DISTANCE PROTECTION OF MULTIPLE-CIRCUIT SHARED TOWER TRANSMISSION LINES WITH DIFFERENT VOLTAGES

RESEARCH PRESENTATION

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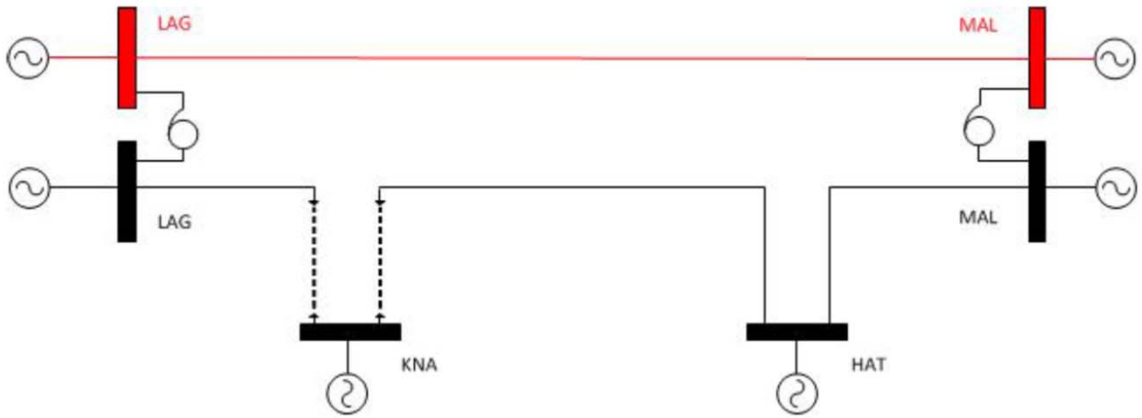
Introduction

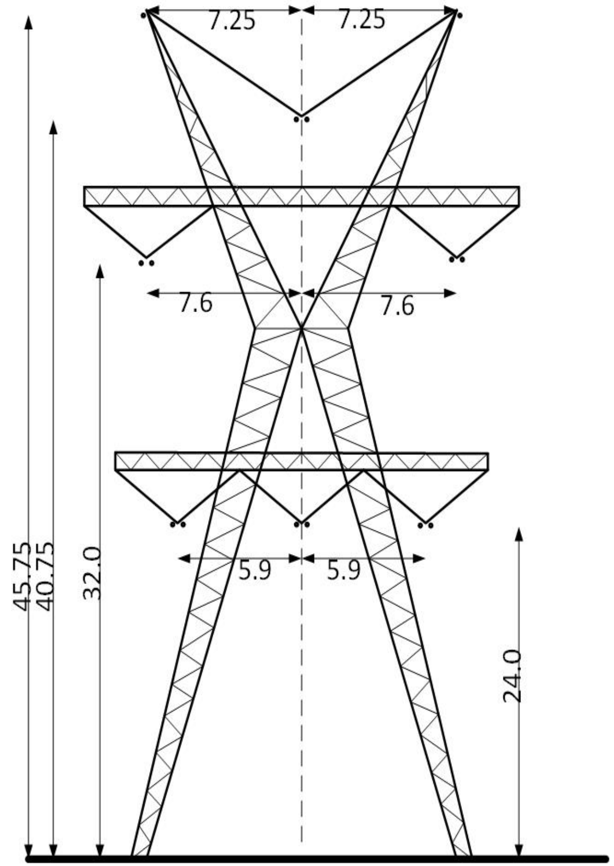
Multiple-circuit transmission lines combining different voltage levels in one tower

Faults between voltage levels are possible

A simple relation between fault loop impedance and line parameters no longer exist

