

FUNDAMENTALS OF BUS PROTECTION

Kevin Wright
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WHAT IS A BUS?

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- Node

8

WHAT IS A BUS?

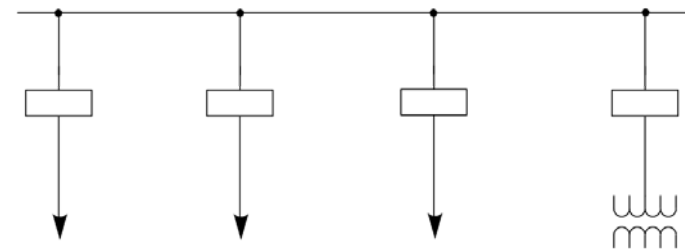
- All connections are at the same voltage.
- Made of bus bar such as in switchgear or, overhead transmission line conductor or tube such as in open air substations.
- Node
- Zero Impedance

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BUS CONFIGURATIONS

Single Bus/Single Breaker

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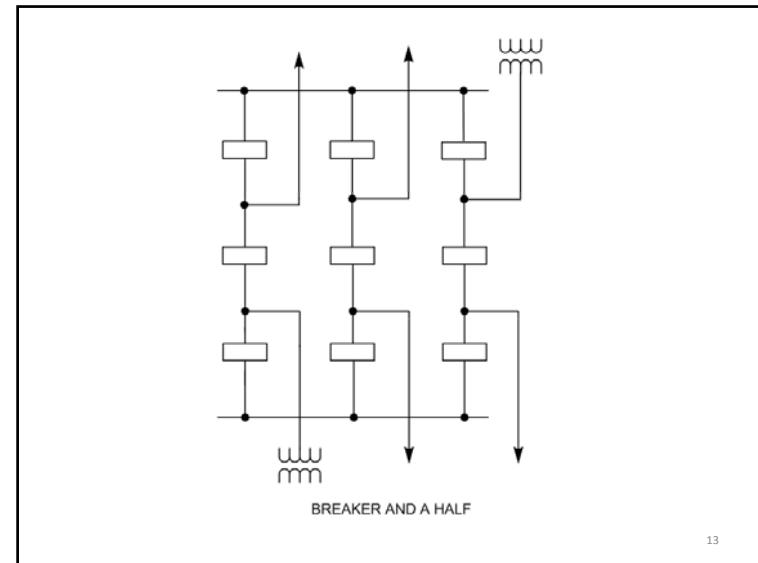
SINGLE BUS / SINGLE BREAKER

