

Cloud-Based End-to-End Testing of Protection Schemes

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Agenda

- Pilot Schemes POTT & PUTT
- Test Considerations
- Test Setup
- Test Cases
- Results & Analysis
- Summary/Conclusions

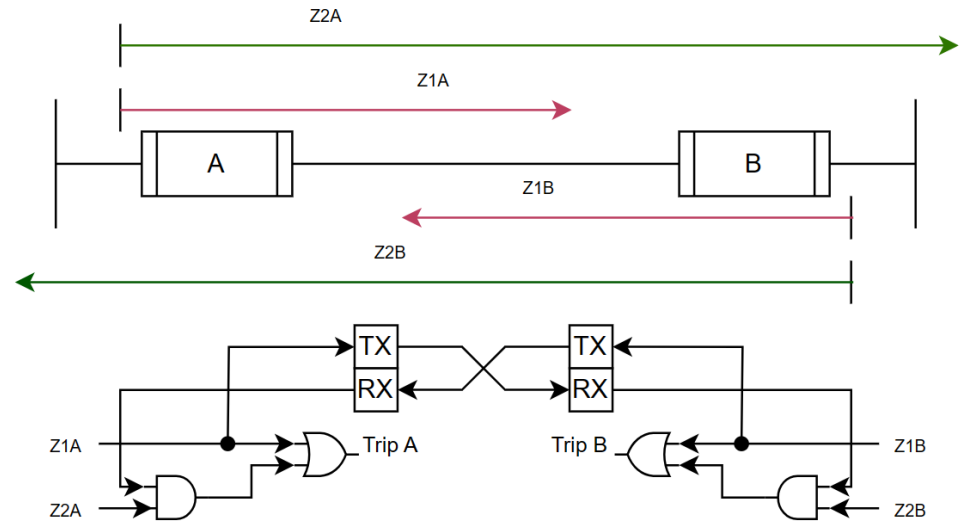
Pilot Schemes POTT and PUTT



PUTT

PUTT schemes use both underreaching ($Z1A$ and $Z1B$) and overreaching ($Z2A$ and $Z2B$) elements.

Each terminal will trip directly for its underreaching element, and the permissive signal sent accelerates the tripping of the other end's overreaching element.

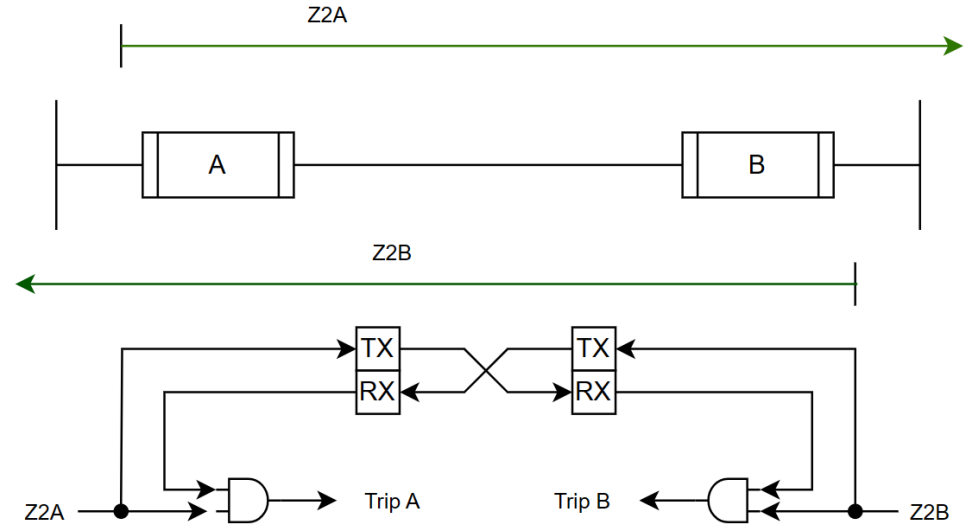


PUTT

POTT

POTT schemes use
overreaching elements.

As long as both relays see
the fault with their
overreaching element the
scheme trips.



