Model Answer

جامعة الفيوم
كلية الهندسة

العام الدراسي : ٢٠٠٩ / ٢٠١٠

الفصل الدراسي : الأول

قسم الهندسة الكهربية - شعبة الآلات والقوى الكهربية

الفرقة الرابعة

مادة : أجهزة الوقاية والحماية

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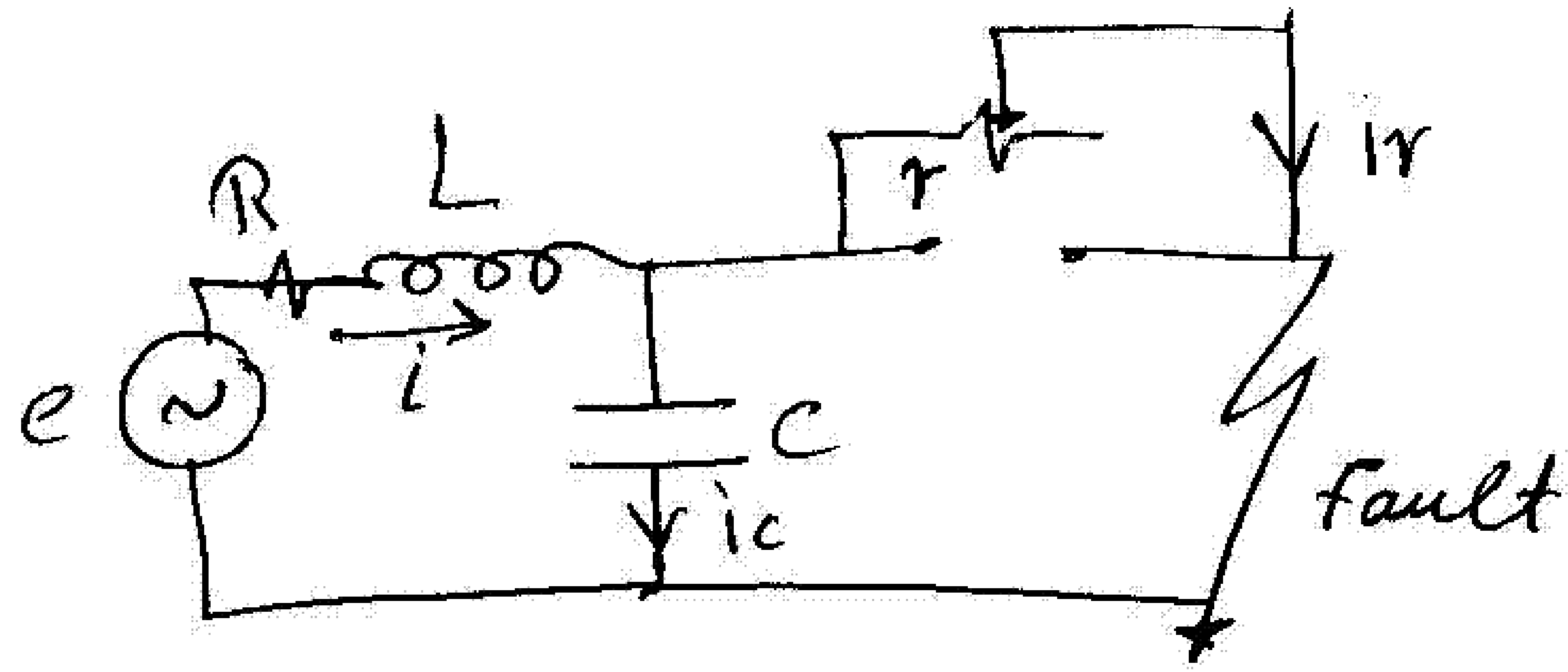
Q1

a)



$$e = iR + L\frac{di}{dt} + \frac{1}{C}\int ic\,dt$$

but $\frac{1}{c}\int ic\,dt = ir * r$ $\therefore \frac{ic}{c} = r\frac{dir}{dt}$

$\therefore ic = rc\frac{dir}{dt}$ & $i = ir + ic$

$$\therefore 0 = \left[ir + rc\frac{dir}{dt}\right]R + L\frac{dir}{dt} + Lrc\frac{d^2 ir}{dt^2} + ir\,r$$

