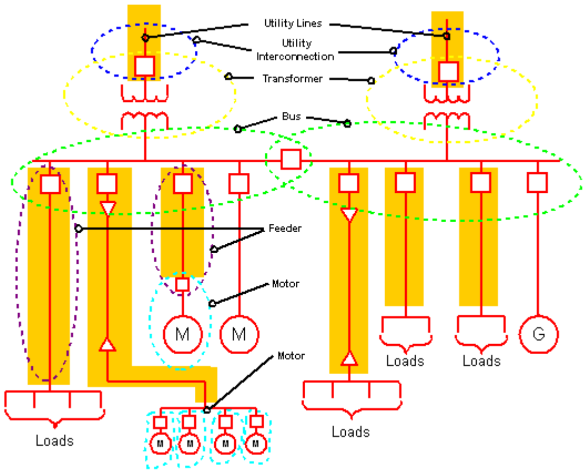
Efficient Applications of Bus Transfer Schemes Utilizing Microprocessor Based Relaying Technology



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Introduction

Main-Tie-Main (MTM) bus transfer & protection for industrial & utility installations has often been accomplished using discrete relays and logic devices

– Discrete relays: overcurrent, overvoltage, undervoltage and synchrocheck
– Logic devices: auxiliary relays and timers, or programmable logic controllers (PLCs)

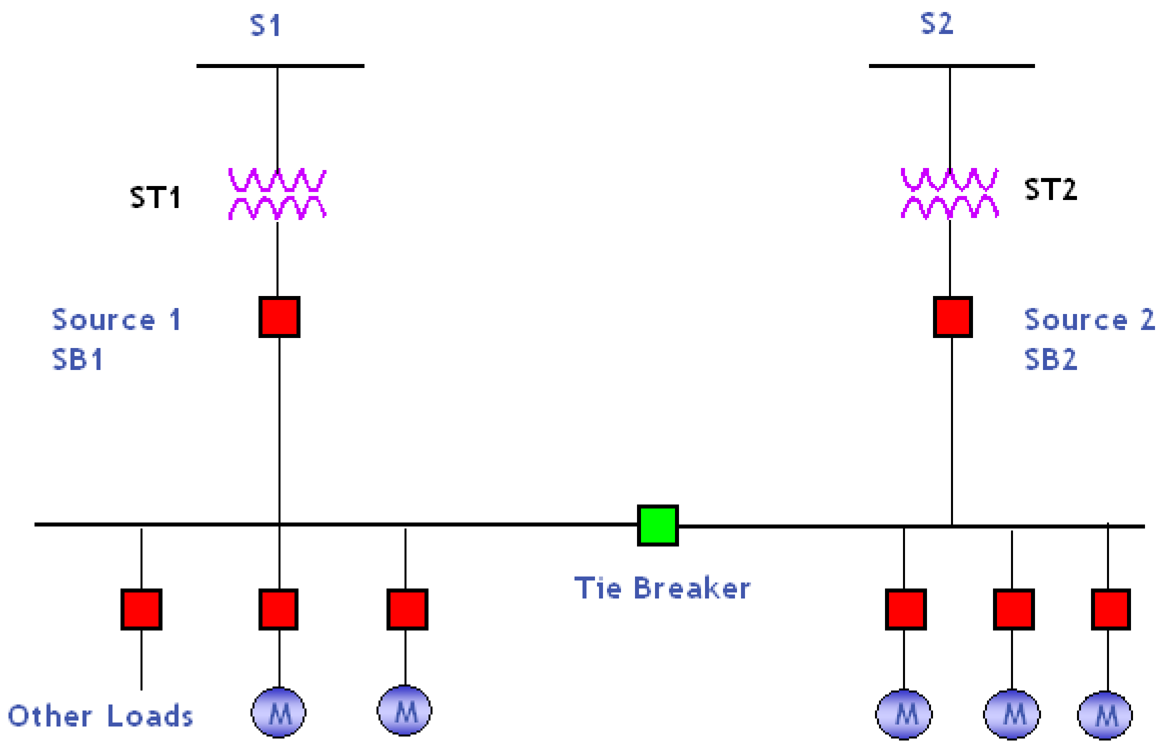
Introduction

Advanced digital protection systems with programmable logic capabilities can simplify and enhance the MTM bus transfer scheme

- Accomplished by reduced amount of devices: “lean” applications!
- Provide necessary inputs / outputs
- Relay-to-relay control logic (IEC 61850 GOOSE)
- Scheme simplification is the result of the protection and logic being programmed in modern microprocessor based protection & control IEDs, such as all protection, transfer logic, interlocking, timing and sequencing functions

Automatic Main-Tie-Main Bus Transfer

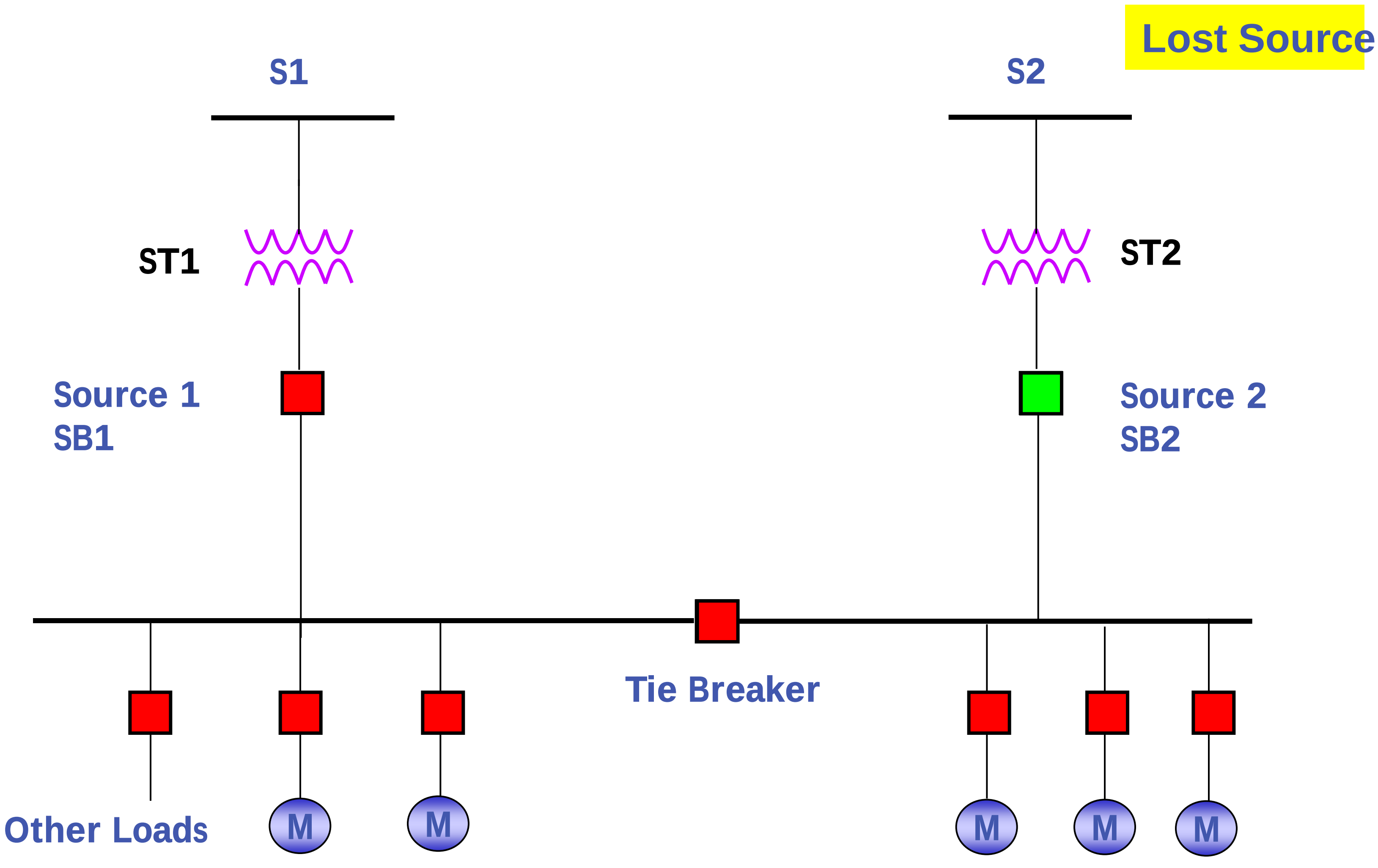
Used to minimize the effect on outages on one of the incoming supplies by opening the normally-closed incoming breaker connected to the supply, and then re-energizing the decaying bus by closing the normally-open tie breaker



