

DIRECTIONAL COMPARISON PROTECTION FOR LINES, BUSES, AND TRANSFORMERS

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DIRECTIONAL COMPARISON PROTECTION FOR LINES, BUSES, AND TRANSFORMERS

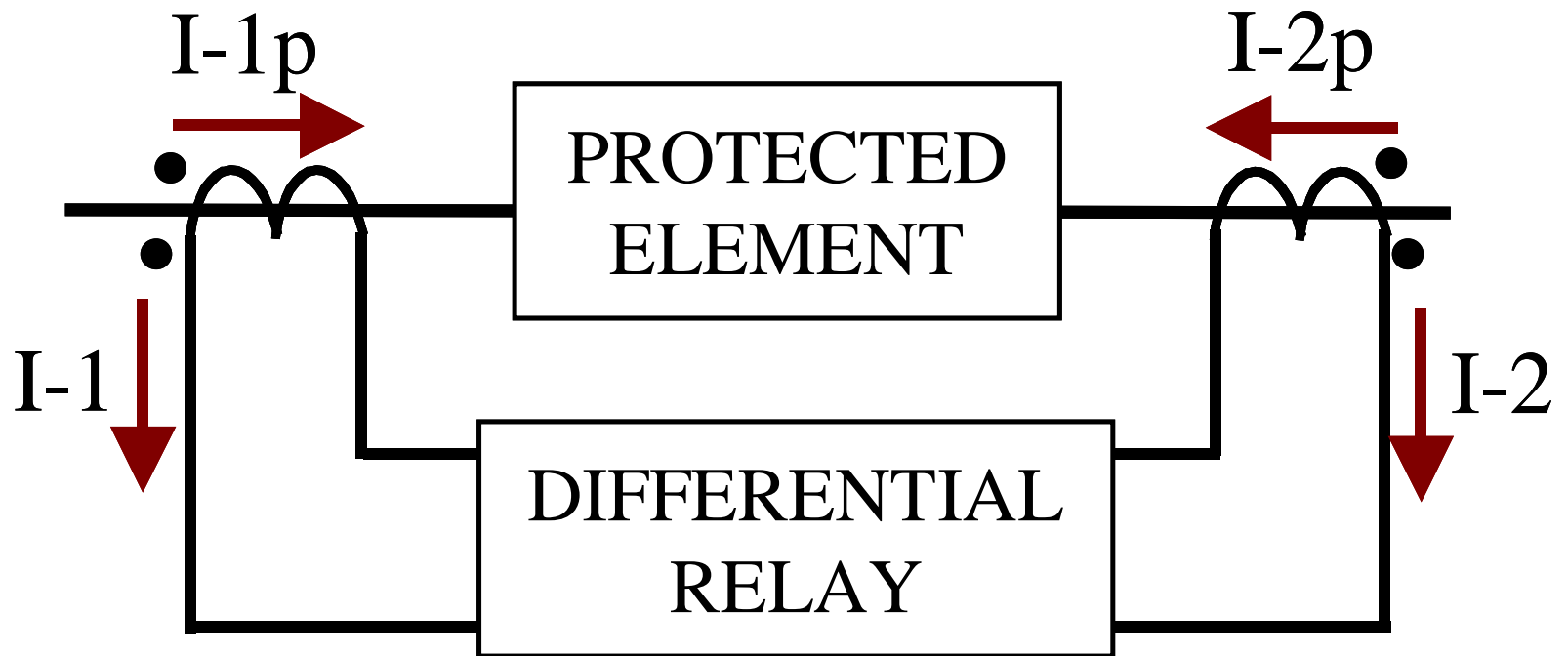
Paper Outline

Differential Review

Directional Comparison

