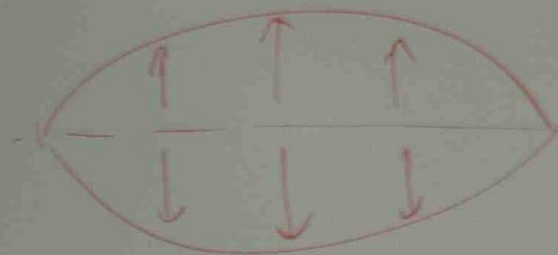
WAVE FORMS IN TELECOMMUNICATION LINE



STANDING WAVE

SECOND WAVE

STANDING WAVE IS A WAVE THAT REMAINS IN A CONSTANT POSITION.

SECOND WAVE → WAVE OF EQUAL AMPLITUDE TRAVELLING IN OPPOSITE DIRECTION.

G042 → 7762AH + 4264T

REFLECTION COEFFICIENT

$$\gamma = \frac{V^-}{V^+} = \frac{I^-}{I^+}$$

VSWR - VOLTAGE STANDING WAVE RATIO

$$VSWR = \frac{|V+| + |V-|}{|V+| - |V-|}$$

$$\gamma = \frac{|V-|}{|V+|}$$

$$VSWR = \frac{1+\gamma}{1-\gamma}$$

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EVERY TRANSMISSION SYSTEM HAS THE FOLLOWING THREE ELEMENTS

(1) GENERATOR

(2) TRANSMISSION LINE

(3) LOAD.

IN IDEAL TRANSMISSION SYSTEM, ALL ENERGY EMITS FROM THE GENERATOR AND PASS UNATTENUATED THROUGH THE TRANSMISSION LINE TO LOAD.

V.S.W.R IS DEFINED AS $\frac{E_{MAX}}{E_{MIN}}$

$\gamma = \Gamma =$ REFLECTION COEFFICIENT

$\bar{E}$ = REFLECTED WAVE VOLTAGE

$\overset{+}{E}$ = INCIDENT WAVE VOLTAGE

Z_S = SOURCE IMPEDANCE

Z_L = LINE + LOAD IMPEDANCE

$$\Gamma = \frac{Z_L - Z_S}{Z_L + Z_S}$$

POWER FLOW ON TRANSMISSION LINE $= \dfrac{|V^+| \times |V^+|}{2 Z_0}$

$|V^+|$ = FORWARD WAVE VOLTAGE

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

CALCULATE (a) POWER DELIVERED TO RESISTIVE PART OF LOAD IMPEDANCE

(b) RMS CURRENT IN IMPEDANCE REFLECTED WAVE VOLTAGE RMS SIZE

(c) PEAK VOLTAGE IN FORWARD AND BACKWARD WAVES

(d) VOLTAGE STANDING WAVE RATIO (VSWR)

(e) RETURN LOSS IN DECIBEL.

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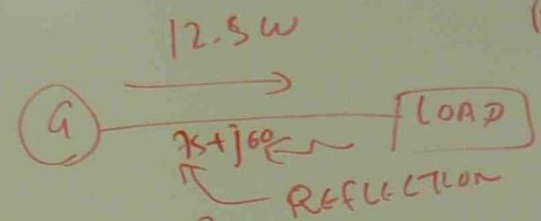
ASSUME - GENERATOR HAS INTERNAL IMPEDANCE 50Ω. (Z_0)

$Z_L = 75 + j60\ \Omega$

$R_0 = Z_0 = 50\Omega$



$Z_0 = 50\ \Omega$

$E_t = 25\ V$

(a) $\text{POWER} = \dfrac{(E_{rms})^2}{R_0} = \dfrac{(25)^2}{50} = 12.5\ W$

(b) $\text{REFLECTED POWER} = \gamma^2 \times \text{FORWARD WAVE POWER}$

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

$$\gamma = \frac{\sqrt{25^2 + 60^2}\ \angle \tan^{-1} 60/25}{\sqrt{125^2 + 60^2}\ \angle \tan^{-1} \frac{60}{125}} = 0.4688$$

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

$= (0.4688)^2 \times 12.5 = 2.747$ WATT.

REFLECTION IS CAUSED BY RESISTIVE COMPONENT OF Z_L (R_L)

$Z_L = 75 + j60$

CAUSE REFLECTION

RMS CURRENT = $\sqrt{\dfrac{\text{REFLECTED POWER}}{R_L}} = \sqrt{\dfrac{2.747}{75}} = 0.3606$ Amp.

