Short Transmission Line: Regulation and Efficiency

Sending-end voltage, voltage regulation and efficiency of a short overhead line or cable (series R and X only) from receiving-end voltage, load and power factor.

Method: Stevenson and Grainger; Power System Analysis (McGraw-Hill, 1994); Kothari and Nagrath; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Receiving-end line voltage	11.000	kV
Load power	2,000.0	kW
Load power factor	80.000	%
Power factor	Lagging (inductive load)	
Resistance per phase	1.5000	Ω
Reactance per phase	2.5000	Ω

Calculated results

Parameter	Value	Unit
Line current	131.22	A
Sending-end line voltage	11.616	kV
Voltage regulation	5.6030	%
Line loss (3 phases)	77.479	kW
Transmission efficiency	96.271	%

Notes for this case

- Short-line model (shunt capacitance neglected): valid up to about 80 km overhead at 50 Hz. Regulation here is (V_S − V_R)/V_R with V_S held.

Formula and method

$$\vec{V}_S = \vec{V}_R + \vec{I}(R + jX), \quad \mathrm{Reg} = \frac{|V_S| - |V_R|}{|V_R|}, \quad \eta = \frac{P}{P + 3I^2R}$$

$$\vec{I} = I(\cos\phi - j\sin\phi), \quad I = \frac{P}{\sqrt{3}\, V_R \cos\phi}$$

Variables

V_R	Receiving-end line voltage	V
P	Load power	W
$\cos\phi$	Load power factor	-
pf	Lagging or leading power factor	-
$\sin\phi$	Positive for a lagging load, negative for a leading one	-
R	Resistance per phase	Ω
X	Reactance per phase	Ω
I	Line current	A
V_S	Sending-end line voltage	V
Reg	Voltage regulation	-
P_{loss}	Line loss (3 phases)	W

η	Transmission efficiency	-

Method and standards

Per-phase phasor model.

Assumptions and limits

- Balanced three-phase; short line.
- Lagging or leading load: with a leading power factor the regulation can be negative (the receiving-end voltage rises).

References

• Stevenson and Grainger
• Power System Analysis (McGraw-Hill, 1994); Kothari and Nagrath
• Modern Power System Analysis
• 4th ed. (2011) (short line model)

Report details

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Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/power/short-line-regulation

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