Table of Contents

What is Zone Interlocking? ........................................................................................................ 3
What is the purpose of Zone Interlocking? ................................................................................ 3
How does it work? ..................................................................................................................... 3
Connection Requirements ..................................................................................................... 5
  Conductor ............................................................................................................................. 5
  Self-interlocking Jumper ...................................................................................................... 6
  Phase and Ground Outputs and Inputs ................................................................................. 6
Products Available .................................................................................................................. 8
  Medium Voltage ................................................................................................................... 8
    FP5000 ............................................................................................................................. 8
    DT 3000 .......................................................................................................................... 11
  Low Voltage ...................................................................................................................... 13
    DS .................................................................................................................................... 13
    Digitrip 510 ...................................................................................................................... 13
    Digitrip 610 ...................................................................................................................... 13
    Digitrip 810 ...................................................................................................................... 13
    Digitrip 910 ...................................................................................................................... 13
    OPTIM 750 ...................................................................................................................... 13
    OPTIM 1050 ..................................................................................................................... 13
  Magnum .................................................................................................................................. 15
    Digitrip 520, 520M .......................................................................................................... 15
    OPTIM 1050 ................................................................................................................... 15
  SPB ..................................................................................................................................... 17
    Series C ............................................................................................................................. 17
    Digitrip 510 ...................................................................................................................... 17
    Digitrip 610 ...................................................................................................................... 17
    Digitrip 810 ...................................................................................................................... 17
    Digitrip 910 ...................................................................................................................... 17
    OPTIM 750 ...................................................................................................................... 17
    OPTIM 1050 ..................................................................................................................... 17
    Molded Case ..................................................................................................................... 19
Applications ............................................................................................................................. 21
  Basic Distribution ................................................................................................................ 21
  Self-Interlocking .................................................................................................................. 22
  Transformer Inrush ............................................................................................................. 22
Advanced Applications .......................................................................................................... 22
  Scheme 1: ............................................................................................................................ 22
  Scheme 2: ............................................................................................................................ 24
  Scheme 3: ............................................................................................................................ 26
  Scheme 4: ............................................................................................................................ 27
  Scheme 5: ............................................................................................................................ 29
Summary ........................................................................................................... 29
  Scheme 1: ......................................................................................................... 29
  Scheme 2: ......................................................................................................... 29
  Scheme 3: ......................................................................................................... 29
  Scheme 4: ......................................................................................................... 29
  Scheme 5: ......................................................................................................... 29
What is Zone Interlocking?

Zone interlocking is a communication scheme used with circuit breakers and protective relays to improve the level of protection in a power distribution system. This is achieved through communication between the downstream and upstream devices in a power distribution system. The zones are classified by their location downstream of the main circuit protective device which is generally defined as zone 1.

This document will review Eaton|Cutler-Hammer protective devices that utilize zone interlocking protection, connections and common practices.

What is the purpose of Zone Interlocking?

The purpose of Zone Interlocking (ZI) is to speed up tripping for some faults without sacrificing the coordination of the system and interjecting nuisance trips into the system. Zone interlocking devices can communicate across distribution zones to determine whether or not a device sees a fault condition.

How does it work?

Zone interlocking monitors phase and ground faults between devices in separate zones using a three or five wire scheme. The three wire scheme has one output, one input and a common. The five wire scheme has two inputs (one for phase and one for ground), two outputs (one for phase and one for ground) and a common. Zone Interlock terminations are discussed in the connection requirements section of this document. If a fault exceeds the short time pick up of a down stream device (zone 2) the trip unit will send a signal upstream to acknowledge that it recognizes the problem. An example of a feeder fault is shown in figure 1; a bus fault is shown in figure 2.

The downstream device signals to the upstream device through the communication wires that it “sees” the fault. This keeps the upstream device from interrupting quickly, therefore maintaining power to the rest of the system.

If the down stream device fails, the upstream device would trip instantaneously after a 3 cycle delay, provided the fault exceeded the short delay pick up set for that device. This shows the benefits of zone interlocking. If a major fault occurs the device closest to the fault will be given the opportunity to clear the condition without disrupting service to other areas of the facility. The ZI feature enhances the coordination of the system without sacrificing protection.

If a bus fault were to occur as shown in figure 2. The down stream device would not recognize the fault condition and the device closest to the fault would trip instantaneously after a 3 cycle delay. This immediate reaction by the upstream device prevents the condition from getting worse by delaying the trip to its coordinated time defined by the inverse time curve. Figure 3 shows the device tripping instantaneously after a 3 cycle delay, instead of tripping in 100 ms (6 cycles). This dramatically reduces the amount of energy consumed by the fault.

![Figure 1](image1)

![Figure 2](image2)
Tables one, two, and three show how much energy would be extinguished for a 10000 amp fault.

**Table One**  
**Fault at load with self zone interlocking jumper applied**

<table>
<thead>
<tr>
<th>Device</th>
<th>Ir</th>
<th>SHORT DELAY</th>
<th>Time to Trip</th>
<th>$I^2t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeder Breaker</td>
<td>1000 A</td>
<td>300mS</td>
<td>100mS</td>
<td>$1 \times 10^9$</td>
</tr>
<tr>
<td>Main Breaker</td>
<td>3200 A</td>
<td>500mS</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

**Table Two**  
**Fault at bus between zone interlocking**

<table>
<thead>
<tr>
<th>Device</th>
<th>Ir</th>
<th>SHORT DELAY</th>
<th>Time to Trip</th>
<th>$I^2t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeder Breaker</td>
<td>1000 A</td>
<td>300mS</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Main Breaker</td>
<td>3200 A</td>
<td>500mS</td>
<td>100mS</td>
<td>$1 \times 10^9$</td>
</tr>
</tbody>
</table>

**Table Three**  
**Fault at bus ZI defeated**

This example shows how much energy is limited by using the ZI on a fault condition.