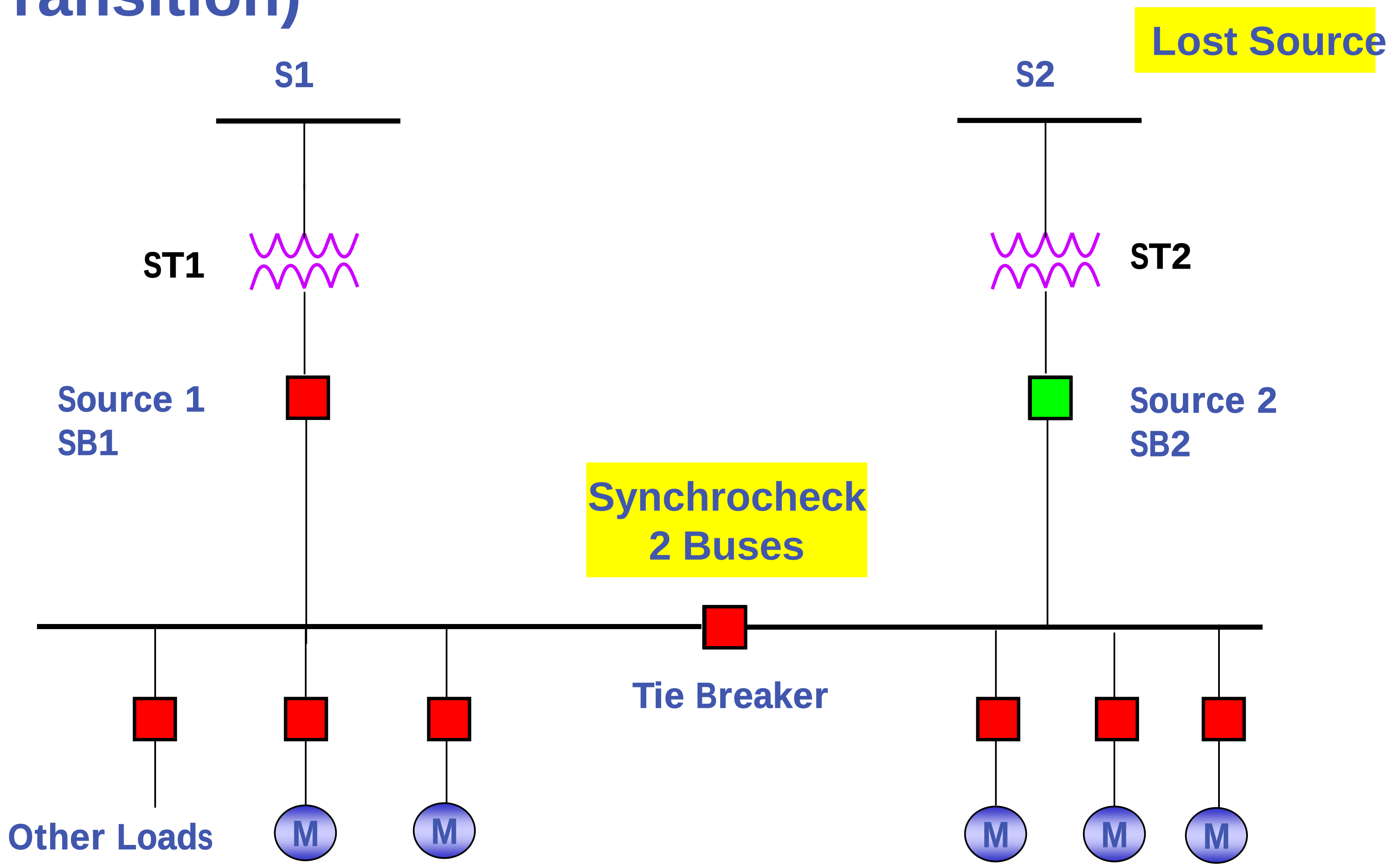
Types of Source Transfer & Applications

- Source transfers can be categorized as closed or open transition
  - *Closed transition* involves brief paralleling of the sources
    - The closed transition transfer is commonly referred to as a hot parallel transfer
  - *Open transition* transfers do not parallel the sources
    - Open transfers can be subcategorized as simultaneous or sequential

Automatic Main-Tie-Main Bus Transfer
(Example – Loss of Incomer S2 – Open Transition)



Automatic Main-Tie-Main Bus Transfer
(Example – Loss of Incomer S2 – Closed Transition)



Why do Automatic Main-Tie-Main Bus Transfer?

- Source transfer may be defined and as the ability to rapidly switch sources to electrical loads
- Rapid source transfer is required to maintain power continuity and therefore process continuity in industrial or utility facility
- Source transfers may be manual or automatic
  - Manual transfers are typically applied when there is advanced notice that a source will be de-energized.
  - Automatic transfers are typically applied by systems that combine protective relaying and automation functions
  - Systems may provide both manual and automatic transfers
- Required control switches
  - *"Select to trip" (device 43/10)*
    [Incomer 1, Incomer 2, Tie]
    This switch selects the breaker that will trip in the event that all three breakers become closed, to prevent the two incoming systems to remain connected in parallel
  - *Auto off (device 43/83)*

Types of Bus Transfer Schemes

- Slow Bus Transfer
- In-Phase Bus Transfer
- Residual Voltage Bus Transfer
- Fast Bus Transfer

Slow Bus Transfer Scheme

- Monitoring of decaying bus voltage not required
- Transfers loads after a pre-determined time delay (typically greater than 0.5s – allowing the motors to coast down)
- Advantages:
  - Cost Effective
  - Easy to Implement
  - Safe for Motors
- Disadvantages
  - Total loss of motor loads – do not use on critical process applications
  - Slight possibility of motor damage if timing not accurate

In-Phase Bus Transfer Scheme

- Monitors decaying bus voltage
- Transfers loads after phase angle difference between incomer S1 and incomer S2 drops to near zero (requires synchrocheck function 25)
- <u>Advantages:</u>
  - Continuous power to motors and loads
  - Minimized impact on the running motors & loads on the decaying bus
  - Huge savings when critical motors are involved
- <u>Disadvantages</u>
  - Load shedding may be required
  - Slight possibility of motor damage
  - Can be expensive and complex to implement

Residual Voltage Bus Transfer Scheme

- Auto-transfer for a loss of supply (incomer S1 or incomer S2) on either bus:
  - Initiated either by an undervoltage condition or by a transformer fault
  - Both incoming breakers must be racked-in and closed with the tie breaker racked-in
  - First step is opening of the source breaker
  - Once voltage has decayed to a safe level, tie breaker is closed
  - No matter what the phase angle between the motors and new source, the resultant V/Hz will not exceed 1.33 V/Hz
  - Transfer is blocked if the undervoltage condition is due to a downstream fault
  - Transfer is blocked if there is an overcurrent fault on incomer

Residual Voltage Bus Transfer Scheme

- Fastest transfer scheme that will not parallel the sources
- Typically applied if the load bus contains large individual motor loads, and may also be applied of the bus does not contain motor loads

Fast Bus Transfer Scheme

- Trip command is issued to the lost source breaker
- As soon as the lost source breaker has started to open (typically indicated by an “early b” contact), a close command is issued to the alternate source breaker
- The close command may be synchrocheck supervised or unsupervised depending on the transfer method employed
- This is the second fastest transfer type that does not deliberately parallel the sources
- This type of transfer is typically applied if the load bus does not contain large individual motor loads
- Power supply is not interrupted to critical motor loads