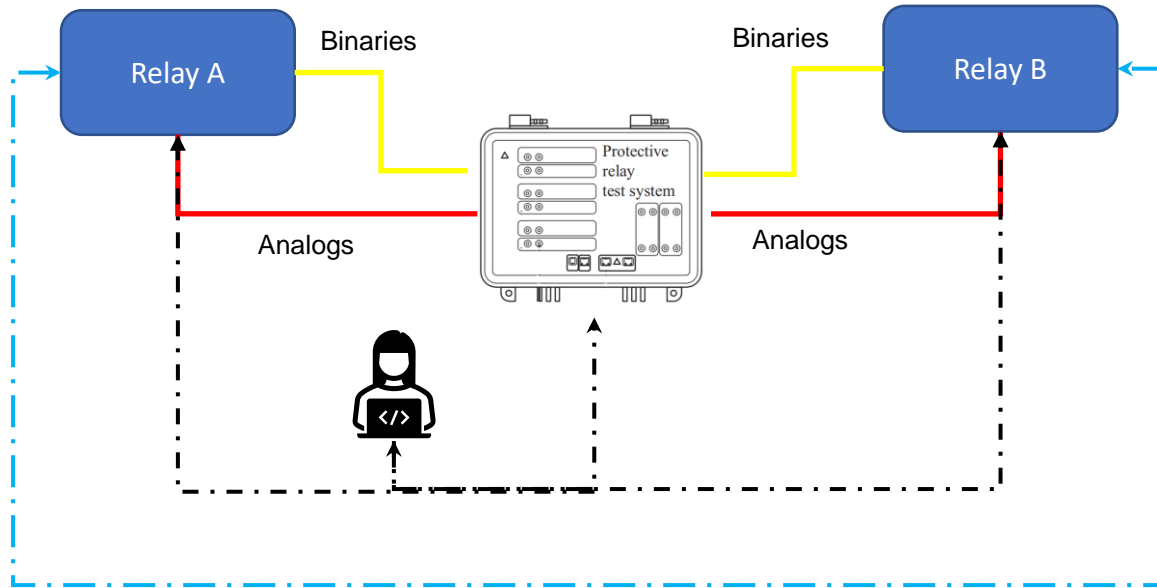
POTT Scheme

Testing Pilot Schemes



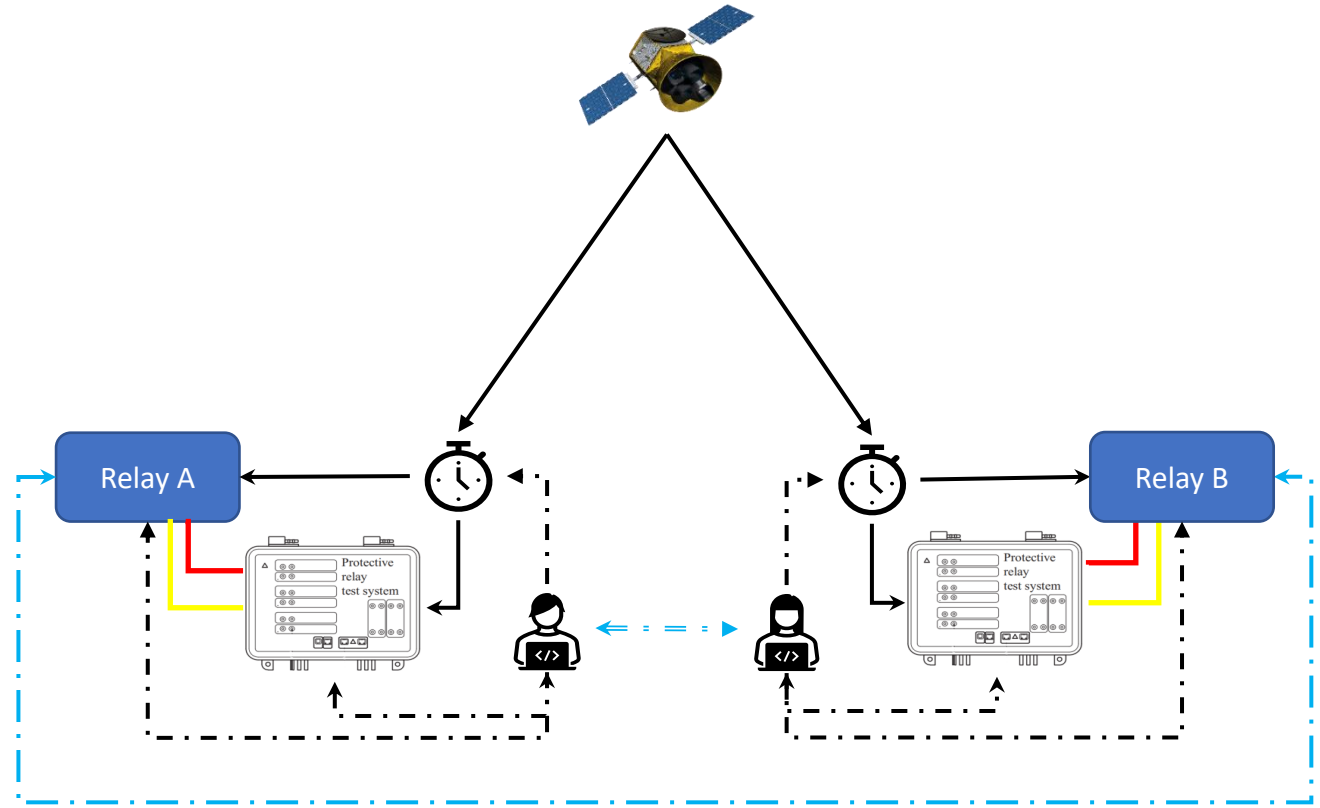
Bench Back-to-Back Testing

- Helps in understanding, troubleshooting, and developing relay settings. (Laboratory Test Environment)

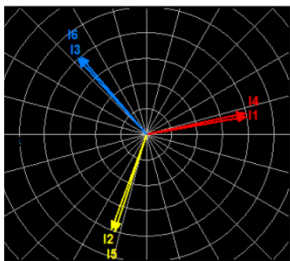


Traditional End-End testing

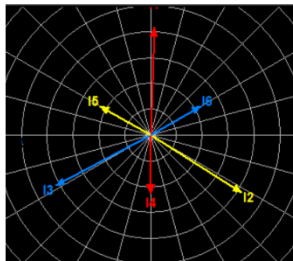
- Two users communicate, coordinate, and simultaneously do the testing at each end.



