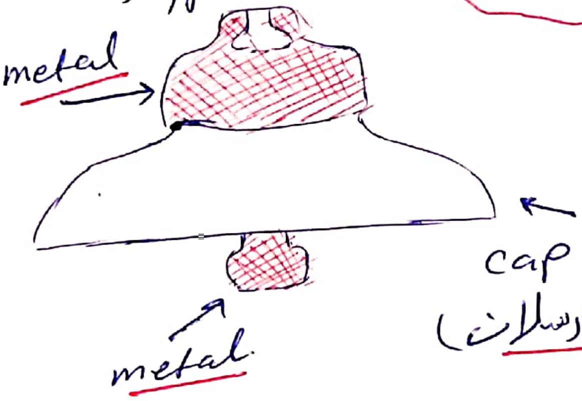
Exp.1

PART ONE

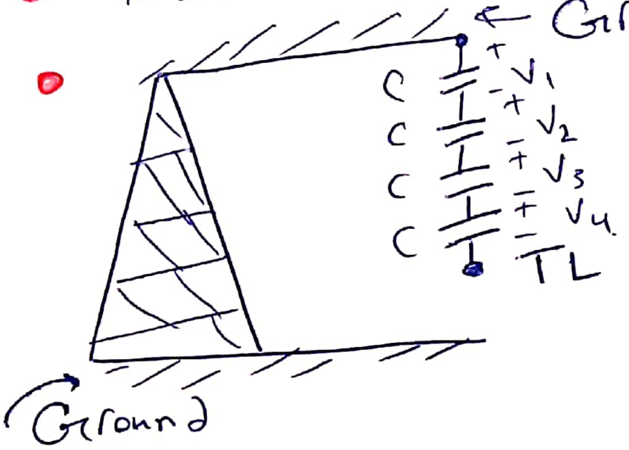
رح نترسم ال
- Voltage distrubution → insulator. (on suspention type insulator)
- over head lines & under ground cables → للطاقة الكهربائية
- Insulator type:- PIN type, post type, and suspention type.

Suspension type ال مميزاتها



1)) cheap
2)) up to 44 KV
3)) بيقدر تركيب اكثر من عازل فوق بعض. ⇒ string of insulator.

- Insulator ≡ capacitor.



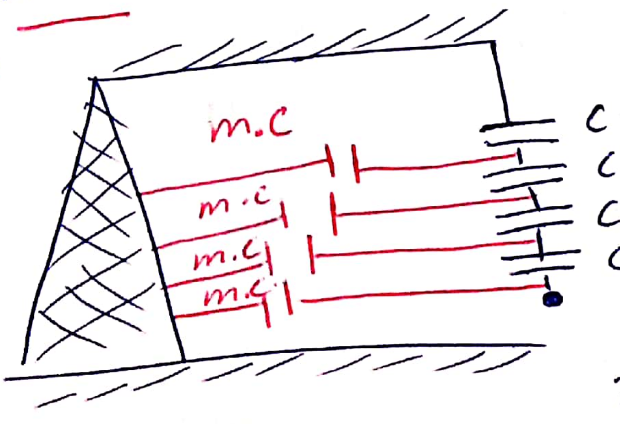
- كل C فيها نفس الشحنات
- $V_1+V_2+V_3+V_4 = \frac{V_L}{\sqrt{3}} = V_{T.L}$
- بوجد ال charging current ال لفها

$V_1 \neq V_2 \neq V_3 \neq V_4$ (non-uniform voltage distribution

- capacitor to ground between:

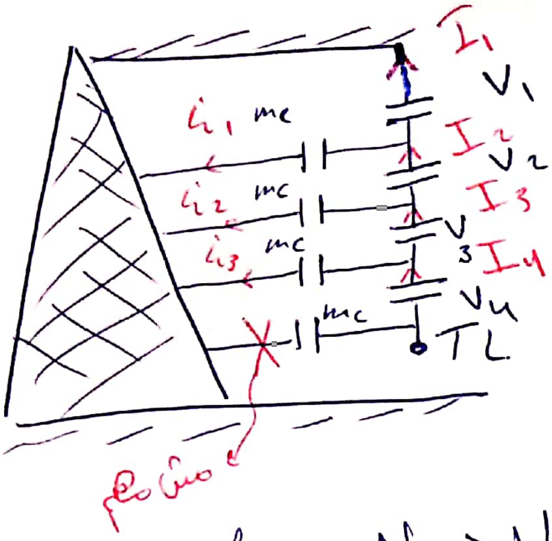
1) cup & Tower 2) of insulator

⇒



- $m = \frac{\text{insulator capacitance}}{\text{Ground capacitance}} = \frac{C}{m.C}$

$m \rightarrow (0 - 1)$ قيمة بين



$$I_2 = I_1 + i_1$$

$$V_2 \omega c = V_1 \omega c + V_1 \omega mc$$

$$\boxed{V_2 = V_1 (1+m)}$$

ومهم!

- Therefore $V_4 > V_3 > V_2 > V_1$

- ولانه كلما قربنا على ال T.L كانت الفولتية اعلى هاد بسبب مشاكل وال insulator ال C_1 يدخلها عليه فولتية اعلى من اللي بتحملها.

flash over → تدهور العازلية

- Solutions: 1) Grading for units.

$$C_1 \neq C_2 \neq C_3 \neq C_4$$

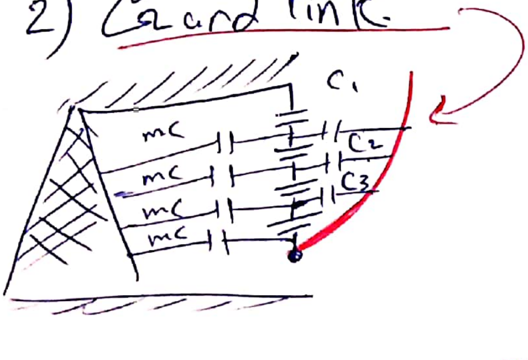
بحيث ال C_4 تكون قيمة اعلى وبتحمل فولتية اعلى.

→ Dis advantage: not practical

لانه اذا خرب واحد من العوازل بدي افحصهم كلهم واعرف كم قيمة لكل واحد.

Hard in maintenance.

