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IEC 61850 Testing and Documentation

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Foreword

This thesis would not be possible without the help of many people such as Dr. Smail Menani from VAMK OY who inspired me with the project idea and technical support. Many thanks to Mr. Olavi Vahamaki from VAMP OY, who assisted me whenever I face difficulties with the VAMP relay. Not to forget mentioning my teachers of the telecommunication module, Dr. Gao Chao, Mr. Virtanen Antti and Mr. Jukka Matila for their valuable instructions during my studies. Special thanks to Vaasa University of Applied Sciences for giving me the opportunity and possibilities to succeed in my studies.

At last, thanks to my family and teammates who gave a lot of support and encouragement during the critical moments.

ABBREVIATIONS

DS	Data Set
GOOSE	Generic Object Oriented Substation Events
GCB	GOOSE Control Block
IED	Intelligent Electronic Device
LD	Logical Device
LN	Logical Node
MMS	Manufacturing Message Specification
ASN.1	Abstract Syntax
BER	Basic Encoding Rule
PDU	Protocol Data Unit
APDU	Application Protocol Data Unit
FC	Functional Constraint
FCDA	Functional Constraint Data Attribute

VAASAN AMMATTIKORKEAKOULU UNIVERSITY OF APPLIED SCIENCES Degree Program of Information Technology ABSTRACT

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The purpose of this thesis is to develop laboratory experiments for a data transmission course. The laboratory experiments deals with the generation of GOOSE messages using VAMP relays on the one hand and the decoding of the generated messages on the other hand. The decoding scheme includes theoretical overview, instructions and practical description related to the laboratory exercises.

The methodology of achieving the result is to intercept proper data matches to the structure of GOOSE through a series of physical connection and software configuration. The set up of the laboratory exercise is based on the connection between a Vamp Relay, a Laptop and a set of programs such as Vampset, IEC 61850 Simple Tester, GOOSE Sender and Wireshark. These programs are used to configure and detect GOOSE messages. Through physical connection and proper configuration of the devices and tools, the data traffic has to be detected and decoded.

The project is divided into 3 tasks: pre-exercise for telecommunication course, laboratory exercise for telecommunication course and decoding GOOSE messages for telecommunication course. In this thesis, the task is to filter GOOSE messages and decode them according to GOOSE structure.

Laboratory exercises documentation is not included in this document but delivered separately to the concerned teacher to be used in the laboratory course.

Keyword GOOSE, Telecommunication, Decode, Target, Analyze, Communication

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1. Laboratory Exercises Description

There are 3 telecommunication laboratory exercises in this project. The first exercise is to activate the digital inputs using RJ45 cable as a transmission medium. This is the basic experiment to find the method to detect required messages. The second exercise utilizes the switchgear to adjust the connection and test for GOOSE transmission between the Vamp Relay and the laptop. The last exercise realizes the Trip and Block functions of the protection Relay by applying the function generator which can change the values of frequency and amplitude. These exercises not only present the outcome from the researched procedure, but also provide different kinds of methods to detect GOOSE messages.

1.1. Laboratory Distribution

Lab 1: Activate to detect message between Relay and Laptop

- 1. Get familiar to the basic configuration on relays
- 2. RJ45 Cable connection between logical nodes in rear panel

Lab 2: Switchgear to simulate GOOSE message

- 1. Connect a switch to Vamp Relay.
- 2. Set the right configuration in software.
- Intercept GOOSE messages from Wireshark and analyze the messages.
 Give interrelated analysis from this exercise.

- 1. Get familiar to datasheet of the relay.
- 2. Connect the power supply to the relay as described in the instructions.
- 3. Give correct configuration in Vampset and compare the result to the principle.

1.2. Technical Laboratory Architecture



1.3. Devices & Software

Devices:

Vamp 257 Feeder Manager

Vamp 257 Feeder Manager is the protection relay used for dangerous prevention in substation. There are series of interrelated choice to set the address, values of voltage, status, and mode and so on. The overview of current information represents whether the settings are requisite in the function. The values in Vamp can be changed by inputting the secret number. Otherwise, it keeps the default information with the initial configuration and cannot be altered without the password. Physical connection and digital inputs can be enabled on the rear panel of the Vamp 257.



Vamp257 Feeder Manager (reference:www.vamp.fi)

Function Generator

The function generator produces various patterns of voltage at a variety of frequencies and amplitude. It is used for testing safety of the circuit to input signals.

Software:

VAMPSET comprises all of the attributes of GOOSE Control Block. GOOSE Enable, GOOSE name, Data Sets included in the attributes can be applied in this program. There is a string of menu which gives detailed information of each attribute and application. From these settings, the Vamp Relay is controlled by Vampset. This program shows the same parameters as in the Vamp Relay. Logical connection is created in tag logic to achieve the aim of GOOSE transmission between the devices.

