

# This webinar brought to you by the Relion<sup>®</sup> product family Advanced protection and control IEDs from ABB

## **Relion.** Thinking beyond the box.

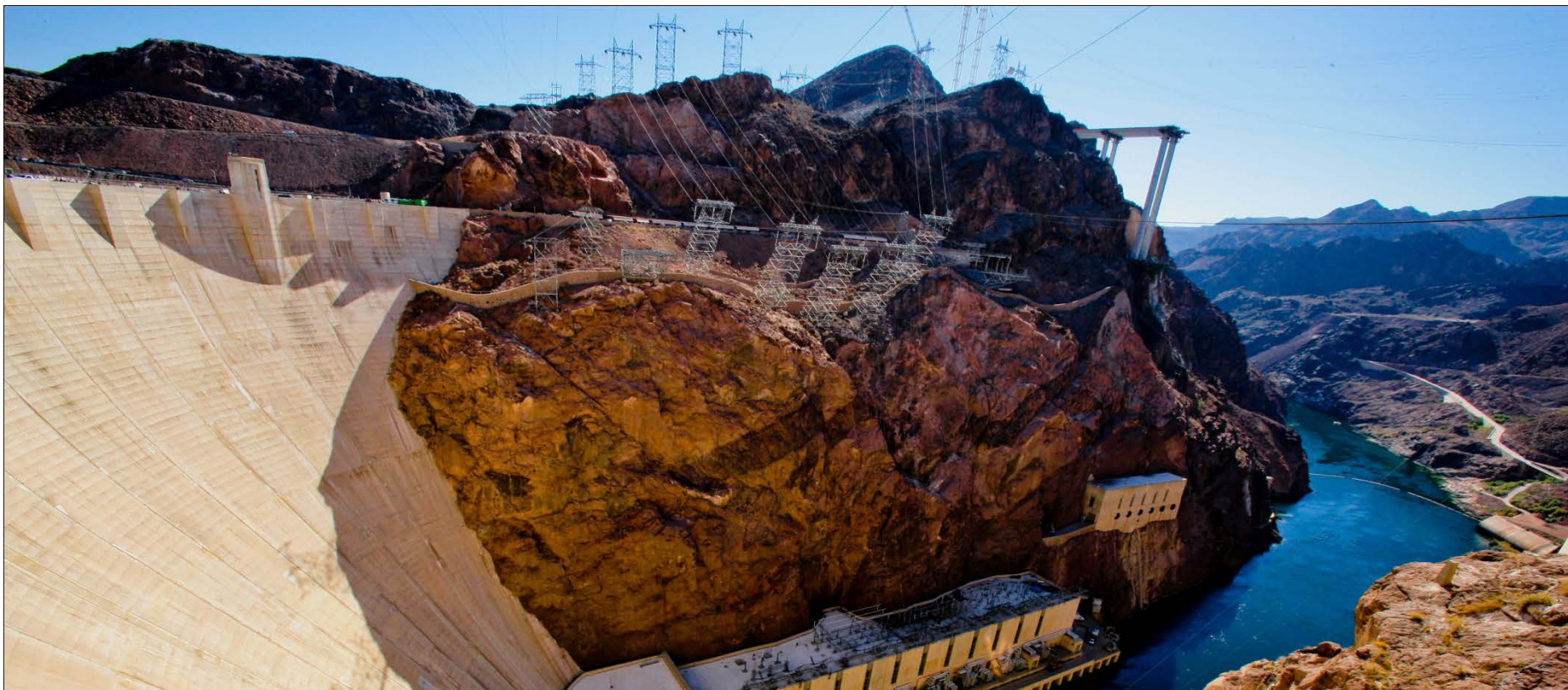
Designed to seamlessly consolidate functions, Relion relays are smarter, more flexible and more adaptable. Easy to integrate and with an extensive function library, the Relion family of protection and control delivers advanced functionality and improved performance.



# ABB Protective Relay School Webinar Series

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# Pre-configured matching unit (PCMU) Thinking beyond the box

# Profile

## Michael Fleck, P.E.



- Regional Technical Manager, Midwest USA
- BSEE, Rose-Hulman Inst. of Technology, Indiana
- MSEE, Arizona State University, Arizona
- Professional Engineer (P.E.), Indiana
- IEEE – Power & Energy Society Member & PSRC
- Experiences:
  - ✓ ABB DA Regional Technical Manager, configuration of products to meet customer applications, customer training
  - ✓ Protection and Control Engineer, system modeling, control design, mentoring junior engineers for national consulting company,
  - ✓ Transmission and Distribution P&C engineer, system modelling, system study, design, relay setting, trouble shooting for utility company

# Learning objectives

- What we will discuss
  - Utility Constraints
  - Issues and Concerns Meeting those Constraints
  - PCMU
    - Mechanical Compatibility
    - Enhanced Communication & Security
    - Enhanced Performance & Functionality
    - Future Proof & Smart Grid Compatibility
    - Reliability

