

Fuseless Capacitor Bank Protection

Minnesota Power Systems Conference

St. Paul, MN.

November 2, 1999

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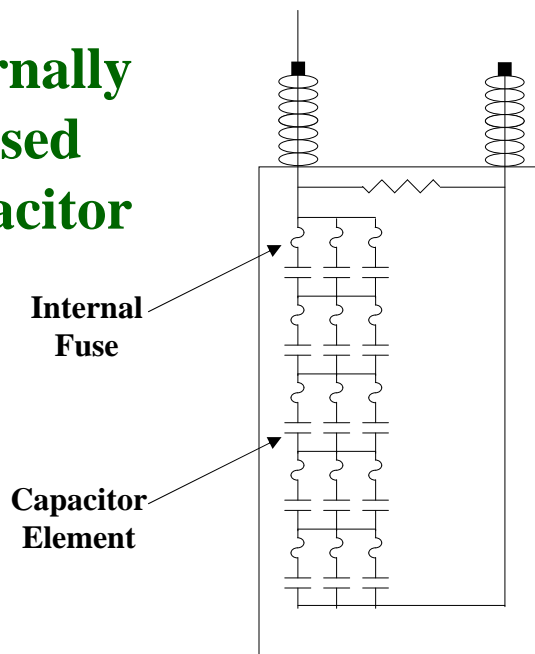
Other Papers of Interest Presented at Western Protective Relay Conference, Oct. 26, 1999

- Protection of Fuseless Shunt Capacitor Banks Using Digital Relays, by M. Dhillon and D. Tziouvaras.
- New Techniques for Capacitor Bank Protection and Control, by J. McCall, T. Day, A. Chaudhary and T. Newton.

Types of Capacitors

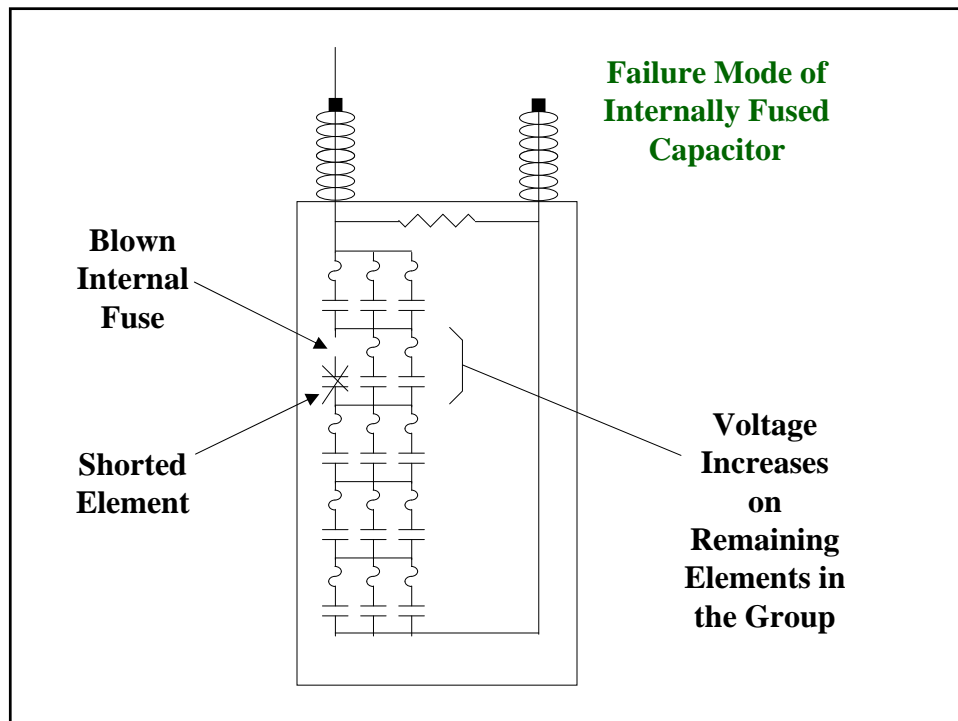
- Internally Fused
- Externally Fused
- Fuseless

