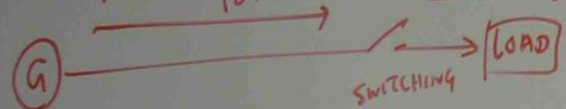
REFLECTION OF TRANSMISSION LINE

POWER LINE

TRANSMITTED POWER
10mW

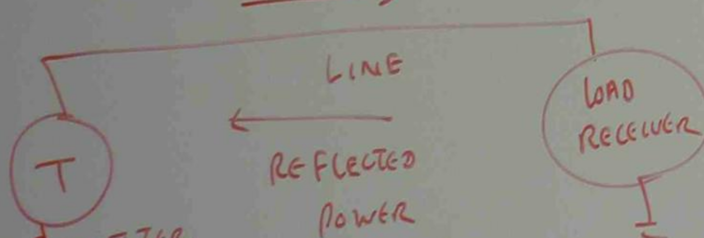
9mW
POWER DELIVERED TO LOAD



1mW

TELECOM LINE

TRANSMITTED POWER

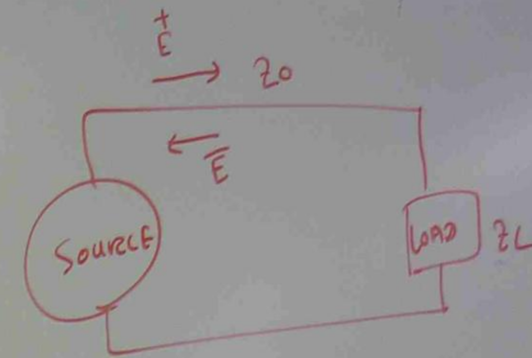


REFLECTED POWER

TRANSMITTER

γ = REFLECTION RATIO

REFLECTION COEFFICIENT



Z_S = SOURCE IMPEDANCE

Z_L = LOAD IMPEDANCE

Z_0 = LINE IMPEDANCE

$$\gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

REFLECTED WAVE POWER $= \gamma^2 \times$ FORWARD WAVE POWER

$$\text{RMS CURRENT} = \sqrt{\frac{\text{REFLECTED WAVE POWER}}{\text{LOAD RESISTANCE}}}$$

E^{+} = FORWARD VOLTAGE

E^{-} = BACKWARD VOLTAGE

$$E^{-} = \gamma E^{+}$$

$$\text{STANDING WAVE RATIO VOLTAGE (VSWR)} = \frac{|E^{+}| + |E^{-}|}{|E^{+}| - |E^{-}|}$$

$$\text{RETURN LOSS DECIBEL (dB)} = 10 \log_{10}\left(\text{REFLECTED WAVE POWER}\right)$$

pb A 50Ω TRANSMISSION LINE CONNECTED TO LOAD IMPEDANCE $75 + j60\ \Omega$. THE FORWARD WAVE RMS VALUE ON LINE IS 25V.

LINE IMPEDANCE $= 50\Omega$

CALCULATE

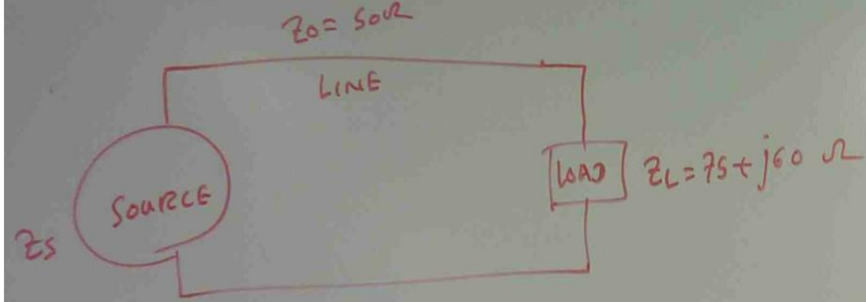
(a) POWER DELIVERED TO THE RESISTANCE PART OF LOAD IMPEDANCE

(b) RMS CURRENT IN IMPEDANCE, REFLECTED WAVE VOLTAGE RMS.

