Coupling between transmission underground cables and pipelines

Alain Xémard EDF R&D

Object of this type of studies

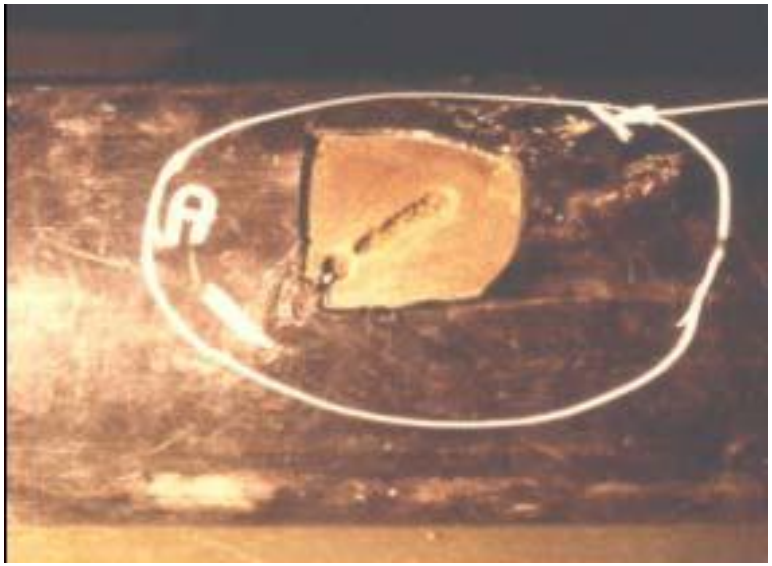
Safety

- In normal operating condition, induced voltage limited by national standards to 50 / 60 V.
- Higher induced voltage accepted in case of fault on the transmission system.

Corrosion of pipelines

- Low level voltage induced by transmission systems disturbs cathodic protection of pipelines and might lead to corrosion.

Examples of pipeline damages due to corrosion



Phenomena involved in case of underground transmission systems

No capacitive coupling because of the screening effect of the earth against electrical field.

Inductive coupling ; voltage induced by the magnetic field generated by the transmission system. It appear both during normal operating condition and during faults.

Conductive coupling ; fault current flowing in the ground during a fault create a potential rise of the electrode and of the neighbouring soil. Coating of tower is subject of the potential difference between local earth voltage and pipe potential.

Evaluation of the inductive coupling

- Application of the line theory at 50 / 60 Hz ;
- Use of EMTP-RV ;
- **Difficulty** : how to use the line theory when the underground cable and the pipeline are not strictly parallel.

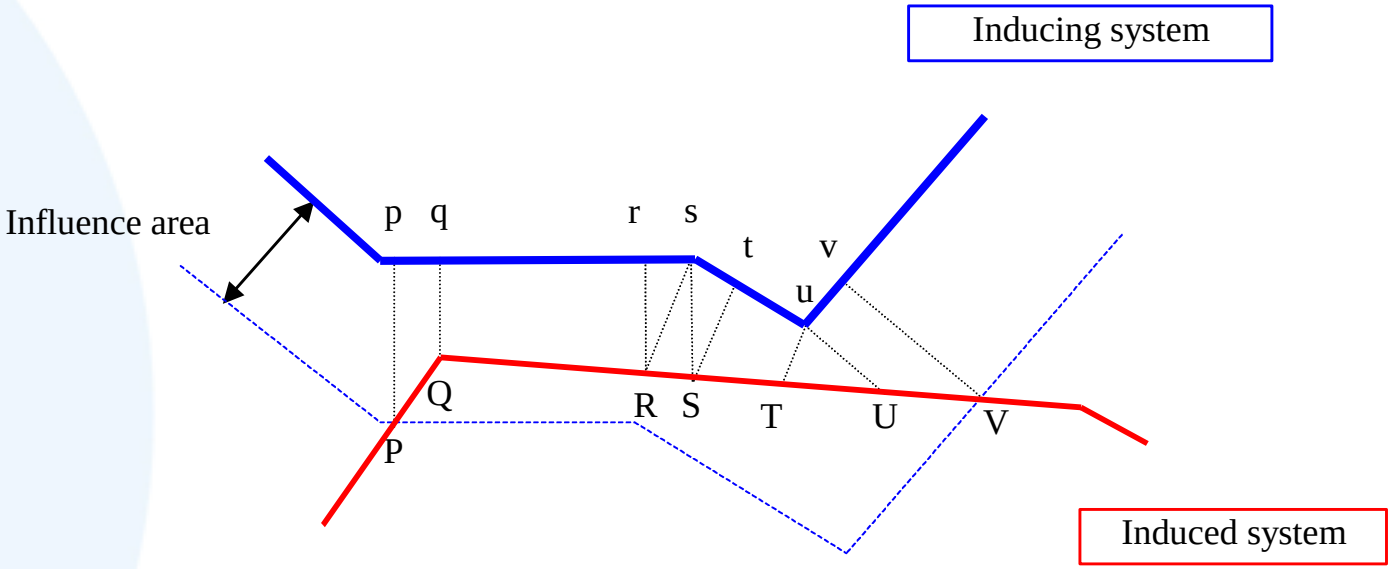
Evaluation of the inductive coupling Processing of the calculation

1 – Determination of the segments for which the line theory can be applied.