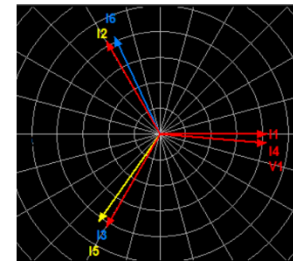
Traditional Static Testing



Pre-Fault



Fault



Post-Fault

Local

CCC	CURRENT			VOLTAGE			
	I (A)	ϕ (°)	f (Hz)	V (V)	ϕ (°)	f (Hz)	
⚡	I1	0.800	-10.00	50.000	66.40	0.00	50.000
⚡	I2	0.800	110.00	50.000	66.40	240.00	50.000
⚡	I3	0.800	230.00	50.000	66.40	120.00	50.000

CCC	CURRENT			VOLTAGE			
	I (A)	ϕ (°)	f (Hz)	V (V)	ϕ (°)	f (Hz)	
⚡	I1	7.400	-88.00	50.000	44.00	0.00	50.000
⚡	I2	7.400	32.00	50.000	44.00	240.00	50.000
⚡	I3	7.400	152.00	50.000	44.00	120.00	50.000

CCC	CURRENT			VOLTAGE			
	I (A)	ϕ (°)	f (Hz)	V (V)	ϕ (°)	f (Hz)	
⚡	I1	1.000	0.00	50.000	66.40	0.00	50.000
⚡	I2	1.000	240.00	50.000	66.40	240.00	50.000
⚡	I3	1.000	120.00	50.000	66.40	120.00	50.000

Remote

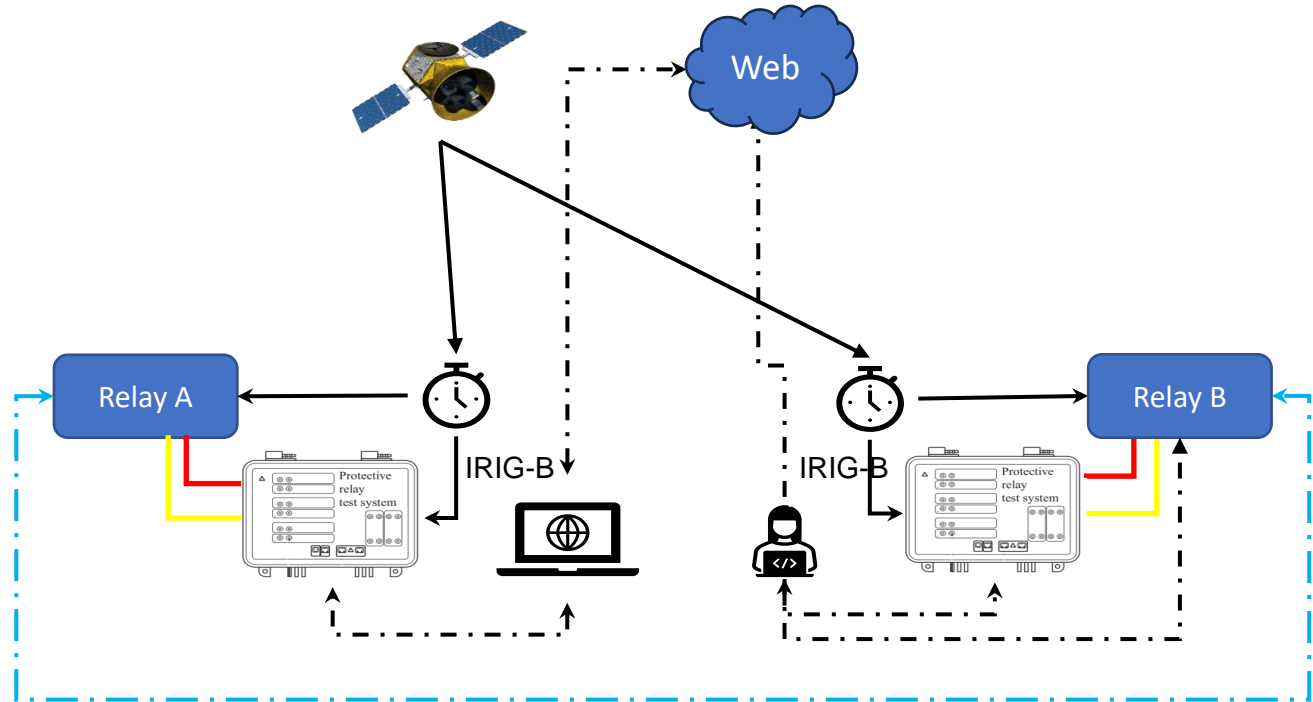
CCC	CURRENT			VOLTAGE			
	I (A)	ϕ (°)	f (Hz)	V (V)	ϕ (°)	f (Hz)	
⚡	I1	0.800	-12.00	50.000	66.40	0.00	50.000
⚡	I2	0.800	108.00	50.000	66.40	240.00	50.000
⚡	I3	0.800	228.00	50.000	66.40	120.00	50.000

