IEC 61850 INTEROPERABILITY BETWEEN RECORDERS AND RELAYS

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ABSTRACT

Today the use of digital IEDs for fault recording, protection and control (and the exchange of critical data between them) using the IEC 61850 protocol is gaining acceptance for new applications. In the past, the use of GOOSE messages for substation automation limited to tripping schemes, triggering disturbance recorders and providing position indication for interlocking.

It is known that disturbance fault recorders (DFRs) can provide crucial power system status information, including fault records, swing records, event capture, and switchgear status. In modern power substations that have been integrated using the IEC61850 standard, protective devices publish tripping events to the LAN; DFRs can subscribe to those messages or commands to trigger the appropriate channels (to save the information needed for future extended evaluation). In other words, relays and recorders should continuously communicate, using GOOSE messages to track power system behavior during both fault and normal conditions.

This paper explains interoperability principles and discusses the benefits of IEC 61850 applications with DFRs. It describes real time simulations that use a relay testing equipment to generate GOOSE messages associated to the protection functions of a multifunction line protection relay. Protective devices trigger the DFRs, capturing the records for post-event analysis of the overall system. Interoperability was confirmed using at least two different relay vendors.

KEYWORDS

IEC 61850, GOOSE, CID, IED, LAN, Digital Fault Recorder, Interoperability

1 INTRODUCTION

In substation automation systems, the global IEC 61850 standard protocol aims to enable interoperability between IDs inside the substation. This paper describes the application and full potential of well-known GOOSE messages (generated by multi-function relays and captured by the digital fault recorder). Protection engineers can use these features, available today in some DFRs; this paper uses 2 vendor IEDs to confirm interoperability, which should be valid for any IED vendor that complies with IEC 61850-8-1.

We present the results of some real tests, using some vendors' configuration tools in order to prove the testing.

Interoperability is the capability of two or more IEDs from one or several vendors to exchange information and to use this information to fulfill a function (in this case trigger records onto the DFR).

Interoperability is the focus and ultimate goal of IEC 61850.

1.1 Definitions and Acronyms

The following terms are used in this paper:

IEC 61850: communication protocol standard.

GOOSE: Generic Object Oriented Substation Event message. Message which provides a fast and reliable mechanism of transferring event data over entire substation networks

CID: Configured IDE Description. A CID File is a SCD file, possibly stripped down to what the concerned IED shall know (restricted view of source IEDs). The use of the CID file depends on the implementation of IEC 61850 in the IED. One option is to directly download the file in the device. Another is to convert it to a proprietary file format that is then downloaded in the IED.

IED: Intelligent Electronic Device. Essentially any physical device which collects information and transmits it digitally.

LAN: Local Area Network.

2 WHAT IS IEC 61850?

IEC 61850 is a 14-part international standard, which defines a communication architecture for substations. It is more than just a protocol and provides:

- standardized models for IEDs and other equipment within the substation
- standardized communication services (the method used to access and exchange data)
- standardized formats for configuration files
- peer-to-peer (e.g. relay to recorder) communication

The standard includes mapping of data onto Ethernet. Using Ethernet in the substation offers many advantages, including:

- high-speed data rates (currently 100Mbits/s, rather than 10's of kilobits/s or less used by most serial protocols)
- multiple masters (called "clients")

- Ethernet is an open standard in everyday use

3 INTEROPERABILITY

A major benefit of IEC 61850 is interoperability. IEC 61850 standardizes the data model of substation IEDs, in order to improve integration between different vendors' products, i.e. interoperability. The protocol ensures that data is accessed in the same manner in different IEDs (Figure 1), even though, for example, the protection algorithms of different vendors' relay types remain different.

The IEC 61850 compliant devices described are not interchangeable; one cannot replace one product with another. However, the terminology is predefined so that anyone with knowledge of IEC 61850 can quickly integrate a new device without mapping all of the new data. IEC 61850 improves substation communications and interoperability, at a lower cost to the end user.

