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We Stop Blackouts.

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Unlocking Efficiency and Reliability: Primary Injection in the Maritime Sector

Dairon Campos, 2023 MTS DP Conference

OUR MISSION

Independent assurance to accelerate the future of clean power.

OUR VALUES

Safe Solutions
Technical Excellence
Trusted Service

AGENDA

Unlocking Efficiency and Reliability: Primary Injection in the Maritime Sector

- Current Sensing Basics
- Testing Current Sensors
  - Secondary Injection
  - Primary Injection (In-situ testing)
- Results from Primary Injection Testing
- Conclusions

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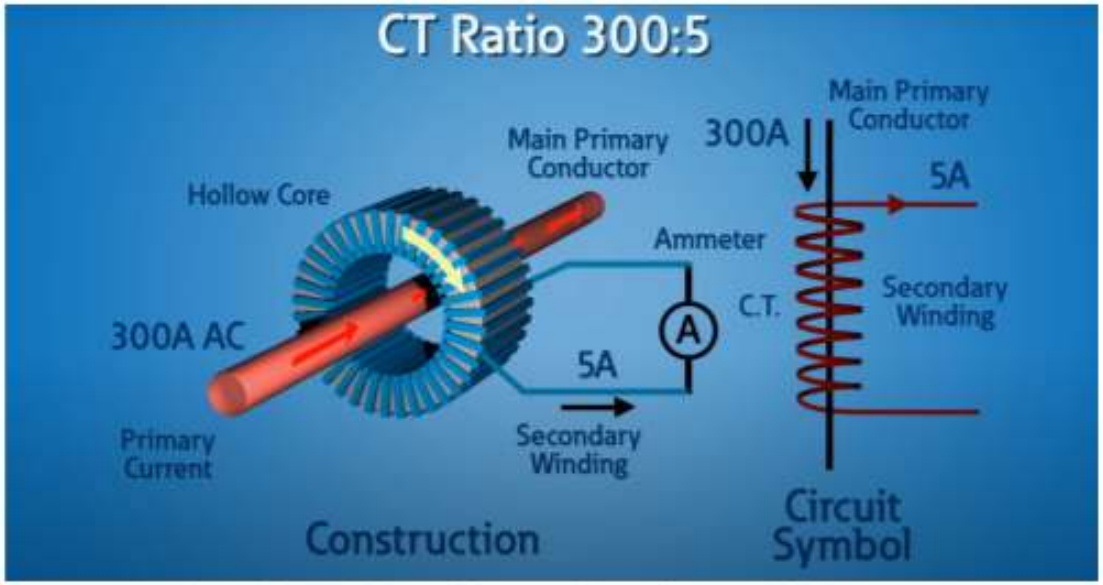
CURRENT SENSING BASICS

Current Transformers (CTs)

+ Traditional method of measuring current
+ Reliable & simple to understand
+ Don't require power source or supporting electronics

- Direction and ratio impacts the reading and must be confirmed
- CTs may become saturated
- CTs are very difficult to install after the initial build