[homogenous solution]

$$\therefore \frac{d^2 ir}{dt^2} + \underbrace{\left(\frac{rcR + L}{Lrc}\right)}_{B_1}\frac{dir}{dt} + \underbrace{\left(\frac{R+r}{Lrc}\right)}_{B_2} ir = 0$$

$$\therefore \frac{d^2 ir}{dt^2} + B_1\frac{dir}{dt} + B_2\,ir = 0$$

The roots of the equation are given as follows

$$\frac{-B_1 \pm \sqrt{B_1^2 - 4B_2}}{2}$$

for oscillations to take place → Complex roots

$$\therefore W = \sqrt{-\frac{\left(\frac{R^2}{L^2} + \frac{2R}{Lrc} + \frac{1}{r^2C^2} - \frac{4}{LC} - \frac{4R}{rLC}\right)}{4}}$$

$$= \sqrt{\frac{-R^2}{4L^2} + \frac{R}{2Lrc} - \frac{1}{4r^2c^2} + \frac{1}{LC}}$$

$$= \sqrt{\frac{1}{LC} - \left(\frac{R^2}{4L^2} - \frac{R}{2Lrc} + \frac{1}{4r^2c^2}\right)}$$

$$= \sqrt{\frac{1}{LC} - \left(\frac{R}{2L} - \frac{1}{2rc}\right)^2}$$

$$\boxed{\therefore f = \frac{1}{2\pi} W} \longrightarrow (1)$$

$L = 0.15H$; $R = 12\Omega$; $C = 0.15\mu F$, $r = 1000\Omega$

Sub in (1) $\therefore f = 922.5277 \text{ HZ}$

For Critical damping $B_1^2 - 4B_2 = 0$

$$\left(\frac{rCR+L}{Lrc}\right)^2 - 4\left(\frac{R+r}{Lrc}\right) = 0$$

$$\frac{(rCR+L)^2}{Lrc} - 4(R+r) = 0$$

$$(rCR+L)^2 - 4Lrc(R+r) = 0$$

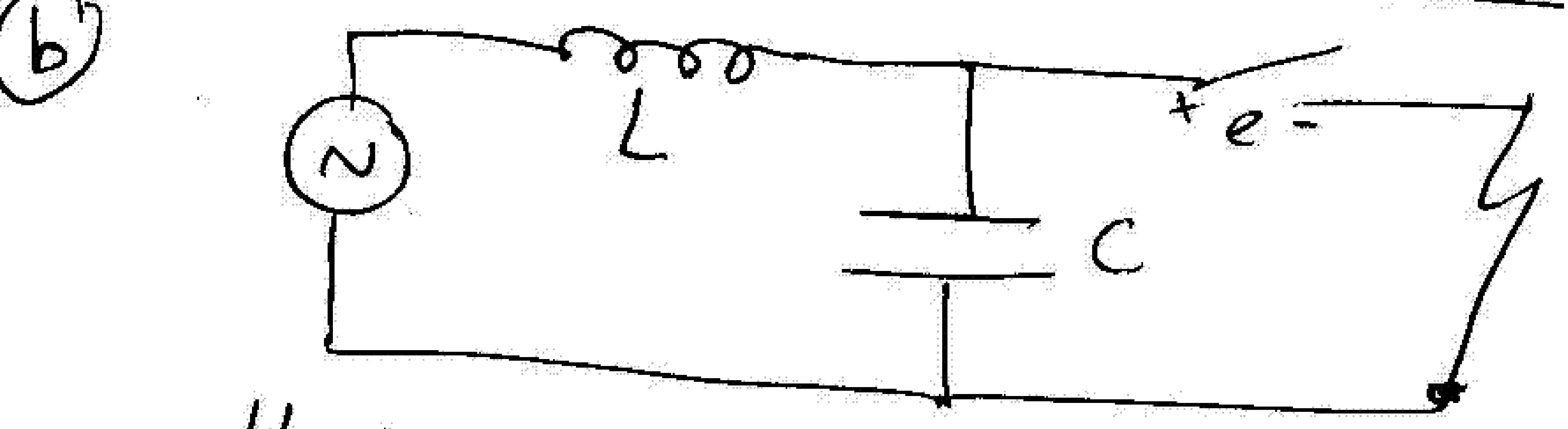
$$r^2c^2R^2 + 2rcRL + L^2 - 4LrRC - 4Lr^2c = 0$$

$$r^2(c^2R^2 - 4LC) + r(2CRL - 4LRC) + L^2 = 0$$

Sub with the Values of L, C, and R

$\therefore r = 497.0179\ \Omega$

(b)



- Maximum RRRV $= \frac{E_m}{\sqrt{LC}} = \frac{13*10^3*\sqrt{2}}{\sqrt{3}*\sqrt{LC}}$

where $L = 0.014\ H$ & $C = 0.012\ \mu F$

$\therefore$ Max RRRV $= 818.923\ MV/s$

(4)

