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Factors Affecting on the Next Generation Protection on Smart Grid based on Wi-Fi Wireless Technology

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Outline

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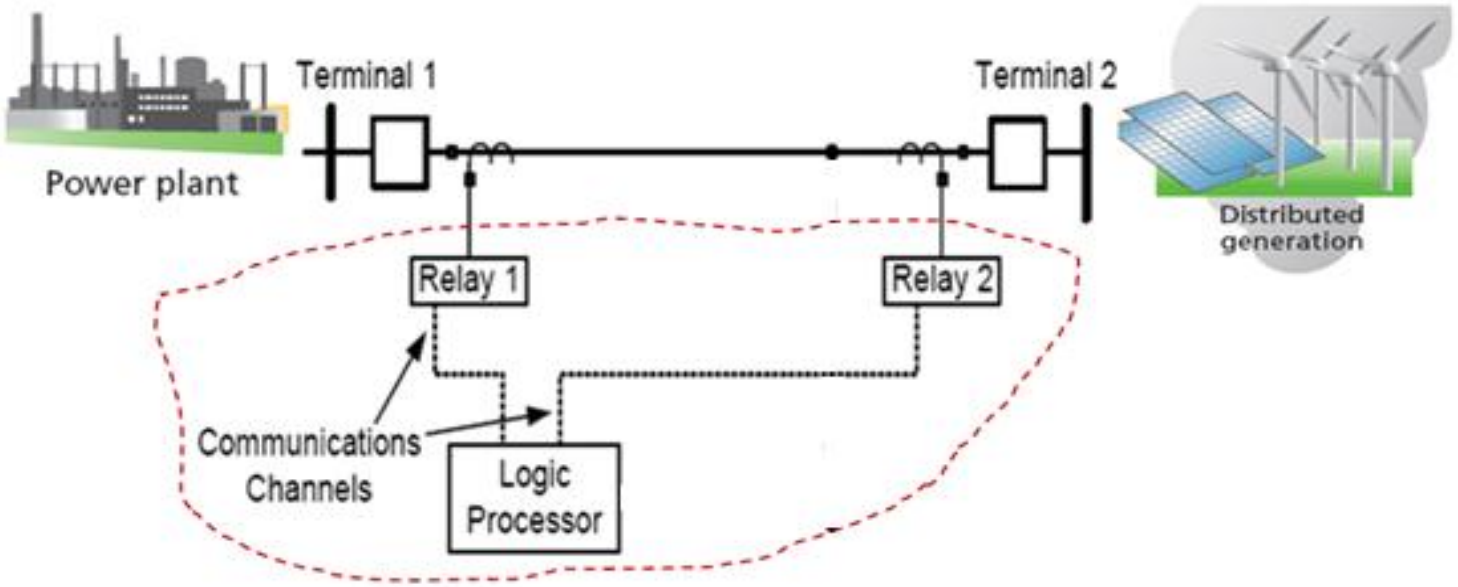
1. Problem Area.
2. Future Protection Technology For Multi-terminal Lines In Smart Grid using wireless communication.
3. Overall Structure Of The System Model
4. Hardware Devices Used In The Laboratory Model.
5. Model Operation
6. Case Study
7. Conclusion

