CURRENT TRANSFORMER SATURATION AND ITS IMPLICATION IN DIFFERENTIAL SCHEMES PROTECTION - DETECTION AND TRIP DECISION USING WAVELET TRANSFORM AND ARTIFICIAL NEURAL NETWORK

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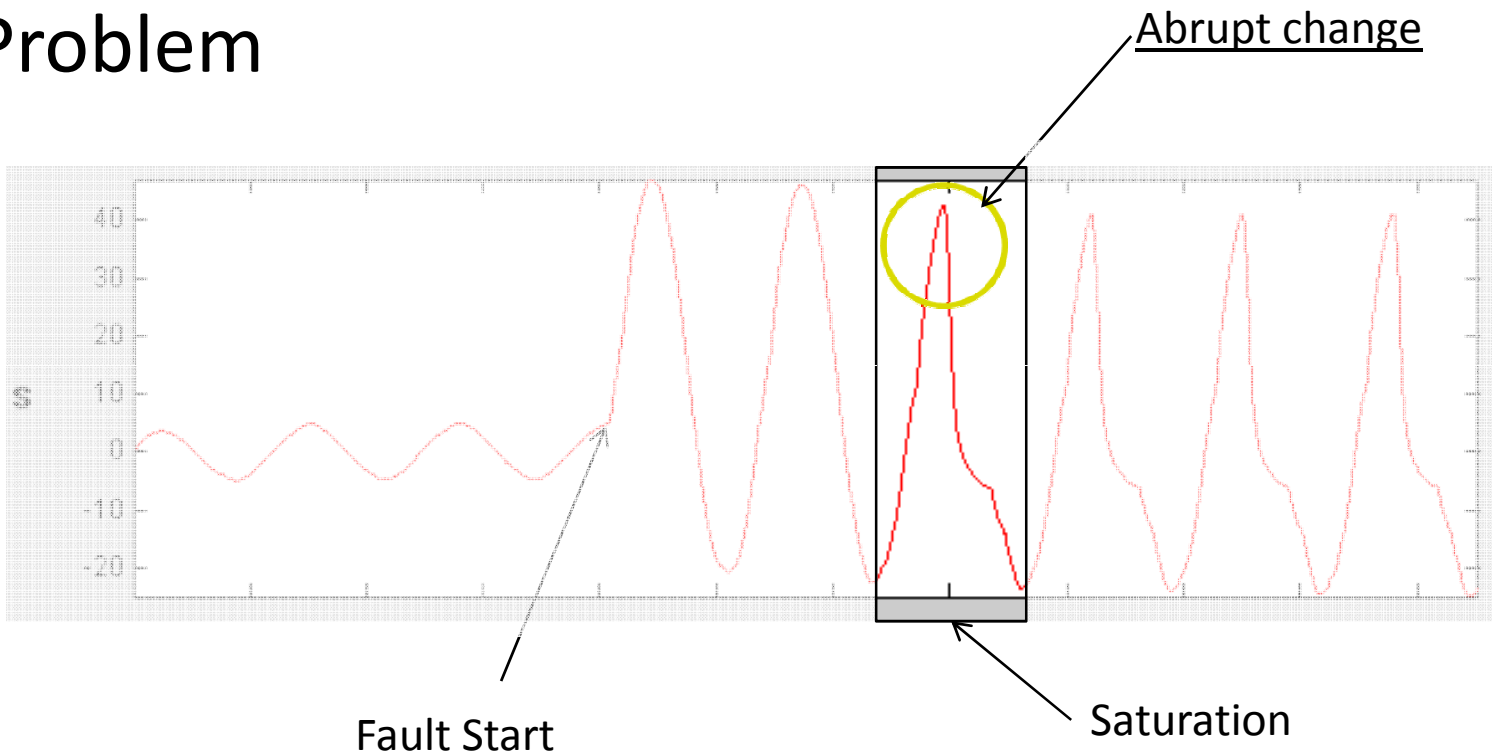
Goals

- Saturation Identification
- Fault Location in relation to the protected object (Internal or external fault)
- Trip Decision

