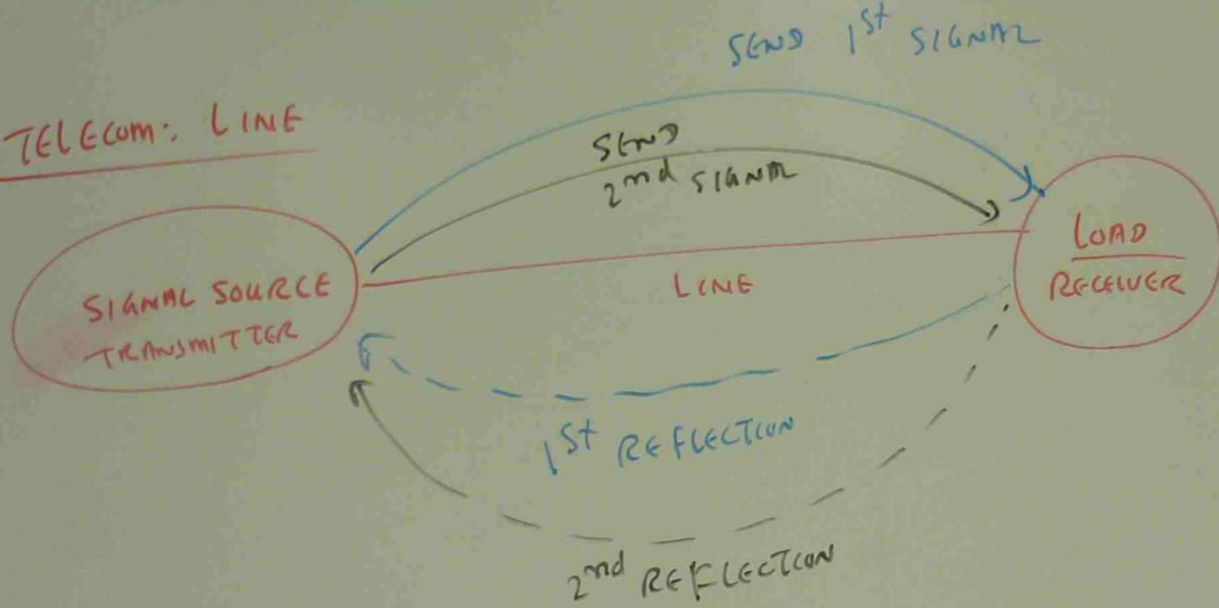
APPLICATION OF REFLECTION AND OSCILLATION FUNCTIONS IN POWER ENGINEERING

TELECOM: LINE



V_s = SOURCE VOLTAGE

Z_0 = LINE IMPEDANCE

Z_S = SOURCE IMPEDANCE

Z_L = LOAD IMPEDANCE

V_+ = SOURCE TO LOAD VOLTAGE

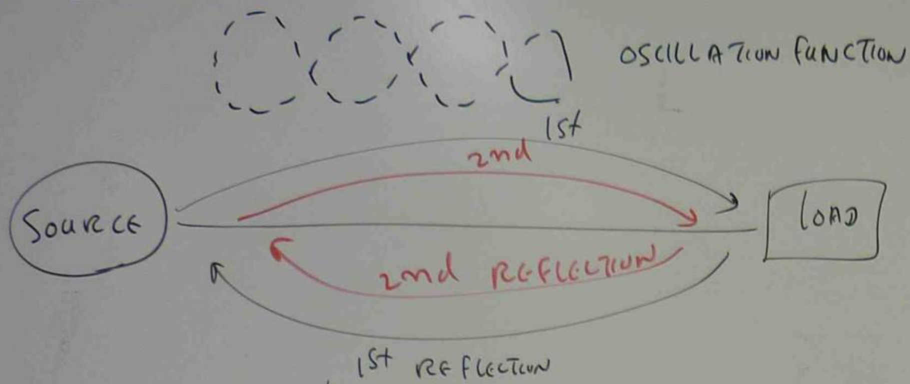
V_- = REFLECTED VOLTAGE

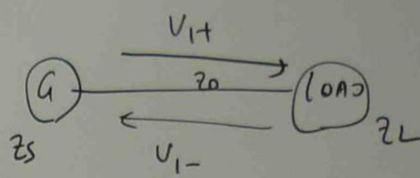
1st REFLECTION AT LOAD = $V_t = V_{1+} + V_{1-}$

$$V_{1+} = V_S \times \frac{Z_0}{Z_0 + Z_S}$$

$$V_{1-} = V_{1+} \times \left(\frac{Z_L - Z_0}{Z_L + Z_0}\right)$$

G047





Z_L = LOAD IMPEDANCE

Z_0 = LINE IMPEDANCE

Z_S = SOURCE IMPEDANCE

1st REFLECTION AT LOAD

$$V_t = V_{1+} + V_{1-}$$

$$V_{1+} = V_s \frac{Z_0}{Z_0 + Z_s}$$

$$V_{1-} = V_{1+} \times \Gamma_L, \quad \Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0}$$

