Electromagnetic transients effect on blocks of $\pi$ circuits with damping resistance

Code: 19.006

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Objectives

- Apply a different organization to the cascade of π circuits with less damping resistances;
- Compare the results obtained with the structure which has damping resistances in all circuits units;
- Analyze which structure returns the best results regarding the minimization of the numerical oscillations.
Introduction

- The transmission line model is based on a large amount of π circuits in a cascade;

- Simulations with this model include numerical oscillations;
Adding damping resistances \((R_D)\) to the circuits units smooth these oscillations;

Tests with different structures of the cascade of circuits.
Structure of a π circuit
Line with distributed parameters;
Model with concentrated parameters;
Defined by the LTIS:

\[ x = Ax + Bu \]
Model calculation

- Damping resistance ($R_D$) calculation:

\[
R_D = k_D \left( \frac{2L}{\Delta t} \right) \\
G_D = \frac{1}{R_D}
\]

\[
\Rightarrow k_D = \frac{R_D \Delta t}{2L} = \frac{\Delta t}{2LG_D}
\]
Results

- First model: without any damping resistance
### Results

- **For a cascade of 200 π circuits:**

  ![Image of voltage-time graph](image.png)

  - Error greater than 25%.

<table>
<thead>
<tr>
<th>Voltage [pu]</th>
<th>Time [s]</th>
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<tbody>
<tr>
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</tr>
<tr>
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<td>6.5</td>
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</tbody>
</table>
Results

- Second model: with damping resistance in all units
Results

- For a cascade of 200 π circuits and factor $k_D = 1$:

- Significant reduction of oscillations.
Results

- Varying the number of circuits and the factor $k_D$:
Results

- Third model: blocks of circuits with and without damping resistance
Results

- Again, for a cascade of 200 π circuits and factor $k_D = 1$:

- Numerical instability and inconsistency.
Results

- Varying the number of circuits and the factor $k_D$:

![3D graph showing the relationship between the number of circuits, the K factor, and voltage peak [pu].]
Conclusions

- Computational cost of simulation is unaltered;
- Inability to reduce Gibbs Oscillations;
- Instability and numerical inconsistency;
- Model with all \( \pi \) circuit units with damping resistance is recommended.
Acknowledgments

Processes:

2015/20590-2
2015/21390-7