1/4 cycle window

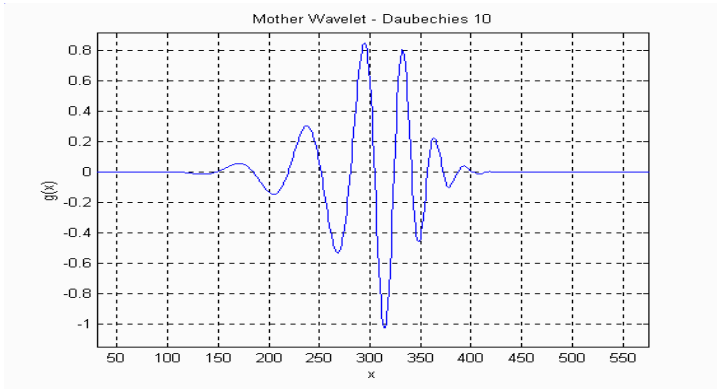
Problem



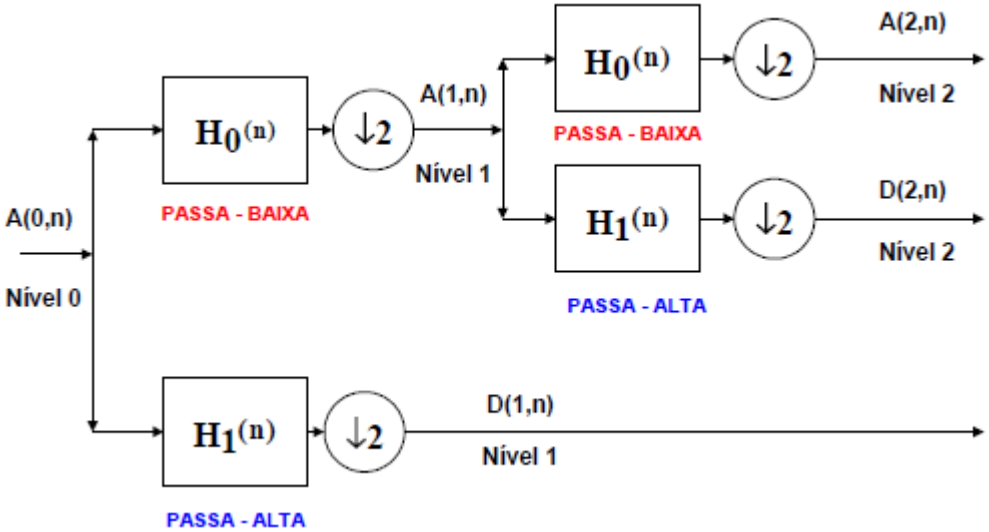
Theoric Basis

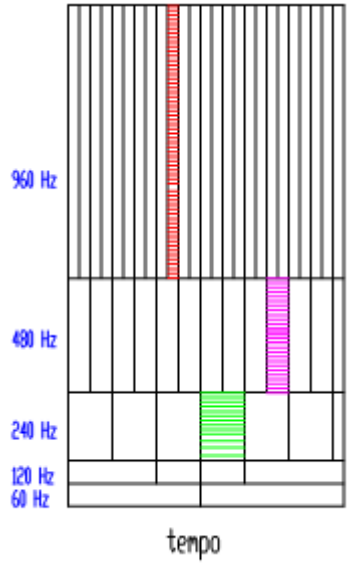
Discrete Wavelet Transform

$$W_g f(m,n) = \frac{1}{\sqrt{a_0^m}} \cdot \sum_{k=-\infty}^{+\infty} f(k) \cdot g\left(\frac{k - n.a_0^m.b_0}{a_0^m}\right)$$



