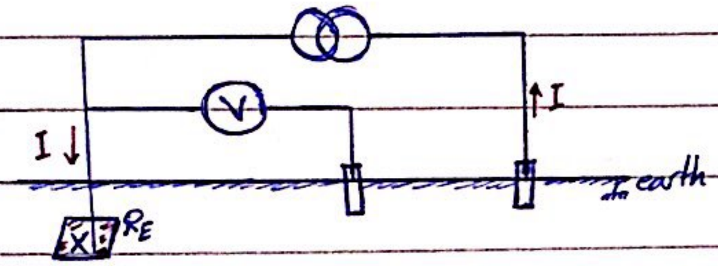
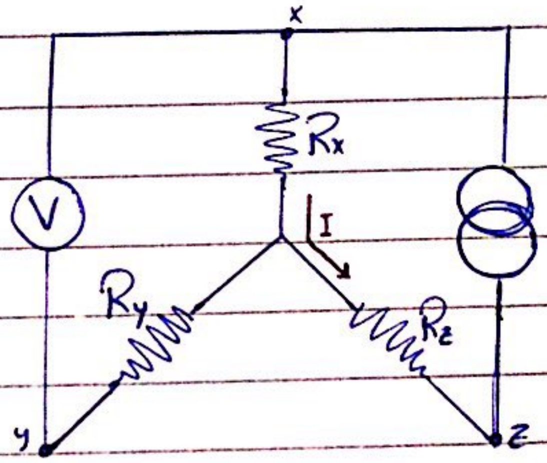
Earth Resistance Measurement.

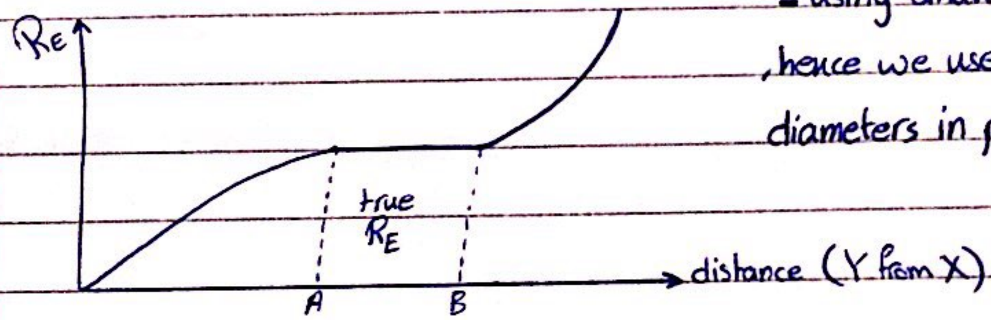
- the Resistance between the earth electrodes : less than 100 ohms.
- the Method of measuring the earth resistance : fall-of-potential.
- the Device we use it to measure the R_E : Digital Earth Resistance tester.





- using math, R_E @ any point → $R_E = \frac{V}{I}$
- R_E value depend on :

placing of the auxiliary electrode. "Y"



- using small electrode diameter → $R_E \uparrow$ high, hence we use big electrodes diameters in parallel → to get $R_E \downarrow$ small

- high electrode diameter & parallel Connection → Can Reduce the R_E
- we Can add chemical & Conductive materials → Suitable soil with $R_E \downarrow$ min.

- Earth Resistance in Jordan → "5 Ω" maximum value for it 5 ohms

But it'll change depend on 'region, Temperature, moisture'

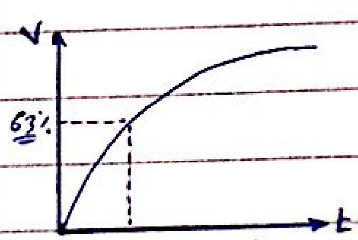
Thermocouple Calibration & Time Constant.