(c) PEAK FORWARD VOLTAGE $|E^+| = \sqrt{2}\, E_{rms} = 1.4142 \times 25 = 35.36\,V$

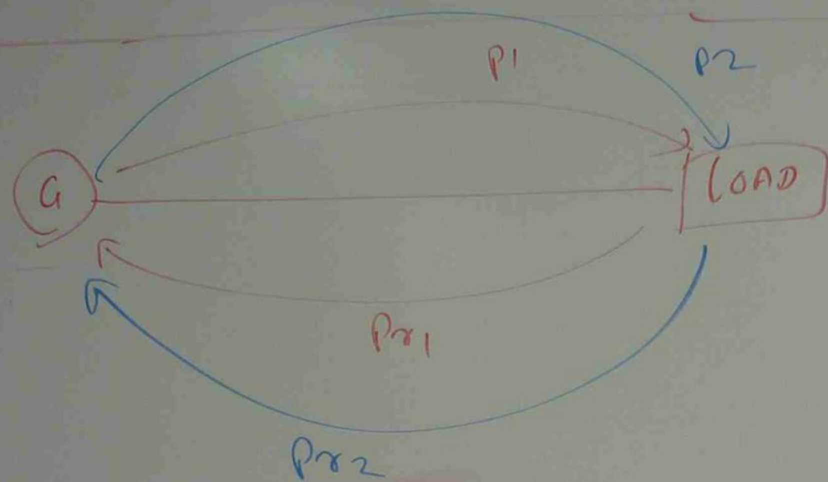
PEAK BACKWARD (REFLECTED) VOLTAGE = $\gamma^2 \times |E^+| = (0.4688)^2 \times 35.36 = 16.57\,V$

$|E^-|$

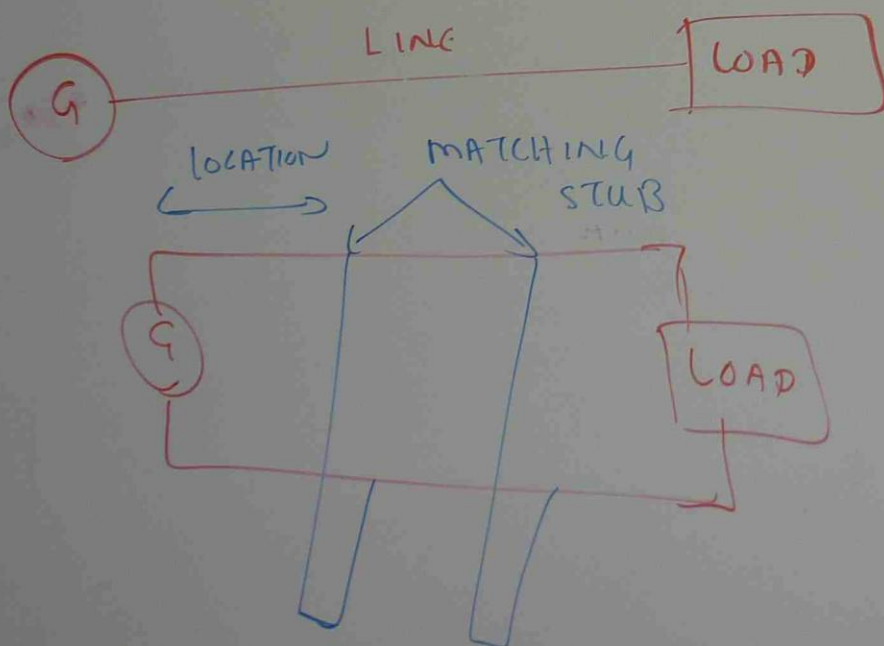
(d) $\text{VSWR} = \dfrac{|E^+| + |E^-|}{|E^+| - |E^-|} = \dfrac{35.36 + 16.57}{35.36 - 16.57} = 2.764$

(e) $10 \log \dfrac{P_r}{P_i} = 10 \log \dfrac{2.747}{12.5} = 10 \times (-0.65) = -6.5\,dB$