<table>
<thead>
<tr>
<th>Device</th>
<th>Ir</th>
<th>SHORT DELAY</th>
<th>Time to Trip</th>
<th>$I^2t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeder Breaker</td>
<td>1000 A</td>
<td>500mS</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Main Breaker</td>
<td>3200 A</td>
<td>500mS</td>
<td>500mS</td>
<td>$5 \times 10^7$</td>
</tr>
</tbody>
</table>
Connection Requirements

Conductor

Twisted-pair instrumentation cable with 16, 18 or 20 gauge conductors is recommended. Install the wiring in metal compartments, conduit or other facilities used to physically separate control circuits from current-carrying power circuits. The loop dc resistance of the connection pair should be under 10 ohms. Shielding is not required, but is acceptable if already present in the cabling system. Use a separate twisted pair for each interlocking circuit; for example, phase versus ground zone interlocking circuits running in parallel.

The stated limitation of connection distance is 75 meters (246 feet). The sending and receiving of the zone interlocking signals should be confirmed by testing before or during commissioning. Devices on the same bus are considered in parallel. No more than 20 devices should be connected in parallel. Figure 4 shows 18 primary feeder breakers in parallel in series with one primary main breaker.

When 20 or more devices are connected in parallel diodes must be used to isolate the input and output signals. This is shown in figure 5.

If the number of devices in table 4 are exceeded steering diodes must be placed on the ground and/or phase outputs due to internal component configurations.
Table Four

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>DIGITRIP</th>
<th>OPTIM</th>
<th>DT3000</th>
<th>FP5000</th>
<th>GFR</th>
</tr>
</thead>
<tbody>
<tr>
<td># OF DEVICES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>without self interlock</td>
<td>20</td>
<td>20</td>
<td>10</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>With self interlock</td>
<td>3</td>
<td>23</td>
<td>10</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>With self interlock</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>NA</td>
</tr>
</tbody>
</table>

Steering diodes are IN4004 or equivalent.

Table Five

<table>
<thead>
<tr>
<th>V_R (volts)</th>
<th>V_RSM (volts)</th>
<th>V_R(RMS) (volts)</th>
<th>I_O (amp)</th>
<th>I_FSM (amps for 1 cycle)</th>
<th>T_J (deg C)</th>
<th>V_F (volts)</th>
<th>V_F(AVG) (volts)</th>
<th>I_R (µA)</th>
<th>I_R(AVG) (µA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>400</td>
<td>480</td>
<td>280</td>
<td>1</td>
<td>30</td>
<td>-65 to +175</td>
<td>0.93</td>
<td>0.8</td>
<td>.05</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Self-interlocking Jumper

**CAUTION**

A self-interlocking jumper must be added to the device in the final zone to keep the device from tripping instantaneously. This jumper is applied from the zone out to the zone input on the phase and ground connections of each device in the final zone.

**WARNING**

Do NOT connect the zone common to earth ground. This is a digital ground and must be isolated from the system ground.

Phase and Ground Outputs and Inputs

Zone input and output interlock connections may be combined on the same terminal for phase and ground or have separate connections. Figure 6 shows an example of the 5 wire DT3000. Figure 7 shows an example of the 3 wire FP5000. Combining the phase and ground outputs or inputs on the same terminal reduces the number of conductors required for adding zone interlocking to a power distribution system. Table 6 shows which products have the zone interlock signal combined or independent. Figure 8 shows a connection diagram of 3 and 5 wire schemes for trip units and relays.

Table Six

<table>
<thead>
<tr>
<th>Device</th>
<th>ZI Connections</th>
</tr>
</thead>
<tbody>
<tr>
<td>FP5000</td>
<td>Combined</td>
</tr>
<tr>
<td>DT3000</td>
<td>Independent</td>
</tr>
<tr>
<td>Magnum Digitrip</td>
<td>Combined</td>
</tr>
<tr>
<td>Digitrip 910</td>
<td>Independent</td>
</tr>
<tr>
<td>Digitrip 810</td>
<td>Independent</td>
</tr>
<tr>
<td>Digitrip 610</td>
<td>Independent</td>
</tr>
<tr>
<td>Digitrip 510</td>
<td>Independent</td>
</tr>
<tr>
<td>OPTIM 1050</td>
<td>Independent</td>
</tr>
<tr>
<td>OPTIM 750</td>
<td>Independent</td>
</tr>
</tbody>
</table>
Figure eight is an example of devices that range from integral molded case trip units using the 5 wire scheme to advance relays using the 3 wire scheme connected together for zone interlocking applications.
Products Available

This section shows what products have Zone Interlocking available, where the terminations are, internal logic diagrams and what elements the zone interlocking recognizes.

Medium Voltage

Table Seventeen

<table>
<thead>
<tr>
<th>Phase/Ground</th>
<th>FP5000</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUT</td>
<td>O</td>
</tr>
<tr>
<td>Common</td>
<td>C</td>
</tr>
<tr>
<td>Shield</td>
<td>S</td>
</tr>
<tr>
<td>Phase/Ground</td>
<td>I</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>J3-1</th>
<th>J3-2</th>
<th>J3-3</th>
</tr>
</thead>
</table>

Table Eighteen

<table>
<thead>
<tr>
<th>Element</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>50G</td>
<td>Instantaneous Ground element</td>
</tr>
<tr>
<td>50P</td>
<td>Instantaneous Phase element</td>
</tr>
<tr>
<td>50R</td>
<td>Instantaneous</td>
</tr>
<tr>
<td>50X</td>
<td>Instantaneous</td>
</tr>
<tr>
<td>51G</td>
<td>Overcurrent Ground</td>
</tr>
<tr>
<td>51P PU</td>
<td>Overcurrent Phase Pick Up</td>
</tr>
<tr>
<td>51P</td>
<td>Overcurrent Phase</td>
</tr>
<tr>
<td>BF TRIP</td>
<td>Breaker Fail Trip</td>
</tr>
</tbody>
</table>
Internal Logic Output Signal

**Definitions:**
- **51P Pickup** = \( I_{rms} > 51P \) Phase Inverse Time Overcurrent Protection Setting
- **50P-1 Pickup** = \( I_{rms} > 50P-1 \) Phase Overcurrent Protection Setting
- **50P-2 Pickup** = \( I_{rms} > 50P-2 \) Phase Overcurrent Protection Setting
- **Zone Out Phase Setting** = “Zone Out” Protection Setting set to “Phase” or “Both”
- **51P Operate** = 51P Phase Inverse Time Overcurrent Protection operation
- **50P-1 Operate** = 50P-1 Phase Overcurrent Protection operation
- **50P-2 Operate** = 50P-2 Phase Overcurrent Protection operation
- **BF Trip** = Breaker Failure Trip signal
- **Zone Interlock Output** = Discrete zone interlocking output signal