IEC61850 Simple Tester

This simple program is used to apply the Logic Nodes, Object and Attributes. It is divided into 5 parts: Host address, Read, Control, Report and GOOSE. The value shows the result monitored from the communication between the switchgear device and the Vamp Relay. The Report Control Block reports whether there's emergency happens if some status changes.

GOOSE Sender

GOOSE Sender is a convenient program for GOOSE transmission. It simulates a GOOSE message directly from the Vamp Relay to other devices. Through the interrelated configuration in the devices, GOOSE Sender makes the communication with GOOSE messages. The request and response are formed by this simulated transmission.

Wireshark

Wireshark is an analyzer of network transmission. It filters useful protocol for users to display the packets needed. Updating the new versions of this program, more functions and details gives more information to the user. This software helps to monitor every frame with the exact time, address and path. Even the structures of some infrequent protocols can be excavated by Wireshark. For saving time in filtering useful messages, it has the function to capture the protocol needed from a large number of frames.

2. GOOSE messages Specification

2.1. Transmission principle of GOOSE messages

GOOSE (Generic Object Oriented Substation Event) is a transmission of exchanging a wide range of data in a dataset. With a fast connection and less communication service which is used for the transfer of time-critical data, the communication network updates the content of messages as soon as the values changed. In order to more applications, GOOSE message exchange is based on the multicast application association. This routing technique provides to deliver messages from one publisher to one or many subscribers. The publisher is referred to as a sender who requests with a group of members in a dataset. These requests are sent to the transmission buffer of the publisher, afterwards this buffer is updated with the publish service and the values are transmitted by a GOOSE message. On the receiver, the reception buffer in the subscriber receives the new values and it is updated by mapping services.



Multicast Application

(Reference: International Standard IEC61850-5)

Publish/Subscribe systems are useful: first of all, while unreliable delivery mechanisms are present, they distribute large quantities of time-critical information well and quickly. Then it can handle very complex data flow patterns. Finally many-to-many model is very efficient in both bandwidth and latency.

2.2. GOOSE Data Structure

The following figure is an overview of ISO/IEC 8802-3 frame structure for GSE management and GOOSE. In a GOOSE message, the header MAC comprises 12 bytes, first 6 bytes are destination address and the last 6 bytes are source address. Next 14 bytes are Priority tags which present Ethertype, Application ID, message length and reserved number. Besides the 26 bytes enumerate the fundamental information of the GOOSE message, from byte 27 to the unlimited number of data

are decoded with APDU (Application Protocol Data Unit). The detailed explanation of GOOSE messages intercepted from the outcome in the laboratories will be revealed in the subsequent chapter.



ISO/IEC 8802-3 frame format

(Reference: International Standard IEC61850-5)

In APDU structure, there are 13 labels which display the specific content in the configuration of the experiments. The labels stand for the attributes of GOOSE Control Block.

Tag	0:	gocbRef (GOOSE Control Block Reference, type: visible-string)
Tag	1:	timeAllowedtoLive (type: integer)
Tag	2:	datSet (Dataset, type: visible-sting)
Tag	3:	goID (GOOSE Identifier, type: visible-string optional)
Tag	4:	t (time&quality, type: UtcTime)
Tag	5:	stNum (Status Number, type: integer)
Tag	6:	sqNum (Sequence Number, type:integer)
Tag	7:	test (type: Boolean default false)
Tag	8:	confRev (Configuration Revision, type: integer)
Tag	9:	ndsCom (needs Commission, type: Boolean value default false)
Tag	10:	numdatSetEntries (Number of Dataset Entries, type: integer)
Tag	11:	allData (sequence of data)
Tag	12:	security (any optional, reserved for digital signature)

APDU Structure

This APDU structure is referred from INTERNATIONAL STANDARD 61850-8-1.

3. Procedure of 3 Laboratories for Detecting GOOSE messages

Equipments used in exercises:

Vamp257 Feeder Manager

Laptop

RJ45 Cable

Ethernet with Optional to baset

Switchgear

Function Generator

Cables for Connection

Physical Connection:

Use a RJ-45 cable to connect the Ethernet port of your Laptop and the VAMP 257. Then run Program Vampset on the Laptop.

Fundamental Settings on Vamp Relay:

For making connections, you should start with setting the IP address of the Vamp Relay to 192.168.65.2 by using the keypad on the obverse of the Vamp Relay. As a prerequisite to set the IP address, ensure you have entered the password. Press the Down arrow key to find the option 'Bus'. Then keep clicking the Right arrow

key until you reach Ethernet Port. Press 'Enter' to go in the menu. Enter the password '0002' for the configuration in the Vamp Relay. Select IP option with the Down key. Make sure the IP addresses of the Relay and the laptop are in the same range. In this case, set the IP address of the laptop to '192.168.65.20'.