Simulation Results

DIFFERENTIAL FUNCTION



DIFFERENTIAL PARAMETERS

Differential Current

$$|I_{DIF}| = |I-1 + I-2|$$

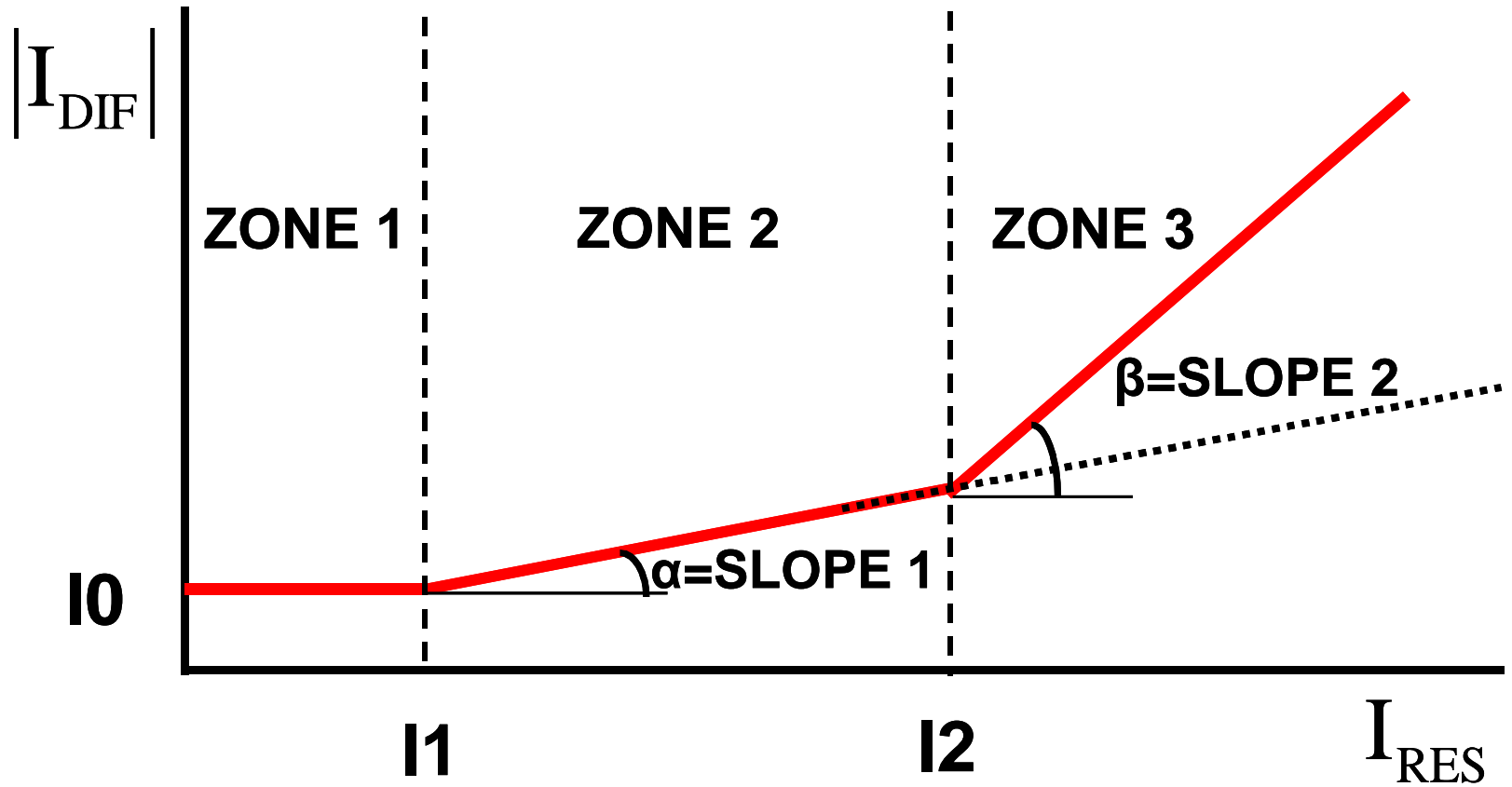
Restraint Current

$$I_{RES} = |I-1| + |I-2|$$

$$I_{RES} = (|I-1| + |I-2|) / 2$$

$$I_{RES} = (|I-1| + |I-2| - |I_{DIF}|) / 2$$