Ground Zone Interlock

**Definitions:**
- **51G Pickup** = \( I_{Xrms} > 51X \) or \( I_{Rrms} > 51R \) Inverse Time Overcurrent Protection Setting
- **50G-1 Pickup** = \( I_{Xrms} > 50X-1 \) or \( I_{Rrms} > 50R-1 \) Overcurrent Protection Setting
- **50G-2 Pickup** = \( I_{Xrms} > 50X-2 \) or \( I_{Rrms} > 50R-2 \) Overcurrent Protection Setting
- **Zone Out Ground Setting** = “Zone Out” Protection Setting set to “Ground” or “Both”
- **51G Operate** = 51X or 51R Inverse Time Overcurrent Protection operation
- **50G-1 Operate** = 50X-1 or 50R-1 Overcurrent Protection operation
- **50G-2 Operate** = 50X-2 or 50R-2 Overcurrent Protection operation
- **BF Trip** = Breaker Failure Trip signal
- **Zone Interlock Output** = Discrete zone interlocking output signal
### Internal Logic

#### Input Signal

![Diagram of Internal Logic Input Signal](image)

- **1.5 * 51P Pickup**
- **50P-1 Pickup**
- **50P-2 Pickup**

**Definitions:**
- **1.5 * 51P Pickup** = \( I_{rms} > 1.5 \times 51P \) Phase Inverse Time Overcurrent Protection Setting
- **50P-1 Pickup** = \( I_{rms} > 50P-1 \) Phase Overcurrent Protection Setting
- **50P-2 Pickup** = \( I_{rms} > 50P-2 \) Phase Overcurrent Protection Setting
- **Zone In Phase Setting** = “Zone In” Protection Setting set to “Phase” or “Both”
- **Zone Input Signal Active** = Discrete zone interlocking input
- **Phase Zone Interlock Pickup** = Pickup flag; does not log an event
- **Phase Zone Interlock Trip** = Trip output; causes event log

---

- **51G Pickup**
- **50G-1 Pickup**
- **50G-2 Pickup**

**Definitions:**
- **51G Pickup** = \( |I_{rms}| > 51X \) or \( |I_{rms}| > 51R \) Inverse Time Overcurrent Protection Setting
- **50G-1 Pickup** = \( |I_{rms}| > 50X-1 \) or \( |I_{rms}| > 50R-1 \) Overcurrent Protection Setting
- **50G-2 Pickup** = \( |I_{rms}| > 50X-2 \) or \( |I_{rms}| > 50R-2 \) Overcurrent Protection Setting
- **Zone In Ground Setting** = “Zone In” Protection Setting set to “Ground” or “Both”
- **Zone Input Signal Active** = Discrete zone interlocking input
- **Ground Zone Interlock Pickup** = Pickup flag; does not log an event
- **Ground Zone Interlock Trip** = Trip output; causes event log
**Table Seven**

Zone Interlock Terminations

<table>
<thead>
<tr>
<th>Ground IN</th>
<th>Drawout</th>
<th>Fixed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase IN</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Phase OUT</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Common</td>
<td>18</td>
<td>15</td>
</tr>
</tbody>
</table>

**Table Eight**

Zone Interlock Availability

<table>
<thead>
<tr>
<th>Device</th>
<th>SHORT DELAY</th>
<th>LONG DELAY</th>
<th>GF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT3000</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>DT-MV</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

**Internal Logic**

**Output Signal**

- Max Phase Irms > Phase O/C Pickup
- Max Phase Irms > Phase SD Pickup

For more information visit: [www.cutler-hammer.eaton.com](http://www.cutler-hammer.eaton.com)
INPUT Signal

- Phase Zone Input
  Signal Active

- Max Phase Irms >
  3 per unit

- Max Phase Irms >
  Phase O/C Pickup

- Max Phase Irms >
  Phase SD Pickup

Ground Zone Input
Signal Active

- Ground Irms >
  Ground O/C Pickup

- Ground Irms >
  Ground SD Pickup

For more information visit: www.cutler-hammer.eaton.com
Low Voltage

Table Nine
Zone Interlock Terminations

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground IN</td>
<td>C5</td>
</tr>
<tr>
<td>Ground OUT</td>
<td>C4</td>
</tr>
<tr>
<td>Phase IN</td>
<td>D9</td>
</tr>
<tr>
<td>Phase OUT</td>
<td>D10</td>
</tr>
<tr>
<td>Common</td>
<td>C1</td>
</tr>
</tbody>
</table>

Table Ten
Zone Interlock Availability

<table>
<thead>
<tr>
<th>Device</th>
<th>SHORT DELAY</th>
<th>LONG DELAY</th>
<th>GF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIGITRIP 510</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>DIGITRIP 610</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>DIGITRIP 810</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>DIGITRIP 910</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>OPTIM 750</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>OPTIM 1050</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>
Internal Logic
Output Signal

- Max Phase Irms > Phase O/C Pickup
  - OR
  - AND
  - 0
  - 175 ms
  - OR
  - Phase Zone Out

- Max Ground Irms > Ground O/C Pickup
  - Max Ground Irms >
  - OR
  - AND
  - 0
  - 175 ms
  - OR
  - Ground Zone Out

Input Signal

- Phase Zone Input Signal Active
  - Latch
  - AND
  - 70 to 90 ms
  - 0
  - OR
  - Phase Trip

- Ground Zone Input Signal Active
  - Latch
  - AND
  - 70 to 90 ms
  - 0
  - OR
  - Ground Trip
Magnum

Digitrip 520, 520M

Table Eleven
Zone Interlock Terminations

<table>
<thead>
<tr>
<th></th>
<th>ZIN</th>
<th>B8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground IN</td>
<td>ZIN</td>
<td>B8</td>
</tr>
<tr>
<td>Ground OUT</td>
<td>ZOUT</td>
<td>B9</td>
</tr>
<tr>
<td>Phase IN</td>
<td>ZIN</td>
<td>B8</td>
</tr>
<tr>
<td>Phase OUT</td>
<td>ZOUT</td>
<td>B9</td>
</tr>
<tr>
<td>Common</td>
<td>COM</td>
<td>B7</td>
</tr>
</tbody>
</table>