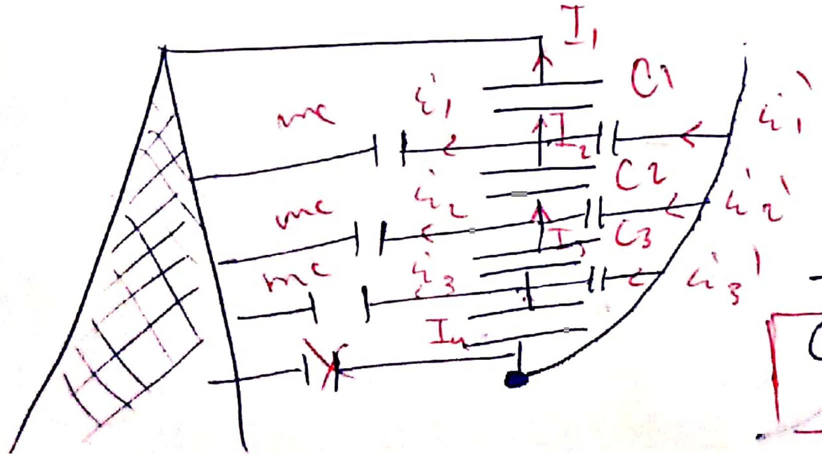
2) Guard link



$$I_2 + i_1' = I_1 + i_1$$

$$i_1' = i_1$$

$$C_1 (4V_1 - V_1) = V_1 mC_1$$



$$V = V_1 + V_2 + V_3 + V_4$$

$$= 4V$$

$$\rightarrow C_1 3V_1 = V_1 mc$$

$$\boxed{C_1 = \frac{mc}{3}}$$

→ This method is also called (Static sheildings).

- $\eta = \dfrac{V_4}{4 * V_{L-g}}$

V_4 → او اقرب insulator Voltage

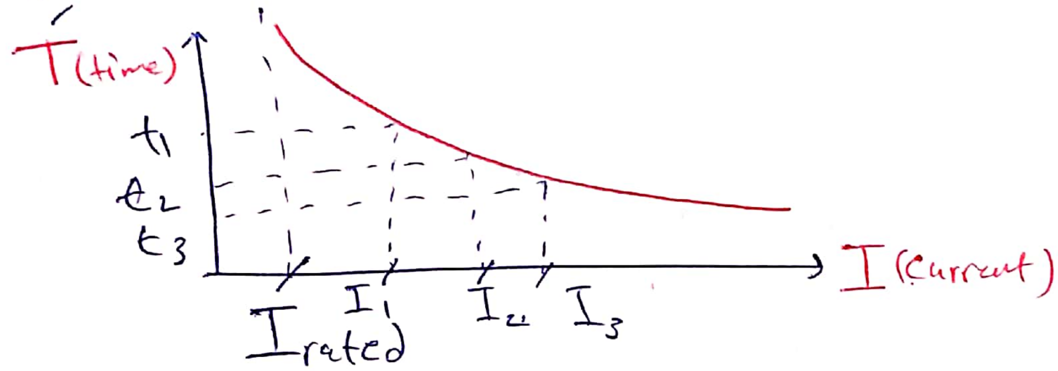
V_{L-g} → Transmission line الـ

- if all V's are equal then $\eta = 100\%$.

PART TWO

- Fuse characteristics → protection.

usually Fuses have rated current → اذا هاد التيار مثل هو ما بيحرق. لكن اذا زاد ال I بيحترق حسب قيمة التيار ← time



I↑↑ , t↓↓

(*) ليه ال fuse جوا كبسولة معزولة من ال O_2 ?? capsulated enclauser ?

[1] حتى لا يتأثر بعوامل الجو.

[2] اذا انقطع ال fuse وصار في arc ، ال O2 يطفي هذا ال Arc .

- عند انقطاع ال fuse ← منع اللهب والاحمرار ايضاً من الظهور.

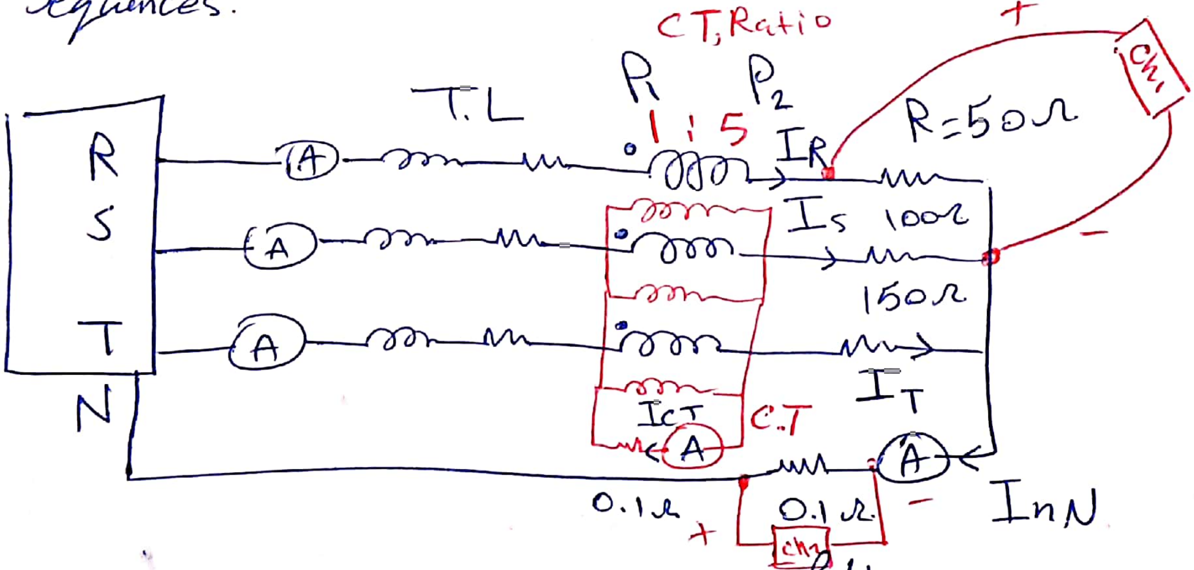
Exp 2

* $t_{withstanding} = \frac{1}{I^2_{negative\ sequence}}$

- our system is balanced → unbalancing the load
  لأنه الكهربا من الشركة وما بنقدر نلعب فيها.

  → +ve sequence ⇝ in all balanced systems.
  → Zero sequence ⇝ when a fault is there.

- We will make filters to obtain +ve, −ve & Zero sequences.



This is a Zero sequence filter.