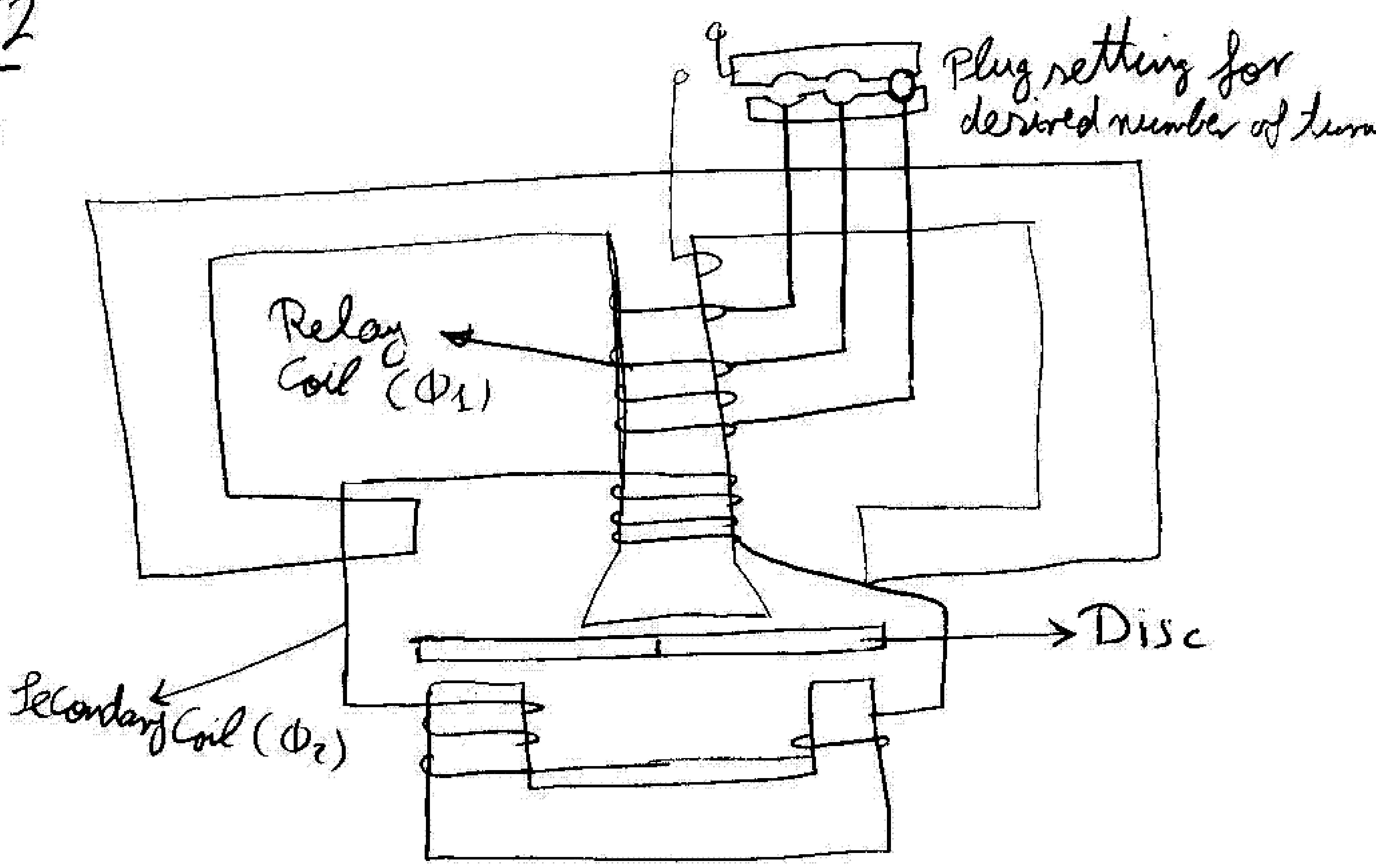
- $e_{max} = 2E_m = 21.2289\ KV$

- $f = \dfrac{1}{2\pi\sqrt{LC}} = 12.279\ KHZ$

- $\dfrac{t}{\sqrt{LC}} = \dfrac{\pi}{2} \therefore t = 20.3598\ \mu s.$

Q2

(a)



Torque is produced on the disc by the interaction between flux and eddy current. The relay coil is tapped at several points, to select the desired plug setting through a knob

The phase angle θ between the 2 fluxes Φ_1 & Φ_2

s adjusted by a reactance connected in parallel to the secondary coil.