2nd REFLECTION AT SOURCE =>

$$V_t = V_{1+} + V_{1-} + V_{2+}$$

$$V_{2+} = V_{1(-)}\,\Gamma_S, \quad \Gamma_S = \frac{Z_S - Z_0}{Z_S + Z_0}$$

3rd REFLECTION AT LOAD =>

$$V_t = V_{1+} + V_{1-} + V_{2+} + V_{2-}$$

$$V_{2-} = V_{2+}\,\Gamma_L, \quad \Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0}$$

Ex

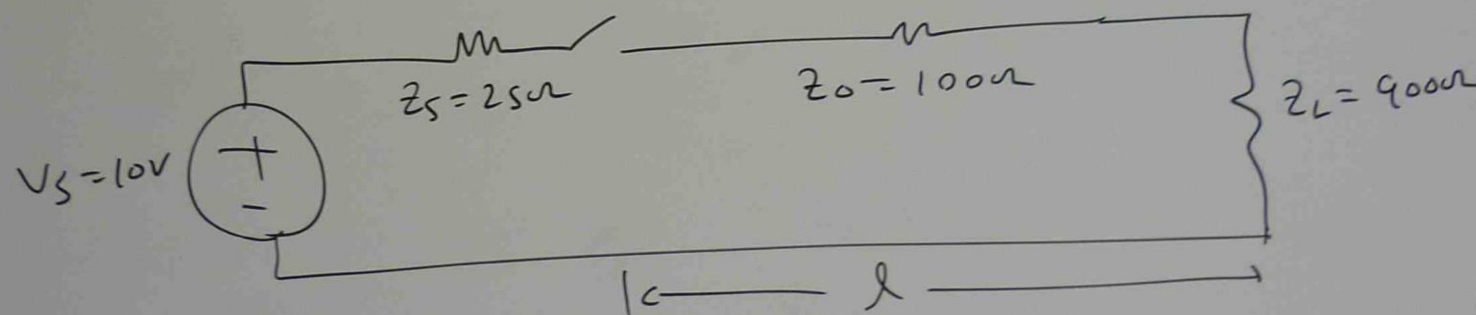
A 10V DC SOURCE WITH AN INTERNAL RESISTANCE OF 25 Ω IS CONNECTED TO A TRANSMISSION LINE OF LENGTH "L" HAVING AN IMPEDANCE OF 100 Ω BY SWITCH. THE TRANSMISSION LINE IS TERMINATED WITH A 900 Ω RESISTOR. T = AMOUNT OF TIME REQUIRED FOR SIGNAL TO TRAVEL THE LENGTH OF THE LINE.

