**IEC 61850 Breaker Failure Demo – IED Configuration Guidelines**

# Timeline

* **July 8** - ICD files due from each participating device are due
* **July 11** – Begin system engineering
	+ **July 18** - Preliminary SCD/CID files for import into IED Config Tools
	+ **July 25** - Second round of ICD files due
	+ **Aug 8** - Final SCD/CID files available for testing
* **Aug 21** - Setup and test at Cigre (Sunday, Aug 24, 9AM)

# ICD File

Pre-defined datasets and pre-configured GOOSE Control Blocks (GCBs) and Report Control Blocks (RCBs) to be included in the ICD files. See details in later sections for Addressing, DataSets, and GOOSE publisher/subscriber info.

Datasets must include data listed in sections below, but can include additional data chosen by vendors. Otherwise, vendors should specify what the SCT should put into the dataset (specific FCDA statements).

If possible, the Inputs/ExtRef section(s) should be set up within the ICD file to assist the system configurator.

The System Configuration Tool will need to support Edition 1 and 2 SCL Files.

# Breaker Failure Demo Overview

The Breaker Failure Demo will include GOOSE, Sampled Values, and Client/Server reporting.

## Process Simulation

The power flow for one of the feeders will be simulated including CT, VT, and Circuit Breaker. This simulation will feed the analog inputs for the merging unit which will send a sampled values stream using 9-2 LE profile to the SV IED. In the simulation, the bus will be 220 kV @ 50 Hz and each of the simulated loads will be 200MW (524A).

## Fault Injection

There will be two options for initiating a trip in the breaker failure demo:

1. Process Simulation Fault – in this case, a process simulation will be performed with a simulated fault (PTOC) that will be detected by an IED (A-N fault with VAN=97.5 kV and IA=1700 A, with unfaulted phases remaining the same as prefault).
2. Panel Trip – in this case, a trip will be initiated from the IED panel.

## Breaker Simulation

IED will need to simulate breaker operation including failure condition. Vendors may also choose to bring a “physical” breaker. The concept is for booth visitors to have a visual indication of the breaker operation

In the case of the process simulation and SV IED, the breaker will be simulated by the process simulation or test set and the breaker failure logic will be in the SV IED. In the case of the other IEDs, the circuit breakers and breaker failure logic will be simulated by the IEDs. Each vendor can choose how to display breaker status, breaker failure, and GOOSE messaging on front panel.

The Doble test set will have scenarios to show both the breaker fail and the breaker successful open. During the first fault injection, the simulated Doble breaker will open successfully. During the second fault injection, the simulated Doble breaker will fail. After a reset, the Doble test set will start over.

## RBRF Logic

RBRF logic will be demonstrated in the IEDs in either the Process Simulation or the Panel Trip scenarios. The SV IEDs will have an RBRF logical node which will monitor the XCBR which is in the process simulation. The SEL IED will monitor the RTDS breaker and the EFACEC IED will monitor the Doble breaker.

## Sampled Values

The sampled values stream will use the 9-2 LE profile. Separate VLAN will be configured to keep Sampled Values only on ports that need to see SV messages.

The SV IEDs will be able to monitor either the SV stream from the Doble test set or the RTDS process simulation. The SV IEDs will manually switch between the two process simulations. When a fault is injected by one of the process simulations, then any of the SV IEDs that are monitoring the SV stream with that fault will indicate an overcurrent condition (PTOC.Str) and send a trip (PTRC.Op).

## GOOSE

Several GOOSE messages will be used to start the demo sequence, indicate trip, breaker failure, and demo reset.

## Client/Server

IEDs will use reports to send relevant data to Clients which will include MMXU, XCBR, RBRF, LGOS, and PTRC status. Optionally, include PTOC.

# Option 1: Process Simulation Fault

## Doble Only - Sequence for Breaker Success Scenario (Not done by RTDS)

The Doble Test Set will perform the following sequence to show the simulated breaker open successfully before performing the breaker failure sequence:

1. Process Simulation or Test Set injects pre-fault conditions for a 220kV system at 200MW load at 50Hz (220 kV L-L, 127 kV L-N and load current 524 A at unity power factor) which is broadcast in sampled values stream. Client can read these values. Process Simulation and Test Set will send breaker status (closed) to SV IEDs (RTDS will send GGIO.Ind and Doble will send XCBR.Pos).
2. Injection transitions to fault condition (this can be started by any of the IEDs/tools sending a GOOSE with GGIO.Ind). Process Simulation or Test Set receive GOOSE and then simulate A-N fault with VAN=97.5 kV and IA=1700 A, with unfaulted phases remaining the same as prefault.
3. SV IED detects the fault and broadcasts GOOSE with PTOC.Str
4. After a preset time delay (long enough to be observable, 5 seconds) SV IED operates and broadcasts GOOSE with PTOC. Op and PTRC.Op
5. Process Simulation and Test Set receive PTRC.Op=True from SV IED and attempt to open breaker
6. Simulated breaker opens (0.1 second CB opening delay to simulate reality) and breaker status (open) is sent to SV IEDs (RTDS will send GGIO.Ind and Doble will send XCBR.Pos). Process Simulation or Test Set will clear fault (zero current, normal voltage).
7. SV IED detects that breaker opened (SEL monitors RTDS, EFACEC monitors Doble) using breaker status info (optionally can use current from sampled values) and resets RBRF logic, and does not send RBRF.Opex=true. Other IEDs do nothing.
8. This “fault cleared” state will last for a duration of 5 seconds, after which simulation will automatically proceed to the next scenario (second fault condition and failure of breaker to open) which is shown in the section below.

Note: Doble Test Set will use a PC tool to subscribe to multiple GOOSE messages from IEDs and OR the inputs together for step 2

## RTDS and Doble - Sequence for Breaker Failure Scenario

The sequence for the breaker failure scenario is shown below. This will be done by both the Doble Test Set and the RTDS process simulation:

1. Process Simulation or Test Set injects pre-fault conditions for a 220kV system at 200MW load at 50Hz (220 kV L-L, 127 kV L-N and load current 524 A at unity power factor) which is broadcast in sampled values stream. Client can read these values. Process Simulation and Test Set will send breaker status (closed) to SV IEDs (RTDS will send GGIO.Ind and Doble will send XCBR.Pos).
2. Injection transitions to fault condition (this can be started by any of the IEDs/tools sending a GOOSE with GGIO.Ind). Process Simulation or Test Set receive GOOSE and then simulate A-N fault with VAN=97.5 kV and IA=1700 A, with unfaulted phases remaining the same as prefault.
3. SV IED detects the fault and broadcasts GOOSE with PTOC.Str
4. After a preset time delay (long enough to be observable, 5 seconds) SV IED operates and broadcasts GOOSE with PTOC. Op and PTRC.Op
5. Process Simulation and Test Set receive PTRC.Op=True from SV IED and attempt to open breaker
6. Simulated failure of breaker (does not open) and fault condition persists. Process Simulation and Test Set will continue to send breaker status (closed) to SV IEDs (RTDS will send GGIO.Ind and Doble will send XCBR.Pos).
7. SV IED detects breaker failure (SEL monitors RTDS breaker, EFACEC monitors Doble breaker) after waiting 5 seconds for breaker status to change to open (optionally can monitor current from sampled values) and broadcasts GOOSE with RBRF.OpEx=true
8. Other IEDs receive RBRF.OpEx and trip breaker (and optionally, broadcast GOOSE with RBRF.OpEx=true)
9. Process Simulation or Test Set will clear fault (zero currents and also zero voltages since all breakers are connected to a single bus) after receiving GOOSE from IED with RBRF.OpEx=true. RTDS Process Simulation will clear fault by opening backup breaker. Doble Test Set will zero voltage and current.
10. Demo is reset by any of the IEDs/Test Tools sending a GOOSE with CSWI.OpCls. IEDs should reset to initial conditions. Process Simulation or Test Set should reset simulation to pre-fault conditions (normal voltages and load current and closed breaker).

Note: Doble Test Set will use a PC tool to subscribe to multiple GOOSE messages from IEDs and OR the inputs together for step 2 and 10

## SV IED Protection Function Settings

* Enable Phase PTOC
	+ Pickup setting = 800 A
	+ Time delay = 5 seconds
* Enable RBRF
	+ Logic based on breaker position (option to use current from sampled values)
	+ Time delay = 5 seconds



# Option 2: Panel Trip

## Sequence for Breaker Failure

Below is a diagram which shows the sequence of the panel trip demo:

1. Initiate trip from front panel of IED
2. IED sends GOOSE with PTRC.Op
3. IED attempts to open breaker
4. Simulated failure of breaker (does not open)
5. IED detects failure and broadcasts GOOSE with RBRF.OpEx
6. Other IEDs receive RBRF.OpEx and trip local breaker. Process Simulations will trip local breakers and set simulated current to zero.
7. Demo is reset by any of the IEDs/Test Tools by sending a GOOSE with CSWI.OpCls. IEDs should reset to initial conditions. Process Simulation or Test Set should reset simulation to pre-fault conditions (normal voltages and load current and closed breaker).