Net force $F = (f_2 - f_1)$

$$(f_2 - f_1) \propto (\phi_2 \, i\phi_1) - (\phi_1 \, i\phi_2)$$

$$i\phi_1 = \frac{d\phi_1}{dt} \propto \phi_1 \cos\omega t$$

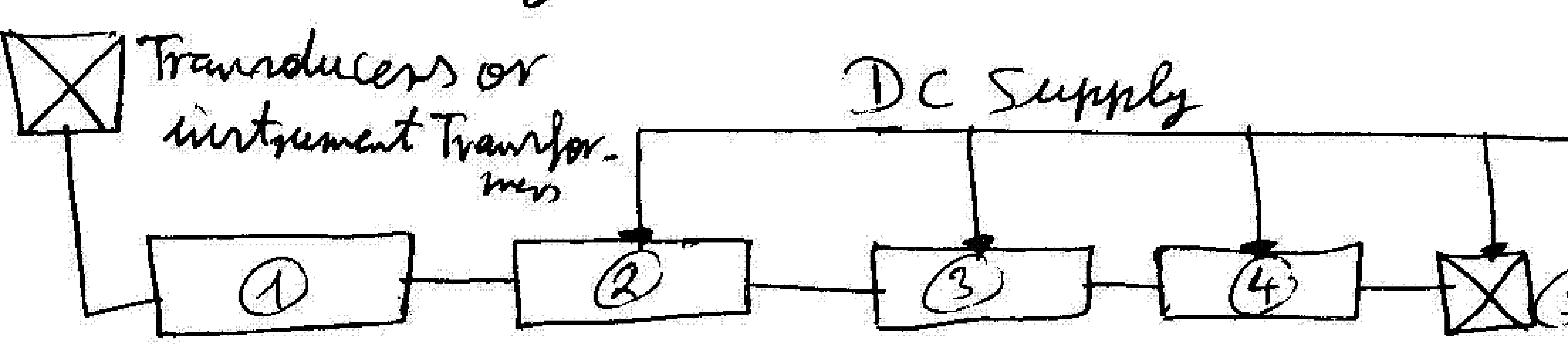
$$i\phi_2 = \frac{d\phi_2}{dt} \propto \phi_2 \cos(\omega t + \theta)$$

$$\therefore F \propto \phi_2 \sin(\omega t + \theta)\phi_1 \cos\omega t - \phi_1 \sin\omega t \, \phi_2 \cos(\omega t$$

$$\therefore F \propto \phi_1 \phi_2 [\sin(\omega t + \theta)\cos\omega t - \sin\omega t \cos(\omega t + \theta)]$$

$$\therefore F \propto \phi_1 \phi_2 \sin\theta$$

(b) Static Relay



Simplified block diagram of a Static Relay

1) Rectifier Circuit to Convert from AC to DC
2) Relay - Measuring circuit consisting of Comparator, level detector, filter and Voltage stabilizer.
3) Amplifier to magnify the signal.
4) Output device to energize the trip coil.
5) Trip Circuit.

Static relays can be arranged to respond to electric inputs. The other forms of inputs, such as heat, light, magnetic field, travelling waves ...etc can be suitably converted into equivalent analogue or digital signals and then fed to the Static Relay

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Q3

a)