(c) PEAK VOLTAGE IN FORWARD AND BACKWARD WAVE

(d) VOLTAGE STANDING WAVE RATIO (VSWR)

(e) RETURN LOSS IN DECIBEL.



(a) POWER IN RESISTIVE PART $= \dfrac{V^2}{R}$

$= \dfrac{(25)^2}{75}$

$= 12.5$ WATT

(b) RMS CURRENT $= \sqrt{\dfrac{\text{REFLECTED WAVE POWER}}{\text{LOAD RESISTANCE}}}$

REFLECTED WAVE POWER $= \gamma^2 \times$ FORWARD WAVE POWER

$$\gamma = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{75 + j60 - 50}{75 + j60 + 50} = \frac{25 + j60}{125 + j60}$$

$$\gamma = \frac{\sqrt{25^2 + 60^2}}{\sqrt{125^2 + 60^2}}$$

$$= \frac{\sqrt{4225}}{\sqrt{14225}} = 0.4688$$

REFLECTED WAVE POWER $= \gamma^2 \times$ FORWARD WAVE POWER

$= (0.4688)^2 \times 12.5$

$= 2.747$ WATT

RMS CURRENT $= \sqrt{\dfrac{2.747}{75}}$

$= 0.191$ Amp

(c) FORWARD WAVE VOLTAGE

$$E^{+} = \sqrt{2} \times \text{LINE VOLTAGE}$$

$$= 1.4142 \times 25$$

$$= 35.5\ V$$

BACKWARD WAVE RMS VOLTAGE

$$E^{-} = \gamma E^{+}$$

$$= 0.4688 \times 35.5$$

$$= 16.57\ V$$

(d)

$$VSWR = \frac{|E^{+}| + |E^{-}|}{|E^{+}| - |E^{-}|} = \frac{35.3 + 16.57}{35.5 - 16.57}$$

$$= 2.754$$

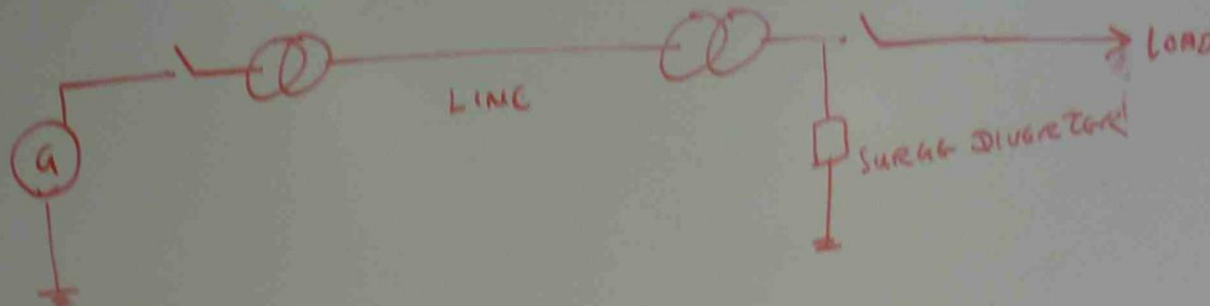
(e)

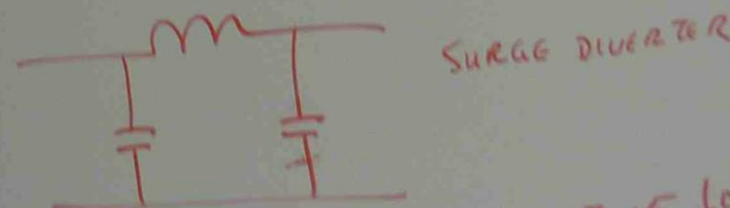
$$\text{RETURN LOSS}_{dB} = 10 \log_{10} \text{REFLECTED WAVE POWER}$$

