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# Modeling and Comparative Analysis of Long and Short Transmission Lines using MATLAB/Simulink

Simulation tool : MATLAB/Simulink | Frequency : 60 Hz | Standard : IEC 60038 & IEC 60909

**Prof. Vishal V. Mehtre<sup>1</sup>, Ms. Shalaka Mirajkar<sup>2</sup>, Ms. Sakshi Nimbalkar<sup>2</sup>**

Assistant Professor, Electrical Engineering, Bharati Vidyapeeth (DU) College of Engineering, Pune, India<sup>1</sup>

Undergraduate Student, Electrical Engineering, Bharati Vidyapeeth (DU) College of Engineering, Pune, India<sup>2</sup>

**ABSTRACT:** Modeling transmission lines is crucial for analyzing power systems, as line length significantly affects their electrical behavior. For short transmission lines, a lumped-parameter approach is used, whereas long lines require a distributed-parameter model to account for line constants and signal propagation along the line. Using MATLAB and Simulink, which follow IEC standards such as IEC 60038 and IEC 60909, enables testing under various load conditions. The results show that long transmission lines have greater voltage drop and reactive power effects than short lines, which affects voltage regulation and system efficiency. The study highlights the importance of choosing the right model for efficient power system design.

**KEYWORDS:** Transmission Lines, Short Transmission Line, Long Transmission Line, MATLAB, Simulink, Voltage Regulation, Power Losses, Power System Analysis.

## I. INTRODUCTION

Electrical power systems rely on transmission lines to move energy from power sources to where it's needed.

The way these lines behave is influenced by their length, the voltage they carry, and their electrical properties, which makes accurate modeling important for analyzing and designing the system. Based on length, transmission lines are usually grouped as short, medium, and long, each requiring different modeling methods.

Short transmission lines are modeled using lumped-parameter models, in which the effect of shunt capacitance is usually ignored.

However, when the line is longer, this simplification isn't enough, and a more detailed approach is needed. Long transmission lines require distributed parameter modeling where resistance, inductance, capacitance, and conductance are taken into account across the entire line. This approach is needed to capture important behaviors like voltage variations, reactive power flow, and the Ferranti effect.

Modern tools like MATLAB and Simulink provide a good environment for analyzing transmission line performance under various conditions.

These tools allow for in-depth analysis of factors like voltage regulation, transmission efficiency, and power losses.

Understanding the differences between short and long transmission line models is key to choosing the right analytical methods and ensuring the system runs efficiently.

A comparative analysis using simulation offers useful insights into their performance and helps in better planning and design of power systems.

## II. LITERATURE REVIEW

Transmission line modeling has received considerable attention in power system studies due to its direct impact on system performance and stability. Early approaches focused on simplified representations, where short transmission lines were modeled using lumped parameters by neglecting shunt capacitance. These models offered ease of analysis and were adequate for short-distance applications; however, their limitations became evident as transmission distances increased.

To address these limitations, more advanced modeling techniques were developed for long transmission lines. Distributed parameter models, which consider resistance, inductance, capacitance, and conductance along the entire length of the line, provide a more realistic description of system behavior. Such models enable the analysis of voltage and current variations, as well as phenomena like voltage rise and reactive power flow, which are significant in long-distance transmission.

With the advancement of computational tools, simulation-based studies have become increasingly prominent. Platforms such as MATLAB and Simulink have been widely used to model and analyze transmission lines under different loading conditions. These tools allow detailed evaluation of performance parameters, including voltage regulation, efficiency, and power losses, making them effective for comparative studies.

Recent research has further explored numerical and analytical techniques to enhance modeling precision, particularly for long transmission lines. These studies highlight that simplified models are insufficient to capture the distributed nature of line parameters and their impact on system behavior. As a result, comparative analyses between short and long transmission line models have gained importance in identifying suitable modeling approaches for different operating conditions.

Overall, existing literature emphasizes the need for selecting appropriate modeling techniques based on transmission line characteristics. Simulation-based comparative analysis plays a crucial role in understanding performance differences and supports improved design and operation of modern power systems.

## III. METHODOLOGY

The objective of this work is to model and analyze the performance of short and transmission lines using MATLAB Simulink, and to compare their electrical behavior under varying load conditions.

### 1) System Classification

Transmission lines are categorized based on length and operating voltage:

- Short Transmission Line: Length < 80 km (capacitance neglected)
- Medium/Long Transmission Line: Length > 80 km (capacitance considered)

### 2) Simulink Model Development

Using MATLAB Simulink, the following steps were implemented:

- A three-phase AC voltage source is used as input
- Transmission line blocks are configured:
  - Short line: Series R-L branch
  - Medium/long line:  $\pi$ -section with shunt capacitors
- Load modeled as:
  - Resistive load
  - RL load (to simulate lagging power factor)
- Measurement blocks added:
  - Voltage (sending & receiving end)
  - Current
  - Power (active and reactive)

### Short vs. Long Transmission Line Comparison

Feature	Short Transmission Line	Long Transmission Line
Line Length	Less than 80 km	Greater than 250 km
Operating Voltage	Below 20 kV	Above 100 kV
Capacitance (C)	Negligible; usually ignored	Critical; considered uniformly distributed
Circuit Model	Lumped parameter (simple series)	Distributed parameter model
Mathematical Tools	Simple algebraic Ohm's Law	Hyperbolic functions/differential equations
Accuracy	Sufficient for small distances	High precision required for stability analysis

### Key Behavioral Differences

- **Charging Current:** In short lines, the charging current is so small it doesn't impact the performance significantly. In long lines, this current is substantial due to the high shunt capacitance between the long conductors and the ground.
- **Voltage Regulation:** Short lines have relatively stable voltage regulation determined mainly by series impedance. Long lines experience the **Ferranti Effect**, where the receiving end voltage can become higher than the sending end voltage under no-load conditions.
- **ABCD Parameters:** For short lines, the generalized constants are simplified (e.g.,  $A=1$ ,  $B=Z$ ,  $C=0$ ,  $D=1$ ). Long lines use complex calculations where  $A = \cosh(l)$  and  $B = Z \sinh(l)$ , accounting for the propagation constant and characteristic impedance ( $Z_c$ ).