Piramidal MRA Algoritm

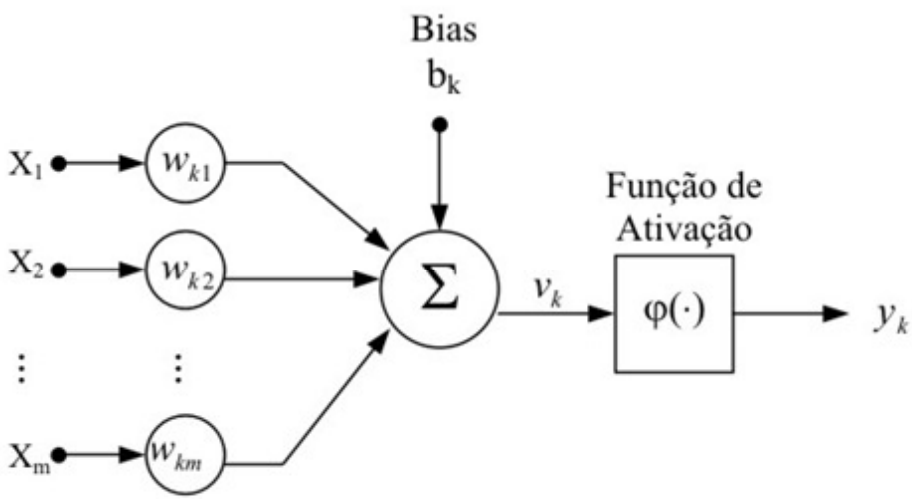




Theoric Basis

Artificial Neural Network

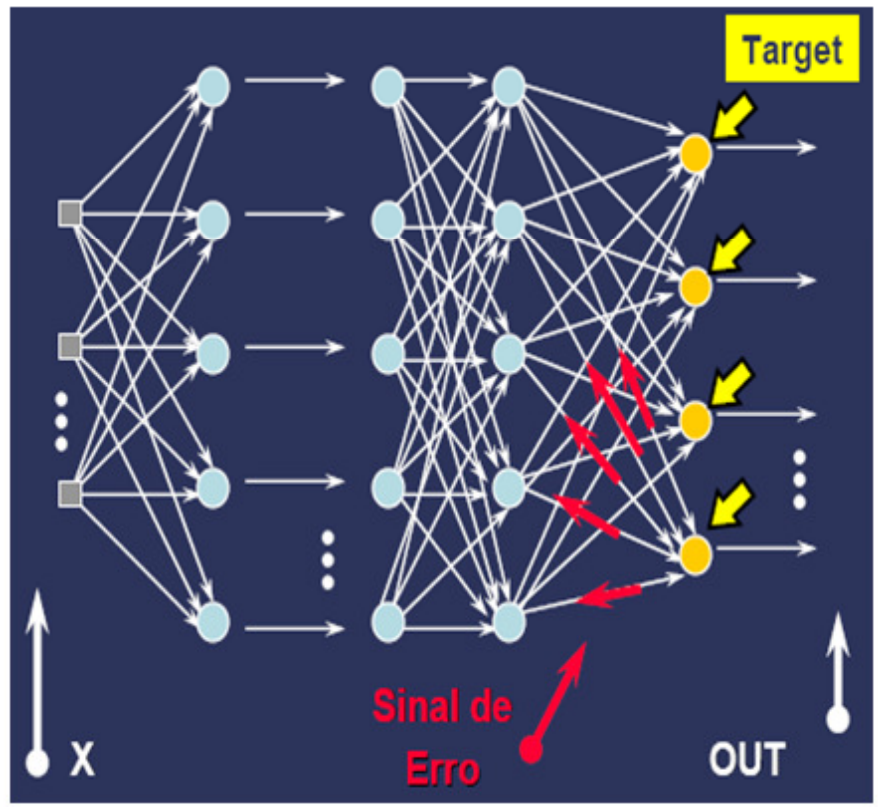
McCulloch & Pitts Model



$$v_k = \sum_{j=1}^{m} w_{kj} x_j + b_k$$

$$y_k = \varphi(v_k)$$

The MLP and the Backpropagation



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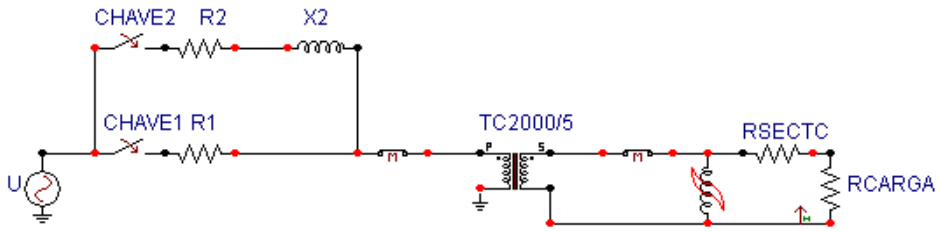
Simulation