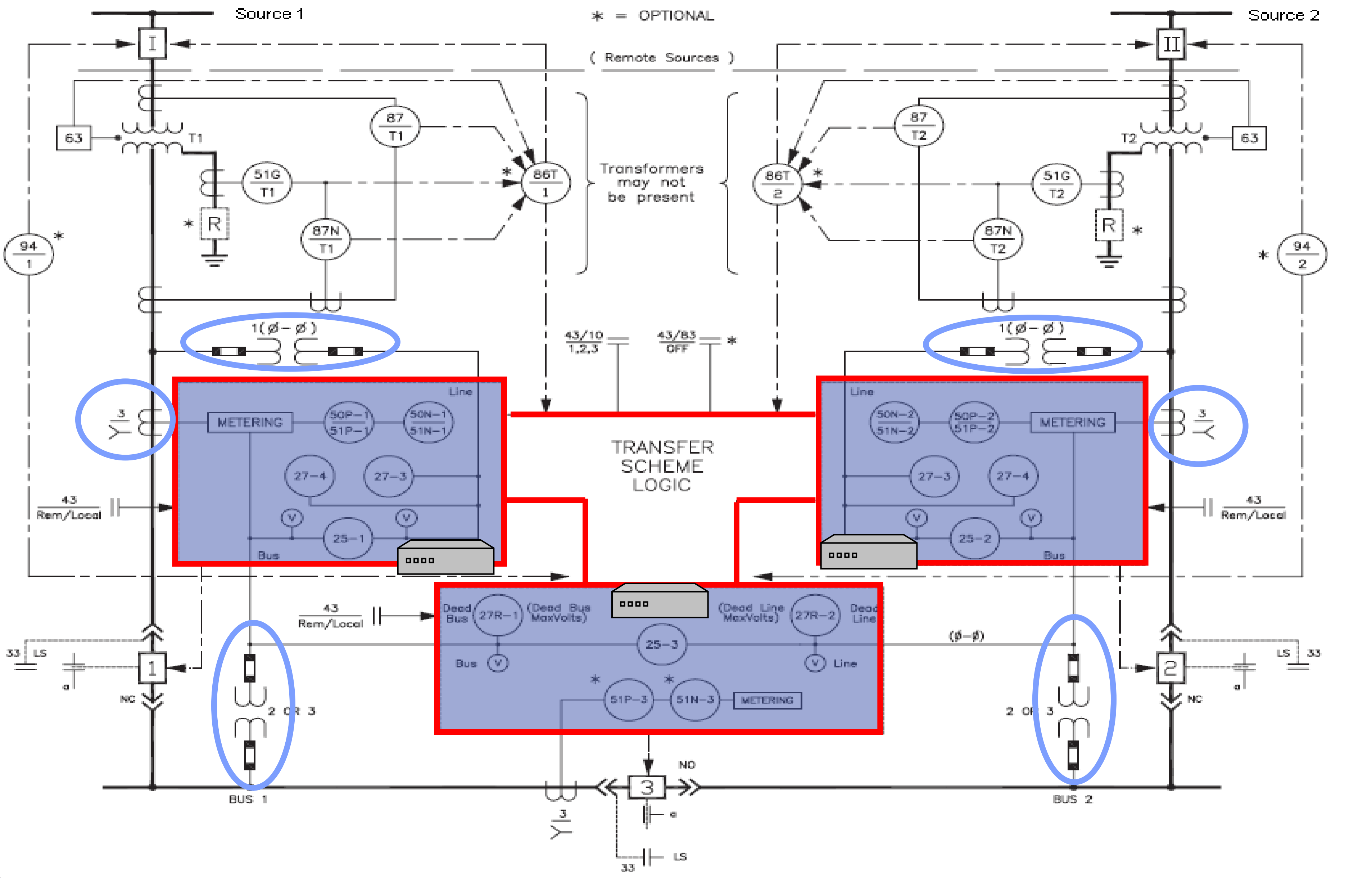
Considerations for Motor Loads

- If large individual motor loads are present, care must be exercised to ensure that the motors are not subjected to electrical and mechanical shock during the transfer process
- For most LV and MV motors, a residual and/or time delayed transfer is used
  - This ensures that the residual voltage from the spinning down motors is less than 0.25 pu.
- For larger motors, typically in the multiple thousands of horsepower, synchronizing relays are sometimes applied to supervise the transfer while voltage on the disconnected spinning down motor is still high (> 0.25 pu).

Transfer Scheme: System Restoration Methods

- Three methods to restore system to normal configuration:
  - Manual method 1: Sources cannot be synchronized
  - Manual method 2: Sources are synchronized with synchrocheck supervision
  - Automatic method: Restoration based on voltage condition of lost source

MTM Bus Transfer Scheme with (3) IEDs

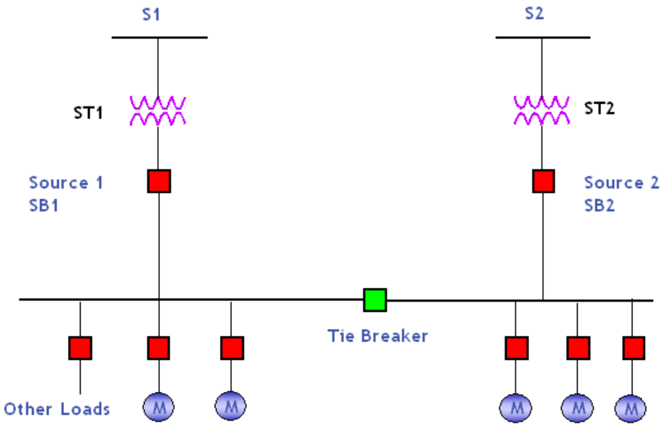


MTM Bus Transfer Scheme with (3) IEDs

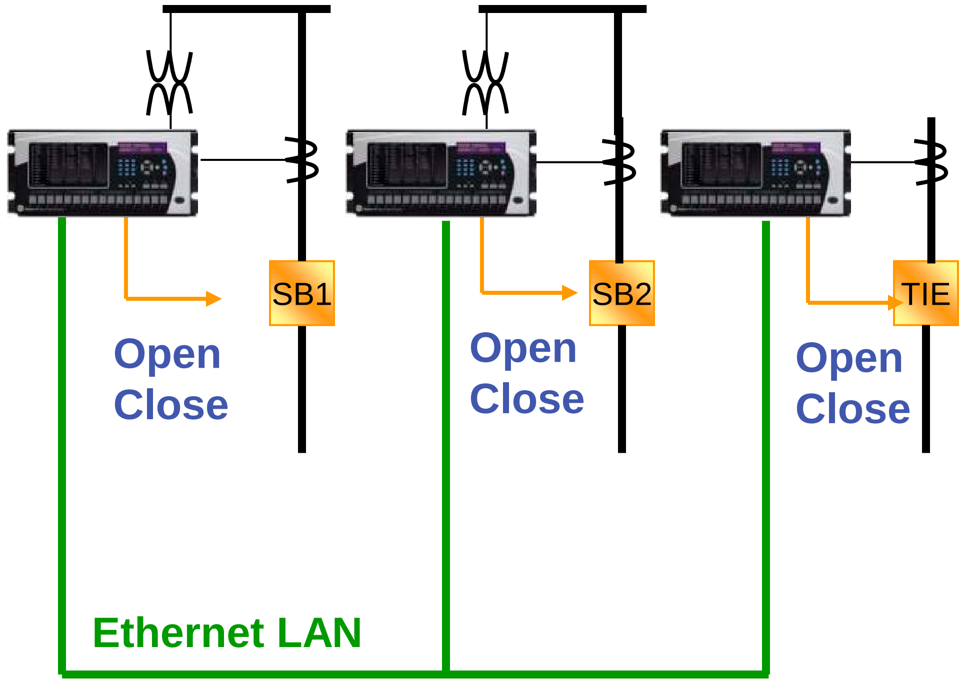
- Utilizes three digital relays for MTM applications:
  - > Relay A: 50P/N, 51P/N, 25, 27 for Source 1
  - > Relay B: 50P/N, 51P/N, 25, 27 for Source 2
  - > Relay C: 25, 27, 51P/N for Tie breaker

