



## Data Article

# Dataset for calculating the currents and voltages induced on underground pipelines by nonparallel overhead power lines

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## ABSTRACT

The electromagnetic interference caused by overhead power lines on nonparallel underground pipelines is assessed in "A numerical model for the calculation of electromagnetic interference from power lines on nonparallel underground pipelines" (Popoli et al., 2020 [1]) by segmenting the pipeline path in a number of traits parallel to the power line. The analysis requires a multi-port electrical component to be extracted for each pipeline segment by means of finite element 2D analysis; circuit analysis can then be applied to the network composed of the cascade of the multi-port electrical components in order to calculate the induced voltages and currents on the pipeline. The data in this paper consist of matrices which represent the multi-port electrical components corresponding to the segments in which the pipeline has been subdivided. These matrices can then be used as constitutive relations in network analysis, as detailed in (Popoli et al., 2019 [2]), in order to find the induced pipeline voltages and currents for different intersection angles between the pipeline and overhead power line routings.

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## Specifications Table

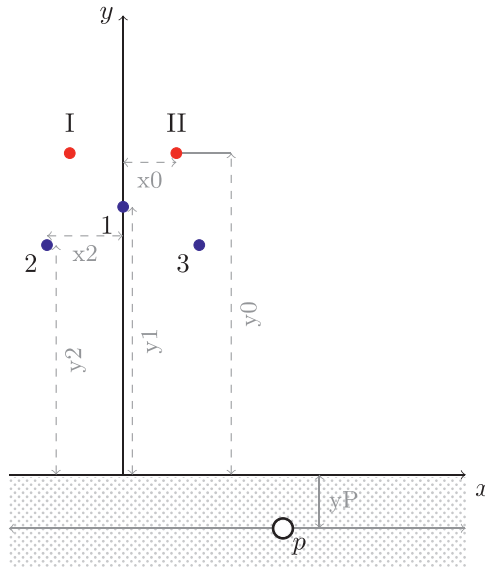
Subject	Electrical and Electronic Engineering Safety, Risk, Reliability and Quality
Specific subject area	Electromagnetic interference, Corrosion, Electrical safety
Type of data	Table Graph Figure Script Raw data
How data were acquired	Numerical simulations by means of finite element method analysis and circuit analysis, using the code described in [1]
Data format	Raw and Analysed
Parameters for data collection	The coupling configuration considered consists of a three-phase overhead power line with two overhead ground wires, a pipeline and the ground. A GMSH script is provided to create 2D triangular meshes corresponding different coupling configurations
Description of data collection	Each cross section of the coupling model corresponding to a segment in which the pipeline has been subdivided is analysed with a 2D finite element code (e.g., FEMM, Elmer, etc.). Enforcing currents or voltages on each conductor of the cross section at a time, a characteristic matrix representing the relations between voltages and currents of the discretized conductors is obtained for each segment.
Data source location	Department of Electrical, Electronic, and Information Engineering "Guglielmo Marconi", University of Bologna, Bologna, I-40136, Italy
Data accessibility	Data are available with the article
Related research article	A. Popoli, L. Sandrolini, A. Cristofolini, A numerical model for the calculation of electromagnetic interference from power lines on nonparallel underground pipelines, Mathematics and Computers in Simulation (2020), <a href="https://doi.org/10.1016/j.matcom.2020.02.015">https://doi.org/10.1016/j.matcom.2020.02.015</a>

## Value of the data

- The matrices representing the different segments into which a corridor (including a pipeline and a power line) is subdivided can be used to assess the interference with overhead power lines for any crossing angle.
- Researchers, students and company people can investigate coupling situations and optimize the routings and the adopted grounding systems accordingly in order to minimize the interference.
- In case a different right-of-way configuration (e.g. a different power line configuration, or different routings of the conductors) needs to be analysed, a script is provided to generate the corresponding cross-section meshes to be analysed with a 2D finite element software.

## 1. Data description

The raw data consist of 17 characteristic matrices representing the different segments into which a corridor (comprising a high voltage power line and a metallic pipeline buried in the soil) is subdivided in the process of assessing an electromagnetic coupling situation. In [1], a crossing angle  $\alpha = 0.8021^\circ$  between the routings of the two structures has been assumed; the angle  $\alpha$  results from a 70m displacement of the horizontal distance of the pipeline with respect to the power line axis, over a longitudinal length of 5km. The typical configuration of the overhead power line and pipeline is shown in Fig. 1. The geometrical positions of the conductors are given in [1] together with the electrical physical properties of the considered materials. The crossing between the overhead power line and pipeline routings has been discretized employing 17 characteristic matrices. The horizontal distance between the power line and the pipeline for each transmission matrix is shown in Table 1.