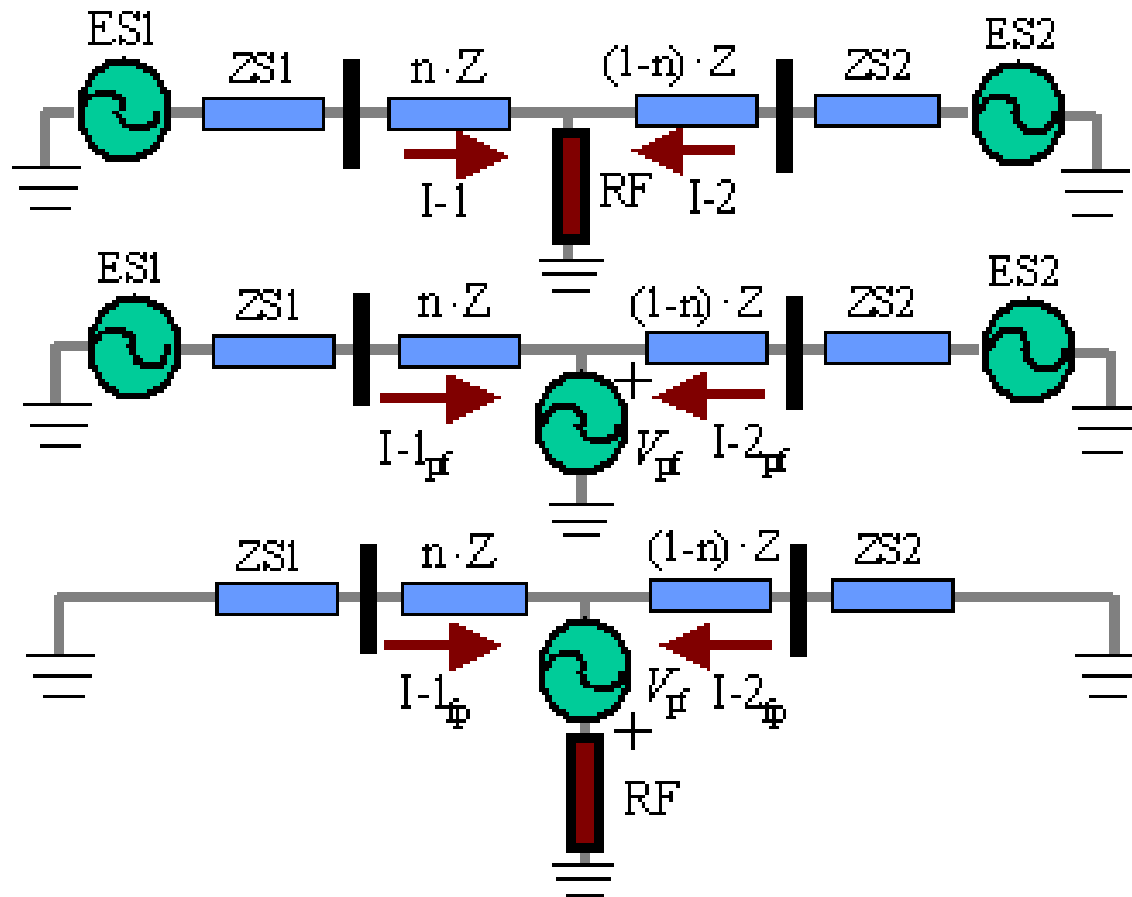
DIFFERENTIAL CHARACTERISTIC



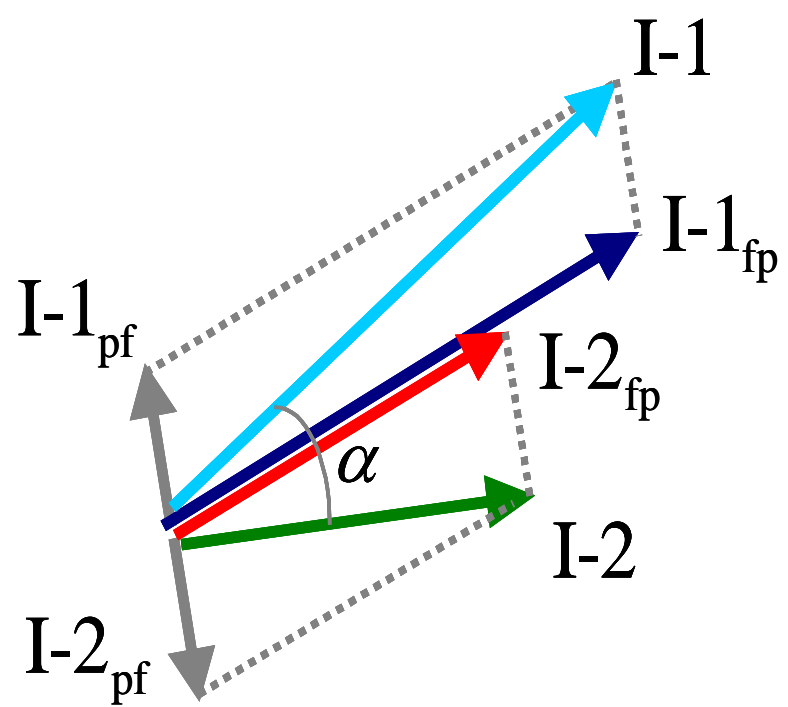
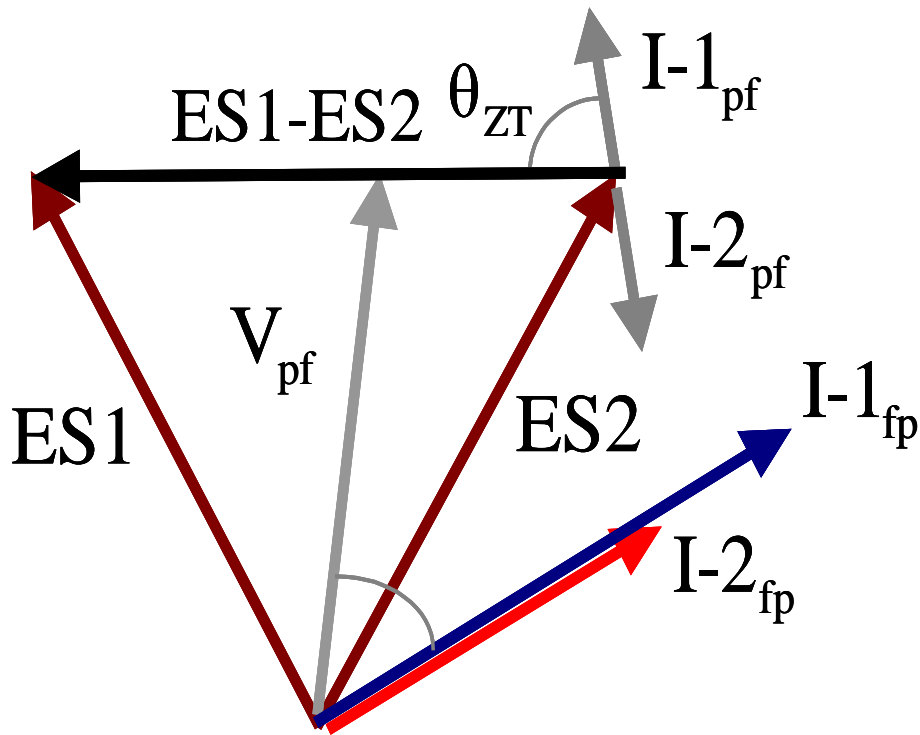
Factors Influencing the Location of IDIF, IRES

- External Faults
 - External Errors
 - CT Saturation
- Internal Faults
 - Load Influence
 - CT Saturation