# The new utility

## Cost constrained... Risk constrained...

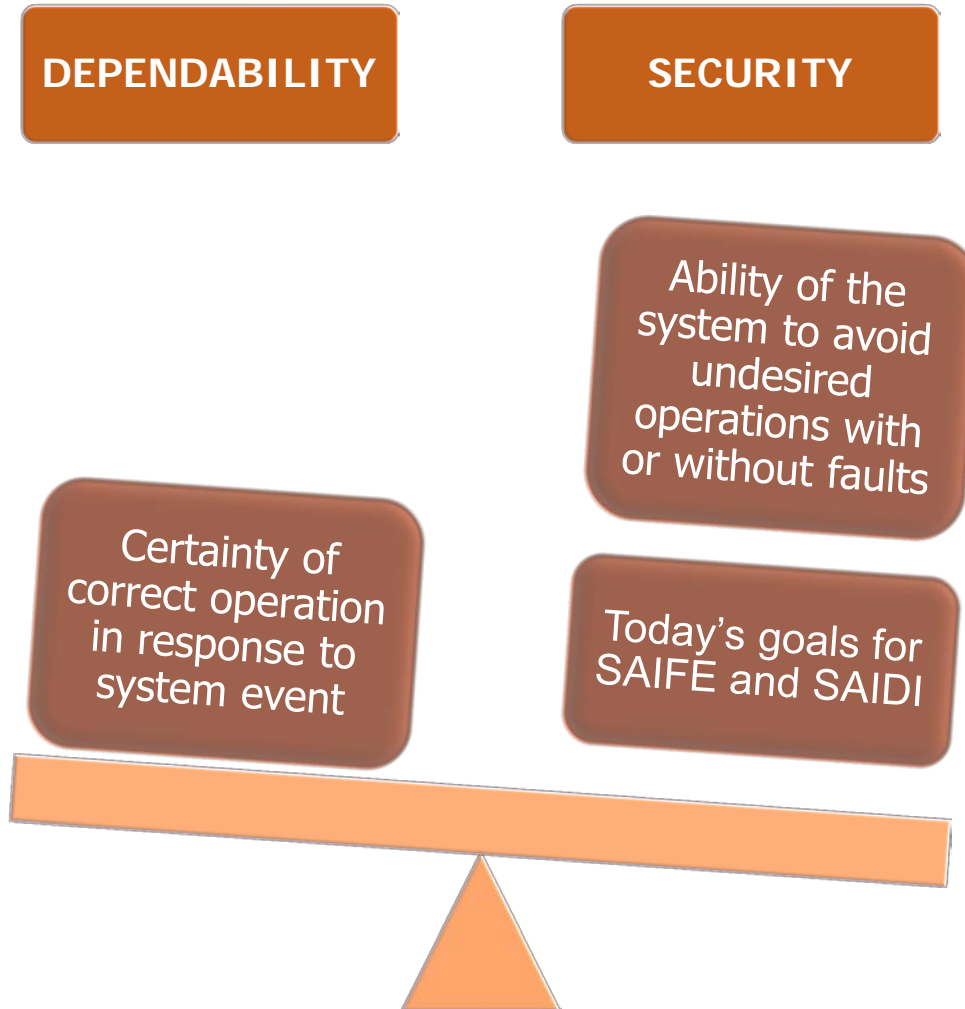
- Capital & Operating budgets under pressure
- Rate case challenges & cost control measures
- Internal competition for money (smart metering & renewable generation higher priority)
- Protection does not have the same access to funds
- Skilled human resource pool shrinking
- Older protection schemes designed for dependability
- Protection needs to be dependable & secure (avoid undesired operations)

**This is the new normal !**



# The new utility

## The art of protection ...



# Why do utilities refurbish relays?

- Cost to repair/replace obsolete assemblies
- Protection for security (versus just reliability)
- Ability to support automation schemes
- Data source for the Smart Grid applications

## Compliance

- NERC PRC
- NERC CIP
- Increase public safety
- Improve outage metrics (SAIFI/SAIDI)

It's obsolete! It does not do what utilities need it to do!  
Replace them as fast as practical



PRC      Protection & Control  
CIP      Critical Infrastructure Protection  
SAIFI    System average interruption frequency index  
SAIDI    System average interruption duration index



# Understanding the cost of refurbishment

Retrofit incurred costs include:

- Modifying drawings
- Mechanical changes to cabinets, doors or cut-outs
- Wiring and labeling
- Integration into existing substation automation system
- Test & commissioning  
Bay, HMI & control center(s)

Most of these costs exceed the price of a relay

How do we reduce these costs & risks to accelerate refurbishment?