Screen shot from Eaton Videos' Current Transformers (CT) Video

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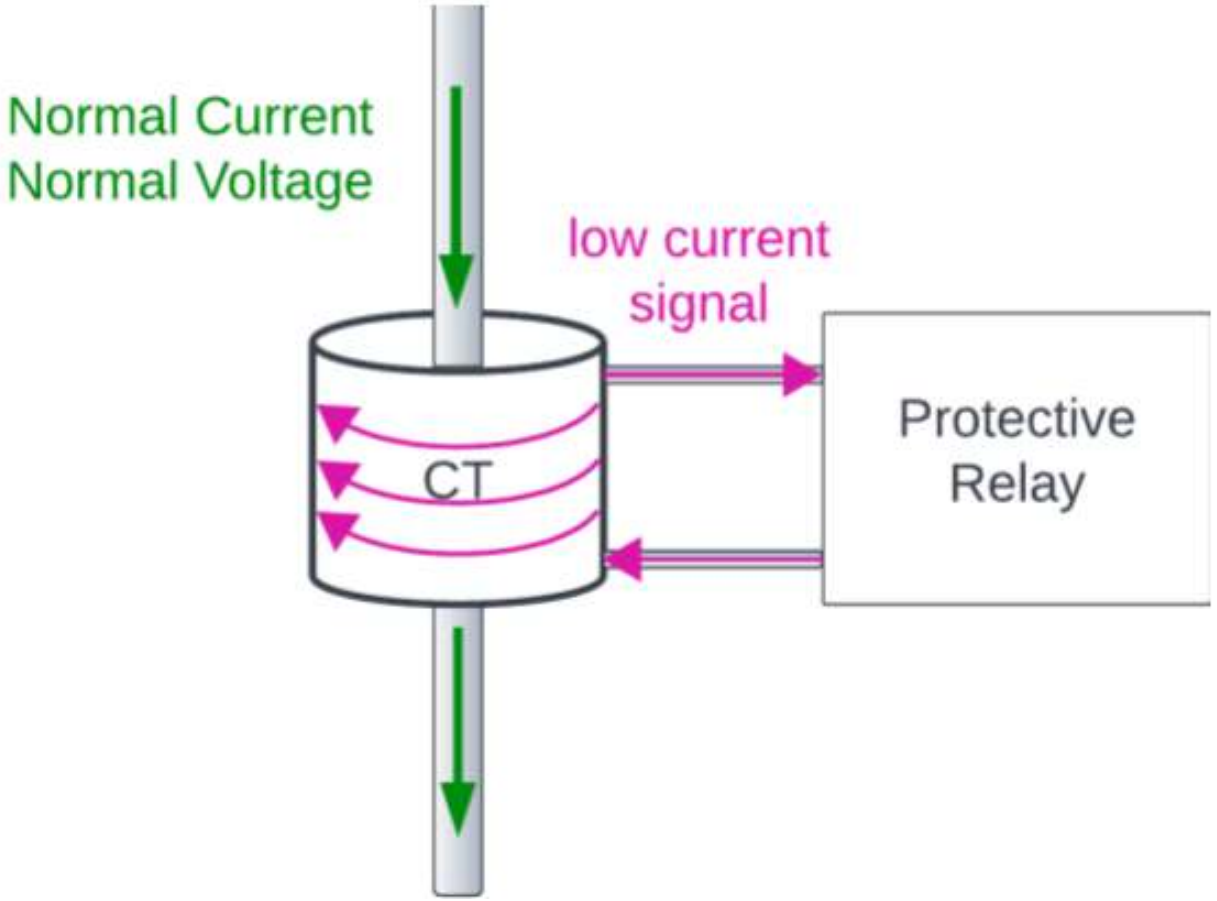
CURRENT SENSING BASICS

Current Transformer & Protective Relay



Simplified Current Transformer/protective relay arrangement.

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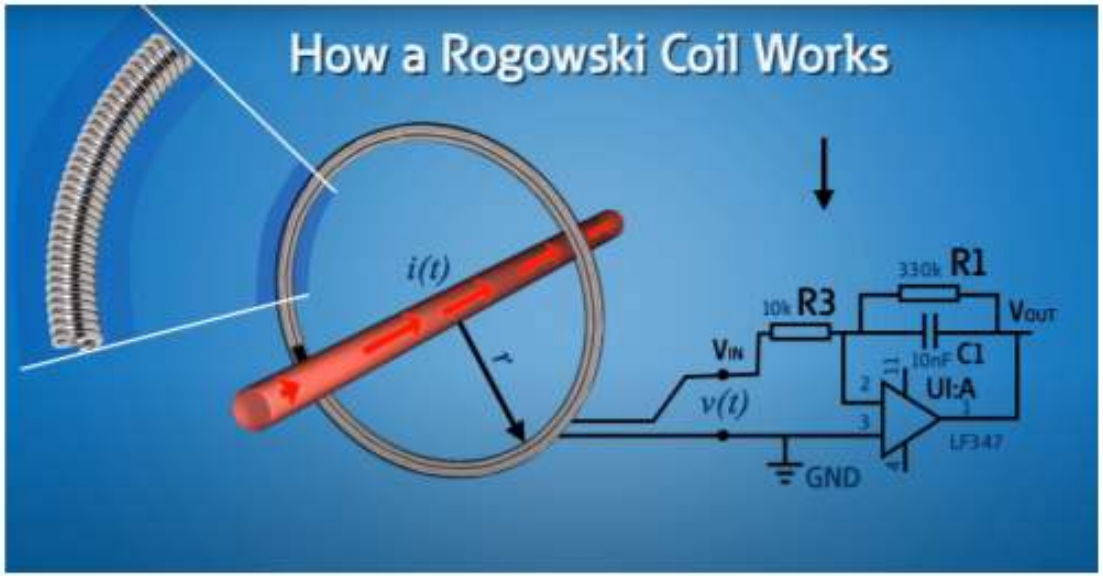
CURRENT SENSING BASICS

Rogowski Coil Transformers

+ Small, flexible
+ Easily retrofittable
+ Don't become saturated

- Direction and ratio impacts the reading and must be confirmed
- Require power source and supporting integrator unit



