Optical Current & Voltage Sensors

IESO

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Eric Langford,
Langford & Associates

John Swindlehurst, P.Eng,
NxtPhase T&D Corp

NXTPHASE Digital and fiber optic solutions for the electric power industry.

Agenda

- Introduction
- The Pieces
- Different Sensor Applications
- Status Update
- Verification to Commissioning
- Sensor Software
- Questions

Introduction

- Optical Current, Voltage, & Combined Sensors manufactured in Vancouver, BC and Phoenix, Arizona
- Developed over the last decade in close collaboration with BC Hydro, Powertech and other partners
- Applications at transmission level voltages for revenue metering, protection and specialized applications

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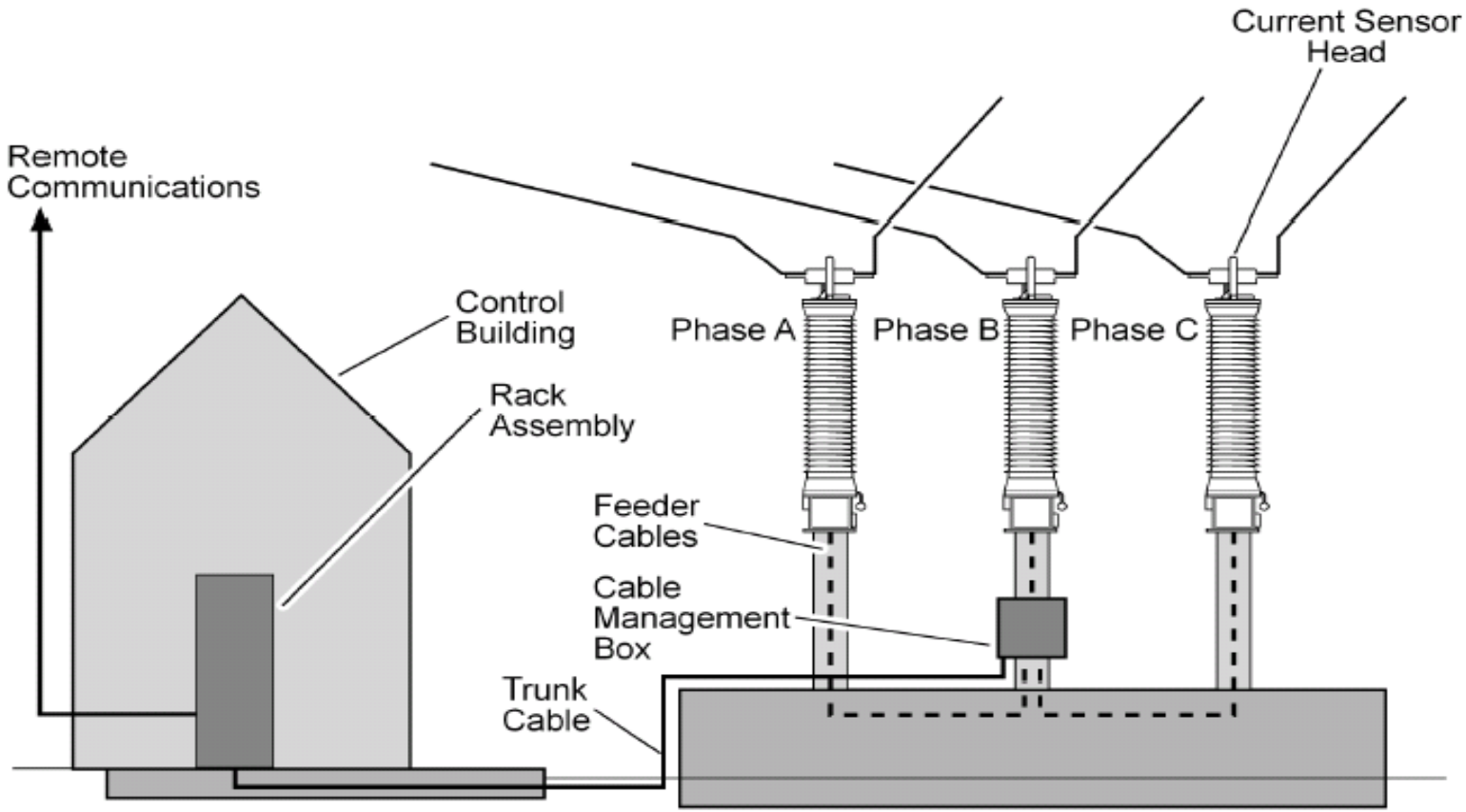
Optical Sensor System