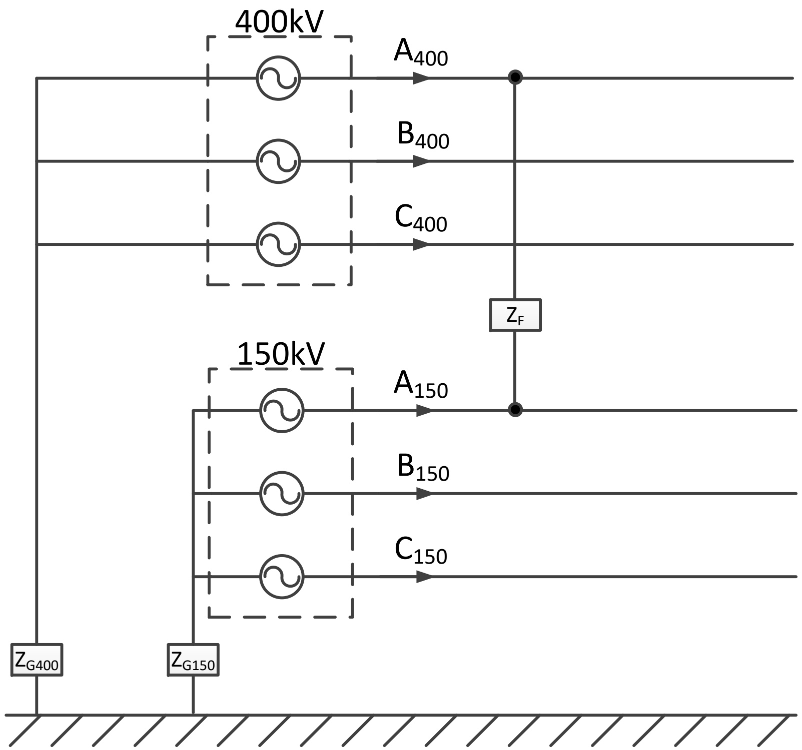
Extra challenges exist to set a protection philosophy, using distance protection

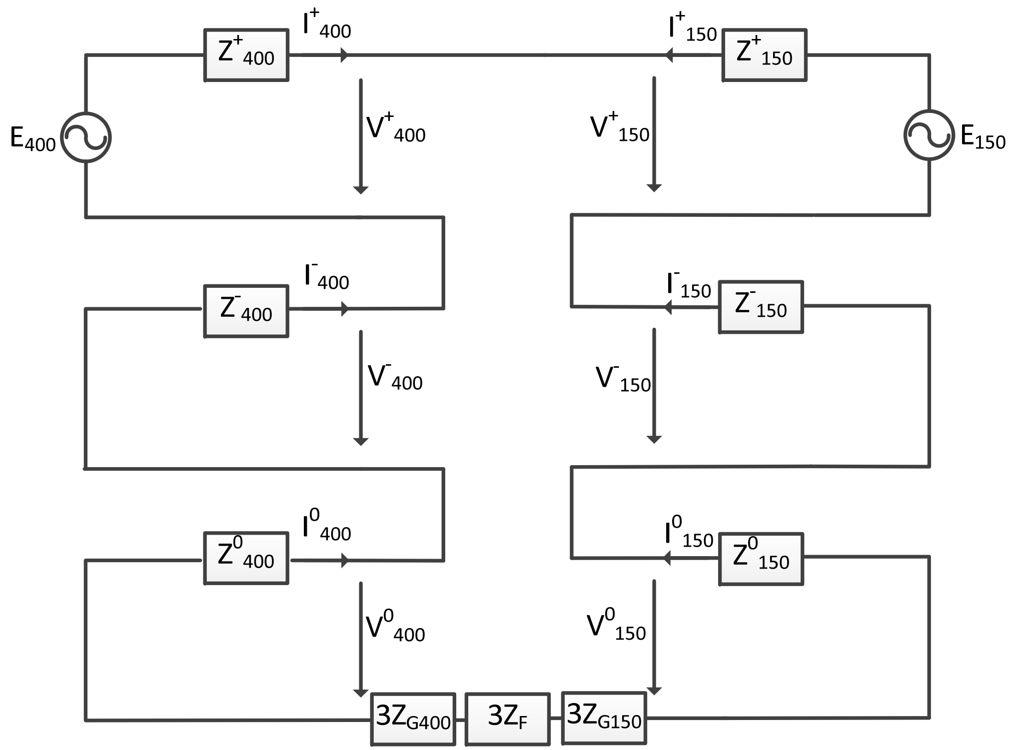




Theoretical Analysis

Symmetrical components are used to design an equivalent system





Comparison of simplified model with simulations

Fault current seen by the relay closest to the fault

	Case A1	Case A2	Case B1	Case B2	Case C1	Case C2
Calculation [kA]	21.9	52.3	20.5	48.0	10.1	21.7
Simulation [kA]	21.5	51.1	19.9	46.6	10.0	21.8

Fault current seen by the relay in the far end of the line

	Case A1	Case A2	Case B1	Case B2	Case C1	Case C2
Calculation [kA]	1.8	3.7	1.8	3.7	1.7	3.6
Simulation [kA]	2.3	5.7	2.2	5.2	2.1	4.7

Case A: Ideal source grounding and solid fault;
Case B: Ideal source grounding and 2Ω fault impedance;
Case C: Source grounding impedance of 5Ω and 2Ω fault impedance;

Proposed philosophy

The theoretical development demonstrated that if the higher voltage level leads the lower voltage level, the fault current flows in the forward direction for the former, whereas the latter sees the fault current flowing in the reverse direction

The opposite happens if the higher voltage level lags the lower voltage level

The distance protection relays of one of the voltage levels sees always the fault in the forward direction

Question: But will the fault impedance be inside of the protection zone?

