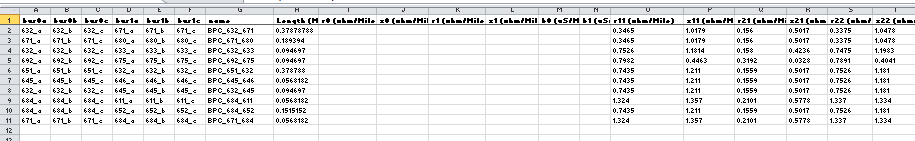
Component: Three-phase Line

**Notes:**

* **The variable names for DiTTo in the first column are exactly copied from DiTTo in order to get the parameters in DiTTo easily.**
* **For ePHASORSIM, the symbols in the third column are put exactly same as the ePHASORSIM user guide and the demo examples.**
* **The DiTTo parameters which match the ePHASORSIM’s parameters are put in the same rows.**
* **If one or more parameters which are available in ePHASORSIM but not in DiTTo, in that case the corresponding columns of the Ditto are left empty or necessary suggestions are provided.**
* **The parameters which are available only in DiTTo but not in ePHASORSIM, in that case the corresponding columns of the ePHASORSIM are left empty.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ditto | | ePHASORSIM | | |  |
| Name of the variable | Description | Symbol | Description | Unit | Default value |
| name | Name of the line object | name | Line name | Name must be unique |  |
| num\_phases | number of phases on the line as a whole | bus0a | Sending bus: phase A | Name must be unique |  |
| bus0b | Sending bus: phase B | Name must be unique |  |
| numwires | number of wires that exists as part of the line |  |
| wires | This parameter is a list of all the wires included on the line |  |
| bus0c | Sending bus: phase C | Name must be unique |  |
| from\_element | The node which connects to the 'from' end of the line | Bus1a | Receiving bus: phase A | Name must be unique |  |
| to\_element | The node which connects to the 'to' end of the line | Bus1b | Receiving bus: phase B | Name must be unique |  |
| Bus1c | Receiving bus: phase C | Name must be unique |  |
| length | This parameter is the length of the Line | Length (Mile) | Length of the line | Unit: mile |  |
| resistance0 | zero sequence series resistance | r0 (ohm/Mile) | Zero-sequence resistance | Unit: ohm/mile |  |
| reactance0 | zero sequence series reactance | x0 (ohm/Mile) | Zero-sequence reactance | Unit: ohm/mile |  |
| Resistance | This parameter is the positive sequence series resistance | r1 (ohm/Mile) | Positive-sequence resistance | Unit: ohm/mile |  |
| Reactance | positive sequence series reactance | x1 (ohm/Mile) | Positive-sequence reactance | Unit: ohm/mile |  |
| susceptance0 | zero sequence series susceptance | b0 (uS/Mile) | Zero-sequence capacitive charge | Unit: uS/mile |  |
| Susceptance | positive sequence series susceptance | b1 (uS/Mile) | Positive-sequence capacitive charge | Unit: uS/mile |  |
| conductance0 | zero sequence series conductance |  |  |  |  |
| Conductance | positive sequence series conductance |  |  |  |  |
| These parameters are not unavailable in DiTTo; the formula for calculating line impedance matrix from the conductor information is given at page-4. |  | r11 (ohm/Mile) | Configuration of Z matrix ( R + j X ):    The elements of the 3 by 4 matrix | Unit: ohm/mile |  |
| x11 (ohm/Mile) | Unit: ohm/mile |  |
| r21 (ohm/Mile) | Unit: ohm/mile |  |
| x21 (ohm/Mile) | Unit: ohm/mile |  |
| r22 (ohm/Mile) | Unit: ohm/mile |  |
| x22 (ohm/Mile) | Unit: ohm/mile |  |
| r31 (ohm/Mile) | Unit: ohm/mile |  |
| x31 (ohm/Mile) | Unit: ohm/mile |  |
| r32 (ohm/Mile) | Unit: ohm/mile |  |
| x32 (ohm/Mile) | Unit: ohm/mile |  |
| r33 (ohm/Mile) | Unit: ohm/mile |  |
| x33 (ohm/Mile) | Unit: ohm/mile |  |
|  |  | b11 (uS/Mile) | Configuration of B matrix: | Unit: uS/mile |  |
| b21 (uS/Mile) | Unit: uS/mile |  |
| b22 (uS/Mile) | Unit: uS/mile |  |
| b31 (uS/Mile) | Unit: uS/mile |  |
| b32 (uS/Mile) | Unit: uS/mile |  |
| b33 (uS/Mile) | Unit: uS/mile |  |
| line\_type | This parameter is added to PSRType which provides additional information for the object |  |  |  |  |
| nominal\_voltage | This parameter defines the base voltage of the wire. |  |  |  |  |
| max\_temperature | This parameter is the maximum allowed temperature for the end of the line |  |  |  |  |
| Positions | '''This parameter is a list of positional points describing the line |  |  |  |  |
| Nameclass | The nameclass (e.g. Sparrow\_ACSR1/0) for the line. |  |  |  |  |
| Ampacity | The ampacity rating for the wire under nomal conditions |  |  |  |  |
| emergency\_ampacity | The ampacity rating for the wire under emergency conditions |  |  |  |  |
| faultrate | The number of faults that occur per year |  |  |  |  |
| limits | This parameter is a list of all the operational constraints on the line |  |  |  |  |
| is\_fuse\_ | This flag indicates whether or not the line is also a fuse |  |  |  |  |
| fuse\_limit | The maximum current that can pass through the wire before the fuse is blown |  |  |  |  |
| is\_switch | This flag indicates whether or not the line is also a switch |  |  |  |  |
| is\_banked | This flag indicates whether or not the switch is banked |  |  |  |  |
| faults | This parameter is used to list the faults that exist on the line |  |  |  |  |