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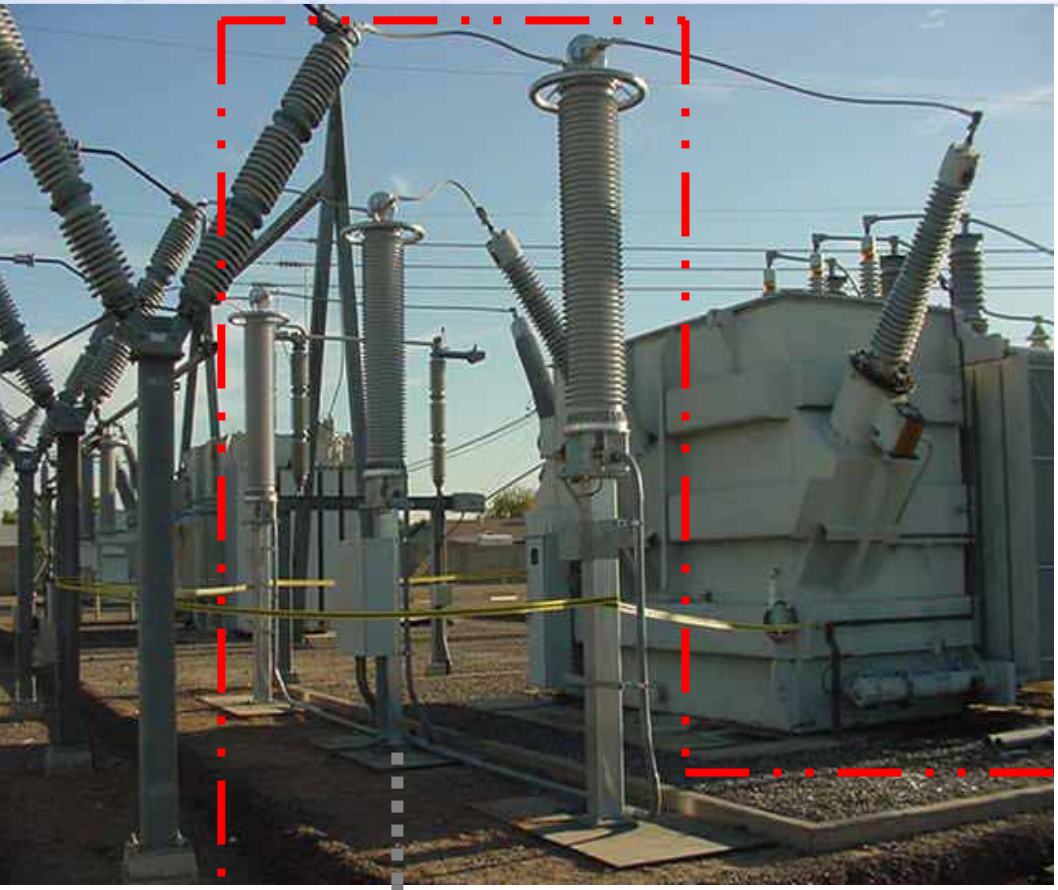
The Pieces



Control Room

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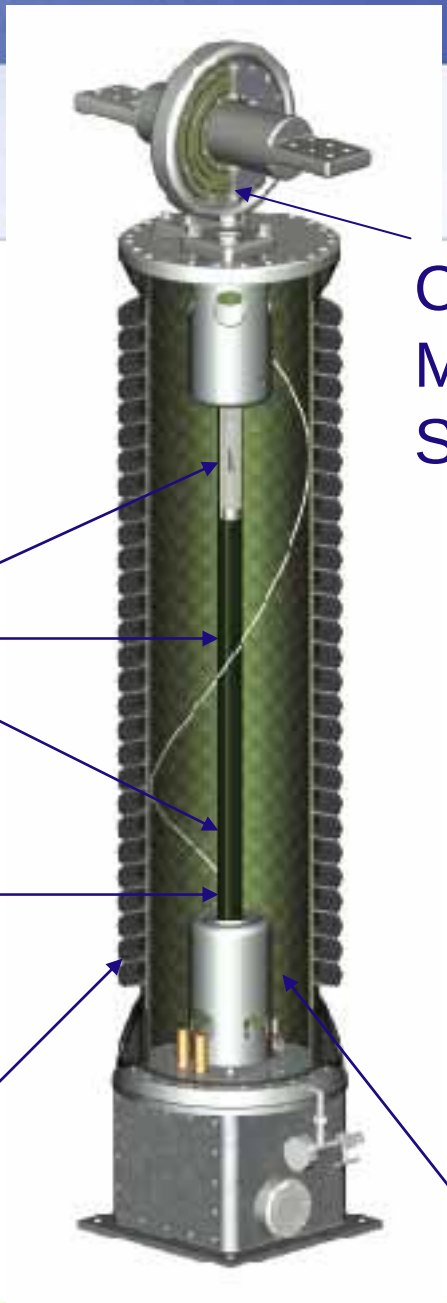
NXVCT



CT Head – can have Multiple Sets of Fiber Sensors

VT Multiple Electric Field Sensors

Internal Shielding to Moderate Surface Perturbation Effects

Composite Insulator

Low pressure dry nitrogen

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Optical Sensors Benefits

- Performance Features
  - Accuracy exceeds ANSI/IEEE class 0.15/IEC class 0.2S
  - Wide dynamic range
  - Bandwidth from dc to 100th+ harmonic
  - Seismic performance
  - User-adjustable turn-ratio
  - No CT Saturation
  - Excellent phase accuracy

- Safety & Environmental Concerns
  - Uses dry nitrogen as insulating gas not oil, cellulose, or SF_6
  - No open secondaries
  - No ferro-resonance
  - Galvanic isolation from HV line

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Optical Sensors Benefits (2)

- Installation Savings & Retrofit Capability
  - Weight is 10% of conventional device
  - Voltage & current in one device
  - Zero footprint CT is possible
  - Metering & protection relaying in one device
- Self Monitoring
- Simple and Flexible Setting
  - Graphical User Interface provides a user-friendly interface to permit system health monitoring and parameter modification
  - Simplifies substation design by allowing a simple template design for multiple applications
- Leads to digital communications & data acquisition

