task_underseacable

Student Group

First Name	Surname	Matrikel Nr.

Table of Contents

Undersea cable capacity.

You are working as an electrical engineer for a company that is planning to lay a power cable between two coastal cities that are $400 ~\rm km$ apart. The company wants to know what the maximum capacity of the cable should be to meet their power requirements. You have been tasked with calculating the cable's capacity.

Assume that the cable's resistance is $0.1 ~\Omega$ per km, and that the voltage at the source end of the cable is $500 ~\rm kV$. The power factor of the cable is 0.8, and the load at the destination end of the cable is $800~\rm MW$.

Calculate the maximum capacity of the cable in $\rm MW$, assuming that the cable is operating at its maximum capacity.

Provide your answer with a brief explanation of your calculations.

Note: You may assume that the cable is a single-phase AC cable.

Result

Given:

- Distance between two coastal cities = $d = 400~{\rm km}$
- Depth of the cable below the ocean's surface = $h = 1000~{\rm m}$
- Resistance of the cable per unit length = $R = 0.1~{\rm \Omega/km}$
- Voltage at the source end of the cable = $V_s = 500~{\rm kV}$
- Power factor of the cable = $\cos \phi = 0.8$
- Load at the destination end of the cable = $P = 800~{\rm MW}$

The total resistance of the cable is:

$$\begin{align*} R_{\rm total} &= R \times L \\ &= 0.1~{\rm \Omega/km} \times 400~{\rm km} \\ &= 40~{\rm \Omega} \end{align*}$$

The current flowing through the cable is:

$$\begin{align*} I &= \frac{V_s}{R_{\rm total}} \\ &= \frac{500~{\rm kV}}{40~{\rm \Omega}} \\ &= 12.5 ~{\rm kA} \end{align*}$$

The real power being transmitted through the cable is:

$$\begin{align*} P &= V_s \times I \times \cos \phi \\ &= 500~{\rm kV} \times 12.5~{\rm kA} \times 0.8 \\ &= 5,000~{\rm MW} \end{align*}$$

The reactive power being transmitted through the cable is:

$$\begin{align*} Q &= V_s \times I \times \sqrt{1 - \cos^2 \phi} \\ &= 500~{\rm kV} \times 12.5~{\rm kA} \times \sqrt{1 - 0.8^2} \\ &= 2,500~{\rm MVAr} \end{align*}$$

The total power that the cable can handle is:

$$\begin{align*} S &= \sqrt{P^2 + Q^2} \\ &= \sqrt{(5,000~{\rm MW})^2 + (2,500~{\rm MVAr})^2} \\ &= 5,590.17~{\rm MVA} \end{align*}$$

Therefore, the maximum capacity of the cable is $S = 5,590.17~{\rm MW}$, which is greater than the required power of $P = 800~{\rm MW}$.