

# International Drive Distribution Loop Protection, Lessons Learned and Improvement Project

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# Outline

- Introduction
- History
- Directionality
- Events
- Analysis
- Communications
- Conclusion
- Questions

# Intro

- 12.47kV Distribution System along International Drive in Orlando, FL
- Design started in 1999 with installation completed in 2000
- 85 microprocessor directional overcurrent relays
- High reliability requirement
- History of protection operations and system changes
- Improvements to the system throughout its history

# History – Prior to 1999

- Area originally supplied by 2 overhead and 4 underground lines, all radial
- Manually operated padmounted switchgear
- Service interruptions leading to decision to upgrade

# History – Initial Installation 1999-2000

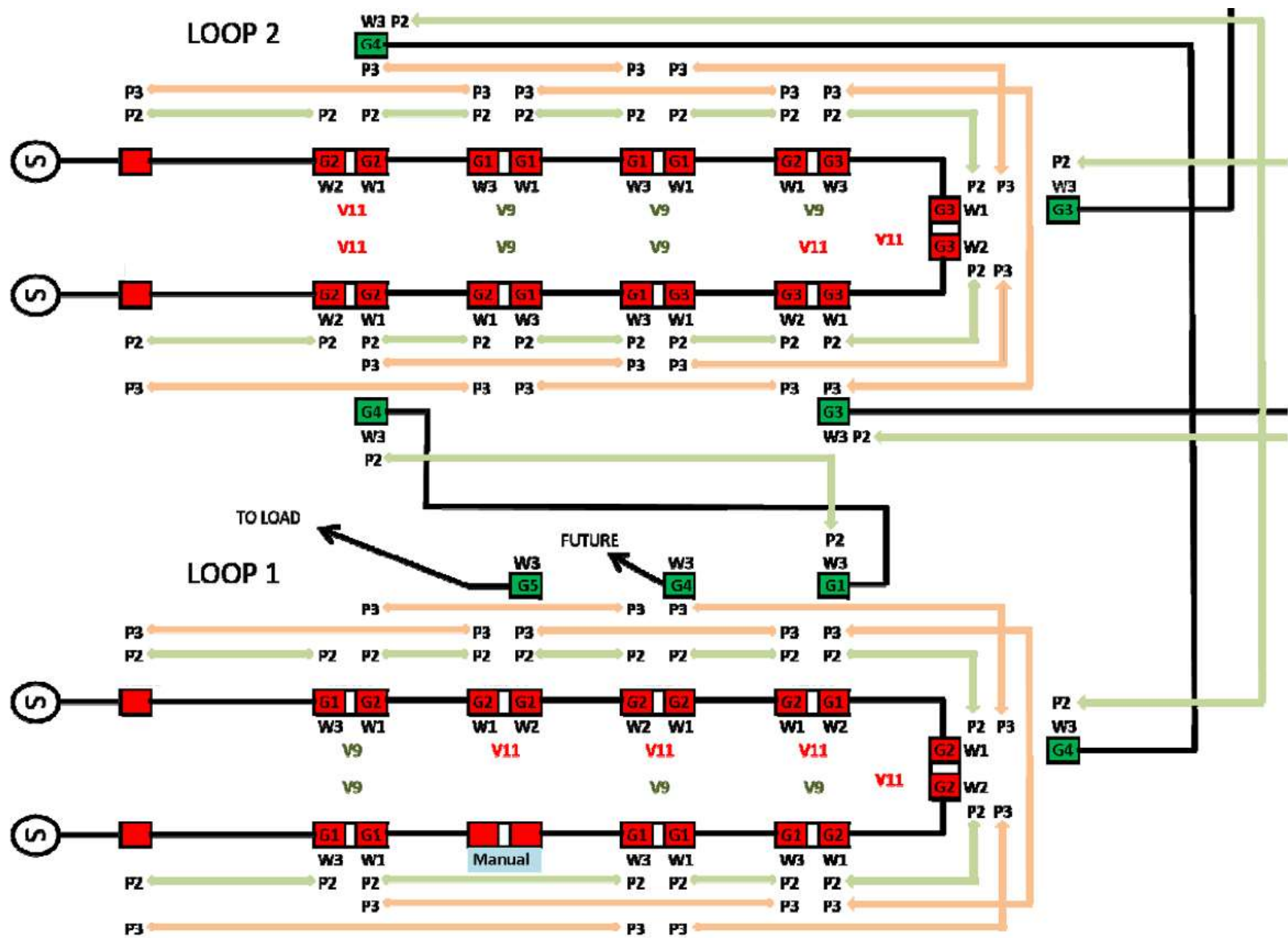
- Initial design added 4 underground lines
- 85 new microprocessor directional overcurrent relays
- The now eight underground feeders paired to create loops
- Upgraded to four-way padmounted motorized vacuum interrupted switchgear
- New communication system using multiplexed fiber optic network