CCC	CURRENT			VOLTAGE			
	I (A)	ϕ (°)	f (Hz)	V (V)	ϕ (°)	f (Hz)	
⚡	I1	4.000	90.00	50.000	46.00	0.00	50.000
⚡	I2	4.000	210.00	50.000	46.00	240.00	50.000
⚡	I3	4.000	330.00	50.000	46.00	120.00	50.000

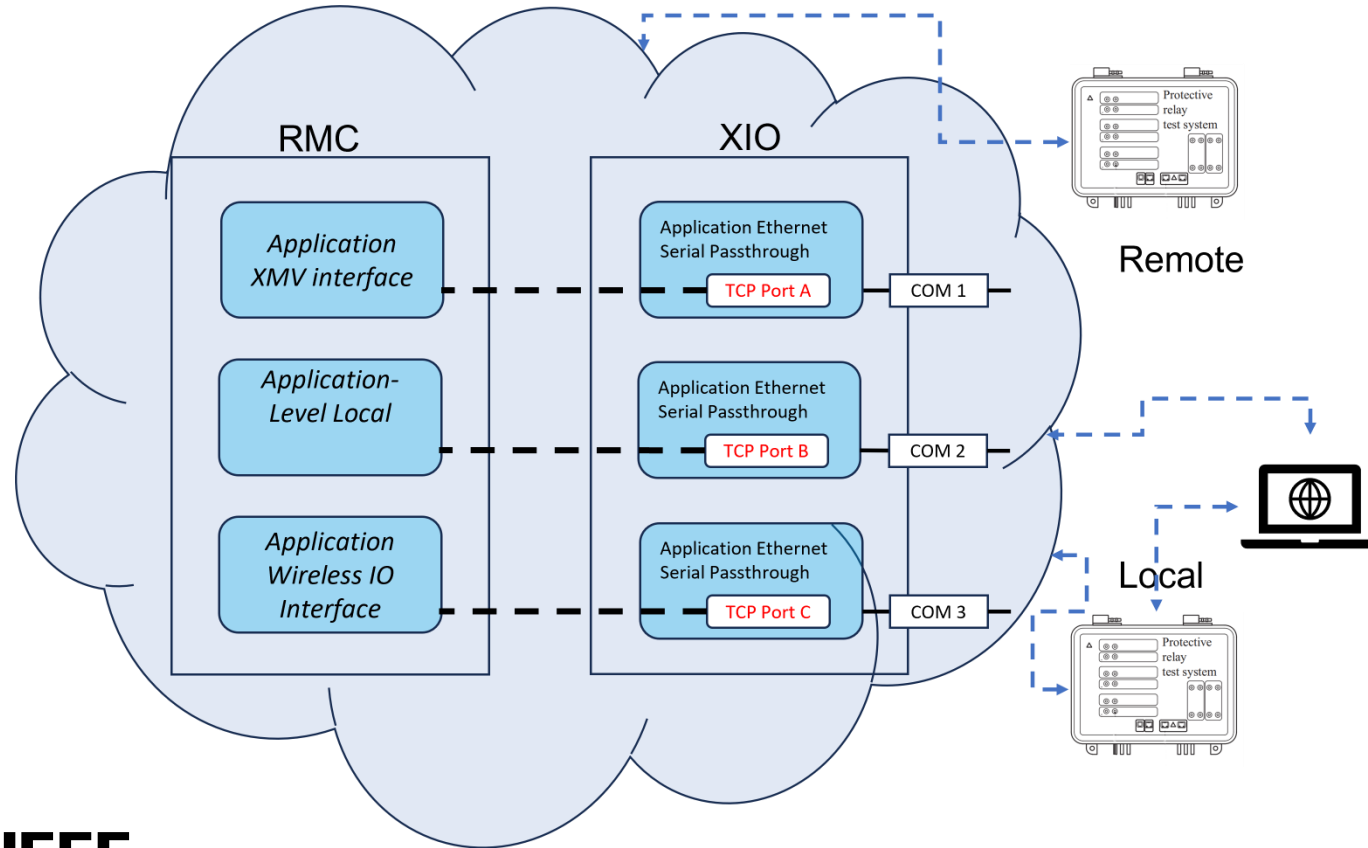
CCC	CURRENT			VOLTAGE			
	I (A)	ϕ (°)	f (Hz)	V (V)	ϕ (°)	f (Hz)	
⚡	I1	1.000	5.00	50.000	66.40	0.00	50.000
⚡	I2	1.000	125.00	50.000	66.40	240.00	50.000
⚡	I3	1.000	245.00	50.000	66.40	120.00	50.000