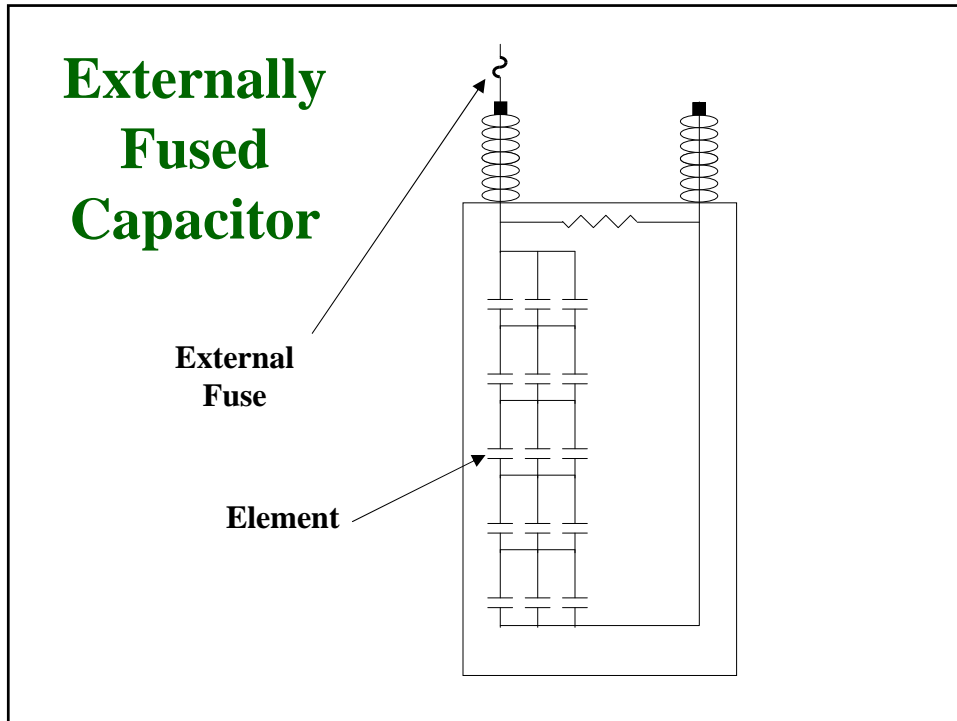
Internally Fused Capacitor



Internally Fused Capacitors

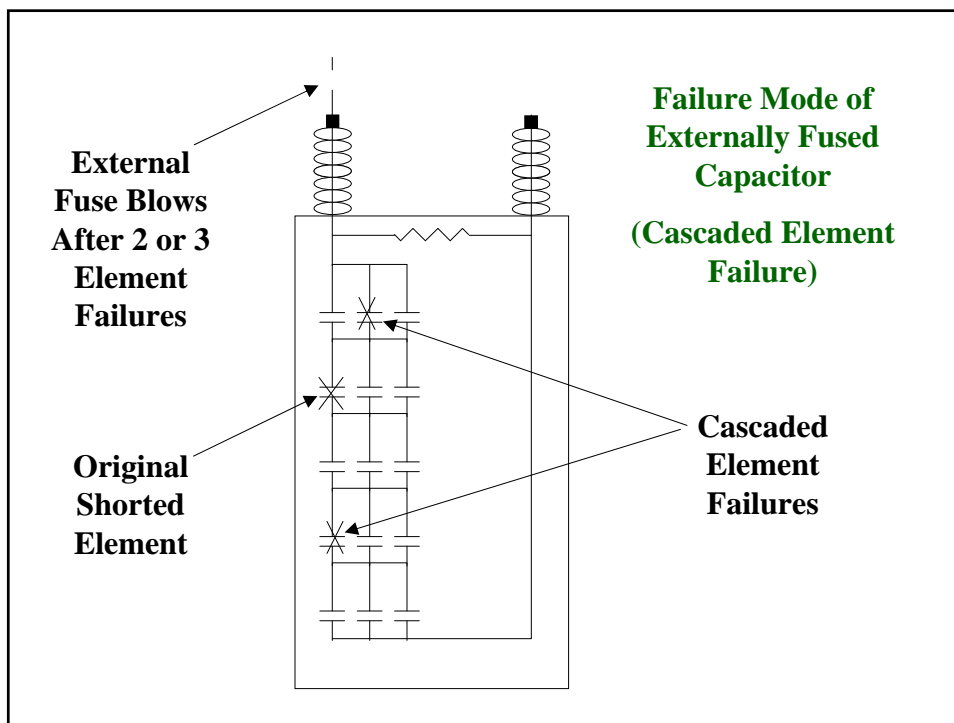
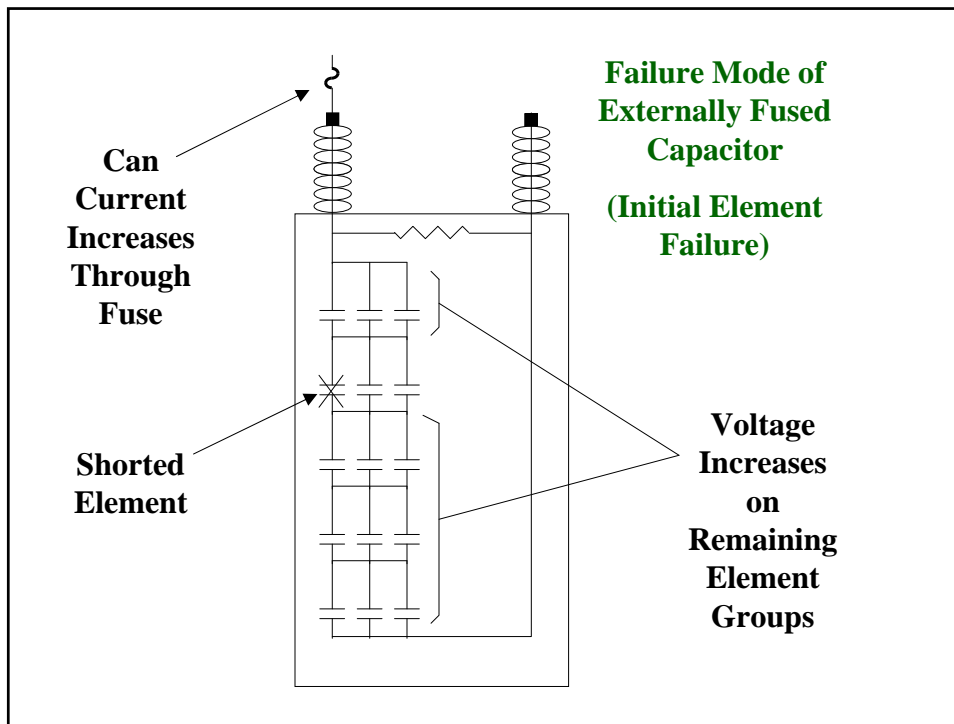
- Element shorts blow internal element fuses
- Can continue to operate with blown element fuse(s)



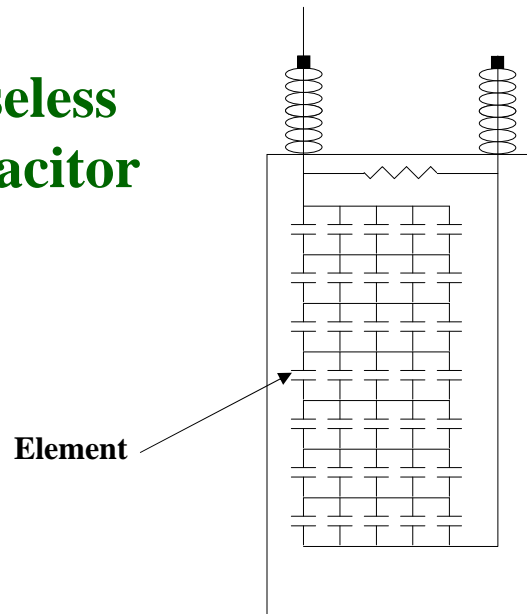


Externally Fused Capacitors

- First element short raises voltage stress on remaining element groups
- Additional elements cascade fail
- External fuse blows for 2 or 3 element groups shorted