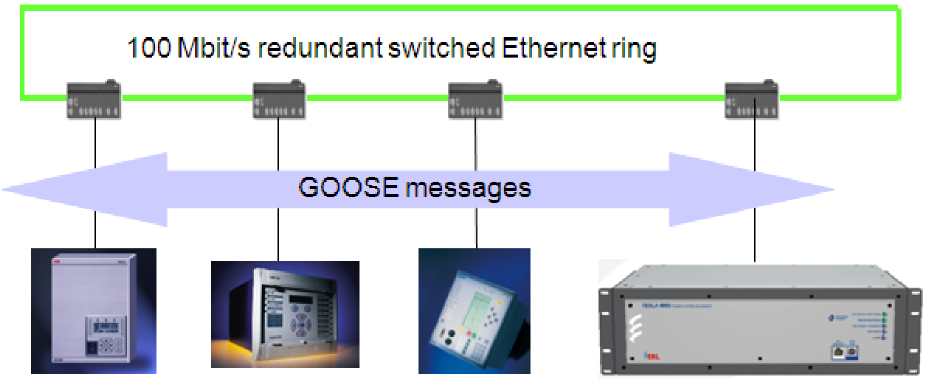

Figure 1 Interoperability between multiple venders

Interoperability is the focus and ultimate goal of IEC 61850. The standard includes Part 10 Conformance Test as an integral part of the standard to verify the communications interfaces.

4 IEC 61850 GOOSE MESSAGING

4.1 Description

Generic **O**bject **O**riented **S**ubstation **E**vent

- GOOSE is a mechanism for the fast transmission of substation events messages, such as commands, alarms, and indications.
- IEC 61850 supports interoperability based on inter-relay and recorder communication.
- A single GOOSE message sent by and IED can be received and used by several receivers.
- GOOSE takes advantages of the powerful Ethernet (LAN/WAN) and supports real time behavior.

4.2 Logical Nodes

The IEC-61850-7-4 protocol defines 91 logical nodes, divided into 13 logical groups. The first letter of the logical node identifies its group (Figure 2).

Logical Group	Name	Number of Logical Nodes
L	System LN	2
P	Protection	28
R	Protection related	10
C	Control	5
G	Generic	3
I	Interfacing and archiving	4
A	Automatic control	4
M	Metering and measurement	8
S	Sensor and monitoring	4
X	Switchgear	2
T	Instrument transformers	2
Y	Power transformers	4
Z	Further power system equipment	15

Figure 2 Logical nodes 0pplied in substation automation

4.3 The P-group, with Protection Logical Nodes

The following table shows some Logical Nodes more frequently applied (Figure 3):

Table 1 Table of Logical Noes

Functionality	**IEEE C.37.2 Reference**	**Defined in IEC-61850-5**	**Modeled in IEC-61850-7-4**
Distance	21	PDIS	PDIS PSCH
Instantaneous Overcurrent	50	PIOC	PIOC
AC Time Overcurrent	51	PTOC	PTOC
Directional Earth Fault	67N	PDEF	PTOC
Frequency	81	PFRQ	PTOF PTUF PFRC
Out-of-step	78	PPAM	PPAM
Differential	87	PDIF	PDIF
Overvoltage	59	PTOV	PTOV
Undervoltage	27	PTUV	PTUV

5 IEC 61850 GOOSE PRINCIPLE

One device X (publisher or sender) sends the information; only device Y or Z (subscriber or receiver) is receiving it, as Figure 4 shows.

A fault can be simulated via a test set to activate protection. In order to simulate a fault via a test set, activate the overcurrent and distance protection functions from a multifunction relay. Based on settings, that relay will generate the corresponding GOOSE messages to perform operation commands for tripping, annunciation, and disturbance recording triggering (Figure 4).