- 0.1Ω : to see phase shifts for wave currents.

$$I_{nN} = I_R + I_S + I_T$$

$$I^{(0)} = \frac{I_{nN}}{3}$$

$$I_{CT} = \frac{I_{nN}}{5} = \frac{3I^{(0)}}{5} = I_{CT}$$

$$\boxed{I^{(0)} = \frac{I_{CT} * 5}{3}}$$

← لينا نحسب ال ① I_R , I_S (V_S)

② I_R , I_t

③ I_R , I_{nN}

④ I_R , I_{CT}

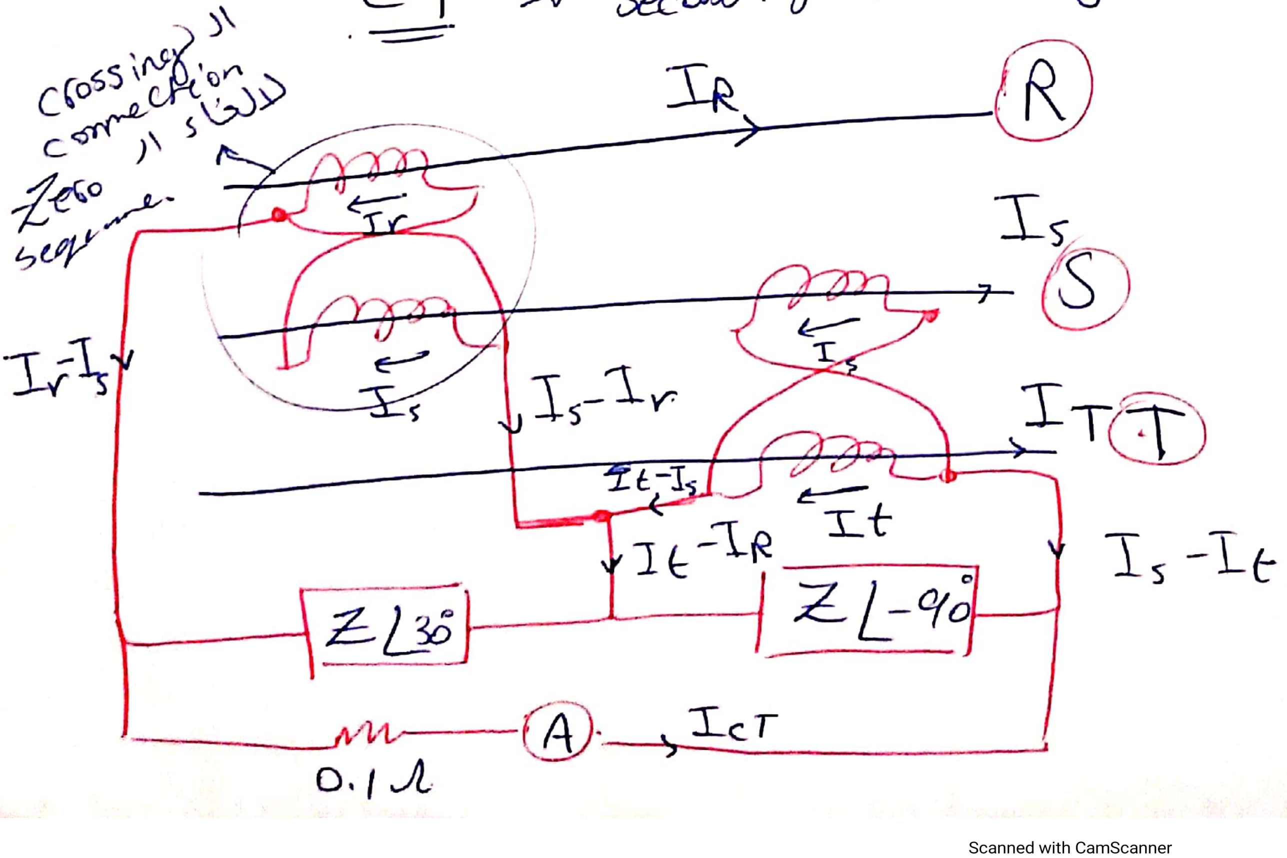
- if $I_R \neq I_S \neq I_T$ ⇒ nutral jump V_{nN}
  ↳ phase shift between them = 120°.

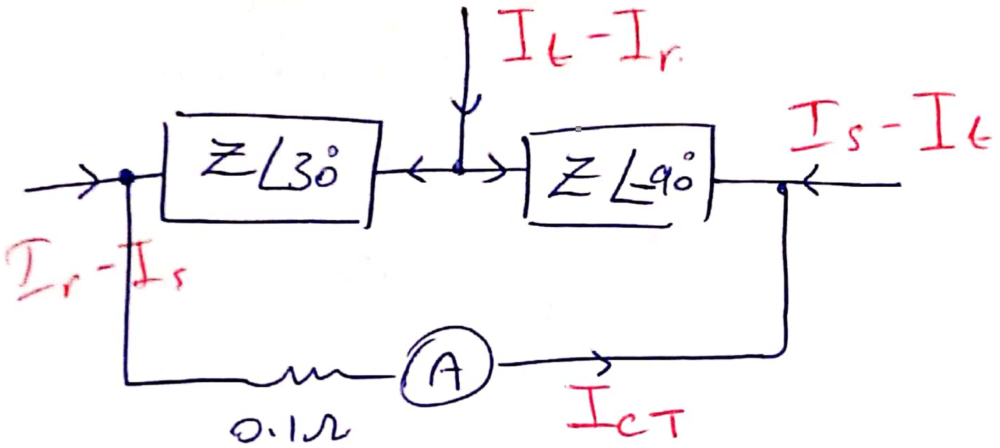
V_{nN}: $V_{RN} = I * R$ .... بتجمعهم

بيساوي $3 * V^{(0)}$

{ positive & negative sequence current. }

- كل الشغل دى ال secondary لل CT





$$I_{CT} = \frac{Z\angle 90°}{Z\angle 30 + Z\angle -90°} * (I_t - I_r) + I_r - I_s$$

$$I_{CT} = -\frac{Z\angle 30°}{Z\angle 30° + Z\angle -90°} * (I_t - I_r) - (I_s - I_t)$$

① Zero Sequence

$$1\angle -60° \,(I_t^{(0)} - I_r^{(0)}) + I_r^{(0)} - I_s^{(0)}$$

$$I_{CT}^{(0)} = Zero$$

② positive Sequence.

$$1\angle -60° \,(I_t^{(1)} - I_r^{(1)}) + I_r^{(1)} - I_s^{(1)}$$

$$1\angle -60° \,(I\angle -120° - I\angle 0°) + I\angle 0 - I\angle 120°$$

Negative = Zero

$$I_{CT\,positive} = 3I^{(1)} \angle +60°$$

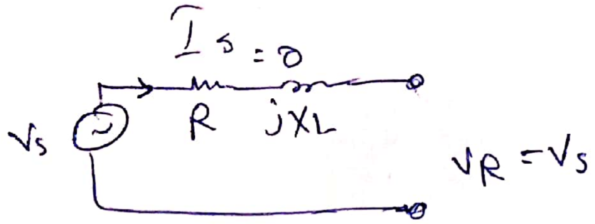
٣ أضعاف ال positive sequence.

