Analogue and binary GOOSE transfer in an A.Eberle REG-DA Voltage Regulating Relay

Transfer of analogue and CB status information between the MV switchboard and a voltage regulating relay (VRR) is one of the few places where significant on-site wiring is required in a modern substation design. Often protection relays are pre-installed at the switchboard factory and voltage regulating relays (VRRs) are installed in a control cubicle physically mounted on the transformer itself and pre-wired at the transformer factory.

To minimise the need for on-site wiring, it was considered that IEC 61850 GOOSE messages could be used to transfer all the required information between the protection relays mounted in the MV switchboard out to the VRR (Figure 1). This would use the existing SCADA Ethernet network within the substation to communicate the required information, rather than additional dedicated hardwired connections.

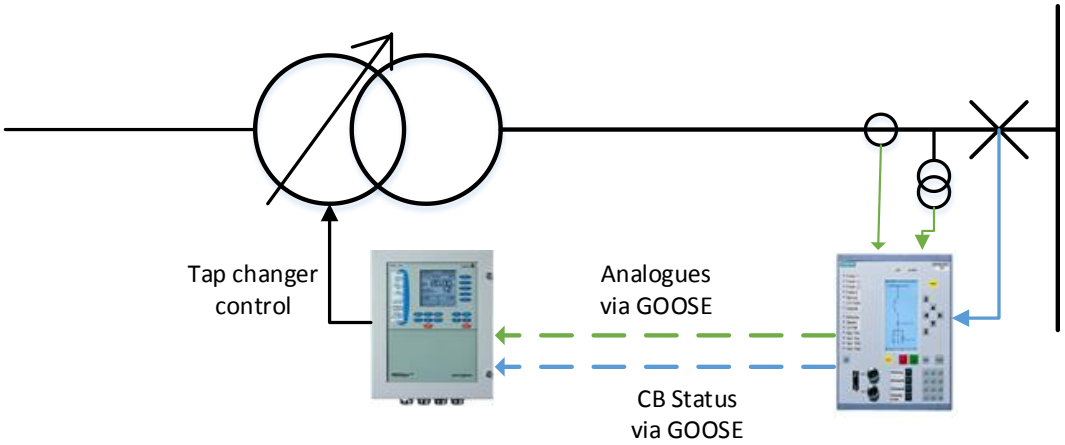

Figure 1. CT and VT status information and CB status values transferred from protection relay to voltage regulating relay via GOOSE.

While the most common use for GOOSE is transfer of binary signals, this application requires the use of the capability within some devices to also transfer analogue values via GOOSE. This allows the analogue values measured by the protection relay to be transferred to the VRR.

This document describes the process of designing and testing a simple bench-top scheme to prove this concept was feasible. A.Eberle REG-DA and Siemens SIPROTEC 7SJ64 relays were used for this design.

GOOSE in an A.Eberle relay

As an ordering option, the REG-DA relay can be fitted with a 'PED' communications card. Among other functions, this supports A.Eberle 'GOOSE Lite'. Using this, GOOSE messages can be transmitted and received from other manufacturers' devices. The difference from standard GOOSE is that the GOOSE Lite processing speed is slower than the IEC 61850 standard. For the purposes of the system being considered here, a short processing delay was not considered significant. The reaction time of a VRR and a tap-changer is typically at least several seconds, so protection-grade GOOSE transfer times are not necessary.

Configuration is via the WinConfig software. A standard GOOSE publishing data-set is preconfigured, as well as a set of subscriptions to double-point status values suitable for input of switch device statuses transmitted by other IEDs. These predefined data-sets are user-editable down to low-level details if required.

