Return of the Dedicated DFR

How IEC 61850 Process bus simplifies DFR installation

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Introduction

• “DFR” is short hand for application requirement:
  • Specific non-operational data to improve power system operation

• Focus should be on the application first, not the device
Need data for...

- Understand and document how secondary equipment and primary equipment respond to abnormal events such as short circuits
- Verify power system models and short circuit calculations
- Identify power quality disturbances and provide for event analysis
- Document, verify, and analyze the performance of primary equipment to enable better maintenance practices
- Detect incipient failure of primary equipment such as bushings and instrument transformers
- Understand wide-area power system disturbances, including power system oscillations
- Provide data for power system planning models
3 types of recording:
- FR (oscillography)
- SER
- Disturbance data (phasor)

Data types and channels (*Measured and calculated*)

Station-wide coherence of data

Triggers (*Supervisory are desired*)

Record length and format (*COMTRADE, COMFEDE*)

Storage

NA: NERC PRC-002-2
DFR Installations

Centralized DFR

Pluses

• Coherent records
• Supervisory triggers
• Record formats
• Storage

Minuses

• Installation cost: up to 10x material cost of recorder!

Diagram:

DFR
V, I, Relay Triggers,
Device Status,
other signals
jumpered from
panels
Pair of CU wires per
channel
DFR Installations

Pluses

• Transfer work of DAU wiring to OEMs
• Like a centralized DFR, but better installation costs

Minuses

• Still installation cost
• Proprietary comms
• DAU are dedicated devices
DFR Installations

Distributed DFRs

Pluses

- Transfer work of DFR wiring to OEMs
- Like a centralized DFR, but better installation costs
- Zone-based recording

Minuses

- Still installation cost
- Proprietary comms
- DFRs are dedicated devices
- Data concentrator is probably standalone, proprietary
DFR Installations

Distributed Recording ("Virtual DFR")

Pluses

- Installation costs: devices are multi-purpose

Minuses

- Triggers
- Data types and channels
- Record length (and format)
- Coherence of data
- Storage
## DFR Installations

### Distributed Recording ("Virtual DFR")

<table>
<thead>
<tr>
<th>Functional Requirement</th>
<th>Centralized</th>
<th>DAUs</th>
<th>Local DFRs</th>
<th>Virtual DFR</th>
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<tbody>
<tr>
<td><strong>Channels</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analog</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
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<td>Binary</td>
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<td>Y</td>
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<td>Calculated</td>
<td>Maybe</td>
<td>Maybe</td>
<td>Maybe</td>
<td>N: protection quantities</td>
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<tr>
<td>Logic</td>
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<td>Y</td>
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<tr>
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<tr>
<td><strong>Records</strong></td>
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<tr>
<td>Length</td>
<td>Long</td>
<td>Long</td>
<td>Long</td>
<td>Short / medium</td>
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<tr>
<td>Sampling Rate</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>L / M</td>
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<td>Coordinated</td>
<td>Y</td>
<td>Y</td>
<td>Y: at DC</td>
<td>N: separate device</td>
</tr>
<tr>
<td>Time Stamp</td>
<td>Y: record</td>
<td>Y: record</td>
<td>Y: record</td>
<td>Y: record</td>
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<tr>
<td>Storage</td>
<td>H, native</td>
<td>H, native</td>
<td>H, at DC</td>
<td>L: separate device</td>
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<tr>
<td><strong>Installation</strong></td>
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<tr>
<td>Wiring</td>
<td>Lots</td>
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<td>None</td>
<td>Analog, serial, digital proprietary</td>
<td>Serial, digital proprietary</td>
<td>Serial, digital Open</td>
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<tr>
<td>Cost</td>
<td>$$$$$</td>
<td>$$$</td>
<td>$$$</td>
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</tr>
</tbody>
</table>
• Industry split between dedicated, virtual
  *Best quality of data vs. Best installed cost*

• But this focus is on managing analog signals: what's the most effective way to acquire the information needed for the “DFR application”.