Z_B & Z_A بنعكس ✗

بيطلع ال negative sequence current.

Power lab Experement 8

- Short transmission line.



open circuit

$I_s = 0$, $V_s = V_R$

$V_s = AV_R + BI_R$

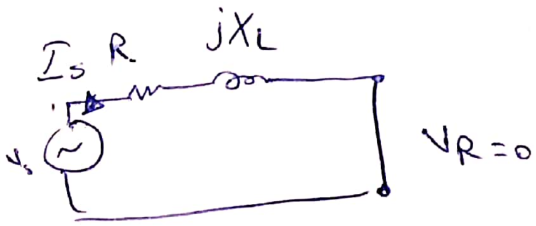
$I_s = CV_R + DI_R$

$$A = \frac{V_s}{V_R}\Big|_{I_R=0} \simeq 1$$

$$C = \frac{I_s}{V_R}\Big|_{I_R=0}$$

short circuit

$$B = \frac{V_s}{V_R}\Big|_{V_R=0} = \text{in ohms}$$



$A = D$

$$\begin{bmatrix} V_s \\ I_s \end{bmatrix} = \begin{bmatrix} 1 & Z \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V_R \\ I_R \end{bmatrix} , \quad Z = R + jX_L$$

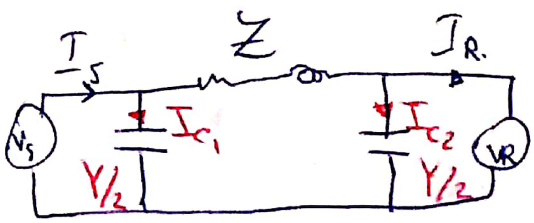
- Voltage Regulation : when there's a load

$VR \Downarrow$ ⇝ Better (no much losses on the receiving side.)

$$VR\% = \frac{V_{RNL} - V_{RFL}}{V_{RFL}} * 100\%$$

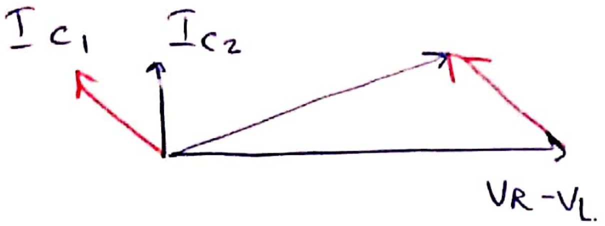
- Medium Transmission line

open circuit test



$$A = D = \frac{ZY}{2} + 1$$

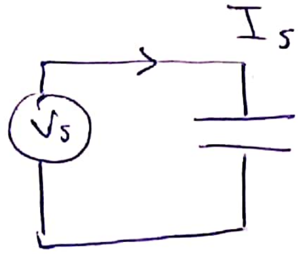
$$B = Z\,(\Omega) , \quad C = Y\left(1 + \frac{ZY}{4}\right)$$



$V_R > V_s$

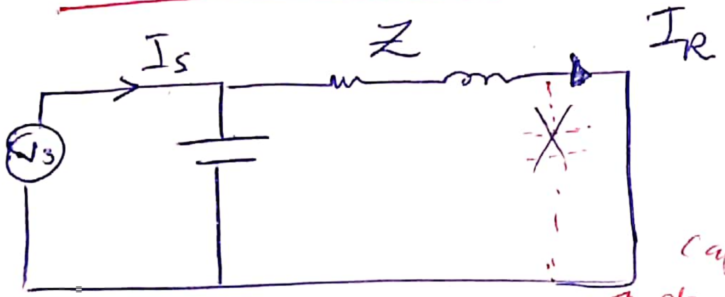
Solution: inductive compensation.

open circuit test



$I_s = Y V_s$

Short circuit test



$P_{sc} = I^2 R$, C ⟶ open circuit test ✓ ⟹ $\underline{\underline{Z}}$ ✓

R ⟶ Short circuit test ✓

✓ $V_s I_s = S$

$(S = P + jQ)$, $Q = I V \sin\theta$

$P = I V \cos\theta$

- Voltage on $\underline{\underline{V_R}}$ very high ⟶ ① light load ② no load.

⟶ Use inductive compensation.

- Voltage drop ⟶ Use capacitive compensation.

change in $\underline{\underline{Q}}$

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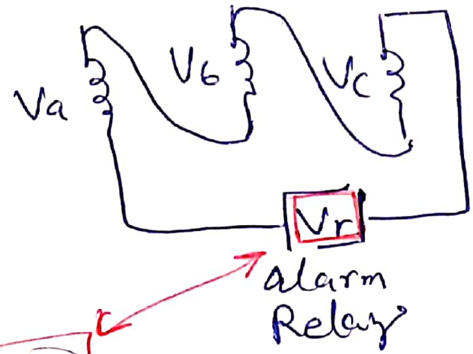
Exp 4

* at balanced conditions **n = earth voltage = Zero**
* If one phase was earth faulted, the other phases V_{L-G} will be 60° out of phase.

→ The current in case of one phase - earth faulted is small and wont be detected except by an alarm circuit from open delta secondary winding of a voltage transformer @ sending

End.

→ To avoid prolonged outages, the line is switched off.



open Δ earth fault detection.

$V_r = 3 V_a$ → fault between a & earth.

* **Arcing ground**: The process by which the clearing and restriking of the arc caused recurring high surge voltages.