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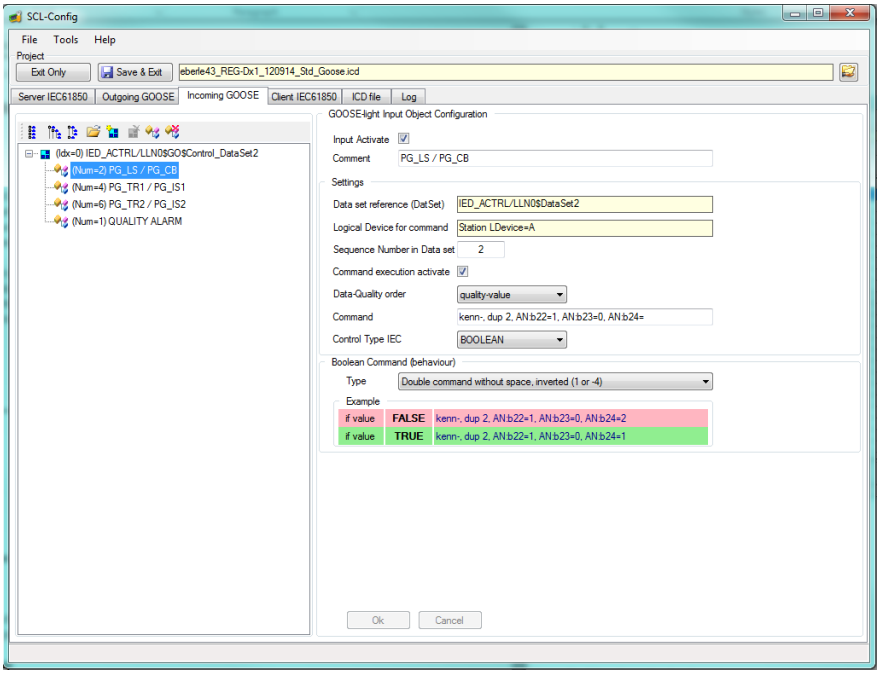

Figure 2. WinConfig GOOSE subscription default settings.

Access to most internal values as sources for GOOSE publishing is possible. Many can also be written to using values received from other IEDs via GOOSE subscription. Manipulation of variables prior to publishing, or after receipt, is also possible using the internal RegL programming language. This contains a range of tools including Boolean logic, bit-wise operators and trigonometric functions.

Configuration

To correctly simulate a practical application of this system, the test was extended to model a simple two-transformer substation. The status of both incoming circuit breakers and the bus section circuit breakers are used by the regulator to determine if the transformers are regulated in a parallel scheme. The A. Eberle Paragrammer function within each relay takes care of this paralleling logic decision – the configuration needed was to map the GOOSE signals as the inputs, rather than the typically used hardwired binary inputs.

The multicast nature of GOOSE simplifies the required CB status transfer between devices, as a signal published by any of the SIPROTEC IEDs can be subscribed to by any of the VRR's.

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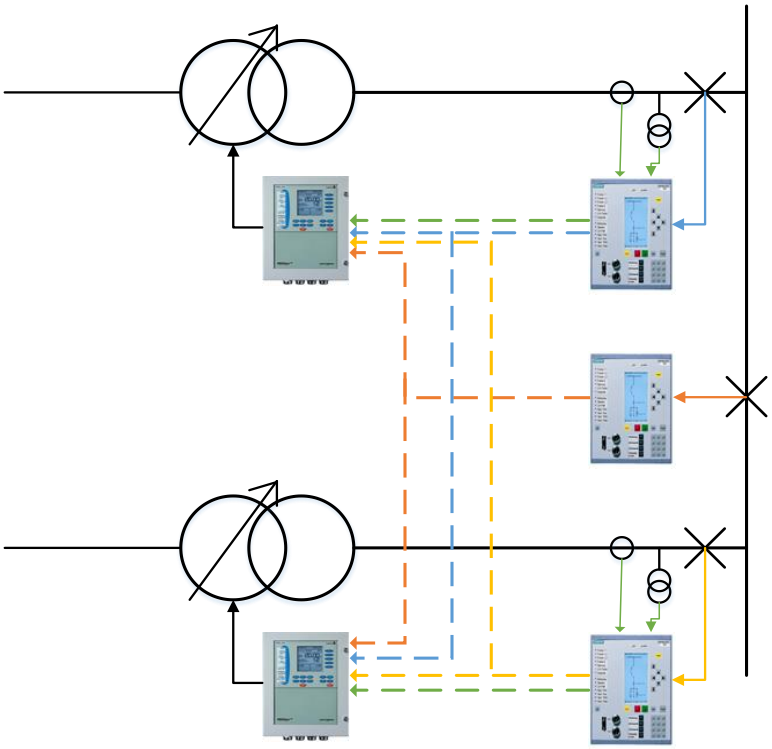

