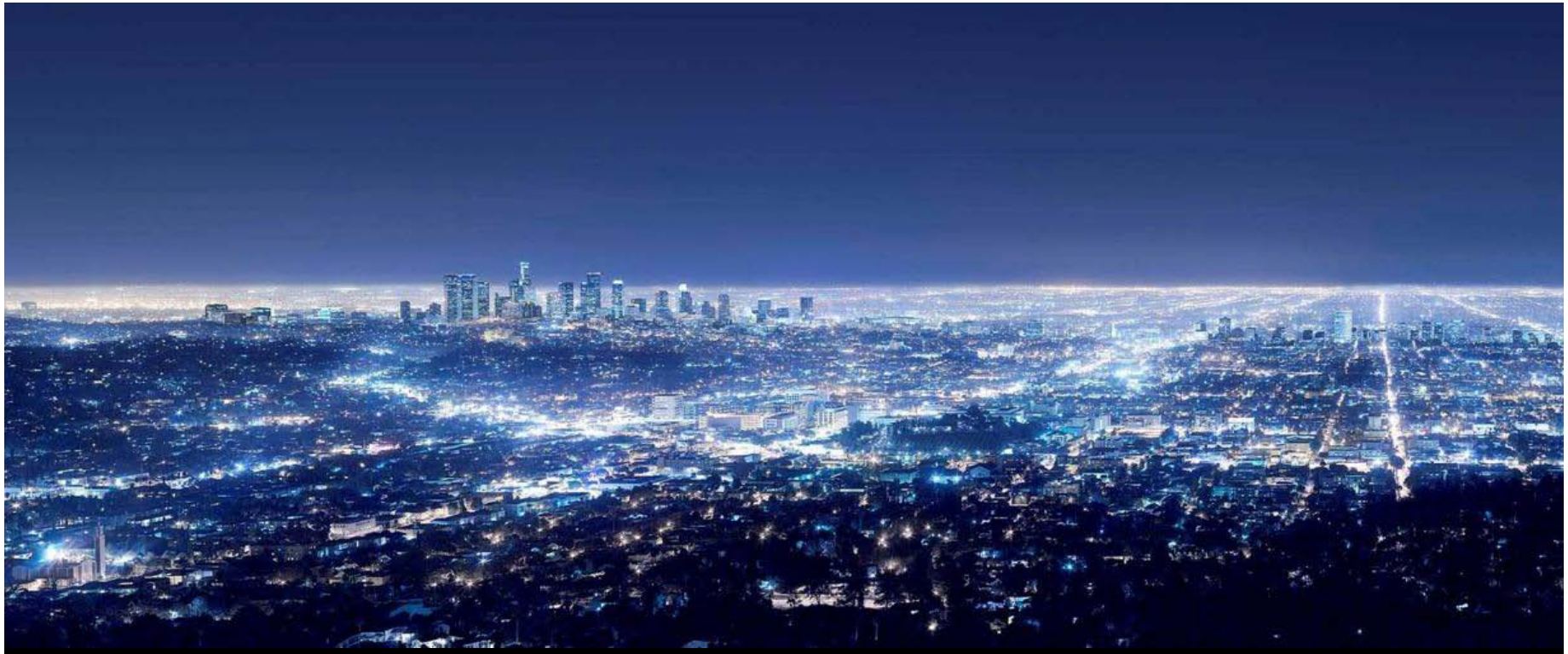
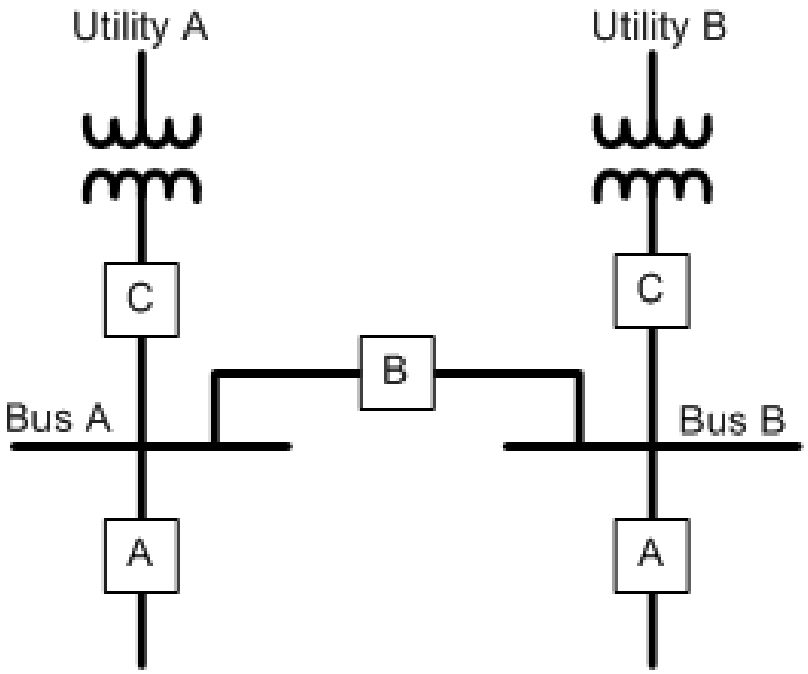