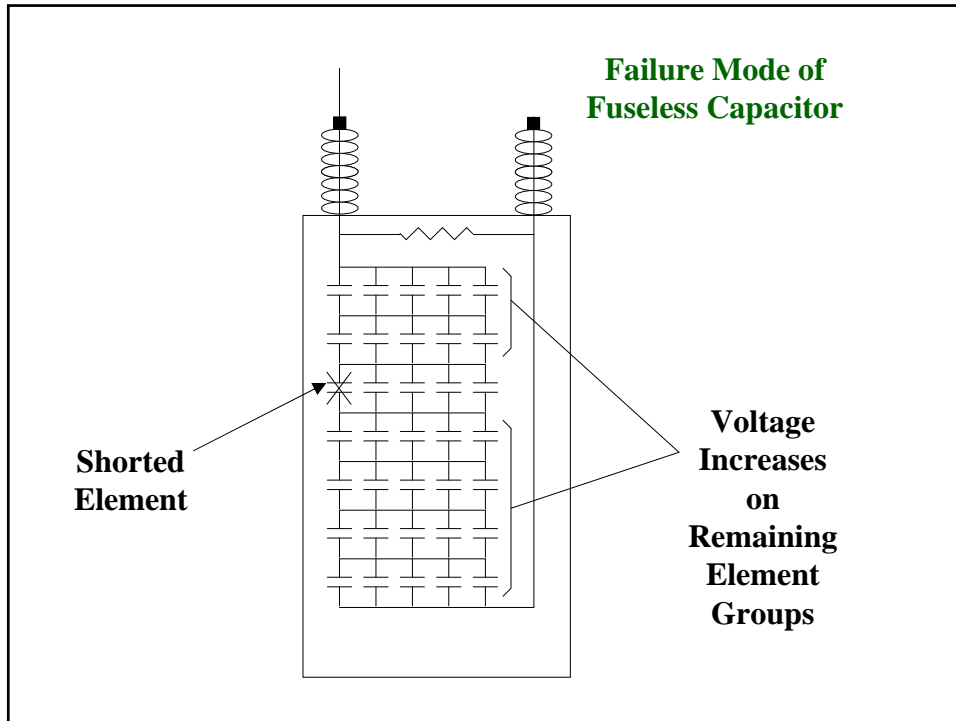


Fuseless Capacitor



Fuseless Capacitors

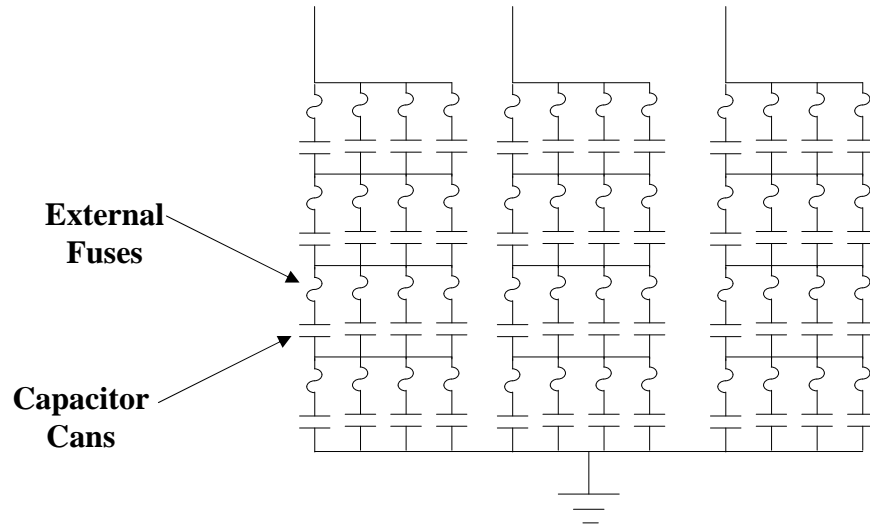
- Element shorts raise voltage stress on remaining element groups
- Can continue to operate with shorted element(s)
- Cascaded element failures are not necessarily in same can