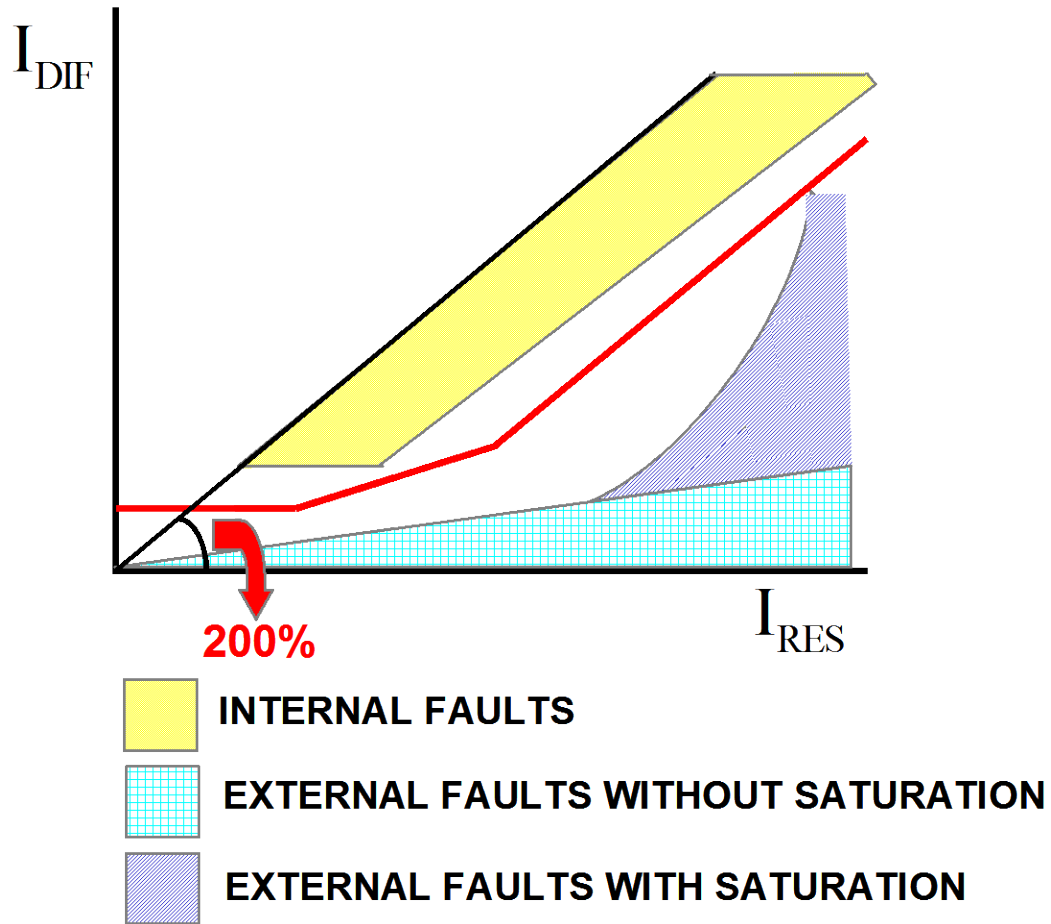
FAULT CIRCUITS



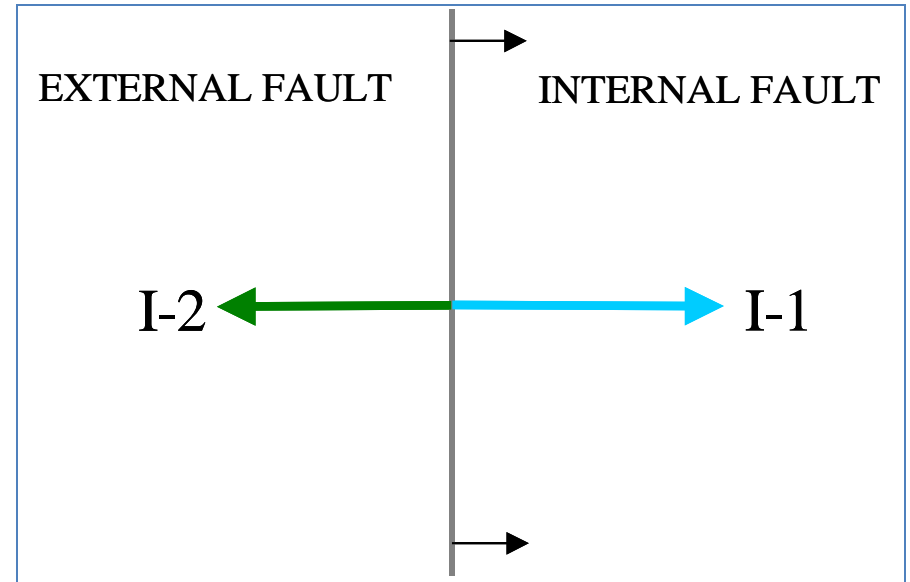
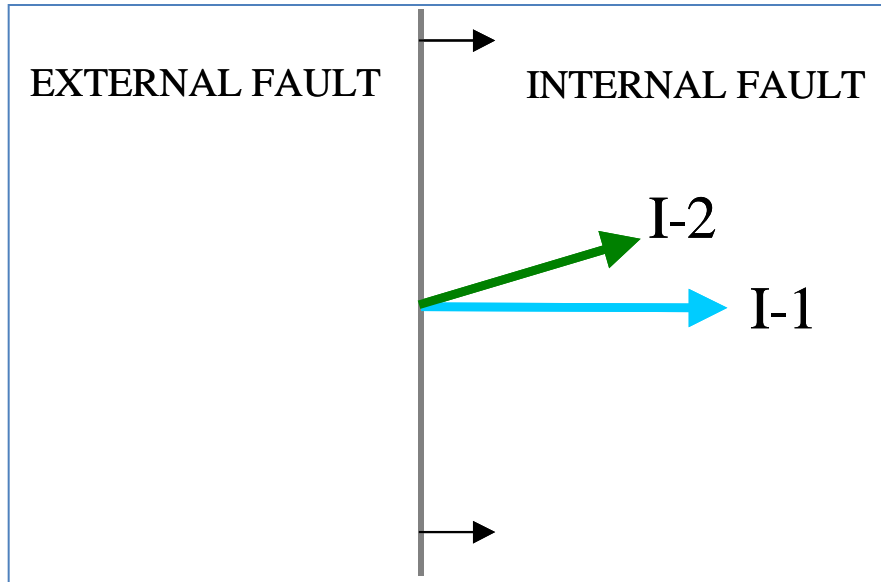
PHASOR DIAGRAMS



