SECURING LINE DIFFERENTIAL ON MULTIPLEXED COMMUNICATION CHANNELS

Craig Wester, Mike Ramlachan – GE Vernova
Jamie Segarra – Orlando Utilities Commission

Introduction

Application of 87L on transmission lines over direct fiber communications has proven to be dependable and secure for electric utilities

Application of line current differential protection over multiplexed communication channels introduces challenges to the protection engineer

Multiplexed communications channels can experience issues during switching or network issues

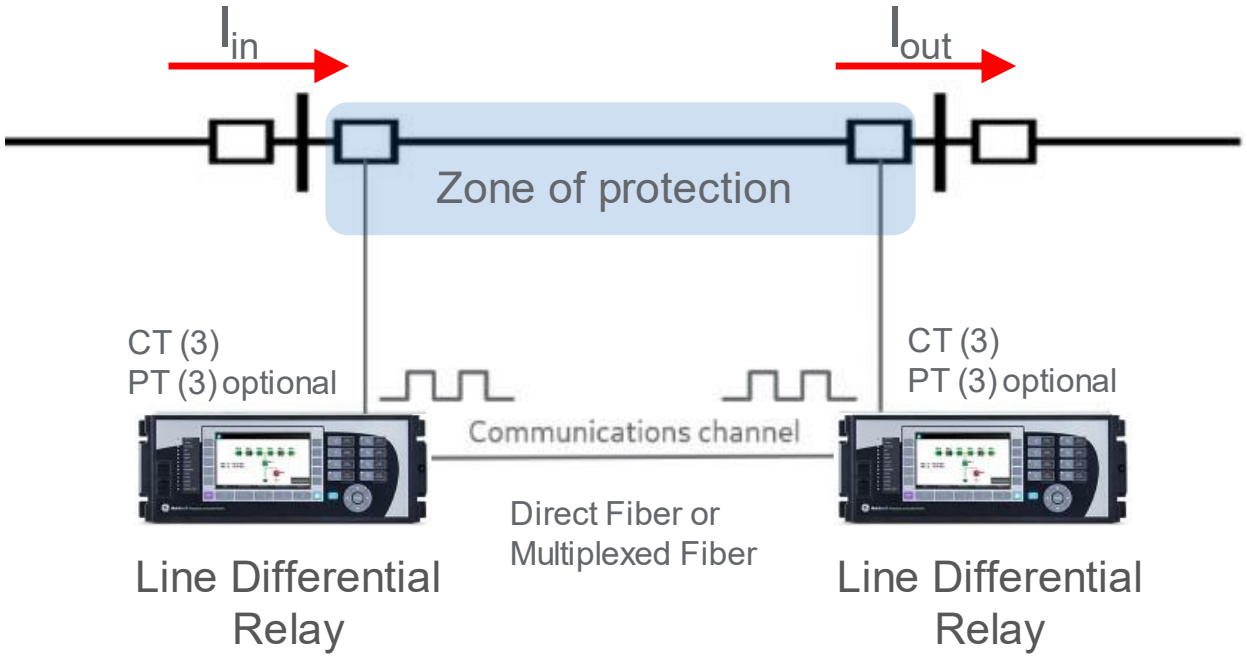
This can cause extensive channel delays and channel asymmetry

We will review several methods of securing line differential protection on multiplexed communication channels

Introduction

Two terminal 87L current differential:

- Uses two separate line differential relays
- Ia, Ib, Ic (mag & angle) compared
- Distinct zone of protection
- High speed detection within 2 cycles
- Includes complete backup distance protection with or without pilot-aided schemes



