



## Optimized Selection Approach of Transformer Protection Devices against Atmospheric Discharges Using Expert System

*Nerivaldo R. Santos (EDP/USP)*  
*Ivan N. da Silva (USP)*  
*Rogério A. Flauzino (USP)*  
*Danilo H. Spatti (USP)*

July 28, 2009



## Introduction

### Main Purpose of the Paper

---

- Design of expert system that assists the procedures involved with the protection design of transformers and equipments against atmospheric discharges.
- Expert system allows to analyze the behavior of the respective voltage transients that are generated at the supplying area.
- Experiment results are showed for validation purposes of the proposed approach.



## Expert System

### General Aspects of Implementation

---

- **Efficient integration of approaches and techniques that take into account the following aspects:**
  - Characteristics of the atmospheric discharges;
  - Experimental analyses that represent the phenomenon;
  - Mathematical models that allow to map the process involved with the formation of the lightning (modified Rusck model).



3

## Conventional Rusck Model

### Application Particularities

---

- **Model used for induced voltage estimation in distribution lines caused by atmospheric discharges.**
  - It uses step function for atmospheric discharge current waveform. Their results are coherent with those obtained by field experiments.
- **However, some modifications are necessary in order to use this methodology to practical situations involved distribution system.**
  - Basically, it is necessary to consider current waveforms for the atmospheric discharge similar to those found in the nature.

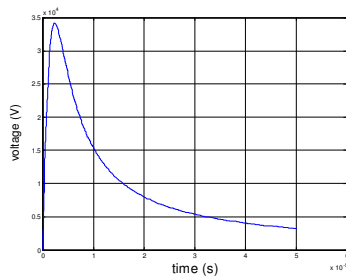


4

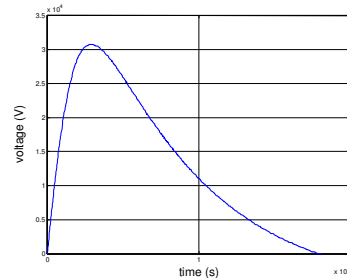
## Modified Rusck Model

### Practical Considerations

- Modified model employees atmospheric discharge modeling by double exponential, taking into account the rising time and current waveform peak time.



Conventional Rusck Model



Modified Rusck Model

5

## Expert System Aspects (I)

### Implementation Considerations

- Their implementation aspects are based on the modified Rusck model presented in previous slides.
- The expert system was developed in order to help in the arresters selection for equipments and distribution transformer protection.
- The protection designs consider the following aspects:
  - Induced voltages in distribution line;
  - Distribution network topology;
  - Atmospheric discharge characteristics of the region.

6

## Expert System Aspects (II) Simulation Results

- Each one of the system elements are adequately registered in the expert system.
- The 75kVA transformer registration window is shown in the figure to the side.

7

## Expert System Aspects (III) Simulation Results

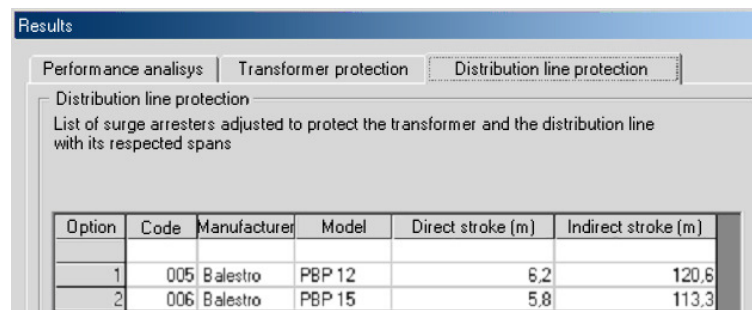
- After registration of each component, inclusively of the arresters, the protection design can be registered.
- The project registration window, as well as it emphasizes the simulation results are shown in the figure to the side.

8

## Expert System Aspects (IV)

### Simulation Results

- This figure presents the window where indicates how each selected arrester can be also employed for protection of distribution network nearby the transformer.



Results

Performance analysis | Transformer protection | **Distribution line protection**

Distribution line protection  
List of surge arresters adjusted to protect the transformer and the distribution line with its respected spans

Option	Code	Manufacturer	Model	Direct stroke (m)	Indirect stroke (m)
1	005	Balestro	PBP 12	6,2	120,6
2	006	Balestro	PBP 15	5,8	113,3

9

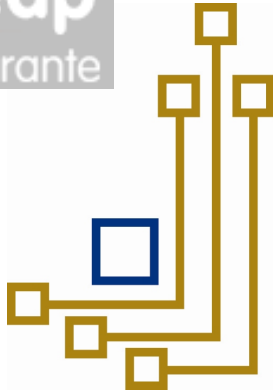
## Conclusions

- The modified Rusck model is valid to estimate induced voltages in overhead distribution lines, assuming a generic discharge current waveform.
  - The model also considers finite distribution line.
- The proposed expert system to help in the equipments and transformers protection specification, providing the following results:
  - The best protection to be adopted to transformers;
  - The best installation distance between arresters, aiming the full protection of the distribution line.
- Exhaustive evaluations indicate that the expert system contributes to optimize the processes related to the equipments and transformers protection.

10

Thanks!

---



11