Figure 3. The multicast format of GOOSE messages allows transfer of signals from each GOOSE publisher to multiple subscribers.

Each SIPROTEC relay was added to an IEC 61850 station using Siemens DIGSI software. Within each relay the double-point status of each CB was already mapped to the system-interface for reporting to SCADA via MMS. All that was required within DIGSI was to create a GOOSE application and map the signals to the data-set via drag-and-drop.

Within the A. Eberle device the GOOSE subscription details were modified to match the signals to be transmitted via the SIPROTEC relays. These signals were then written to the relevant internal CB status variables so that Paragrammer was correctly updated.

GOOSE messages

Source	CDC	Description
IEC61850 station		
GOOSE application1		
IED_000000006/CTRL/LLN0/DataSet1 (2/60)		
IED_A/CTRL/LLN0/DataSet1 (16/60)		
IED_A/CTRL/Q0CSWI1/Pos	DPC	Control/BreakerCSWI/Position
IED_A/CTRL/Q0CSWI1/Pos/Status value	DPC	Control/BreakerCSWI/Position/Status value
IED_A/CTRL/Q1CSWI1/Pos	DPC	Control/Disc.Swit.CSWI/Position
IED_A/CTRL/Q2GGIO1/DPCSO1	DPC	Control/Q2GGIO1/0= not valid (DP)
IED_A/CTRL/TestGGIO1/ISCSO1	INC	Control/TestGGIO1/external Counter IL1 (ExMV)
IED_A/CTRL/TestGGIO1/ISCSO2	INC	Control/TestGGIO1/external Counter UL1E (ExMV)
IED_A/CTRL/TestGGIO1/ISCSO3	INC	Control/TestGGIO1/external Counter PF (ExMV)
IED_A/CTRL/TestGGIO1/ISCSO4	INC	Control/TestGGIO1/external Counter Frequency (ExMV)
IED_A/CTRL/TimeTeGGIO1/SPCSO1	SPC	Control/TimeTeGGIO1/BI13
IED_A/CTRL/TimeTeGGIO1/SPCSO1/Status value	SPC	Control/TimeTeGGIO1/BI13/Status value
IED_B/CTRL/LLN0/DataSet1 (14/60)		
REGT1/A/LLN0/GoDs_RegATCC		
REGT2/A/LLN0/GoDs_RegATCC		

Figure 4. Mapping of signals in DIGSI IEC 61850 System Configurator.

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The transfer of the required analogue values was performed in a similar manner. The Measured Values from the SIPROTEC device were configured to be published via GOOSE as integer values. In the REG-DA device, scaling in the opposite direction was applied using RegL code, prior to the signals being written to the analogue value variables in the relay. The reason for the use of integer values was simplicity of testing. Direct transfer of real values should be possible, but this has not yet been tested.

Test method

A complete set of SIPROTEC Protection Relays and REG-DA Voltage Regulating Relays were configured and connected to an Ethernet switch for bench testing. A circuit breaker simulator was connected to each SIPROTEC relay to allow simple testing of breaker status changes and a secondary injection test set was connected to each of the incomer CB relays (Figure 5).