66thTexas A&M Relay Conference, April 10, 2013

Reducing Tripping Times in Medium Voltage Switchgear

Typical Main-Tie-Main Layout



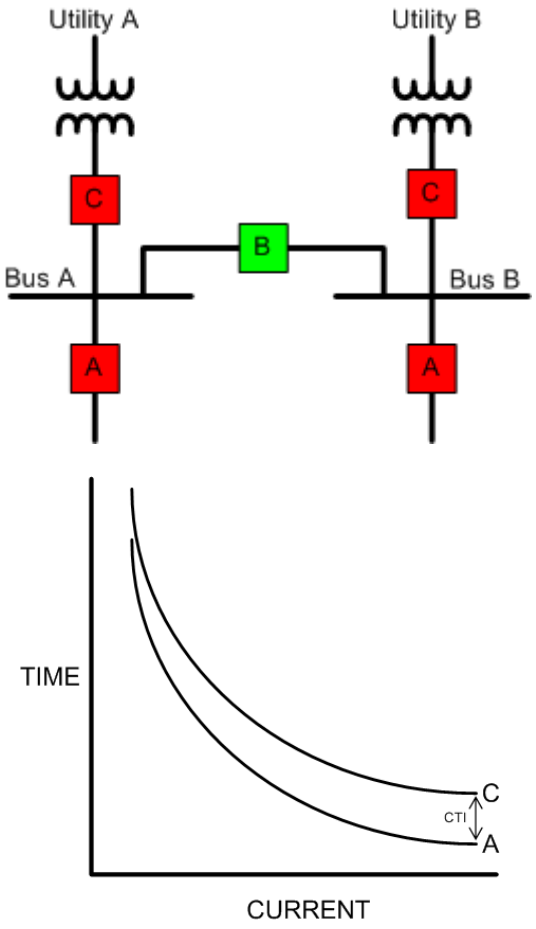
- Tie Breaker (B) is normally open
- Tie Breaker may be closed if one transformer has failed or is being maintained

Typical Main-Tie-Main Layout
Three Strategies for Improving Coordination Times

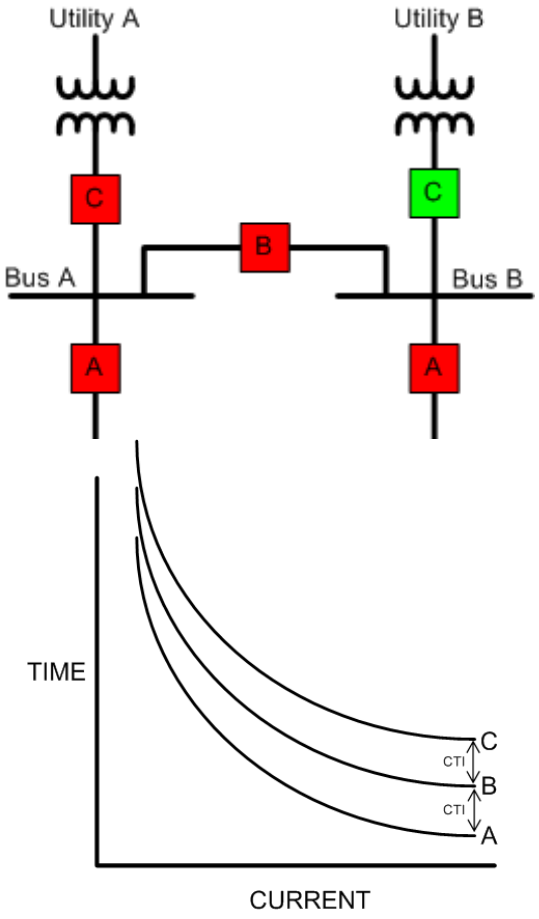
- Dynamic Setting Group Change
- IEC61850 GOOSE Blocking Scheme (aka zone interlock scheme)
- Electronically Triggered Fault Current Limiter (ET-FCL)