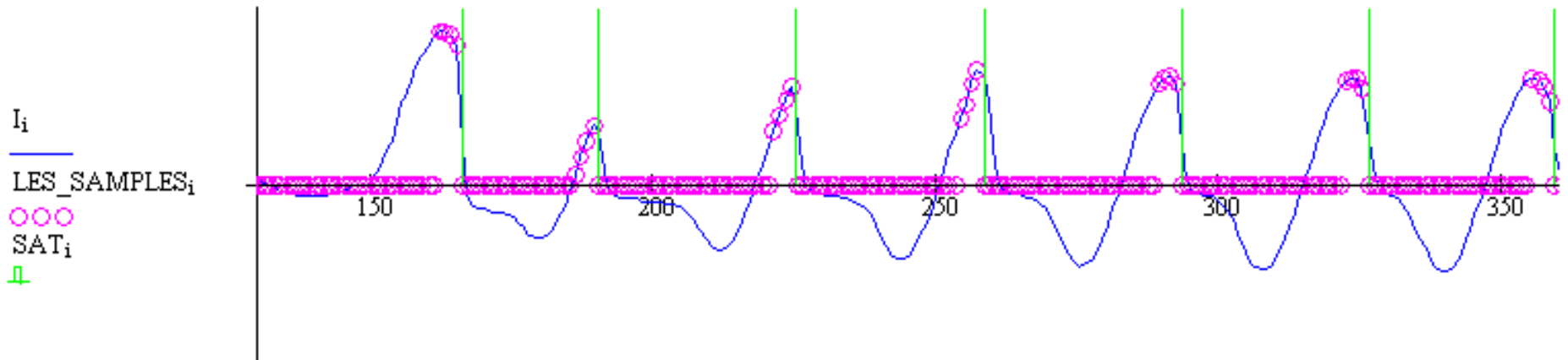
LOCATIONS OF I_{DIF} , I_{RES}



DIRECTIONAL CRITERIA

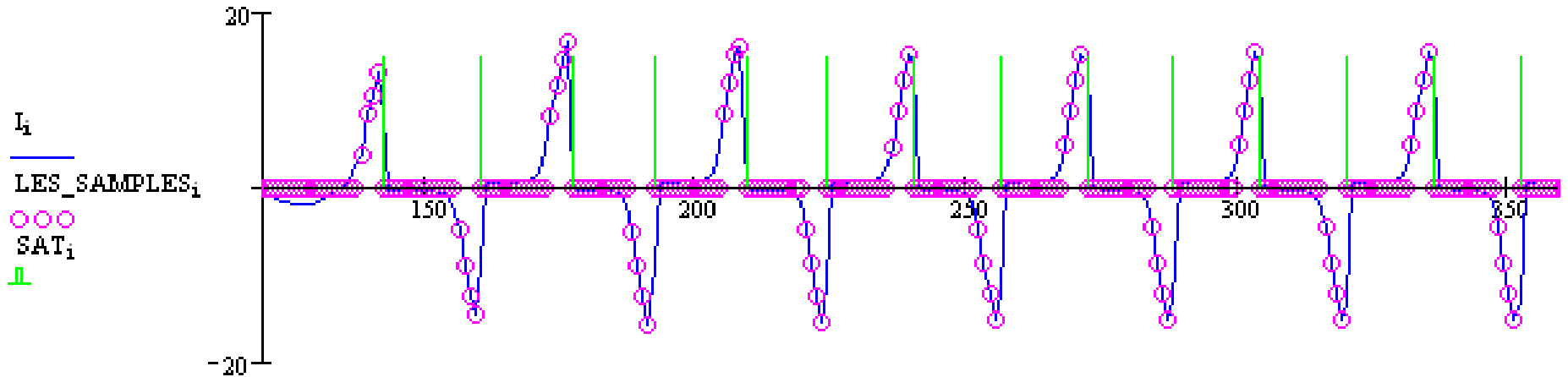


FAULT WITH CT SATURATION



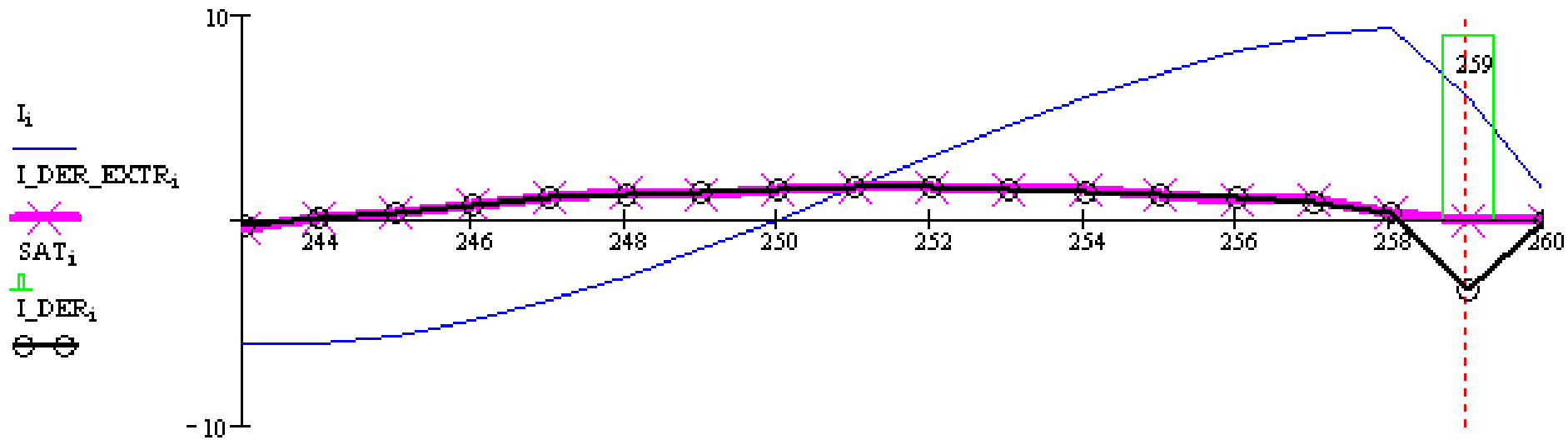
Current I , samples taken for phasor estimation by least squares method, and saturation detection signal for fault with DC offset

FAULT WITH CT SATURATION



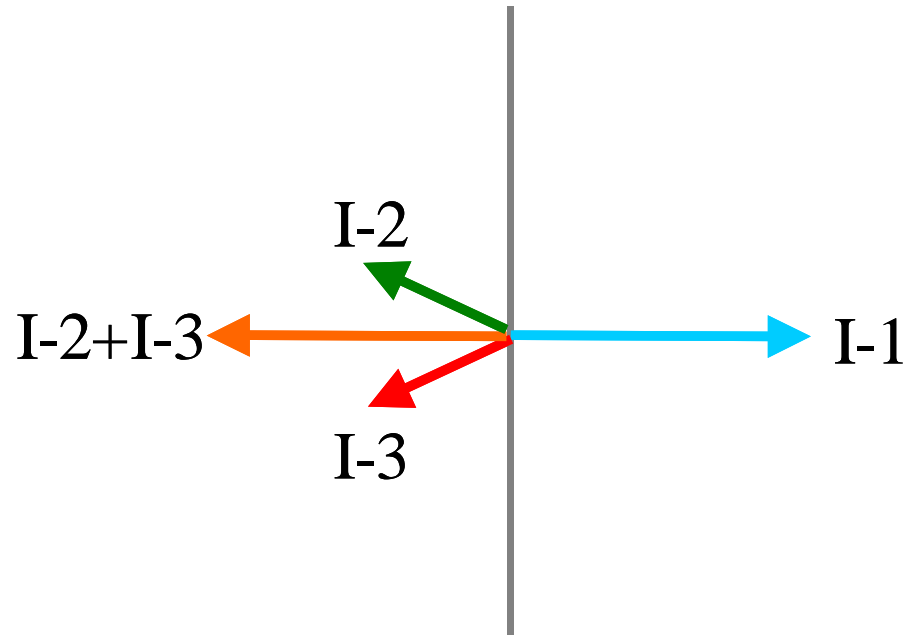
Current I , samples taken for phasor estimation by least squares method, and saturation detection signal for fault without DC offset