3.1. Laboratory 1 Activate DI's to Detect messages

Based on the previous connection, start Vampset to control the Vamp Relay. Firstly, on the left menu of the program choose 'Data Map (2)' in 'IEC61850 main config' to ensure 'digital input 1' is set to 'yes'. Then Select the sequenced tag 'Data Map (3)'. The digital inputs from pin2 to pin 7 are shown on the right of Vampset. Set them to 'yes'. These pins mapped in map (3) in this software correspond to the logic nodes from LN1 to LN6. At last remember to save the configuration and write the changes to the device. These configurations are clearly shown in Figure 3.1 and Figure 3.2.

TEC 61850 main config	53	CN31GGI0133	Counter 31	No	No	No	No
IEC 61850 data map(1)	54	CN32GGI0134	Counter 32	No	No	No	No
IEC 61850 data map(2)							
IEC 61850 data map(3)	55	CTAImGGI022	CT alarm	No	No	NO	No
IEC 61850 data map(4)	56	DEF1PT0C9	loDir>	No	No	No	No
IEC 61850 data map(5)	67	DEE3DTOC40	InDires.	Ha	No	No	Ha
IEC 61850 data map(6)	91	DEFZPTUCTU	1001172	MU	NU	NU	NU
IEC 61850 data map(7)	58	dfdtPFRC1	df/dt>	No	No	No	No
IEC 61850 data map(8)	60	DIRACCIO45	Digital input	Vee	No	No	Vee
TRC 61850 deadhand config	00	0101001040		169	NU	NU	109

Figure 3.1 DI1 in use

Index	LN	Description	Dataset 1	Dataset 2	Dataset 3	In use
60	DI02GGI046	Digital input 2	Yes	No	No	Yes
61	DI03GGI047	Digital input 3	Yes	No	No	Yes
62	DI04GGI048	Digital input 4	Yes	No	No	Yes
63	DI05GGI049	Digital input 5	Yes	No	No	Yes
64	DI06GGIO50	Digital input 6	Yes	No	No	Yes
65	DI07GGI051	Digital input 7	Yes	No	No	Yes

Figure 3.2 DI2 to DI7 in use

3.1.1. Setting in Read Menu

🚰 IEC61850 Simple Tester	
Connect Disconnect Host 192 . 168 . 65 . 3 Create ICD About	Exit
Read	Read
Control LN Obj1CSWI1 Volue False	Execute
Report LN DI01GGI045 Volue Value Value	Enable RCB Disable RCB
GOOSE Network adapter Adapter 1 MAC: 00:13:CE:CD:9A:74 Refresh	Start
MAC 01:0C:CD:01:00:00 AppID 0001 StNum 0 Values	Stop
F Any F Any F Latch on change	Continue
	P

Figure 3.3 Setting in IEC Simple Tester

After setting the digital inputs in Vampset, open IEC Simple Tester. Figure 3.3 indicates how to set the address in hot and the elements in Read menu. Set the host address to the IP address of the Vamp Relay. In read position, select the digital input enabled in Vampset. The name of LN 'DI01GGIO45' can be selected here when digital input 1 is used in Vampset. Set the Object to 'Ind' (indication) and Attribute to 'StVal' (state value).

Remember to write all changes after adding every new LN. And then enable the RJ45 cable connected the pins' connectors on the rear slot. Pin 1 is digital input1, it must be always connected to one side of the cable. Connect the other side of the cable to other digital inputs one by one (from pin 2 to pin 7). Insert the cable to a different pin

every time and set the corresponded LN name in 'read' menu. When insert the cable to a pin and press 'read' button, the value becomes 'true' at the moment. Take out the side of cable which is not connected to pin 1 and press 'read' again, the value is affected to 'false'. From this test, every LN name includes the number which is calculated by adding 1 to the corresponded pin number. For instance, the LN name of Pin2 is 'DI01...'; pin 3 is 'DI02...'; pin 4 is 'DI03...'...

3.1.2. Setting in Control Menu

EC61850 Simple Tester	
Connect Disconnect Host 192 , 168 , 65 , 3	Create ICD About Exit
Read LN Obj1CSWI1 • Obj Pos • Attr stVal •	Value 10 Read
Control LN Obj1CSW11 • Obj Pos • Attr Oper •	Value True ÷ Execute
Report LN DI01GGI045 • Obj Ind • Attr q •	Value Enable RCB
GOOSE Network adapter Adapter 1 MAC: 00:1F:16:C6:3D:EB Refresh	Sart
MAC 01:0C:CD:01:00:00 AppID 0001 StNum 0	Values Stop Continue
opported Decres Views device is connected Views back	VAMP

Figure 3.4 Settings in Control Area

Figure 3.4 shows the selections of elements in Control menu. In the Control Menu, set object to 'pos' and attribute to 'Oper'. In this case, 'Obj1CSWI1' is the unique option in LN. This LN is used to control the circuit breaker. Choose the value to 'false' and press "Execute". At the same time a blip can be heard clearly from VAMP

Feeder Manager and the switch of the circuit shown on the relay is turning off. This operation affects the value in read area which changes to"01". In opposite way when set the value in Control menu to true, the value in Read changes to"10". It shows whatever the value in CONTROL changes during the configuration, the value in READ never goes to"00" or"11". That is because two connectors must be different values when it is not known that the power is on or off. In this case there should be a setting to a safety mode.