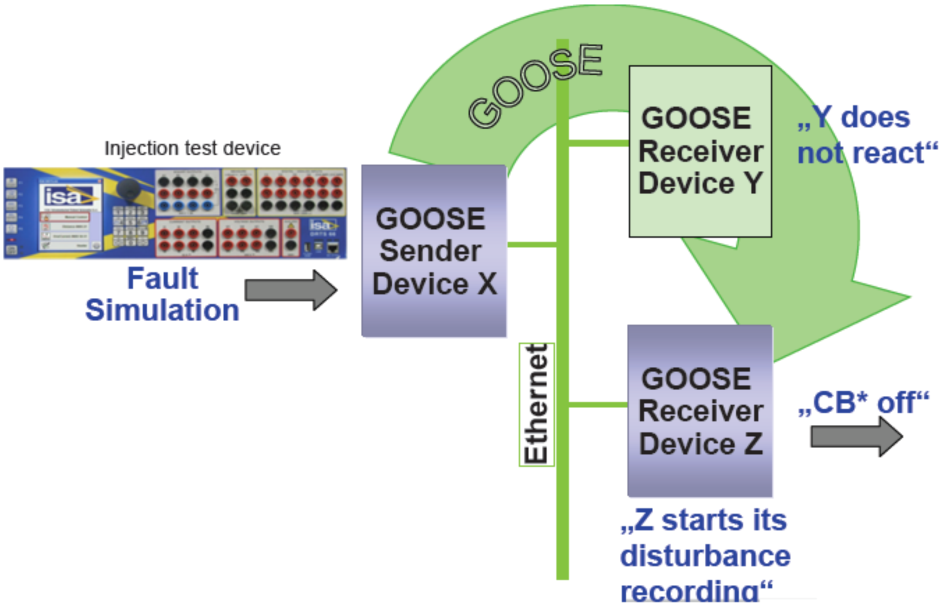

Figure 3 GOOSE on the LAN

6 CASE STUDY

Our case study uses three different vendors' IEDs (ABB, ERL and ISA), as shown in the system diagram below (Figure 5). Both distance relays are getting AC analog values for simulation, causing the operation of the relays acting as line protection system. Two scenarios of faults were tested to activate the overcurrent functions (50/51) and distance functions (21).

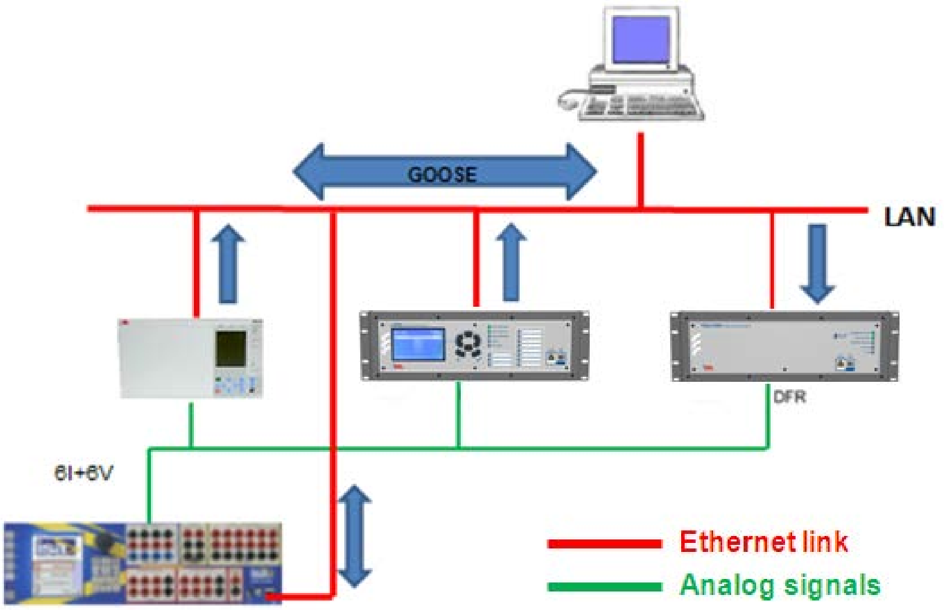

Figure 4 Test Connection Diagram

7 IEC GOOSE MAPPING

In order to do the map, we need IEDs for publication and subscription; the following table shows an IEC 61850 configuration tool to achieve adequate mapping of ID publication and subscription. There are several trigger options by distance relays associated to transmission lines, and have chosen the

Overcurrent (PTOC) and Distance (PDIS) protection functions for mapping. The DFR is acting as subscriber, so it can trigger the records while the messages exist (Figure 6).