FAULT WITH CT SATURATION



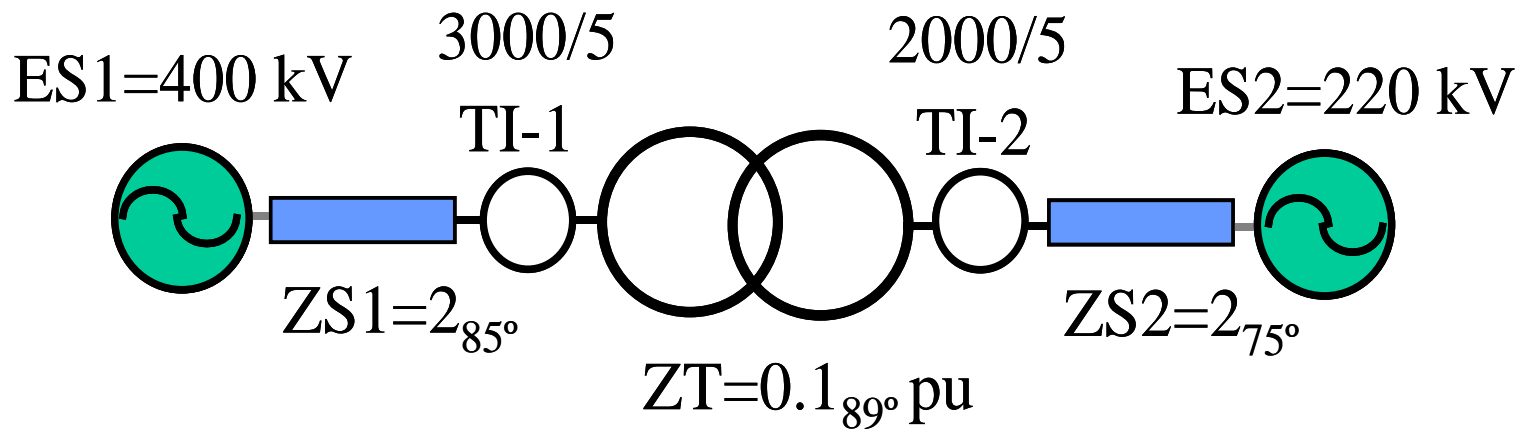
Current I , current derivative, extrapolated current derivative, and saturation detection for fault with offset