# History – 2008 Upgrade

- Response to increasing reliability issues
- Relay settings reconfigured
  - Automatic tie between loops
  - Loss of source conditions

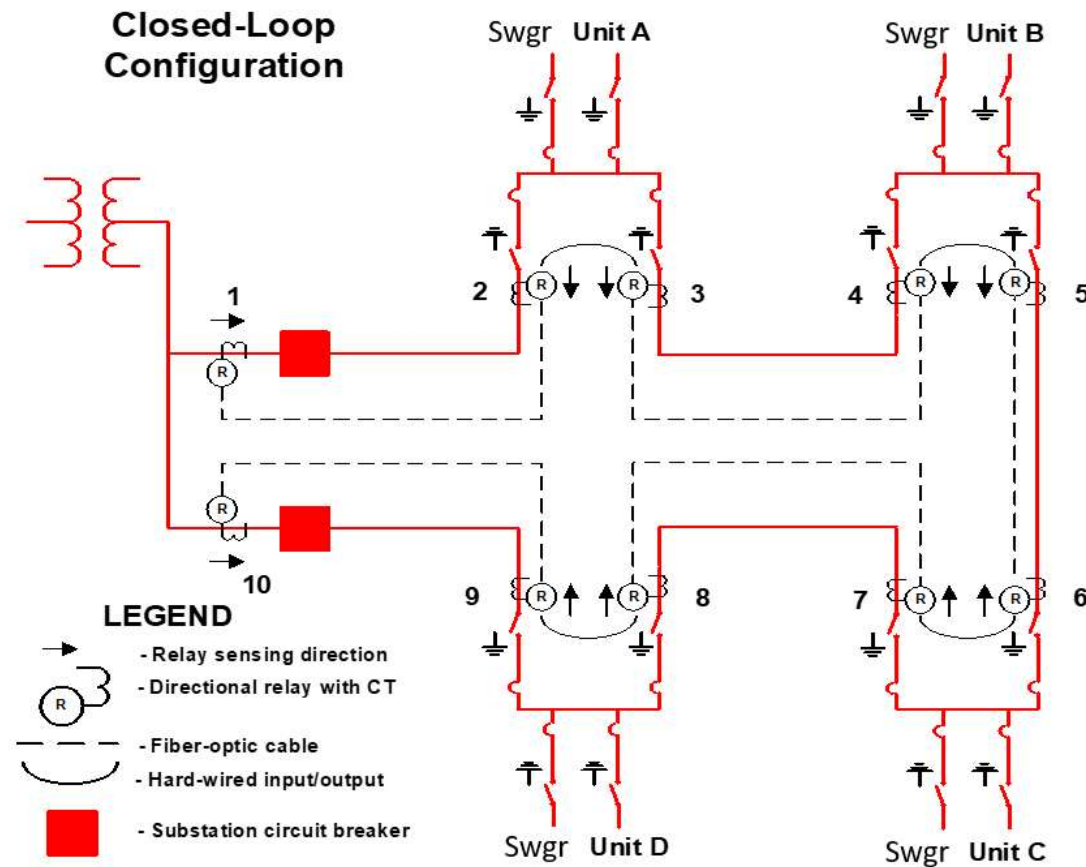
# History – 2013 Upgrade

- Relays reached the end of their effective life
- Decision was made to replace with the same model relay and maintain the DCB/POTT scheme
- Communication network upgraded to more modern multiplexed fiber system