3.1.3. Settings in Report Menu

After controlling step, set object to 'Ind' and attribute to 'StVal' in Report menu. Click 'enable RCB'. On the rear of Vamp Relay, one side of the RJ45 cable is fixed to the pin1. Connect the unfixed side of the cable to pin 2 and select the corresponded name 'DI01GGIO45' in 'LN'. Then the value in the Report menu becomes 'true'. Take out the unfixed side of the cable. The value changes to 'false'. This result presents when the emergency happens, the report part reacts the change in the value as soon as possible.

3.2. Switchgear to simulate GOOSE messages

In this exercise, connect the vamp relay to a switch. With the configuration in Vampset, GOOSE Sender and IEC Simple Tester, the reaction in Simple Tester and data in Wireshark will correspond to each other by adjusting the switch.

There are 3 wires connected to the switch. Distinguish the three wires from different colors: red, yellow and black. They are connected to different logic nodes. The wires are connected to Pin 1, 2, 3 at the beginning.

3.2.1. GOOSE Sender Configuration for GOOSE

GOOSE message is a timely message. It detects and operates as soon as the

mistake is sending. This notation will also be mentioned in the next laboratory exercise. Our target in this part is sending GOOSE message and intercepted it when there are changes. At first, open GOOSE sender to configure. The configuration is shown as Figure 3.5. The Network adapter must be chosen to the second MAC address because another is for wireless.

🚙 GOOSE Sender		- 🗆 ×
<u>F</u> ile <u>E</u> dit <u>T</u> ransmission <u>H</u> elp		
D 🛋 🕂 🗶 🚳 🐨 Network	adapter Adapter 2 MAC: 00:16:36:28:81:25 💌 🕥	-
Ethernet	GC Adapter 1 MAC: 00:15:00:00:04.74 Adapter 2 MAC: 00:16:36:28:81:25	
Source 00:16:36:28:B1:25 Own	App ID 1	StNum 5 🚖
Destination 01 : 0C : CD : 01 : 00 : 00 M-cast	TTL 8192 🗲	SqNum 12 🚖
VLAN	DSRef LLN0\$DS4	CfgRev 1 🚖
Priority 4	CBRef LLN0\$gcb1	NComm FALSE -
VLAN header CFI 0	GID G1	Test FALSE -
ID 0 🗲	Time 2010-2-16 13:50:31.578000	
Data items		
Idx Type Value	Formula	
0 BOOL FALSE 1		

Figure 3.5 Configurations in GOOSE Sender

Then control the switch. The switch is connected to pin 1 to pin 3 on Relay A. Control the switch, LEDA of Relay B lights on. After that reclose the switch, you'll find LED A on relay B is turned off. Relay B reacts as soon as the switch connected to Relay A is adjusted.

3.2.2. Vampset Configuration for GOOSE

Open Vampset, click connect button, input the code number 0002 to

complete the connection. After few minutes, it finishes connection and shows the menu details on the left as in figure 3.6. Click 'GOOSE configuration'. The right side shows Publisher parameters, Publisher Configuration GCB 1 and Publisher configuration GCB 2.

THERMAL OVERLOAD STAGE T> 49	^	Publisher paramete	rs
+ EARTH-FAULT STAGE		Max retransmission timeout	5 s
+ DIRECTIONAL E/F			
TRANSIENT INTERMITTENT E/F 67NI			
+ OVERVOLTAGE STAGE		Publisher configuration	GCB 1
+ UNDERVOLTAGE STAGE		Enable	
+ ZERO SEQ. VOLTAGE STAGE			
+ FREQUENCY STAGE		GOOSE ID	VAMP
+ UNDERFREQUENCY STACE		Configuration Revision *	1
FREQUENCY STAGE df/dt 81R		Neede Commissioning	
+ PROGRAMMABLE STAGE		Needs Commissioning	
CB FAILURE PROTECTION 50BF		Test mode	
+ ARC		MAC Address	01-0C-CD-01-00-00
OBJECTS			
AUTO RECLOSING 79		VLAN Priority	4
AR Shot settings 79		VLAN ID	0
AR COUNTER TEXTS		Application ID *	4
LEWBAR		Application in	+
T SUPERVISOR		* Important for VAMP subscriber	
+ MATDIX			
		Dublisher configuration (CCD 2
MIMIC		Fublisher configuration	3CD 2
+ LOCAL		Enable	
SCALING		GOOSE ID	VAMP
STAGE EVENT ENABLING		Configuration Dovision t	
+ EVENT MASKS for AR		Configuration Revision *	1
DI EVENT TEXTS		Needs Commissioning	
+ EVENT ENABLING		Test mode	
CLOCK SYNC			
P R O T O C O L CONFIGURATION		MAC Address	01-0C-CD-01-00-00
+ IEC 61850		VLAN Priority	4
GOOSE configuration		VI AN ID	0
GOOSE GCB1: DATA POINTS			U
GOOSE GCB2: DATA POINTS		Application ID *	1
GOOSE Subscriber: DATA POINTS		* Important for VAMP subscriber	
DIAGNOSIS	\mathbf{r}		

Figure 3.6 GOOSE configuration

Make sure to enable Publisher Configuration GCB 1. The Mac address must be 01-0C-CD-01-00-00 and fill the Application ID with 4. Figure 3.7 shows the configuration of enabling GOOSE Control Block in Vampset.