1. Problem Area

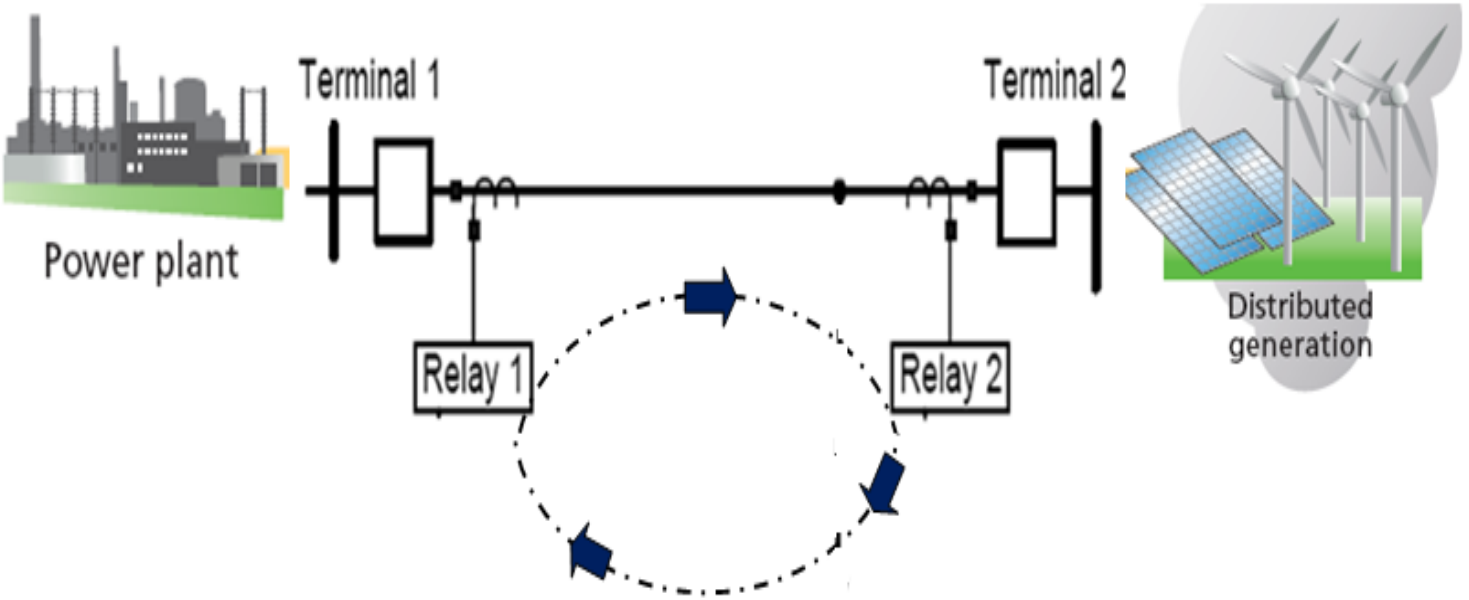
Transmission Line Differential Protection



The disadvantages of using pilot wire protection are:

- Limited line length because of the effects of resistance and capacitance of the pilot wire.
- Loss of the relay functions due to line disconnection.
- The wire link needs additional protection.
- High cost.

2. Future Protection Technology For Multi-terminal Lines In Smart Grid using wireless communication.



- The current signals are exchanged using Wi-Fi protocol through wireless communication network.
- The protection system for multi-terminal lines consists of the IED relays (Intelligent Electronic Devices),
- The relays make the final decision based on the shared information (current signals) sent through a wireless communication network.

Applying the wireless technology in transmission line protection satisfies the following features:

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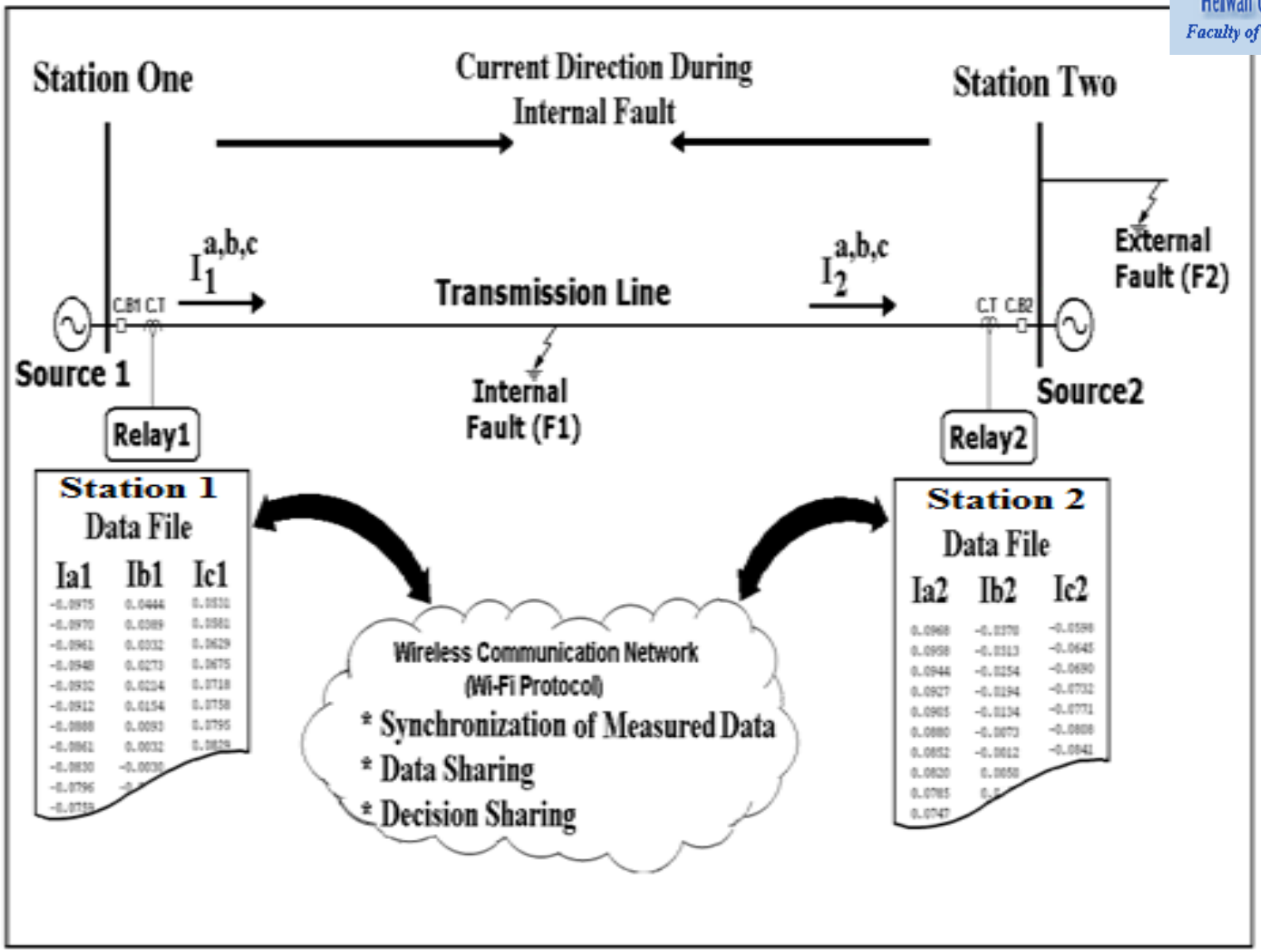
- Synchronized measurements.
- Decision is not stand alone based.
- Information exchange with the neighbors.
- Relays behave adaptively according to any change in system parameters.
- Wireless communication (no need for pilot wires).
- Lower cost compared to leased lines.
- Response time, less than one half-cycle, is fast.

3. Overall Structure Of The System Model



4. Hardware Devices Used In The Laboratory Model.

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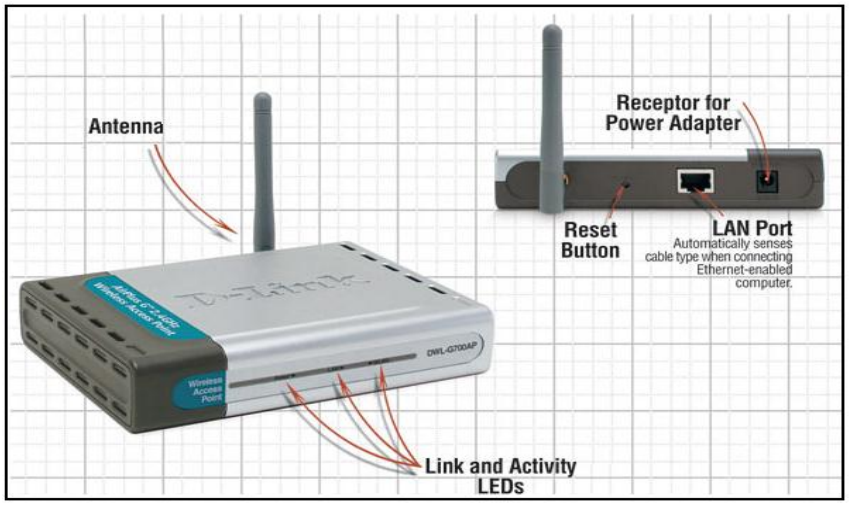

Wireless Access Point

Data Acquisition Card (DAC).

- The windows XP version is used as operating system in both computers.
- The network and sharing center built in function in windows XP is used to setup a wireless network between both computers.
- The software program on both computers read the current signals using DAC and stores this data in both computers.
- The Data are exchanged through two wireless access points using the Wi-Fi protocol. In the study the DWL-G700AP Wi-Fi IEEE 802.11g is used.
- The lab View program controls the capacity of data files.