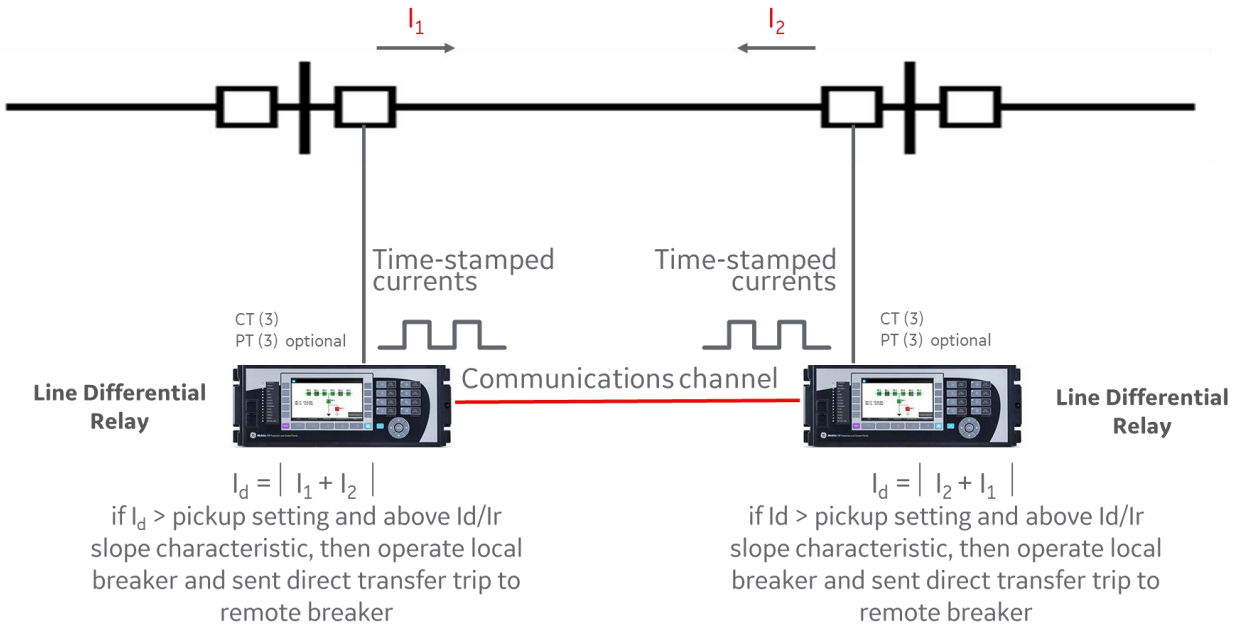
Introduction

The two 87L relays synchronize their internal clocks via the communication channel

Each 87L relay measures the currents at its phase CTs and sends the currents (with a time stamp) to remote 87L relay

Differential performed on a per-phase basis

Direct transfer trip signal sent between two 87L relays via communications channel



Challenges for Line Differential Protection Using Multiplexed Fiber Communications Channels

Multiplexed fiber communication channels may experience communication issues during switching or network issues

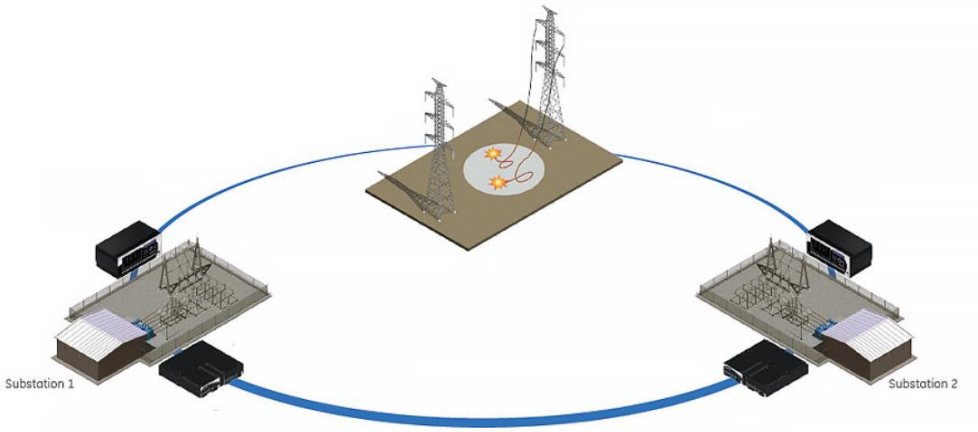
From a protection engineer perspective, an inconsistent communication channel for line differential protection is unacceptable

Typical round trip channel delay is 8 to 16 ms for multiplexed fiber communication channels. An extensive communication channel delay can cause delayed protective relay tripping of 87L line differential protection.