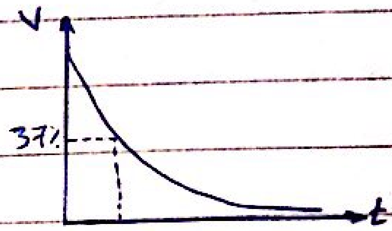
- Concept : pair of electrical Conductors is joined together, thermal emf is generated when the Junctions are at different temperatures.
  (generated: in Range of millivolt; temperatures: in Range of [0-100 c°])

- Thermocouple : two wires of two different materials joined at each end.
- Seebeck effect : when one of the thermocouple ends is heated, Current will flow and when the circuit is broken, there'll be $V_{o.c}$ at the wires
- Voltage is function of : Temperature & metal type
- V linear with Temp° → for small temp. difference.
- V not linear with Temp° → for large temp° differene.
- thermocouple Calibration → by measuring the temperature of known standards.

- thermocouple Types:
  - Type J (iron-Constantan)
  - Type k (Nickel-Nickel)
  - Type B (platinum-platinum)
  - Type E (Nickel-Constantan)
  - Type T (Copper-Constantan)
  - Type N (Nicrosil-Nisil)

- Time Constant : → Exponential Growth or Dec↓
the time required to reach 63% of the final Value, after one time Constant, and after ~5τ we reach 100% of the value.





$v(t) = c[1 - e^{-t/\tau}]$

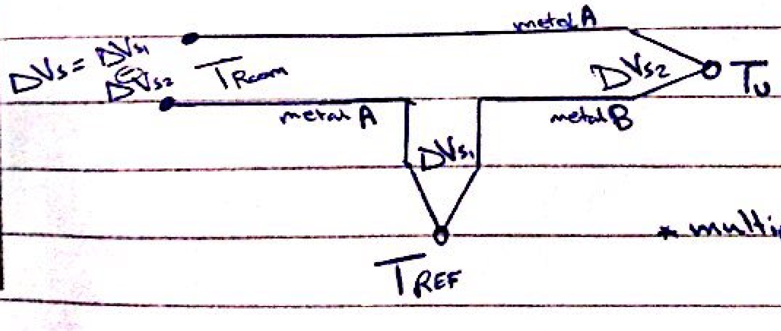
$v(t) = c[1 - e^{-1}]$

$v(t) = 0.63C$

(i) $V_2 - V_1 = V$

$\tau \rightarrow V \times 0.37$ "graph"

(ii) $\tau = 0.37 * T_{V_2 \rightarrow V_1}$



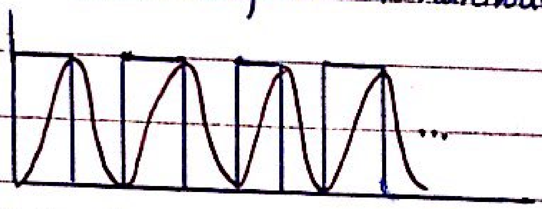
* multiple, thermocouple setup

LabVIEW & DAQ.

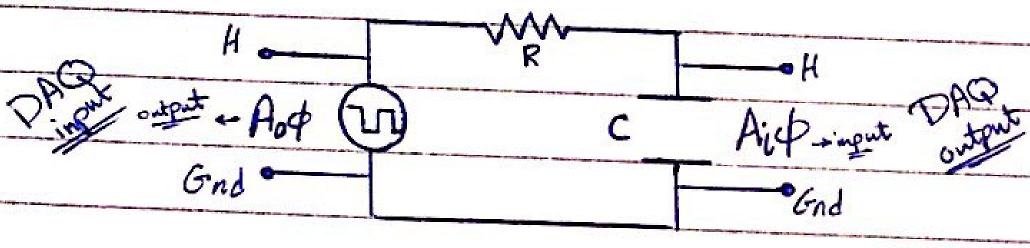
- labVIEW : graphical programming language by National instrument that uses icons instead of text to create applications.

- DAQ : data Acquisition system is for acquiring and measuring A or D signals from sensors or test probes or generating A or D signals.
- DAQ system Consist of : plug-in DAQ board & LabVIEW application.