THERMAL OVERLOAD STAGE T> 49	Publisher parameters	
+ EARTH-FAULT STAGE	Max retransmission timeout	5 s
+ DIRECTIONAL E/F		
TRANSIENT INTERMITTENT E/F 67NI		
+ OVERVOLTAGE STAGE	Publisher configuration G	CB 1
+ UNDERVOLTAGE STAGE	Enable	
+ ZERO SEQ. VOLTAGE STAGE		
+ FREQUENCY STAGE	GOOSE ID	VAMP
+ UNDERFREQUENCY STAGE	Configuration Revision *	1
FREQUENCY STAGE df/dt 81R		_
+ PROGRAMMABLE STAGE	Needs Commissioning	
CB FAILURE PROTECTION 50BF	Test mode	
+ ARC	MAC Address	04.0C CD 04.00.00
OBJECTS	MAC AUGIESS	01-00-00-01-00-00
AUTO RECLOSING 79	VLAN Priority	4
AR Shot settings 79	VI AN ID	0
AR COUNTER TEXTS	VEHN ID	•
CBWEAR	Application ID *	4
+ SUPERVISOR	* Important for YAMP subscriber	
RELEASE OUTPUT MATRIX LATCHES		

Figure 3.7 GCB enable

Then select GOOSE GCB 1: DATA POINTS on the left side menu in Figure

3.8. Change Signal to Vl1 as the settings shown in Figure 3.9 and the IEC-

61850 variable changes automatically.