* **Solidly earthed nutrals**: earthing conductor between earth rod and grand..
  - ↳ also called effectively earthed. → when phase fault voltage do not exceed 80% of V_{phase}. $\frac{X_0}{X_1} < 3$ or $\frac{R_0}{R_1} < 1$

* Treating nutral points:

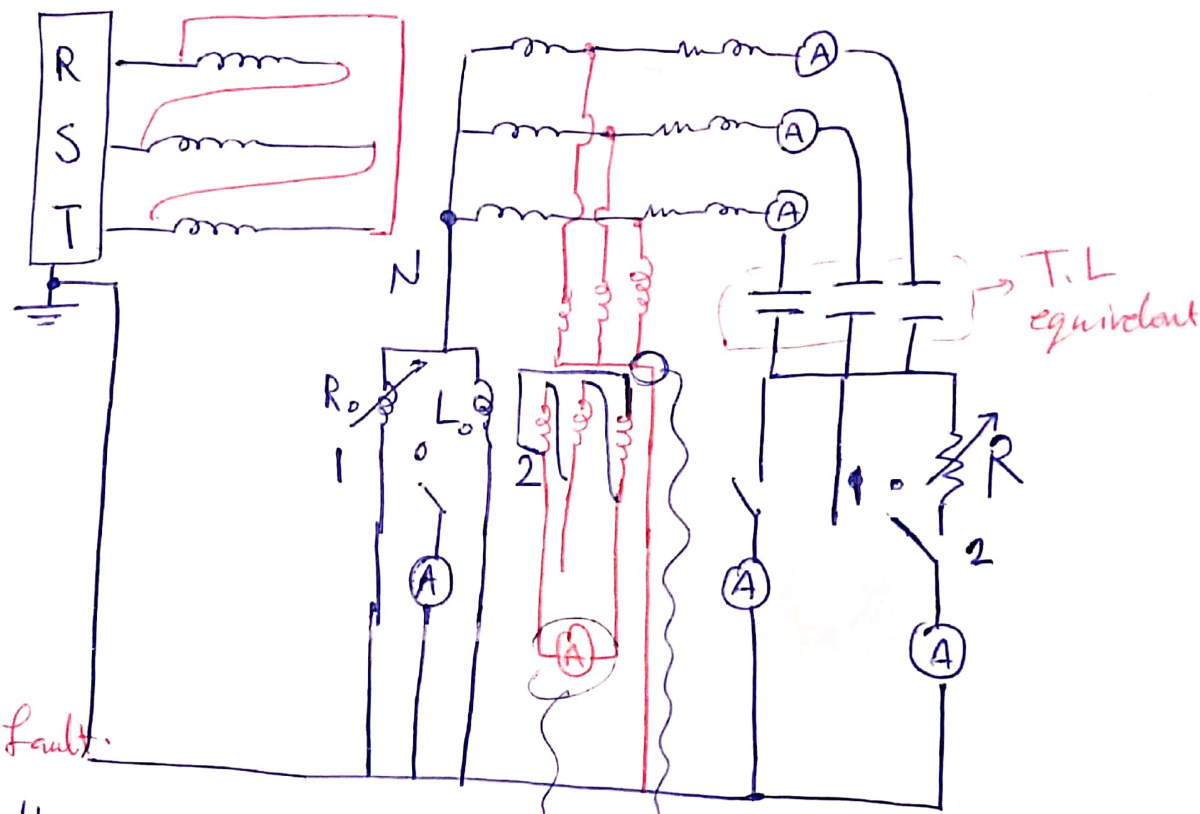
1. Δ Y 6.6K or 11K / 380 or 415 solidly grounded
2. Δ Y 33/11K or 132/11K or 132/33K through resistance
3. 132K & above are solidly earthed

Experement 4

[1]

- Grounding? to protect human & Equipments

220/230 → Isolator



Earth fault:

for fault detection

Voltage transformer

هاي ال connection
لما اشغل ويصير فيه
شي راح يطفطفه
وعلشان اقرا
ال Current

- When fault occures:
  change in one phases ↑↑ = Zero
  & healthy? = V_{L-L}

- **Solid Earth fault**
  ↳ without a resistor:

$I_t = 0.$

$I_c = I_R + I_s$

$I_c = \frac{V_{LL}}{X_c} + \frac{V_{LL}}{X_c}$

$= \frac{\sqrt{3} V_p}{X_c} + \frac{\sqrt{3} V_p \angle -120}{X_c}$

$$I_c = \frac{3V_P}{X_c}$$

- When there's an $\underline{R}$ (Grounding)
  ↳ current ((fault)) will decrease

(Tip) → minimum I_{fault} is when (inductor) is Resonated with capacitors in transmission line.

Note - Best grounding

Resonance $I_c = I_L$ ⇒ equal.

$$\frac{V_P}{X_L} = \frac{3V_P}{X_c}$$

$$X_c = 3X_L$$

$$\frac{1}{\omega c} = 3\omega L$$

$$1 = 3\omega^2 c L$$

for minimum fault current — الشيقة

$$\boxed{L = \frac{1}{3\omega^2 C}}$$

- Question in Final Exam:- Given:

→ $I_f = 0$, X_c ✓ & $V_{n-?L,P}$, I_c ⇝ you can calculate them & find $I_L = I_c$. X_L can also be found! ✓
& find other thing ↗
This is the way to begin.

Exp 5

→ In lab, the current base value is 2.5A

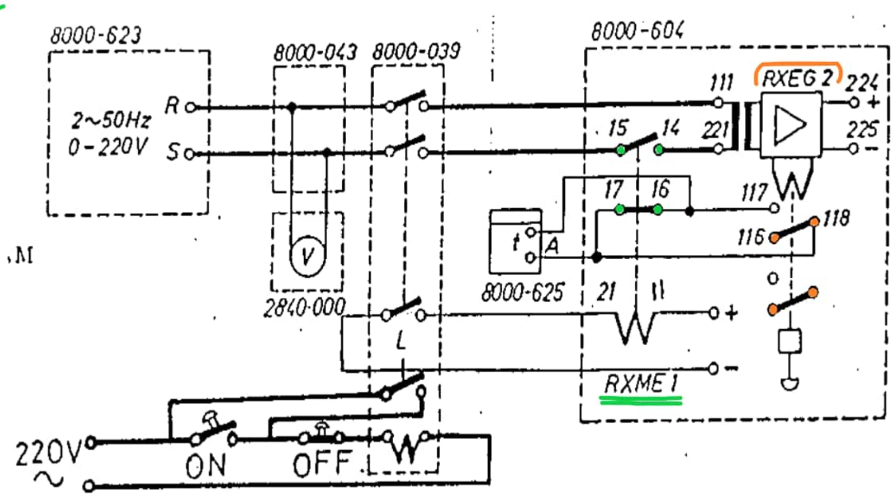
RXIG → I: over current relay.