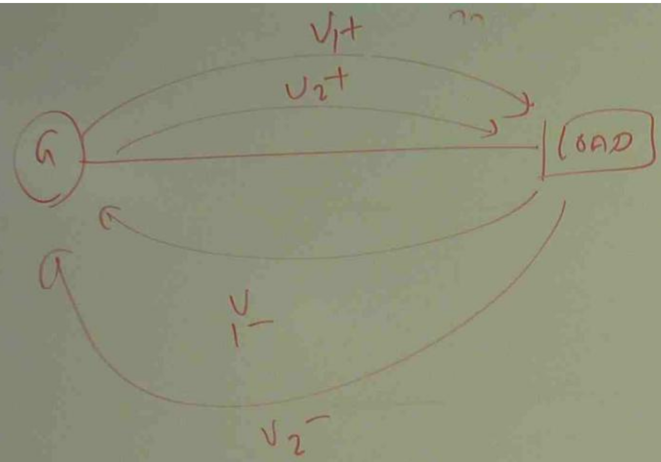
EFFECT OF REFLECTION AND IMPEDANCE MATCHING



MATCHING STUBS ARE TO BE INSERTED TO LINE WIRE TO KEEP SOURCE AND LOAD IMPEDANCES ARE EQUAL



IF THE LINE IMPEDANCE IS NOT MATCHED WITH LOAD IMPEDANCE, SEVERAL OSCILLATIONS OCCUR BETWEEN SOURCE AND LOAD.



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

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

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

FIRST OSCILLATION

$$V_{T_1} = V_{1+} + V_{1-}$$

SECOND OSCILLATION

$$V_2+ = V_{1(-)} \times \Gamma_S$$

$$\Gamma_S = \frac{Z_S - Z_0}{Z_S + Z_0}$$

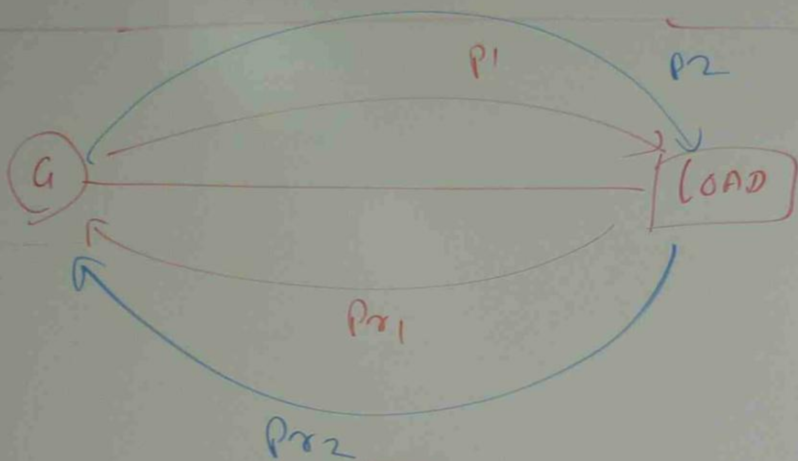
$$V_2- = V_{2(+)}\ \Gamma_L$$

$$V_{T_2} = V_{1(+)} + V_{1(-)} + V_{2(+)}$$

THIRD

$$V_{T3} = V_{1(+)} + V_{1(-)} + V_{2(+)} + V_{2(-)}$$

EFFECT OF REFLECTION AND IMPEDANCE MATCHING



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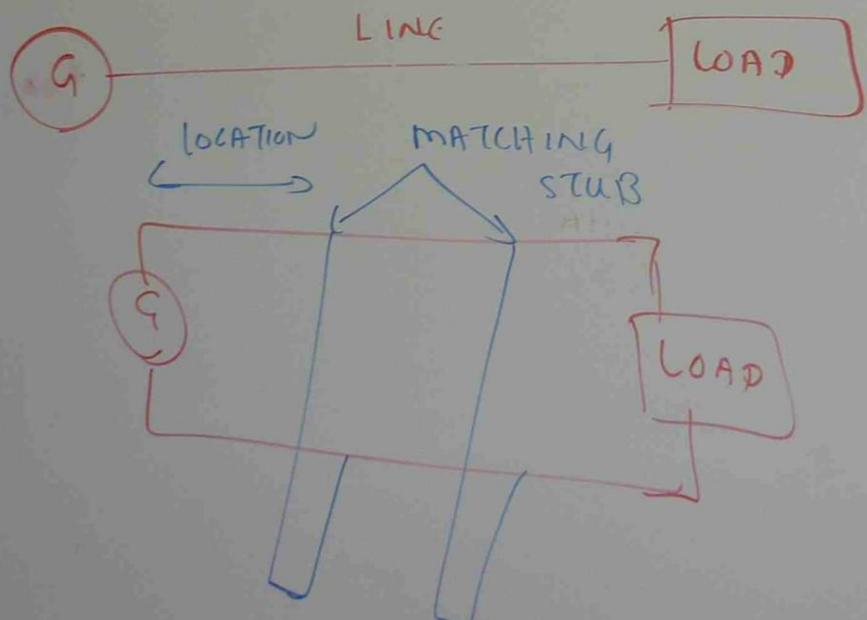