- Logic I/O hardwired between the 3 digital relays (many wires)

- Two manually-controlled, three-position switches are required:
  - > "Select to trip" (device 43/10) [Incomer 1, Incomer 2, Tie]
    This switch selects the breaker that will trip in the event that all three breakers become closed, to prevent the two incoming systems to remain connected in parallel

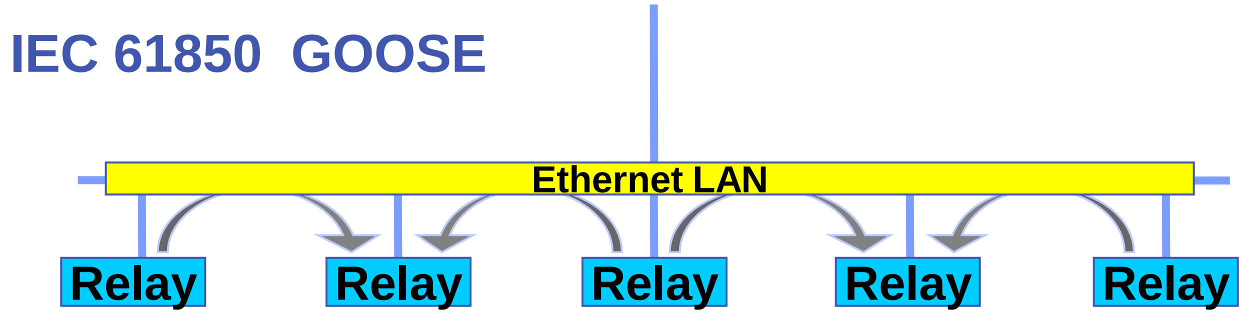


Peer-to-Peer Communications Using IEC 61850 GOOSE

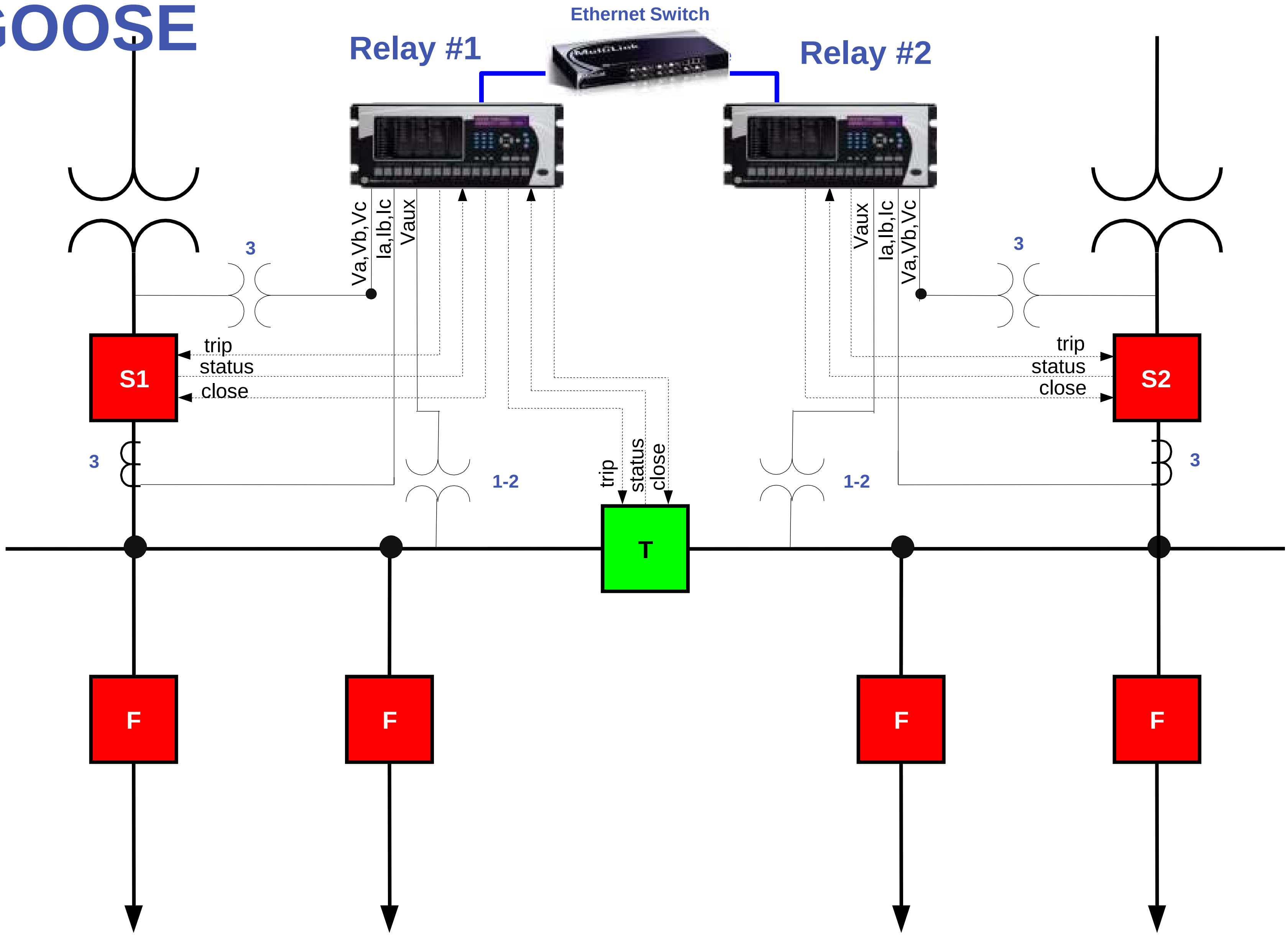


Requirements:

- Reliable message delivery from one to multiple devices - simultaneously
- Fast delivery (< 4ms)
- Multicast message – sent on change of state

