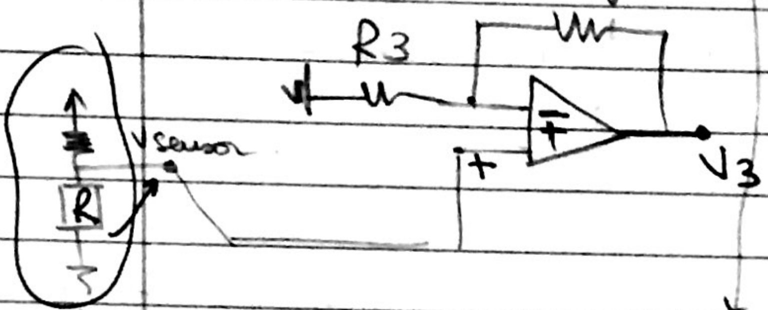
it increases by using this circuit.

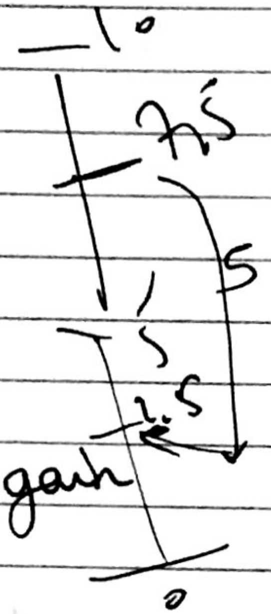
② Translation circuit :

$\Delta V_{in} = 1$

$\Delta V_{out} = 4$

gain = 4 = 4





* remember this : $V_3 = V_{sensor} \left(1 + \frac{R_f}{R_3}\right)$ → gain

4 gain

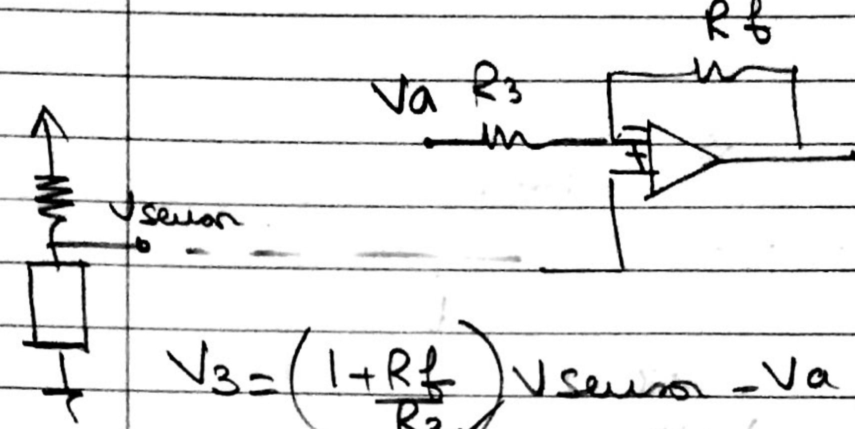
$V_{3min} = 1 \times 4 = 4V$

$V_{3max} = 2 \times 4 = 8V$

→ we need to shift it back from 4 → 8

we shift till 0 → 4V

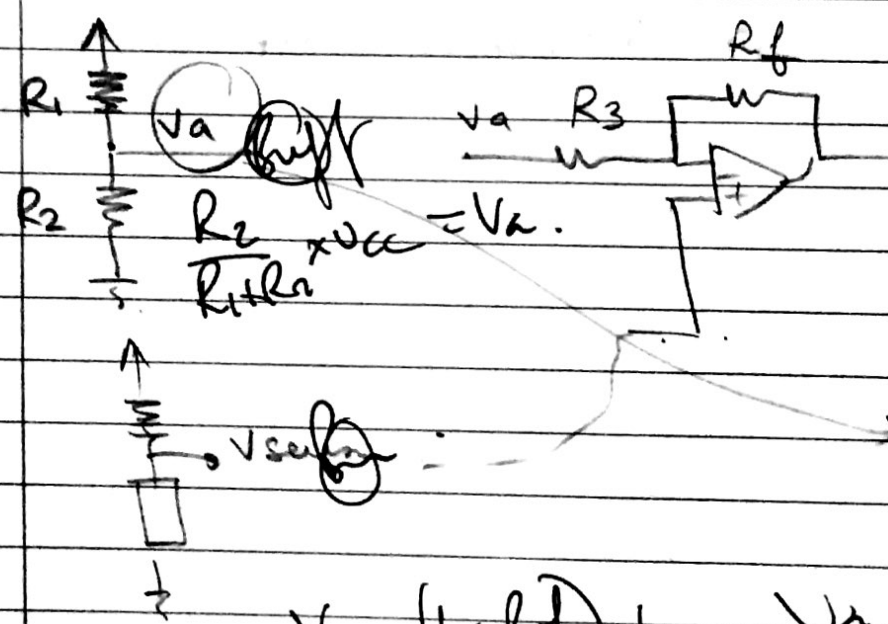
· we need to fix :



$V_3 = \left(1 + \frac{R_f}{R_3}\right) V_{sensor} - V_a \frac{R_f}{R_3}$

(derivation) in appendix.

? How to get Va? from voltage division



$\frac{R_2}{R_1 + R_2} \times V_{cc} = V_a$.