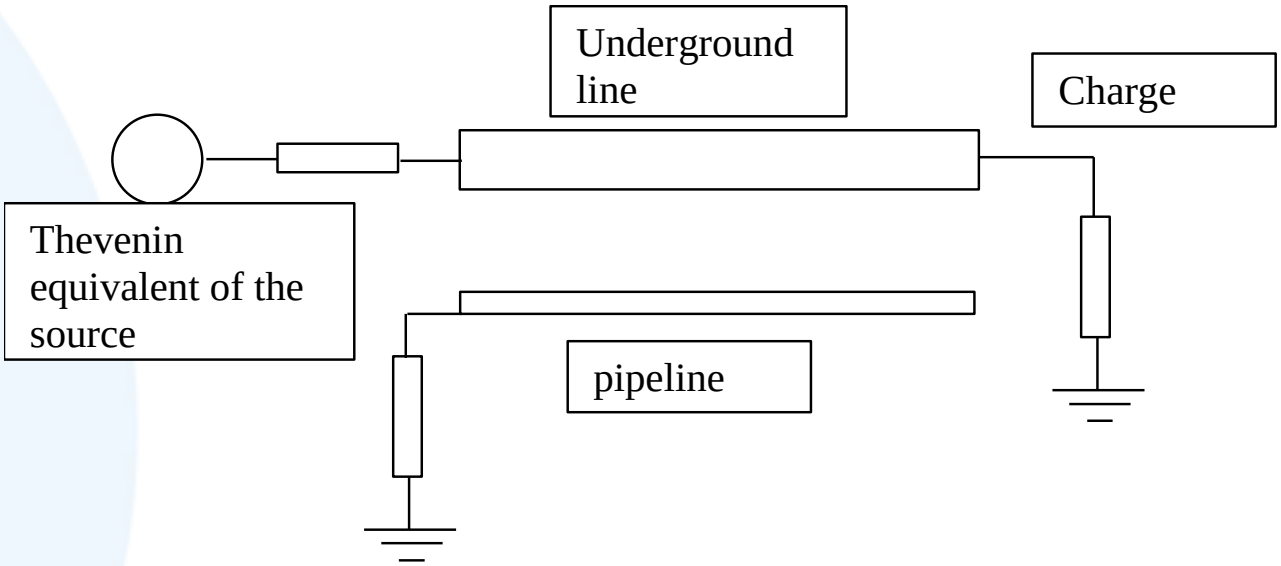
2 – Evaluation of the parameters of the line model for each segment (PI-Exact).

3 – Construction of the EMTP-RV design and simulation in the frequency domain.

Determination of segments for which the line theory can be applied



Example of Application



Description of the configuration

the 225 kV underground system is constituted of 3 single core cables single point grounded at the end of the cable.

The pipeline is located 10 m from the underground cable, The length of parallelism is 600 m. The pipeline has a depth of 1 meter and a diameter of 300 mm ; permeability of 300.

Modelling used to represent the system

Pi-exact model to represent the cable in parallel with the pipeline

Use of find steady state solution at 50 Hz

Example of results

Induced voltage versus the type of coating

coating	ρ (Ω.m)	Tan (δ)	Induced voltage (V / kA / kV)
Bitumen coated pipeline	0.2 10^6	0.36 10^3	1.1
Polyethylene coated pipeline	1 10^8	0.71	2.1

Values not to be exceeded for the voltage according to CIGRE 290 :

- 10 Vrms if soil resistivity is higher than 25 Ohm.m ;
- 4 Vrms if soil resistivity is lower than 25 Ohm.m.

Perspectives

A toolbox based on EMTP-RV, CRINOLINE, has been developed by a group of partners to facilitate the calculation of voltage induced on pipelines and telecommunication cables.

This group of partners is constituted of : Hydro-Québec, CEATI (representing US and Canadian utilities), RTE, ELIA, GRT Gaz, France Telecom and EDF.

The goal of CRINOLINE is to calculate directly the induced voltage using the characteristics of both inducing and inducing systems With a software internationally recognized.