# Minimizing retrofit costs & risks

## What to ask for from relaying solutions

### Mechanical Compatibility

Relay assembly that replaces a legacy relay without modifying the existing cutout and existing CT, VT, I/O wiring.

### Communication & Security

Enhanced Performance & Functionality

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# Form/Fit mechanical compatibility

## PCMU Direct Wire-Like Replacements



DPU 245/445



DPU2000



Vertical Mount



PCMU

## REF615R Direct Wire-Like Replacements



DPU2000R



3U, 19" Case



REF615R

Eliminates the need to modify panels/doors or cutouts

# Wire-like compatibility

## Different relays, same terminal blocks



Eliminates the need to modify engineering drawings  
& reduce scope of testing

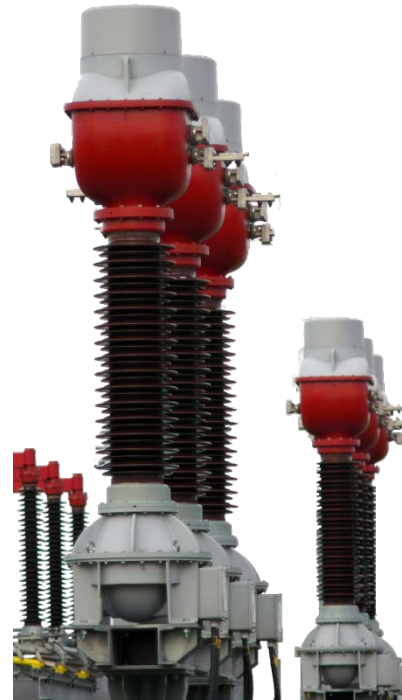
# Minimizing test scope

## Design for easy validation

Certify to the test switches ...