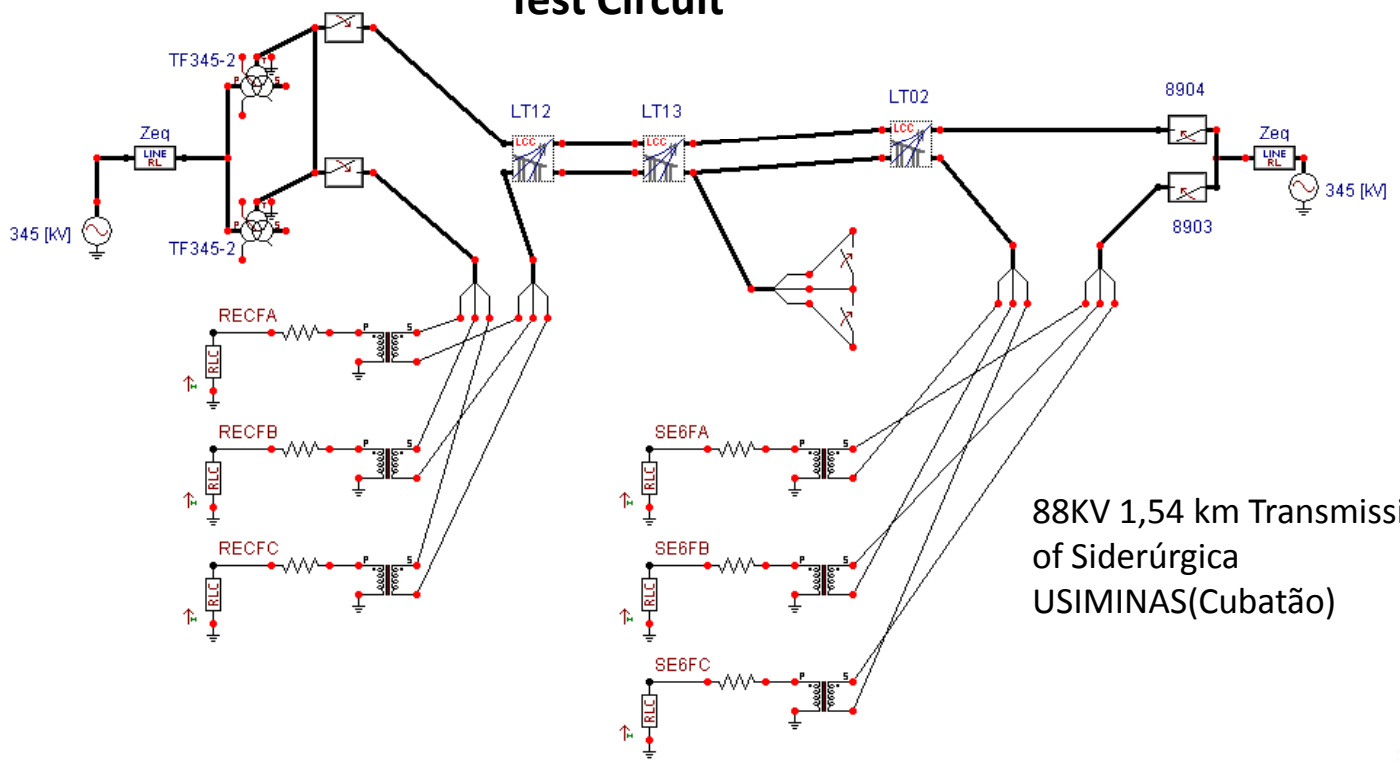
Training Circuit



R1 – Change the Steady State Current

X2/R2 – Changes fault current also the DC component