Screen shot from Eaton Videos' Current Transformers (CT) Video. The Rogowski coil method relies on electronic intervention from a device referred to as an "integrator"

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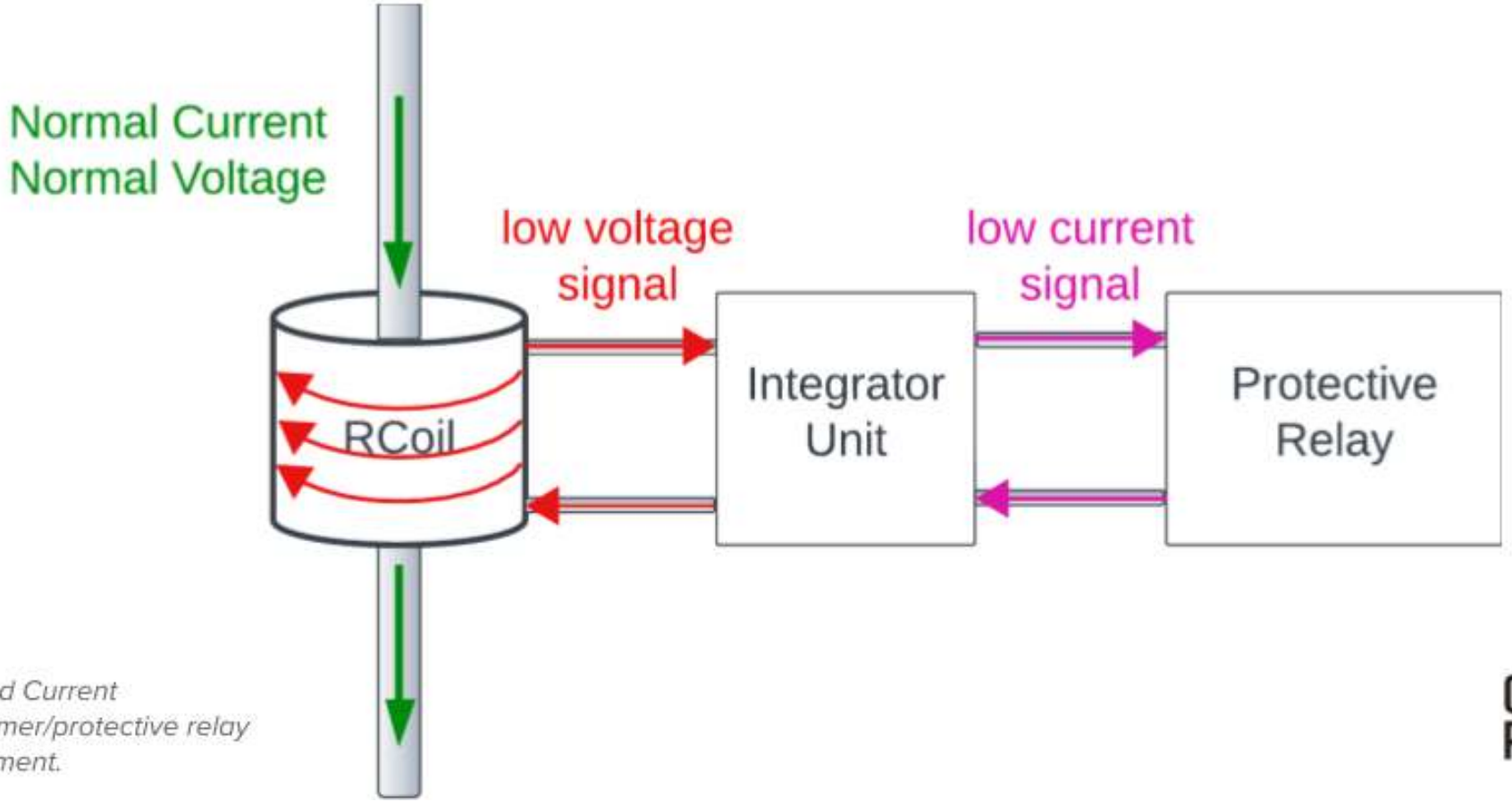
CURRENT SENSING BASICS

Rogowski Coil, Integrator & Protective Relay



Simplified Current Transformer/protective relay arrangement.