5. Model Operation

Differential Element

The differential element calculates the sum of the sampled current signals during ¼ cycle using (3.1).

$$\Delta i^{a}(k) = \sum_{j=1}^{k} \left[i_1^{a}(j) - i_2^{a}(j) \right]$$

$$\Delta i^{b}(k) = \sum_{j=1}^{k} \left[i_1^{b}(j) - i_2^{b}(j) \right] \qquad (3.1)$$

$$\Delta i^{c}(k) = \sum_{j=1}^{k} \left[i_1^{c}(j) - i_2^{c}(j) \right]$$

where:

Δi is the deviation current signal (the sum of ¼ cycle instantaneous current samples for phases a, b and c).

j is the index.

k is the number of samples during ¼ cycle

i_1 Station One Bus end current.

i_2 Station Two Bus end current.

5. Model Operation

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Decision Element

For normal operation and external faults:

$$\left|\Delta i^{a,b,c}\right| = \left|\Delta i_{pre}^{a,b,c}\right| \qquad (3.2)$$

For internal faults:

$$\left|\Delta i^{a,b,c}\right| > \left|\Delta i_{pre}^{a,b,c}\right| \qquad (3.3)$$

6. Case Study

Three Phase Short Circuit Fault At 100km From The Generator Bus.

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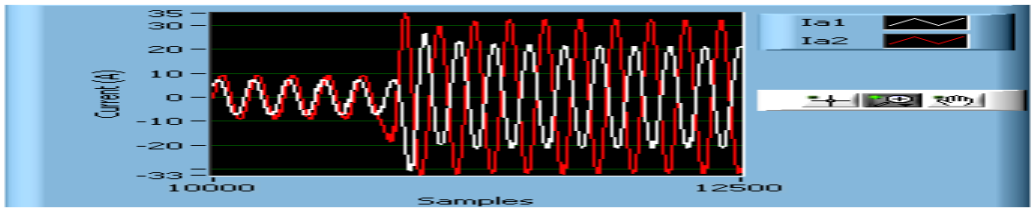
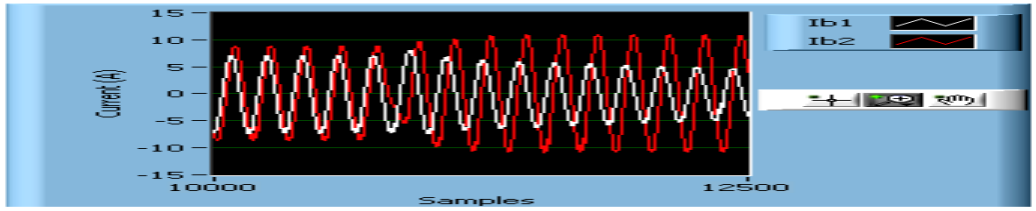
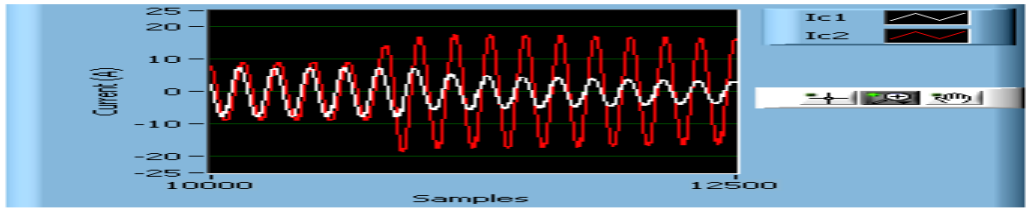