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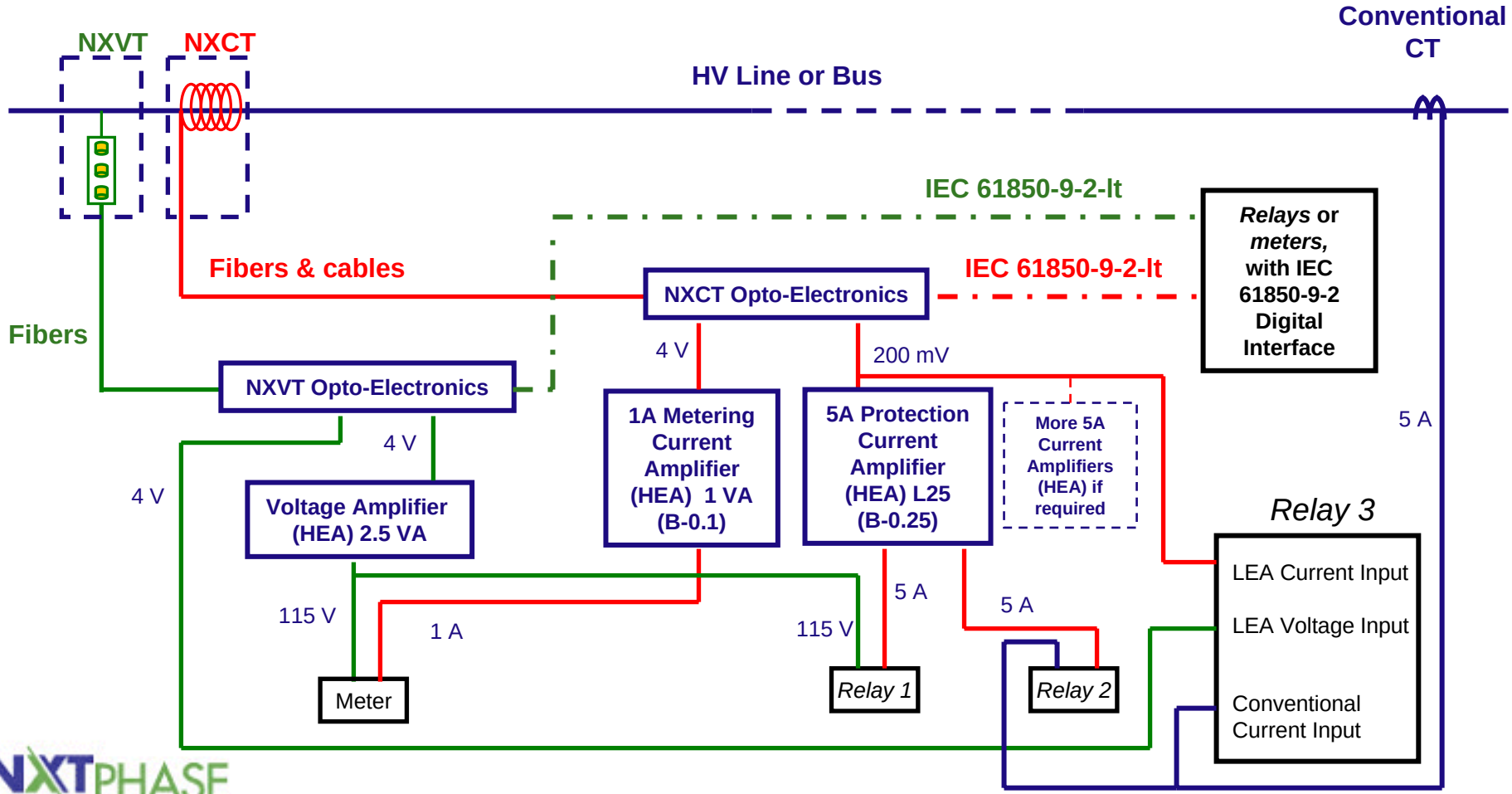
Interface (One-line diagram)

Many types of interface are available:



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Optical Sensors NXCT, NXVT, NXVCT

BC Hydro's Ingledow Substation – 230 kV
Combined Voltage & Current Optical Sensor

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Installation Example NXVCT-115

Hydro Quebec's Rolls-Royce Substation – 115kV
Combined Voltage & Current Optical Sensor

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Installation Example NXVCT-230

APS's Deer Valley Substation – 230 kV
Combined Voltage & Current Optical Sensor

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Installation Examples NXVCT-500

BC Hydro's Ingledow Substation – 500 kV
Combined Voltage & Current Optical Sensor

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Installation Examples NXCT-69