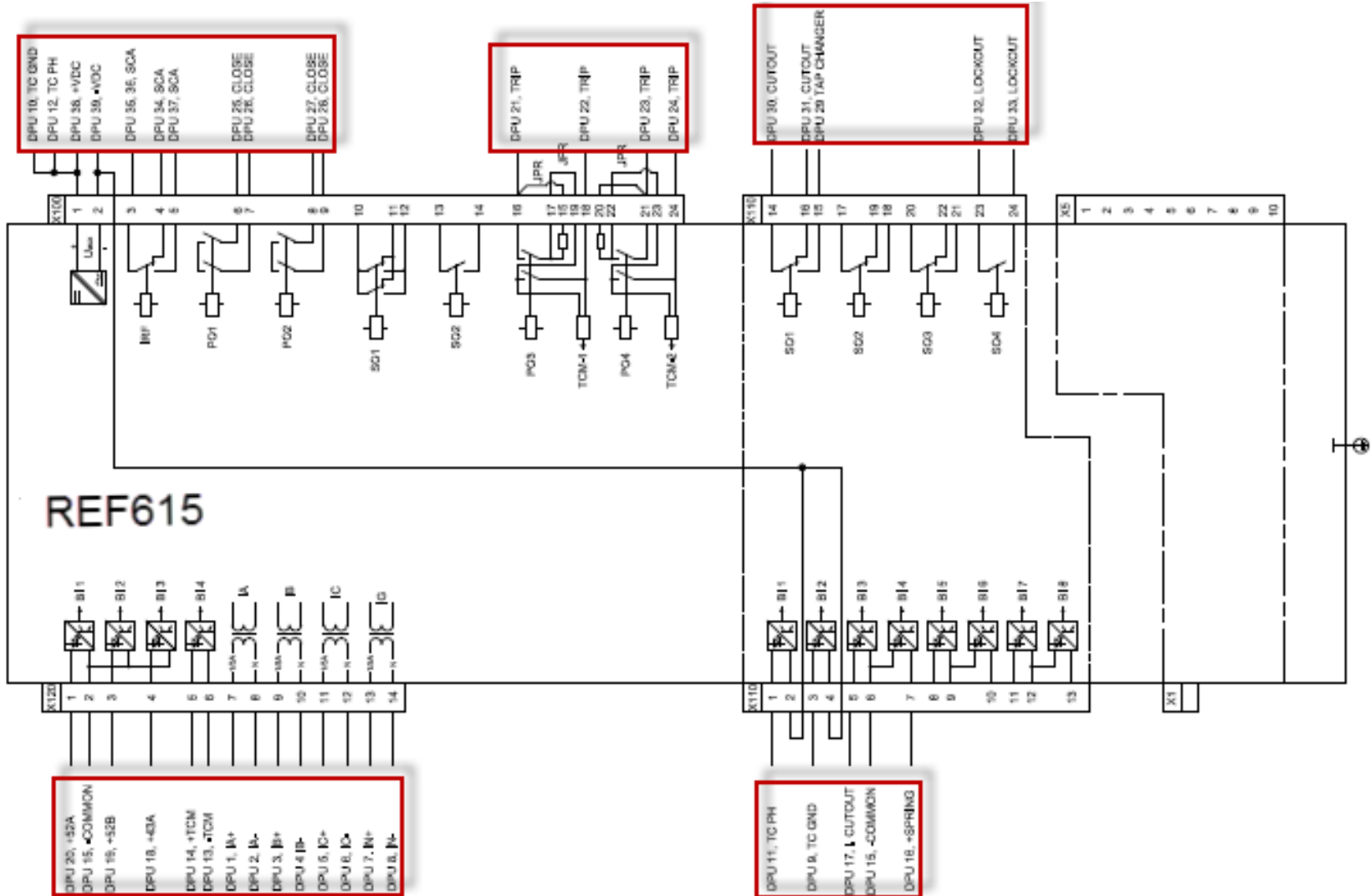
and not at the CT/PT



(where procedures allow)

# Pre-made mapping drawings

## Shorten the design effort



# Pre-made mapping drawings

## Shorten the design effort

### Design Effort

- Reduced by up to 70%
- Drawing updates non-existent – Wire alike solution
- Design savings in converting old settings and logic to new devices
- No fabrication of adapter plates needed

	Competitor solution			PCMU		
Engineering of solution	16	hr	\$3,200	4	hr	\$800
Translate protection settings to match old relays	4	hr	\$800	Included in PCMU		
Translate logic settings to match relays	4	hr	\$800	Included in PCMU		
New autocad dwgs	8	hr	\$1,600	2	hr	\$400
Adapter plate	\$50	1	\$50	Included in PCMU		
Miscellaneous	\$100	1	\$100	\$50	1	\$50
Factory prewiring to relay terminals	6	hr	\$300	Included in PCMU		
Removing existing relay & associated wiring	1	hr	\$50	1	hr	\$50
Drill hole, mount plate, wire to terminal blocks	1	hr	\$50	0.5	hr	\$25
Programming set up of new relay, including protection settings	2	hr	\$100	Included in PCMU		
Wire check (ring out)	1	hr	\$50	0.5	hr	\$25
Updating of drawings by customer	35	hr	\$7,000	10	hr	\$2,000
	TOTAL		\$14,100			\$3,350

Note: Calculation is typical and may vary depending on specific customer conditions. Calculation assumes replacement is planned so no utility downtime is considered.

# Minimizing retrofit costs & risks

## What to ask for from relaying solutions

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# Data-communication compatibility

Relays should support multiple communication interfaces:

- Multiple Ethernet 10/100BaseT (RJ45) ports
- RS-232/RS-485 for legacy communication
- DNP 3.0 and IEC 61850 protocol support
- IRIG-B and SNTP for time synchronization
- Cyber-security support for NERC CIP compliance



The future is about secure, shared and actionable data

# Data-communication compatibility

## Pre-configured data mapping for DNP 3.0

REF615A - Parameter Setting

Group / Parameter Name	IED Value	PC Value	Unit	Min	Max
DNP3.0/DNP3.0: DNP3.0: 1					
DNP3.0					
✓ DNP physical layer		TCP/IP			
✓ Unit address		1			65519
✓ Master address		3		1	65519
✓ Serial port		Not in use			
✓ Need time interval		30	min	0	65535
✓ Time format		Local			
✓ CROB select timeout		10	sec	1	65535
✓ Data link confirm		Never			
✓ Data link confirm TO		3000	ms	100	65535
✓ Data link retries		3		0	65535
✓ Data link Rx to Tx delay		0	ms	0	255
✓ Data link inter char delay		4	char	0	20
✓ App layer confirm		Disable			
✓ App confirm TO		5000	ms	100	65535
✓ App layer fragment		2048	bytes	256	2048
✓ UR mode		Disable			
✓ UR retries		3		0	65535
✓ UR TO		5000	ms	0	65535
✓ UR offline interval		15	min	0	65535
✓ UR Class 1 Min events		2		0	999
✓ UR Class 1 TO		50	ms	0	65535
✓ UR Class 2 Min events		2		0	999
✓ UR Class 2 TO		50	ms	0	65535
✓ UR Class 3 Min events		2		0	999
✓ UR Class 3 TO		50	ms	0	65535
✓ Legacy master UR		Disable			
✓ Legacy master SBO		Disable			
✓ Default Var Obj 01		1		1	2
✓ Default Var Obj 02		2		1	2

REF615A - Disturbance Handling / REF615A - Application Configuration / REF615A - Communication Management / REF615A - Signal Matrix