$$= 10 \log_{10} 2.747$$

$$= 4.388\ dB$$

IMPACT OF SWITCHING IN POWER LINE

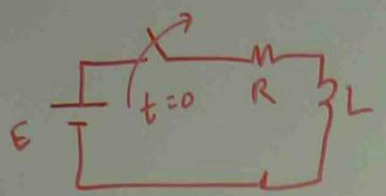




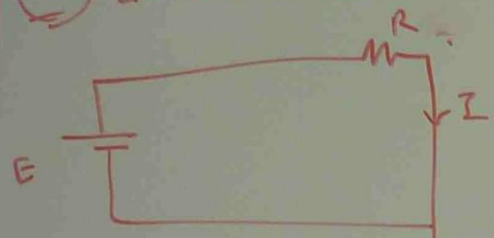
INDUSTRIAL LOADS ARE INDUCTIVE LOADS WHICH STORE THE ENERGY.

WHEN THE SWITCH IS OFF, THE STORED ENERGY IS DELIVERED AND HIGH VOLTAGE OCCURS ACROSS THE SWITCH CONTACTS.

TRANSIENT CURRENT CHARACTERISTICS OF INDUCTIVE LOAD RELATES TO SWITCHING VOLTAGE SURGE IN POWER LINE.

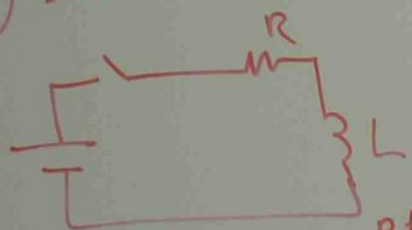


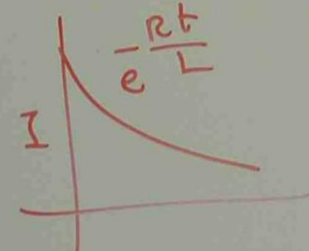
(I) DURING SWITCH ON



$$I = \frac{E}{R} \quad \text{(Amp)}$$

(II) SWITCH OFF





$$I(t) = I\, e^{-\frac{Rt}{L}}$$

$$I(t) = I(0)\, e^{-\frac{Rt}{L}}$$

Pb A COIL OF 10 H INDUCTANCE AND 5 Ω RESISTANCE IS CONNECTED IN PARALLEL WITH A 20 Ω RESISTOR ACROSS A 100 V DC SUPPLY WHICH IS SUDDENLY DISCONNECTED.

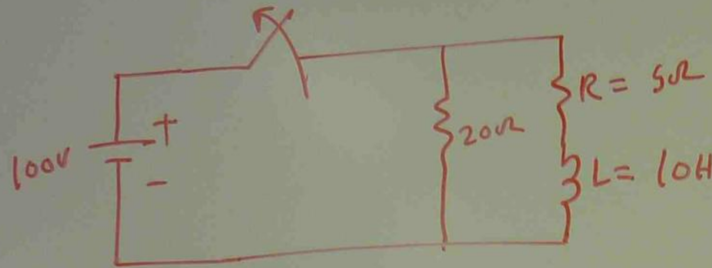
FIND

(a) INITIAL RATE OF CHANGE OF CURRENT AFTER SWITCHING

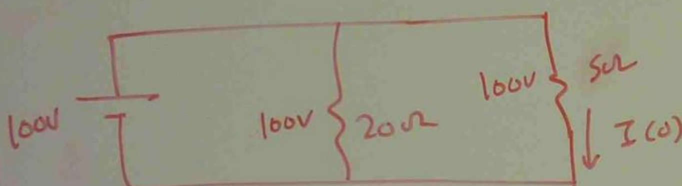
(b) THE VOLTAGE ACROSS 20 Ω RESISTOR INITIALLY AFTER 0.3 Sec

(c) THE VOLTAGE ACROSS THE SWITCH CONTACTS AT THE INSTANCE OF SEPARATION

(d) THE RATE AT WHICH THE COIL IS LOSING STORED ENERGY 0.3 Sec AFTER SWITCHING.