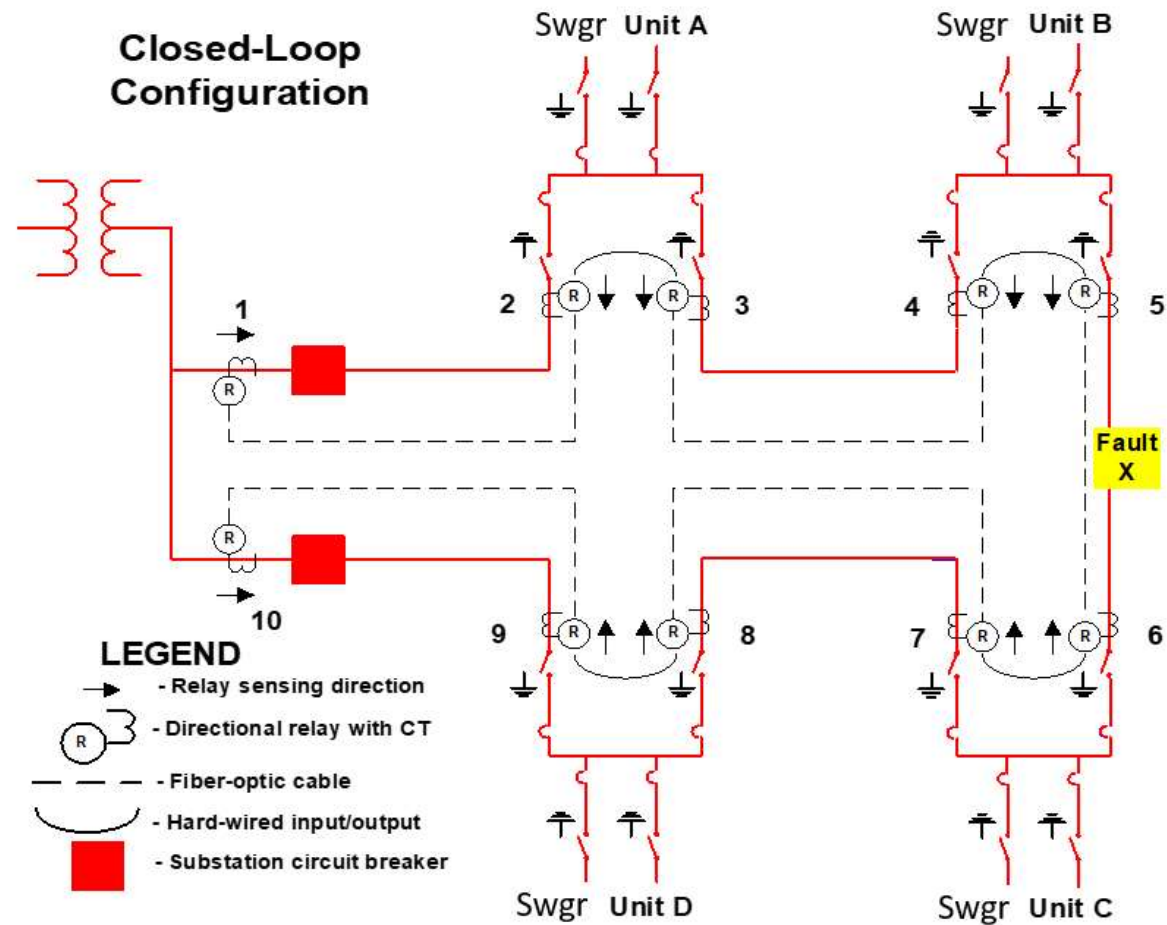




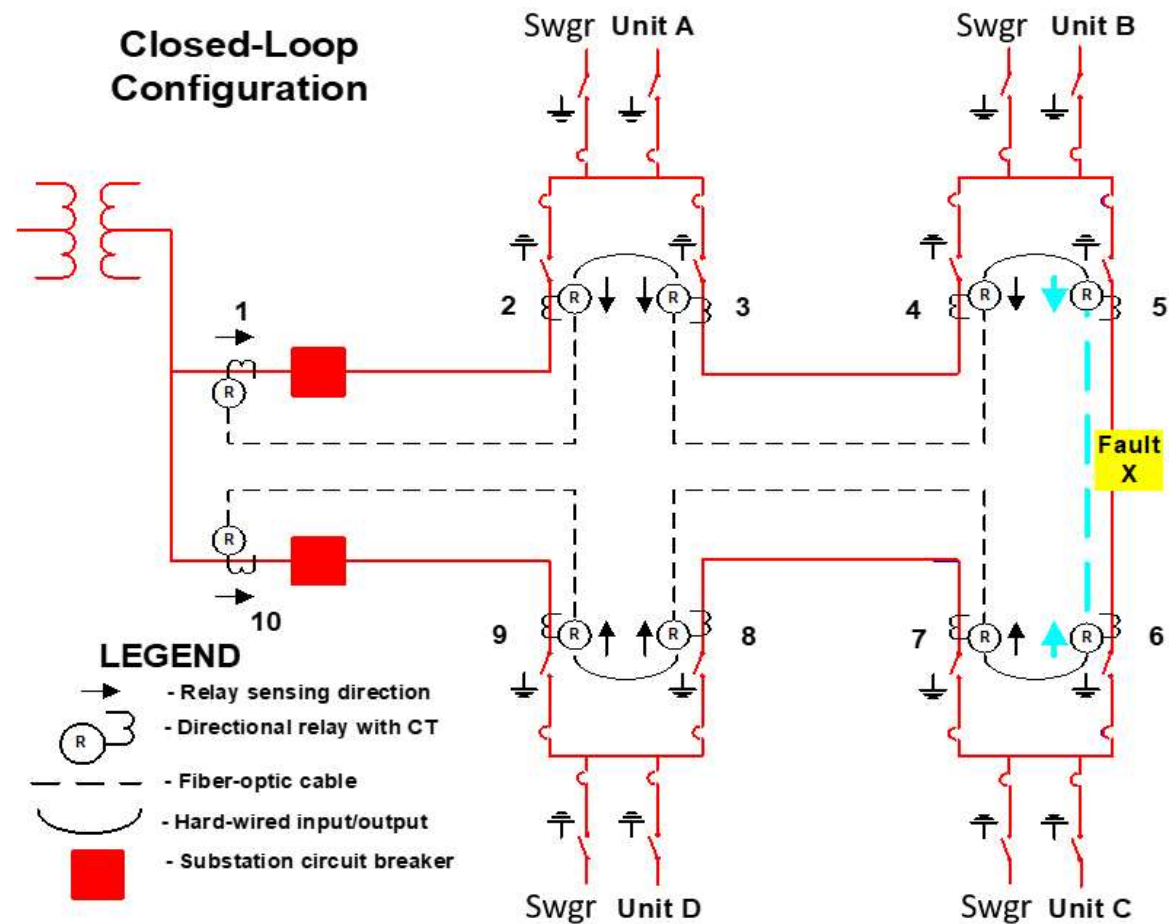
# Closed Loop Configuration – Normal Operation