DIRECTIONAL CRITERIA

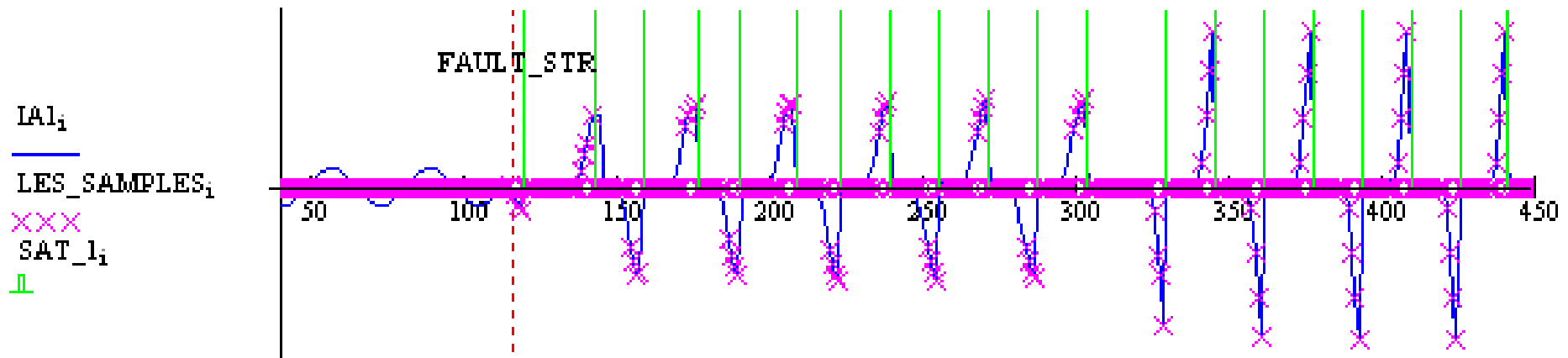


External Fault for Three Terminal Element

SIMULATION MODEL

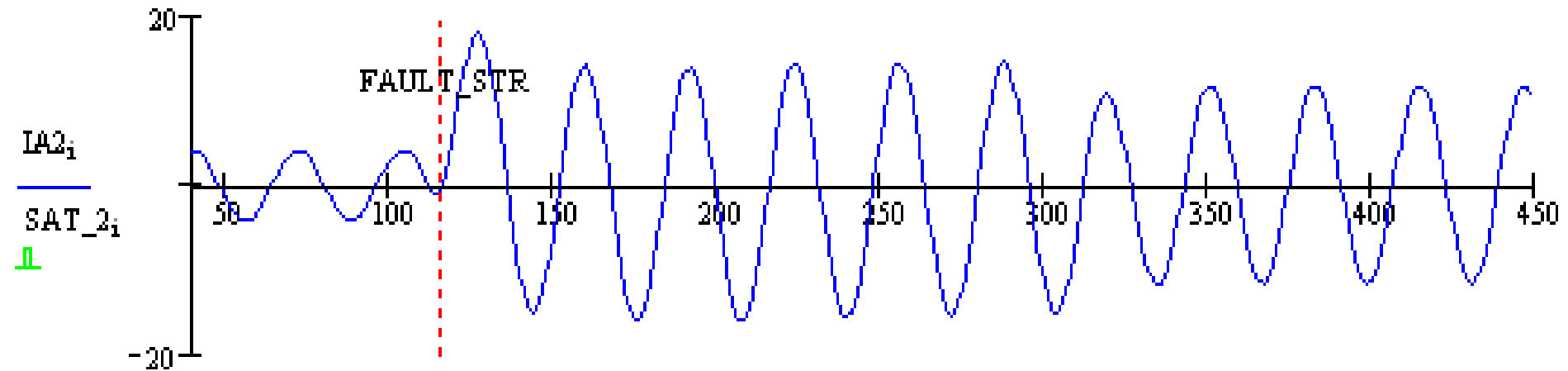


EXTERNAL FAULT AG EVOLVING TO INTERNAL FAULT



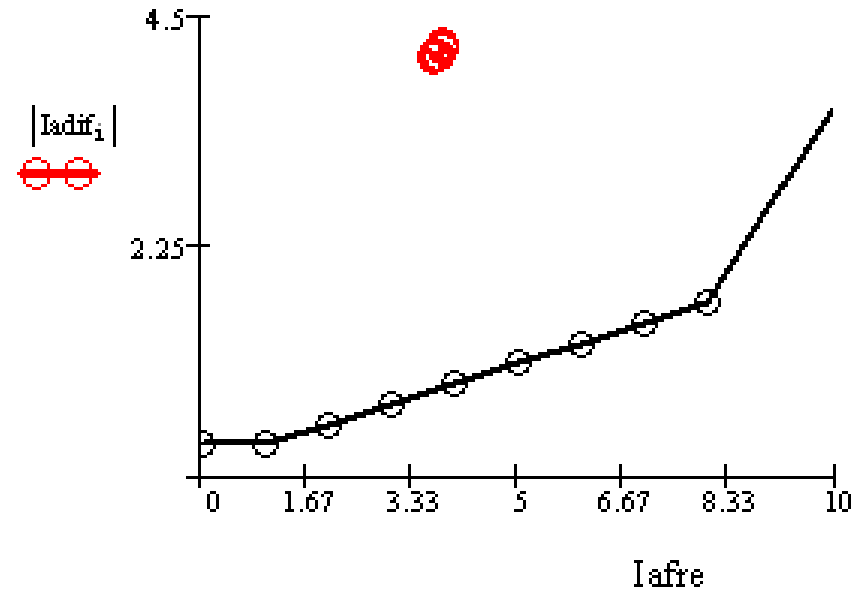
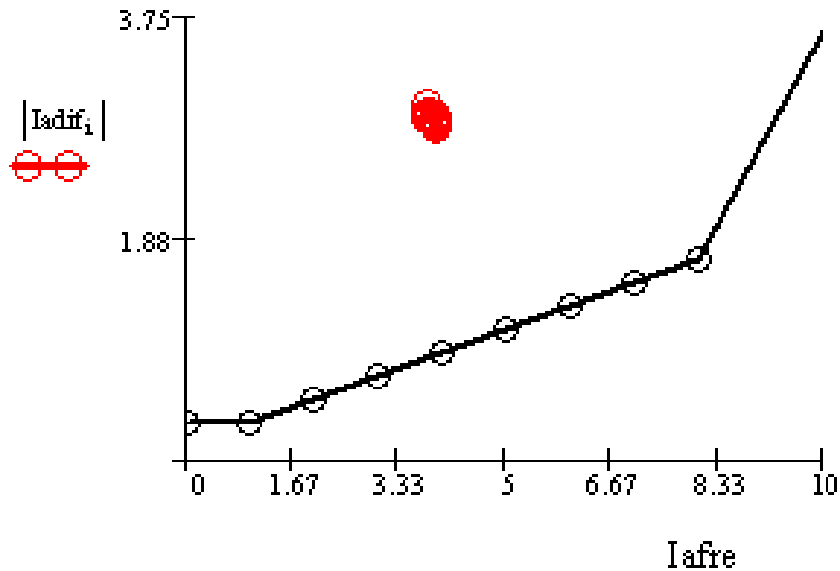
Current IA-1, samples taken for phasor estimation by least squares method, and saturation detection signal

EXTERNAL FAULT AG EVOLVING TO INTERNAL FAULT



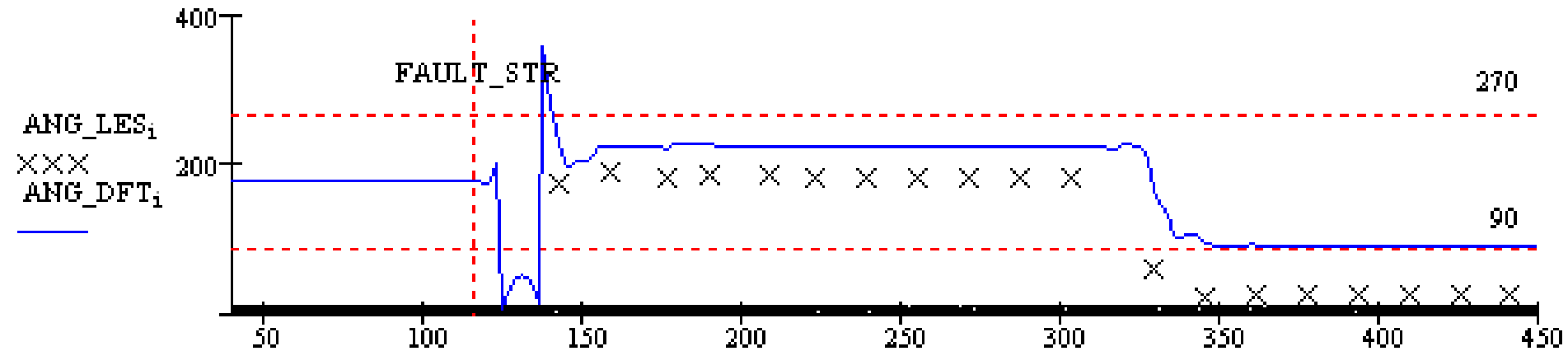
Current IA-2 and saturation detection signal