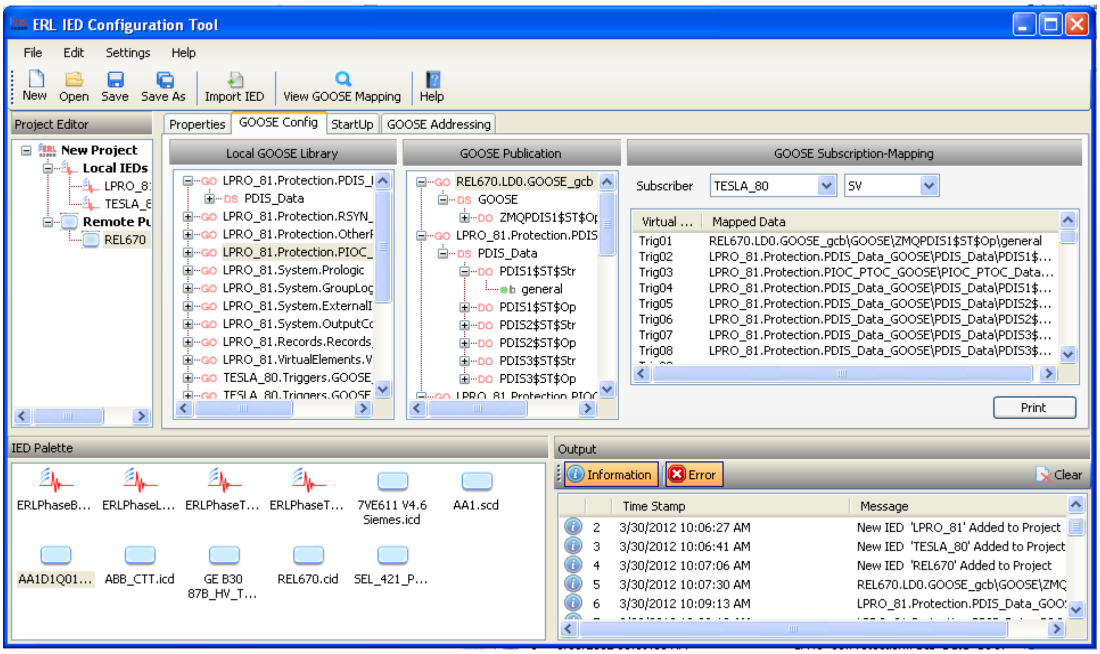

Figure 5 GOOSE mapping of the system

8 INTEROPERABILITY TESTING

8.1 Vendor 1: Distance Relay

8.1.1 Trigger by Distance Protection

This scenario uses several testing points (Figure 7) to activate distance protection function (PDIS), with a Quadrilateral type phase-to-phase shape and testing several points of zones 1 and 2. After activation, the relay sends a GOOSE message to the recorder, which will be used to capture a transient or swing record.

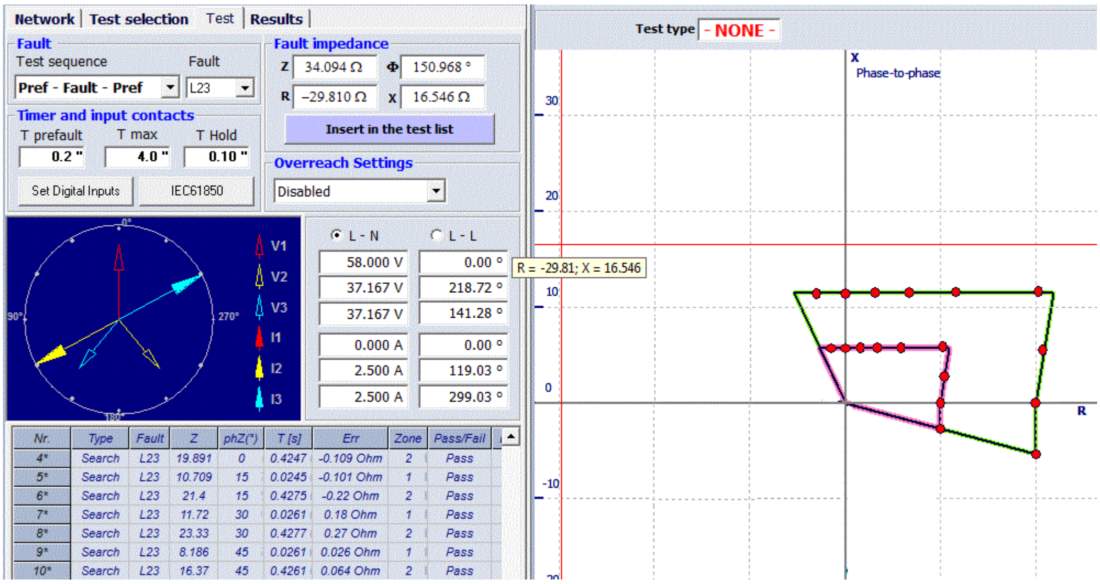

Figure 6 Testing points of distance protection function.