Table Twelve
Zone Interlock Availability

<table>
<thead>
<tr>
<th>Device</th>
<th>SHORT DELAY</th>
<th>LONG DELAY</th>
<th>GF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIGITRIP 520</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>DIGITRIP 520M</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>OPTIM 1150</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>
Internal Logic
Output Signal

Max Phase Irms >
Phase O/C Pickup

Max Phase Irms >
Phase SD Pickup

OR1

0

175 ms

OR

Decision to Trip

AND

Phase Zone Out

Ground Zone Out

OR

Decision to Trip

AND

Input Signal

Phase Zone Input Signal Active

Max Phase Irms >
Phase SD Pickup

OR

Latch

AND

70 to 90 ms

ZI Fast Trip

OR

Phase Trip

SD Time

Short Delay Trip

Ground Zone Input Signal Active

Ground Irms >
Ground SD Pickup

OR

Ground Trip

Latch

AND

70 to 90 ms

ZI Fast Trip

OR

Ground Trip

SD Time

Short Delay Trip
### Table Thirteen
#### Zone Interlock Terminations

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground IN</td>
<td>C5</td>
</tr>
<tr>
<td>Ground OUT</td>
<td>C4</td>
</tr>
<tr>
<td>Phase IN</td>
<td>D9</td>
</tr>
<tr>
<td>Phase OUT</td>
<td>D10</td>
</tr>
<tr>
<td>Common</td>
<td>C1</td>
</tr>
</tbody>
</table>

### Table Fourteen
#### Zone Interlock Availability

<table>
<thead>
<tr>
<th>Device</th>
<th>SHORT DELAY</th>
<th>LONG DELAY</th>
<th>GF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIGITRIP 510</td>
<td>●</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>DIGITRIP 610</td>
<td>●</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>DIGITRIP 810</td>
<td>●</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>DIGITRIP 910</td>
<td>●</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>OPTIM 750</td>
<td>●</td>
<td></td>
<td>●</td>
</tr>
<tr>
<td>OPTIM 1050</td>
<td>●</td>
<td></td>
<td>●</td>
</tr>
</tbody>
</table>
Internal Logic

Output Signal

- Max Phase Irms > Phase O/C Pickup
- Max Phase Irms > Phase SD Pickup
  \[ \text{OR} \]
  \[ \text{AND} \]
  \[ 0 \]
  \[ 175 \text{ ms} \]
  \[ \text{OR} \]
  \[ \text{Phase Zone Out} \]
  \[ \text{Decision to Trip} \]

- Max Ground Irms > Ground O/C Pickup
- Max Ground Irms > Ground SD Pickup
  \[ \text{OR} \]
  \[ \text{AND} \]
  \[ 0 \]
  \[ 175 \text{ ms} \]
  \[ \text{OR} \]
  \[ \text{Ground Zone Out} \]
  \[ \text{Decision to Trip} \]

Input Signal

- Phase Zone Input Signal Active
  \[ \text{Latch} \]
  \[ \text{AND} \]
  \[ 70 \text{ to } 90 \text{ ms} \]
  \[ 0 \]
  \[ \text{OR} \]
  \[ \text{Phase Trip} \]
  \[ \text{SD Time} \]
  \[ 0 \]
  \[ \text{Short Delay Trip} \]

- Ground Zone Input Signal Active
  \[ \text{Latch} \]
  \[ \text{AND} \]
  \[ 70 \text{ to } 90 \text{ ms} \]
  \[ 0 \]
  \[ \text{OR} \]
  \[ \text{Ground Trip} \]
  \[ \text{SD Time} \]
  \[ 0 \]
  \[ \text{Short Delay Trip} \]
**Table Fifteen**

**Zone Interlock Terminations**

<table>
<thead>
<tr>
<th>Device</th>
<th>SHORT DELAY</th>
<th>LONG DELAY</th>
<th>GF</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIGITRIP 510</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>DIGITRIP 610</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>DIGITRIP 810</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>DIGITRIP 910</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>OPTIM 750</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>OPTIM 1050</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>
**Internal Logic**

**Output Signal**

- Max Phase Irms > Phase O/C Pickup
- Max Phase Irms > Phase SD Pickup

\[ OR \]

\[ AND \]

\[ 0 \quad 175 \text{ ms} \]

- Decision to Trip

\[ OR \]

\[ Phase Zone Out \]

- Max Ground Irms > Ground O/C Pickup
- Max Ground Irms > Ground SD Pickup

\[ OR \]

\[ AND \]

\[ 0 \quad 175 \text{ ms} \]

- Decision to Trip

\[ OR \]

\[ Ground Zone Out \]

**Input Signal**

- **Ground Zone Input Signal Active**

\[ Latch \quad AND \]

\[ 70 \text{ to } 90 \text{ ms} \quad 0 \]

- ZI Fast Trip

\[ OR \]

- **Ground Trip**

\[ SD Time \quad 0 \]

- Short Delay Trip

- **Phase Zone Input Signal Active**

\[ Latch \quad AND \]

\[ 70 \text{ to } 90 \text{ ms} \quad 0 \]

- ZI Fast Trip

\[ OR \]

- **Phase Trip**

\[ SD Time \quad 0 \]

- Short Delay Trip
Applications

Basic Distribution

Zone Interlocks communicate fault conditions across zones. A zone is a section of the power distribution system that is connected at a common point above ground. Zone interlocking works in parallel with a coordinated protection of a power distribution system. Figure A shows a system that uses zone interlocks. Eaton|Cutler-Hammer can utilize zone interlocks on Medium and Low voltage distribution systems. When a device with the zone interlock option senses an irregular condition, such as a fault or overcurrent condition, a signal is sent to the upstream device to prevent it from tripping instantaneously. Only the local device will trip unless the coordinated protection levels are exceeded. The protection levels are not compromised.

If a fault would occur at point B and the 100 A breaker feeding load LP-1 does not have ZI capabilities no signal will be sent upstream. If the fault magnitude is high enough the upstream devices may also trip. This will protect the system from further damage but may also take out the additional device fed by the upstream breaker creating a larger outage than necessary.

If a fault were to occur at C the 100 A breaker feeding load LP-2 with ZI capabilities would send a signal upstream. This signal would be used to communicate a disturbance and the upstream device will trip after its coordinated time delay. The device immediately preceding disturbance, the 100 A breaker feeding load LP-2, will extinguish the fault condition. There are three benefits by applying ZI to the system.