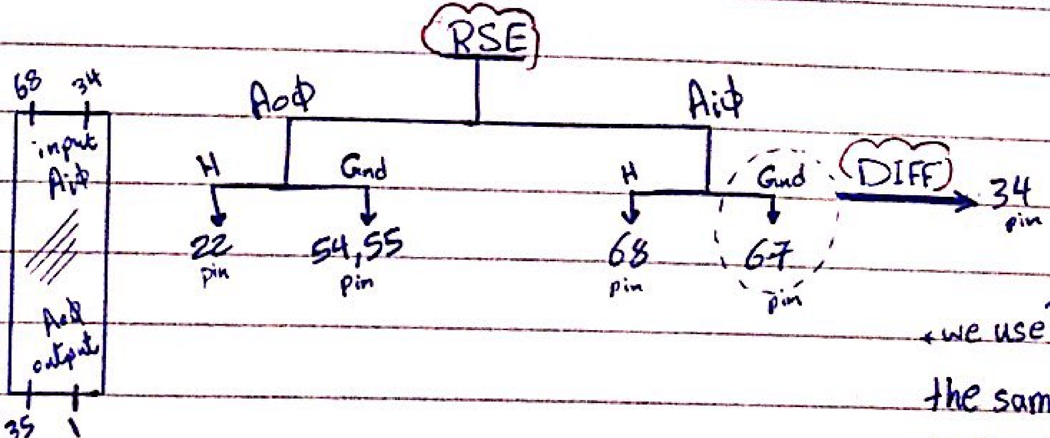
- labVIEW software & DAQ hardware : Connect and interface PC with the Circuit by observing outputs, measuring errors, generating the singals.



- DAQ input is the output of RC-circuit, and vice versa.



- input configuration :
i) "DIFF" differential → Ai(N+8) → Ai8 "for the Ground"
ii) Referanced Signal-Ended "RSE" → Ao∅ , Ai∅



"PCI-6221"

- we use 'DIFF' to have the same ground for both channels, to reduce the RC output noise err.

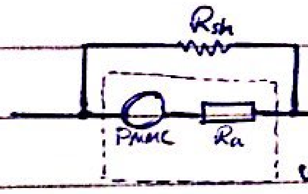
Measuring Resistance Using Voltmeter-Ammeter Method.

- Concept: measure the Current & Voltage across a variable resistance using VA.
- we use two Glvanometers and three decade Resistance boxes "DRB"
  - First Box: Variable Res "R_x" → the value of R_s & R_{sh} changes according to R_x value.
  - second Box: shunt Res "R_{sh}" → PMMC // R_{sh} : Ammeter
  - third Box: series Res "R_s" → PMMC + R_s : Voltmeter

  } → to increase the full-scale deflection.

- Galvanometer permenent magnetic moving coil (PMMC) specification.
  i) Ammeter (PMMC as A) → $R_{sh} = 75\,\Omega$, FSD = 1mA ← max. min = 0mA
  ii) Voltmeter (PMMC as V) → $R_s = 1300\,\Omega$, FSD = 100 μA ← max. min = 0 μA

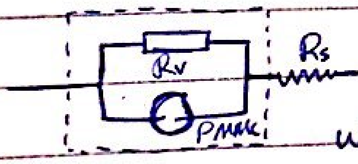
- Case(I) Value of DBR "R_{sh}" used to Convert the PMMC to Ammeter.



$$(FSD') * 75\,\Omega = R_{sh} * (FSD' - 1mA)$$

where FSD': new FSD that you want to use, i.e.: 3 mA.

- Case(II) value of DBR "R_s" used to convert the PMMC to Voltmeter.



$$(FSD') - 100\,\mu A * 1300\,\Omega = 100\,\mu A * R_s$$

where FSD': new FSD that you want to use i.e.: 10 Volt.

- internal Resistances: R_a & R_v → effects the reading of the current measured.

as ammeter: $I_{meas.} = V/(R_x + R_a)$ as Voltmeter: $I_{meas.} = V/(R_x // R_v)$

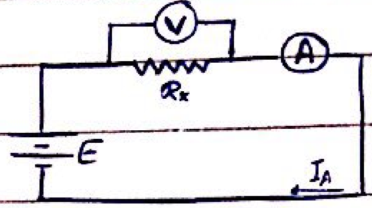
$V_{FSD} = R_a * I_{FSD}$ $V_{FSD} = R_v * I_{FSD}$