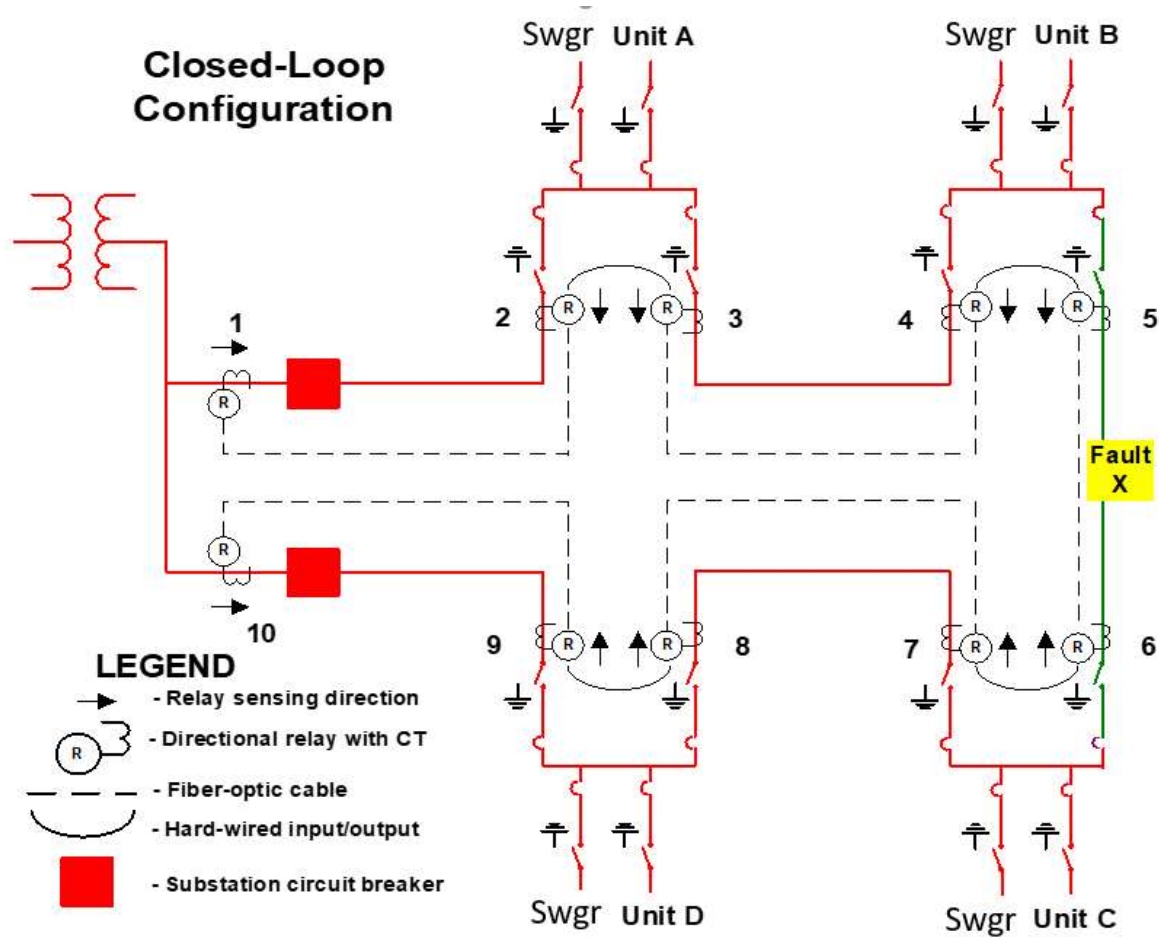
# Fault Condition



# Fault Communication



# Fault Isolation

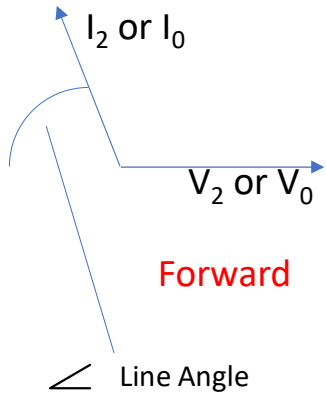


# DCB/POTT

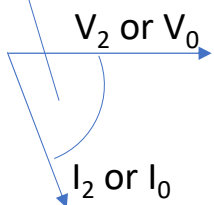
- DCB is Directional Comparison Blocking
  - Local relay receives a block from remote relay if faults are not in section
- POTT is Permissive Overreaching Transfer Trip
  - Local relay receives a permissive from remote if fault is in section

# Directional Element Settings

Negative cross product



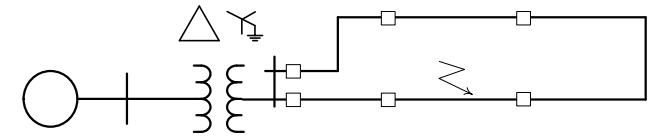
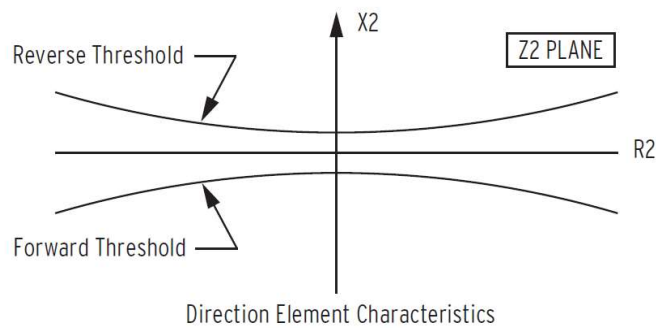
Reverse