* If the scale factor is 1, the relay will trip at $1 * 2.5 = 2.5A$
  2 ⟹ $2 * 2.5 = 5A$

* It's an Instantenous over current relay (High sensitivity)

* the Signal to trip will change the State of switches : N.O ⟶ closes.
  N.C ⟶ opens.

دائماً بالرسمات
اتبع الخط المنقط
حتى تعرف كل Relay
Switch لأي
تابع.



Exp 5 cont.

RXEG
E → E: over voltage relay.

→ Base value for the relay in lab = 80v.

* If the scale factor = 1 , the relay will give signal to trip @ 1*80 = 80v.

* **Resetting Value**: the amount of time that the relay take to be able to clear another fault after the clearing the first one.

* RXEG has a flag for when a fault occurs. → (Disadvantage): لا يمكن اعادة هذا الـ flag إلا manually

والسبب هو عند حدوث fault يمكن ان يزول بعد فترة، لكن على العنصر ان يعلم بحدوثه ولهذا يبقى الـ flag.

* **RXF₁**: Indecation relay. — بطلع لما الـ flag overvoltage relay يشتغل.

* $$\text{Resetting ratio} = \frac{\text{Resetting Value}}{\text{Operating Value}}$$

→ $\langle 0.95 - 0.98 \rangle$

كلما كان اعلى بتكون الـ Sensitivity أكبر

$RR < 1$

Exp5 cont.

* RxF₁ → Flag is up @ resetting value.
  → Flag is down @ operating value.

* RXIG & RXEG are designed for Ac. But need Dc auxiliary supply.

→ Has two change over contacts and one flag.

→ RXIG → Has airgap in input transformer: Insensitive to Dc component.
  → Doesn't have airgap:
  1. Sensitive to Dc.
  2. Low power consumption
  3. High sensitive earth-fault protection.
  4. High operating Values @ higher frequencies.
  5. High overload capacity.

→ RXEG
Up to 400HZ → operating Values has no Variations.

* power consumption: $V_{operating} * I_{operating}$
≃ 0.3 VA due to High input Impedance.

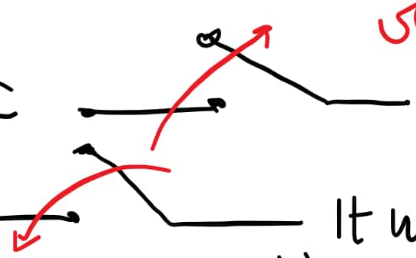
Exp 5 cont.

* RXME : this relay to trigger the timer.

→ measure pickup time.

* when the switch is N.C

But when it's N.O



بتفتح على طول!

It will take time to close.

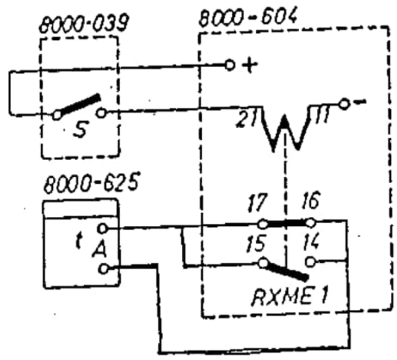
* That's why we have two times

[1] Real time [2] Correct time

→ بأخذه من ال timer

→ بحسبه عن طريق

Correct time = Real time − Switch time



بحسب ال Switch بإجراء تجربة عليه

≃ (12−14) msec.

* Changing Voltage doesn't affect time

لأنه ال Relay instantenous.

→ It takes one cycle to calculate the RMS

therefore: (20−30) msec ← عشان بيشتغل

1. RXIC Relay (Electromechanical)

. Description of RXIC Relay

$$RMS = \sqrt{(D_c^2) + (A_c)^2_{RMS}}$$

The operation principle of this relay depends on the electromagnetic force created by energizing the electromagnet (1), as shown in **Figure 1**.

Then after energizing, the force produced will attract the armature (2).

When the current is no longer running in the coil attached to (1), the spring will help bringing back (2) to its original position.

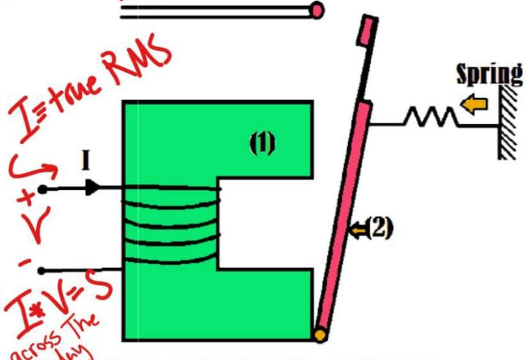


Figure 1: Electromechanical Relay

. Advantage and Disadvantage of the Electromechanical Relay:

- The Apparent Power is greater after energizing the relay compared to the Apparent Power before energizing it.
- It uses Permanent Magnet Moving coil meter (PMM) thus, it works on a linear scale.
- The PMM reads Dc values so it can give us the average value only.
- In order to read the Root Mean Square value (RMS), we must rectify the input, and then use a Form Factor (FF).
- This type of relays can be connected in series with the source and will take the energy directly from it. No need for external sources (Auxiliary).
- The sitting ratio depends on the spring.
- It has low accuracy and sensitivity.
- It may use Moving Iron meter (IM) and when it does, the scale becomes nonlinear.
- In case of IM, the meter reads the True RMS value. This value can be obtained due to the effect of the torque applied on it.

RXIG Relay (Electrostatic)

. Description of RXIG Relay

The input circuit to this relay is a transformer (1) as shown in **Figure 2**.

The transformer with its air gap works as a filter for the Dc component. The relay thus will be affected by the AC part of the input. The relay needs an external Dc source (Auxiliary voltage source) to operate (2).

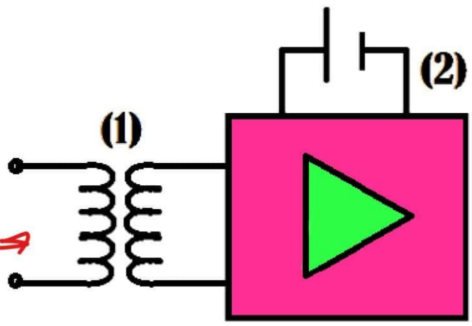


Figure 2: Electrostatic Relay

. Advantage and Disadvantage of the Electrostatic Relay:

- The Apparent Power is fixed and does not change during energizing.
- The value of the apparent power is lower compared to the electromechanical relay.
- The relay works only on the AC and the readings are proportional the instantaneous rate of change.
- It has very low input impedance.
- Very sensitive compared to the electromechanical relay.
- Setting ratio is very high compared to the electromechanical relay.
- Very high accuracy.
- Needs an external DC voltage source.