1. The disturbance is cleared sooner.
2. The disturbance is isolated from the rest of the system.
3. Trouble shooting can be more efficient.

Assuming that the tie is open and the backup generator is isolated from the 380 Vac bus. If a fault would occur at a bus location, point A for example, the 2500 A main breakers would trip instantaneously. This is because a signal would not be sent from a down stream device. Due to the location of the fault the main breakers will trip instantaneously because there will be no devices to
send a signal to the 2500 A mains. The breaker immediately upstream of the fault will react instantaneously to the disturbance eliminating the programmed time delay. This functionality greatly reduces the amount of stress on the system because of the quick response.

Self-Interlocking

If preferred the ZI signal may be defeated by sending the output signal to the input. This can be accomplished by placing a jumper between the output and input signals on the device. When a disturbance occurs, the signal output will be fed into the input defeating an instantaneous response. This may be applied to breakers that serve loads that should not be interrupted unless the protection limits are exceeded.

Transformer Inrush

Applying zone interlocking on the primary side of a transformer may cause false trips due to high transformer inrush currents that may be greater than 12X the FLA rating of the transformer with the secondary open. In order to prevent the breaker on the primary side from tripping in a nuisance condition a self interlocking jumper should be installed during the energizing of the transformer, which can last from 10 cycles to several minutes.

This may be accomplished by using a timer that closes a contact during the inrush period of the transformer across the zone interlock output and input terminals of the device. If a harmonic restrain unit that monitors 2nd order harmonics is available; a contact closure from the harmonic restraining unit can be used as a self-interlocking jumper. The self-interlocking jumper would allow the device to trip according to preset coordinated time current curves and temporarily disable the instantaneous zone interlock feature.

Advanced Applications

The following applications are for main tie main (M-T-M) configurations. M-T-M configuration is used to maintain a reliable backup source of utility power should the primary fail.

Scheme 1:

M-T-M, without Digitrip on Bus TIE breaker and without partial differential

---

The self interlocking jumper must be installed in the device of the last zone or coordination will be lost!

---

CAUTION

Scheme 1:

a) Bus TIE Circuit Breaker Open, M1 and M2 Closed.

Fault at XF1

The DT3000 on F1 will detect a fault at point XF1. It will send a zone interlock signal to zone one devices located on M1 and M2. This will keep the M1 and M2 devices from tripping unless their coordinated protection times are exceeded.

Fault at XF2

The DT3000 on F2 will detect a fault at point XF2. It will send a zone interlock signal to zone one devices located on M1 and M2. This will keep the M1 and M2 devices from tripping unless their coordinated protection times are exceeded.

Fault at X1

The DT3000 on M1 will detect a fault at point X1 and the fault will be ignored by F1 and F2. M1 will not receive a zone interlock signal and will trip instantly. This will limit damage to the system bypassing the coordinated trip time.

Fault at X2

The DT3000 on M2 will detect a fault at point X2 and the fault will be ignored by F1 and F2. M2 will not receive a zone interlock signal and will trip instantly. This will limit damage to the system bypassing the coordinated trip time.
Fault at XS1 or at XS2
Source devices upstream of M1 and M2 must clear these faults.

b) Bus TIE Circuit Breaker Closed, M1 Closed and M2 Closed.
Fault at XF1
The DT3000 on F1 will detect a fault at point XF1. It will send a zone interlock signal to zone one devices located on M1 and M2. This will keep the M1 and M2 devices from tripping unless their coordinated protection times are exceeded.

Fault at X1
The DT3000s on M1 and M2 will not receive a zone interlock signal; M1 and M2 will trip instantaneously. This will limit damage to the system bypassing the coordinated trip time. This will also be difficult to determine which side had the fault since both mains tripped.

Fault at XF2
The DT3000 on F2 will detect a fault at point XF2. It will send a zone interlock signal to zone one devices located on M1 and M2. This will keep the M1 and M2 devices from tripping unless their coordinated protection times are exceeded.

Fault at X2
Again the DT3000s on M1 and M2 will not receive a zone interlock signal; M1 and M2 will trip instantaneously. This will limit damage to the system bypassing the coordinated trip time. This will also be difficult to determine which side had the fault since both mains tripped.

Fault at XS1
Source 2 will feed the fault at XS1 through M2, the Tie and reverse feed M1.

The DT3000 at M2 and the DT3000 at M1 will both see and measure the same current because polarity does not have an affect on the DT3000.

If M1 opens first, power to Bus-1 and Bus-2 will continue. The fault will ultimately be cleared by opening the Source 1 upstream device.

If M2 opens first, supply to Bus-1 and Bus-2 is lost. Opening the Source 1 upstream device will ultimately clear the fault.

Fault at XS2
Source 1 will feed the fault at XS2 through M1, the Tie and reverse feed M2.

The DT3000 at M2 and the DT3000 at M1 will both see and measure the same current because polarity does not have an affect on the DT3000.

If M2 opens first, power to Bus-1 and Bus-2 will continue. Opening the Source 1 upstream device will ultimately clear the fault.

If M1 opens first, supply to Bus-1 and Bus-2 is lost. Opening of the Source 1 upstream device will ultimately clear the fault.

c) Bus TIE Circuit Breaker Closed, M1 Closed, M2 Open
Fault at XF1
The DT3000 at F1 will restrain M1 DT3000 and M2 DT3000. The restrain signal will not have an affect on M2 DT3000 since the breaker M2 is already open and is not carrying any current. The DT3000 at F1 will clear the fault or the DT3000 at M1 will clear the fault after its coordinated time delay.

Fault at XF2
The DT3000 at F2 will restrain M1 DT3000 and M2 DT3000. The restrain signal will not have an affect on M2 DT3000 since the breaker M2 is already open and is not carrying any current. The DT3000 at F1 will clear the fault or the DT3000 at M1 will clear the fault after its coordinated time delay.

Fault at X1 or X2
No restrain signal will be sent to the DT3000 at M1. The DT3000 at M1 will clear the fault instantaneously minimizing damage to the power distribution system.