Typical Capacitor Bank Installations

- Externally Fused
- Fuseless

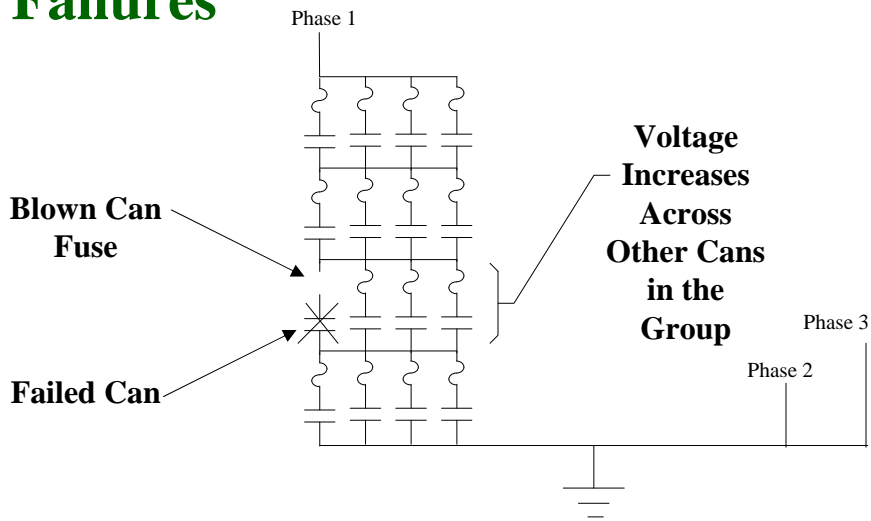
Externally Fused Capacitor Bank



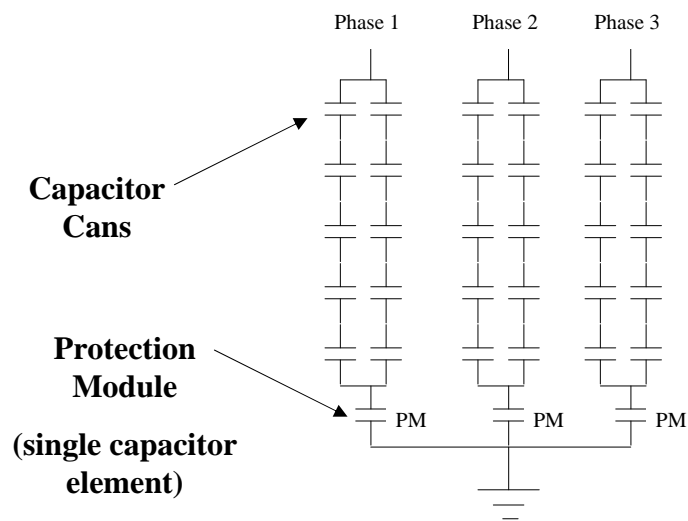
Externally Fused Capacitor Banks

- First blown fuse raises voltage stress on remaining cans
- Cans can cascade fail after exceeding 110% of can nameplate

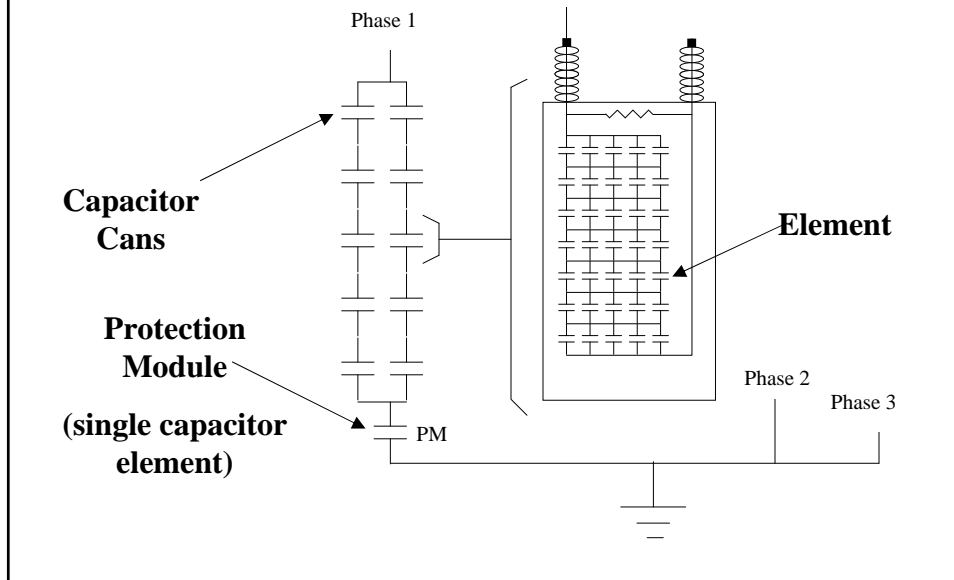
Externally Fused Capacitor Bank Failures