LEDS

		Programmable LED 1	Programmable LED 2	Programmable LED 3	Programmable LED 4	Programmable LED 5	Programmable LED 6	Programmable LED 7	Programmable LED 8
X120 (AIM)	X120-Input 1								
	X120-Input 2								
	X120-Input 3								
	X120-Input 4								
- X130 (AIM)									
X130 (AIM)	X130-Input 1								
	X130-Input 2								
	X130-Input 3								
	X130-Input 4								
- AND:1									
AND:1	O	X							
- AND:2									
AND:2	O		X						
- AND:3									
AND:3	O			X					
- AND:6									
AND:6	O								
- ARC SARC1(AFD-1:ARC(1)):11									
ARC SARC1(AFD-1:ARC(1)):11	TRIP								
	ARC_FLT_DET								
- ARC SARC2(AFD-2:ARC(2)):21									
ARC SARC2(AFD-2:ARC(2)):21	TRIP								
	ARC_FLT_DET								
- ARC SARC3(AFD-3:ARC(3)):31									
ARC SARC3(AFD-3:ARC(3)):31	TRIP								
	ARC_FLT_DET								
- CBXCBR1(52-1):<-O CB(1):1									
CBXCBR1(52-1):<-O CB(1):1	SELECTED								
	LXE_OP								

Binary Inputs / Binary Outputs / Analog Inputs / Functions

Reduces the substation automation integration effort

# Minimizing retrofit costs & risks

## What to ask for from relaying solutions

### Mechanical Compatibility

Relay assembly that replaces a legacy relay without modifying the existing cutout and existing CT, VT, I/O wiring.

### Communication & Security

### Enhanced Performance & Functionality

Future proof for Smart Grid migration

Reliability



# Enhanced human machine interface

## Improves accuracy of operation



Look for large displays with programmable target LED's to support existing and future protection philosophies

# Ease of use

## Simplifying the user experience

The image displays three overlapping screenshots of the ABB REF615 user interface, illustrating its ease of use and graphical nature.

**Left Screenshot: Phasor Diagrams**  
The interface shows a phasor diagram with the following data:

Phase	Value	Angle
IA	138.59A	+43.07°
IB	138.6A	136.93°
IC	138.59A	+43.07°
VA	13.57kV	0°
VB	13.57kV	-180°
VC	0kV	0°

**Middle Screenshot: Events**  
The interface displays a table of events:

Date	Time	Device	Object text
02/13/2012	0:00:46.976	79	SHOT_PTR
02/13/2012	0:00:46.964	79	UNSUCL_RECL
02/13/2012	0:00:46.964	79	LOCKED
02/13/2012	0:00:46.964	79	STATUS
02/13/2012	0:00:37.897	S2-1	ENA_CLOSE
02/13/2012	0:00:36.993	1G	HIGH_WARN
02/13/2012	0:00:36.993	1G	HIGH_ALARM
02/13/2012	0:00:36.966	79	UNSUCL_RECL
02/13/2012	0:00:36.966	79	ACTIVE
02/13/2012	0:00:36.966	79	STATUS
02/13/2012	0:00:36.964	79	LOCKED
02/13/2012	0:00:36.958	S2-1	POSITION
02/13/2012	0:00:36.964	79	SHOT_PTR
02/13/2012	0:00:36.962	S2CM-1	NO_OPR
02/13/2012	0:00:36.947	S2-1	ENA_CLOSE
02/13/2012	0:00:36.947	TCM-2	ALARM
02/13/2012	0:00:36.947	TCM-1	ALARM
02/13/2012	0:00:36.945	S1G	TRIP
02/13/2012	0:00:36.945	79	OPEN_CB

**Right Screenshot: Terminal Window**  
The terminal window shows a command-driven interface with a red octagonal sign that says "WHOA!". The output of the terminal session is as follows:

```
vsilva@li368-249: /usr/openquake — ssh — 76x26
vsilva@li368...quake$ ssh
GACK! at col 4 row 3
Point at 15.64 38.13 isnt on grid
GACK! at col 4 row 4
Point at 15.64 38.17 isnt on grid
GACK! at col 4 row 5
Point at 15.64 38.21 isnt on grid
GACK! at col 4 row 6
Point at 15.64 38.25 isnt on grid
GACK! at col 4 row 7
Point at 15.64 38.29 isnt on grid
INFO:serializer:> insert_output
INFO:serializer:output = 'Output object'
INFO:serializer:< insert_output
INFO:serializer:> serialize
INFO:serializer:serializing 47 points
INFO:serializer:output = 'Output object'
INFO:serializer:serialized 47 points
INFO:serializer:< serialize
Mean region loss value: 65656509844.0
Standard deviation region loss value: 38803793778.9
vsilva@li368-249: /usr/openquake$ INFO:root:Process 10617 not running
INFO:root:Recording stop time for job 54 to job_stats
INFO:root:Cleaning up after job 54
INFO:root:KVS garbage collection removed 50 keys for job 54
INFO:root:Exiting supervisor for job 54
```