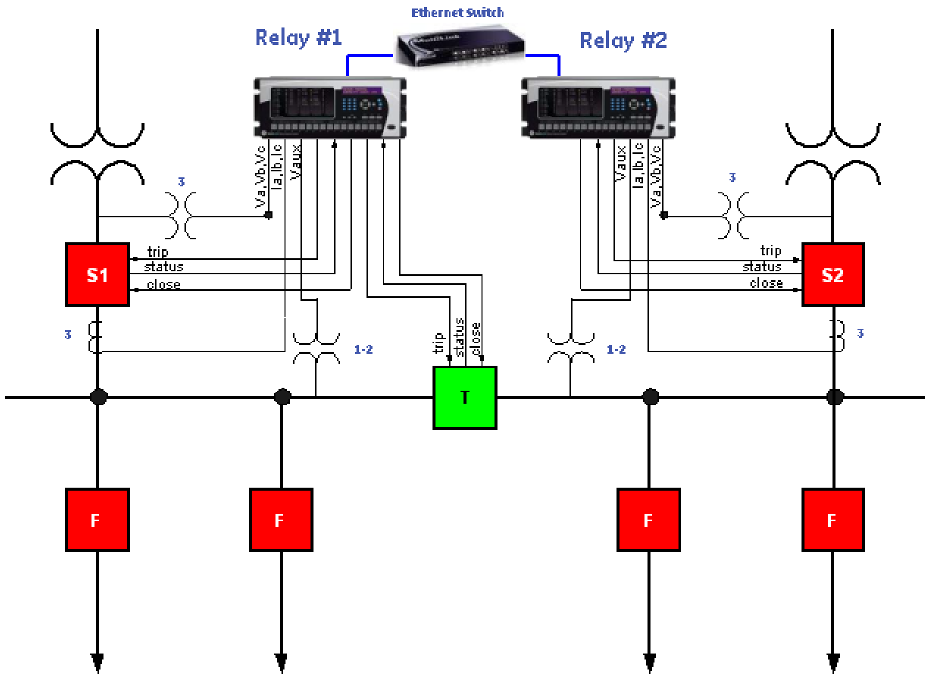


MTM Scheme Using (2) IEDs – IEC 61850 GOOSE

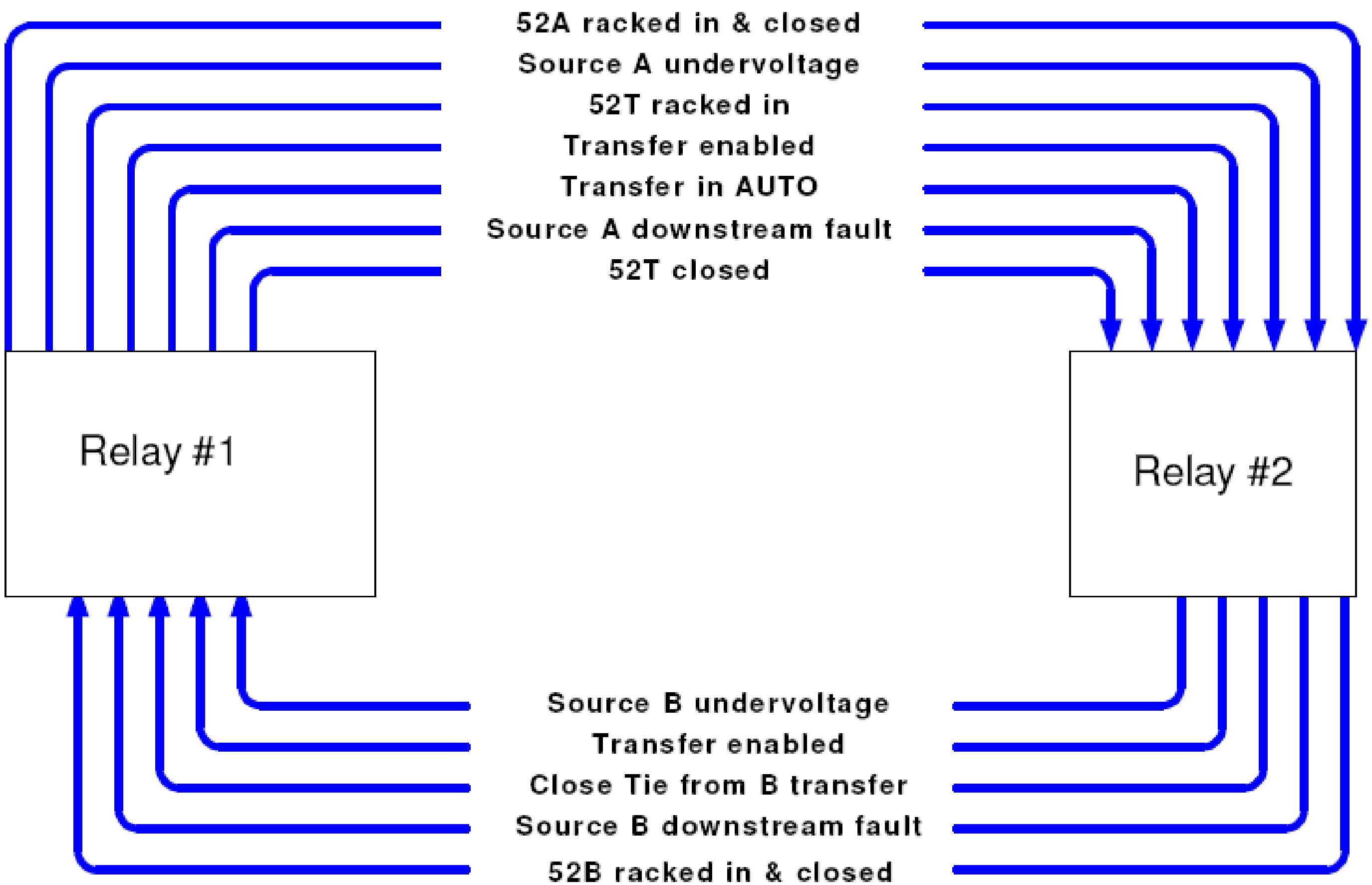


MTM Scheme Using (2) IEDs – IEC 61850 GOOSE

- Peer-to-peer relay communications between Relay 1 and Relay 2 using IEC61850 GOOSE messaging
- Bus transfer logic and protection implemented using Relay 1
- Relay 1 controls Main 1 and Tie Breaker
- Relay 1 provides protection for Main 1
- Relay 2 provides protection and transfer control for Main