<pre> OVERVOLTAGE STACE OVERVOLTAGE STACE UNDERFOLTAGE STACE t ZERO SEQ. VOLTACE STAGE FREQUENCY STACE t UNDERFREQUENCY STAGE FREQUENCY STACE df/dt 81R PROCENTION SOBF ARC CB FAILURE PROTECTION 50BF ARC O B J E C T S AUTO RECLOSING 79 AR Shot settings 79 AR COUNTER TEXTS CBWEAR t SUPERVISOR RELEASE OUTPUT MATRIX LATCHES MATRIX L 0 C I C M I M I C t LOCAL S C A L I N G STAGE EVENT ENABLING t EVENT MASKS for AR DI FUENT TEVTS </pre>	
<pre>+ UNDERVOLTACE STAGE + ZERO SEQ. VOLTACE STAGE + FREQUENCY STAGE + UNDERFREQUENCY STAGE + UNDERFREQUENCY STAGE FREQUENCY STAGE df/dt 81R + PROGRAMMABLE STAGE CB FAILURE PROTECTION 50BF + ARC O B J E C T S AUTOR RELOSING 79 AR Shot settings 79 AR Shot settings 79 AR Shot settings 79 AR Shot settings 79 AR COUNTER TEXTS CBWEAR + SUPERVISOR RELEASE OUTPUT MATRIX LATCHES + MATRIX L 0 G I C M I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR DI WURT TEXTS</pre>	
<pre>+ ZERO SEQ. VOLTACE STACE + FREQUENCY STACE + UNDERFREQUENCY STACE FREQUENCY STACE df/dt SIR + PROGRAMMABLE STACE CB FAILURE PROTECTION 50BF + ARC O B J E C T S AUTOR RELOSING 79 AR Shot settings 79 AR Shot settings 79 AR Shot settings 79 AR COUNTER TEXTS CBWEAR + SUPERVISOR RELEASE OUTPUT MATRIX LATCHES + MATRIX L O C I C M I M I C + LOCAL S C A L I N G STACE EVENT ENABLING + EVENT MASKS for AR DI WURN TEVTS</pre>	Status
<pre>t VARQUENCY STACE FREQUENCY STAGE df/dt 81R t PROGRAMMABLE STACE CB FAILURE PROTECTION 50BF t ARC O B J E C T S AUTO RECLOSING 79 AR Shot settings 79 AR Shot settings 79 AR COUNTER TEXTS CBWEAR t SUPERVISOR RELEASE OUTPUT MATRIX LATCHES t MATRIX L 0 G I C M I M I C t LOCAL S C A L I N G STAGE EVENT ENABLING t KUMPT TEVTS </pre>	
1 None No PREQUENCY STACE df/d SIR + PROCRAMMABLE STACE SIR CB FAILURE PROTECTION SOBF AUTO RECLOSING 79 AR Shot settings 79 6 None NN 7 None None Number Texts 7 CBWEAR None + SUPERVISOR 7 RELEASE OUTPUT MATRIX LATCHES None + MATRIX 1 L O G I C 1 M I M I C 1 + SUPERT MASKS for AR 1 DI BURDET TENTES 1	п ок
+ PROGRAMMABLE STAGE 2 None None CB FAILURE PROTECTION 50BF 3 None None A B J E C T S 4 None None None AUTO RECLOSING 79 AR Sober None None AUTO RECLOSING 79 AR Sober None None AR Shot settings 79 AR Sober None None None CBWEAR + SUPERVISOR RELEASE OUTPUT MATRIX LATCHES None None None H I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING The VENT MASKS for AR The VENT MASKS for AR	one OK
CB FAILURE PROTECTION 50BF + ARC O B J E C T S AUTO RECLOSING 79 AR Shot settings 79 AR COUNTER TEXTS 70 AR COUNTER TEXTS 7	one OK
<pre>+ ARC O B J E C T S AUTO RECLOSING 79 AR Shot settings 79 AR COUNTER TEXTS CBWEAR + SUPERVISOR RELEASE OUTPUT MATRIX LATCHES + MATRIX L O C I C M I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR D L EVENT TEVTS</pre>	nne OK
0 B J E C T S 4 None Nu AUTO RECLOSING 79 5 None Nu AR Shot settings 79 6 None Nu AR SUMTRE TEXTS 7 6 None Nu CBWEAR + SUPERVISOR 7 None Nu RELEASE OUTPUT MATRIX LATCHES + MATRIX 0 1 C L 0 C G L C M I M I C 1 S C A L I N G STAGE EVENT ENABLING 5 + SUPERT TEVES FUENT TARKS for AR 5 D FUENT TEVES 5	01
AUTO RECLOSING 79 AR Shot settings 79 AR COUNTER TEXTS CBWEAR + SUPERVISOR RELEASE OUTPUT MATRIX LATCHES + MATRIX L O G I C M I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING + WENT MASKS for AR DI WURNT TEVTS	Jne UK
AR COUNTER TEXTS CBWEAR + SUPERVISOR RELEASE OUTPUT MATRIX LATCHES + MATRIX L O G I C M I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR DI FUENT TEVTS	one OK
AL COOMING TAKES CBUEAR + SUPERVISOR RELEASE OUTPUT MATRIX LATCHES + MATRIX L O G I C M I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR D L EVENT TEVES	one OK
+ SUPERVISOR RELEASE OUTPUT MATRIX LATCHES + MATRIX L O G I C M I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR D F EVENT TEVES	ne OK
RELEASE OUTPUT MATRIX LATCHES + MATRIX L O G I C M I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR DI EVENT TEVES	
+ MATRIX L O G I C M I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR DI EVENT TEVES	
L O G I C M I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR DI EVENT TEVES	
M I M I C + LOCAL S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR DI EVENT TAYNS	
+ LOCAL S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR DI EVENT TEXTS	
S C A L I N G STAGE EVENT ENABLING + EVENT MASKS for AR	
STAGE EVENT ENABLING	
+ EVENT MASKS for AR	
DT FURNT TEVTS	
+ RUFNIT FNABLING	
THE CLOSED	
GOOSA CONFIGURATION	
GOOSA GEBT: DATA POINTS	

Figure 3.8 VI1 in use

GOOSE	GCB1: DATA POINTS		
	DSG1 data config	uration	
Index	IEC-61850 Variable	Signal	Status
0	VI1GGI0137.SPCS0.stVal(ST)	_	ОК
1	None	None	• ОК
2	None	DI1	ок
3	None		ок
4	None	DIA	ок
5	None	DIS	ок ок
6	None	None	ок
7	None	None	ок

Figure 3.9 Select Signal

There are 3 LED lights on the relay: A, B and C. These three lights represent in the Logic menu. Figure 3.10 illustrates the logic map created in the program. You can choose which LED light by setting in Vampset. Following Logic figure shows the logic connection for LED. LA after the AND logic gate stands for LED A. You can add any LED from A to C in the logic menu. In this case it works successfully in our testing process.





After the configuration, adjust the switch, you can turn on and turn off the LED light.

```
3.2.3. GOOSE in Wireshark
```

Open Wireshark and click the first button to list the available capture interfaces. Figure 3.11 shows the interface selecting button.



Figure 3.11 Select Interface

In the selective capture interfaces, start the second one (Ethernet).

🕂 Vireshark: Capture Interfaces					
Description	IP	Packets	Packets/s	Stop	
📇 Adapter for generic dialup and VPN capture	unknown			Start Options	Details
🔊 Broadcom NetXtreme Gigabit Ethernet Driver (Microsoft's Packet Scheduler)	fe80::216:36ff:fe2b:b125	2	0 +	Start Options	Details
👰 Intel(R) PRO/Wireless 2200BG Network Connectio (Microsoft's Packet Scheduler)	fe80::213:ceff:fecd:9a74	3	3	Start Options	Details
🔊 MS Tunnel Interface Driver	fe80::ffff:ffff:fffd			Start Options	Details
<u>Help</u>				9	lose

Figure 3.12 Start to detect messages

Following picture 3.13 points out the GOOSE message intercepted when the switch reclose and LED A is on.