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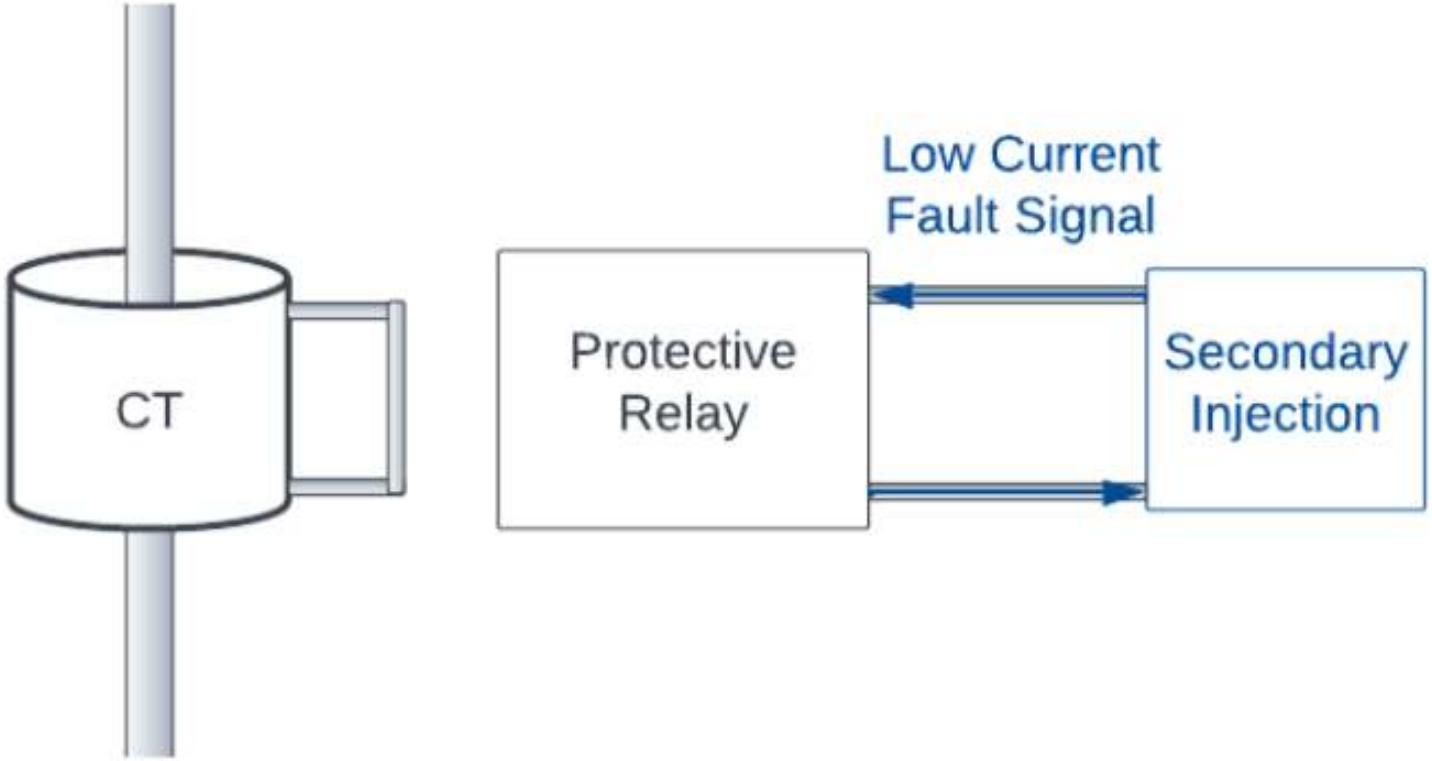
TESTING CURRENT SENSORS

Secondary Injection



Simplified Secondary Injection arrangement.
Note the disconnection of the CT from the relay during testing.
Also bypasses R-Coil integrator unit