Entergy Gulfrich Substation –
69 kV Optical Current Sensor

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ComEd Wind Farm

138kV NXVCT

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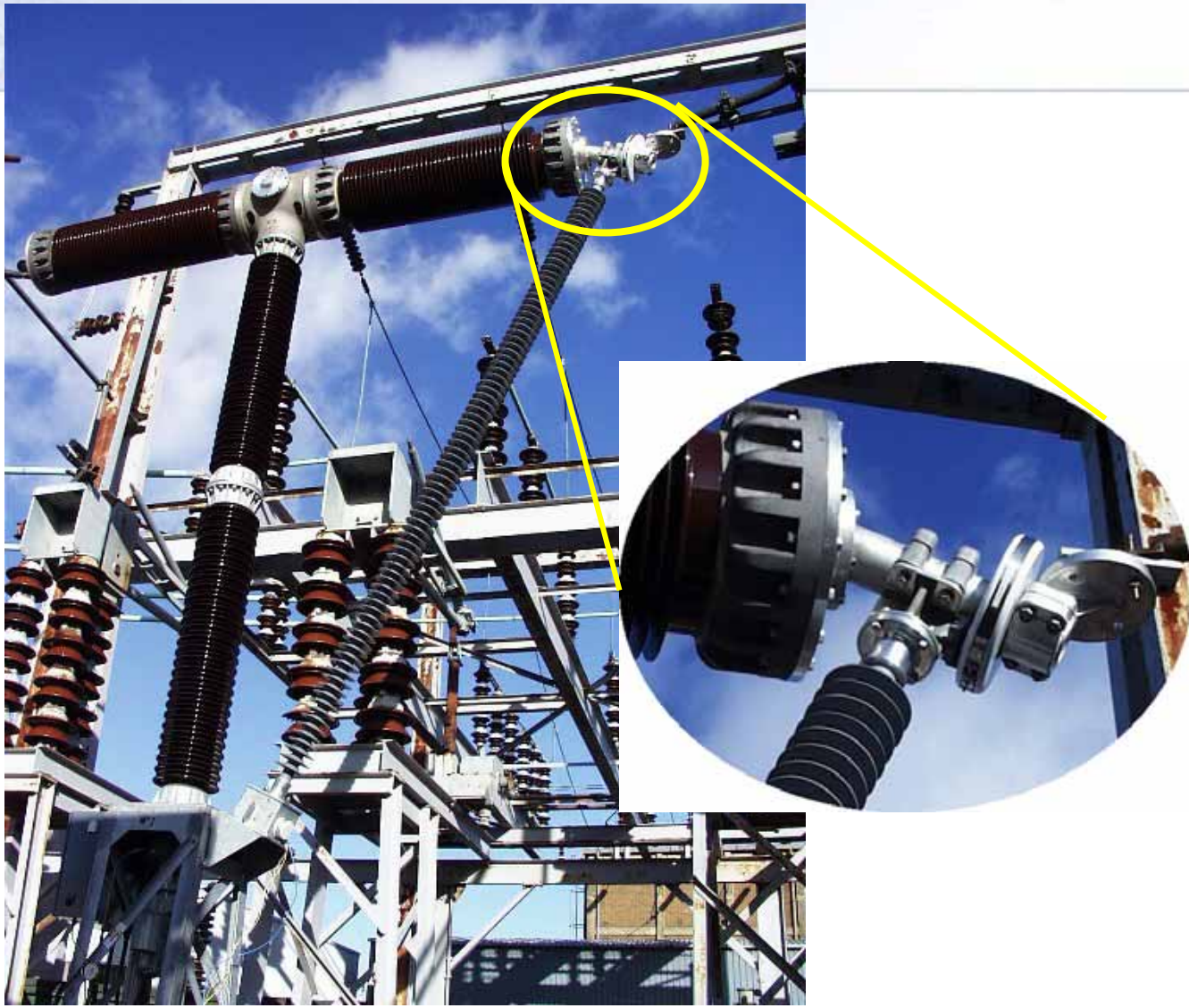
AIS, Breaker Mounted

- NXCT Mounted on a 420 kV class 4000 A circuit breaker for protection application
- Successfully tested with >2000 breaker operations on two different models



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Sundon Substation, Breaker Mounted

Sundon Substation

National Grid (UK)

420 kV

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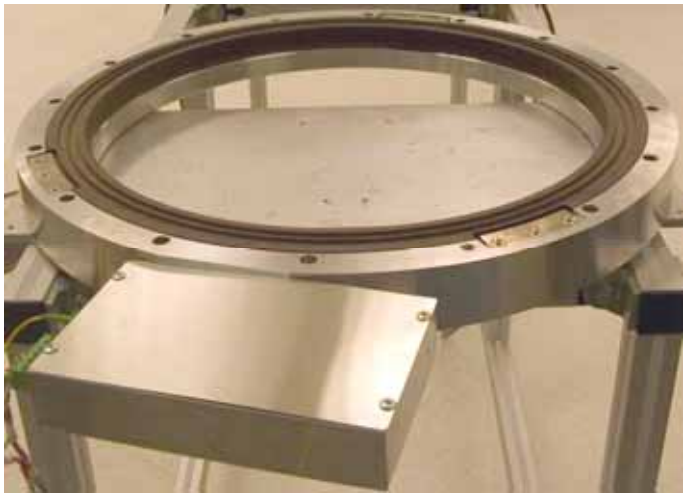
SB6-2Y Circuit Breaker with NXCT