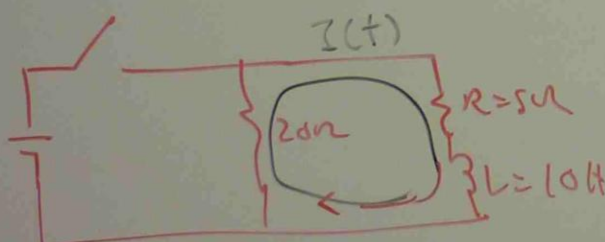


WHEN THE SWITCH IS ON



$$I(0) = \frac{100V}{5\Omega} = 20A$$

WHEN THE SWITCH IS OFF



$$I(t) = I(0)\ e^{-\frac{Rt}{L}}$$

$$R = 20 + 5 = 25\Omega$$

$$L = 10H$$

$$I(t) = 20\ e^{-\frac{25}{10}t}$$

$$I(t) = 20\ e^{-2.5t}$$

(a) RATE OF CHANGE OF CURRENT $= \frac{d}{dt} I(t)$

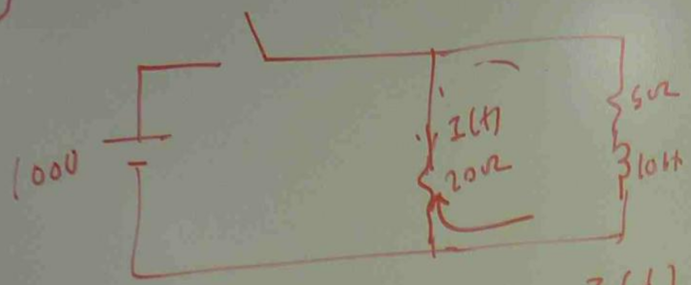
$$= \frac{d}{dt} 20 e^{-2.5t}$$

$$= 20 \times (-2.5)\ e^{-2.5t}$$

$$\frac{dI(t)}{dt} = -50\ e^{-2.5t}\ A/\text{sec}$$

(b)

(b)



$$V(t) \text{ of } 20\Omega = 20\Omega \times I(t)$$

$$= 20 \times 20\, e^{-2.5t}$$

$$V(t)_{20\Omega} = 400\, e^{-2.5t}$$

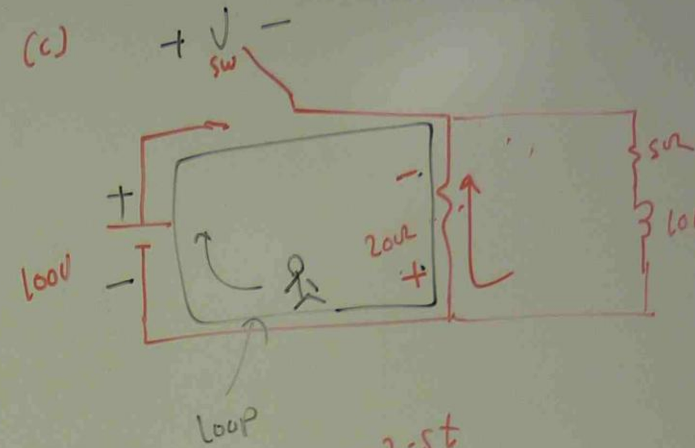
$t = 0.3$ sec

$$V(0.3) = 400 \times e^{-2.5\times 0.3}$$

$$= 400 \times e^{-0.75}$$

$$= 188 \text{ V}$$

(c)



$$I(t) = 20\, e^{-2.5t}$$

$$I(0) = 20 \times e^{-2.5\times 0} = 20 \times e^{0} = 20 \times 1 = 20 \text{ A}$$

$$(-100) + (+V) + (-400) = 0$$

$$V_{sw} - 500 = 0$$

$$V_{sw} = 500 \text{ V}$$

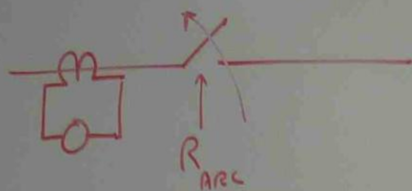
V_{sw} = VOLTAGE ACROSS SWITCH

FROM THIS PROBLEM, IT IS FOUND THAT THE VOLTAGE ACROSS THE OPENING TERMINALS OF THE SWITCH IS MUCH HIGHER THAN THE SYSTEM VOLTAGE.