Positive cross product

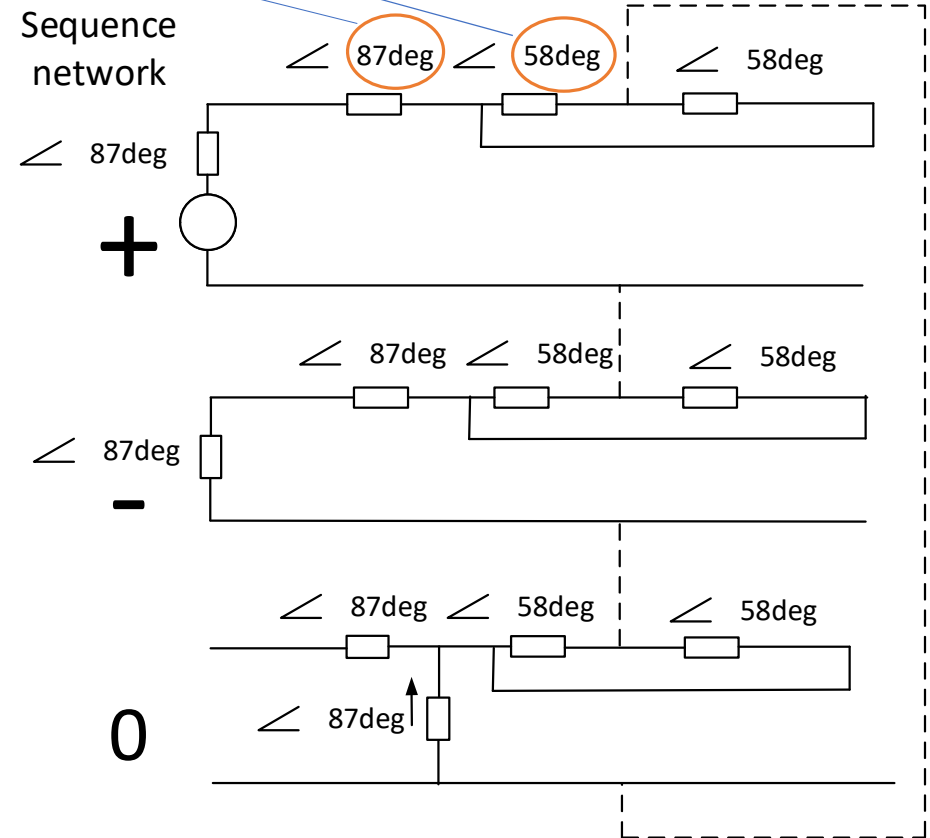
Which angle 87, 58 or something in between