Typical Main-Tie-Main Layout
Dynamic Setting Group Change

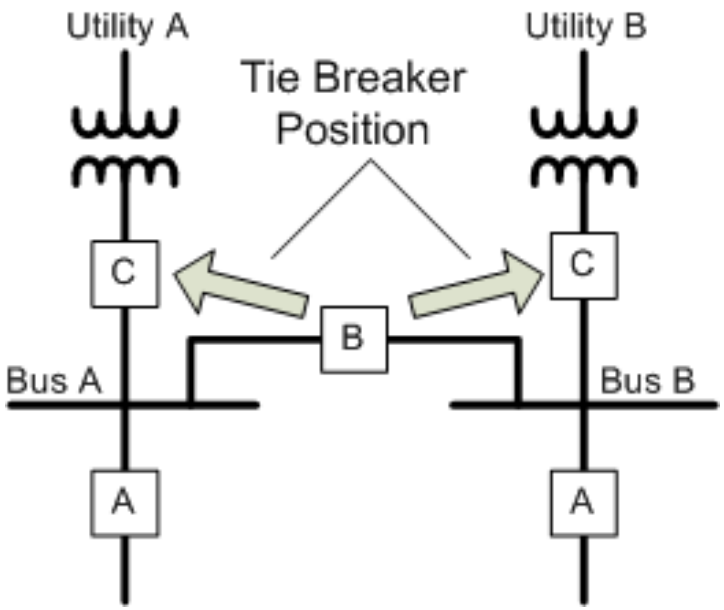
Open-Tie (Normal)



Tie-Closed (xfmr maintenance)

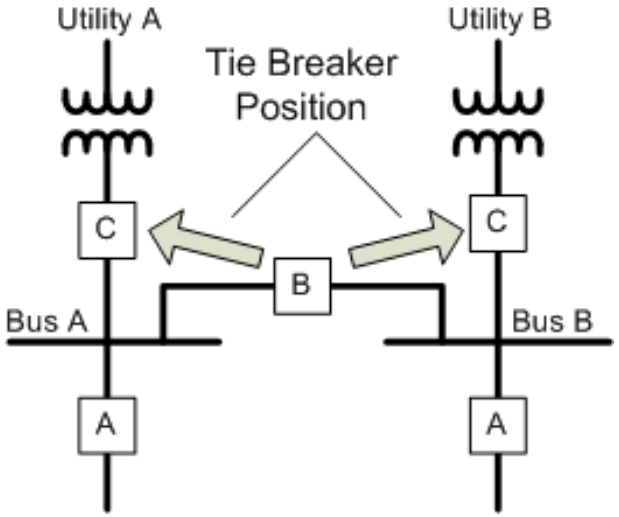


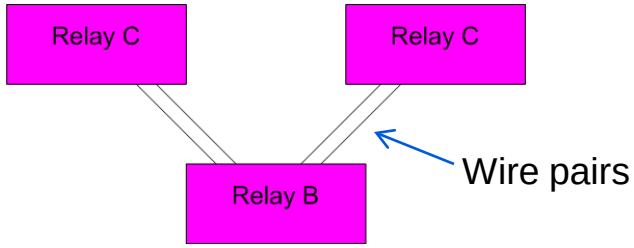
Typical Main-Tie-Main Layout
Dynamic Setting Group Change



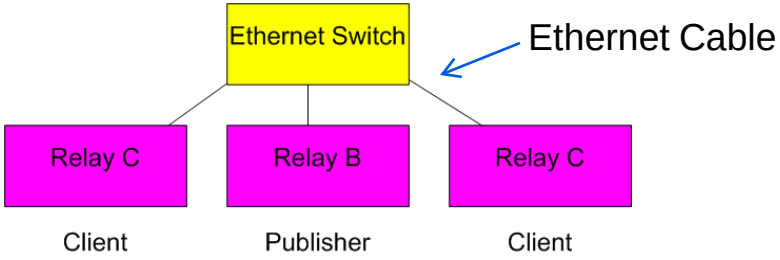
- Tie Breaker Open –
  Relay C coordinates with Relay A
  Setting Group #1 at Relay C
- Tie Breaker Closed –
  Relay C coordinates with Relay B
  Setting Group #2 at Relay C