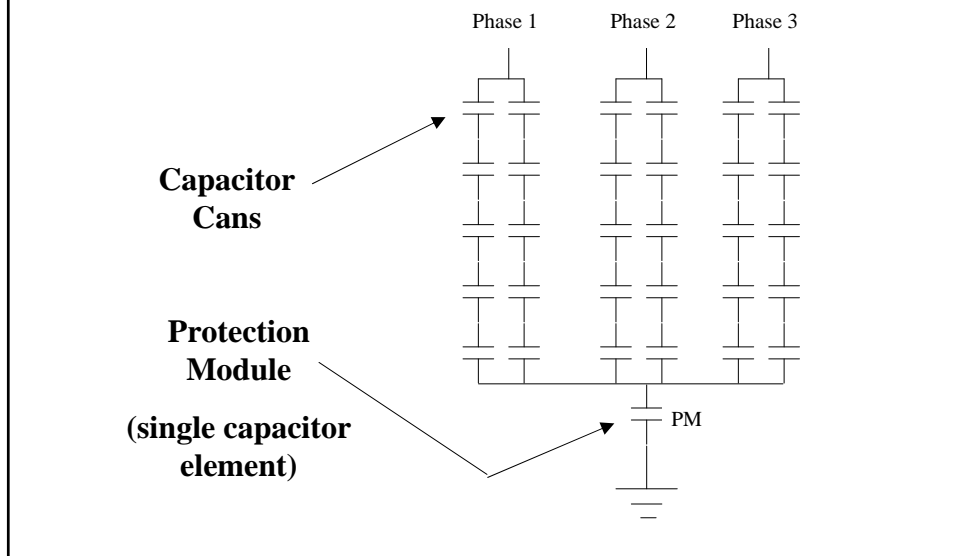
Fuseless Capacitor Bank



Fuseless Capacitor Bank



Fuseless Capacitor Bank with Neutral Protection Module

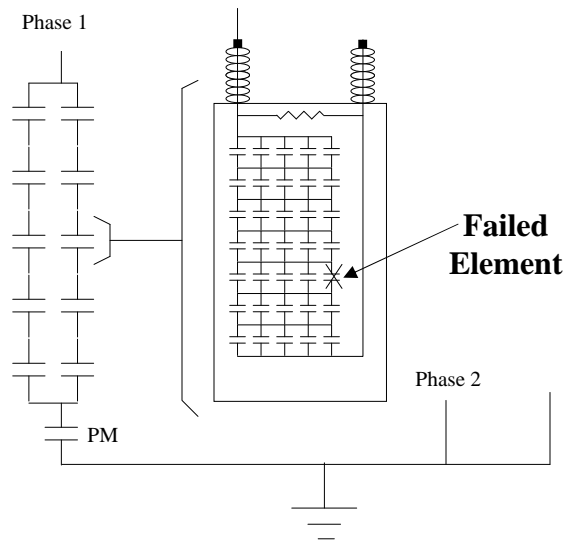


Fuseless Capacitor Banks

- First failed element raises voltage stress on remaining elements in series group
- Elements can cascade fail after exceeding 110% of element nameplate
- Element failures do not necessarily occur in same can

Fuseless Capacitor Bank Failures

**Voltage
Increases
Across
Other
Elements in
the Series
Group**



Protection Objectives

- Short circuit protection for phase and ground faults
- Overvoltage protection resulting from excessively high power system voltages
- Overvoltage protection resulting from element failures

Short Circuit Protection

- Phase overcurrent relaying (50/51) on breaker phase CTs
- Overlapping bus differential relays (87B)
- Residual overcurrent relaying (50/51G)
- Trip and lock-out bank

System Overvoltage Protection

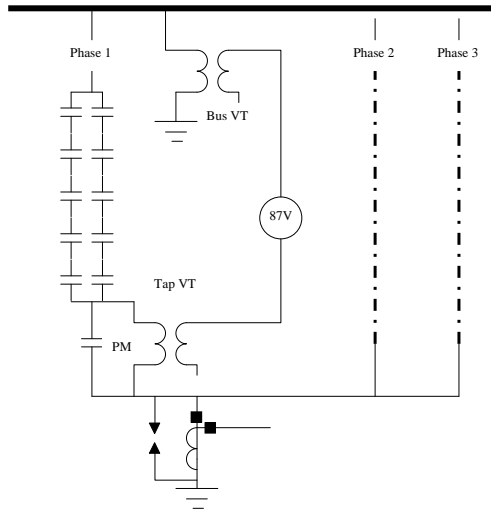
- Phase overvoltage relaying (59B) connected to bus PTs.
- Trip bank for 110% of nameplate voltage (no lock-out)