CALCULATE (a) THE VOLTAGE WHEN THE SWITCH IS CLOSED AT T=0

(b) FIRST REFLECTION AT LOAD

(c) SECOND REFLECTION AT SOURCE

(d) THIRD REFLECTION AT LOAD



(a) VOLTAGE AT $t=0$

$$V_{1+} = V_S \times \frac{Z_0}{Z_0 + Z_S}$$

$$= 10 \times \frac{100}{100+25} = 8V$$

(b) $V_{1(-)} = V_{1(+)} \Gamma_L$

$= 8 \times \frac{Z_L - Z_0}{Z_L + Z_0}$

$= 8 \times \frac{900 - 100}{900 + 100}$

$= 8 \times \frac{800}{1000} = 6.4V$

FIRST REFLECTION AT LOAD $V_{(+)} = V_{1(+)} + V_{1(-)}$

$= 8 + 6.4$

$= 14.4V$

(c) $V_{2+} = V_{(-)} \times \Gamma_S$

$= 6.4 \times \frac{Z_S - Z_0}{Z_S + Z_0}$

$= 6.4 \times \frac{25 - 100}{25 + 100}$

$= -3.84V$

2nd REFLECTION AT SOURCE $= V_{1(+)} + V_{1(-)} + V_{2(+)}$

$= 8 + 6.4 + (-3.84)$

$= 10.56\ V$

(d) $V_{2(-)} = V_{2(+)} \Gamma_L$

$= (-3.84) \times \frac{Z_L - Z_0}{Z_L + Z_0}$

$= -3.84 \times \frac{900 - 100}{900 + 100}$

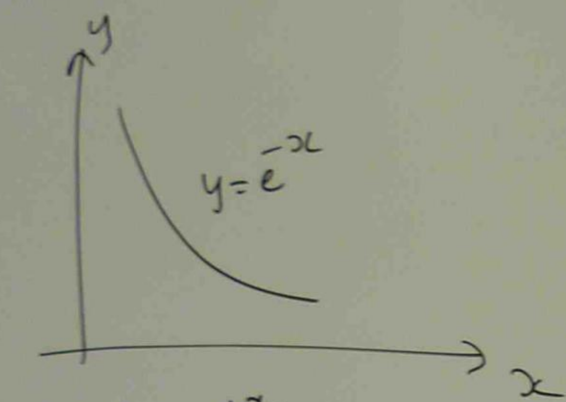
$= -3.072V$

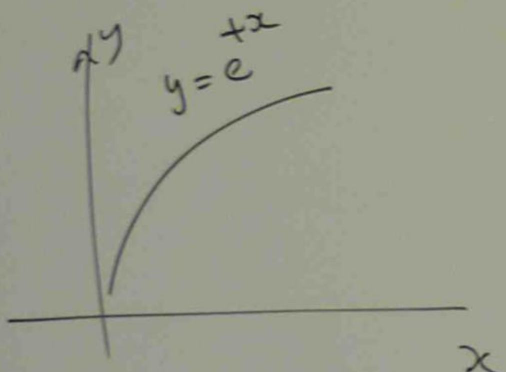
3rd REFLECTION AT LOAD $= V_{1(+)} + V_{1(-)} + V_{2(+)} + V_{2(-)}$

$= 8 + 6.4 + (-3.84) + (-3.072)$

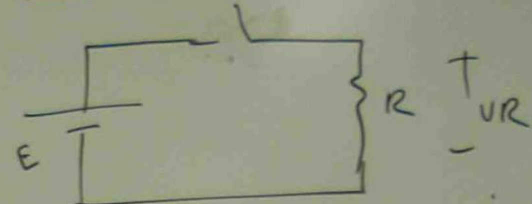
$= 7.488V$

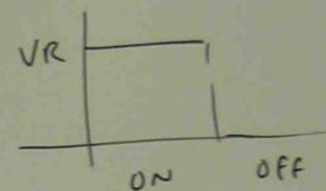
APPLICATION OF EXPONENTIAL FUNCTION IN POWER ENGINEERING CALCULATIONS

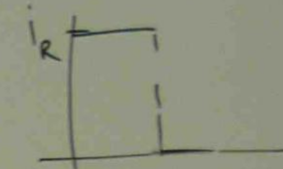


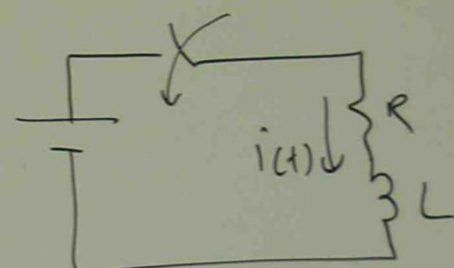


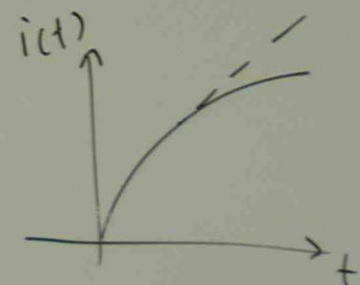
PURE RESISTANCE











$$i(t) = \frac{V}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$$

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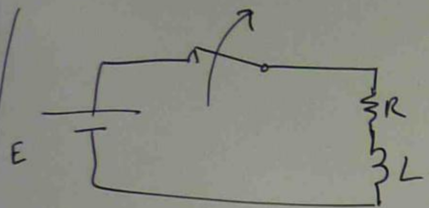
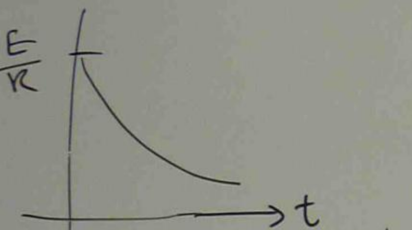