There is also the option to show the successful breaker opening scenario in which the breaker opens and the RBRF logic is reset and the IED does not send RBRF.Opex=true to the other IEDs.



# GOOSE Publishing/Subscribing

## Table : Process Sim Case

|  |  |  |  |
| --- | --- | --- | --- |
| **Purpose** | **Publisher** | **Subscriber** | **Dataset must include** |
| Start Fault Injection | Any IED or Test Tool | Process Sim/Test Set | GGIO.Ind1.stVal (RTDS)GGIO.Ind2.stVal (Doble) |
| Start of Fault Detection | SV IEDs | Monitoring tools | PTOC1.Str.general (RTDS)PTOC2.Str.general (Doble) |
| Trip | SV IEDs | All other IEDs | PTRC1.Op.general (RTDS)PTRC2.Op.general (Doble) |
| Breaker Status | Process Sim/Test Set | SV IEDs | GGIO.Ind.stVal (RTDS)XCBR.Pos.stVal (Doble) |
| Breaker Failure | SV IEDs | All other IEDs | RBRF.OpEx.general |
| Reset Demo | Any IED or Test Tool | All IEDs | CSWI.OpCls.general |

## Table : Panel Trip Case

|  |  |  |  |
| --- | --- | --- | --- |
| **Purpose** | **Publisher** | **Subscriber** | **Data** |
| Trip | IED | All other IEDs | PTRC.Op.general |
| Breaker Failure | IED | All other IEDs | RBRF.OpEx.general |
| Reset Demo | Any IED or Test Tool | All IEDs | CSWI.OpCls.general |

## GOOSE Datasets

FCDA elements in GOOSE datasets must include the data attributes (i.e. daName must be specified) listed in Table 1 and Table 2 above for compatibility with all devices. Data objects can be added in addition to the data attributes if desired.

## Start Fault Injection

Any IED or Test Tool can send this GOOSE to start the Process Sim demo sequence. GGIO.IndX=True is received by Process Sim/Test Set to inject fault into process sim. The X addressing is used to identify the target Process Sim/Test Set device (X=1 for RTDS, X=2 for Doble) to inject fault.

DataSet should include: GGIO.Ind1.stVal (RTDS), GGIO.Ind2.stVal (Doble)

## Start of Fault Detection by SV IED

When the SV IED detects the fault in the SV stream, it will send PTOC.Str

DataSet must include: PTOC1.Str.general, PTOC2.Str.general

## Trip

When the SV IED detects the fault in the SV stream, it will send PTRC.Op.general (PTRC1 for RTDS and PTRC2 for Doble)

DataSet must include: PTRC1.Op.general, PTRC2.Op.general

## Breaker Status

Process Simulation or Test Set will send a GOOSE indicating the breaker position. The SV IEDs will monitor this to determine if the breaker was able to operate or if it failed.

DataSet must include: GGIO.Ind.general (RTDS) or XCBR.Pos.stVal (Doble)

## Breaker Failure

When the breaker fails to open, the IED will send RBRF.OpEx.general

DataSet must include: RBRF.OpEx.general

## Reset Demo

CSWI1.OpCls is used to reset the breaker failure scenario (first GOOSE message to set TRUE and a second GOOSE about 1 second later to set it FALSE). IEDs to subscribe to this GOOSE as input to XCBR.

Test set should reset simulation to pre-fault conditions (normal voltages and load current and closed breaker). IEDs should reset to initial conditions: XCBR(Pos=on), RBRF (Str=false, OpEx=false), PTOC (Str=false, Op=false), PTRC (Op=false), GGIO(Ind1=false, Ind2=false)

DataSet should include: CSWI.OpCls.general

## GOOSE Subscription Notes

Vendors to specify (in writing) how to set up SCD file for subscriptions to external GOOSE to show the state of the Boolean(s).

If possible, the Inputs/ExtRef section(s) should be set up within the ICD file to assist the system configurator.