Fault at XS1 or XS2
The source devices upstream of M1 and M2 must clear these faults.

d) Bus TIE Circuit Breaker Closed, M1 Open, M2 Closed
Fault at XF1
The F1 DT3000 will restrain M1 DT3000 and M2 DT3000. The restrain signal does not have an affect on M1 DT3000 since the breaker M1 is already open and is not carrying any current; F1 DT3000 will clear the fault. This will keep the M2 device from tripping
unless its coordinated protection time is exceeded.

Fault at XF2
The F2 DT3000 will restrain M1 DT3000 and M2 DT3000. The restrain signal does not have an affect on M1 DT3000 since the breaker M1 is already open and is not carrying any current; F2 DT3000 will clear the fault. This will keep the M2 device from tripping unless its coordinated protection time is exceeded.

Fault at X1 or X2
No restraining signal is given to M2 DT3000. The M2 DT3000 will clear the fault instantaneously.

Fault at XS1 or XS2
The source devices upstream of M1 and M2 must clear these faults.

Scheme 2:
M-T-M ZSI, with a dedicated Digitrip provided on Bus TIE, but without partial differential

a) Bus TIE Circuit Breaker Open, M1 Closed, M2 Closed
Fault at XF1
F1 DT3000 will provide restrain signal to M1 DT3000, M2 DT3000 and TIE DT3000. The signal does not have an affect on the TIE DT3000 since the TIE breaker is already open and not carrying any current. The F1 DT3000 clears the fault after the coordinated time delay.

Fault at X1
No restraining signal is transmitted to M1 DT3000. M1 clears the fault instantaneously.

Fault at XF2
F2 DT3000 will provide restrain signal to M1 DT3000, M2 DT3000 and TIE DT3000. The signal does not have an affect on the TIE DT3000 since the TIE breaker is already open and not carrying any current. The F2 DT3000 clears the fault after the coordinated time delay.

Fault at X2
No restraining signal is transmitted to M2 DT3000. M2 clears the fault.

Fault at XS1 or at XS2
Source devices upstream of M1 and M2 must clear these faults

b) Bus TIE Circuit Breaker Closed, M1 Closed and M2 Closed
Fault at XF1
Both sources will feed into this fault. F1 DT3000 will provide restrain signal to M1 DT3000, Bus TIE DT3000 and M2 DT3000. The Bus TIE DT3000 will also provide restrain signal to M1 DT3000 and M2 DT3000. The F1 DT3000 will clear the fault after the coordinated time delay.

Fault at XF2
Both sources will feed into this fault. F2 DT3000 will provide restrain signal to M2 DT3000, Bus TIE DT3000 and M1 DT3000. The Bus TIE DT3000 will also provide restrain signal to M1 DT3000 and M2 DT3000. The F2 DT3000 will clear the fault after the coordinated time delay.

Fault at X1
Both sources will feed into this fault through M1, M2 and the closed TIE. The Bus TIE DT3000 will provide restrain signal to M1 DT3000 and M2 DT3000. The Bus TIE will TRIP instantaneously because no restraint signal will be sent from the DT3000s on F1 and F2. The M1 will TRIP instantaneously after the restrain signal from the TIE is removed and will clear the fault. Service to Bus-2 will continue.

Fault at X2
Both sources will feed into this fault through M1, M2 and the closed TIE. The Bus TIE DT3000 will provide restrain signal to M1 DT3000 and M2 DT3000. The Bus TIE will TRIP instantaneously because the restraint signal will not be sent from the DT3000s on F1 and F2. The M2 will TRIP instantaneously after the restrain
signal from the TIE is removed and will clear the fault. Service to Bus-1 will continue.

Fault at XS1

Source 2 will feed into this fault via M2, Bus TIE and M1. The Bus TIE DT3000 will restrain M1 and M2. Bus TIE breaker will OPEN. The fault is ultimately cleared by Source 1 upstream device. Service to Bus-2 will continue.

Fault at XS2

Source 1 will feed into this fault via M1, Bus TIE and M2. The Bus TIE DT3000 will restrain M1 and M2. Bus TIE breaker will OPEN. The fault is ultimately cleared by Source 2 upstream device. Service to Bus-1 will continue.

c) Bus TIE Circuit Breaker Closed, M1 Closed, M2 Open

Fault at XF1

The DT3000 at F1 will restrain M1 DT3000, Bus TIE DT3000 and M2 DT3000. The restraining signal will not have an affect on the M2 DT3000 since the breaker M2 is already open and is not carrying any current. The F1 DT3000 will clear the fault instantaneously.

Fault at XF2

F2 DT3000 will restrain M2 DT3000, Bus TIE DT3000 and M1 DT3000. The Bus TIE DT3000 will also restrain M1 DT3000 and M2 DT3000. The restrain signals will not have an affect on the M2 DT3000 since the breaker M2 is already open and is not carrying any current. The F2 DT3000 will clear the fault instantaneously.

Fault at X1

No restraining signal is transmitted to M1 DT3000. M1 clears the fault.

Fault at X2

Bus TIE DT3000 will provide restrain signal to M1 DT3000 and M2 DT3000. The restrain signal will not have an affect on M2 DT3000 since the breaker M2 is already open and is not carrying any current. The Bus TIE will TRIP instantaneously to clear the fault. Service to Bus-2 will continue.

Fault at XS1 or XS2

The source devices upstream of M1 and M2 must clear these faults.

d) Bus TIE Circuit Breaker Closed, M1 Open, M2 Closed

Fault at XF2

F2 DT3000 will restrain M2 DT3000, Bus TIE DT3000 and M1 DT3000. The restrain signal has no effect on M1 DT3000 since the breaker M1 is already open and is not carrying any current. The F2 DT3000 will clear the fault after the coordinated time delay.

Fault at XF1

F1 DT3000 will restrain M1 DT3000, Bus TIE DT3000 and M2 DT3000. The Bus TIE DT3000 will also restrain M1 DT3000 and M2 DT3000. The restrain signals do not have an affect on M1 DT3000 since the breaker M1 is already open and is not carrying any current. The F1 DT3000 will clear the fault after the coordinated time delay.

Fault at X2

No restraining signal is transmitted to M2 DT3000. M2 clears the fault instantaneously.

Fault at X1

Bus TIE DT3000 will provide restrain signal to M1 DT3000 and M2 DT3000. The restrain signal does not have an affect on the M1 DT3000 since the breaker M1 is already open and is not carrying any current. The Bus TIE will TRIP to clear the fault instantaneously. Service to Bus-2 will continue.