Element-Failure Caused Overvoltage Protection

- Voltage differential (87V)
- Neutral overvoltage (59N)
- Neutral overcurrent (51N)

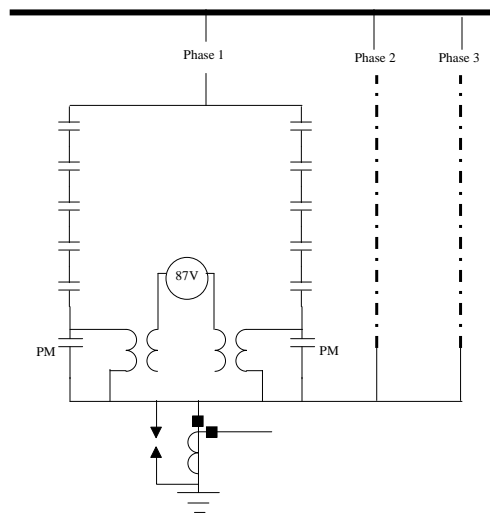
Voltage Differential (87V)

**Monitors
the voltage
difference
between the
bus and the
protection
module**



Alternate Voltage Differential (87V)

**Monitors
the voltage
difference
between the
protection
modules on
each series
group**

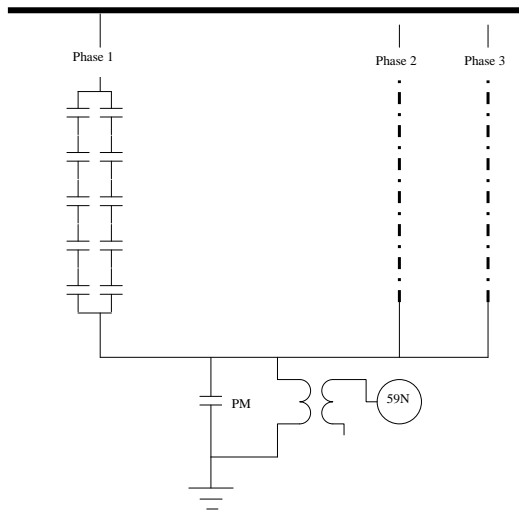


Voltage Differential Objectives

- Alarm for 2 or 3 failed elements (4 - 5% element overvoltage)
- Trip and lock-out bank for 10% element overvoltage

Neutral Overvoltage (59N)

Operates on the voltage across the neutral PM caused by phase unbalances

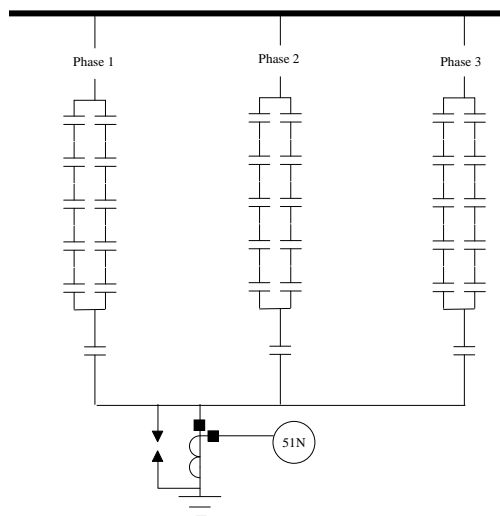


Neutral Overvoltage Objectives

- Alarm for 2 or 3 failed elements (4 - 5% element overvoltage)
- Trip and lock-out bank for 10% element overvoltage
- Calculations assume all failed elements are in the same phase

Neutral Overcurrent (51N)

**Monitors
the neutral
unbalance
current to
detect
failed
elements**



Neutral Overcurrent Objectives

- Alarm for 2 or 3 failed elements (4 - 5% element overvoltage)
- Trip and lock-out bank for 10% element overvoltage
- Calculations assume all failed elements are in the same phase

Questions
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