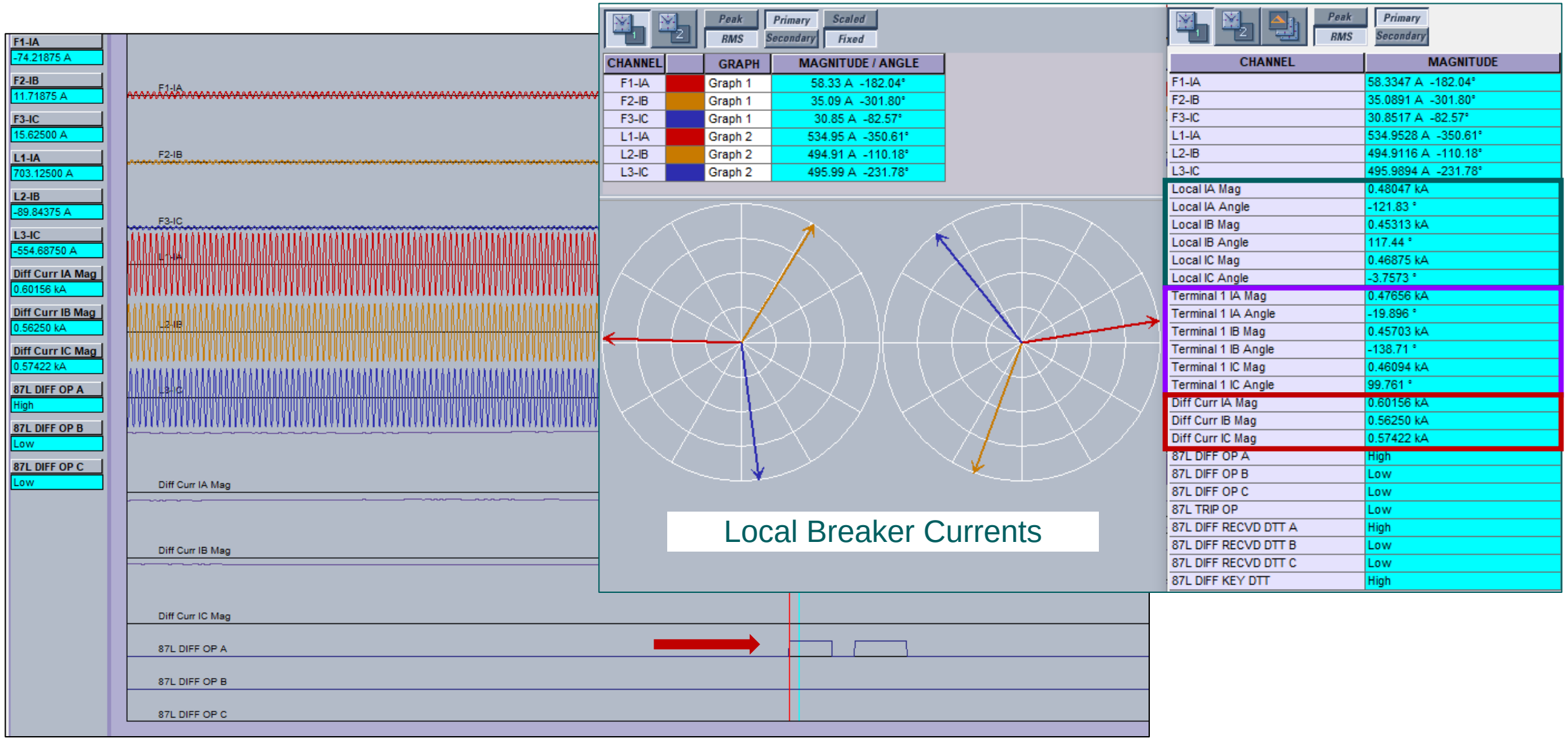
Channel asymmetry occurs when the send/transmit and receive paths are not equal (i.e., not symmetrical). Typical channel asymmetry is less than 3 to 4ms.

87L line differential protection relays do have capability to automatically compensate for channel asymmetry

Excessive channel asymmetry can give higher angular difference between local and remote currents of 87L line differential protection and result in higher differential currents which can cause 87L element to operate



87L Line Protection Operation Due to Excessive Channel Asymmetry



Methods of Securing Line Differential Protection Using Multiplexed Communication Channels