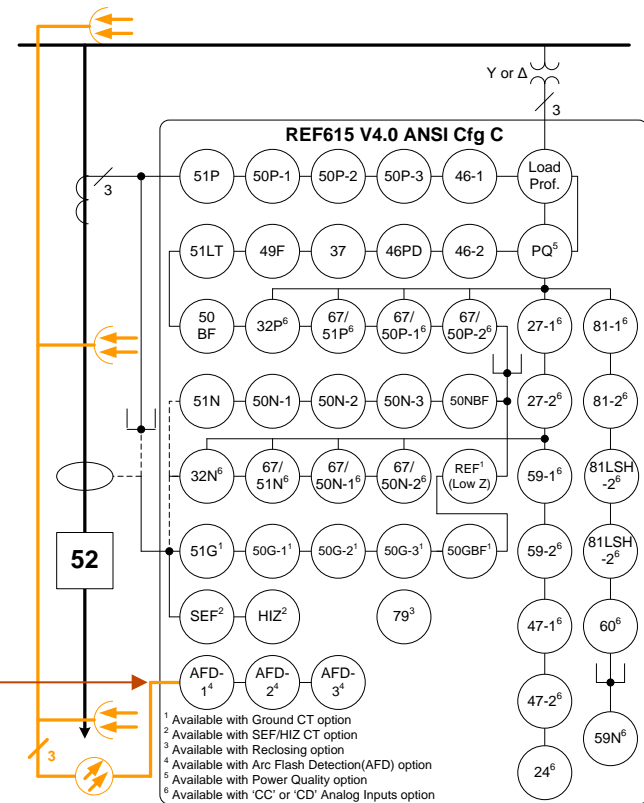
Intuitive “command-less” graphic user interface  
Eliminates command driven line access

# Enhanced performance & functionality

## Value add features to ask for

- Added protection functions for better coordination / enhanced feeder protection and control
- Voltage Protective Functions
- Arc Flash
- Frequency Protection

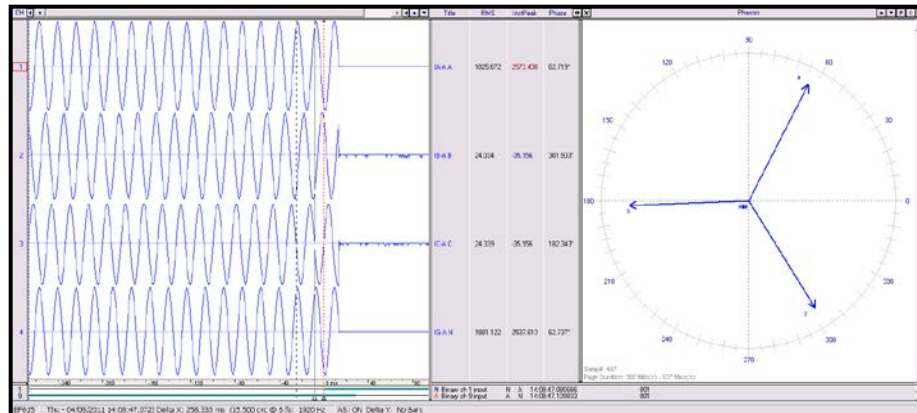
The more ANSI functions supported (circles) the greater the application flexibility



# Enhanced performance & functionality

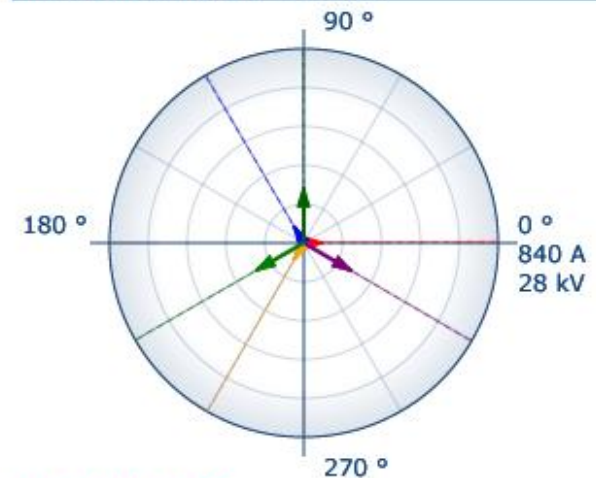
## Value add features to ask for

- Integrated sequence of event (SOE), fault and digital fault waveform recording & reporting (open formats)



### Phasor diagrams

Phase currents and voltages



IA: 60.49A 0.45°  
IB: 59.66A -119.71°  
IC: 60.08A 120.42°  
VA: 8.03kV -30.38°  
VB: 7.98kV -150.02°  
VC: 8.03kV 90.22°

# Enhanced performance & functionality

## Value add features to ask for

- Enhanced monitoring of Power Quality(PQ)
- Condition Based Monitoring of plant operations
- Cable Fault Detection (CFD) using existing CT input wiring. Detects underground cable faults