66KV 11KV

$I_{L\Delta} = 400A$

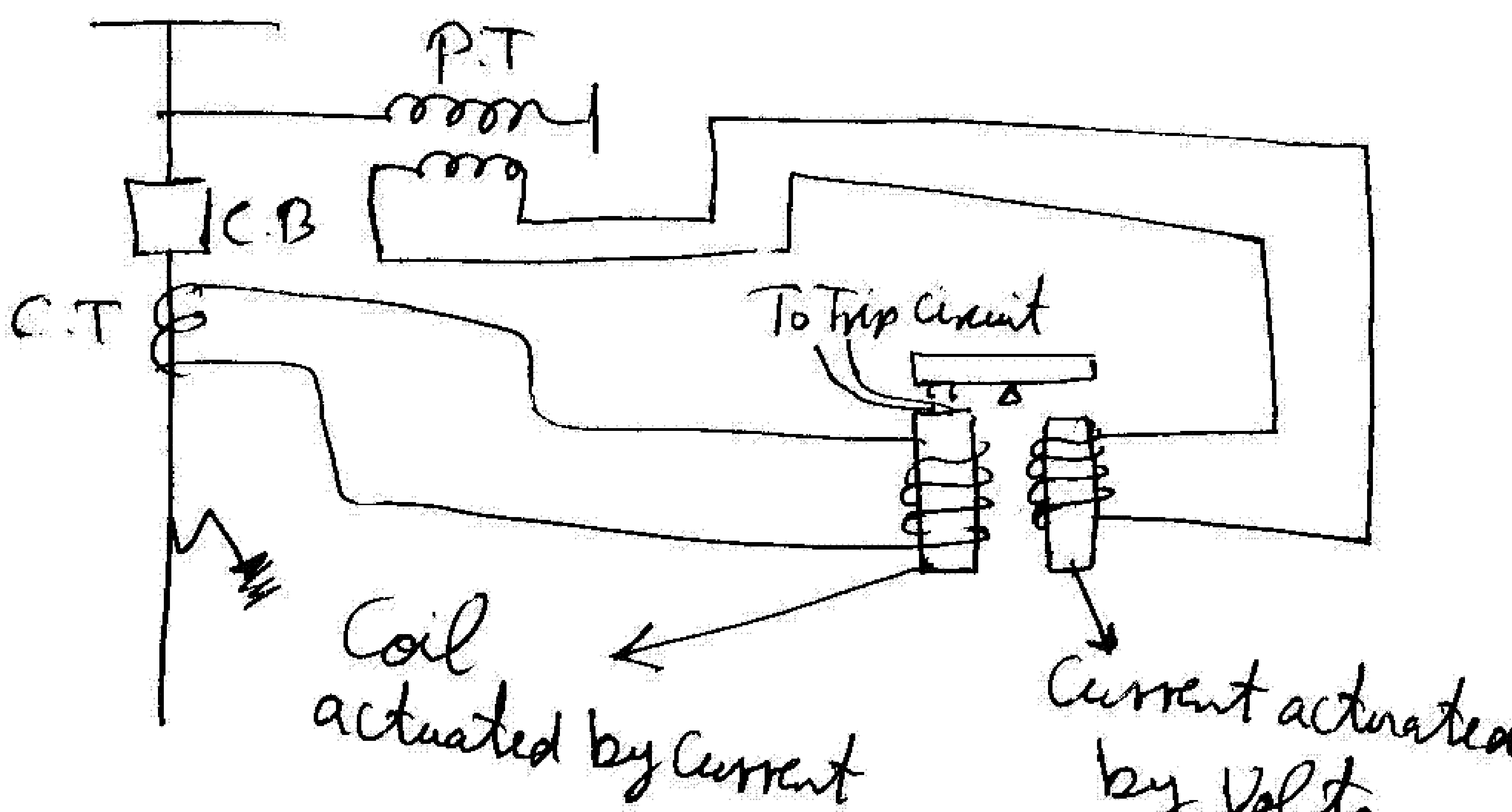
$I_L Y = \frac{11 * 400}{66} = 66.67A$

$I_L C.T = 5A$

$\therefore$ Primary side turns ratio $= 66.67 : \frac{5}{\sqrt{3}}$

$\simeq 115 : 5$

(b) Plain impedance Distance Relay



T_1 = operating Torque ; T_2 = restraining Torque, T_3 = Spring Torque
I = Current proportional to feeder Current.
V = Voltage " to feeder Voltage
K_3 = Spring Constant

∴

$$T = \underbrace{K_1 I^2}_{T_1} - \underbrace{K_2 V^2}_{T_2} - \underbrace{K_3}_{T_3}$$