Fault at XS1 or XS2

The source devices upstream of M1 and M2 must clear these faults.
**Scheme 3:**

M-T-M ZSI without a separate Digitrip on Bus TIE, but with partial differential CT wiring, M2 DT3000 will not see the fault current and will not pickup. (Notice that the current flowing from Source 2 through M2 and Bus TIE will balance out in the CT secondary circuit of the M2 DT3000). F1 DT3000 will restrain M1 DT3000 keeping the M1 and TIE devices from being activated by the 86-1 device. The F1 DT3000 will clear the fault after coordinated time delay. Service to Bus-1 and Bus-2 will not be affected.

**Fault at X1**

Both sources will feed into this fault. Because of partial differential CT wiring, M2 DT3000 will not see the fault current and will not pickup. (Notice that the current flowing from Source 2 through M2 and Bus TIE will balance out in the CT secondary circuit of the M2 DT3000). Also, no restrain signal is transmitted to M1 DT3000. The M2 DT3000 will see sum total of the two sources. It will instantaneously open M1 and Bus TIE via 86-1 to clear the fault. Service to Bus-2 will not be affected.

**Fault at X2**

Both sources will feed into this fault. Because of partial differential CT wiring, M1 DT3000 will not see the fault current and will not pickup. (Notice that the current flowing from Source 1 through M1 and Bus TIE will balance out in the CT secondary circuit of the M1 DT3000). Also, no restrain signal is transmitted to M2 DT3000. The M1 DT3000 will see sum total of the two sources. It will instantaneously open M2 and Bus TIE via 86-2 to clear the fault. Service to Bus-1 will not be affected.

**Fault at XS1 or XS2**

The source devices upstream of M1 and M2 must clear these faults.

**b) Bus TIE Circuit Breaker Closed, M1 Closed and M2 Closed**

Fault at XF1

Both sources will feed into this fault. Because of partial differential CT wiring, M2 DT3000 will not see the fault current and will not pickup. (Notice that the current flowing from Source 2 through M2 and Bus TIE will balance out in the CT secondary circuit of the M2 DT3000). F1 DT3000 will restrain M1 DT3000 keeping the M1 and TIE devices from being activated by the 86-1 device. The F1 DT3000 will clear the fault after coordinated time delay. Service to Bus-1 and Bus-2 will not be affected.

**Fault at X1**

Both sources will feed into this fault. Because of partial differential CT wiring, M2 DT3000 will not see the fault current and will not pickup. (Notice that the current flowing from Source 2 through M2 and Bus TIE will balance out in the CT secondary circuit of the M2 DT3000). Also, no restrain signal is transmitted to M1 DT3000. The M1 DT3000 will see sum total of the two sources. It will instantaneously open M1 and Bus TIE via 86-1 to clear the fault. Service to Bus-2 will not be affected.

**Fault at X2**

Both sources will feed into this fault. Because of partial differential CT wiring, M1 DT3000 will not see the fault current and will not pickup. (Notice that the current flowing from Source 1 through M1 and Bus TIE will balance out in the CT secondary circuit of the M1 DT3000). Also, no restrain signal is transmitted to M2 DT3000. The M2 DT3000 will see sum total of the two sources. It will instantaneously open M2 and Bus TIE via 86-2 to clear the fault. Service to Bus-1 will not be affected.

**Fault at XS1 or XS2**

The source devices upstream of M1 and M2 must clear these faults.

**c) Bus TIE Circuit Breaker Closed, M1 Closed, M2 Open**
Fault at XF1
F1 DT3000 will restrain M1 DT3000. The F1 DT3000 will clear the fault after the coordinated time delay.

Fault at XF2
M1 DT3000 will not see the fault current due to partial differential CT connections. M2 DT3000 will see this fault current via Bus TIE CTs. However, it is restrained by F2 DT3000. The F2 DT3000 will clear the fault after the coordinated time delay.

Fault at X1
No restrain signal is transmitted to M1 DT3000. It will clear the fault instantaneously.

Fault at X2
M1 DT3000 will not see the fault current due to partial differential CT connections. M2 DT3000 will see this fault current via Bus TIE CTs. Also notice, there is no restrain signal provided to M2 DT3000. It will clear the fault by instantaneously opening Bus TIE via 86-2.

Fault at XS1 or XS2
The source devices upstream of M1 and M2 must clear these faults.

d) Bus TIE Circuit Breaker Closed, M1 Open, M2 Closed

Fault at XF2
F2 DT3000 will restrain M2 DT3000. The F2 DT3000 will clear the fault after the coordinated time delay.

Fault at XF1
M2 DT3000 will not see the fault current due to partial differential CT connections. M1 DT3000 will see this fault current via Bus TIE CTs. However, it is restrained by F1 DT3000. The F1 DT3000 will clear the fault after the coordinated time delay.

Fault at X2
No restrain signal is transmitted to M2 DT3000. It will clear the fault instantaneously.

Fault at X1
M2 DT3000 will not see the fault current due to partial differential CT connections. M1 DT3000 will see this fault current via Bus TIE CTs. Also notice, there is no restrain signal provided to M1 DT3000. It will clear the fault by instantaneously opening Bus TIE via 86-1.

Fault at XS1 or XS2
The source devices upstream of M1 and M2 must clear these faults.

**Scheme 4:**
M-T-M ZSI with a separate Digitrip on Bus TIE and with partial differential

![Scheme 4](image)

a) Bus TIE Circuit Breaker Open, M1 Closed, M2 Closed

Fault at XF1
F1 DT3000 will restrain M1 DT3000 and Bus TIE DT3000. The F1 DT3000 will clear the fault after the coordinated time delay.

Fault at X1
No restrain signal transmitted to M1 DT3000. The M1 DT3000 clears the fault instantaneously by opening M1 via 86-1.

Fault at XF2
F2 DT3000 will restrain M2 DT3000 and Bus TIE DT3000. The F2 DT3000 will clear the fault after the coordinated time delay.

Fault at X2
No restrain signal transmitted to M2 DT3000. The M2 DT3000 clears the fault instantaneously by opening M2 via 86-2.

