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Simulation Model for Electrical Power Lines

The solution of simulation requires the construction of a system model composed of equivalents of the real elements, which must simulate those characteristics, which are relevant to the real behaviour. In this paper the simulation is realised by a designed network analyser represented the electrical line by a connection of three-phase π-inductors represent units, which are symmetric, and the mutual inductive coupling between phases only.

***Keywords**: model, octopole, network analyser, electrical power line*

1. Introduction

The means of establish a proper model in system studies is generally different in transient network analyser (TNA) and digital methods. The proposed transient network analyser is shown in figure 1 where the line is assumed to be continuously transposed, the mutual inductive coupling is represented by inductors only and there are 8-capacitors arrangement used.

2. The choice of π -unit length

The partial line length, which is represented by one π -unit, influences the frequency bandwidth of the model line. This frequency band increases with decreasing partial line length of one π -unit, and its choice is an important factor in line representation. The use of an insufficient number of π -units will cause local distortion on the overvoltage wave shape, which can affect the maximum overvoltage peak. In the chain of octopoles that modelate an electric line, waveforms are more or less different from the actual ones and the processes are altered as result of the impossibility of accurate modelling the wave impedance (Z_c^M) and propagation coefficient ($\underline{\nu}^M$).

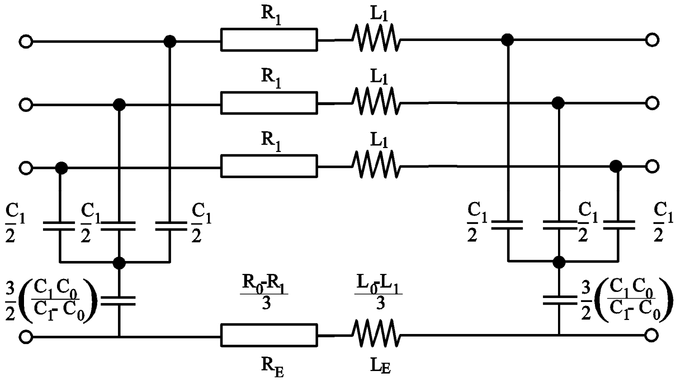

Figure 1

The propagation coefficient in an octopole, $\underline{\nu}^M$ is different from the actual one. Therefore, the quantity $\underline{\nu}^M$ differs from ν , and their relation may be expressed with an approximation, as:

$$\nu^M n_x = \nu l_x \left(1 + \frac{\omega^2 L_{(0)} C_{(0)} (\Delta l)^2}{24} \right) = \nu l_x \left(1 + \frac{\omega^2 L_{(0)} C_{(0)} l^2}{24 n^2} \right) \tag{1}$$

The error occurring between model and actual line is:

$$\Delta\nu = \frac{\nu^M n_x - \nu l_x}{\nu l_x} = \frac{\omega^2 l^2 L_{(0)} C_{(0)}}{24 n^2} = \frac{\omega^2 l^2}{v^2 24 n^2} \tag{2}$$

Knowing the actual characteristic impedance, one finds the characteristic impedance of a Π cuadripole, $\underline{Z}_M{}^C$, as follows:

$$\underline{Z}^M{}_c = \frac{\underline{Z}_c}{\sqrt{1 + 0,25 \underline{\nu} \Delta l^2}} = \underline{Z}_c \left(1 - \frac{\underline{\nu}^2 l^2}{8 n^2}\right) \tag{3}$$

Hence, the characteristic impedance error is:

$$\Delta Z_c = \frac{Z^M{}_c - Z_c}{Z_c} = \frac{Z_c \left(1 - \dfrac{\underline{\nu}^2 l^2}{8 n^2} \right) - Z_c}{Z_c} = \frac{\omega^2 l^2}{v^2 8 n^2} \tag{4}$$

In table 1 are lists the errors Δνl [%] and Δ (Z_c) [%] for various frequencies and a line length of 25 km. By comparing the error of the characteristic impedance to the one of propagation coefficient, one finds that the latter is sensibly higher than the late.

Table 1.

f[Hz]	50	100	200	500	1000	1300	1600	2000
Δ(ul)%	$2,85 \cdot 10^{-5}$	$11,41 \cdot 10^{-5}$	$45,66 \cdot 10^{-5}$	$2,853 \cdot 10^{-3}$	$11,41 \cdot 10^{-3}$	$1,93 \cdot 10^{-2}$	$2,92 \cdot 10^{-2}$	$3,456 \cdot 10^{-2}$
Δ(Z_c)%	$8,56 \cdot 10^{-5}$	$34,23 \cdot 10^{-5}$	$1,37 \cdot 10^{-3}$	$8,56 \cdot 10^{-3}$	$34,23 \cdot 10^{-2}$	$5,79 \cdot 10^{-2}$	$8,76 \cdot 10^{-2}$	$10,37 \cdot 10^{-2}$

$$\Delta Z_c = \frac{k^2\omega^2 l^2}{8 v^2 n^2} \quad \Delta\nu = \frac{k^2\omega^2 l^2}{24 v^2 n^2} \tag{5}$$

According to expression (5), for a Δl=100 km line, modelled as an octopole, the model may allow through, without distortions, superior harmonics up to 19th grade and for a Δl=25 km line, the number of non-distorted harmonics is 76, which is fully satisfactory for our study.

3. Lines electrical parameters

The values of some electrical parameters are frequency-dependent and must be taken into consideration in the calculation. Sequence parameters were calculated, based on Carson’s formulas with a calculus program PARAMRLC conceived by authors for typical lines of 110-220 kV, 400 kV, 750 kV.

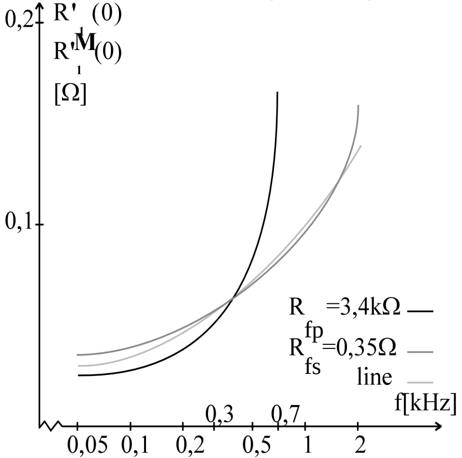

Figure 2

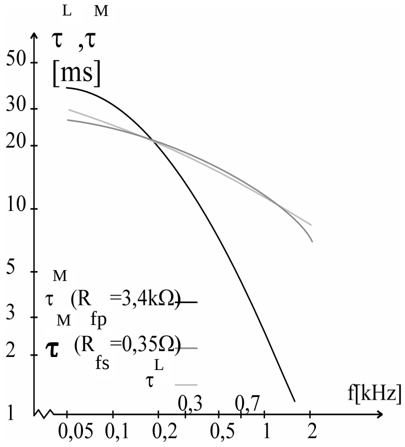

Figure 3

In figure 2 and 3 are given the model direct sequence parameters and propagation time for 110-220 kV lines.

4. Conclusion

Apart from the educational benefits of TNA`s simulation method it is also improves the confidence of potential and practising engineers to deal with operations and associated problems. In this way the user (students) can make the significant circuit connections, which enhances the learning process.

The test simulation made on the transient network analyser for aerial power line proven this idea prospective for further detailed analysis and possible practical implementation.

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