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BUS CONFIGURATIONS

Single Bus/Single Breaker
Breaker and A Half

12

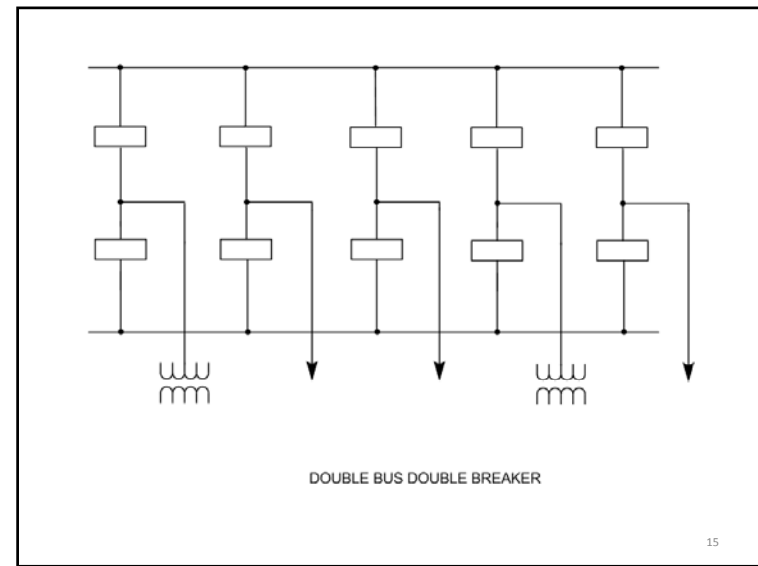


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BUS CONFIGURATIONS

Single Bus/Single Breaker
Breaker and A Half
Double Bus/Double Breaker

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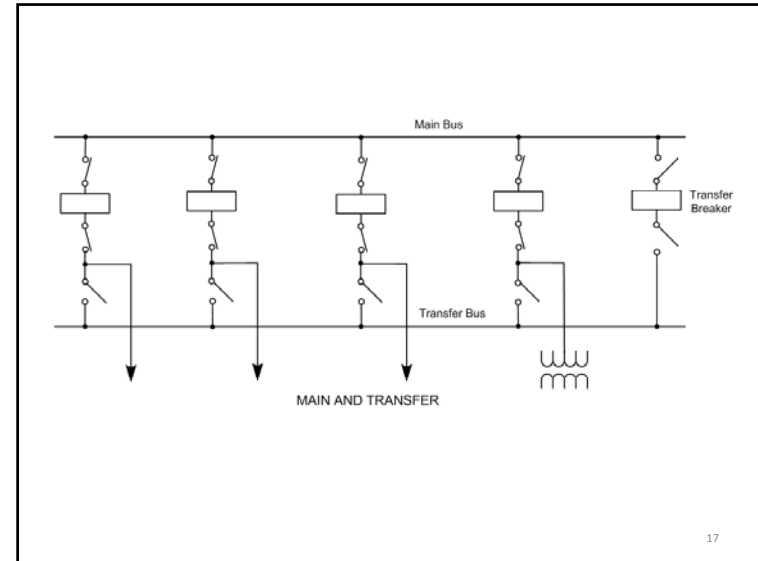


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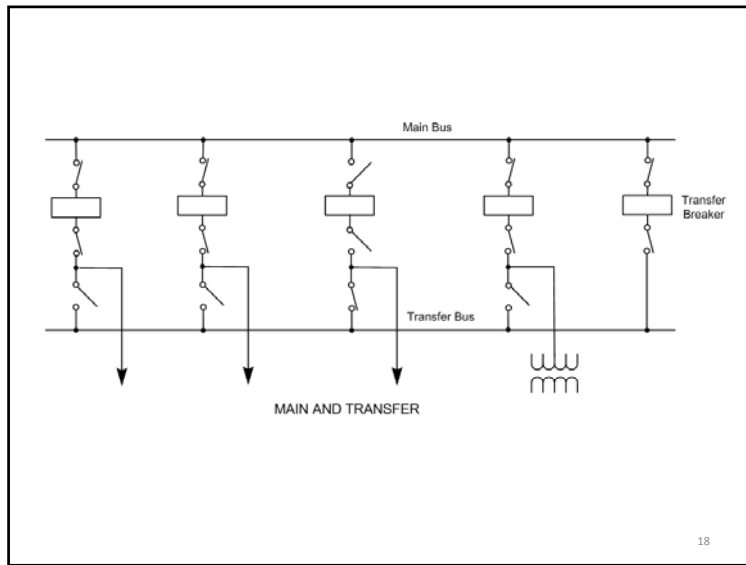
BUS CONFIGURATIONS

Single Bus/Single Breaker
Breaker and A Half
Double Bus/Double Breaker
Main and Transfer

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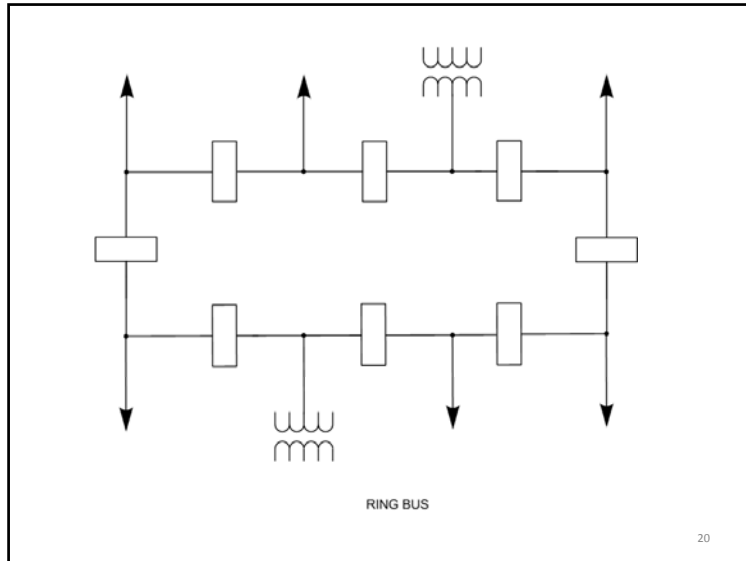