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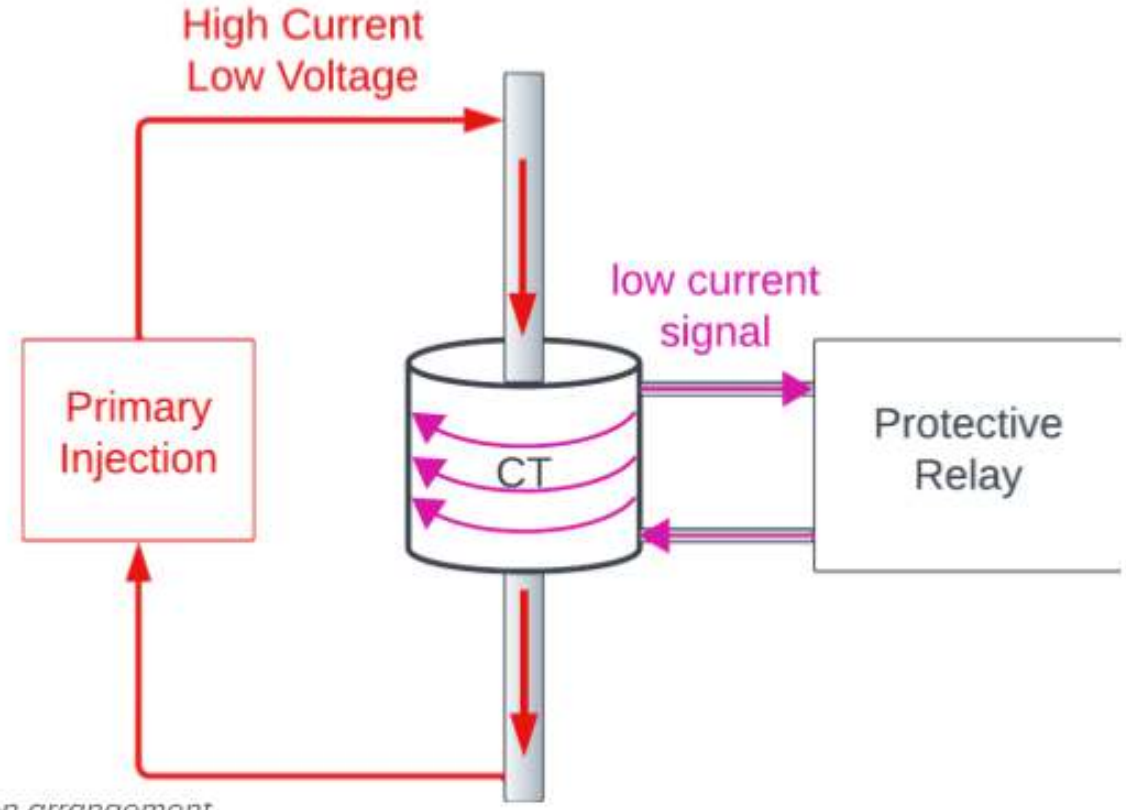
TESTING CURRENT SENSORS

In Situ Primary Injection



Simplified in situ Primary Injection arrangement.
This test also verifies R-Coil integrator

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TESTING CURRENT SENSORS

Testing for WCFDI

Primary injection testing onboard for all CTs and R-Coils:

- on the main bus,
- feeders from the main buses, and
- generators

should be checked for function and direction.

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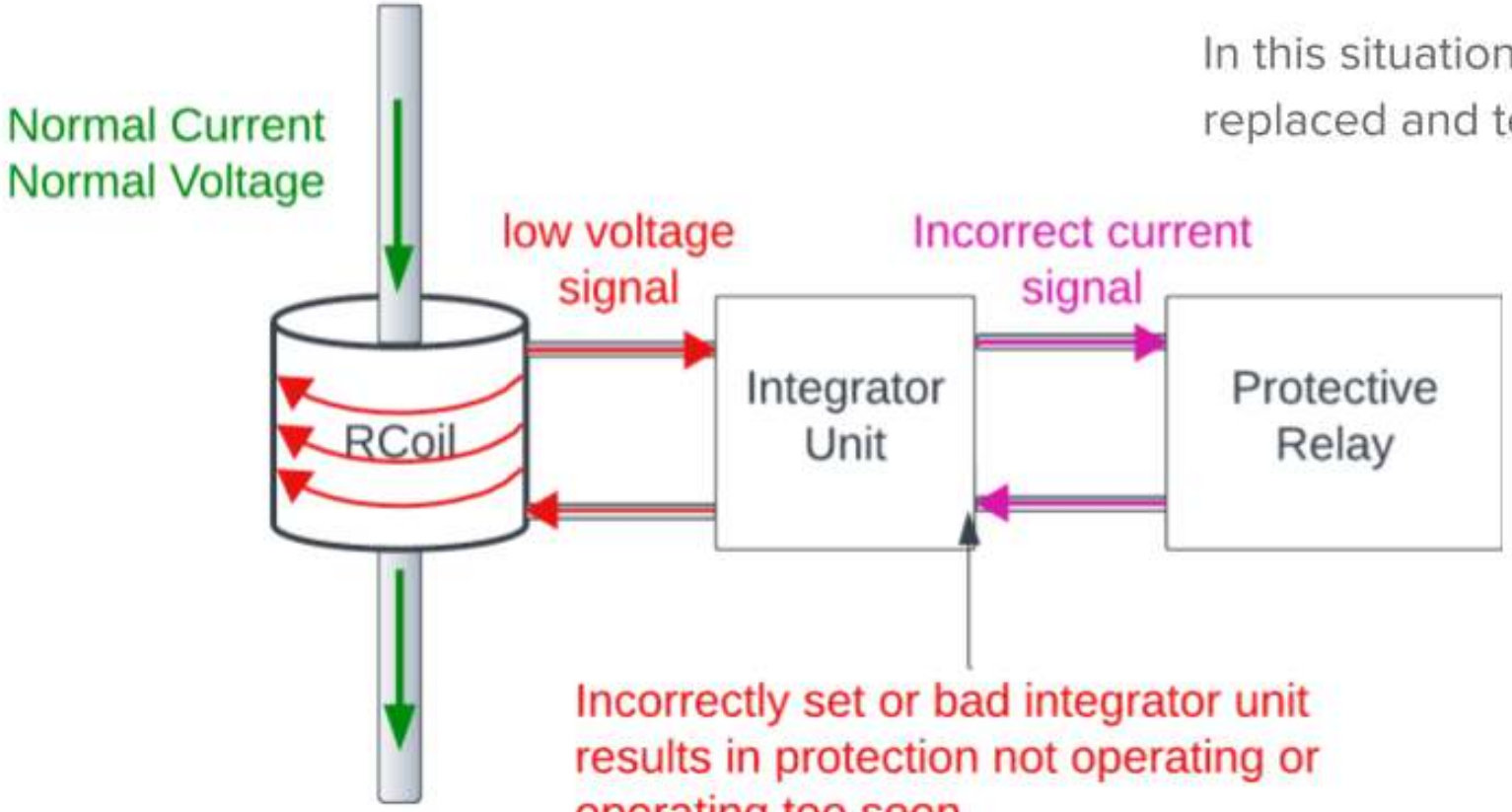
RESULTS OF PRIMARY INJECTION