CANDIA

Enel Terna Substation

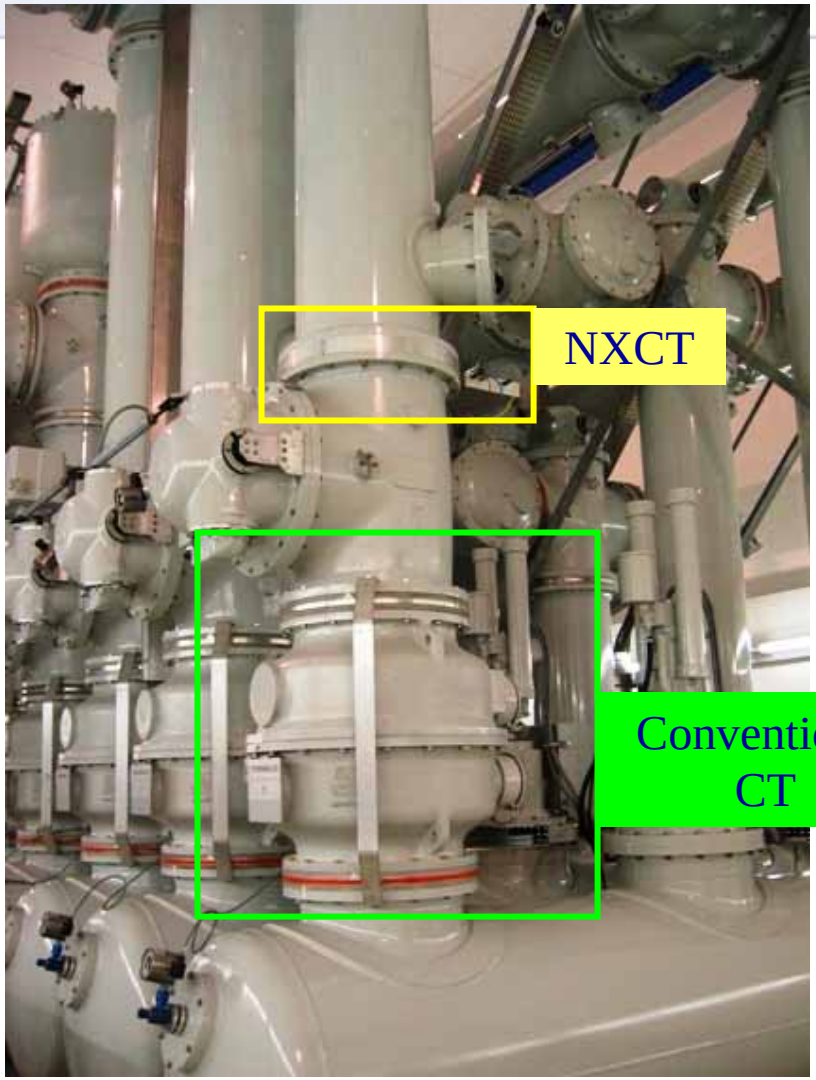
420 kV

NXCT in Gas Insulated Substations



GIS-NXCT-420

Wienstrom, Austria



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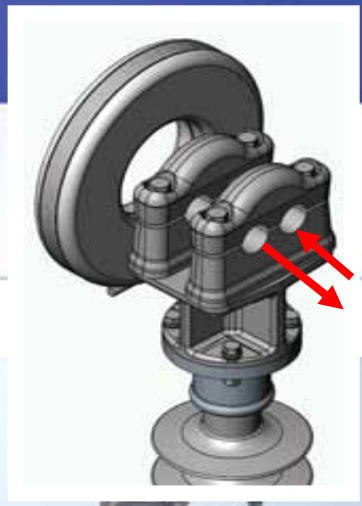
Low Ratio CT, for Capacitor Bank Unbalance Protection



NXCT-230

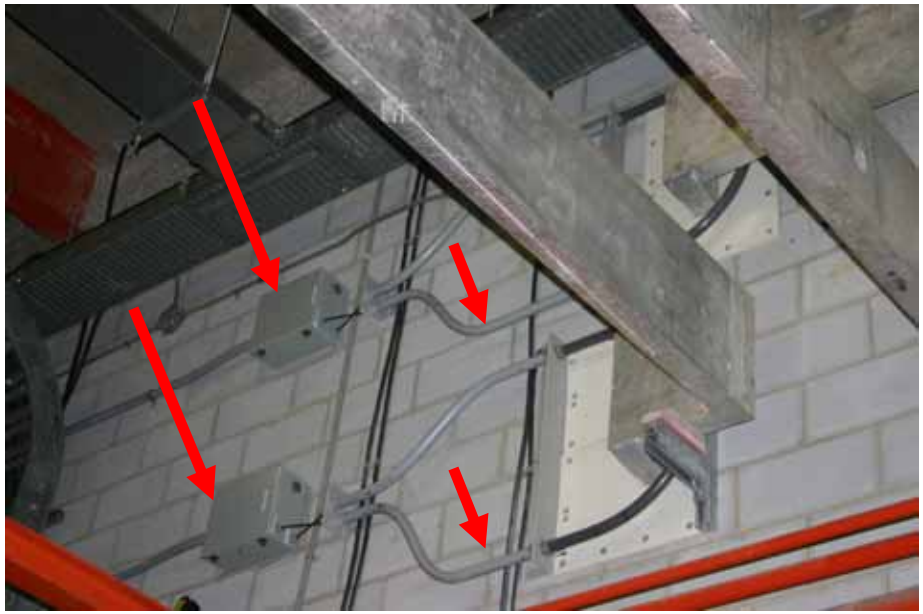
Calgary, Alberta

NXCT-F3 (Flexible Form Factor)

- Large aperture, all dielectric sensing head
- AC / DC
- Variants to measure up to 500 kA continuous (widely used in aluminum smelting/electrochemical)
- Ideal for generation CT, field calibration, temporary monitoring applications, direct measurement of neutral current