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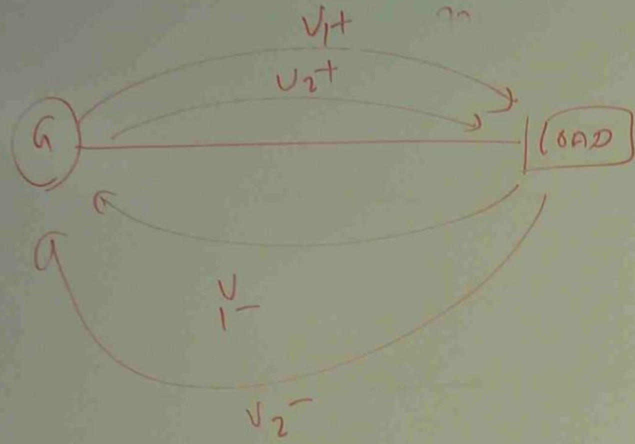

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THIRD

$$V_{T3} = V_{1(+)} + V_{1(-)} + V_{2(+)} + V_{2(-)}$$

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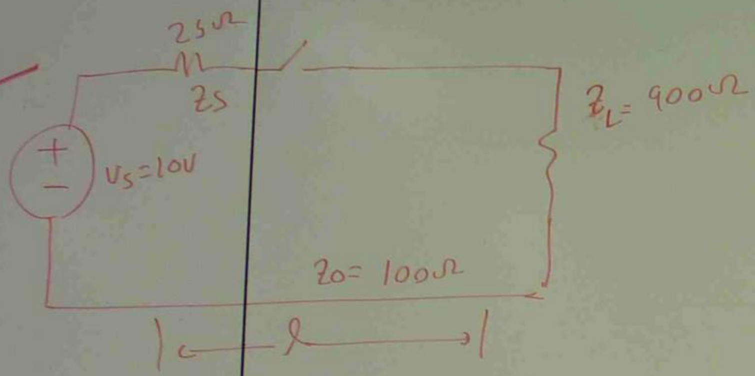

A 10 V DC SOURCE WITH INTERNAL RESISTANCE 25 Ω IS CONNECTED TO A TRANSMISSION LINE OF LENGTH l HAVING AN IMPEDANCE OF 100Ω BY THE SWITCH. THE TRANSMISSION LINE IS TERMINATED WITH 900Ω RESISTOR.

T = AMOUNT OF TIME REQUIRED FOR A SIGNAL TO TRAVEL THE LENGTH OF TRANSMISSION LINE

CALCULATE (a) TOTAL VOLTAGE OF THE FIRST REFLECTION AT LOAD

(b) TOTAL VOLTAGE OF THE SECOND REFLECTION AT SOURCE

(c) TOTAL VOLTAGE OF THE THIRD REFLECTION AT LOAD.

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

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

$$\Gamma_L = \frac{Z_L - Z_0}{Z_L + Z_0} = \frac{900 - 100}{900 + 100} = 0.8$$

$$V_{1(-)} = V_{1(+)} \Gamma_L = 8 \times 0.8 = 6.4V$$

(a) FIRST REFLECTION AT LOAD

$$V_{T_1} = V_{1(+)} + V_{1(-)}$$

$$= 8 + 6.4 = 14.4V$$

(b) $V_{2(+)} = V_{1(-)}\Gamma_S$

$$\Gamma_S = \frac{Z_S - Z_0}{Z_S + Z_0}$$

$$= \frac{25 - 100}{25 + 100} = -0.6$$

$$V_{2(+)} = V_{1(-)}\Gamma_S = 6.4 \times (-0.6) = -3.84V$$

SECOND REFLECTION

$$V_{T2} = V_{1(+)} + V_{1(-)} + V_{2(+)}$$

$$= 8 + 6.4 + (-3.84) = 10.56V$$

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

$$= -3.84 \times 0.8 = -3.072V$$

THIRD REFLECTION

$$V_{T3} = V_{1(+)} + V_{1(-)} + V_{2(+)} + V_{2(-)} = 8 + 6.4 + (-3.84) + (-3.072) = 7.488V$$

BOUNCED DIAGRAM