No	Time	Source	Destination	Protocol	Info
117	10.436652	Vamp_00:19:97	Iec-Tc57_01:00:00	GOOSE	
110	10.446644	Vamp_00:19:97	Iec-Tc57_01:00:00	GOOSE	
120	10.476504	Vamp_00.19.97	Tec-Tc57_01:00:00	GOOSE	
121	10.516517	Vamp 00:19:97	Iec-Tc57 01:00:00	GOOSE	
122	10.586502	Vamp_00:19:97	Iec-Tc57_01:00:00	GOOSE	
123	10.716488	Vamp_00:19:97	Iec-Tc57_01:00:00	GOOSE	
124	10.976450	Vamp_00:19:97	Iec-Tc57_01:00:00	GOOSE	
125	11.017505	192.168.65.20	192.168.65.3	TELNET	Telnet Data
126	11.020229	192.168.65.3	192.168.65.20	TCP	telnet > optima-vnet [ACK] :
127	11.050108	192.168.65.3	192.168.65.20	TELNET	Telnet Data
128	11.051006	192.168.65.20	192.168.65.3	TELNET	Telnet Data
129	11.060244	192.168.65.3	192.168.65.20	TCP	telnet > optima-vnet [ACK] :
🗄 Frame	121 (105 bytes on wire, 10	5 bytes captured)			
🗉 Ether	net II, Src: Vamp_00:19:97	(00:1a:d3:00:19:97), D	st: Iec-Tc57_01:00:00	(01:0c:cd	1:01:00:00)
E GOOSE					
APP	ID: 0x0004 (4)				
Len	ath: 91				
Res	erved 1. 0x0000 (0)				
Res	erved 2: 0x0000 (0)				
RE3	enveu 2. 0x0000 (0)				
_ <u> </u>	SEFUU				
0000 01	0 c cd 01 00 00 00 1a d3 0	00 19 97 88 b8 00 04			
0010 00	56 00 00 00 00 61 51 80 0	09 4c 4c 4e 30 24 67	.[a0LLN0\$0		
0020	62 31 81 02 00 80 82 15	56 61 6d 70 5f 32 52	cb1		

Figure 3.13 GOOSE message in Wireshark

02 00 01 06 08 08 40 8 40 7a a5 37 ee 35 32 00 085 02 02 ba 86 01 06 87 01 00 88 01 01 89 01 00 8a 01 02 ab 06 83 01 01 83 01 00

0030 0040 0050 0060

This exercise is like a Test-Equipment simulation. Relay A is the protection Relay. The protection Relay A issues a trip signal to the switchgear-Relay B indicating that the relay has picked up on receiving a fault current. When Relay B receives GOOSE messages form Relay A, it trips and turns on the LED light to react the trip. Then it sends a GOOSE message which contains the status of the circuit breaker and switches to tell our laptop. Each time when a new GOOSE message arrives at the laptop, the publisher details that GOOSE messages are displayed together with the response in relay to the GOOSE message. For receiving at the Relay B which includes the GOOSE subscription and notification packets as well as the GOOSE message. The size of GOOSE subscription and notification packets are measured as 74 bits whereas the size of the GOOSE as 244 bits.

Relay B receives a total number of 8 GOOSE messages. Only two of them are the event-driven GOOSE message. The remaining six messages are the retransmissions of the original ones. The 2 event-driven GOOSE messages are the original ones. Hence, three transmissions take place for every original message.

3.3. Trip/Block Functional Simulation for GOOSE

The functions of Tripping and Blocking on Vamp Relay are used for protection. In the protection simulation in this exercise, the configuration of GOOSE Control block in Vampset and the voltage boundary is set in Vamp Relay. The communication is between vamp relay and function generator.

3.3.1. Physical Connection

In this exercise connect a Function Generator to the Vamp Relay. The lights of Vamp Relay are affected by controlling the generator with Frequency and Amplitude. Pin 11 and 12 on the rear panel of the relay is connected to the Positive and negative power of the Function Generator. For this lab, only one Relay is used to connect to the laptop.