METHOD 1

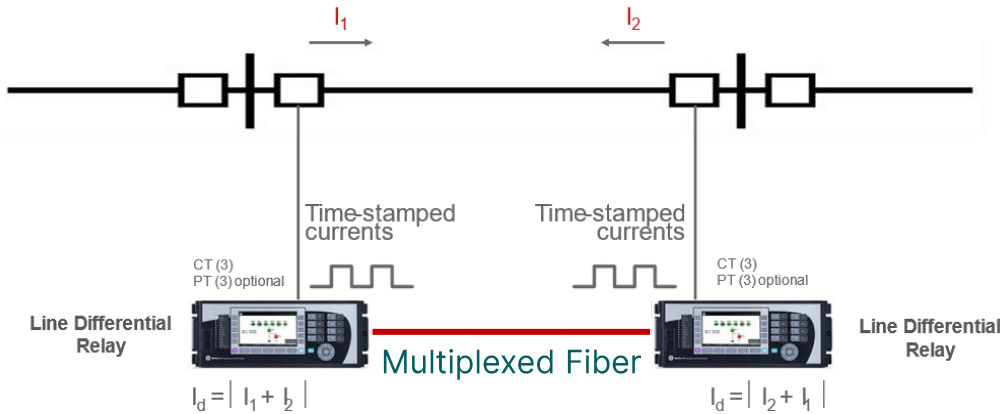
Use channel asymmetry compensation within 87L line relay

Channel asymmetry compensation is based on absolute time reference provided by a high precision system (PTP or IRIG-B)

There will be a maximum asymmetrical channel delay compensation that can be provided using an absolute time reference

87L element could be blocked if maximum asymmetrical channel delay goes over a set value

Channel asymmetry can be monitored within 87L relay and indication/alarm given when maximum channel asymmetry is above user programmable setpoint

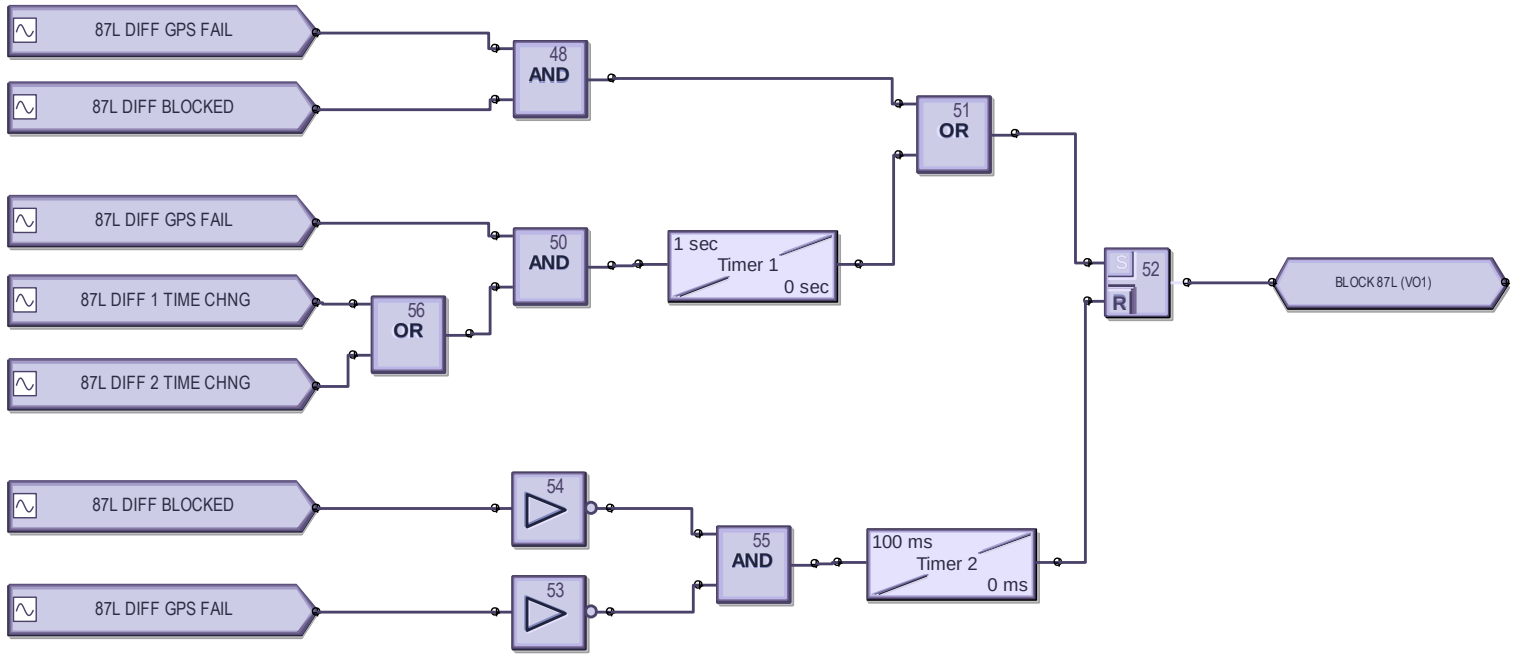


Methods of Securing Line Differential Protection Using Multiplexed Communication Channels