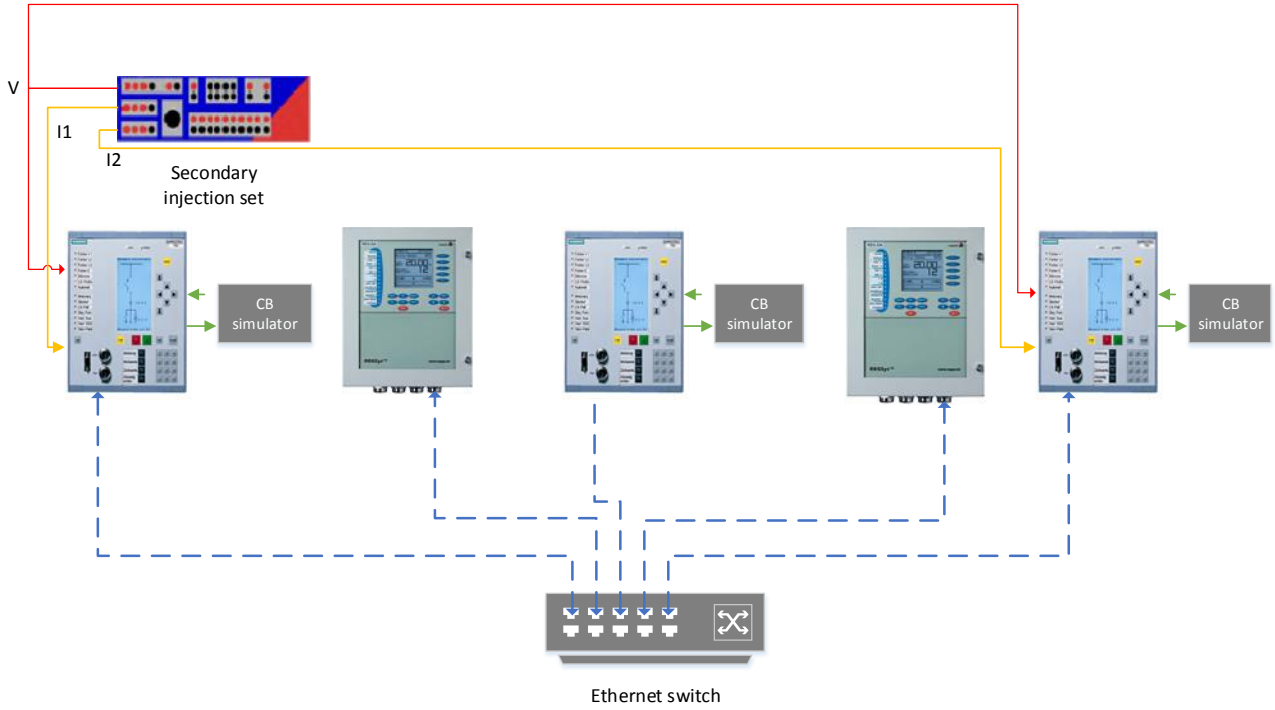

Figure 5. Physical test setup. The IEDs were connected via fibre cables to an Ethernet switch.

The graphic display of each A.Eberle VRR device was used to confirm that CB status was correctly being transferred to each device and that parallel-mode switching occurred as expected. Secondary test voltages and currents were applied to the SIPROTEC devices and measured values checked on the display of the VRR.

The A.Eberle devices were then placed in automatic mode and the correct behaviour of the voltage regulation function was confirmed.

Conclusions and future work

As a proof-of-concept, the testing proved successful. Analogue and CB status value transfer between devices worked as predicted and allowed the VRR control functions to operate correctly.

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To allow use within a real substation environment, further work is needed to improve the ruggedness of the application. Redundancy of Ethernet connections, monitoring of the GOOSE signals and error checking all need to be implemented.

More information

For further information on transformer control with A.Eberle Voltage Regulating Relays refer to http://www.hvpower.co.nz/TechnicalLibrary/VoltageRegulators.html or contact HV Power.

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