- Voltmeter Sensitivity: total Resistance of the meter / Range of voltmeter [Ω/V]

$$V_{sen} = R_{TOT} / V_{FSD}$$

- inc.↑ R_v will Reduce E% of $V_{meas.}$
- dec.↓ R_a will Reduce E% of $I_{meas.}$

• Case(I) :



• $I_A = V/R_x$ i.e: V=10 & R_x = 5, 50, 500 Ω

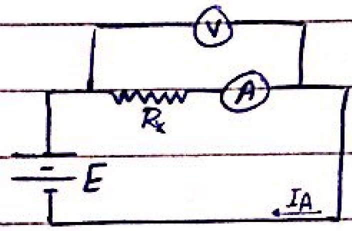
• Calculated $R_x \rightarrow R_x = R_x R_v / (R_x + R_v)$

• Measured $R_x \rightarrow R_x = V_{measured} / I_{measured}$

• error percent $\rightarrow E\% = R_x/(R_x+R_v) \times 100\%$

→ this method is used to measure the small values of R_x. • big error at high R_x.

• Case(II) :



• $I_A = V/R_x$ i.e: V=10 & R_x = 5, 50, 500 Ω

• Calculated $R_x \rightarrow R_x = R_x + R_a$

• Measured $R_x \rightarrow R_x = V_{measured} / I_{measured}$

• error percent $\rightarrow E\% = (R_a/R_x) \times 100\%$

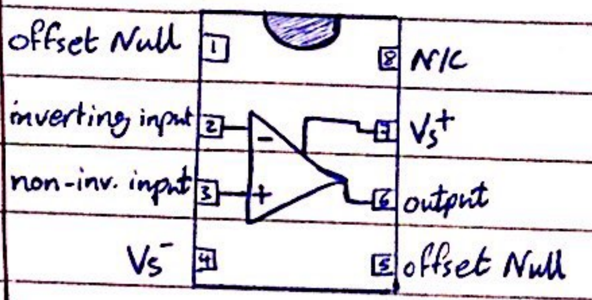
→ this method is used to measure the big values of R_x. • small error at low R_x.

- we can use the voltage galvanometer as an ammeter
  → by Connecting the R_s of the voltmeter to R_{sh} in the ammeter.
- We Can use the current glavanometer as an Voltmeter
  → by reconnecting the R_{sh} of the ammeter to R_s in the voltmeter.

- Changing the value of R_x, dosen't effect the Voltmeter readings "wasn't change"
  → because the voltage across R_x isn't effected by the changing
  it's value, because changing R_x value is going to change also
  the Current value : $R_x \downarrow$ $I_A \uparrow$ V — Const.
  hence, the voltage remains the same
  which is equal to the value of the source voltage. ~10 volt.

OP-AMP as DC electronic milli-Voltmeter.

→ use Op-Amp as DC Voltmeter using permenent magnet moving Coil meter (PMMCM)
→ using "LM741" Op-amp



→ offset Null Adjustment
'balancing out the input offset null pins '1&5' by varying the external Resistance by adjusting the potentiometer, until the voltage offset becomes zero.

→ the impotance of this operation is removing any zero drift in the output Voltage.

→ after adjustment, we need to measure the voltage by setting up three ranges for the milli-voltmeter (FSD) : 100 mV, 300 mV, 1000 mV

→ inorder to do this, we need to calculate DRB's → R_1, R_2, R_3 series with PMMC, then Comparing V_{in} → DMM with V_{out} → PMMC with DRB's