Test outcomes



In this situation, the unit can be replaced and tests re-performed.

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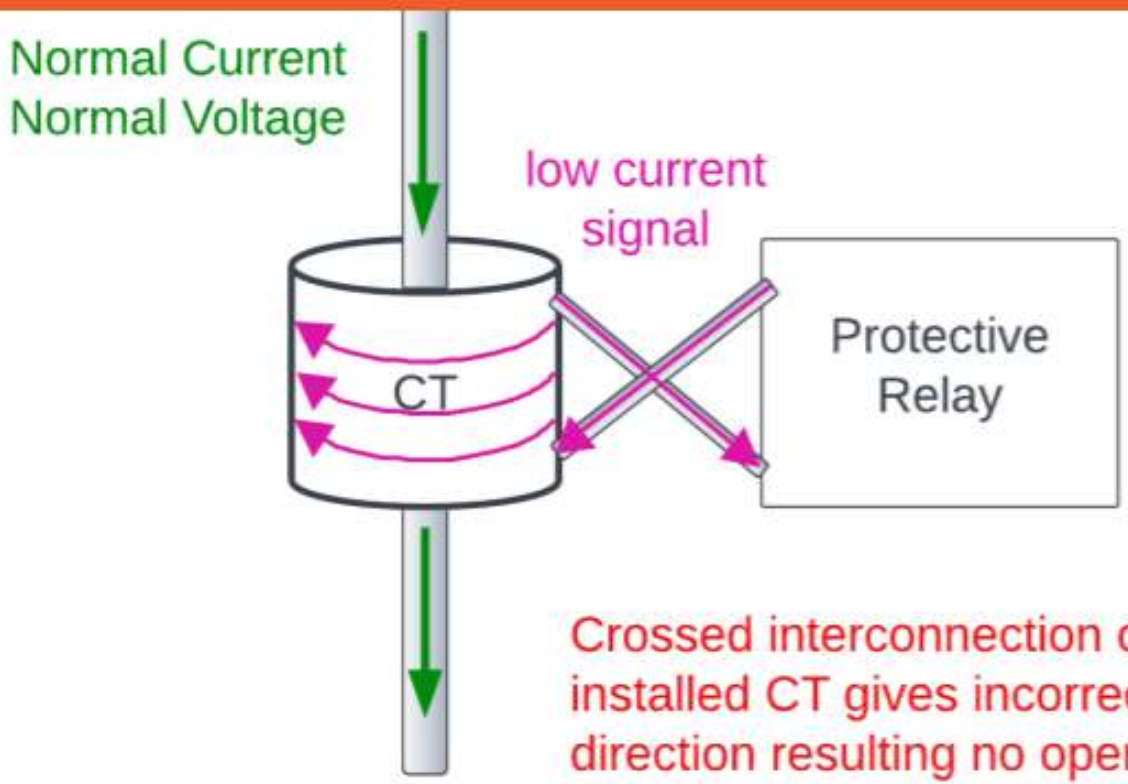
RESULTS OF PRIMARY INJECTION