The relay is on the verge of operation if $T = 0$

$$\therefore K_2 V^2 = K_1 I^2 - K_3$$

$$\frac{V^2}{I^2} = \frac{K_1}{K_2} - \frac{K_3}{K_2 I^2}$$

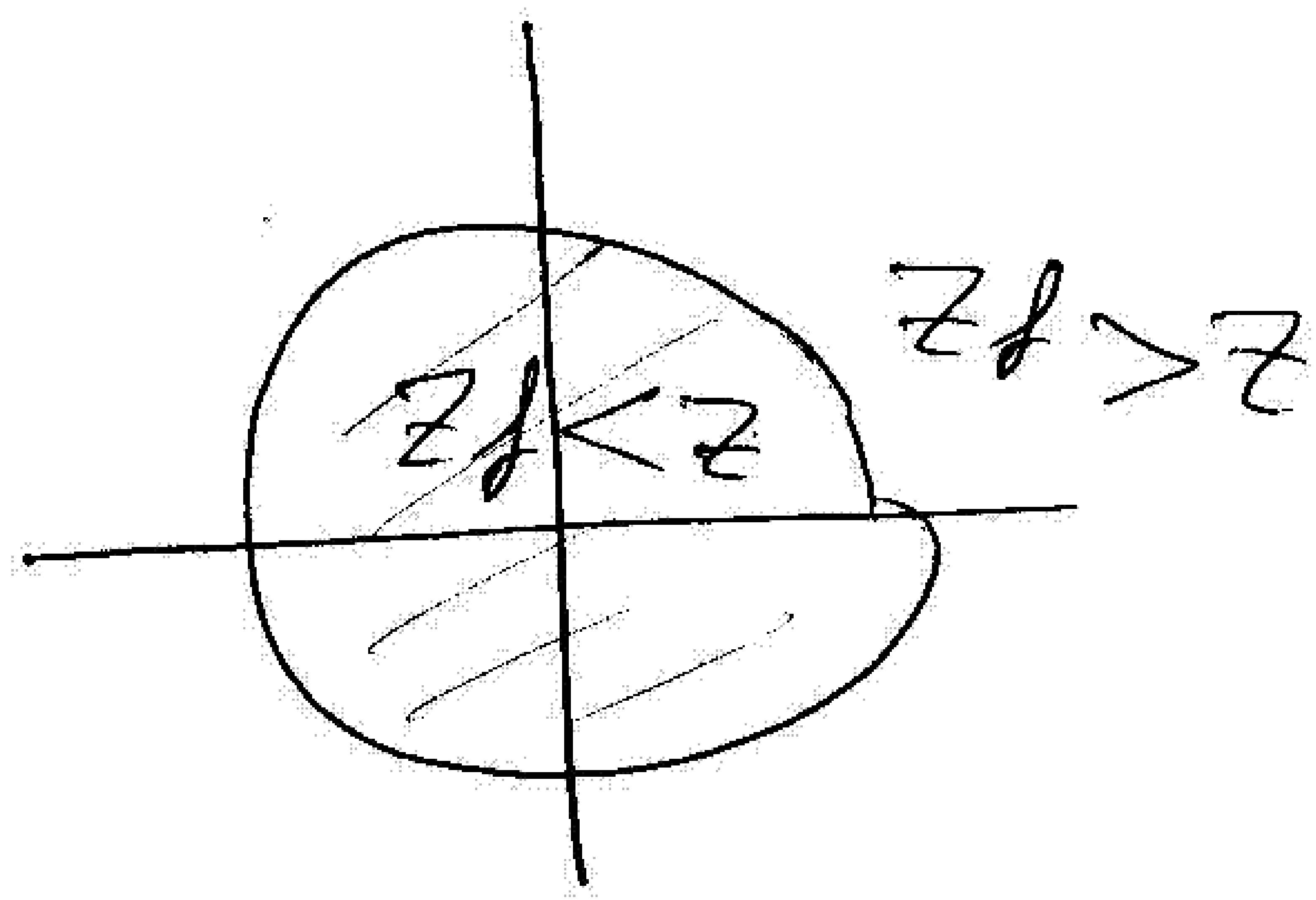
but $\frac{V}{I} = Z$

$$\therefore Z^2 = \frac{K_1}{K_2} - \frac{K_3}{K_2 I^2}$$

$$\therefore Z = \sqrt{\frac{K_1}{K_2} - \frac{K_3}{K_2 I^2}}$$

but $\frac{K_3}{K_2 I^2} << \frac{K_1}{K_2}$

$$\therefore Z = \sqrt{\frac{K_1}{K_2}} = \text{Constant}$$



The problems are

① It is non directional. It responds to faults on both sides of CT & PT location
This can be solved by adding a directional elem[ent] to modify the C/C's

② Under Reach Problem, in which the arc resis[tance] may affect the relay operation. The fault appears t[o] be out of Zone. This can be solved using reactance type Relay

③ Over Reach in which faults outside the operating Zone appears to be inside [as the case of doubl[e] Circuit, when one circuit is disconnected and mutual coupling no more exists]. 2 different settings may be used ...

4a] The initial inrush magnetizing current has a high component of 2nd harmonic

order of harmonic	amplitude as % of fundamental
2nd	63
3rd	23
4th	5
5th	4
6th	3
7th	2

The main protection against the magnetizing inrush current is the second harmonic restraint. It contains a 100 HZ blocking filter in operating coil and 50 HZ blocking filter in restraining coil. During inrush currents the 2nd harmonic component is predominant and the operating relay is blocked.
During short circuits, 50 HZ component is predominant, hence operating relay operates and relay contact circuit is closed.

b) $I_f = 2000A$

for relay 1 $I_R = 10A$

$\therefore P.S.M = \frac{2000}{200 * 1} = 10$

from C/C's o.t = 3 s

but actual o.t = 3 * 0.2 = 0.6 s

$\therefore$ O.T for second Relay = 0.6 + 0.5 = 1.1 s.