**Fig. 1.** Scheme of the considered coupling configuration: symmetric three-phase overhead power line with two overhead ground wires (OGW) and a buried pipeline (longitudinal cross-section).

**Table 1**

Horizontal distances between the overhead power line and pipeline routings for the 17 corridor segments considered.

Characteristic matrix	Horizontal distance (m)
1	50
2	47.67
3	43
4	38.33
5	33.67
6	29
7	24.33
8	19.67
9	15
10	10.33
11	5.67
12	1
13	-3.67
14	-8.33
15	-13
16	-17.67
17	-20

Each characteristic matrix has dimensions  $7 \times 7$ , given by the number of conductors in the cross section: three phase conductors, two overhead ground wires, the pipeline and the ground. As described in [2], the even and odd columns of the characteristic matrix correspond respectively to the real and imaginary part of the currents induced on the 7 conductors when a unit voltage potential is enforced on one of the remaining 6 conductors. As an example, the real and imaginary parts of the currents on 7 conductors for one of the characteristic matrices  $\mathbf{M}$  [1] computed using the geometry depicted in Fig. 1 is shown in Table 2. The provided 17 characteristic matrices share the same structure and ordering shown in Table 2 for  $\mathbf{M}$  [1].

Each characteristic matrix represents the physical relations between voltages and currents on the 7 conductors for a particular section of the pipeline-power line right-of-way. It can thus be

**Table 2**  
Characteristic matrix obtained using the geometry in Fig. 1, with the pipeline in position 1 of Table 1.

	RE	IM	RE	IM	RE	IM	RE	IM	RE	IM	RE	IM	RE	IM
Ph_1	7.05E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Ph_2	0.00E+0	0.00E+0	7.05E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
Ph_3	0.00E+0	0.00E+0	0.00E+0	0.00E+0	7.05E-4	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0	0.00E+0
OGW_1	-1.75E-4	-2.43E-5	-1.72E-4	-2.56E-5	-1.48E-4	-1.75E-5	4.67E+2	-1.56E+3	-2.89E+2	5.46E+2	-2.56E+1	3.21E+2	-2.45E+2	4.02E+1
OGW_2	-1.74E-4	-2.41E-5	-1.49E-4	-1.75E-5	-1.69E-4	-2.53E-5	-2.89E+2	5.46E+2	4.69E+2	-1.57E+3	-3.33E+1	3.40E+2	-2.40E+2	4.01E+1
Pipeline	-1.17E-4	2.56E-5	-1.21E-4	2.51E-5	-1.35E-4	2.46E-5	-2.56E+1	3.21E+2	-3.33E+1	3.40E+2	1.27E+2	-2.39E+3	-6.49E+2	2.33E+2
Soil	-3.98E-5	-7.81E-5	-4.19E-5	-8.78E-5	-4.05E-5	-8.40E-5	-2.45E+2	4.02E+1	-2.40E+2	4.01E+1	-6.49E+2	2.33E+2	1.23E+4	-2.99E+3

associated to a multi-port electrical component. The coupling between the power line and the pipeline can be represented by cascading the multi-port components; the cascade of multi-ports can then be used in network analysis to find the induced voltages and currents at any section of the pipeline.

The matrices are organized in text files named as “characteristic\_matrix\_n” where “n” is an integer number comprised between 1 and 17 indicating the segment into which the geometry (and hence the pipeline) has been subdivided.

## 2. Experimental design, materials, and methods

The calculation method is presented in detail in [1]. A 2D FEM approach is combined with circuit analysis yielding a quasi-3D solution of the problem reducing the computational effort compared with a full 3D approach and without introducing the weak coupling assumption. The latter is typical of the approaches based on employing analytical formulas to compute the mutual impedances between earth-return conductors. The provided data allow the calculation of voltages and currents induced on the pipeline versus the distance between the overhead power line and the pipeline. In case a different crossing angle must be considered, the characteristic matrices can still be used to embody the electrical relation between the conductors by changing the pipeline segments length and order to need.

Different configurations of the overhead power line and distances between the power line and pipeline can still be considered: for this purpose, a script is provided with this paper to generate the corresponding 2D mesh of the longitudinal cross-sections using GMSH, an open source 3D finite element mesh generator [3]. These meshes can then be imported into any open source (e.g., FEMM [4], Elmer [5], or the FEM solver developed by the authors [2]) or commercial 2D finite element electromagnetic solver and solved in order to extract the characteristic matrices relevant to each considered cross-section of the pipeline-power line corridor. Once all the matrices have been found, network analysis can be carried out to obtain the induced voltages and currents in the pipeline.

### Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.dib.2020.105643](https://doi.org/10.1016/j.dib.2020.105643).

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