Impact on the fault impedance

A theoretical comparison is made comparing changes in the fault impedance for combined faults and single-phase-to-ground (SPRG) faults

The fault impedance shifts 30º and the fault magnitude is maintained for strong network

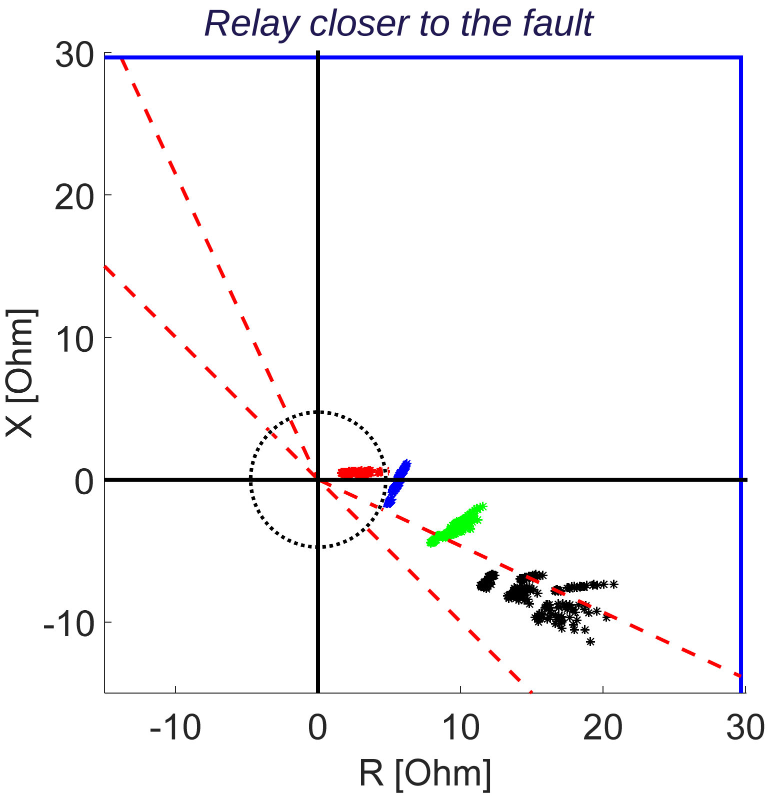
Large variations in both phase and magnitude exist for weaker networks and the fault may even be seen as capacitive

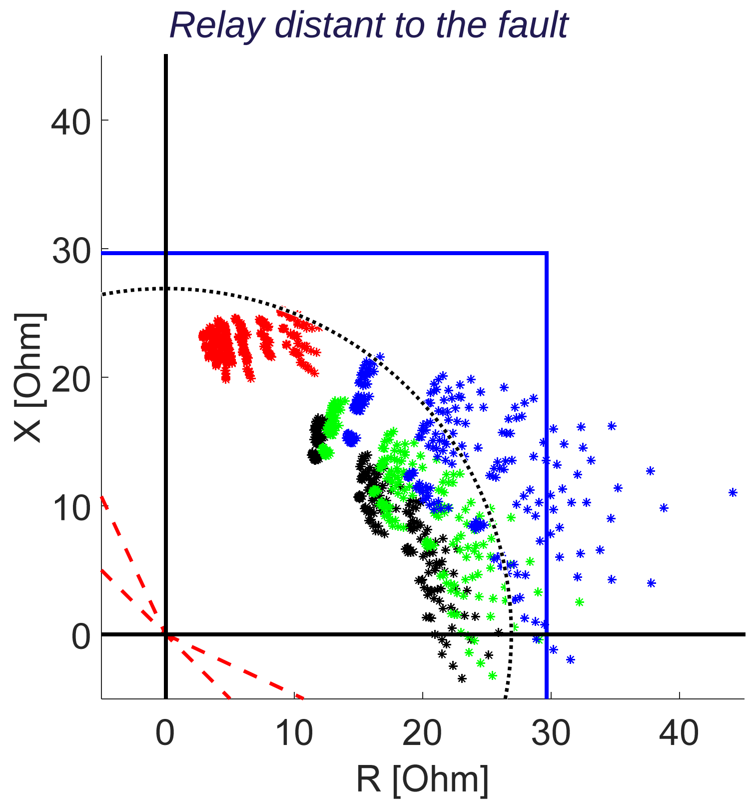
It is demonstrated that if the higher voltage level relays are the ones to operate no substantial problem exists, the same is not true if the lower voltage level relays are expected to operated

Impact on the fault impedance

Fault impedances seen by the relays for different short-circuit for a fault at 1% of the line