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BUS CONFIGURATIONS

Single Bus/Single Breaker
Breaker and A Half
Double Bus/Double Breaker
Main and Transfer
Ring

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BUS PROTECTION CHALLENGES

- Variety of configurations

BUS PROTECTION CHALLENGES

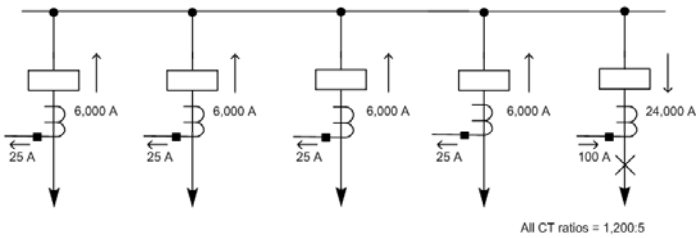
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- Large number of connections

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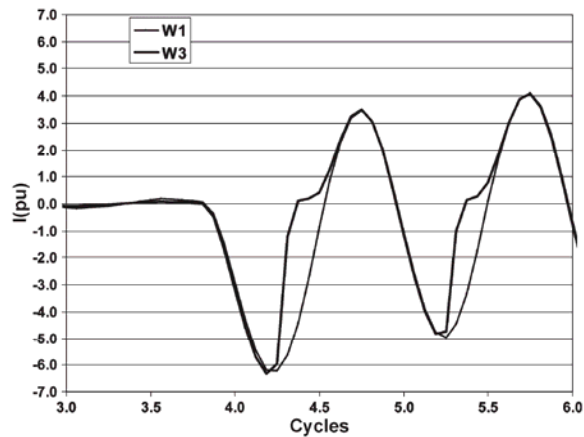


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BUS PROTECTION CHALLENGES

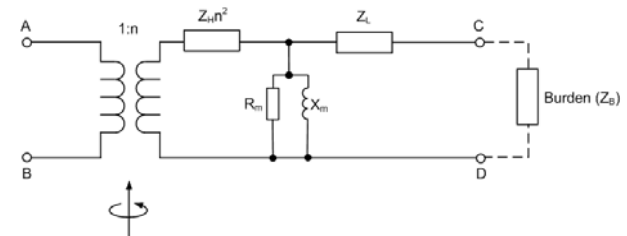
- Variety of configurations
- Large number of connections
 - For an external fault, one set of current transformers (CTs) will see total current
- High available fault current
 - CT saturation

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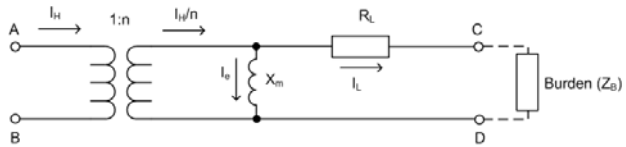
[1] 26

CURRENT TRANSFORMER EQUIVALENT CIRCUIT

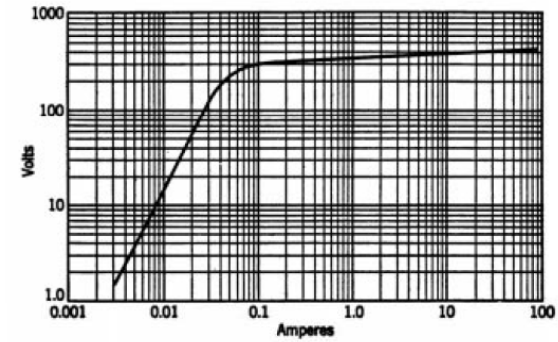


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CURRENT TRANSFORMER EQUIVALENT CIRCUIT



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Secondary-excitation characteristic.