Fault at XS1 or XS2
The source devices upstream of M1 and M2 must clear
these faults.

b) Bus TIE Circuit Breaker Closed, M1 Closed and M2 Closed

Fault at XF1

Both sources will feed into this fault. Because of partial differential CT wiring, M2 DT3000 will not see the fault current and will not pickup. (Notice that the current flowing from Source 2 through M2 and Bus TIE will balance out in the CT secondary circuit of the M2 DT3000). F1 DT3000 will restrain M1 DT3000 and Bus TIE DT3000. The F1 DT3000 will clear the fault after the coordinated time delay. Service to Bus-1 and Bus-2 will not be affected.

Fault at X1

Both sources will feed into this fault. Because of partial differential CT wiring, M2 DT3000 will not see the fault current and will not pickup. (Notice that the current flowing from Source 2 through M2 and Bus TIE will balance out in the CT secondary circuit of the M2 DT3000). Also, no restrain signal is transmitted to M1 DT3000 or Bus TIE DT3000. The M1 DT3000 will see sum total of the two sources. The Bus TIE DT3000 will see the current contribution from Source 2. The M1 DT3000 will instantaneously open M1 and Bus TIE via 86-1 to clear the fault. The Bus TIE DT3000 may also pickup at the same time and trip Bus TIE. Service to Bus-2 will not be affected.

Fault at XF2

Both sources will feed into this fault. Because of partial differential CT wiring, M1 DT3000 will not see the fault current and will not pickup. (Notice that the current flowing from Source 1 through M1 and Bus TIE will balance out in the CT secondary circuit of the M1 DT3000). F2 DT3000 will restrain M2 DT3000 and Bus TIE DT3000. The F2 DT3000 will clear the fault after the coordinated time delay. Service to Bus-1 and Bus-2 will not be affected.

d) Bus TIE Circuit Breaker Closed, M1 Open, M2 Closed

Fault at XF2

F2 DT3000 will restrain M2 DT3000 and Bus TIE DT3000. The F2 DT3000 will clear the fault after the coordinated time delay.

Fault at XF2

M1 DT3000 will not see the fault current due to partial differential CT connections. M2 DT3000 and Bus TIE DT3000 will see this fault current. Also, no restraining signal is transmitted to M1 DT3000 or Bus TIE DT3000. The M2 DT3000 will clear the fault after the coordinated time delay. Service to Bus-1 and Bus-2 will not be affected.

Fault at FS1 or FS2

The source devices upstream of M1 and M2 must clear these faults.
restrained by F1 DT3000. The F1 DT3000 will clear the fault after the coordinated time delay.

Fault at X2

No restrain signal is transmitted to M2 DT3000. It will clear the fault instantaneously.

Fault at X1

M2 DT3000 will not see the fault current due to partial differential CT connections. M1 DT3000 and Bus TIE DT3000 will see this fault current. Also notice, a restrain signal is not provided to M1 DT3000 or Bus TIE DT3000. The fault is cleared instantaneously by the action of either Bus TIE DT3000 or M1 DT3000.

Fault at XS1 or XS2

The source devices upstream of M1 and M2 must clear these faults.

**Scheme 5:**

Three Mains, Two Ties, with ZSI, with partial differential CT connections

Summary

**Scheme 1:**

- Zone selective interlocking provides excellent coordination for feeder faults.
- When operating with the bus TIE breaker closed, this Scheme is unable to discriminate bus-1 faults from bus-2 faults. Bus fault on either bus will result in total outage.

**Scheme 2:**

- Zone selective interlocking provides excellent coordination for feeder faults. It discriminates bus-1 faults from bus-2 faults.
- When operating with both mains and bus TIE breaker closed, bus faults are cleared by first opening of the bus TIE breaker and then the main breaker associated with the faulted bus. The total clearing time for bus fault is slightly longer when compared to Scheme 3 or 4.

**Scheme 3:**

- Zone selective interlocking provides excellent coordination for feeder faults. It discriminates bus-1 faults from bus-2 faults.
- When operating with both mains and bus TIE closed, in case of a bus fault, the Digitrip unit associated with the faulted bus sees the current contribution of Source 1 and Source 2. The unit detects the bus fault in a shortest possible time, and isolates the faulted bus by simultaneous tripping of the bus TIE and the associated main breaker.

**Scheme 4:**

- The performance of this Scheme is the same as Scheme 3 above except it includes an additional dedicated DT3000 unit in bus TIE circuit. The additional DT3000 unit (and its associated set of CTs) provides backup protection for both, the bus and feeder faults, when operating with the Bus TIE closed.

**Scheme 5:**

- In the case of three mains and two ties (and other ring bus configurations with more than two sources with bus ties), zone selective interlocking, with partial differential CT connections, provides excellent coordination for feeder faults. It discriminates bus faults and quickly isolates the faulty bus by opening the associated main and bus tie breakers associated with the faulty bus.

In this scheme, feeders on each bus are grouped and zone interlocked with the trip unit on the respective main breaker. The feeder DT3000 units clear the feeder faults. In case of a bus fault, DT3000 on the main breaker associated with the faulted bus will see the sum total of all sources. It will quickly energize its lockout relay to isolate the fault by opening the associated main and bus tie breaker(s). The main DT3000 units on non-faulted bus will not see the fault current fed from its source due to differentially wired CT connections. It is very complicated and difficult to zone interlock this system without the benefits of differentially wired CT connections.
· The bus faults are detected in the shortest possible time and isolated by simultaneous tripping of the main and bus tie breakers associated with the faulted bus.

· With multiple mains and bus ties, partial differential CT connections allow use of zone selective interlock feature of Digitrip units without complicated control wiring.

As you can see, Scheme 3 has advantage over Scheme 2 as far as total clearing time during a bus fault when operating with both mains and bus tie closed. Scheme 2 uses a dedicated DT3000 and 3 CTs on bus TIE and 2 diodes in the ZSI wiring (1 for phase ZSI and 1 for ground ZSI), whereas Scheme 3 uses 6 CTs on the bus TIE for partial differential wiring and two lockout relays, 86-1 and 86-2. Eaton|Cutler-Hammer recommends Scheme 3 over Scheme 2 because the cost of hardware for both is about the same.

The additional dedicated DT3000 and set of CTs add cost in Scheme 4, but provide a very important backup protection for bus and feeder faults when operating with Bus TIE breaker closed. Therefore, supply it if customers ask for a separate DT3000 on the bus tie circuit.