Comparison between the two relay types

. Operating and resetting values:

The RXIG relay works on Ac and the RXIC relay works on DC. The RXIC relay has lower accuracy and sensitivity compared to the RXIG relay. The resetting ratio of the relay RXIG relay is higher than the RXIC relay.

. Power Consumption:

The RXIG relay has lower apparent power consumption compared with the RXIC relay, but the RXIC relay changes apparent power when energizing.

. Effect of the DC component:

The RXIG relay is not affected by the DC component because of the input circuit it has. Its input circuit consists of a transformer that filters out the DC component and keeps the AC part only. As for the RXIC relay, it is highly affected by the DC components. It actually operates on it.

Conclusion

In practice, we use both relays for protection. They are usually connected in series so that we are getting advantages from both; the electromechanical relay (RXIC) and the electrostatic relay (RXIG).

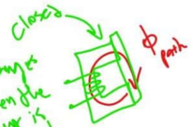
Apperant power

ES (electrostatic) Before Energizing = After Energizing

EM (electromechanical) Before Energizing < After Energizing

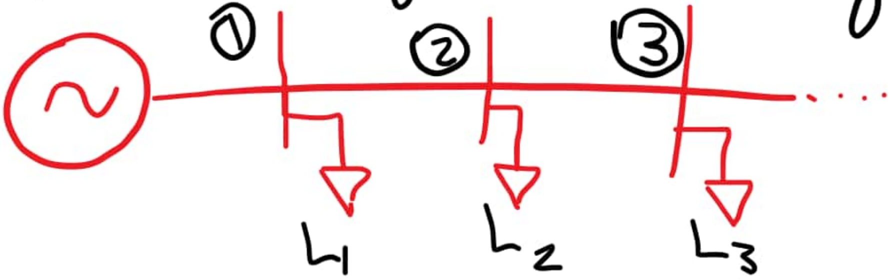
$L_{Before} < L_{after}$

$L \propto \mu_r$ — change when the relay is Energized



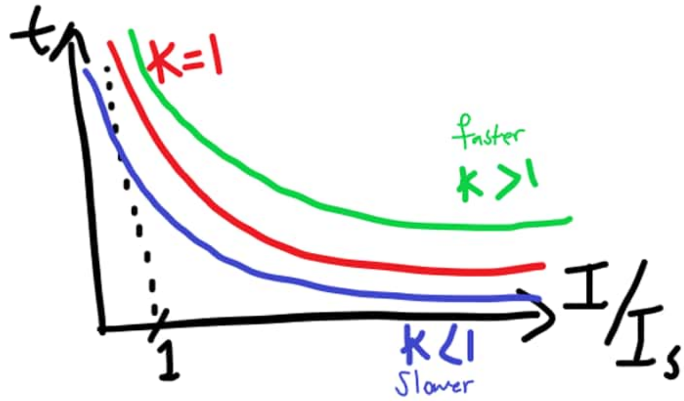
Exp 7 RXIDE

• Inverse time lag overcurrent relay.



$I_{rated_1} > I_{rated_2} > I_{rated_3} \ldots$

$I_{setting_1} > I_{setting_2} > I_{setting_3}$



* if $I < I_s$ (normal)
* if $I_s < I < I_{max}$ (inverse)
* if $I > I_{max}$ (instantenous over-current relay)

Three control knobs:

① A → current settings

② B → Instantenous settings ($I_B = 4$ in lab)

③ C → time settings (K)

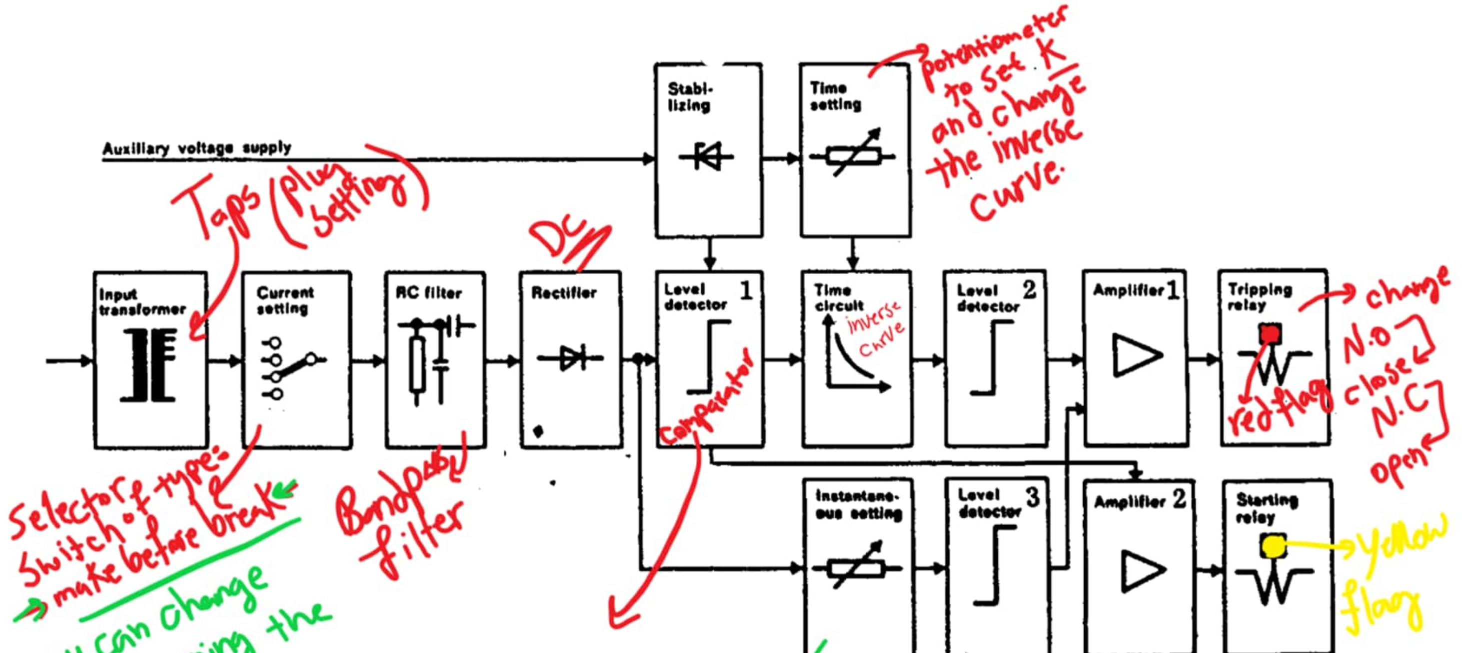
Exp7 cont.