# Enhanced performance & functionality

## ARC Flash protection

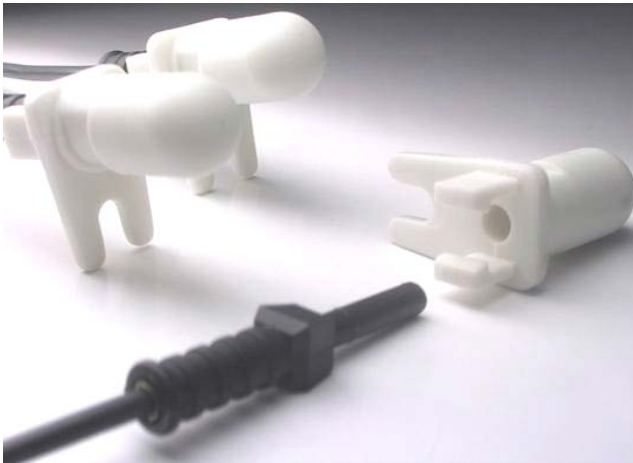


Arc Trip based on:

- Current and light
- Current and binary input signal
- Light only

Operate time depends on options:

- 1 / 12 ms (current and light)
- 1 / 10 ms (light only)



Continuously supervises the CB, cable and busbar compartment of metal-enclosed switchgear

\* Distribution Feeder specific feature

# Minimizing retrofit costs & risks

## What to ask for from relaying solutions

### Mechanical Compatibility

Relay assembly that replaces a legacy relay without modifying the existing cutout and existing CT, VT, I/O wiring.

### Communication & Security

### Enhanced Performance & Functionality

### Future proof for Smart Grid migration

### Reliability



# Planning for the future



New relays support multi-object protection and value-add applications ... based on signals from other bays

## Reality check

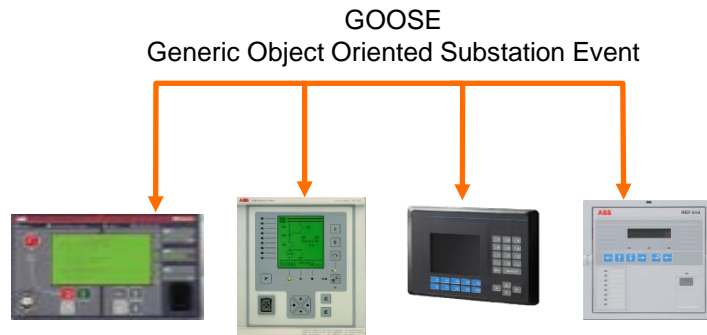
- Retrofits and wire-for-wire replacements limit cabling to existing signals
- “Form fit” limits adding of I/O modules
- There is a fixed number of inputs/outputs a relay can support

## How to extend the application capability?

- High speed Ethernet communication
- GOOSE messaging, a subset of IEC 61850 (Global Object Oriented Substation Event)

