Transient and CPOW monitoring for renewable generation connections

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Over 80% of new US generation capacity in 2021 from renewables

From: https://www.eia.gov/todayinenergy/detail.php?id=46416
Conventional power system...
Modern power systems
Future power systems…
Impact of reduced inertia on frequency control – loss of 1.32 GW generation in Great Britain grid

Lower frequency nadir

Higher RoCoF magnitude

Increase in primary response
Protection of converter-dominated systems

Three-phase fault: 0% converter penetration level

Voltage \((\text{pu})\)

"Standard" well-known response

Current \((\text{pu})\)
Protection of converter-dominated systems

Three-phase fault: 50% converter penetration level

Voltage (pu)

Current (pu)

50% Inverter: reduced fault level – but ok?
Protection of converter-dominated systems

Three-phase fault: 100% converter penetration level

100%: OK? Delay in response, waveform distortion...?

Response delay, current magnitude and ramp rate are all configurable
“Designer” fault currents
CPOW sensing scheme overview

- One powered Interrogator
- Arrays of passive sensors measure **voltage, current, strain, vibration, temperature**
- Integrated into existing standard telecoms fiber network
- 5P / 0.2M class electrical measurements
- Microsecond time accuracy on all measurements
- Delivers CPOW data from every sensor
Sensor integration

- Current and voltage sensors are integrated with **standard CTs and VTs**, connected in series through single-mode fiber

- Primary or secondary connected

- No data, power, comms infrastructure or clocks outside substation
Remote DER monitoring

Summary of value:

- Visibility of remote DER assets
- Immediate warnings of network PQ violations
- Reduced outages due to PQ-related side-effects of converter control
- Enables more DER connections due to better understanding of constraints

Passive, remote DER monitoring

Immediate, actional DER status

✓ Voltage and current RMS, phase, harmonics
✓ Real and reactive power
✓ Continuous flicker and harmonics assessment
✓ Event and threshold alarms
Wide-area line protection

Substation A

Substation B

Single-mode optical fiber

Synaptec Interrogator IED

PTP time sync

IEC 61850-9-2 LE
Sampled Values to Process Bus

Remote current samples delivered in <1 ms

CPOW-based protection
Wind farm monitoring

Synchronous, permanent PQ monitoring at all locations

Offshore substation
Enables:

- Detailed wide-area visibility
- PQ and synchrophasor delivery
- Captures CPOW data – in real-time and for events
- Visualise long-term trends

Synthesis – waveform data analysis

Wide-area sensor networks

Synaptec Interrogator IEDs

Local Process Bus and SCADA integration

Substation

Secure connection

Lossless data compression
(e.g. 10 three-phase measurements in 1 Mbps, including TLS)

Synthesis
Data processing & analytics

Secure private access to dashboard

Local or cloud server and data storage

High-resolution event data (kHz)

Long-term data trends (Hz)

Event and trend data storage
Synchronised transient detection and archiving

Synchronous measurements: see time-aligned voltage notching

Arcing fault

Re-ignition

All data available here: http://c2c.eee.strath.ac.uk
Zero-power sensor arrays and unique analytics

**DIGITAL SUBSTATIONS**
- Multipoint synchronous protection and asset monitoring
- Centralised busbar protection
- Less copper wiring and active devices in yard

**RENEWABLE GENERATION**
- Termination temperature monitoring
- Real Time Thermal Rating
- Permanent Power Quality from every generator
- Auto-reclose for every cable
- Simplified substation and grid connection instrumentation

**WIDE AREA MONITORING**
- Upgrade from PMU to streaming multipoint CPOW data
- Synchrophasors without networks or latency
- Better state estimates and frequency control
- OHL monitoring
- Real Time Thermal Rating
- Sag and vibration monitoring

**COMPLEX CIRCUITS**
- Wide area protection
- Multi-zone faulted section identification
- Multi-ended circuits and meshed cable systems
- Underground monitoring

**CABLE FAULT DETECTION**
- Enables auto-reclose on OHL, blocks command for cable sections
- No power or comms required in remote locations
- Multiple cable sections
- Additional temperature monitoring

**SINGLE-MODE OPTICAL FIBRE**
Up to 30 sensors per 60 km fibre

**INTERROGATOR**
Connected in digital or conventional substation

**SINGLE MODE OPTICAL FIBRE**

**VATTENFALL**

**DB**
Summary

- Secure
- Maintenance-free
- Live, real-time data
- New, integrated data sources
- Supports new CPOW applications
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