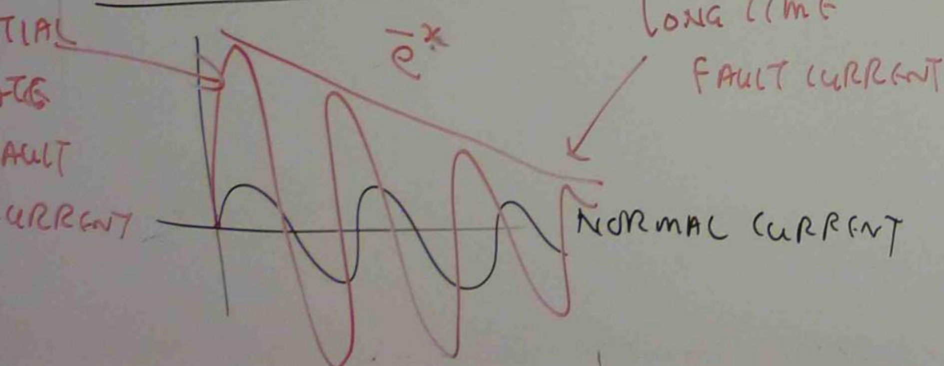


$$i(t) = \frac{E}{R} e^{-\frac{Rt}{L}}$$

TRANSIENT CIRCUIT CALCULATION

USES EXPONENTIAL FUNCTION

POWER LINE FAULT



EX

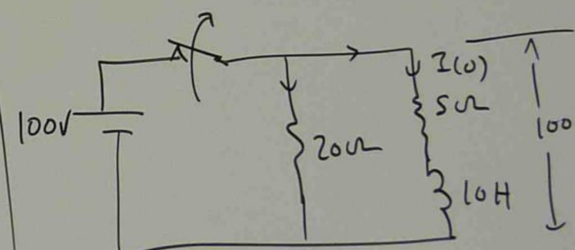
A COIL OF 10 H INDUCTANCE AND 5 OHM RESISTANCE IS CONNECTED IN PARALLEL WITH A 20 OHM RESISTOR ACROSS A 100 V DC SUPPLY WHICH IS SUDDENLY DISCONNECTED.

FIND (a) INITIAL RATE OF CHANGE OF CURRENT AFTER SWITCHING

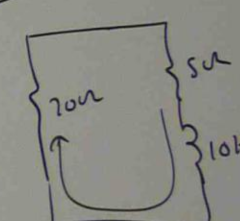
(b) THE VOLTAGG ACROSS 20 Ω RESISTOR INITIALLY AFTER 0.3 S

(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.



OFF THE SWITCH



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

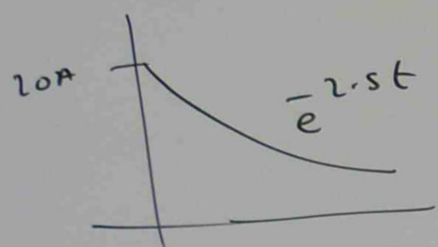
$I(t) = I(0)\, e^{-\frac{Rt}{L}}$

$R = 20+5 = 25\Omega$

$L = 10H$

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

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



5Ω

$10H$

(a)

$$\frac{dI(t)}{dt} = \frac{d}{dt}\left(20 e^{-2.5t}\right)$$

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

$$= -50\, e^{-2.5t}$$

(b)

$V_{20\Omega}(t) = I(t) \times 20\Omega$

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

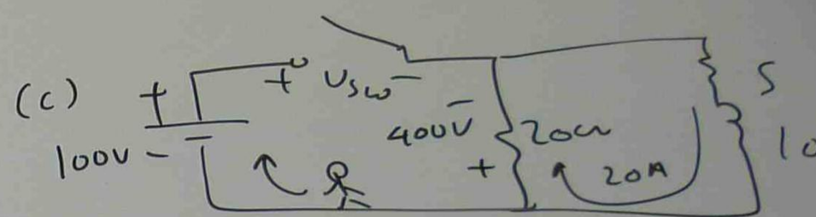
$= 400\, e^{-2.5t}$

$V_{20\Omega}(0.3) = 400 \times e^{-2.5\times 0.3}$

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

$= 188V$

(c)



$v_{20\Omega}(0) = 20\times 20 = 400V$

$(-100) + v_{sw} + (-400) = 0$

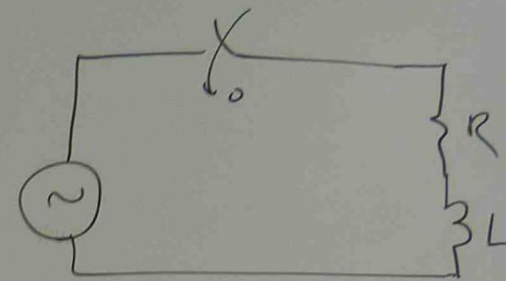
$v_{sw} = 500V$

(d)