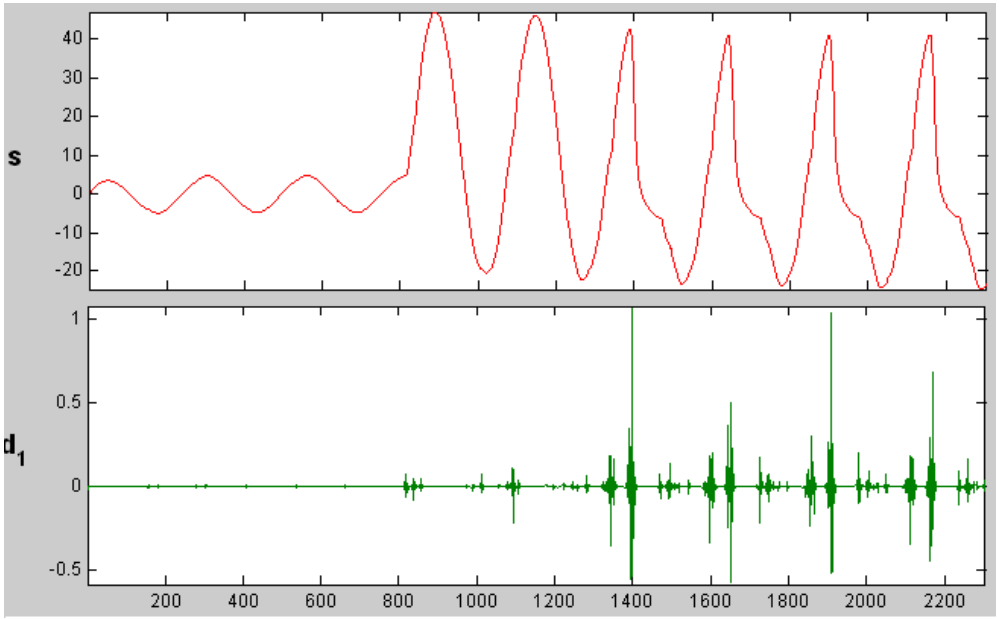
Test Circuit

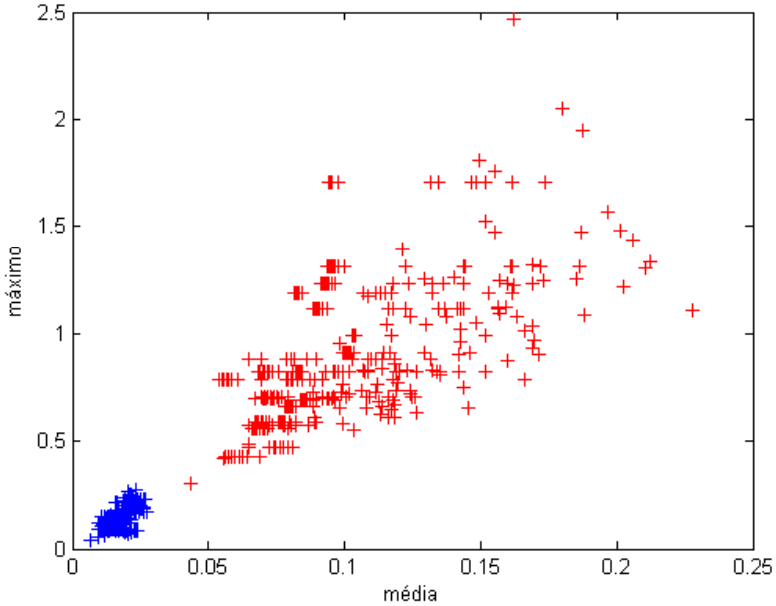


88KV 1,54 km Transmission Line of Siderúrgica USIMINAS(Cubatão)