$$Z2 = \frac{\text{Re}[V_2 \cdot (I_2 \cdot 1 \angle Z1L)^*]}{|I_2|^2}$$



DER Step-Up Transformer

Sequence network



# EVENTS

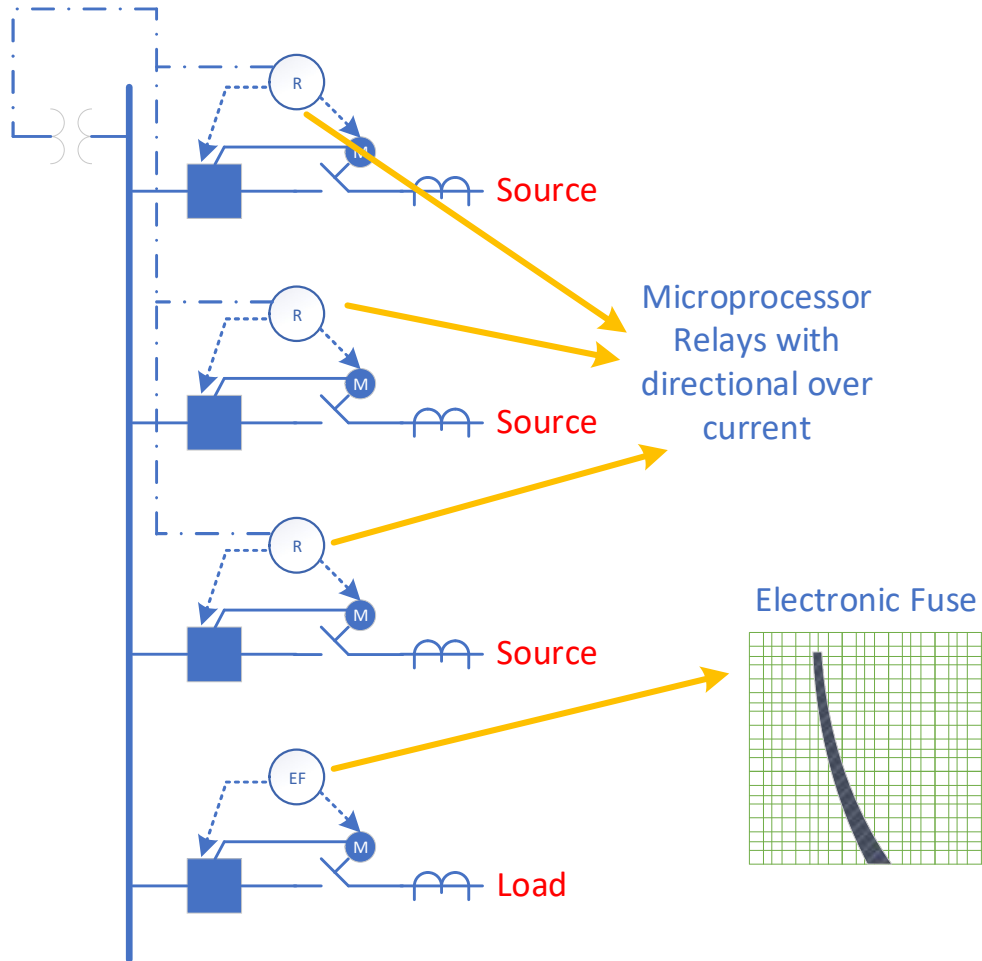
- Battery aging
- Communication bit inconsistencies
- Phase rotation inconsistencies
- Switchgear orientation inconsistencies
- Port connection inconsistencies