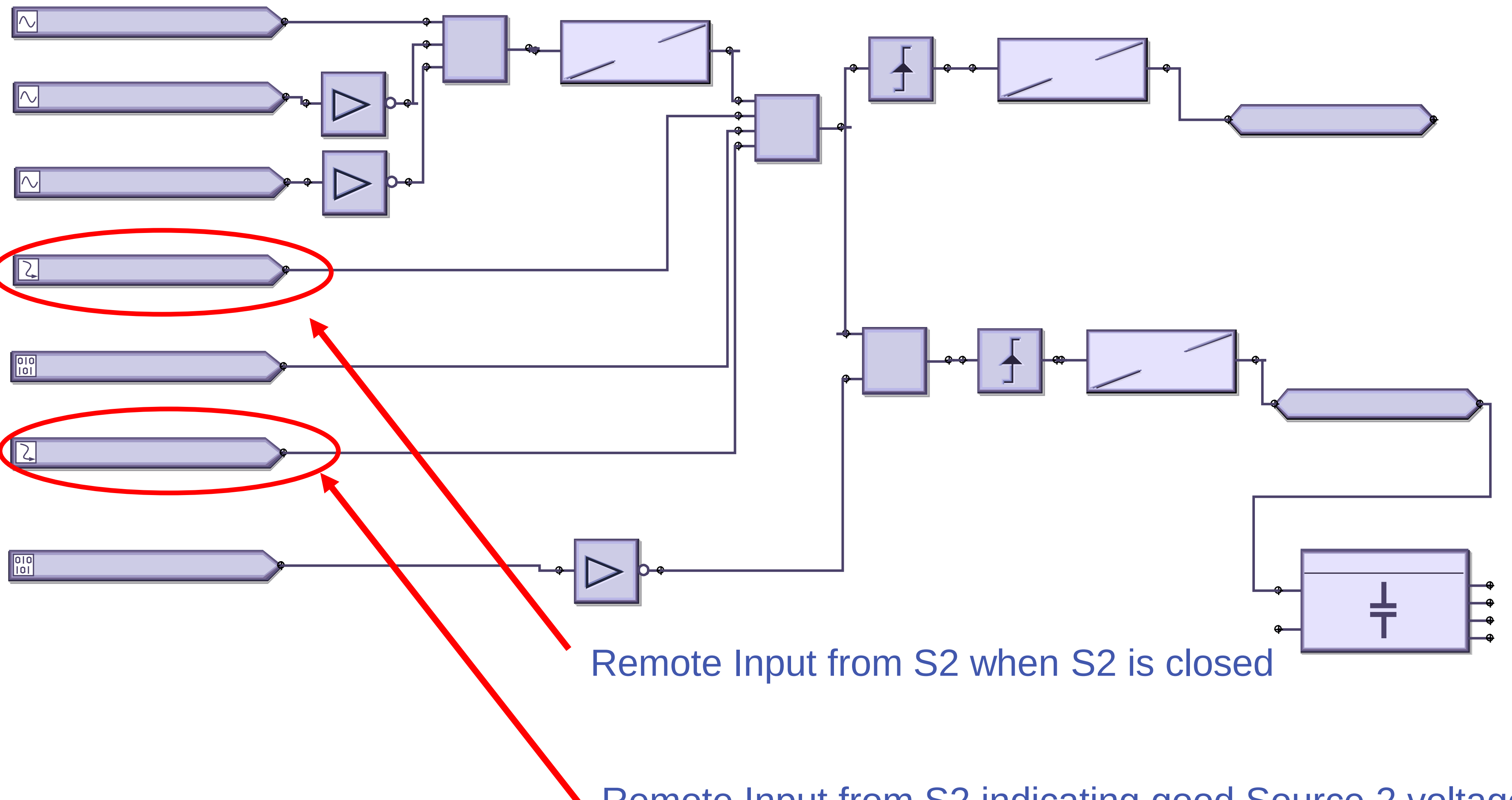


MTM Bus Transfer Scheme Using (2) IEDs and IEC 61850 GOOSE



MTM Bus Transfer Scheme Using (2) IEDs and IEC 61850 GOOSE

Transfer Logic

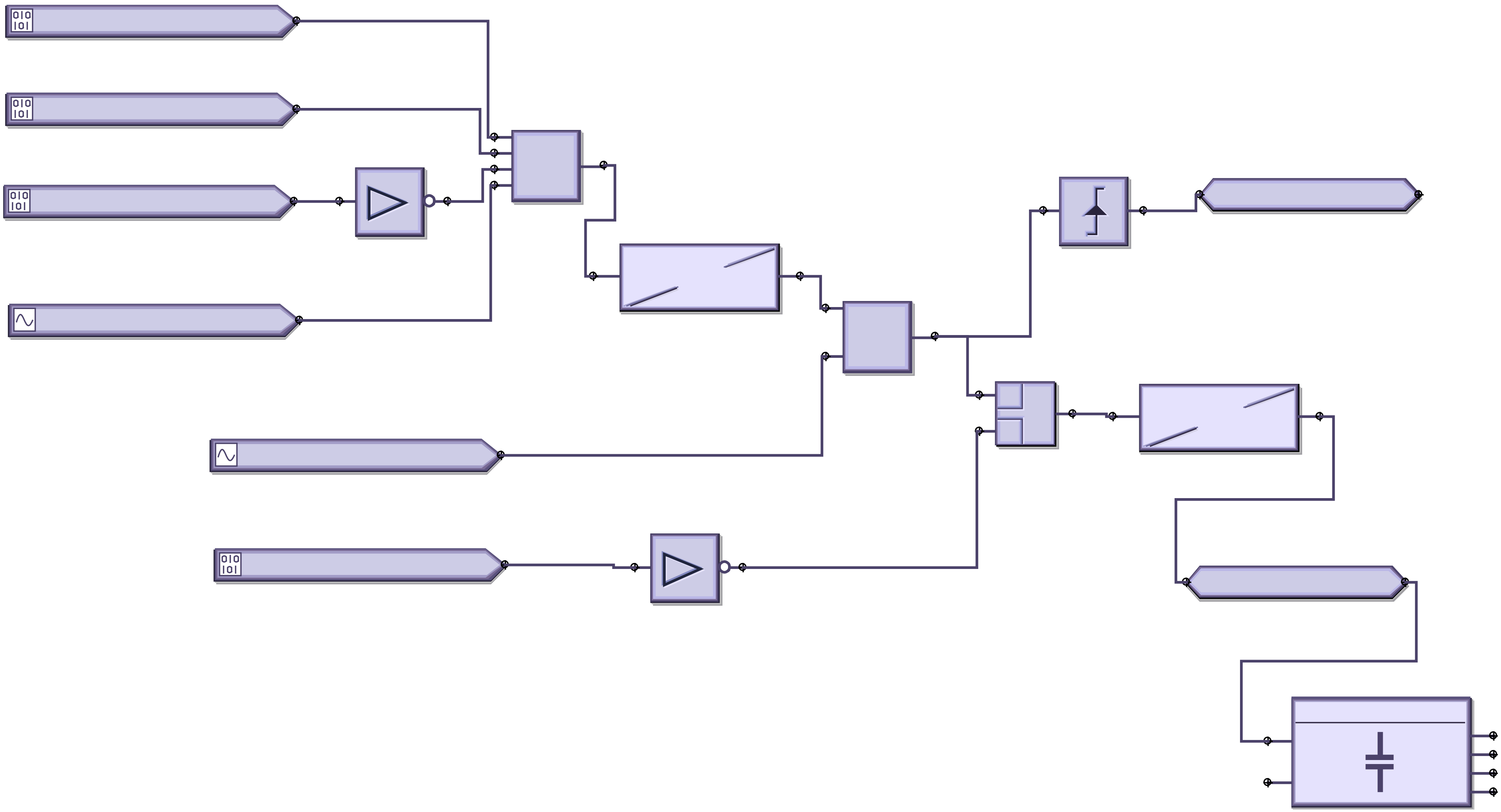


Remote Input from S2 when S2 is closed

Remote Input from S2 indicating good Source 2 voltage

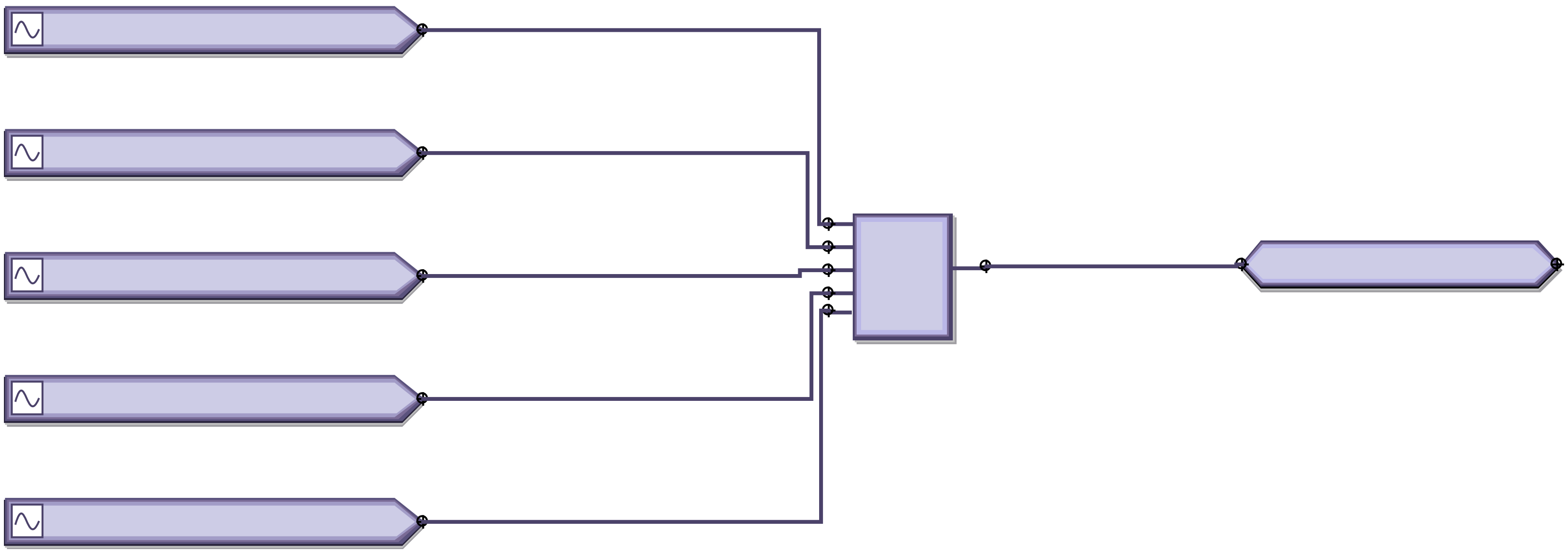
MTM Bus Transfer Scheme Using (2) IEDs and IEC 61850 GOOSE