• **BUT THIS IS WRONG:** focus should be on data needs and application

*Question: can IEC 61850 make this better?*
IEC 61850 is essentially two concepts:

• That we can “know” a piece of data
  Where it comes from
  What it represents
  That we can trust it

• That once we “know” a piece of data, we can “share” this data
  Using “right now” communications
  Using “must trust” communications
How 61850 works

• Functional modeling of the power system - *Logical Nodes*

• Self description of data – *Common Data Classes*

  Source Device::Logical Node::Data Class::Data Attribute::Data

• Application-based transmission
  • Publish-subscribe for “right now” data – *GOOSE, SV*
    Multicast messages operating at media level (MAC address)
  • Client-server for “must trust” data – *MMS*
    “Two party association” operating at network level (IP address)

• XML for configuration, documentation
Simple modeling example

- **TVTR**
- **TCTR**
- **XCBR**
- **Relay**
- **DFR**
- **PTRC**
- **RDRE**

TVTR: V as SV
TCTR: I as SV
XCBR: Circuit Breaker
PTRC: Protection Trip
RDRE: Disturbance Recording

Shared with “Relay” for P, R functions:
- TVTR
- TCTR
- XCBR
- PTRC

Shared with “DFR” for RDRE function:
- TVTR
- TCTR
- XCBR
- PTRC
Recording under IEC 61850

Analog Channel 1
Analog Channel 2
Analog Channel n
Binary Channel 1
Binary Channel 2
Binary Channel n

DFR

TVTR
TCTR
RADR
RADR
RADR
RADR

XCBR
PTRC
RBDR
RBDR
RBDR
RBDR

RDRE
IEC 61850 Message Types

Each GOOSE message is a set of data used for signaling

Dataset Item 1
Feeder12.LD6.XCBR.ST.Pos

- Device location “Feeder 12”
- Subset of device “LD6” used for control
- Logical Node “XCBR” = breaker status

Data Attribute “Position”

Functional Constraint “Status”

Each SV messages contains an instantaneous sample of I, V

IA  IB  IC  IG  VA  VB  VC  VG
“Process Bus”

Distributed I/O for protection & control

Process bus I/O devices

**simple example**

- **TVTR**
- **TCTR**
- **XCBR**

- **MU**

- **RIO**

- **PIU**

Process bus I/O devices

**generically**

- **G**
  - Generic LN
- **K**
  - Mechanical equipment
- **P**
  - Protection
- **R**
  - Protection Related
- **S**
  - Supervision
- **T**
  - Inst. Transformers
- **X**
  - Switchgear
- **Y**
  - Power Transformers
- **Z**
  - Further equipment

- **RIO / PIU**

- **MU / PIU**

- **Relay**
Simple process bus system

But what about recording?
Why can’t I do this?

You can: this is the virtual DFR made better

- Timestamped data for record coherence
- But still limited by devices!
61850 tells a nice story: can put function anywhere. But there are still requirements that are device dependent, not covered by 61850:

• How do you trigger?
• How long a record?
• What types of records?
• How much data storage?

So a DFR “device”
• “DFR” triggers and capabilities
• Natively coherent data
• Installation cost of $0

All the advantages of the Centralized DFR, w/o the cost disadvantage
Dedicated DFR Considerations

• Configuration process is:
  Subscribe to SV messages for analog data
  Subscribe to GOOSE messages for Boolean data
  Configure channel triggers against 61850 data

But how to handle brownfield substations?
Hybrid 61850 Dedicated DFR

- Adding DAUs simpler than adding PIUs
- Configuration of channels should be seamless
- Time coherence of data is design challenge
Hybrid DFR: channel configuration
Electrosul: Palhoça Substation
CTEEP: Embu-Guaçu Substation

- PIU
- DAU
- Fiber Optic Cable 100m
- 13.8kV Bus
- AL-60 Feeder

Marshalling Cabinet at Circuit Breaker Station Bus

100m

DAU (optical)

Fiber Optic Cable
61850 Impact on other DFR apps

• Synchrophasors / PMUs
  No impact: DFR can act as PMU (or PMUs)

• Fault location
  No impact on traditional techniques
  Challenge for traveling wave fault location (TWFL)

• TWFL uses high frequency data
  Not supported by any MU, PIU
  Huge communications bandwidth requirements
  May required dedicated DAUs for short term
Conclusions

• The DFR **application** is necessary for the modern utility
  *Capture non-operational data to analyze performance*

• Utilities have moved to the “virtual DFR” due to the cost of installation of DFR **devices**
  *Quality of data vs. cost of installation*

• Process bus under IEC 61850 changes these calculations
  *Dedicated DFR device (or application) to provide quality data with no cost of installation.*
Thank You

Questions?