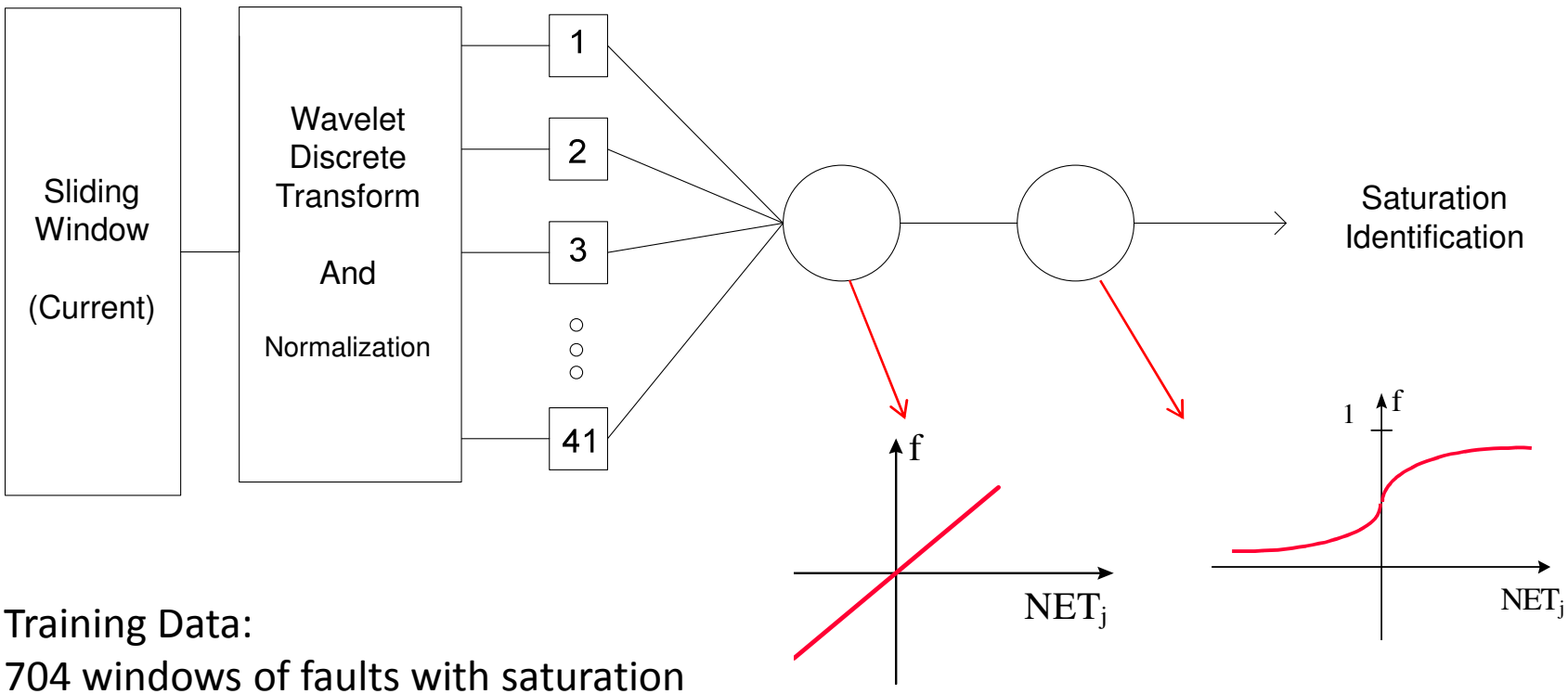
Data Generation

Discrete Wavelet Transform





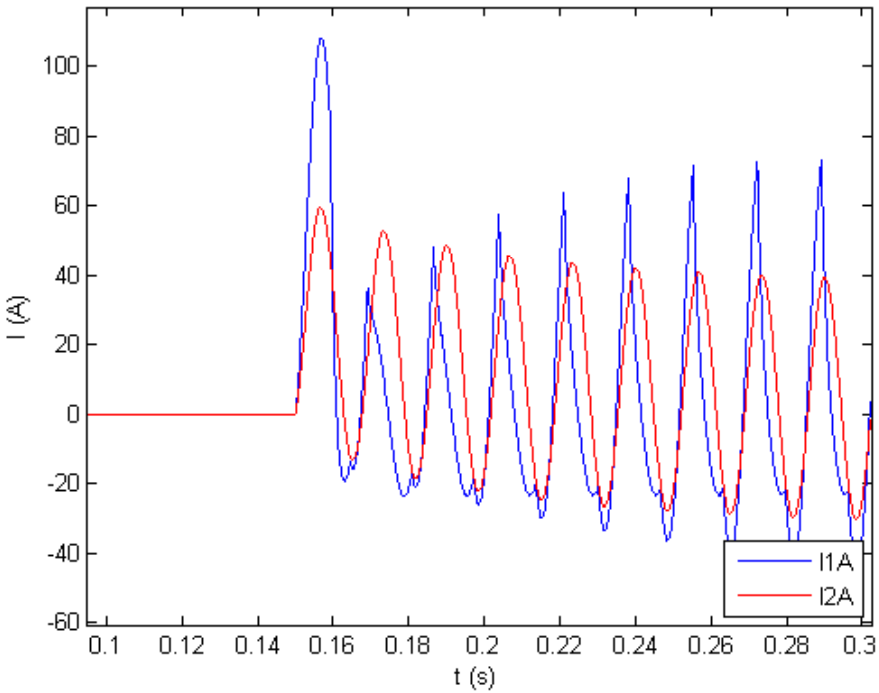
Neural Network Modeling and Training



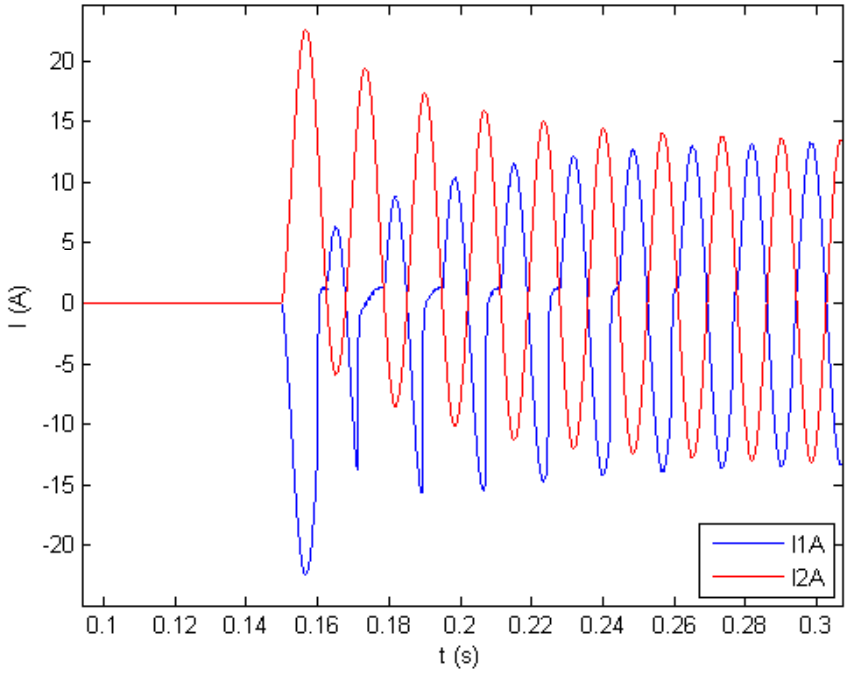
Training Data:
704 windows of faults with saturation
704 windows of normal faults

Fault Location