8.1.2 Trigger by Overcurrent Protection

For this scenario, we have caused the activation of the overcurrent function by testing the time inverse O/C function (PTOC), and sending a GOOSE message to the recorder that will be used to capture the fault record (Figure 8).

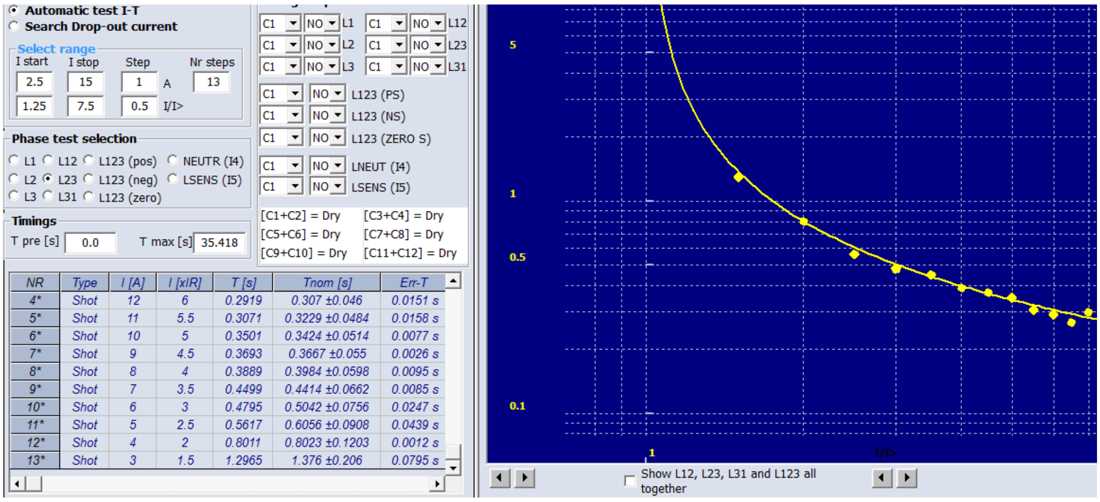

Figure 7 Testing points of overcurrent protection function

8.2 Vendor 2: Distance Relay

8.2.1 Trigger by Distance Protection

For this scenario we have caused the activation of the distance protection function again (PDIS), with a Mho type phase-to-phase shape testing several point of zones 1, 2 and 3 (Figure 9). GOOSE messages were sent to the recorder that will be used to capture the corresponding records.