Web based End-End testing

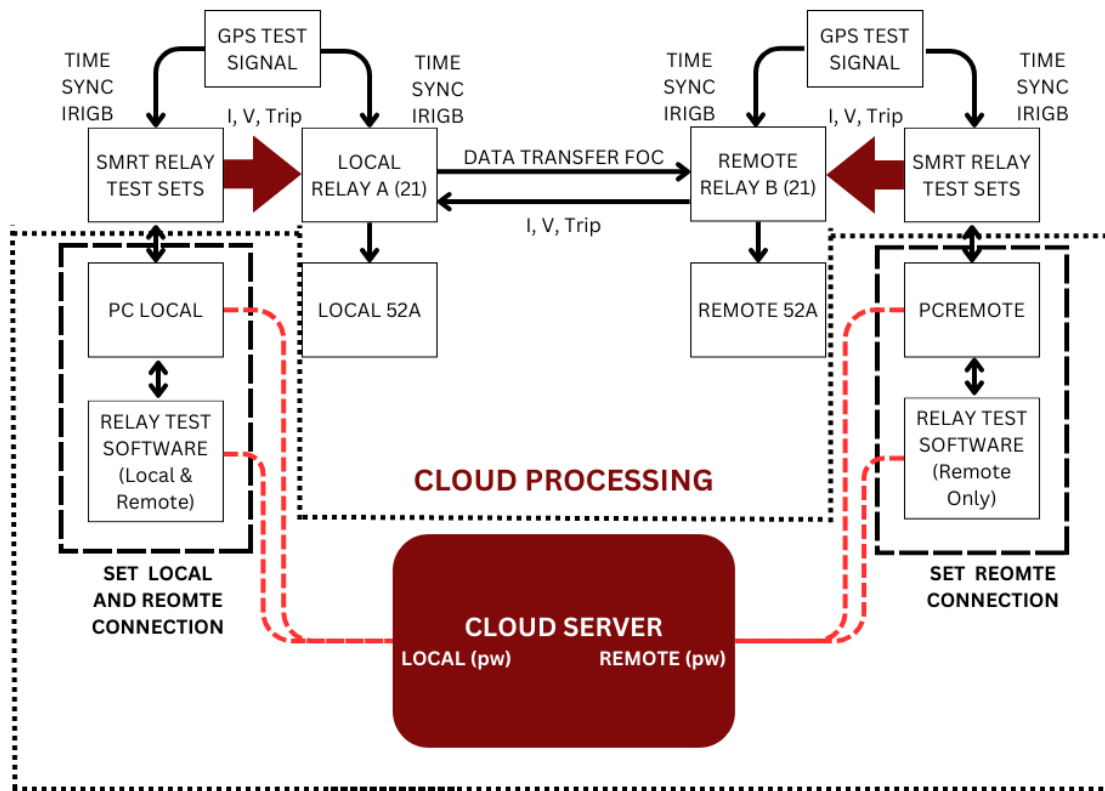
- Using the cloud, One user can do the testing of Pilot Scheme from one end.



Architecture – Cloud Explained



Architecture – Cloud Explained

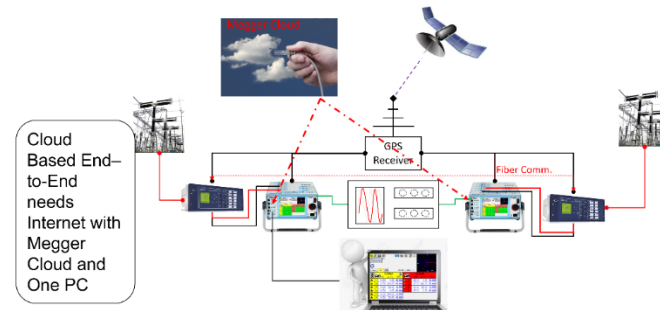


• Testing

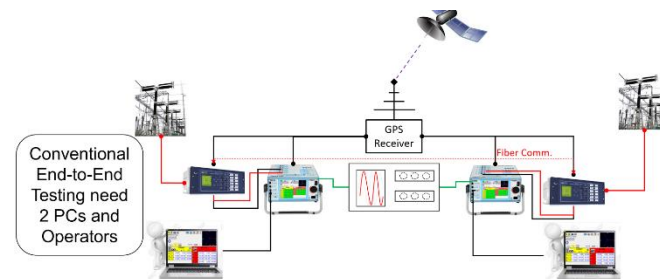


Test Setup

- Every case was tested using both a conventional setup and a cloud-based setup



Cloud-based Test Setup



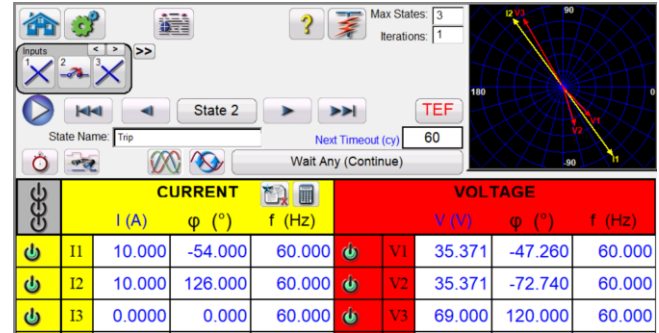
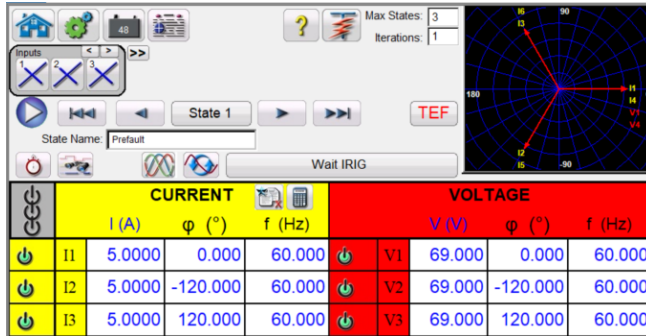
Conventional Test Setup