# ANALYSIS

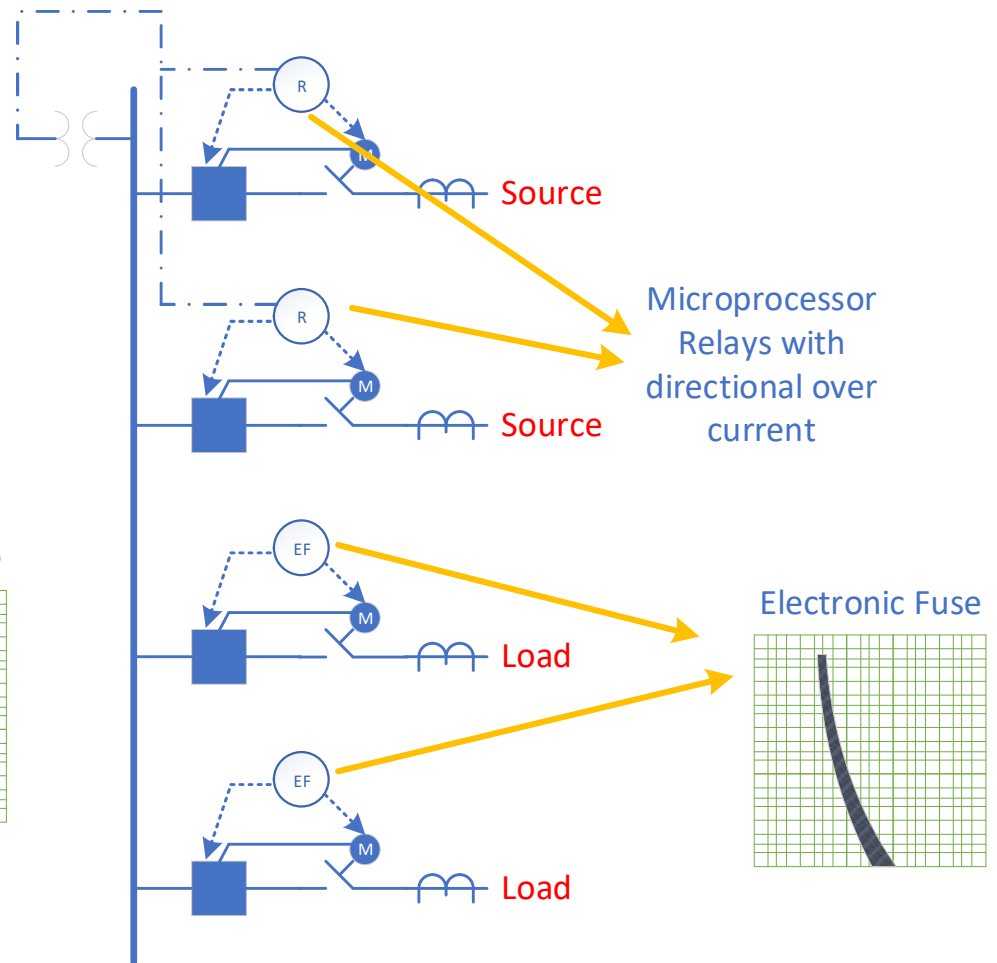
- There are two protection configurations, 2-Ways and 3-Ways
  - 2-Ways have two source connections and two load connections, 3-Ways have 3 source connections and one load connection
  - The 3-Way configuration is utilized when a third feeder connects to an adjacent loop
- There are 18 2-Ways and 15 3-Ways switchgear
- One relay per source connection
- The I/O for the relaying on 2 Way and 3 Way is quite different



3 Ways  
Switchgear



2 Ways  
Switchgear



# ANALYSIS - 2017

- Examination of the protection system **showed consistency between the many relays**
- **No protection settings** concerns were found
- **Backup inverse-time overcurrent protection settings vary.** This is acceptable and perhaps **necessary to coordinate with load Way overcurrent settings** as well as feeder relay time-overcurrent settings.

# COMMUNICATIONS

- 85 relays, most communicating with two remote relays  
→ 160 communication links
  - 320 communication ports involved
- Each relay has **only four address values built into the communication**
- Each switchgear has between 4 and 6 communication connections
- Multiplexer system can potentially map to any port on the system

**MUST HAVE UNIQUE ADDRESSES**

# THE CHALLENGE

- Port addressing value allows for **only 4 unique addresses**
- **Extra comm. bit used to supplement** addressing
- 6 comm. bits used with addressing value to create **256 possible unique addresses**
- Relay must receive all appropriate bits from remote relay
- **Incorrect communication will ALARM**

# THE SOLUTION

- Increased the quantity of possible unique addresses
- Alarming when incorrect communication is detected

		Way	
		Existing	New
Port	Transmit	2,1	(1-4)
	Receive	1,2	(1-4)
Comm. Bit	Bit1	NA	0,1
	Bit2	NA	0,1
	Bit3	NA	0,1
	Bit4	NA	0,1
	Bit5	NA	0,1
	Bit6	NA	0,1
	Bit7	OC Elem.	OC Elem.
	Bit8	OC Elem.	OC Elem.
Alarm Variable		CH. FAIL	CH.FAIL*Bit1*Bit2*Bit3*Bit4*Bit5*Bit6*Bit7*Bit8

# COMMISSIONING PROCESS

- Process setting updates consecutively through the loops (1, 2, 3, 4)
  - Read **As-Found** settings
  - **Update settings (in pairs)** and test changes
  - **Collect data:** comm. alarm status, and phasors on commissioning of the settings
  - Read **As-Left** Settings
- Ensure every relay has **no alarms** before the end of the day

# CONCLUSION

- The I-Drive system has been reliably delivering power for the last 21 years
- History of few events and subsequent changes to the system
- Special directional POTT/DCB scheme
- Secure communication addressing system

QUESTIONS?