# Client/Server

Below are Client/Server services that will be demonstrated:

## Reports

The following Clients will subscribe to Report Control Blocks (RCB’s) from the IED’s. Specific RCB’s will be allocated to the different vendors so that there is always an available RCB for each Client.

|  |  |  |
| --- | --- | --- |
| **Vendor** | Client | Assigned RCB # |
| **SISCO** | AX-S4 61850 Client | 1 |
| **DNV GL** | Client Simulator | 2 |
| **SUBNET** | HMI – Client | 3 |
| **Triangle MicroWorks** | Distributed Test Manager | 4 |
| **Doble** | 61850TesT – client simulator | 5 |
| **RTDS** | MMS Voyageur | 6 |
| **SEL** | SEL 3355 | 7 |
| **Efacec** | System Point | 8 |

At a minimum the RCB for each IED should include:

* RBRF (Str, OpEx, OpIn)
* PTOC (Str, Op)
* PTRC (Str, Tr, Op)
* XCBR (Pos)
* LGOS (if the IED supports this)
* MMXU (3ph currents and voltages)

Clients will show time delay between PTOC.Str and PTOC.Op because the SV IED will include a 5 second delay between these two objects.

# Sampled Values Publishing Subscribing

## Process Sim Case

|  |  |  |  |
| --- | --- | --- | --- |
| **Purpose** | **Publisher** | **Subscriber** | **Data** |
| CT/VT data | Process Sim/Test Set  | SV IEDs | 9-2 LE Profile |

There will be two process sims running and each will publish sampled values.

There will be multiple SV IEDs that will be able to monitor either the SV stream from the Doble test set or the RTDS process simulation. The SV IEDs will manually switch between the sampled values stream from the two process simulations. When a fault is injected by one of the process simulations, then any of the SV IEDs that are monitoring the SV stream with that fault will indicate an overcurrent condition (PTOC.Str) and send a trip (PTRC.Op).

# Addressing

Each vendor will have a range of addresses to use:

X = unique participation ID (from Table 3)

Y = ordinal number for each device assigned by each vendor (first in SCL is 0, next is 1, etc.)

Z = ordinal number for GoID and SvID and APPID usage assigned by each vendor

IP addresses:  172.16.X.Y (in decimal)

Netmask: 255.255.0.0

Gateway: 172.16.16.1 (if used)

GOOSE MAC addresses are 01-0C-CD-01-00-XZ where XZ in hex

SV MAC addresses are 01-0C-CD-04-00-XZ where XZ in hex

GOOSE APPID = 0x00XZ where XZ in hex

SV APPID = 0x40XZ where XZ in hex

GoID = Vendor\_Device\_XZ

VLAN ID = 1 for Client/Server

VLAN ID = 2 for Station Bus (GOOSE)

VLAN ID = 3 for Process Bus (SV)

VLAN Priority = 4 for GOOSE/SV

## Table : Addressing by Vendor

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Vendor** | Vendor #(X) | Device #(Y) | GOOSE/SV #(Z) | IED | Client | GOOSE Monitor |
| **RTDS** | 1 | 0-15 (0-F) | 0-15 (0-F) | IED Simulator | MMS Voyageur | GOOSE Simulator |
| **Doble** | 2 | 0-15 (0-F) | 0-15 (0-F) | F6150sv test set | 61850TesT sw | 61850TesT sw |
| **Cisco** | 3 | 0-15 (0-F) | 0-15 (0-F) |  |  |  |
| **SEL** | 4 | 0-15 (0-F) | 0-15 (0-F) | SEL-411L |  |  |
| **SISCO** | 5 | 0-15 (0-F) | 0-15 (0-F) | AX-S4 61850 IED Simulator | AX-S4 61850 Client | AX-S4 GOOSE |
| **EFACEC** | 6 | 0-15 (0-F) | 0-15 (0-F) |  |  |  |
| **DNV GL** | 7 | 0-15 (0-F) | 0-15 (0-F) | IED Simulator | Client Simulator | UniCA 61850 Analyzer |
| **SUBNET** | 8 | 0-15 (0-F) | 0-15 (0-F) |  | HMI - Client | GOOSE Monitor |
| **Triangle MicroWorks** | 9 | 0-15 (0-F) | 0-15 (0-F) | Anvil IED Simulator | Distributed Test Manager | Hammer |
| **NR Electric** | 10 (A) | 0-15 (0-F) | 0-15 (0-F) | PCS-902 |  |  |