for the second Relay $P.S.M = \frac{2000}{200 * 1.25} = 8$

from C/C's O.T =

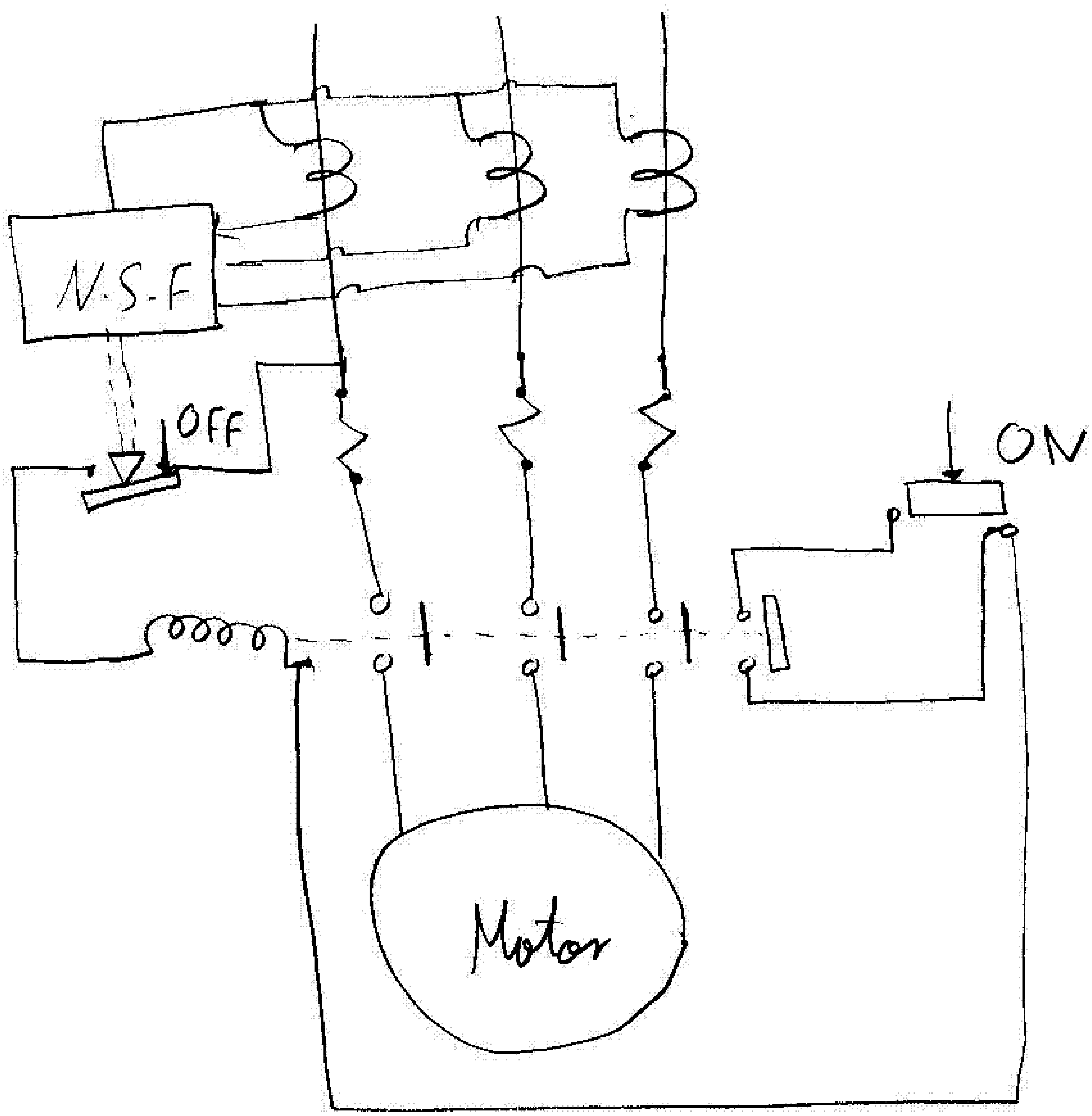
$\therefore$ actual o.T = 1.1 s

$\therefore$ ~~P.S.M = 1.1~~

$T.S.M = \frac{1.1}{\text{Time from C/C}} = \frac{1.1}{3.3} = 0.333$

Q5

(a)



NSF ≡ Negative Sequance Filter

The -ve seq. filter receives the 3phase line currents. Its output is fed to a level detector, which sends tripping command to the starter or circuit breaker when the -ve sequance current exceeds a pre-set limit. It is so harmful, because the motor draws heavy current and harmonics are generated, which cause overheating to the Motor.