Traditional Test POTT

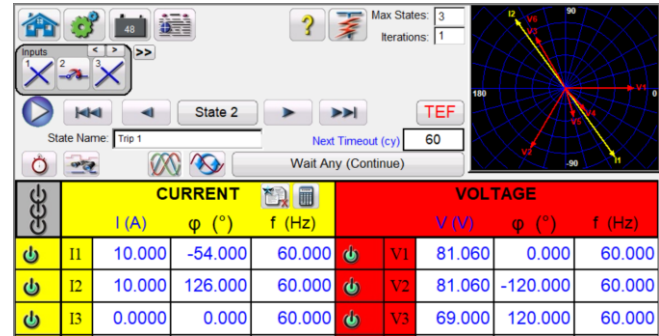
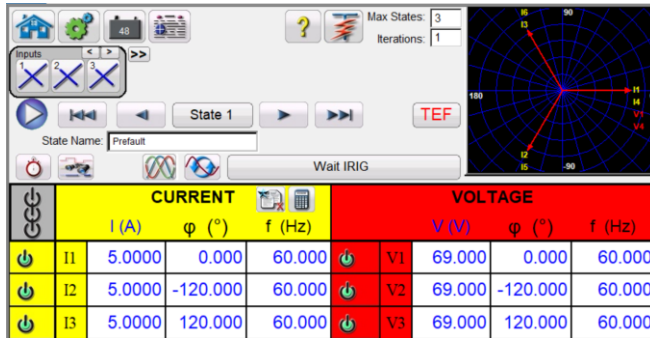
Prefault

Fault

Relay A



Relay B



Traditional Test POTT

=>ser

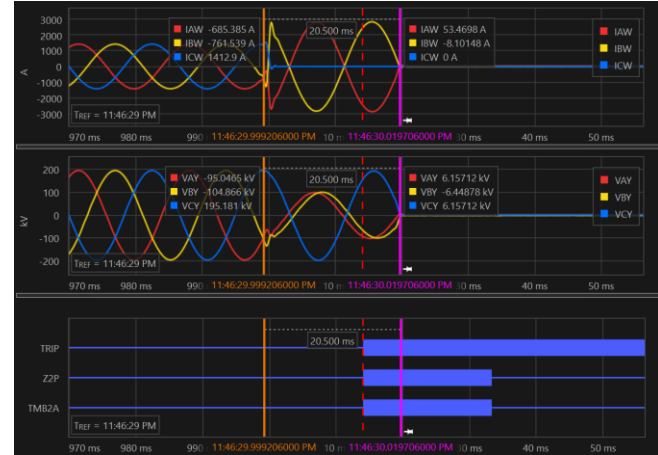
Relay 1
Station A

Date: 03/08/2024 Time: 23:46:47.174
Serial Number: 1170370041

FID=SEL-411L-1-R124-V2-Z015003-D20201009

#	DATE	TIME	ELEMENT	STATE
6	03/08/2024	23:46:30.0135	Z2P	ASSERTED
5	03/08/2024	23:46:30.0135	TRIP	ASSERTED
4	03/08/2024	23:46:30.0135	TMB2A	ASSERTED
3	03/08/2024	23:46:30.0320	Z2P	DEASSERTED
2	03/08/2024	23:46:30.0320	TMB2A	DEASSERTED
1	03/08/2024	23:46:30.2135	TRIP	DEASSERTED

=>



Web Based Test POTT

Prefault

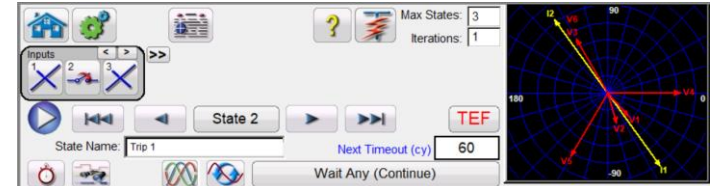
Fault

Relay A

Relay B



	CURRENT			VOLTAGE		
	I (A)	ϕ (°)	f (Hz)	V (V)	ϕ (°)	f (Hz)
I1	5.0000	0.000	60.000	V1	69.000	0.000
I2	5.0000	-120.000	60.000	V2	69.000	-120.000
I3	5.0000	120.000	60.000	V3	69.000	120.000
I4	5.0000	0.000	60.000	V4	69.000	0.000
I5	5.0000	-120.000	60.000	V5	69.000	-120.000
I6	5.0000	120.000	60.000	V6	69.000	120.000