Test outcomes



Crossed interconnection or backward installed CT gives incorrect current direction resulting no operation or incorrect operation of protection in some situations

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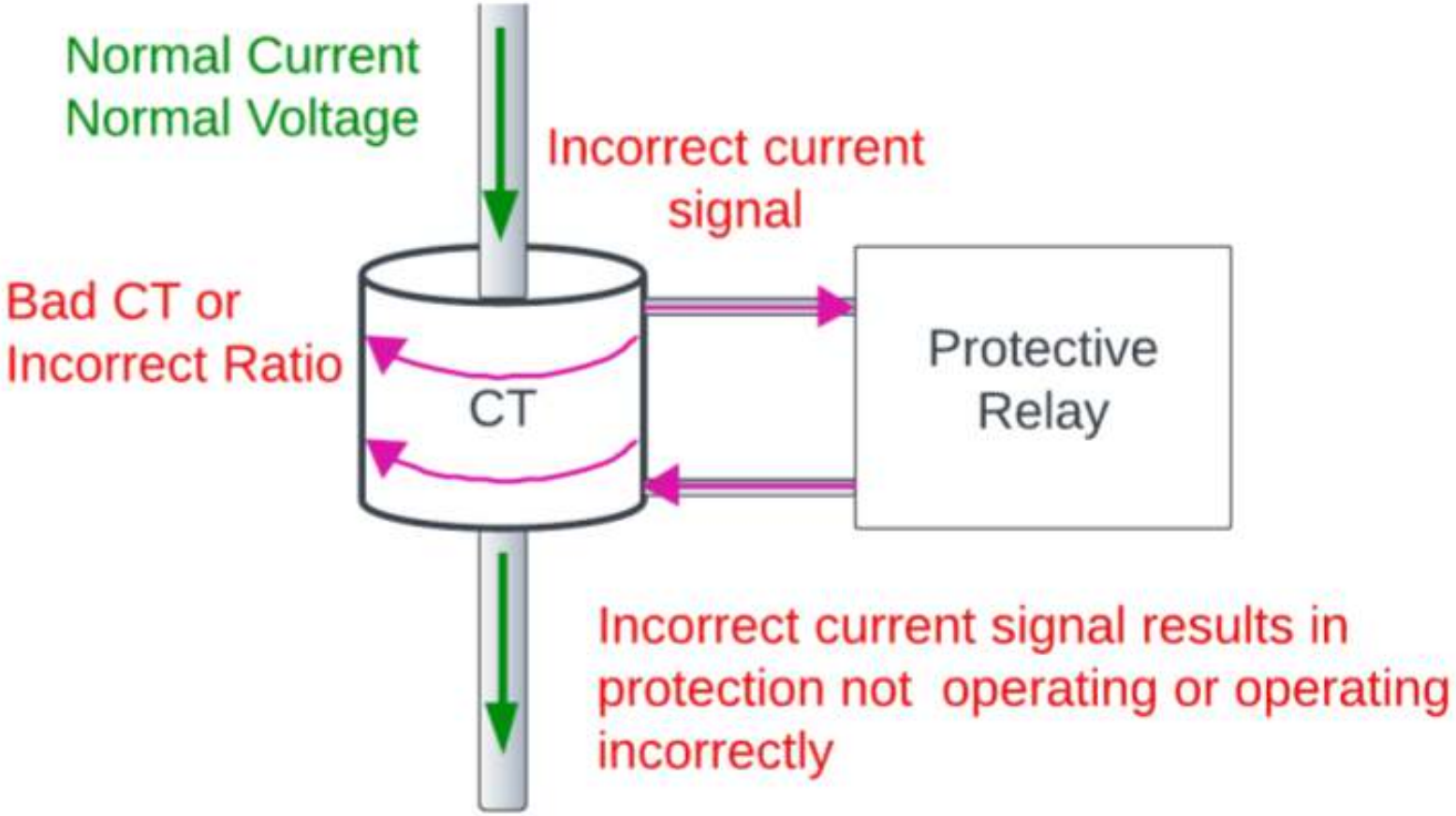
RESULTS OF PRIMARY INJECTION