# Secure horizontal communication

## What is GOOSE messaging?

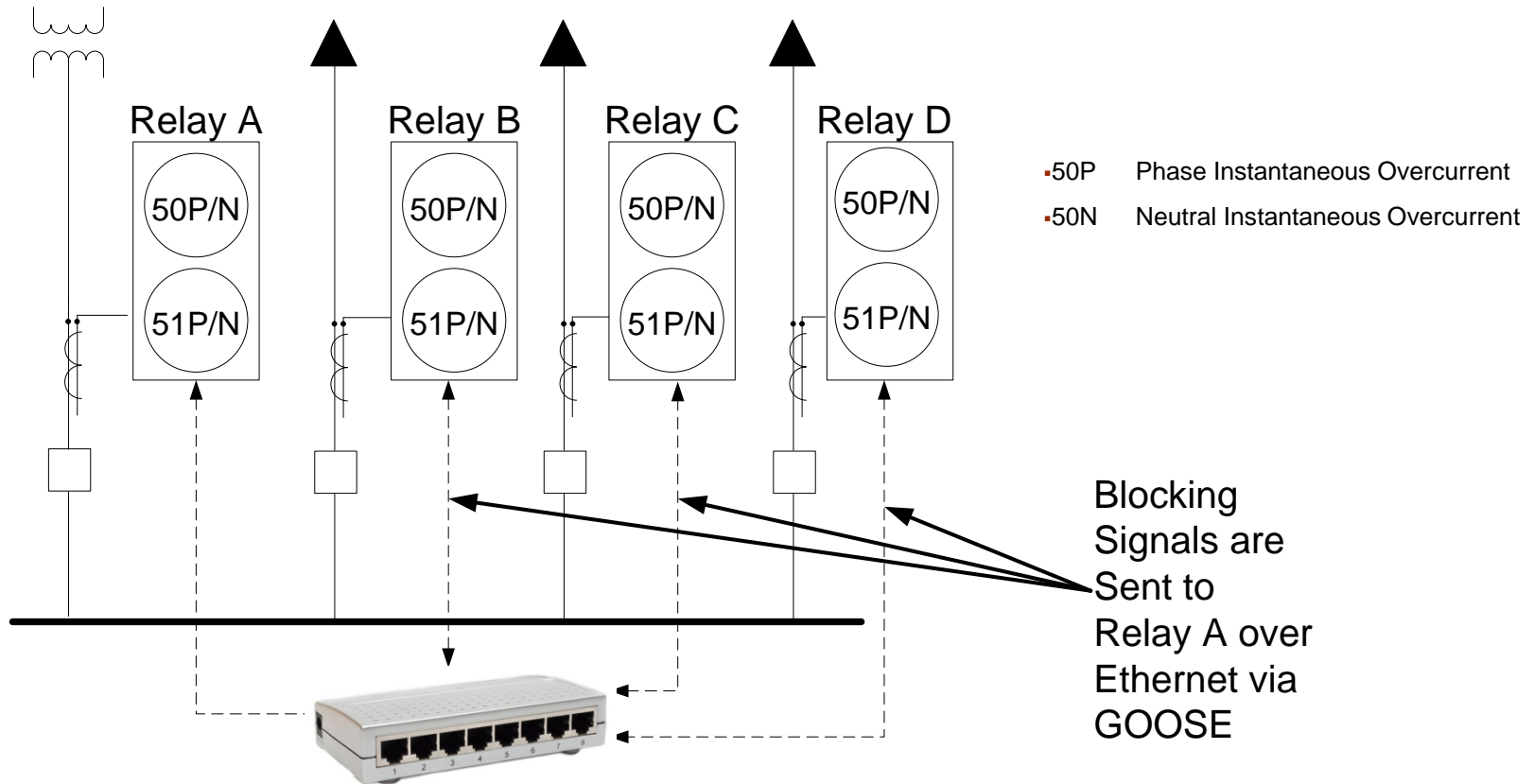


Illustrative purpose only

- Standards based (IEC 61850) horizontal communication
- Replaces hard-wiring between IEDs
- Supports multi-vendor products
- GOOSE broadcasts events to peer IEDs in a substation using Ethernet
- Transmits binary and analogue process data between IEDs
- Should be supported on replacement relays for new applications
- Designed by protection engineers for protection engineers

# Application example

## Bus blocking on feeder relay, GOOSE driven



# Minimizing retrofit costs & risks

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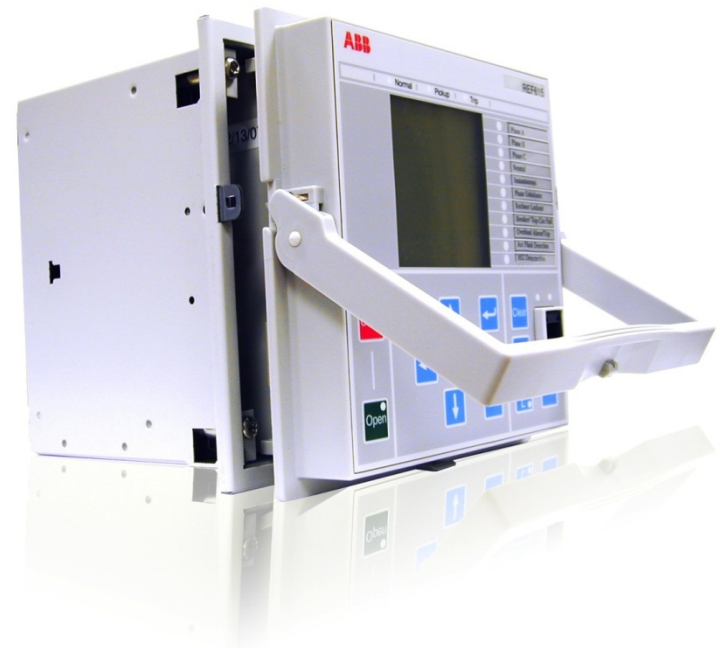


# Reliability

## Is the solution easily repairable?

- Is the relay designed for 15+ years of uninterrupted service by a reputable vendor?
- Are faults easy to diagnose (with limited skills)
- Cost of non-modular repair outweighs benefits of extended warranties

Draw-out and modular designs improve system maintainability (MTTR)



# In Summary ...



The PCMU is a direct wire-like, panel cutout replacement for existing ABB relays (DPU245, DPU445, and DPU2000)

The PCMU reduces engineering and installation time while keeping operational functions similar to legacy product and providing added relay functionality when system requirements evolve.

The PCMU is the most cost effective solution for replacement of older 245/445 and DPU2000 relays that takes advantage of the communication required for the evolving smart grid.



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# Thank you for your participation

Shortly, you will receive a link to an archive of this presentation.  
To view a schedule of remaining webinars in this series, or for more  
information on ABB's protection and control solutions, visit:

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