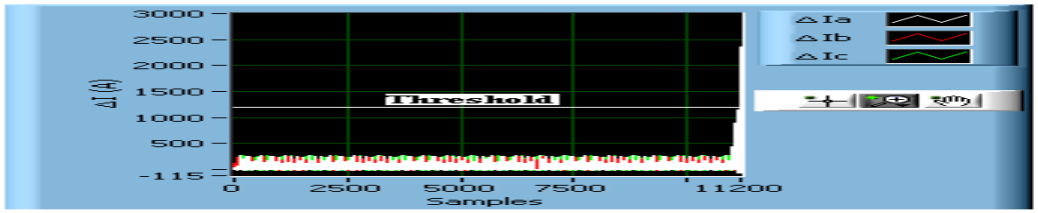
(a) Phase a Currents



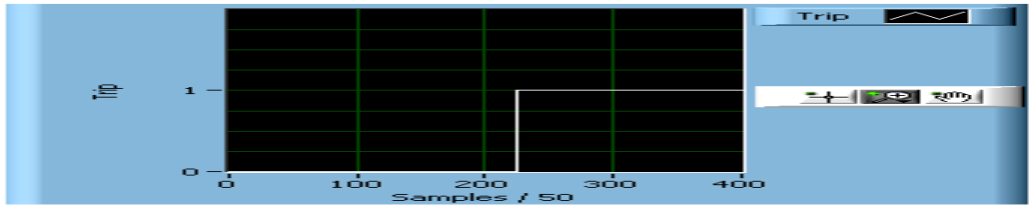
(b) Phase b Currents



(c) Phase c Currents

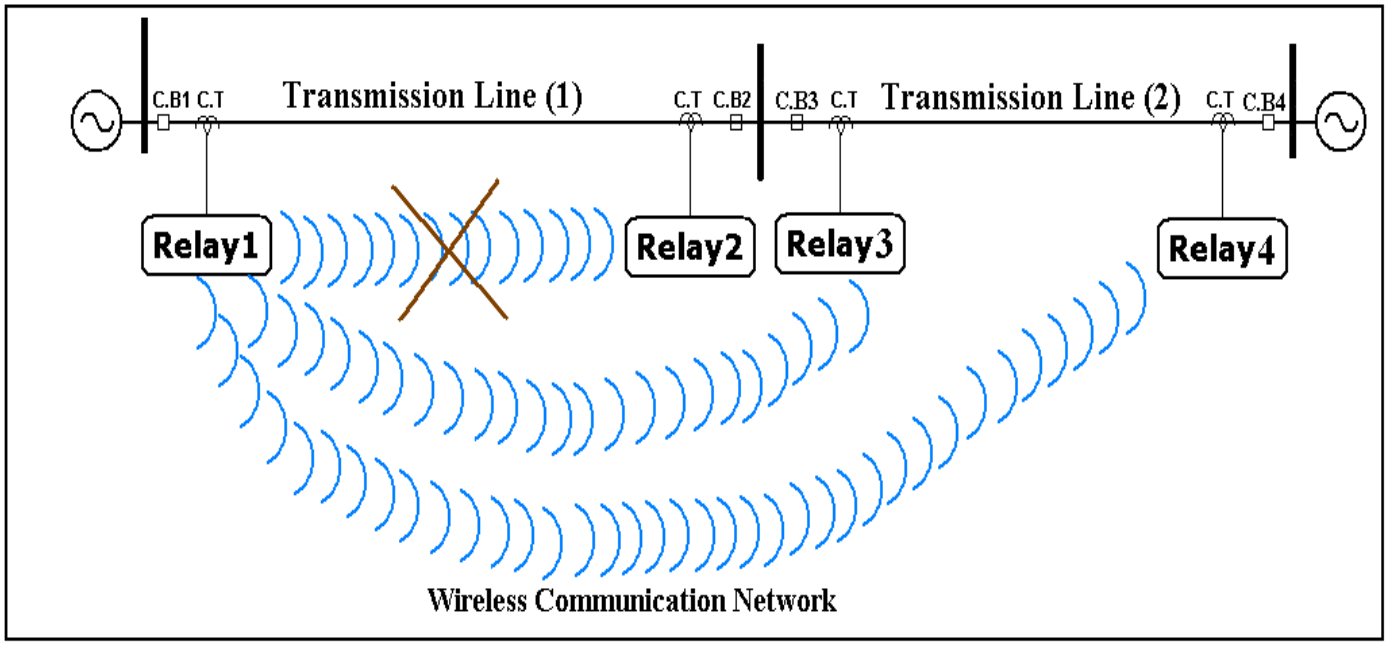


(d) Deviation Current signals for a, b & c



(e) Tripping Signal

6. Case Study
Failure in the Communication Network



- One of the advantages of the new proposed technique is the facility to exchange the measured current signals between relays.
- As shown in Figure, Relay-1 can exchange the measured current signals with Relay-2, Relay-3 and Relay-4.
- This facility will help the relays to take an accurate decision in the case of a failure in some communication channels.