IF THE SWITCH INSULATION IS ONLY BASED ON SYSTEM VOLTAGE, THE HIGH VOLTAGE CAN DOWNGRADE AND DAMAGE THE SWITCH INSULATION.

SURGE DIVERTER IS REQUIRED TO BE FITTED TO DIVERT THE VOLTAGE SURGE.

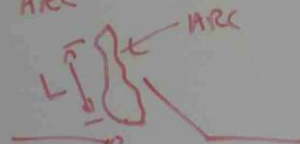
CALCULATION OF ARC RESISTANCE



R_{ARC} = ARC RESISTANCE

$$R_{ARC} = \frac{2.9 \times 10^4 \, L}{I^{1.4}} \quad (\Omega)$$

L = LENGTH OF ARC



I = FAULT CURRENT (AMP)

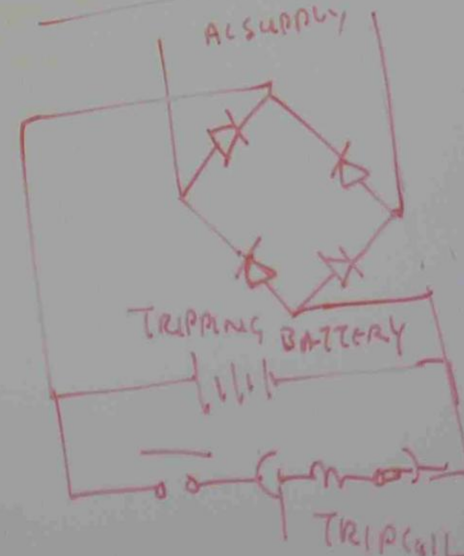
$$R_{ARC} = \frac{50}{I} \left(V_L + 47 \, v \, t \right)$$

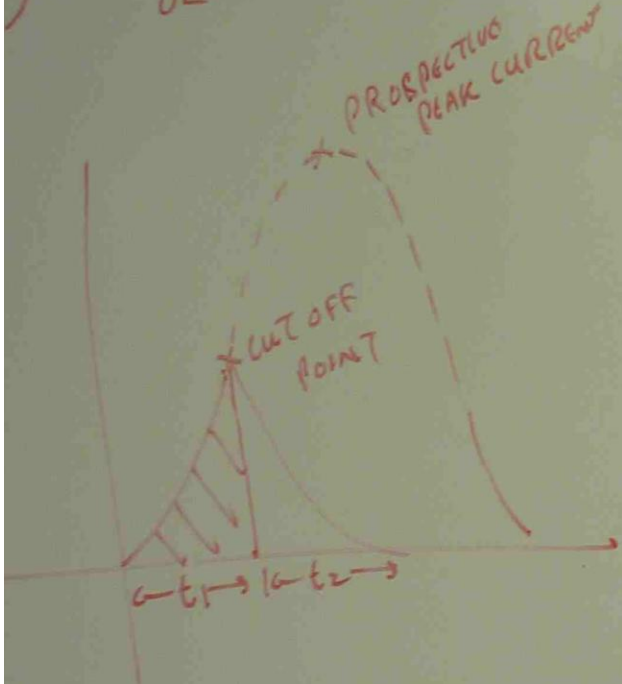
V_L = SYSTEM VOLTAGE (V)

v = WIND VELOCITY

t = ARCING TIME

TRIP CIRCUIT





t_1 = PRE ARCING TIME

t_2 = ARCING TIME

$t = t_1 + t_2$ = TOTAL OPERATING TIME

VOLTAGE SURGE ACROSS OPENING CONTACTS $= R_{ARC} \times I_{FAULT}$

$$I_{FAULT} = \frac{I_{FULL\ LOAD}}{\%\ FAULT\ IMPEDANCE} \times 100$$