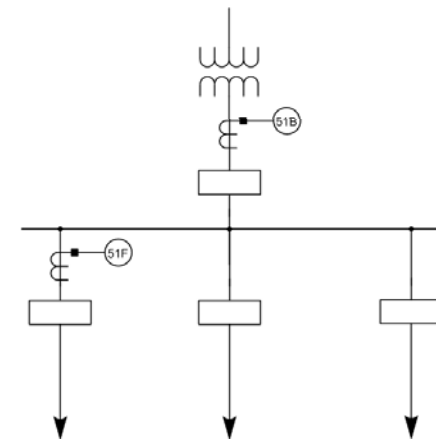
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TYPES OF BUS PROTECTION

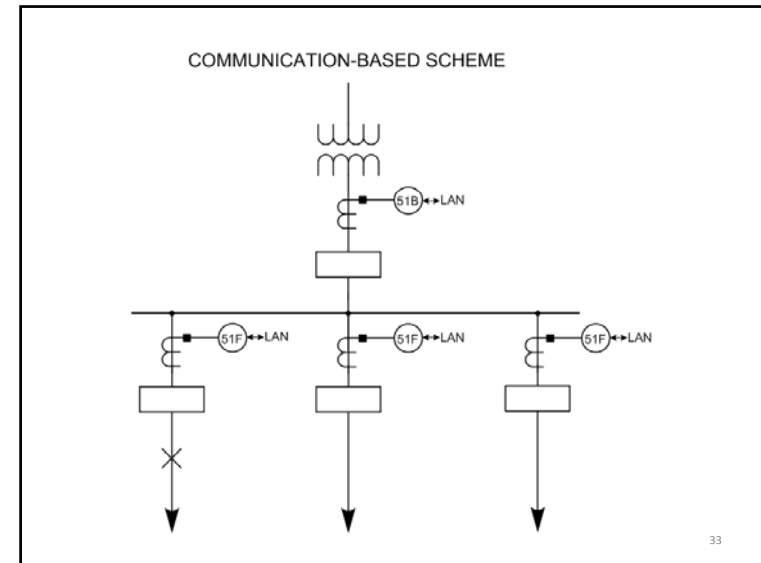
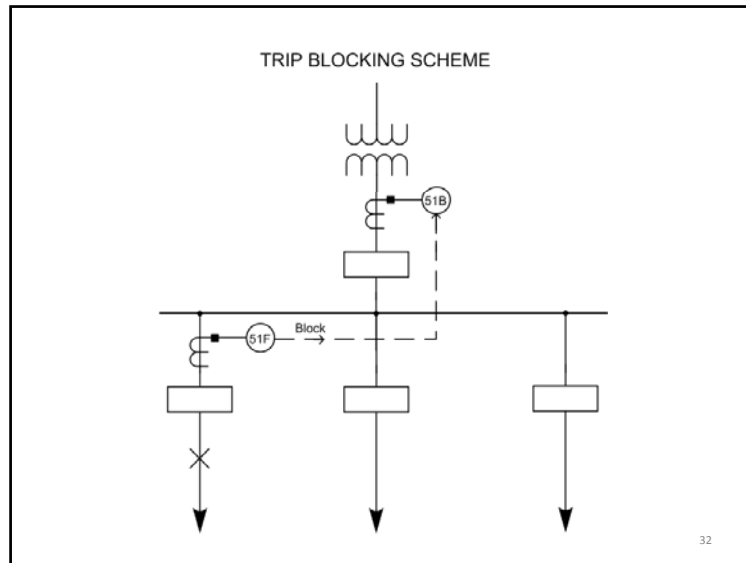
- Overcurrent
- Trip Blocking Schemes
- Communication-Based Schemes
- High-Impedance Current Differential
- Low-Impedance Current Differential
- *Distance*
- Linear Coupler
- Arc Flash Detection

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MAIN BREAKER OVERCURRENT



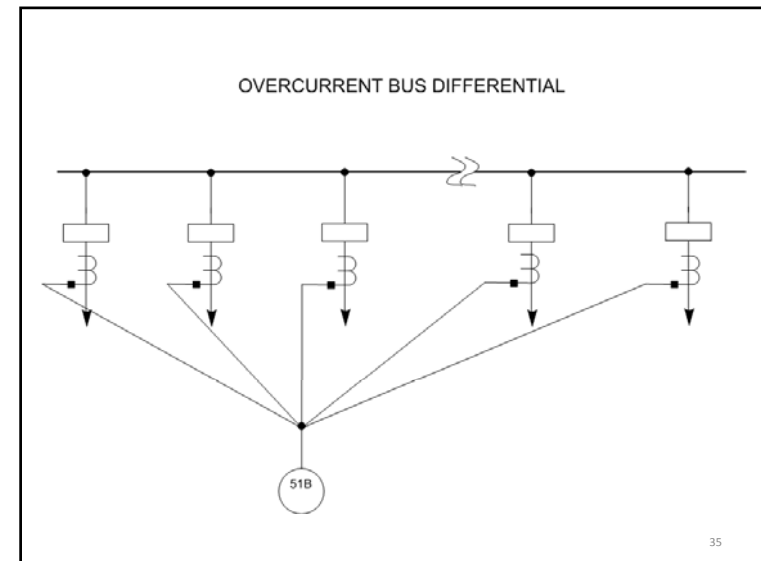
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DIFFERENTIAL PROTECTION

- Current differential protection verifies that all current that flows into a piece of equipment also flows out.