6. Case Study
Failure in the Communication Network

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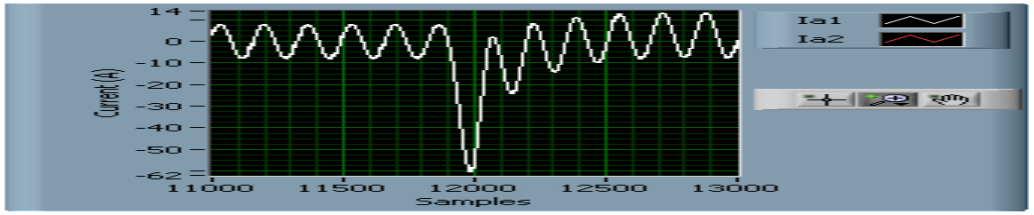
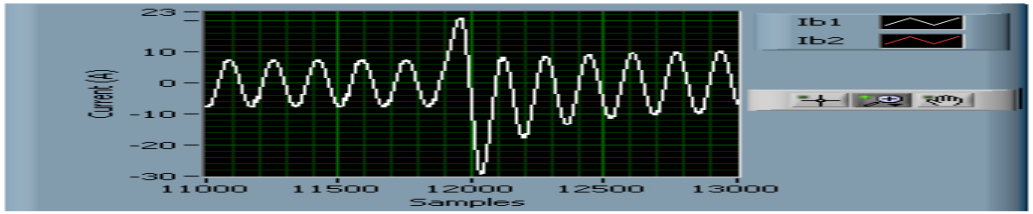
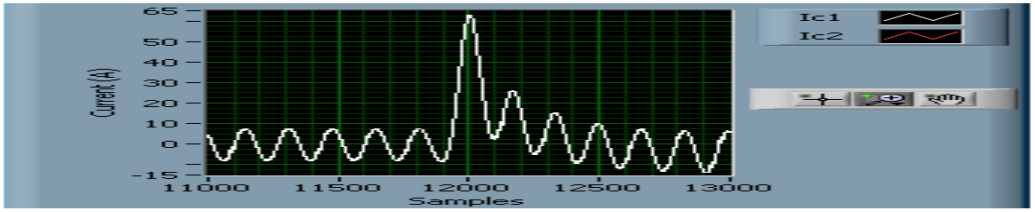


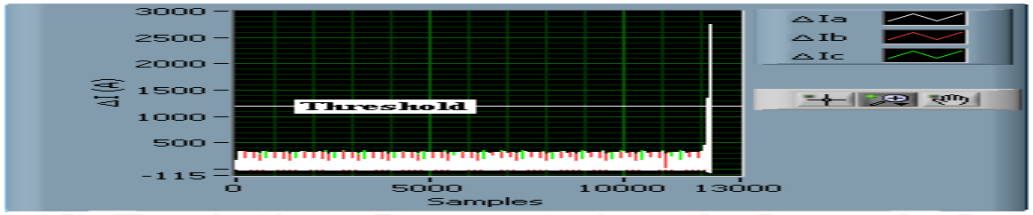
(a) Phase a Currents



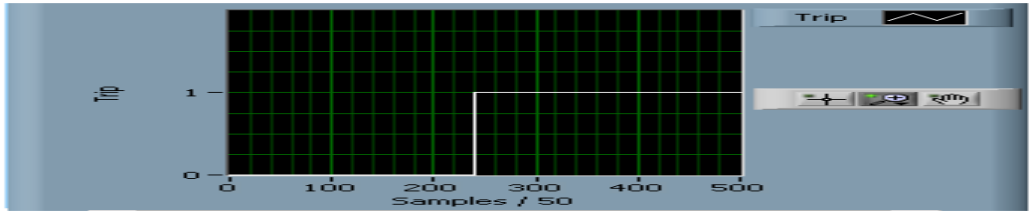
(b) Phase b Currents



(c) Phase c Currents



(d) Deviation Current signals for a, b & c



(e) Tripping Signal

7. Conclusion

- a laboratory model using Wireless Fidelity (Wi-Fi) communication protocol for data sharing between two relays located at ends of the transmission line is demonstrated.
- The protection algorithm applied in relays at each end of the line is based on current signals measured at the two ends of the transmission lines.
- The data is exchanged through the wireless communication network.
- The relay algorithm detects and classifies all internal faults within one half-cycle of the fundamental frequency after the fault inception
- The paper introduced new application for system protection using wireless communication protocol.
- The experimental results encourage wide applications for protecting complex topology of power system and smart grids.

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Thank you for your attention