Example: in ePHASORSIM



**Calculation of the line impedance matrix from the conductor information [1, 2]:**

The primitive impedance matrix

|  |  |
| --- | --- |
|  | (1) |

The self-impedance components are,

|  |  |
| --- | --- |
| Ω/mile | (2) |

Where, is resistance in ohms per conductor per mile and is geometric mean radius in feet.

The mutual-impedance components are,

|  |  |
| --- | --- |
| Ω/mile | (3) |

Where, is distance between conductors i and j.

The dot (●) in the above equation (1) separates the matrix into four different matrixes between the third and fourth columns. The matrix can be written as bellow

|  |  |
| --- | --- |
|  | (4) |

Where

|  |  |
| --- | --- |
|  | (5) |
|  | (6) |
|  | (7) |
|  | (8) |

According to Kron reduction method, the phase impedance matrix,

|  |  |
| --- | --- |
|  | (9) |

Where, is a 3 by 3 matrix given in (3)

|  |  |
| --- | --- |
| Ω/miles | (10) |

Symmetrical component impedance matrix

|  |  |
| --- | --- |
|  | (11) |

Where

|  |  |
| --- | --- |
|  | (12) |

Where

a = 1<120°

For a flat line configuration, the self-impedance elements are equal, = = =

For a transposed line, the off-diagonal mutual-impedance elements are equal, = = = .  Then line impedance matrix

|  |  |
| --- | --- |
|  | (13) |

Symmetrical component impedance matrix

|  |  |
| --- | --- |
|  | (14) |

|  |  |
| --- | --- |
|  | (15) |

Where,

Zero-sequence component,

Positive-sequence component,

Negative-sequence component,

In ePHASORSIM information are put as phase-1, phase-2, phase-3. In that case, the above equations are replaced by a = 1, b = 2, and c = 3.

In that case, the line impedance matrix,

|  |  |
| --- | --- |
| Ω/miles | (16) |

Where

|  |  |
| --- | --- |
| = | (17) |
| = | (18) |
| = | (19) |
| = | (20) |
| = | (21) |
| = | (22) |

**Calculation of the line capacitive susceptance matrix from the conductor information [2, 3]:**

At first, it is required to calculate the primitive potential coefficient matrix, .

|  |  |
| --- | --- |
|  | (1) |

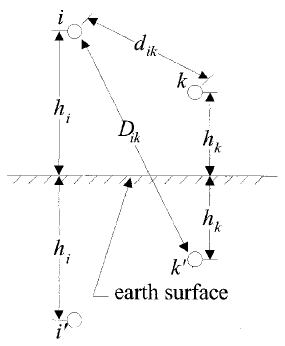


Figure: Geometry of transmission line for capacitance calculation.