RXIDE

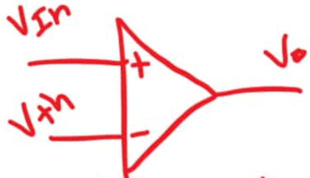
→ It has Two Flags: RED, Yellow

- Yellow → $I > I_s$
- RED → $I_{max} > I > I_s$ and $I > I_{max}$

→ Set ∞ to avoid Instantenous operation.



↳ if not set to ∞ and $A*B > I_{max}$ will work Inst. and bypass inverse



- if $V_{In} < V_{th}$ or $V_{In} = V_{th}$ (low V_o) ✗
- if $V_{In} > V_{th}$ (V_o High) → signal to trip ✓

Scanned with CamScanner

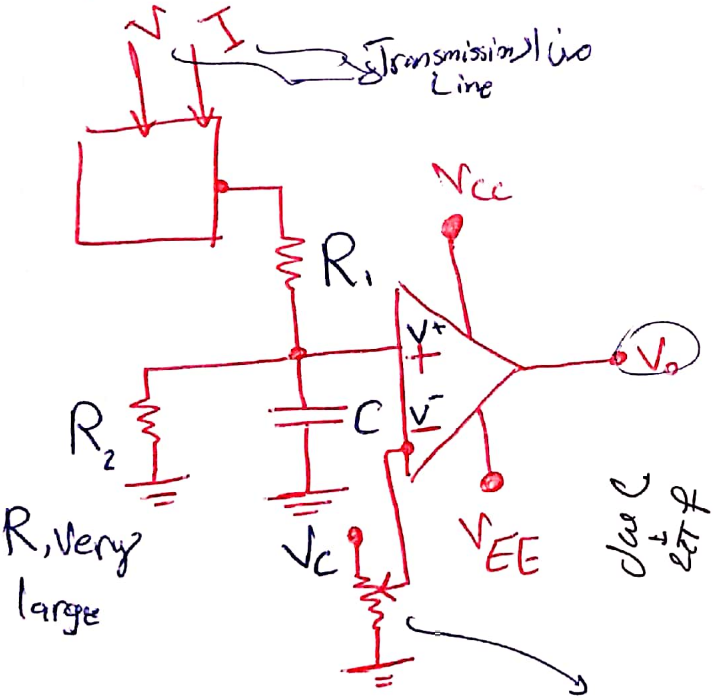
Experement 8 RXPE-40 (40 اوله)

- Type RXPE Directional Relay: also called Power relay:

→ operates on 1-4 times Scale constant

* two contacts BUT only one changeover contact

The second contact is a flag that is reset manually.



★ نحدد ال Threshold من قيمة K

Constant → Current Multiplier

Higher scale factors → higher operating time.

- Op-Amp Comparator:

V_o ← احتمالها

(1) Zero or negative if $V^- > V^+$

(2) Highe or positive = Trip signal if $V^+ > V^-$

← متى يحصل هذا الكلام؟

$$I_s < I \cos(\phi - \alpha)$$

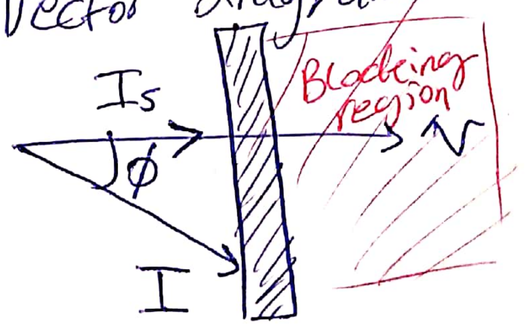
I_s: Setting current; I: Transmission Line; ϕ: phase angle; α: Zero بال Relay تابع التجربة

نجد من هون I

$$I = \frac{I_s}{\cos(\phi)}$$

عوضنا ال α, ϕ لأنها Zero

- Vector diagram



- There are two coils:
  - → Current coil
  - → Voltage coil (as referance)

القراءة غير صحيحة من غير كـ Reference.

← اذا انعكست ال Voltage يعطي بس fault وبس لأنه Directional. (عكس ال connection بأثر.)

عشان هيك ال two coils → Power Relay.

→ the When Inductive Load.

- φ : affects the Sensitivity
- α : كمان phase angle left
  لكن هاي بتعطي ال
  maximum Sensitivity
  called characteristic angle.

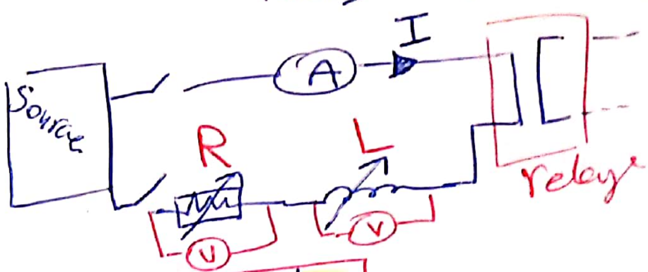
if $\alpha = 0$ → relay will operate for very low values of input voltage.

- لا يتأثر ال Relay بال
  Dc voltage or current
  لوجود Transformer.
- RXPE-40 has low power consumption compared to mechanical Relays.
  → not affected by temperature variations.
- يجب الانتظار 30 - 15 sec until the capacitor discharge (الرحمة اليدورا)

① $I = \frac{I_s}{\cos(\phi - \alpha)}$

② J_2 : prevent current from entering the circuit & build up voltage accross the capacitor and correctly set the settings.

يمكننا ان نرى تأثير φ عند
وضع inductor
in series مع مقاومة
معروف قيمتها.



$$\tan\phi = \frac{V_L}{V_R}$$

$$V_L = IR\tan(\phi)$$

- Questions:
  How to measure PF using only multimeter?
  → الجواب بال Inductor
  وقيس ال voltage across it.

③ The voltage coil is used as reference & to know direction changes in current.