Typical Main-Tie-Main Layout
Dynamic Setting Group Change





Hardwire Implementation

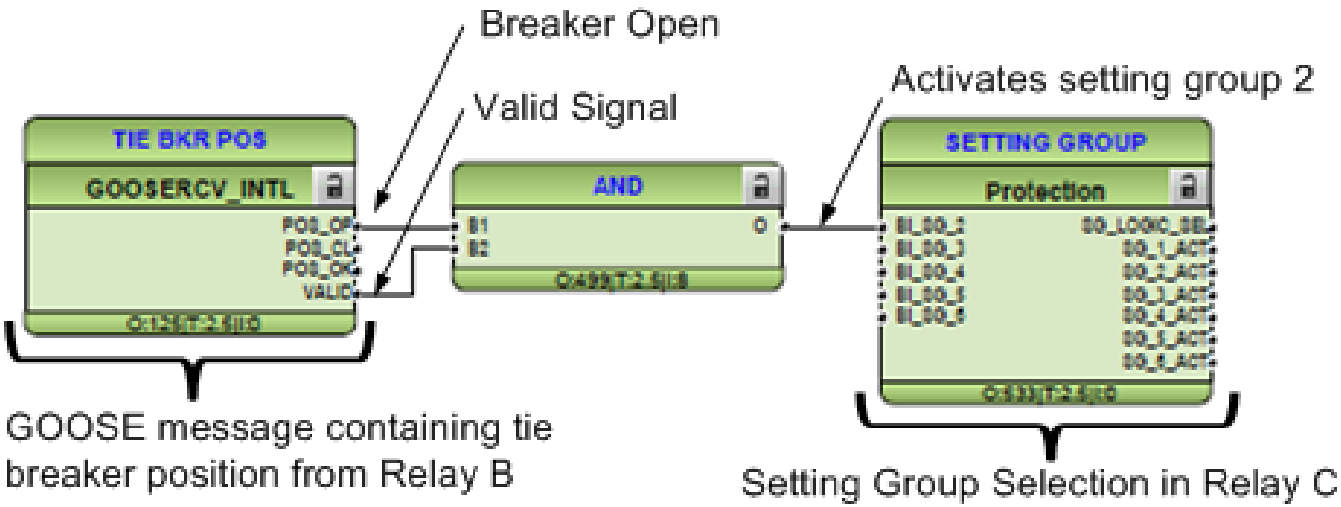


GOOSE Implementation

GOOSE = Generic Object Oriented Substation Event

Typical Main-Tie-Main Layout
Dynamic Setting Group Change

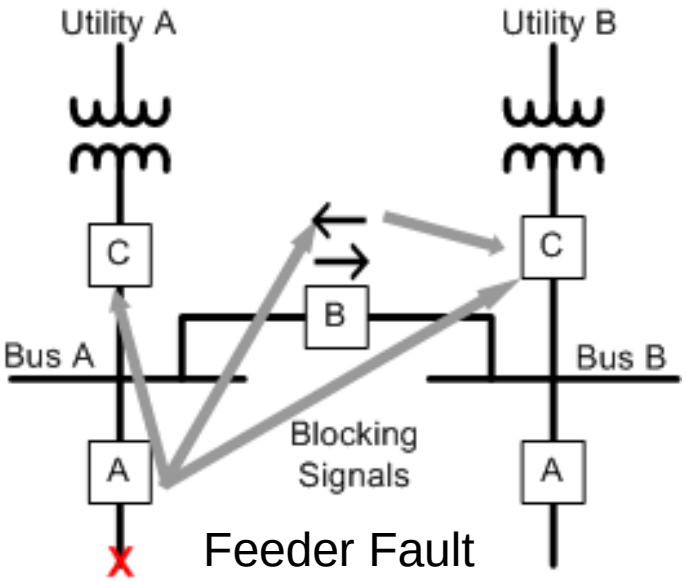
Typical GOOSE Implementation of Dynamic Setting Group Change Logic



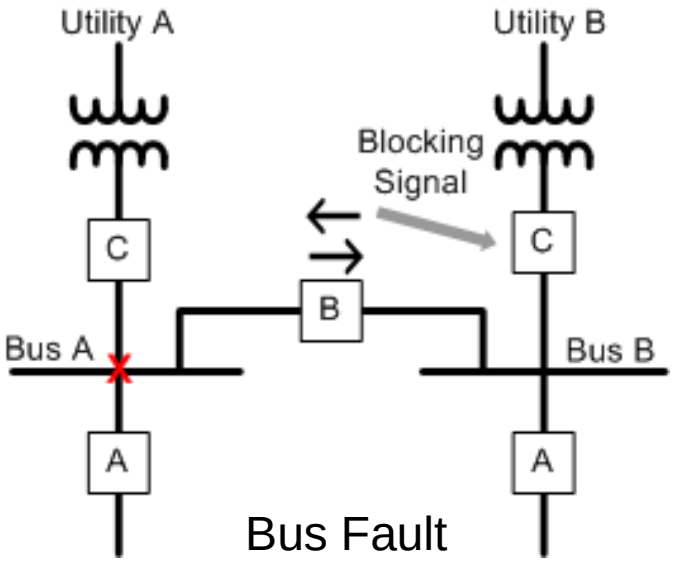
Typical Main-Tie-Main Layout
Dynamic Setting Group Change