- Comparison sample to sample from each window of a quarter cycle;
- If more than 70% of the window (45 samples) the signals have the same polarity, the fault is an internal fault.

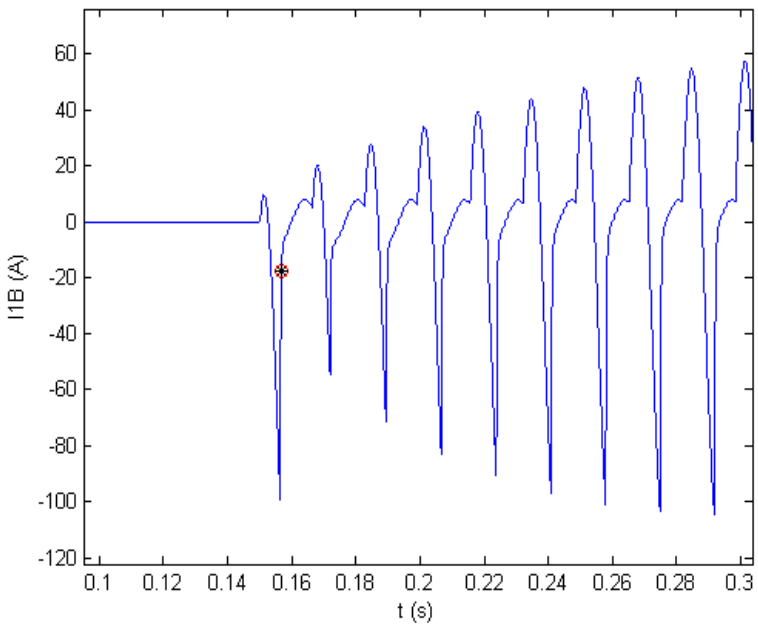


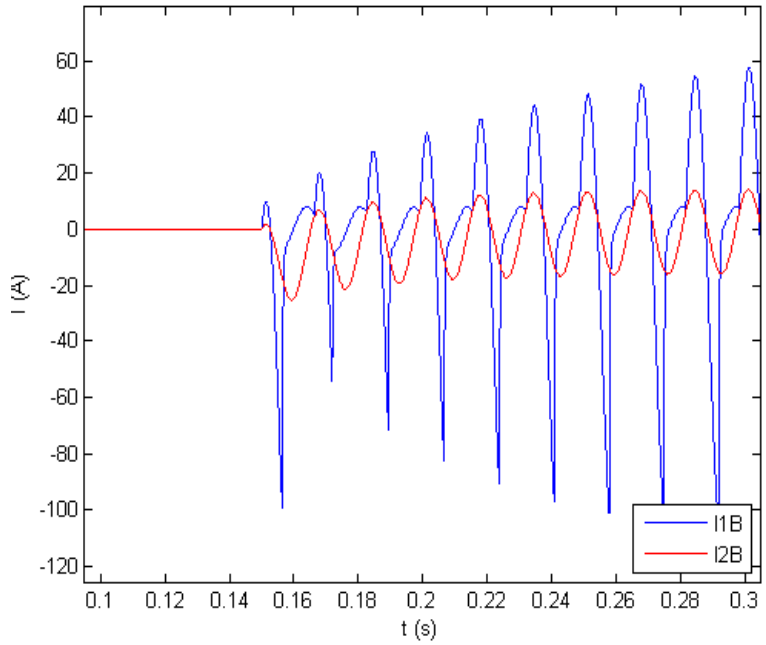
Internal Fault
(Current in phase)