NXCT-F3-DC 25 kA Installation

EKA Chemicals, Magog, Quebec



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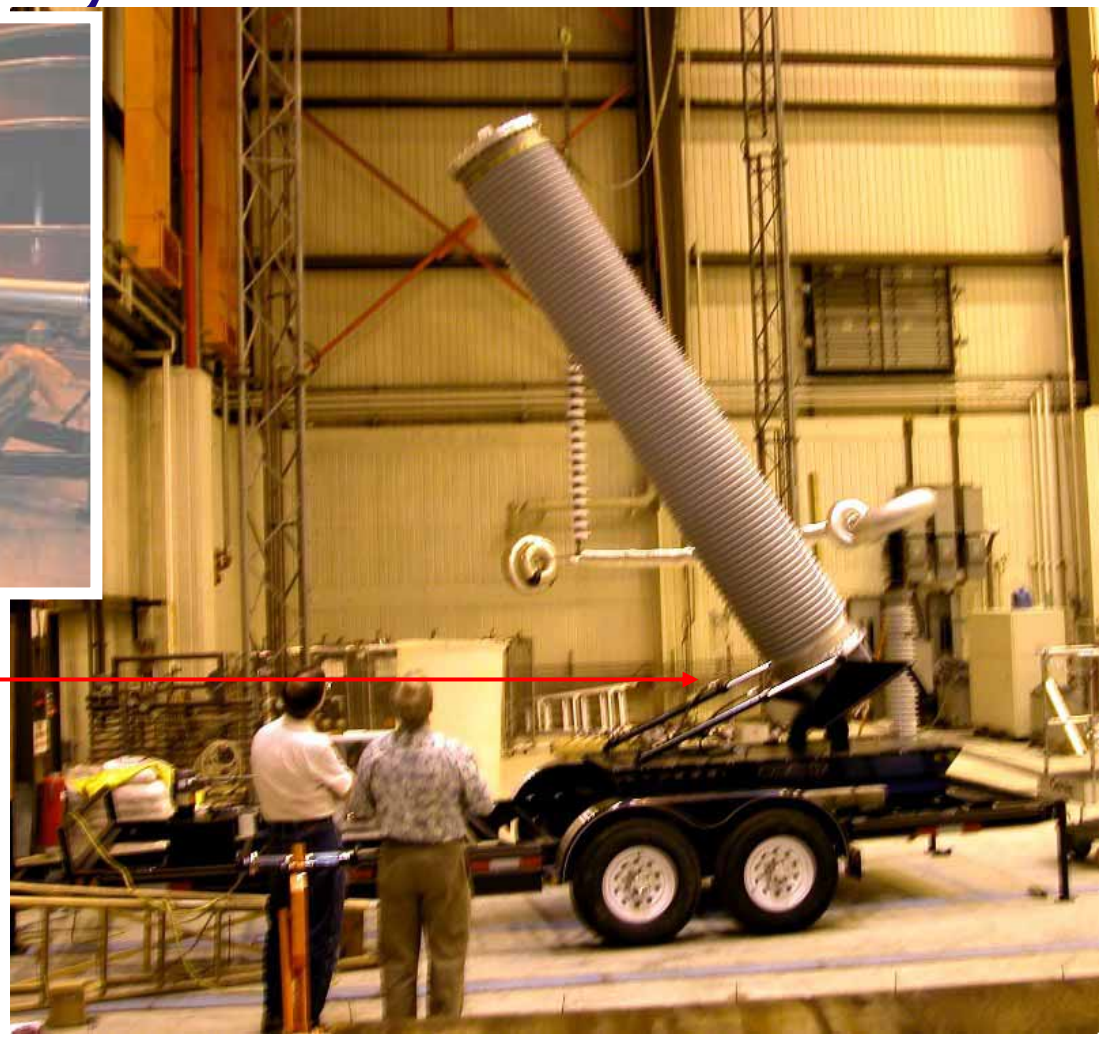
Trailer-Mounted Portable NXVT for Calibration NXVT-500kV, BC Hydro

Hydraulics to lift and/or tilt



- Software-Adjustable Ratio: Same unit used for 525 kV, 245 kV, and 145 kV applications

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Adjustable Lifting Mechanism for Live Connection

Scissors lift platform for live line connection

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Status Update

- NxtPhase is ISO 9001-2000 registered.
- NxtPhase Receives Contribution from Sustainable Development Technology Canada Toward the Development of Optical Sensors for the Electric Power Industry
- Measurement Canada has completed all testing for both CT and VT and expects to grant conditional notice of approval very soon.
- Accuracy measurement metrology will undergo approval by NRC

Conditional Notice of Approval (cNOA)

- For full NOA, CSA standards for non-conventional instrument transformers are needed. These standards are prepared, balloted, and approved. They are due to be published by CSA in mid 2007.
- Meanwhile, provisional specifications are drawn up by MC and are used for cNOA for optical CTs and VTs
- With cNOA, NxtPhase needs to inform MC of every single sale of an optical system. MC staff will attend NxtPhase Vancouver office to witness (and seal) CT and VT verification procedure.
- Approval is issued per individual system, and the end user has to be notified that the device is under cNOA, and not NOA, and all the details of cNOA (if any) shall be communicated to the user before purchasing the system

Verification

- Verification procedures are drawn up by MC (with NxtPhase help) for verification of optical instrument transformers.
- Factory verification includes
  - Measurement of RCF and TCF (effectively ratio and phase errors) as a compete system.
  - Key part verification steps (to be used as basis for re-verification)
    1. Measurement of amplifier gains (used for converting 4 V output of CT or VT to 1A/5A or 115 V output for standard meters).
    2. Measurement of the light wavelength (using an optical spectrum analyzer – similar to a scope)
    3. Verification of the accuracy of the temperature sensor (if any used)

Re-verification

- Re-verification procedures are drawn up by MC (with NxtPhase help) for field re-verification of optical instrument transformers.
- Basic re-verification does not require a HV outage
  - It involves checking the calibration of key parts:
    1. Measurement of amplifier gains (±0.1%)
    2. Measurement of the light wavelength (± 2 nm)
    3. Verification of the accuracy of the temperature sensor (±7°)
  - Every 8 years (maximum)
  - Interruption in measuring service should be limited to minutes
- If the deviation is larger than above, then full end-to-end re-verification (measurement of TCF, RCF, …) and/or removal from service for laboratory verification may be required.