$V_3 = \left(1 + \frac{R_f}{R_3}\right) V_s - V_a \left(\frac{R_f}{R_3}\right)$

lets get Va: → to Bias.

at (V_{min})

$V_3 = (0) = \left(1 + \frac{R_f}{R_3}\right) V_{min} - V_a \left(\frac{R_f}{R_3}\right)$ (at zero)

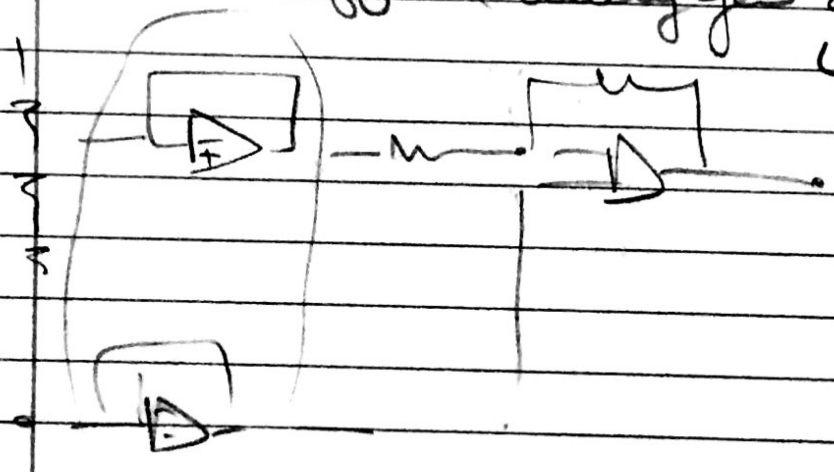
0 = min.

at V_{min}

$\Rightarrow V_a = \left(1 + \frac{R_3}{R_f}\right) V_{min}$

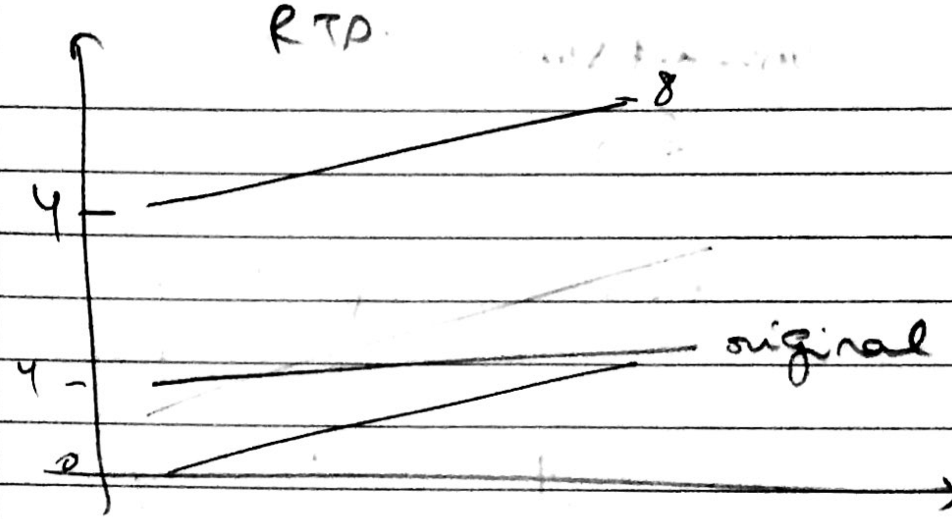
and from this Va we get values of R_1 and R_2

• we need to add Buffer (unity gain op amp)



Buffers: mon cher ma to 5 bon ✓ voltage divider.

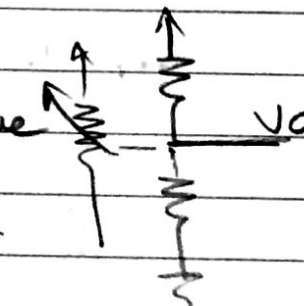
RTD.



→ use measured values

Vcc used = 12V

we have



we put variable resistor in order to make life easier.

N.B: Vcc = 12V because range 0 – 10V (so it must be 5V) (maybe not precise, more than 10V)

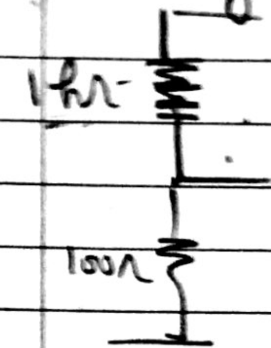
assume R_{sensor} min = 1 kΩ } metal RTD
R_{sensor} max = 1.2 kΩ } in order to simulate at ± degrees (instead of peltier)

these are theoretical.
measure the resistance

1.2 kΩ   1 kΩ

exp = 1.1889 kΩ.   exp: 0.9775 kΩ.

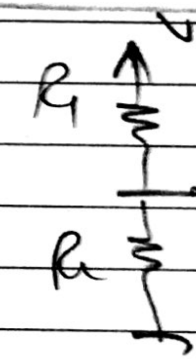
let say



→ measured: 1077.8 Ω

$\frac{R_f}{R_3} = 16$

2.2016
2.2040
$R_1 = 1.1019$



$V_a = \frac{R_2}{R_1+R_2} \times V_{cc}$

12

$\frac{6.06037}{12}$

$= 0.50503 = \frac{R_2}{R_1+R_2}$

2.2
2k → 2.2
2k → 1k 1.028

$0.50503 = \frac{x}{1000+x}$

$(1000+x)\,0.50503 = x$

0.4941.

$1000 \times 0.50503 = (1 - 0.50503)\,x$