External Fault
(Current 180° shifted)

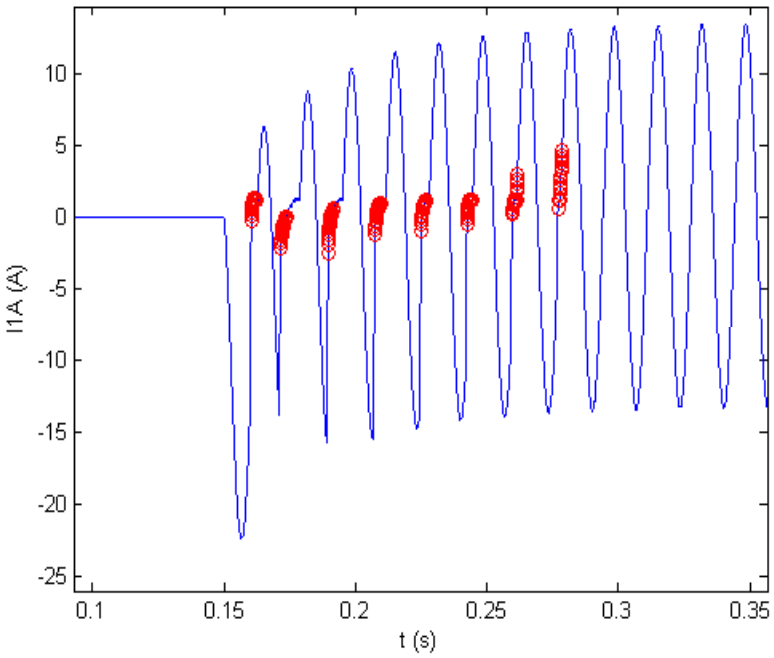
Results

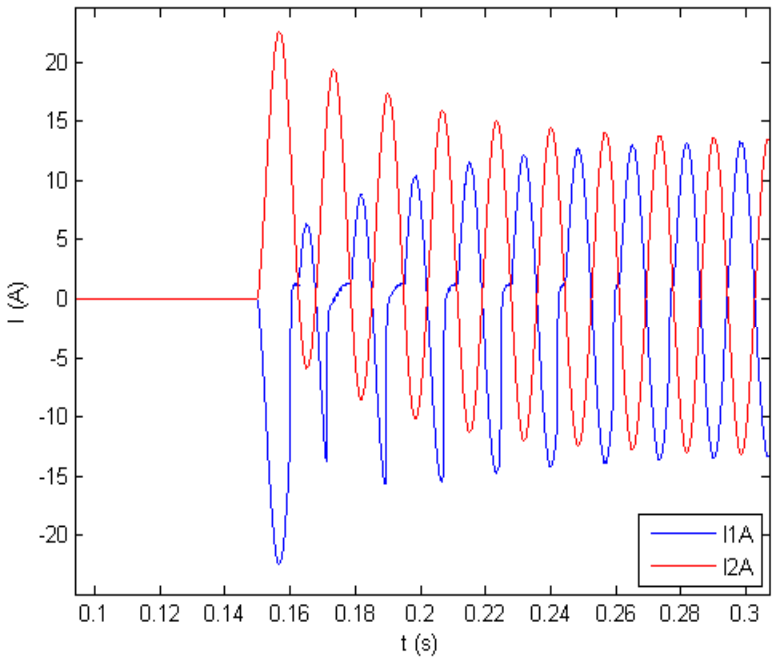




1ϕ Internal Fault

Results





3ϕ External Fault

Conclusions

Was Presented:

- Methodology for Identification of Saturation of Current Transformers
  - Discrete Wavelet Transform has proven effective in the discrimination of normal fault with and without CT saturation;
  - This enables a more sensitive set of differential protection.
- Fault location criterion
  - Was effective for the cases presented
- Trip Decision

1/4 Cycle Window

Future Works:

- Generate a greater number of tests
- Variation of some system parameters such as:
  - Angle of fault;
  - Fault resistance;
  - DC level of the fault current;
  - CT residual flow;
  - Source impedance of the system.