Installation and Commissioning

- Installation and commissioning instructions (in the manual).
- No dissipation factor test (Doble test) required
  - For VTs, a DC resistance measurement at 1 kV is recommended
- Alarm monitoring via electronics and alarm log
  - Maintenance required alarm and dry contact
  - Data-invalid alarm and dry contact
- Windows based graphic user interface (GUI) for reading status information from the electronics (demonstration later)
  - Helps verify that all connection are made and the system is working correctly

Factory tests

- Type test books/reports available upon request
- Routine tests according to CSA C60044-7/8 2007.
- Accuracy test report submitted with every unit
- See a sample of accuracy test report

Sample Accuracy test report

Metering CT Linearity Test Report

Project	**Approval of Type - NXCT**										
Test Date	**November 7, 2006**				Tested By	**Farnoosh Rahmatian**					
System Type and Serial Number		NXCT 69				**SN D00246R00.04-042**					
Column Serial Number						**SN D00246R00.04-042-A**					
CT Sensor Chassis Serial Number, and CT#						**SN D00246R00.04-042-EO, CT#1**					
CAPSU Chassis Serial Number						**1002-C**					
Rated Primiary Current	**600**	A			Rated Secondary Output	**1**	A				
RF	**2.0**	Accuracy Class	**CSA 0.3**		Burden	**B0.1**	CT Ratio = 600A:1 A				
Polarity Check	**YES**										
Notes:	Witnessed by: V. Nguyen, C. Renaud, G. Smith, K. Hogarth, and Dr. E. So. Accuracy classes 0.15 and 0.15 S are also considered and satisfied.										

Nominal Current (A)	% of Rated Current	**Ratio Error** (±%)	**Phase Error** (±min)	**TCF** (IEEE/ CSA)	Arbiter Ratio (**RCF**)	Arbiter Phase (^{o})	Measured Current (A)		CSA / IEEE C57.13 class 0.3	CSA / IEEE C57.13.6, class 0.15S	0.3 Class Test Result
1200	200	-0.03	0.6	1.0001	**1.0003**	**0.01**	1200		TCF & RCF =1±0.003	TCF & RCF =1±0.0015	**PASS**
600	100	0.00	0.0	1.0000	**1.0000**	**0.00**	604		TCF & RCF =1±0.003	TCF & RCF =1±0.0015	**PASS**
900	150	0.02	0.6	0.9996	**0.9998**	**0.01**	903				
60	10	0.10	-1.2	0.9995	**0.9990**	**-0.02**	58		TCF & RCF =1±0.006		**PASS**
30	5	-0.01	-1.2	1.0006	**1.0001**	**-0.02**	29			TCF & RCF =1±0.0015	**PASS**

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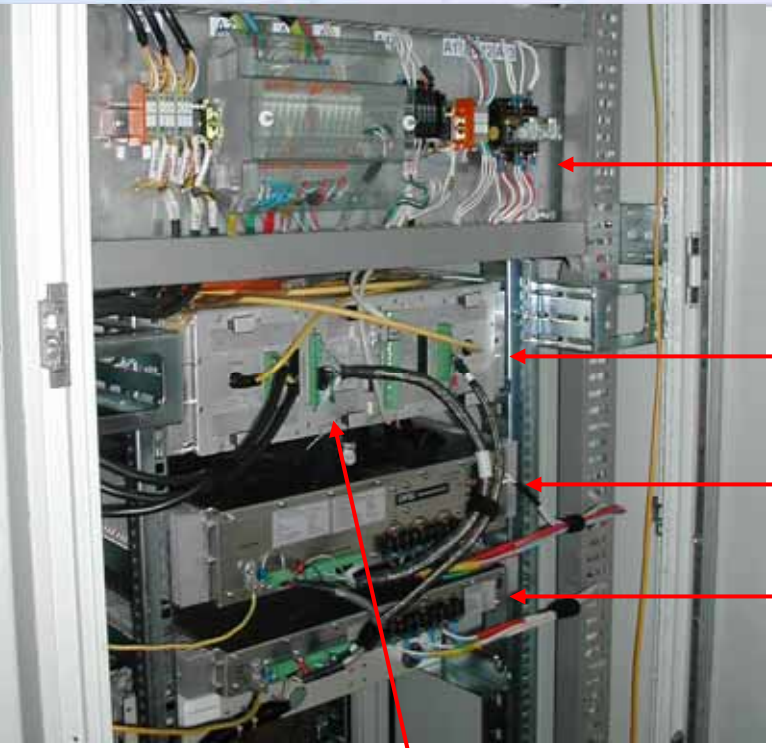
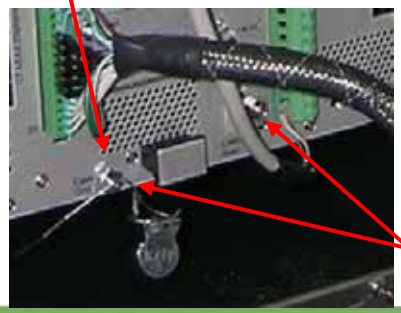
Sealing

- During cNOA, MC applies the seal in the factory
- After NOA, the manufacturer (in its accredited facility) will apply the seal to the electronics
- The seal is similar to that for meters
  - A wire seal is applied at the back of every electronics chassis to indicate/block tampering with the chassis
  - Software adjustable metrology factors will be inaccessible through the GUI (ratio can't be changed) while under seal
    - Changing the ratio would require breaking the seal and re-sealing under MC supervision
- If the site wiring requires sealing, that is treated similar to conventional instrument transformers in the field

Metering Cabinet (3 phase VCT)