- Advantages
  - Simple to implement (with microprocessor relays)
  - Can be implemented with either hardwires or GOOSE (if relay supports GOOSE)
  - Improves main relay coordination 1 level
- Disadvantages
  - Hardwire connections are not typically monitored

Typical Main-Tie-Main Layout
IEC61850 GOOSE Blocking Scheme



Feeder Fault

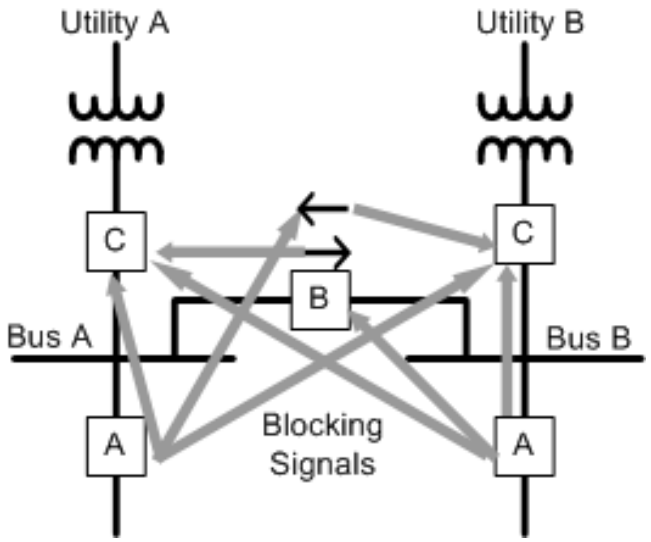


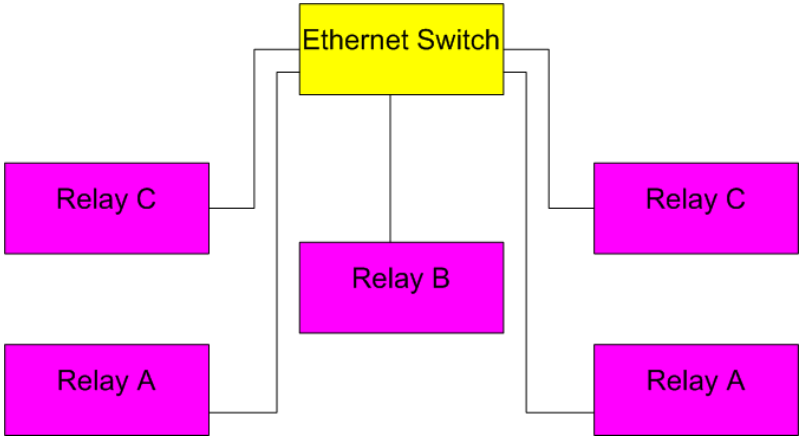
Bus Fault

Several relays may pick up but the most downstream relay sends blocking signals upstream to temporarily prevent them from tripping.

Upstream relay inst trips are delayed about 1 cycle to allow receipt of a blocking signal. If no blocking signal is received, upstream relays are allowed to trip for fast bus fault clearing (about 2 cycles + breaker op time)