STORED ENERGY $= L\frac{di(t)}{dt} \times i(t)$

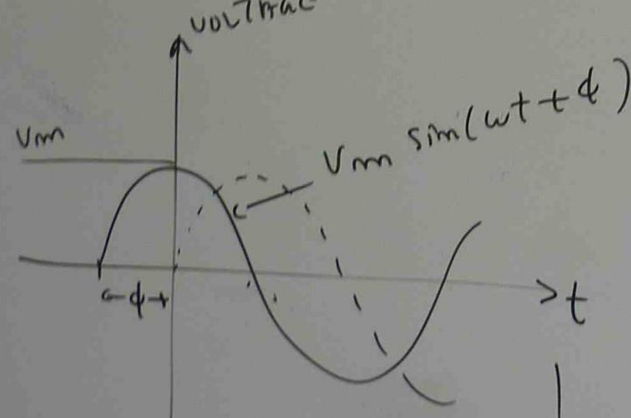
$10 \times (-50 e^{-2.5t} \times 20 e^{-2.5t} = -10000\, e^{-5t}$

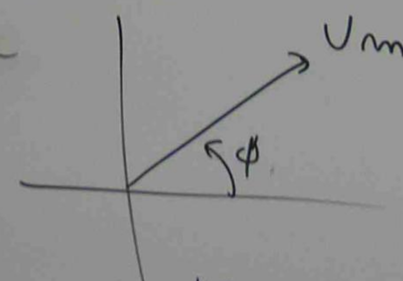
TRANSIENT / EXPONENTIAL FUNCTION IN AC CIRCUITS



$V = V_m \sin(\omega t + \phi)$

TIME DOMAIN REPRESENTATION

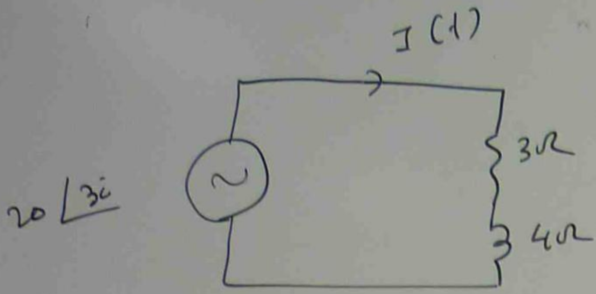




VECTOR

$$V = \frac{V_m}{\sqrt{2}} \angle \phi$$

FREQUENCY DOMAIN REPRESENTATION



FIND THE CURRENT IN

(a) FREQUENCY DOMAIN REPRESENTATION

(b) TIME DOMAIN REPRESENTATION

FREQUENCY = 50 Hz

$$I = \frac{V}{Z} = \frac{20\angle 30}{3+j4} = \frac{20\angle 30}{\sqrt{3^2+4^2}\ \angle \tan^{-1} 4/3}$$

$$= \frac{20\angle 30}{5\angle 53.2}$$

(a) FREQUENCY DOMAIN CURRENT

$$= 4\angle -23.2$$

OMAIN

ATION

(b) TIME DOMAIN CURRENT

$$I(t) = I_m \sin(\omega t + \phi)$$

$$= \sqrt{2}\times 4 \sin(2\pi f t + (-23.2))$$

$$= 1.4142\times 4 \sin(2\times 3.1416\times 50t - 23.2)$$

$$= 5.62 \sin(314t - 23.2)$$

(b) TIME DOMAIN CURRENT

$$I(t) = I_m \sin(\omega t + \phi)$$

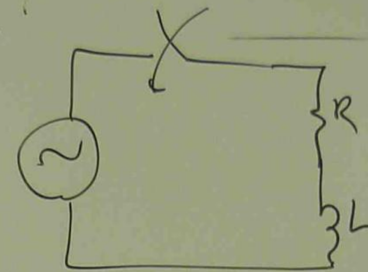
$$= \sqrt{2} \times 4 \sin(2\pi f t + (-23.2))$$

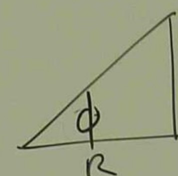
$$= 1.4142 \times 4 \sin(2 \times 3.1416 \times 50 t - 23.2)$$

$$= 5.62 \sin(314 t - 23.2)$$

$\tan^{-1} 4/3$

3.2





$$X_L = 2\pi f L = \omega L$$

$$i(t) = \frac{V_m}{\sqrt{R^2 + \omega^2 L^2}} \left(\sin(\omega t - \phi) + \sin\phi \; e^{\frac{-Rt}{L}} \right)$$

$$\phi = \tan^{-1} \frac{\omega L}{R}$$

PURE RESISTANCE