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DIFFERENTIAL PROTECTION

- Current differential protection verifies that all current that flows into a piece of equipment also flows out.
 - High-Impedance bus differential protection can accommodate any number of terminals. Minimizes saturation effect.

HIGH-IMPEDANCE BUS DIFFERENTIAL

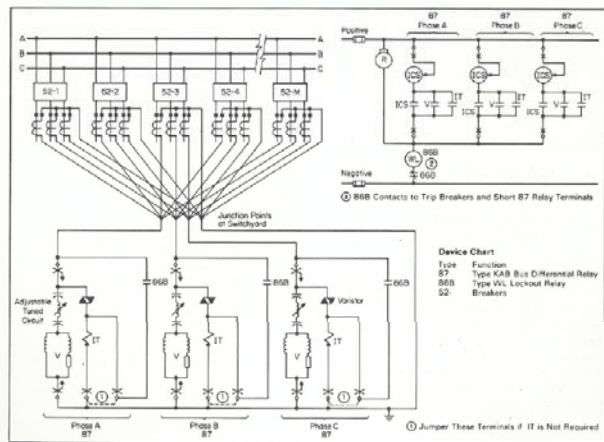
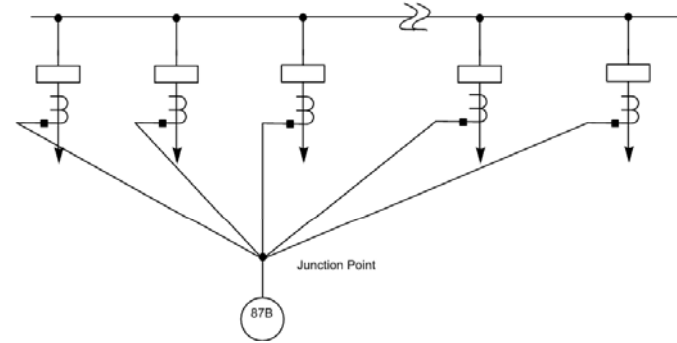
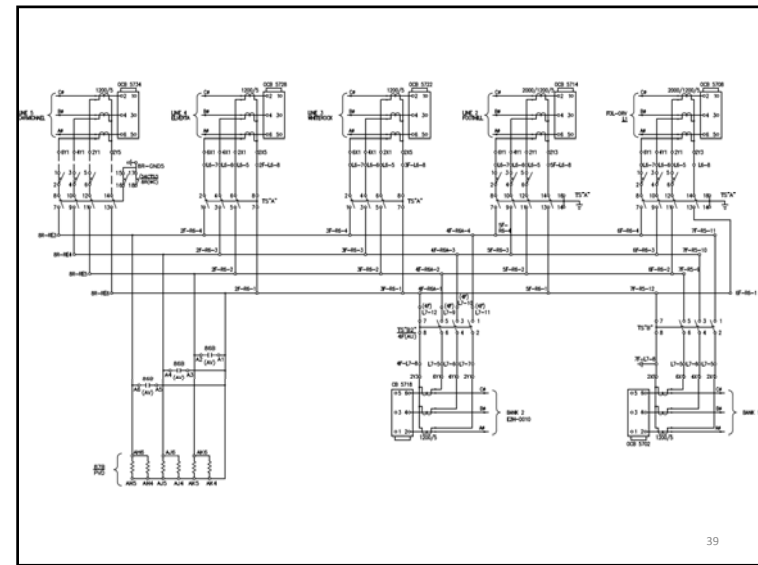


Figure 9-9: External Connection of Type K4B Bus Differential Relay.