The self and mutual potential coefficients are calculated according to equations (2) and (3)

|  |  |
| --- | --- |
| mile/µF | (2) |

Where, is the height of the conductor from the ground and is the radius of the conductor.

|  |  |
| --- | --- |
| mile/µF | (3) |

Where, is the distance between the conductor i and the image below earth surface of the conductor k, is is the distance between the conductors i and k.

The dot (●) in the above equation (1) separates the matrix into four different matrixes between the third and fourth columns. The matrix can be written as bellow

|  |  |
| --- | --- |
|  | (4) |

Where

|  |  |
| --- | --- |
|  | (5) |
|  | (6) |
|  | (7) |
|  | (8) |

If the neutral is grounded, the primitive matrix- of equation (4) can be reduced by following the Kron reduction method. According to Kron reduction method, the reduced potential coefficient matrix,

|  |  |
| --- | --- |
|  | (9) |

Taking the inverse of the potential impedance matrix, the capacitance matrix is

|  |  |
| --- | --- |
|  | (10) |

The capacitive susceptance matrix is

|  |  |
| --- | --- |
| µS/mile | (11) |

|  |  |
| --- | --- |
| Ω/miles | (16) |

References

1. Amberg, Ariana, Alex Rangel, and Greg Smelich. "Validating transmission line impedances using known event data." In *Protective Relay Engineers, 2012 65th Annual Conference for*, pp. 269-280. IEEE, 2012.
2. Kersting, William H. *Distribution system modeling and analysis*. CRC press, 2012.
3. Rivas, Richard A. "Overhead transmission lines and underground cables." *Handbook of electric power calculations* (2001): 9-1.

Component: Single phase line

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Ditto | | ePHASORSIM | | |  |
| Name of the variable | Description | Symbol | Description | Unit | Default value |
|  |  | name | Line name | Name must be unique |  |
|  |  | bus0a | For single phase line, this first sending bus information should be used for phase A or B or C. | Name must be unique |  |
| bus0b | Must be empty whether it is phase A or B or C. |  |  |
|  |  |  |
|  |  |  |
| bus0c | Must be empty whether it is phase A or B or C. |  |  |
|  |  | Bus1a | For single phase line, this first receiving bus information should be used for phase A or B or C. | Name must be unique |  |
|  |  | Bus1b | Must be empty whether it is phase A or B or C. | Name must be unique |  |
| Bus1c | Must be empty whether it is phase A or B or C. | Name must be unique |  |
|  |  | Length (Mile) | Length of the line | Unit: mile |  |
|  |  | r0 (ohm/Mile) | Must be empty | Unit: ohm/mile |  |
|  |  | x0 (ohm/Mile) | Must be empty | Unit: ohm/mile |  |
|  |  | r1 (ohm/Mile) | Must be empty | Unit: ohm/mile |  |
|  |  | x1 (ohm/Mile) | Must be empty | Unit: ohm/mile |  |
|  |  | b0 (uS/Mile) | Must be empty | Unit: uS/mile |  |
|  |  | b1 (uS/Mile) | Must be empty | Unit: uS/mile |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  | r11 (ohm/Mile) | For single phase line, only the value of r11 and x11 should be provided and others (r12, x12,….) should be empty. | Unit: ohm/mile |  |
| x11 (ohm/Mile) | Unit: ohm/mile |  |
| r21 (ohm/Mile) | Unit: ohm/mile |  |
| x21 (ohm/Mile) | Unit: ohm/mile |  |
| r22 (ohm/Mile) | Unit: ohm/mile |  |
| x22 (ohm/Mile) | Unit: ohm/mile |  |
| r31 (ohm/Mile) | Unit: ohm/mile |  |
| x31 (ohm/Mile) | Unit: ohm/mile |  |
| r32 (ohm/Mile) | Unit: ohm/mile |  |
| x32 (ohm/Mile) | Unit: ohm/mile |  |
| r33 (ohm/Mile) | Unit: ohm/mile |  |
| x33 (ohm/Mile) | Unit: ohm/mile |  |
|  |  | b11 (uS/Mile) | For single phase line, only the value of b11 should be provided and others (b12, b13,….) should be empty. | Unit: uS/mile |  |
| b21 (uS/Mile) | Unit: uS/mile |  |
| b22 (uS/Mile) | Unit: uS/mile |  |
| b31 (uS/Mile) | Unit: uS/mile |  |
| b32 (uS/Mile) | Unit: uS/mile |  |
| b33 (uS/Mile) | Unit: uS/mile |  |