Auto Restore Logic



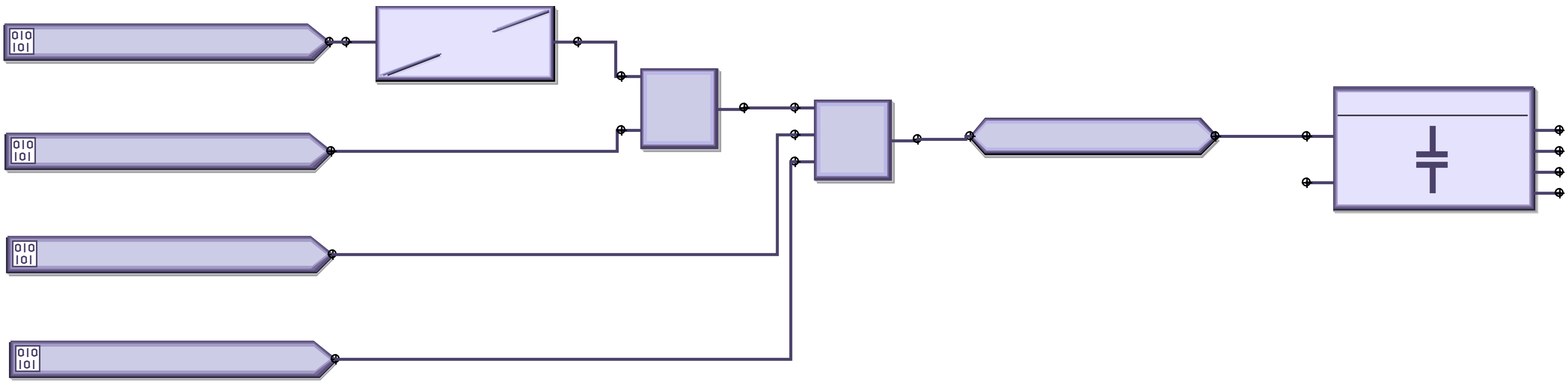
MTM Bus Transfer Scheme Using (2) IEDs and IEC 61850 GOOSE

Protective Trip Logic

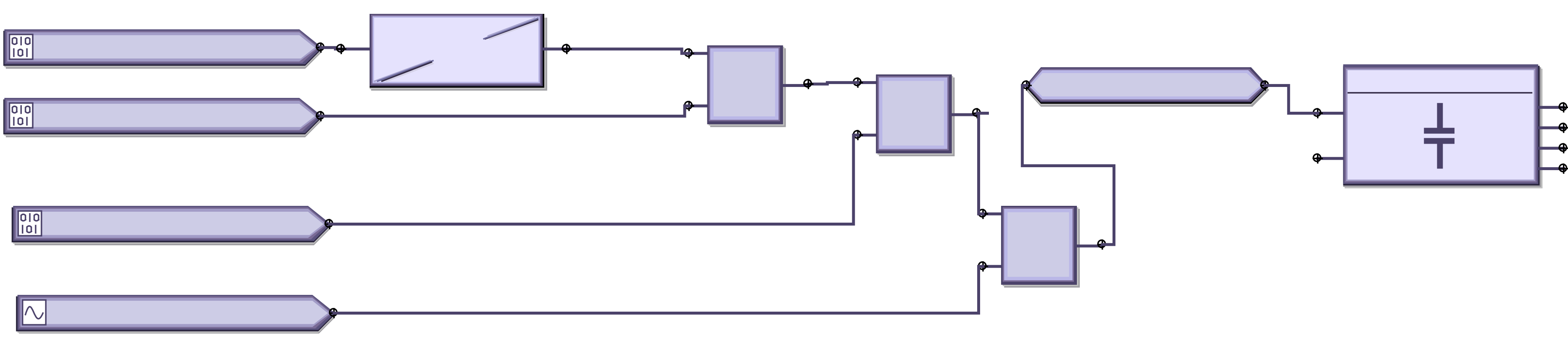


MTM Bus Transfer Scheme Using (2) IEDs and IEC 61850 GOOSE

Open Breaker Logic



Close Breaker Logic



MTM Bus Transfer Scheme Using (2) IEDs and IEC 61850 GOOSE

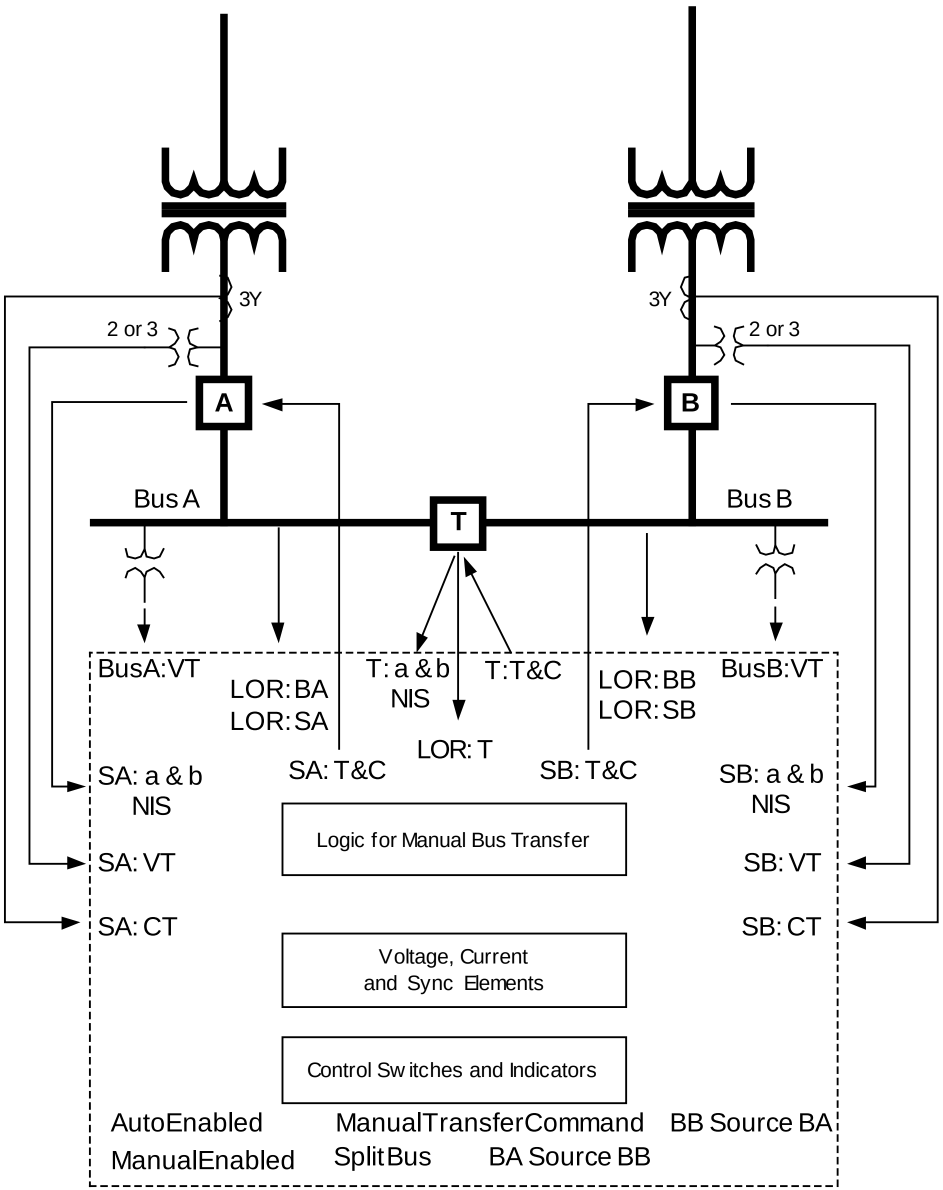
Advantages

- Digital inputs from devices are IEC61850 GOOSE messages using Ethernet port
- Selector switch functions (select to trip, auto transfer on/off) can be traditionally wired switches, or implemented via relay faceplate programmable pushbuttons, eliminating components and installation costs
- Interlocking (bus protection) with downstream relays can be accomplished with IEC61850 GOOSE messaging
- Scheme alarms when either digital

Minimum wiring required on a digital relay with IEC 61850:

- 3 phase & ground currents
- 3 phase bus voltages
- 1-3 phase line voltages
- 52a contact
- TOC contact
- Trip output
- Close output

MTM Bus Transfer Scheme using Single IED



- Position & status indications for each breaker
- Phase & neutral/ground overcurrent protection for Main 1 and Main 2
- Undervoltage supervision for Main 1, Main 2, and Tie
- Synchronism check for closing Main 1 & Main 2 breakers
- Transfer auto/manual selection
- Transfer scheme lockout and block logic
- Trip selector
- Oscillography & sequence of events capture entire scheme operation and timing

MTM Bus Transfer Scheme using Single IED

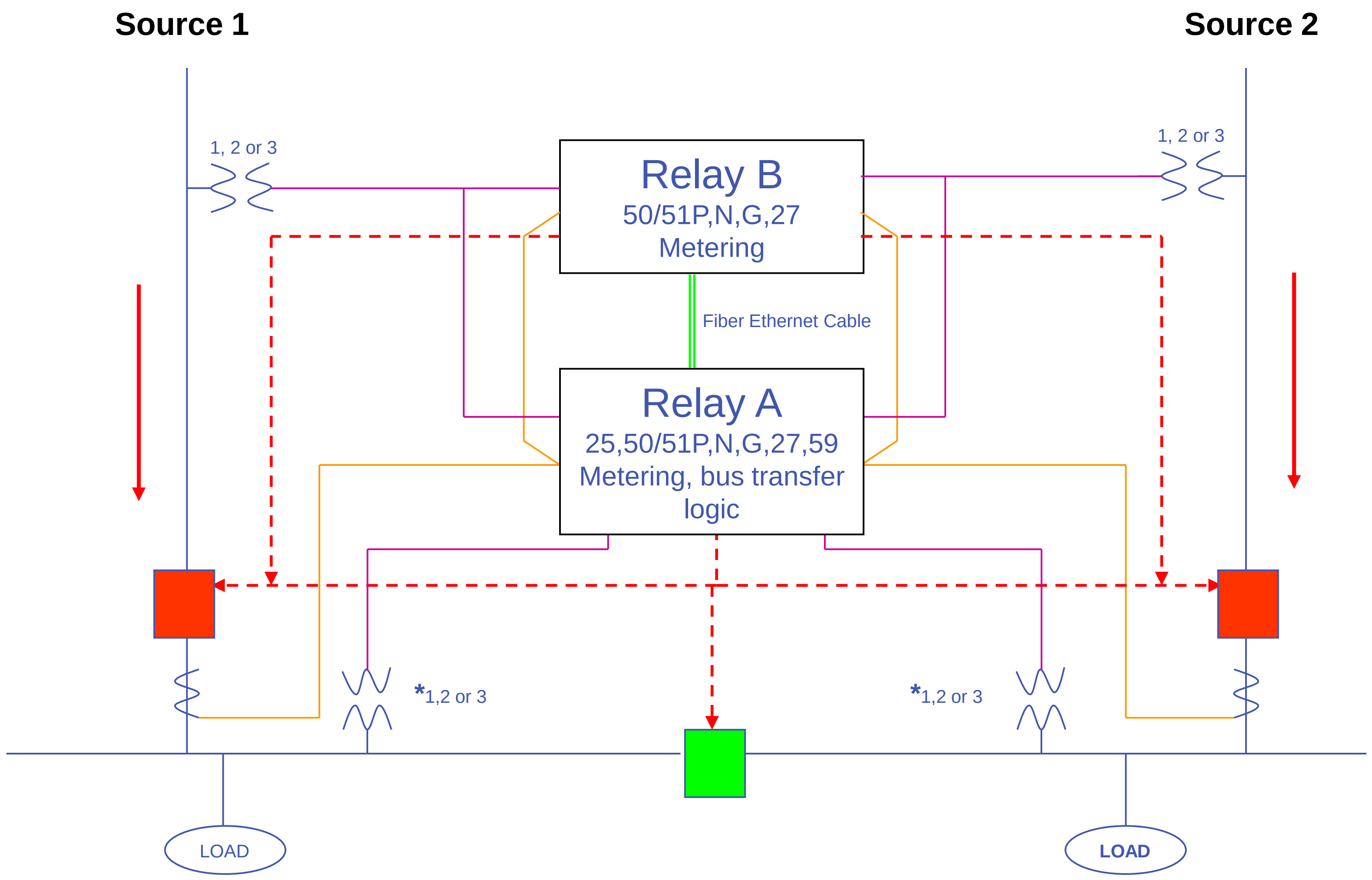
Advantages

- "Lean" solution for MTM applications
- All bus transfer control and protection functions are implemented with one digital relay using programmable logic
- Significant reduction in wiring
- No need for external alarm I/O
- No interfacing with other IEDs required
- Scheme is flexible & can accommodate different arrangements of PT's (3 phase on incoming or bus side, no pts on the bus side)
- Oscillography & sequence of events capture entire scheme operation and timing

Disadvantage

- Single point of failure, so could use redundant IED for protection only

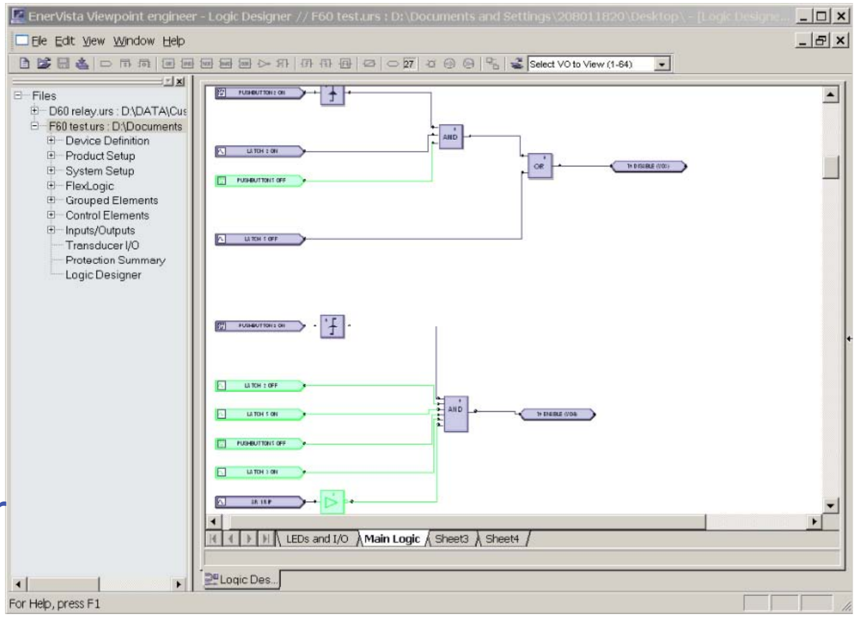
Bus Transfer w/ Redundant Protection



If either relay is taken out of service for maintenance at any time, full protection and metering still provided on both incomers

Testing & Commission Procedures for Digital IEDs used in MTM Bus Transfer Schemes

- Ensure that the date & time in each relay is configured
- Program digital relay LEDs to help in understanding status of transfer scheme
- Verify that all contact inputs are registered by each digital relay (52a, racked-in, etc.)
- Check synchrocheck feature blocking
- Use available sequence of event recording for protection element state changes, logic state changes, and connected switchgear state changes
- In addition, digital oscillography functionality can record entire transfer scenarios
- Dynamic logic monitor software tools aids in troubleshooting and reduces installation time



Conclusions

The benefits of using of digital relaying technology and advanced programmable logic in transfer schemes are numerous:

- Increased self diagnostic capabilities to verify adaptive logic & protection inputs
- Reducing in wiring
- Increased security and reliability as any failures in the system can be alarmed, and corrective action can be taken
- Redundant overcurrent and undervoltage protection functions possible
- “Lean” single IED solution possible
- Schemes using IEC 61850 GOOSE messaging help reduce wiring between cubicles
- Dynamic logic monitoring aids in testing and commissioning

Thanks for the time