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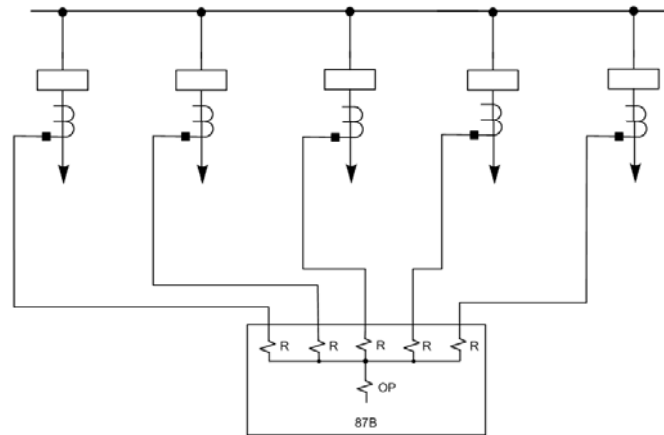


DIFFERENTIAL PROTECTION

- Current differential protection verifies that all current that flows into a piece of equipment also flows out.
 - Low-impedance bus differential protection can accommodate a variety of current transformer ratios, but has a limited number of current inputs.

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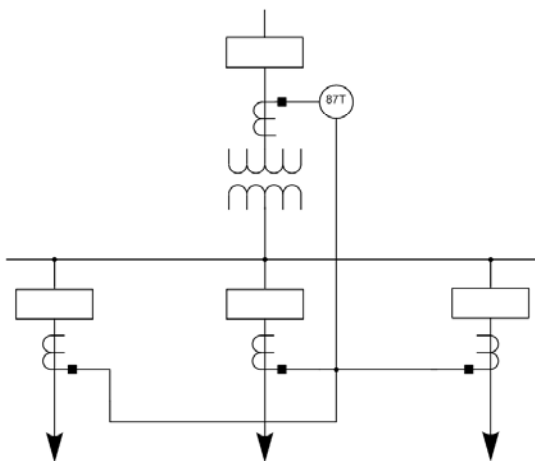
LOW-IMPEDANCE BUS DIFFERENTIAL



R=Restrain
OP=Operate

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TRANSFORMER DIFFERENTIAL



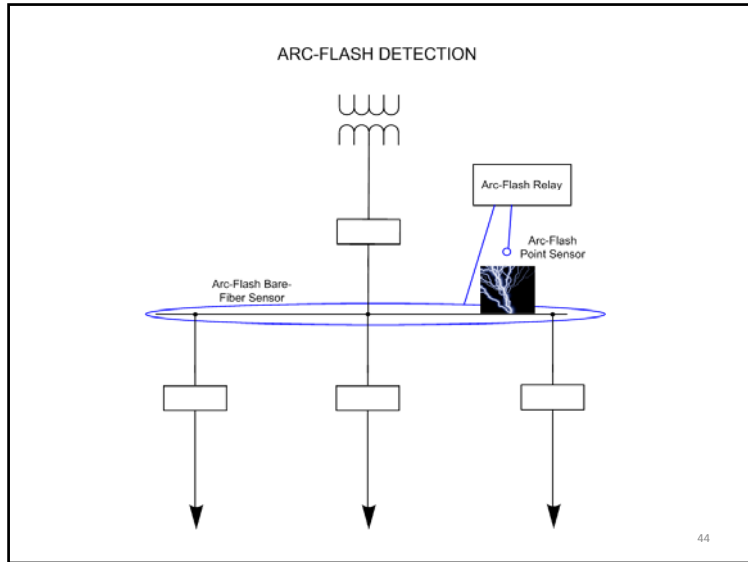
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LINEAR COUPLER

Voltage Differential

- Air-Core Mutual Reactors
- Couplers are connected in series
- No saturation due to air core

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PROS AND CONS

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Overcurrent	Simple Inexpensive	Slow Not highly selective

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Low-Impedance Differential	High speed Selective Can use shared unmatched CTs Flexible	Limited number of circuits

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Linear Coupler	High speed Selective Reliable	Expensive Dedicated couplers

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Linear Coupler	High speed Selective Reliable	Expensive Dedicated couplers
Arc-Flash Detection	High speed	Limited application

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References

- [1] A. R. Leoni and J. E. Bowen, "Improving Safety and Reliability Via Cost-Effective Upgrades of Existing Systems", *IEEE Trans. Ind. Appl.*, vol. 43, no. 1, pp. 130-138, Jan./Feb. 2007
- [2] H. J. Li of Westinghouse, "Applied Protective Relaying", 1979