→ error percent : (True − Measure)/True * 100% → [DMM − PMMC]/DMM * 100%

→ Evaluating DRB's : R_1, R_2, R_3

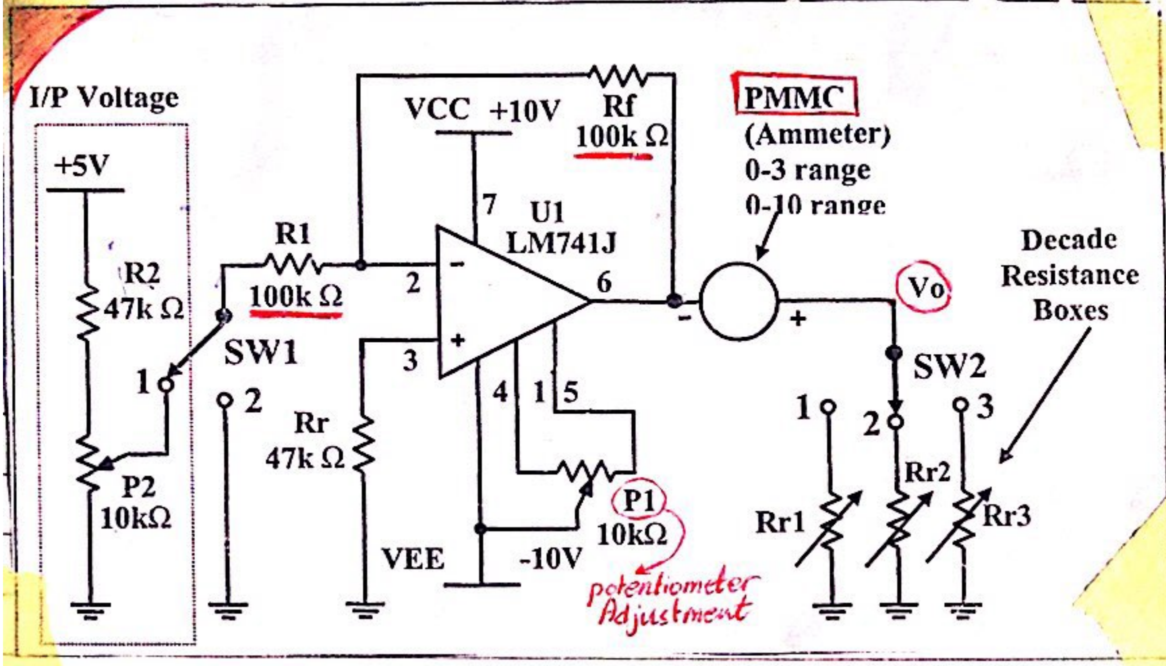
* specification without DBR's → PMMC : $I_{fsd} = 1\,mA$, $R_{coil} = 75\,\Omega$
DMM : $R_{in} = 10\,M\Omega$

→ maximum voltage PMMC can measure without DBR's : $V = IR = 75\,mV$.

→ with DBR's : $R = (FSD - 75mV)/I_{fsd}$ i.e : $R_1 = (100-75)mV/1mA = 25$ ohms

→ PMMC FSD is 1 mV, hence for the Ranges 100 mV, 300 mV, 1000 mV
True Value = Our Reading * (10 or 30 or 100) based on the used Range.

→ Source of error in this Exp : "parallax" when Reading from PMMC device



← important circuit.

→ offset Null Adjustment (@switch 2 and without PMMC & DRB's)
→ measuring Voltage (@switch 1 and with PMMC & DRB's) → to inc.↑ the FSD for V

- R range is 1000 mV FSD, but we are unable to reach this value. (why?)

$R_1 = 47\,k\Omega$ $\quad R_2 = 10\,k\Omega$ $\quad x$: % of potentiometer (100%) for this Case

$V_{out} = 5 \dfrac{xR_2}{R_2 + R_1}$ → $V_{out} = 877.19\ mV$ (max. Vout based on R values & V_{input} 5 Volt)

→ to get the FSD → $1000\,mV = 5 \dfrac{10}{10 + R_1}$ → $R_1 = 40\,k\Omega$

- R_2 is Connected series with the potentiometer which determine the Vin P2. (why?)

with the series Res → $V_{out} = 877.19\ mV$, without series Res = 5 Volt

series Res. helps to reduce the Voltag scale from 5V to 877.19 mV

thus increased the sensitivity of the potentiometer.

- if $R_f = 200\,k\Omega$, then what's the value of R_2 & R_r. (why?)

→ maximum Amp Gain = 2 → thus max Voltage must be devided by 2

$V_o = 5 \dfrac{10}{10 + R_1} = \dfrac{877.19\,mV}{2}$ → $R_1 = 104\,k\Omega$

→ Thevenin equivalent parallel resistors

$R_r = R_f // R_1 = 66.67\,k\Omega$

وقل اعملوا .... فسيرى الله عملكم

:)