Typical Main-Tie-Main Layout
IEC61850 GOOSE Blocking Scheme





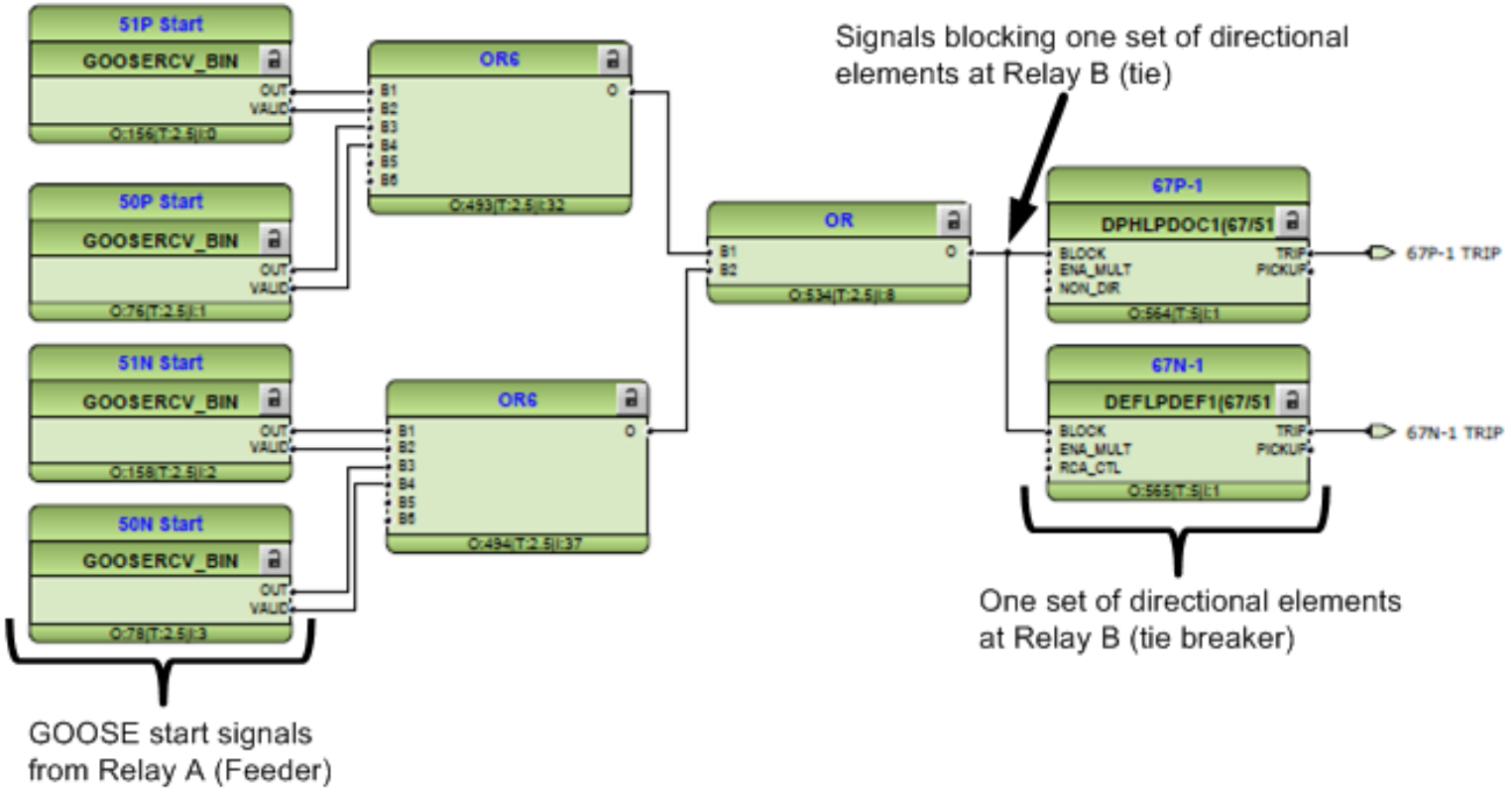
Hardwire Implementation

- Each arrow represents a wire pair
- Each additional feeder adds 3 wire pairs
- Communication paths are not monitored
- Typical blocking delay is 5+ cycles

GOOSE Implementation

- Single Ethernet connection between relays and switch
- Each additional relay adds 1 Ethernet cable
- All communication paths are continuously monitored
- Typical blocking delay is 1 cycle

Typical Main-Tie-Main Layout
IEC61850 GOOSE Blocking Scheme



Typical Main-Tie-Main Layout
GOOSE Blocking Scheme

- Advantages
  - Simple physical implementation
  - Very fast operation…typically 2 cycles
  - Very little extra cost…Ethernet switch & cables
  - Eliminates time coordination. All faults can be cleared in a few cycles
  - Can be expanded to multiple levels
  - All communication paths are monitored
  - “Virtual wiring” can be copied to other relays

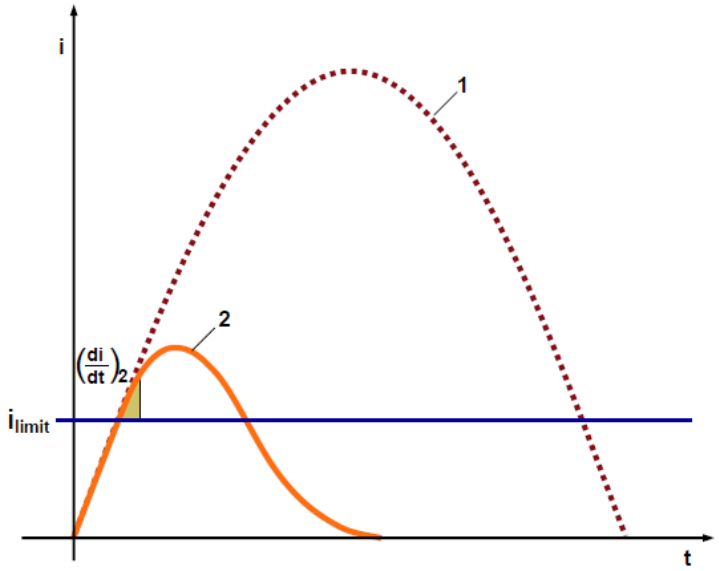
- Disadvantages
  - Requires IEC61850 compliant relays
  - GOOSE messaging is somewhat complex (takes practice)

