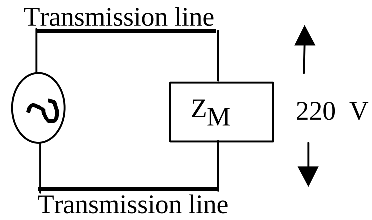
Prob3455: An electric motor consumes 5 kW of power at 220 V amplitude with a power factor of 0.80. This motor runs at the end of a transmission line of resistance 2.5 Ω. What voltage and power must be supplied at the input end of the transmission line.



Solution:
Let us first find the current through the motor - this given the resistance of the transmission line will give us the additional voltage needed.

The power in the motor

$$< P_M > = \left(\frac{V_0^{\ 2}}{2 Z_M} \right) Cos j \; = 5 \text{ kW}$$

Therefore $Z_M = \dfrac{V_0^{\ 2}}{2 < P_M >} Cos j \; = 3.87 \ \Omega$

Hence the peak current thru the motor is $I_0 = \dfrac{V_0}{Z_M} = 56.8$ A

In order to use this information to find the peak voltage needed from the generator we need to find the total impedance Z_T

> Note: You cannot set $V_{0T} = I_0 . Z_M + I_0 . Z_t$. This is because in AC circuits impedances do not add linearly just like simple resistors. The reactive parts and the resistive parts of two series impedances must be treated separately according to the recipe
>
> $$Z_T = \sqrt{[(X_{L1} + X_{L2}) - (X_{C1} + X_{C2})]^2 + (R_1 + R_2)^2}$$

In our case this means that:
$Z_T = \sqrt{[X_{LM} - X_{CM}]^2 + (R_M + R_t)^2}$ since the reactive parts of the transmission line are zero.
Since $Z_M = \sqrt{[X_{LM} - X_{CM}]^2 + R_M^{\ 2}}$ implies that $Z_M^{\ 2} - R_M^{\ 2} = [X_{LM} - X_{CM}]^2$ we have
$Z_T = \sqrt{Z_M^{\ 2} - R_M^{\ 2} + (R_M + R_t)^2}$ = 6.07 Ω (since $R_M = Z_M$ Cosφ = 3.87 x 0.8 = 3.1 Ω).
Thus
$V_{0T} = I_0 . Z_T$ = 56.8 x 6.1 = 345 V
The power that needs to be supplied is:

$$< P_T > = \left(\frac{V_{0T}^{\ 2}}{2 Z_T^{\ 2}} \right) (R_t + R_M) = 9.05 \text{ kW}$$

Final Note: This is a lot harder way to do the problem than by using complex numbers !