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5b) $I_f = 0.8 * \frac{2000}{5} = 320A$

$V_f = 320 * 12 = 3840 V$

$\therefore$ % of unprotected winding $= \frac{3840}{11*10^3 * \frac{1}{\sqrt{3}}} = 60.46\%$

$\therefore$ % of protected winding $= 39.54\%$

If 90% are protected $\therefore$ 10% are unprotected

$\therefore V_f = \frac{11*10^3}{\sqrt{3}} * 0.1 = 635.085 V$

$R_f = \frac{V_f}{I_f} = 1.985 \Omega$

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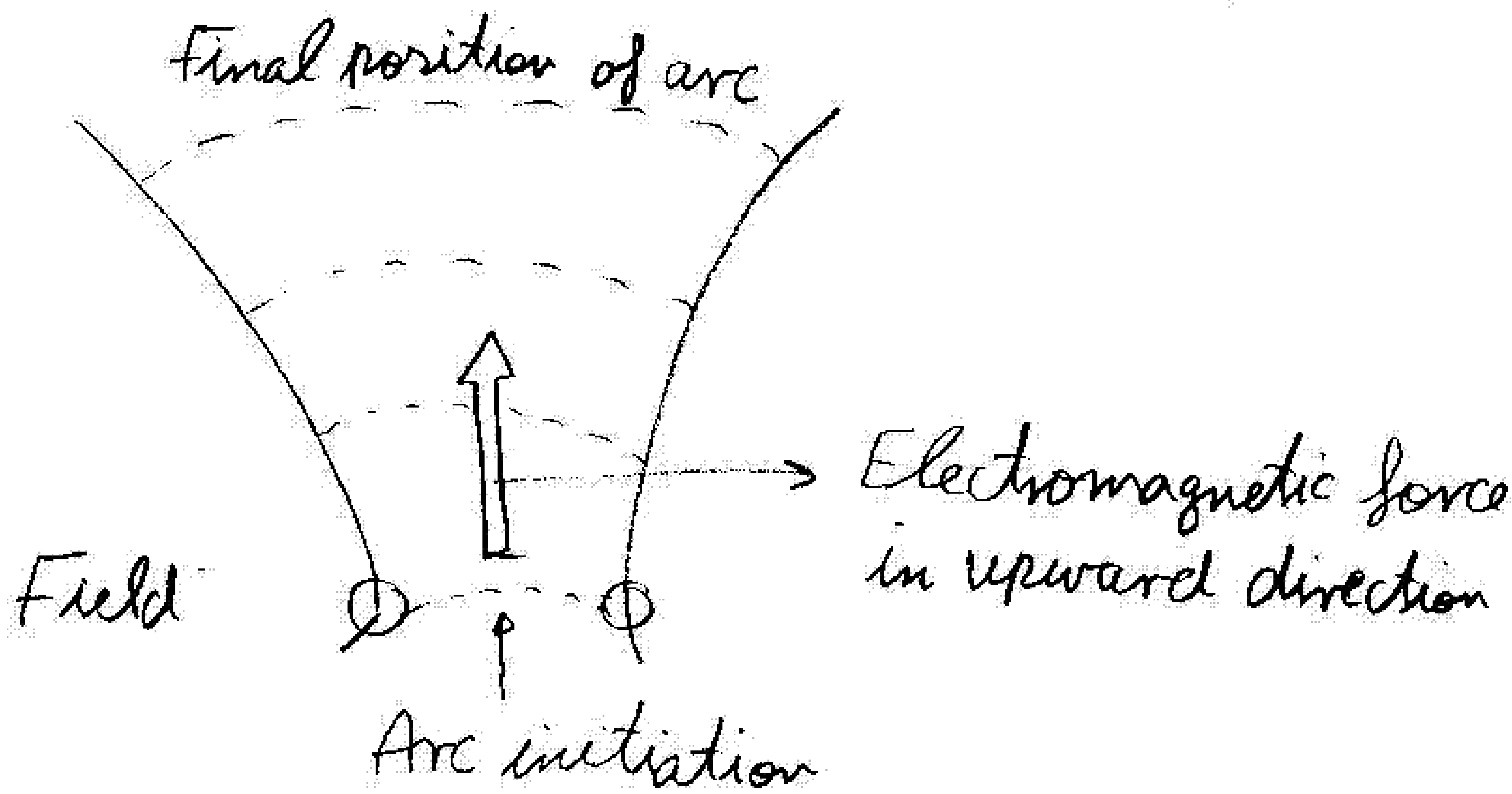
c)



In this method the arc length is increased by using arc runners which are horn like blades of conducto material. The arc runners are connected to arcing contacts and it is in the shape of letter 'V'. The arc is initiated at the bottom and blows upwards due to elegtromagnetic force. Due to this arc length increases and consequently arc is extinguished.

(d) An auxiliary compressed air system is required. This supply air to air reservoir of the breaker. During the opening operation, the air is allowed to enter the extinction chamber which pushes away moving contacts. The contacts are separated and the blast of air will take ionized gases with it and helps in extinguishing the arc. There are two major types, cross blast and axial blast.