Typical Main-Tie-Main Layout
Electronically Triggered Fault Current Limiter (ET-FCL)

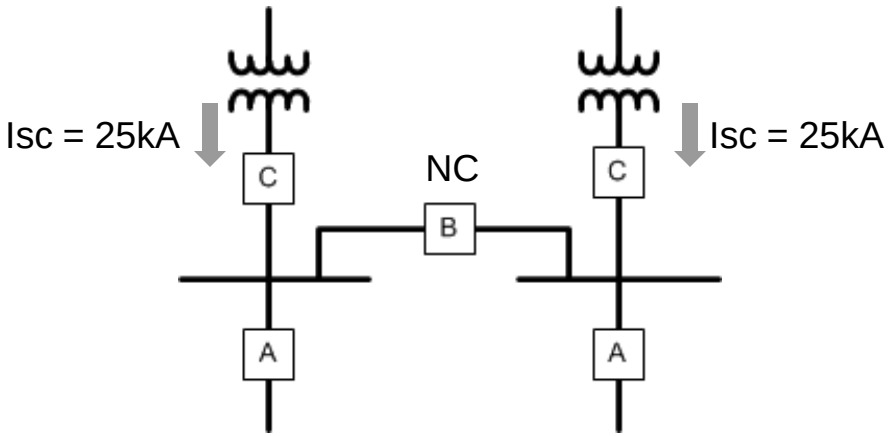
- ET-FCL Characteristics
  - Ultra fast opening switch
  - Triggered to open at an adjustable “X” kA
  - Limits the first current rise in less than 1ms
  - Voltage ratings from 0.75kV to 40.5kV
  - Continuous current ratings from 630A to 5000A
  - Rated breaking current up to 210kA

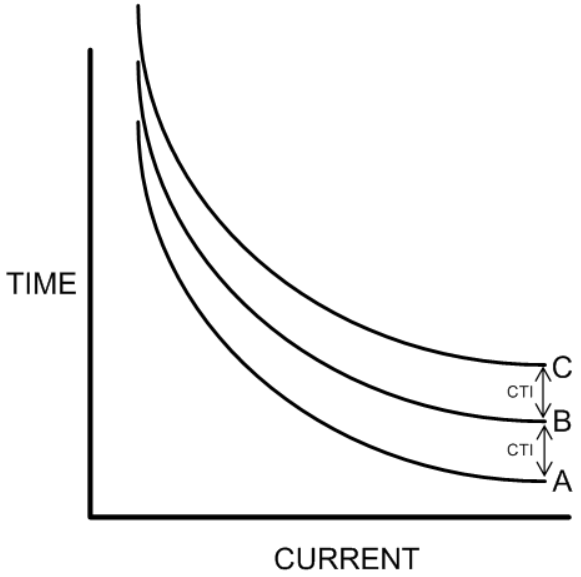
Typical Main-Tie-Main Layout
Electronically Triggered Fault Current Limiter (ET-FCL)

- ET-FCL Characteristics
  - Triggered to trip based on di/dt slope level
  - Di/dt applied to prevent false trips
  - Curve#1 is potential fault waveform
  - Interruption occurs in ¼ - ½ cycle, system x/r ratio dependent