EXTERNAL FAULT AG EVOLVING TO INTERNAL FAULT



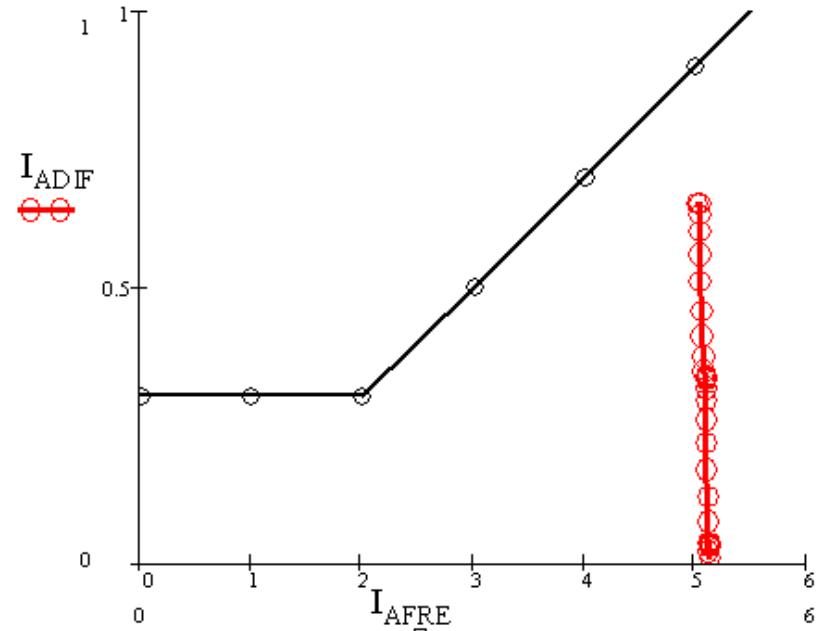
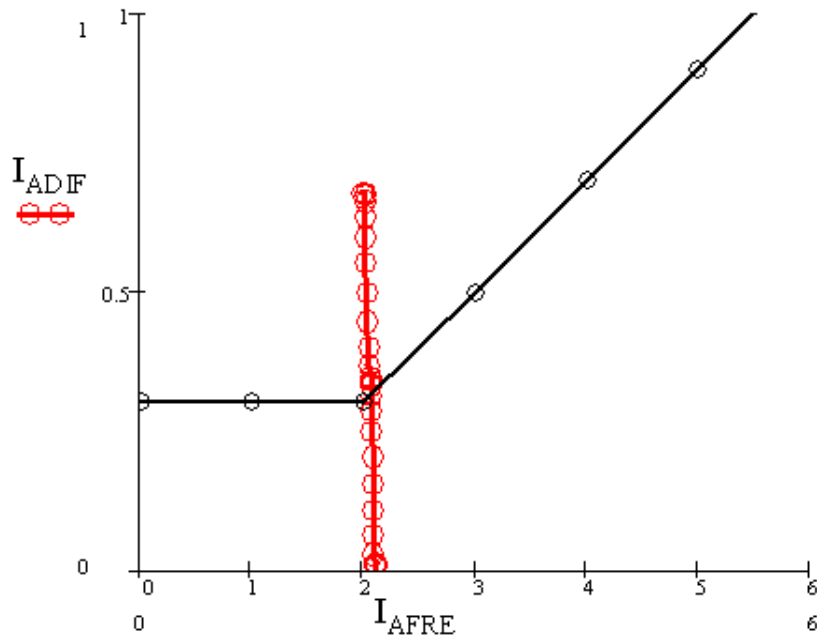
Point (I_{DIF}, I_{RES}) in relation to the differential characteristic

EXTERNAL FAULT AG EVOLVING TO INTERNAL FAULT



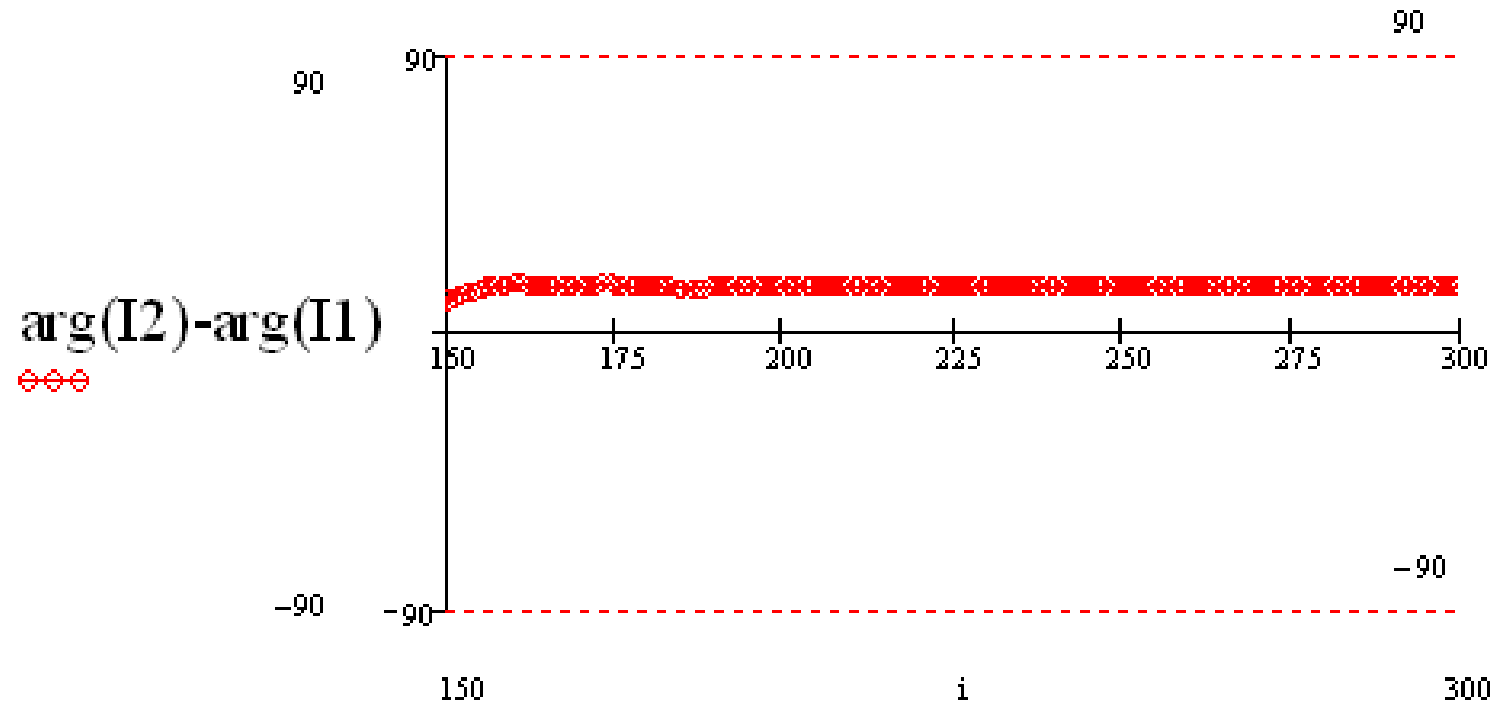
Phase difference between IA-1 and IA-2
measured by the least squares method and by
DFT

FAULTS WITH OUTFEED



Point (I_{DIF} , I_{RES}) in relation to the differential characteristic

FAULTS WITH OUTFEED



Phase difference between
pure fault I1-1 and I1-2

CONCLUSIONS

- Increased Security and dependability
- Usage of Pure Fault Currents
 - Eliminate load influence
 - Higher sensitivity for faults with outfeed
- Usage of Phase Currents
 - Determine directionality with CT saturation
- One-cycle DTF plus Least Squares
 - Reduces CT saturation influence