METHOD 1A DETAILS

Enable GPS channel compensation and continue to operate the 87L differential element until a change in channel round-trip delay is detected during a loss of GPS signal

- Assign GPS receiver failsafe alarm contact (indicating GPS receiver problems or time inaccuracy) to block GPS channel compensation
- Block 87L differential element on GPS loss if step change in channel delay occurs during GPS loss conditions or on startup before the GPS signal is valid



Methods of Securing Line Differential Protection Using Multiplexed Communication Channels

METHOD 1B DETAILS

Enable GPS channel asymmetry compensation and for loss of GPS signal at any terminal - block the 87L differential element after a specified time

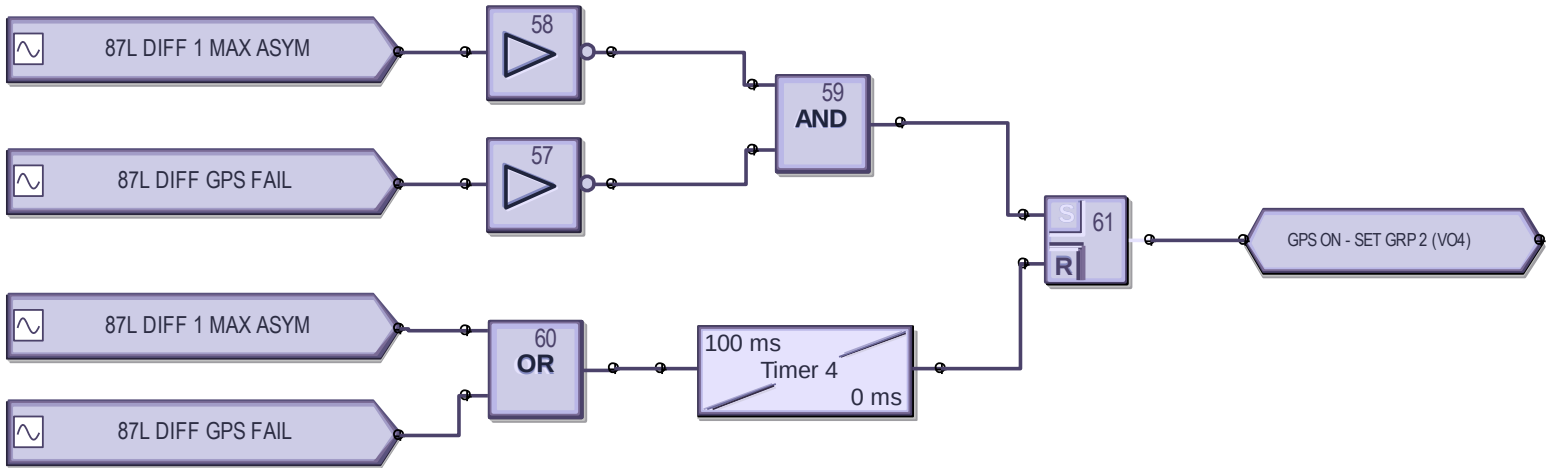
- This is a simple and conservative way of using GPS channel asymmetry compensation feature
- Assign GPS receiver failsafe alarm contact (indicating GPS receiver problems or time inaccuracy) to block GPS channel compensation
- Block 87L differential element on GPS loss after a period of time

Methods of Securing Line Differential Protection Using Multiplexed Communication Channels

METHOD 1C DETAILS

Continuously operate 87L differential element but enable GPS channel asymmetry compensation only when valid GPS signals are available

- This provides less sensitive protection on GPS signal loss at any terminal and requires higher 87L pickup and restraint settings
- Assign GPS receiver failsafe alarm contact (indicating GPS receiver problems or time inaccuracy) to block GPS channel compensation
- Use logic to switch 87L element to settings group 2 (with most sensitive settings) if 87L line relay has valid GPS time reference. If GPS or 87L communications failure occurs, 87L line relay switches back to Settings Group 1 with less sensitive setting.
- This method can be used carefully if maximum channel asymmetry is known and does not exceed certain values (typically 2 to 3 ms)