	CURRENT			VOLTAGE		
	I (A)	ϕ (°)	f (Hz)	V (V)	ϕ (°)	f (Hz)
I1	10.000	-54.000	60.000	V1	35.371	-47.260
I2	10.000	126.000	60.000	V2	35.371	-72.740
I3	0.0000	0.000	60.000	V3	69.000	120.000
I4	10.000	-54.000	60.000	V4	81.060	0.000
I5	10.000	126.000	60.000	V5	81.060	-120.000
I6	0.0000	0.000	60.000	V6	69.000	120.000

Web Based Test POTT

Relay 1
Station A

Date: 03/08/2024 Time: 21:10:12.317
Serial Number: 1170370041

FID=SEL-411L-1-R124-V2-Z015003-D20201009

#	DATE	TIME	ELEMENT	STATE
6	03/08/2024	21:10:00.0155	Z2P	ASSERTED
5	03/08/2024	21:10:00.0155	TRIP	ASSERTED
4	03/08/2024	21:10:00.0155	TMB2A	ASSERTED
3	03/08/2024	21:10:00.0345	Z2P	DEASSERTED
2	03/08/2024	21:10:00.0345	TMB2A	DEASSERTED
1	03/08/2024	21:10:00.2155	TRIP	DEASSERTED

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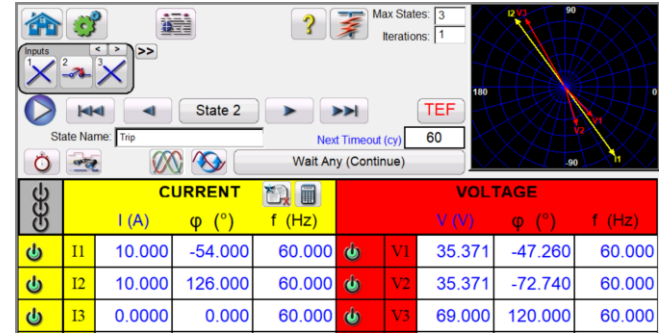
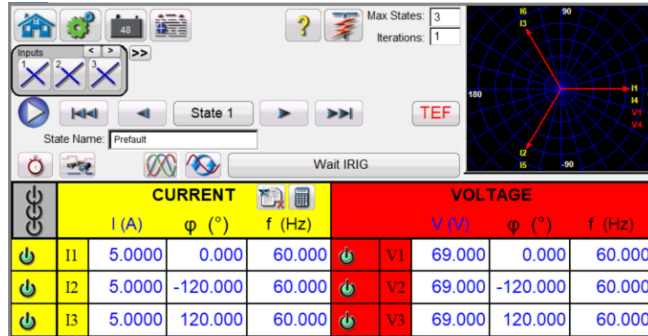


Traditional Test PUTT

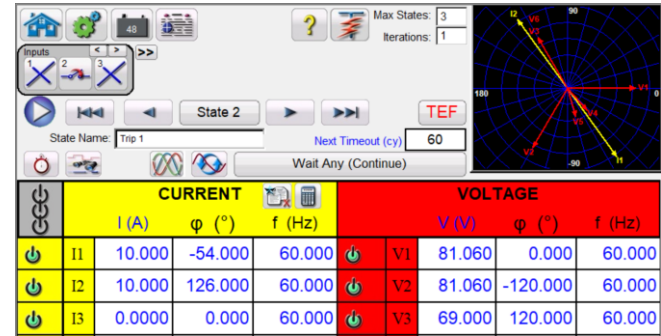
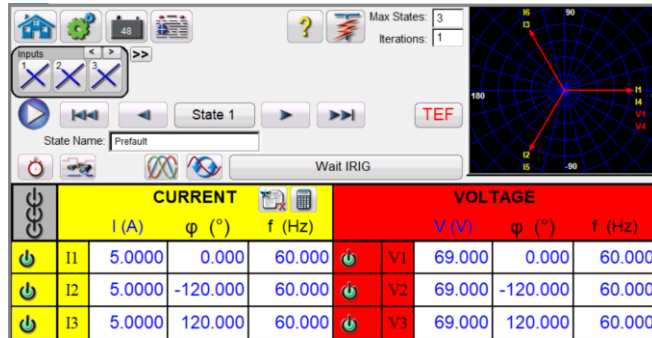
Prefault

Fault

Relay A



Relay B



Traditional Test PUTT

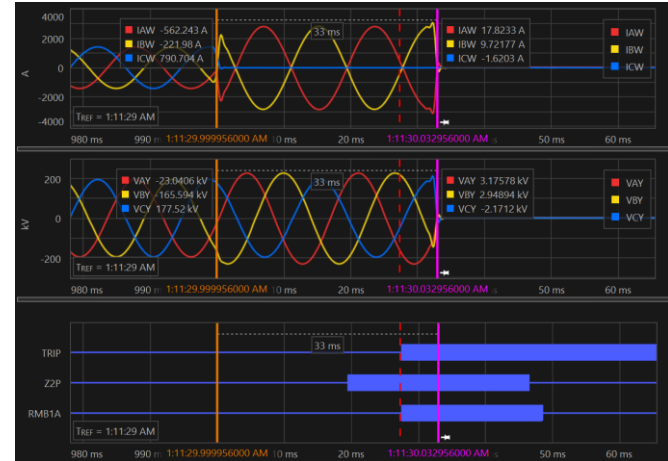
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=>ser
```