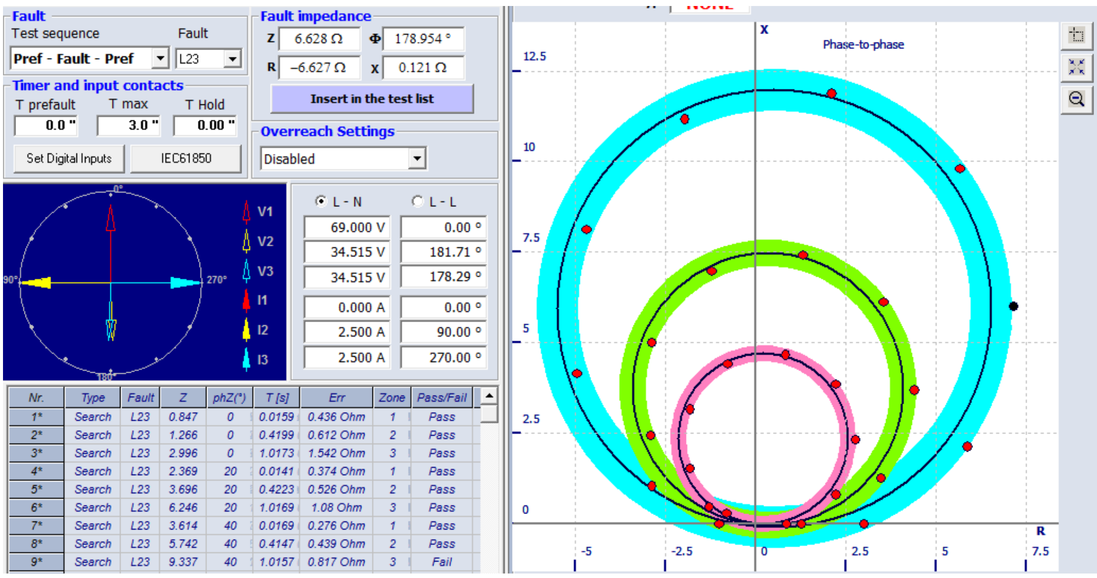

Figure 8 Testing points of distance protection function

8.3 Publishing GOOSE Messages by Relays

Using an IEC 61850 network exploring tool, one can see the published GOOSE messages by the relays (Figure 10). Messages published by the relays can be seen identified as PDIS and PTOC.

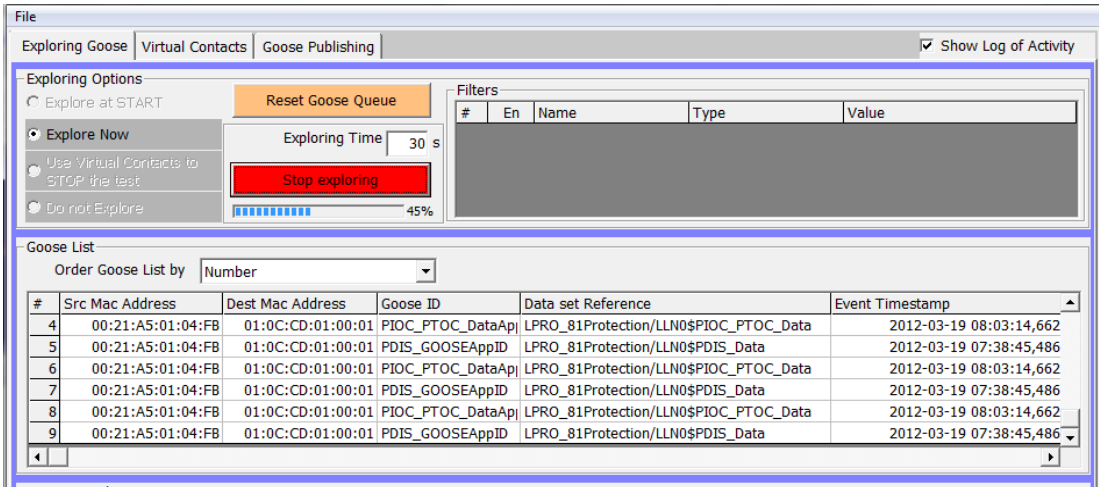

Figure 9 GOOSE Exploring Tool

8.4 Vendor 3: Recorder

The subscriber IDE, in this case the recorder, will receive the GOOSE commands from local or remote IEDs as mapped, enabling the record trigger functionality. Figure 11 shows the list of events from the recorder as a result of the testing points.