87L Settings Group 1

Pickup	0.50 pu
CT Tap 1	1.00
Restraint 1	40 %
Restraint 2	70 %
Breakpoint	2.0 pu

87L Settings Group 2

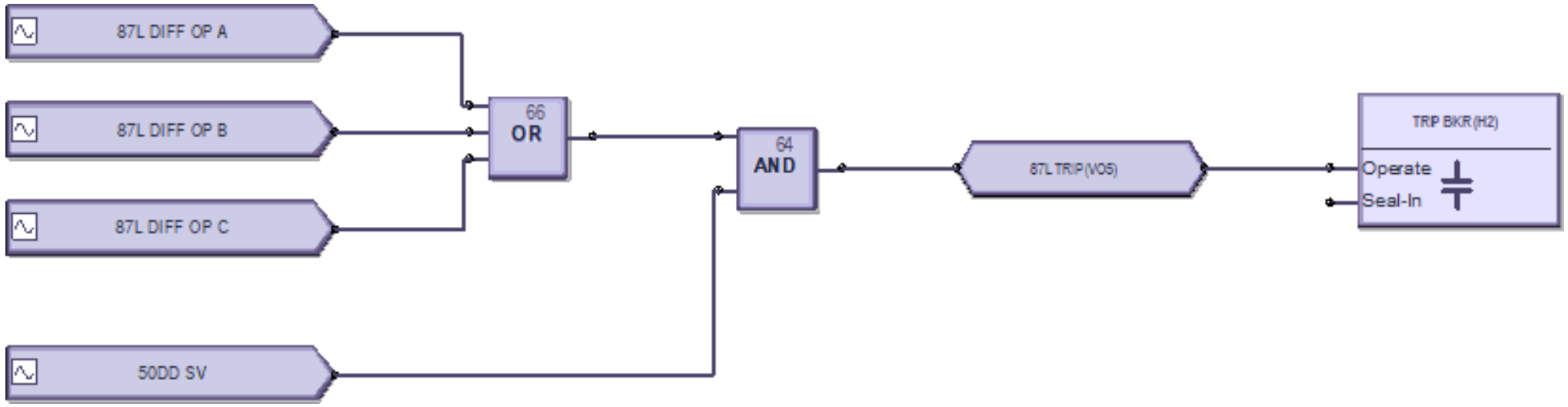
Pickup	0.20 pu
CT Tap 1	1.00
Restraint 1	25 %
Restraint 2	45 %
Breakpoint	2.0 pu

Methods of Securing Line Differential Protection Using Multiplexed Communication Channels

METHOD 2

Secure 87L line differential protection by adding additional security to 87L differential element by supervision with a high-speed disturbance detector (50DD)

- Disturbance detector (50DD) element is sensitive current disturbance detector that is used to detect any disturbance (or possible fault) on protected system
- Method 2 uses Method 1 recommendations plus the additional 50DD security logic



Additional Items for Consideration

Valuable when troubleshooting communication channel issues to have information from 87L line relay regarding communications channel

Round trip channel delay, channel loop delay and channel asymmetry can be metered and logged by 87L line relay

To alert the user of possible issues, SCADA alarms could be created for:

- 87L differential element blocked
- Excessive channel round trip time change
- Excessive channel asymmetry
- GPS failure

Conclusions

87L line current differential protection over multiplexed communication channels introduces challenges to the protection engineer

Multiplexed communications channels can experience issues during switching or network issues which can cause extensive channel delays and channel asymmetry and cause issues to 87L line relay and possible misoperation of 87L line relay

Several methods of securing line differential protection on multiplexed communication channels can be implemented, such as GPS channel asymmetry compensation and supervising 87L differential operation with a high-speed disturbance detector

Various methods were discussed regarding handling a loss of GPS signal to 87L line relay

Channel asymmetry, channel round trip delay, channel loop delay can metered and recorded by 87L line relay for troubleshooting purposes

SCADA alarms such as 87L differential element blocked, excessive channel round trip time change, excessive channel asymmetry and GPS failure are beneficial

QUESTIONS ?