Test outcomes



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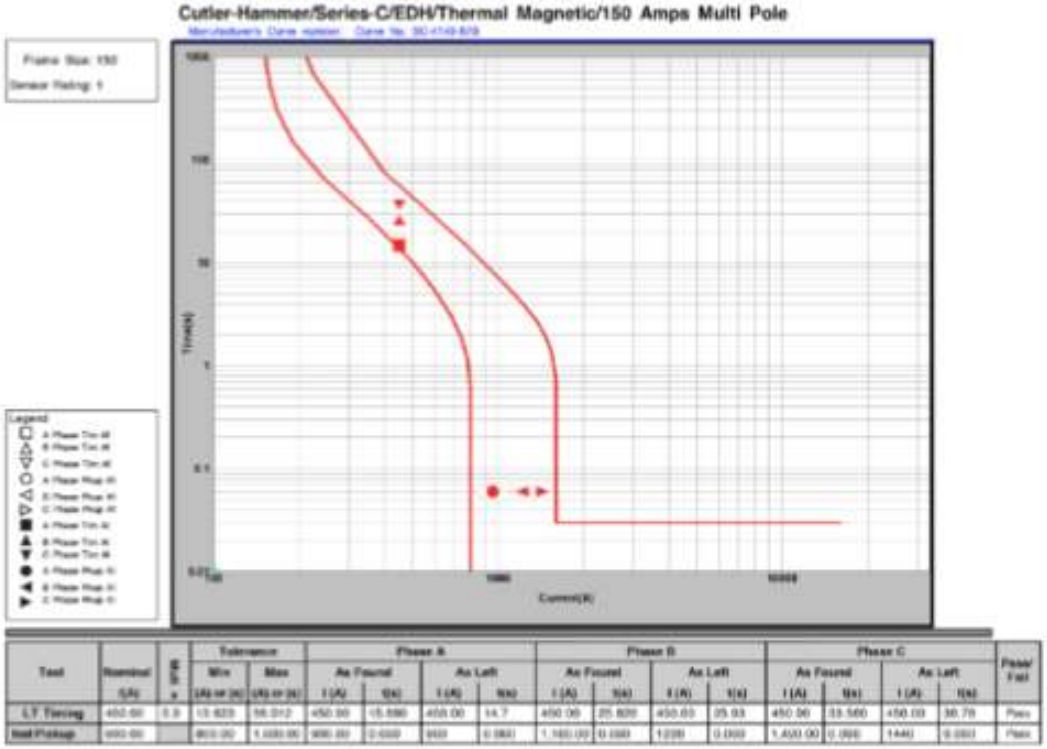
RESULTS OF PRIMARY INJECTION

Test outcomes

ALL TESTS PASSED



Test	Nominal		Tolerance		Phase A				Phase B				Phase C				Pass/ Fail
			Min	Max	As Found		As Left		As Found		As Left		As Found		As Left		
	I (A)	t	I (A) or t (s)	I (A) or t (s)	I (A)	t (s)	I (A)	t (s)	I (A)	t (s)	I (A)	t (s)	I (A)	t (s)	I (A)	t (s)	
LT Timing	450.00	0.0	13.629	56.012	450.00	15.880	450.00	14.7	450.00	25.829	450.00	25.93	450.00	33.560	450.00	36.78	Pass
Inst Pickup	900.00		810.00	1,080.00	900.00	0.020	900	0.082	1,160.00	0.030	1200	0.030	1,400.00	0.050	1440	0.033	Pass

Example of Megger primary injection test report.

Test Cards:

CTRogowski 1:

Card Type:	CTRogowski	
Date/Time:	06/29/2021 19:06:42	
Overload:	no	
Assessment:	n/a	
Range:	CB2 2000A	
Nominal values:		
I prim.:	1000 A	
V sec.:	120.00 mV	
Frequency nom:	60.0 Hz	
Frequency:	60.00 Hz	
I test:	500 A	
Automatic:	yes	
Results:		
I prim.:	499.9 A	0.00 °
V sec.:	0.10 mV	
I sec.:	8.3e+2 mA	57.52 °
Ratio:	1000 A:1.6673 A	-99.83 %
Polarity:	Failed	

Example of CPC-100 output file, note the failed polarity check.

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COMPREHENSIVE TESTING

Example: testing regime for Closed Bus

1. Protection setting audit (inc. version control)
2. Fuelling Testing
3. Excitation Testing
4. Over-Voltage Testing
5. Earth Fault Testing
6. Relay & Protective Device Testing
7. Current Sensing Testing
8. Load application & Rejection Testing
9. Phase Failure Testing
10. Blackout Recovery Testing
11. Harmonic Distortion Testing
12. Fault Ride Through Testing

Image by David Mark from Pixabay

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