```
Relay 1  
Station A
```

```
Date: 02/25/2024 Time: 01:24:33.563  
Serial Number: 1170370041
```

```
FID=SEL-411L-1-R124-V2-Z015003-D20201009
```

#	DATE	TIME	ELEMENT	STATE
6	02/25/2024	01:11:30.0182	Z2P	ASSERTED
5	02/25/2024	01:11:30.0267	TRIP	Asserted
4	02/25/2024	01:11:30.0267	RMB1A	Asserted
3	02/25/2024	01:11:30.0452	Z2P	DEASSERTED
2	02/25/2024	01:11:30.0472	RMB1A	Deasserted
1	02/25/2024	01:11:30.2267	TRIP	Deasserted



Web Based Test PUTT

Prefault

Fault

Relay A

Relay B



	CURRENT			VOLTAGE			
	I (A)	ϕ (°)	f (Hz)	V (V)	ϕ (°)	f (Hz)	
I1	5.0000	0.000	60.000	V1	69.000	0.000	60.000
I2	5.0000	-120.000	60.000	V2	69.000	-120.000	60.000
I3	5.0000	120.000	60.000	V3	69.000	120.000	60.000
I4	5.0000	0.000	60.000	V4	69.000	0.000	60.000
I5	5.0000	-120.000	60.000	V5	69.000	-120.000	60.000
I6	5.0000	120.000	60.000	V6	69.000	120.000	60.000



	CURRENT			VOLTAGE			
	I (A)	ϕ (°)	f (Hz)	V (V)	ϕ (°)	f (Hz)	
I1	10.000	-54.000	60.000	V1	35.371	-47.260	60.000
I2	10.000	126.000	60.000	V2	35.371	-72.740	60.000
I3	0.0000	0.000	60.000	V3	69.000	120.000	60.000
I4	10.000	-54.000	60.000	V4	81.060	0.000	60.000
I5	10.000	126.000	60.000	V5	81.060	-120.000	60.000
I6	0.0000	0.000	60.000	V6	69.000	120.000	60.000

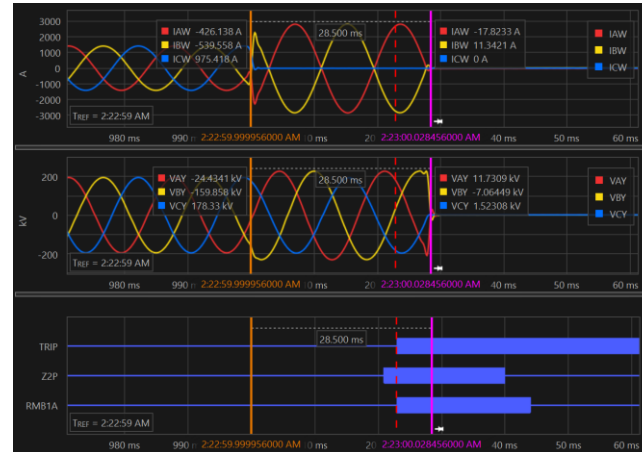
Web Based Test PUTT

Relay 1
Station A

Date: 02/25/2024 Time: 02:03:49.156
Serial Number: 1170370041

FID=SEL-411L-1-R124-V2-Z015003-D20201009

#	DATE	TIME	ELEMENT	STATE
14	02/25/2024	01:11:30.0182	Z2P	ASSERTED
13	02/25/2024	01:11:30.0267	TRIP	Asserted
12	02/25/2024	01:11:30.0267	RMB1A	Asserted
11	02/25/2024	01:11:30.0452	Z2P	DEASSERTED
10	02/25/2024	01:11:30.0472	RMB1A	Deasserted
9	02/25/2024	01:11:30.2267	TRIP	Deasserted
8	02/25/2024	02:02:00.0187	Z2P	ASSERTED
7	02/25/2024	02:02:00.0227	TRIP	Asserted
6	02/25/2024	02:02:00.0227	RMB1A	Asserted
5	02/25/2024	02:02:00.0332	Z2P	DEASSERTED
4	02/25/2024	02:02:00.0372	Z2P	ASSERTED
3	02/25/2024	02:02:00.0397	Z2P	DEASSERTED
2	02/25/2024	02:02:00.0437	RMB1A	Deasserted
1	02/25/2024	02:02:00.2227	TRIP	Deasserted



Conclusions



Summary

- The proposed method centralizes control at one end of the line,
- Streamlines the testing process and significantly reduces the need for highly trained personnel.
- Training requirements and costs are lower.
- Centralized control improves the test's manageability & and repeatability of results.
- Unlike traditional methods limited to individual trip tests, this approach allows the user to automate testing.
- Its versatility extends to regression testing, type testing, and commissioning testing.
- With automated reporting, the results remain untouched and incorruptible, providing a much more reliable and trustworthy tool for analysis and evaluation.

Questions?