Higher voltage level relays should operate in this case

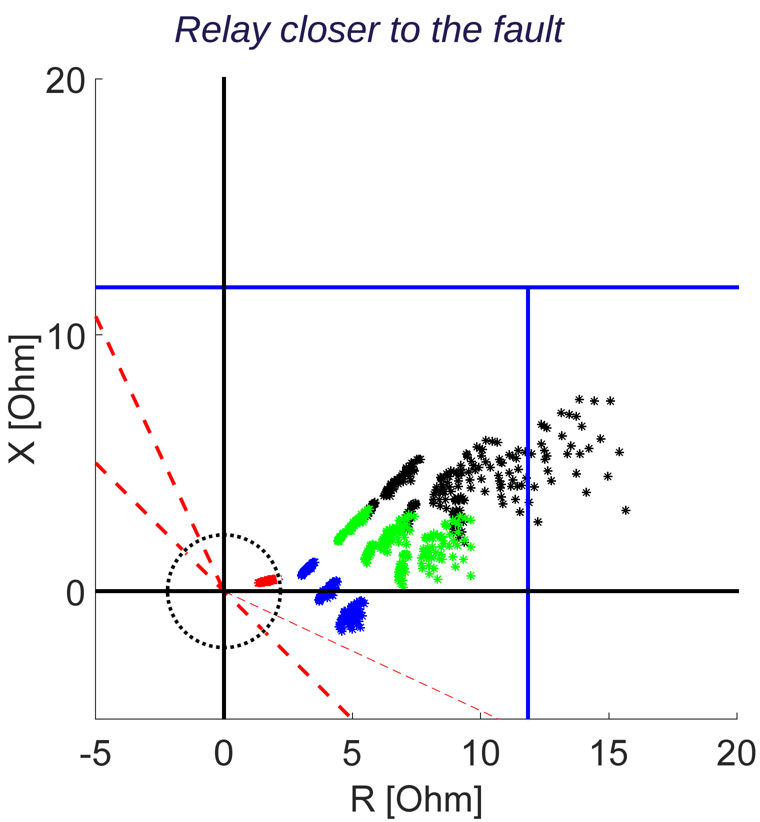


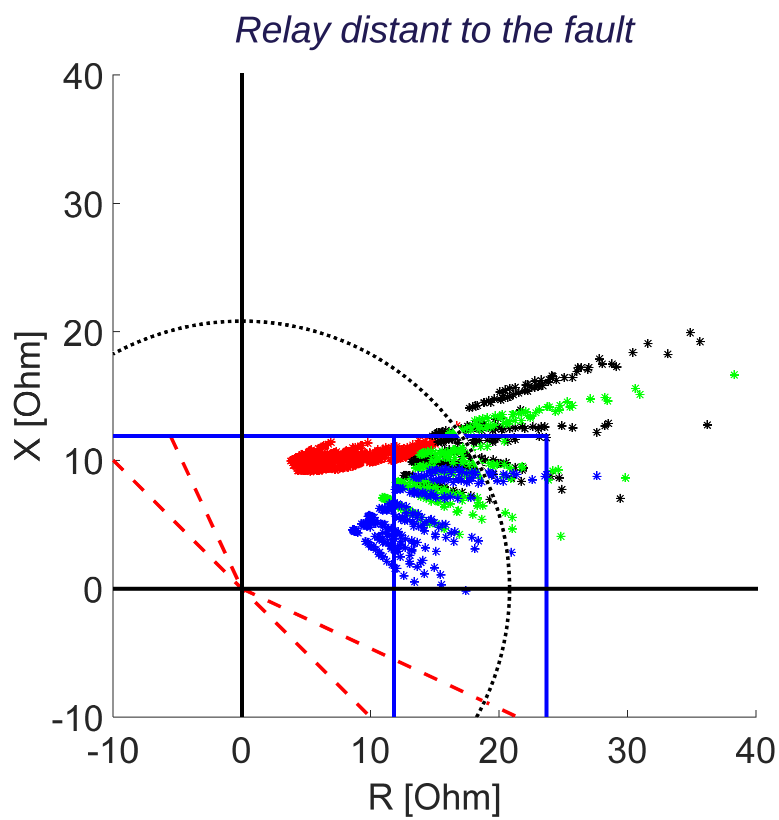


Impact on the fault impedance

Fault impedances seen by the relays for different short-circuit for a fault at 1% of the line

Lower voltage level relays should operate in this case





Conclusions

The settings used to protect line against SPTG faults also protected the line against combined voltage faults

However, one has to assure that the higher voltage level leads the lower voltage level

In other words, a small precaution saves a lot of problems later