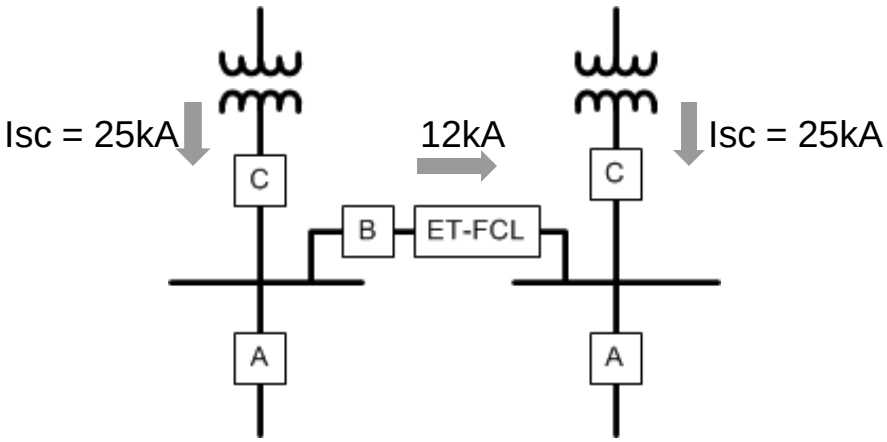


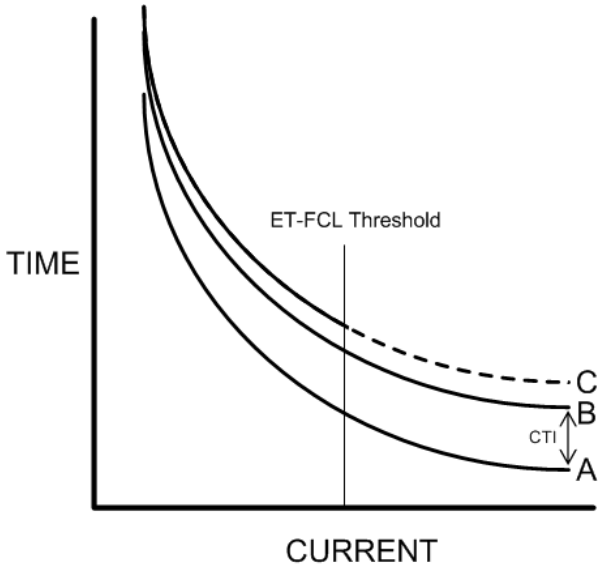
Typical Main-Tie-Main Layout
Electronically Triggered Fault Current Limiter (ET-FCL)





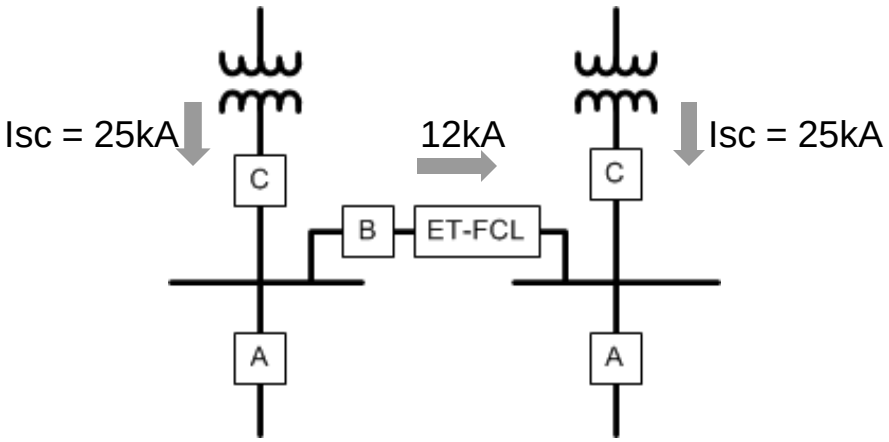
Typical Main-Tie-Main Layout
Electronically Triggered Fault Current Limiter (ET-FCL)

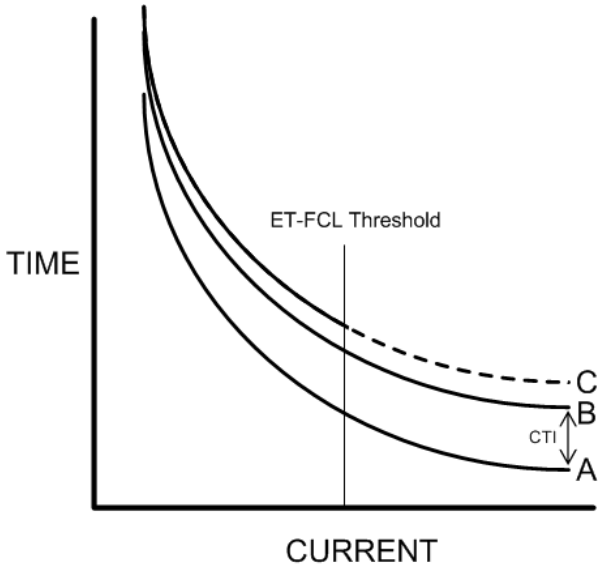




- ET-FCL limits the current to its threshold setting
- Relay C only needs to coordinate with Relay B up to the ET-FCL trip value setting

Typical Main-Tie-Main Layout
Electronically Triggered Fault Current Limiter (ET-FCL)





- Additional ET-FCL Benefits
  - Can delay switchgear upgrades by limiting through-fault current
  - Allows buses to be tied together that otherwise would not be permitted.
  - May eliminate the need for MV motor soft starters
  - Improves voltage regulation by tying buses together

Typical Main-Tie-Main Layout
Summary

Method	Implementation	Cost	Benefits
Setting Group Change	Easy	Low	Low
GOOSE Blocking	Moderate	Low	High
ET-FCL	Difficult	High	High

- Benefits of the ET-FCL extend beyond coordination and include many system improvements such as motor starting and delayed switchgear upgrades.