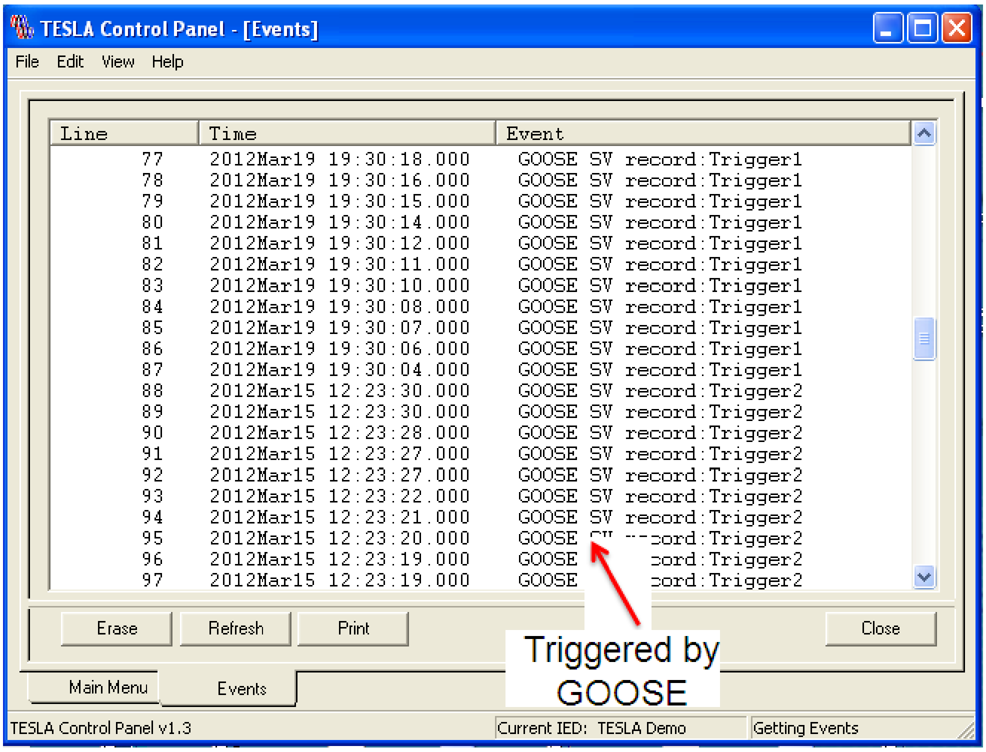

Figure 10 List of events and records generated by GOOSE

9 FAULT RECORDS CAPTURED BY THE RECORDER

Several records were captured by the recorder as a result of the simulation, a sample of which can bee seen in (Figure 12). This demonstrates that DFRs can be triggered by means of GOOSE messages published by protection devices.

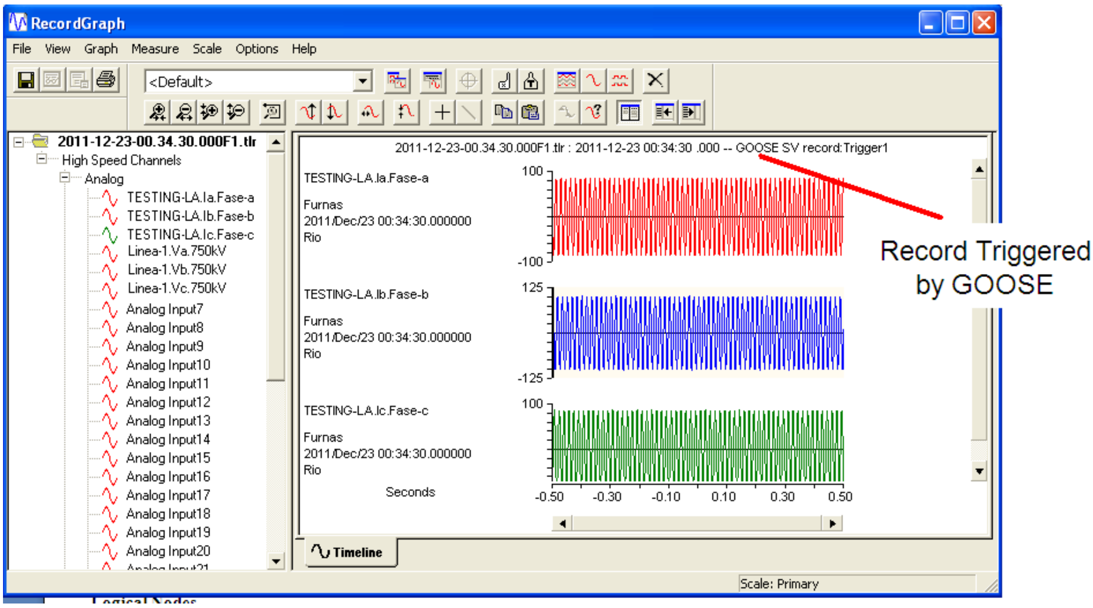

Figure 11Fault records generated by GOOSE coming from the relays

10 CONCLUSIONS

Disturbance fault recorders (DFRs) having larger storage capabilities as compared with protective relas, are used to collect crucial power system information, including longer fault records, swing records, and larger number of sequence of event records. This paper has demonstrated that DFRs can now be utilized to interoperate with relays in a IEC 61850 environment and be triggered by relays with the use of GOOSE messages.

Traditionally GOOSE messages were used in substation automation between protective relays for interlocking, blocking, to achieve relay coordination, load shedding, etc. Today we can comfortably add the function of triggering a digital fault recorder.

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