## IV. RESULTS AND DISCUSSION

### 1. Voltage Regulation

- In short transmission lines, voltage drop is mainly due to resistance and inductive reactance.
- In medium/long lines, the presence of capacitance improves voltage profile under load but causes voltage rise during no-load (Ferranti effect).

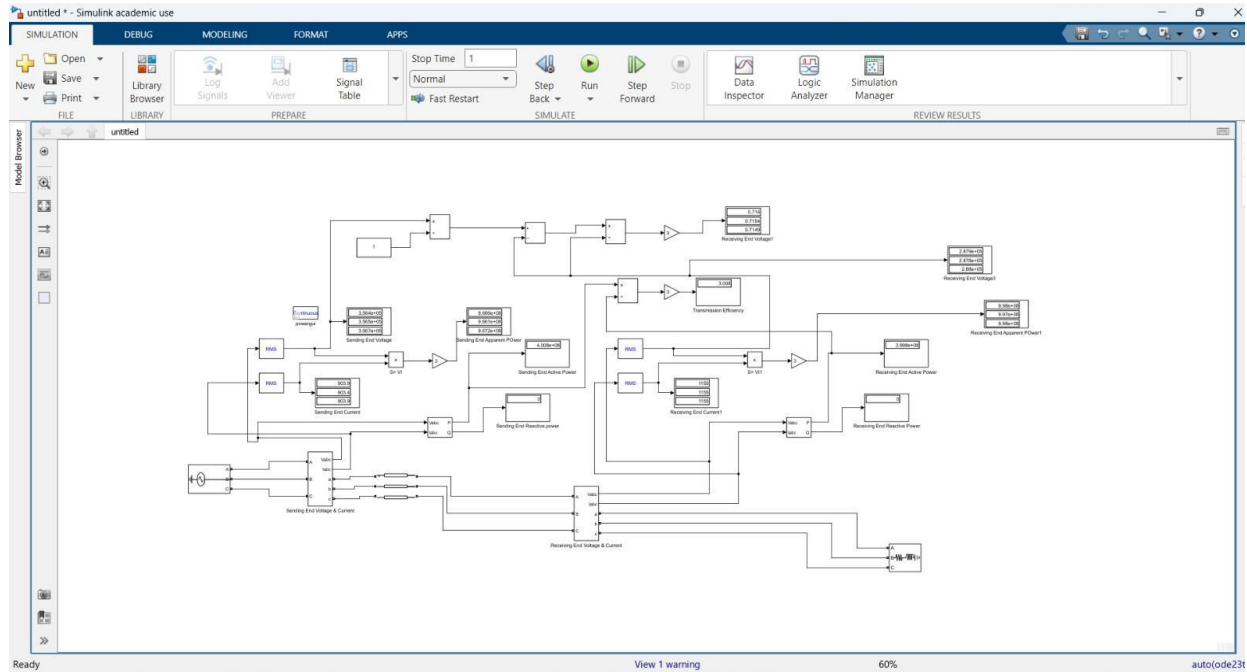
#### Observation:

Voltage regulation is poorer in long lines at heavy load but may show voltage rise at light load.

#### Effect of Capacitance

- Negligible in short lines → simple behavior
- Significant in long lines:
  - Supplies reactive power
  - Reduces net current under certain conditions

### Simulation Model:



### Key Insight:

Capacitance improves efficiency at medium loads but can destabilize voltage under no-load conditions.

The simulation results demonstrate that short transmission lines can be effectively modeled using simple impedance representation, while medium and long lines require more detailed modeling to capture capacitive effects. The comparative analysis highlights the importance of considering line length and reactive power in system design for maintaining voltage stability and efficiency.

### V. CONCLUSION

The comparative analysis of short and long transmission lines highlights the significant impact of line length on system performance. Short transmission lines can be effectively represented using simplified models, while long transmission lines require distributed parameter modeling to capture their behavior. Simulation using MATLAB and Simulink demonstrates that long lines exhibit higher voltage drop and reactive power effects, affecting overall efficiency and voltage regulation. The study emphasizes the importance of selecting appropriate models for reliable power system analysis and design.

### REFERENCES

- [1] J. J. Grainger and W. D. Stevenson, *Power System Analysis*. New York, USA: McGraw-Hill, 1994.
- [2] C. L. Wadhwa, *Electrical Power Systems*. New Delhi, India: New Age International, 2010.
- [3] Hadi Saadat, *Power System Analysis*. New Delhi, India: Tata McGraw-Hill, 2002.
- [4] International Electrotechnical Commission, *IEC 60038*, IEC Standard, 2009.
- [5] International Electrotechnical Commission, *IEC 60909*, IEC Standard, 2016.
- [6] MathWorks, *MATLAB Documentation*, 2024. [Online]. Available: <https://www.mathworks.com>
- [7] MathWorks, *Simulink User Guide*, 2024. [Online]. Available: <https://www.mathworks.com>
- [8] A. R. Bergen and V. Vittal, *Power Systems Analysis*, 2nd ed. New Delhi, India: Pearson, 2009.



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