Back



Seal

Revenue meter

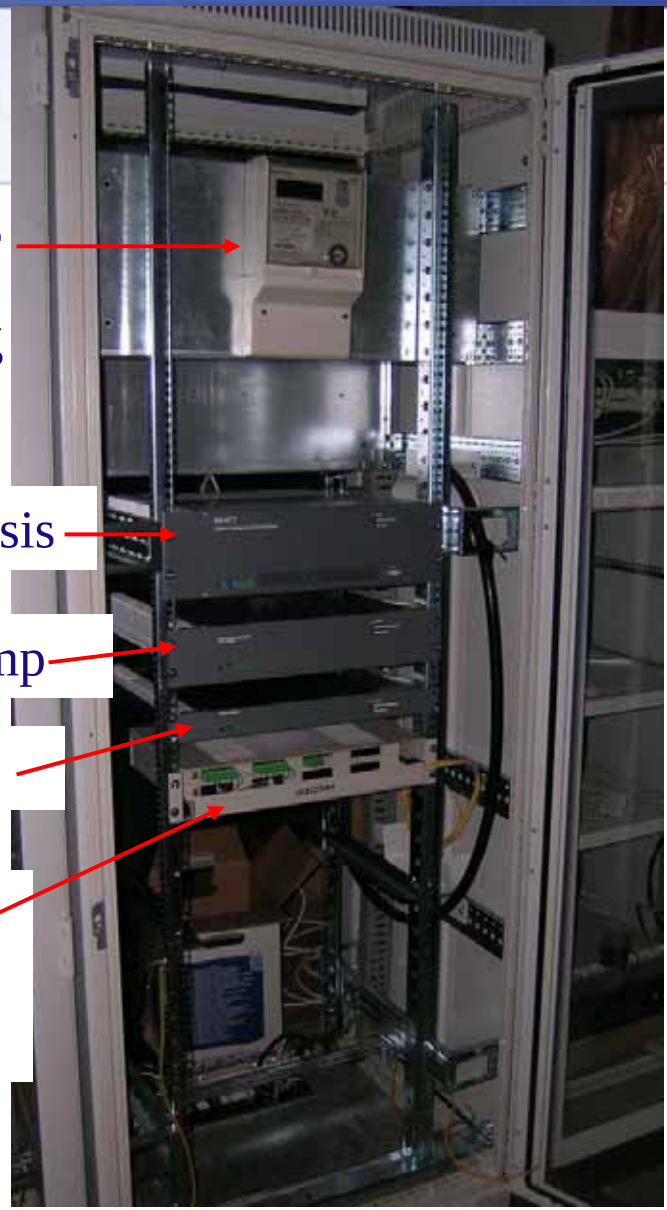
Std meter wiring

VCT Sensor chassis

Current Amp

Voltage Amp

Fiber connection Tray



Front

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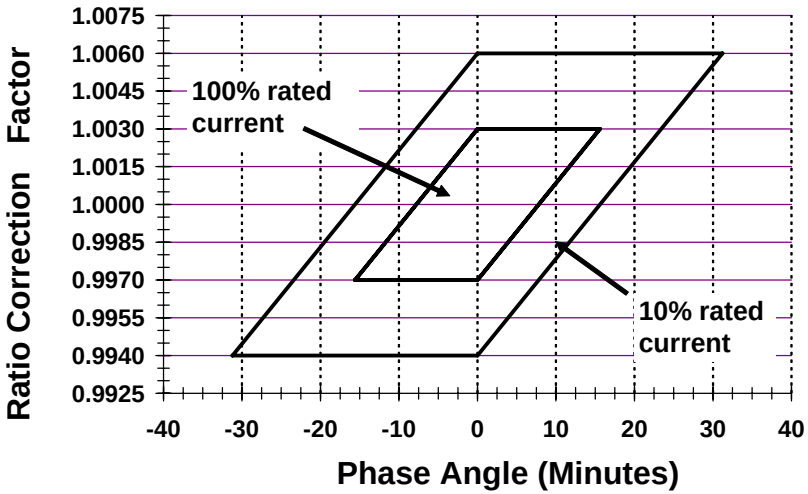
Third party Labs

- Optical CTs and/or VTs, over the past years, have been independently tested by
  - NRC labs in Ottawa
  - Measurement Canada Labs in Ottawa
  - Powertech Labs in Surrey, BC
  - LAPEM, in Mexico
  - NIST, in the US
  - Russian Metrology Institute – St Peters Burg (on site in Vancouver)
  - Siemens factory, Grenoble, France

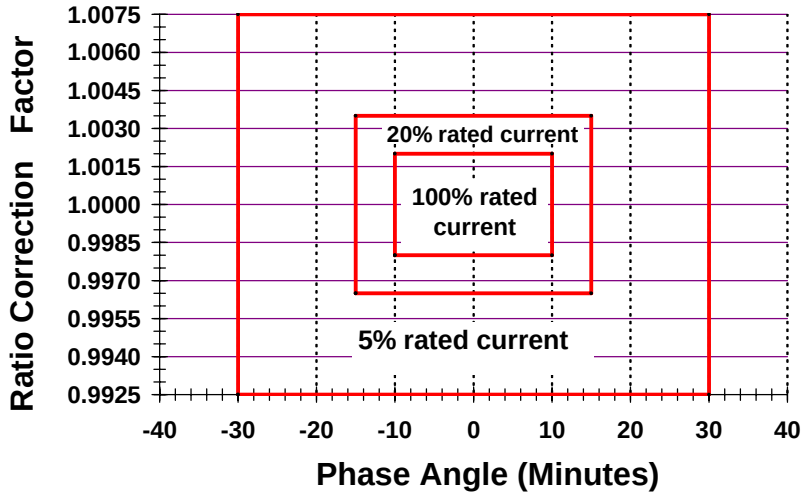
Accuracy Standards - examples

- IEEE/CSA parallelogram
- Power factor > 0.6
- Tighter on phase



0.3 Accuracy Class

- IEC rectangle
- Power factor > 0.8
- Tighter on amplitude



IEC 0.2 Accuracy Class

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The Software

NXTPHASE Digital and fiber optic solutions for the electric power industry.

Questions?

NXTPHASE Digital and fiber optic solutions for the electric power industry.

Contacts

- Eric Langford
  - Eric.langford@langford-assoc.com
- John Swindlehurst
  - jswindlehurst@nxtphase.com
- Farnoosh Rahmatian
  - frahmatian@nxtphase.com