3.3.2. Software Configuration& Test Procedure

Configuration of Vamp Relay

Status: Blocked
f < 48Hz
t < 3.00s
LVBlk 40%Un

Status setting

CONF	
Un	200V
Usec	50V
Uose	100.000V
Umode	2LL+U0

Voltage configuration

Mode Auto	
fAdop	50.0Hz

Mode setting

U>	U>>	U>>>
300V	300V	300V
150%Un	150%Un	150%Un
t>0.20s	t>>0.10s	t>>>0.10s
		Hyster 3.0%

Configuration of U>,U>>,U>>>

Status: Trip		
U<	U<<	U<<<
60V	140V	140V
30% Un	70%Un	70%Un
t<1.00s	t<<2.00s	T<<<1.00s
LVBlk 12%Un	LVBlk 80%Un	LVBlk 72%Un
RlsDly 0.06s		
Hyster 3.0%		
PreFlt 5.0%Un	PreFlt 1.9%Un	PreFlt 7.9%Un
Edly 100%	Edly 100%	Edly 100%

Trip Status Setting

Configuration in Software Vampset

Firstly, go to IEC Data Map (7) to make "U<","U<<","U<<~"in use. It like the figure 3.14 shows below. This configuration creates the corresponding values of the three factors in Vamp Relay settings "in use".

+ ZERO SEQ. VOLTAGE STAGE	^	183	RevP	1PDOP1	P< reverse power	No	No	No	No
+ FREQUENCY STAGE		18	RevP.	2PDOP2	P<< reverse power	No	No	No	No
FREQUENCY STAGE df/dt 81R	i l	100	SCIV	MMXU14	Synchrocheck fy	No	No	No	No
+ PROGRAMMABLE STAGE		186	SCfzf	MMXU15	Synchrocheck fz	No	No	No	No
CB FAILURE PROTECTION 50BF	e C	187	SCUy	MMXU16	Synchrocheck Uy	No	No	No	No
OBJECTS		181	SCUZ	MMXU17	Synchrocheck Uz	No	No	No	No
AUTO RECLOSING 79		185	SGIG	GI0135	Setting group 1	No	No	No	No
AR Shot settings 79 AD COUNTED TEXTS	·	10	5626	GI0435	Setting group 2	No	No	No	No
CBWEAR		1961	Ctall	MCC4	let>	No	Mo	No	Ho
+ SUPERVISOR		13	THE	111331		Ho		No	no No
RELEASE OUTPUT MATRIX LATCHES		192	THDIA	AHAIT	THU IL1,IL2,IL3	NO	NO	NO	NO
LOGIC		193	THOU	MHAI2	THD Ua,UD,UC	No	No	No	No
нтитс		194	TOPT	TR1	Þ	No	No	No	No
+ LOCAL		195	U3pM	IMXU4	UL1,UL2,UL3	Yes	No	No	Yes
S C A L I N G STACE FORMT ENADLING		196	i U3ppi	MMXU5	U12,U23,U31	Yes	No	No	Yes
+ EVENT MASKS for AP		197	UCPT	UC1	ĸ	No	No	No	No
DI EVENT TEXTS		194	UF1P	TUF1	1<	No	No	No	No
+ EVENT ENABLING		195	UF2P	TUE2	155	No	No	No	No
P R O T O C O L CONFIGURATION		201	UIBCI	TOCR	Door DM>	No	No	No	No
IEC 61850 main config		2,04	linder	TANA		Ho	10	No	Ho
IEC 61850 data map(1)		20	UUTP	1001	00>	NU	NU	NU	NU
IEC 61850 data map(2)		202	U02P	TOA5	Uo>>	No	No	No	No
IEC 61850 data map(4)		203	UoM	AXU10	Uo	No	No	No	No
IEC 61850 data map(5)		204	UV1P	TUV1	U<	Yes	No	No	Yes
IEC 61850 data map(6)	- 11	205	i UV2P	TUV2	U<<	Yes	No	No	Yes
IEC 61850 data map(8)		206	UV3P	тиуз	Uccc	Yes	No	No	Yes
IEC 61850 deadband config		207	VHG	510137	Virtual input 1	Yes	No	No	Yes
INC 61850 BRCB configuration		201	VI2G	510138	Virtual input 2	No	No	No	No
ABC GIGGE DRUB COnfiguracion	5	300	1 1/12/24	10139	Virtual locut 3	No	No	No	No
	P.1	2.01	01000	10102	an cour inport a	10			10

Figure 3.14 Use U<, U<<, U<<

Add a new logical map in this Logic tag. "VO6" is virtual output 6. This factor value isn't the same as the name used in the previous logic map. It is an important logical connection for representing GOOSE messages during the trip.



Figure 3.15 Apply the signals

Because many new digital inputs and outputs are used in the logic part, be sure to make them variable in "GOOSE GCB1". Then add Signals such as digital input 1, virtual input 1 and virtual output 6 on Figure 3.16. The logic map goes through AND gate makes sense to transmit with GOOSE messages.



Figure 3.16 Settings in DSG1

Figure 3.16 shows data points in GOOSE Control Block1. Digital input 1, virtual input 1 and virtual output 6 are the signals used in logic menu to detect GOOSE message. Then apply the three signals and create a new logical circuit in this part. These two parts react to each other to transmit through GOOSE messages. GOOSE Control Block name is unique within the Logical Node 0, for instance, the Logical Device. Different applications within this station must have unique application ID value.

Following figure (Figure 3.17) illustrates the result in IEC 61850 Simple Tester. This result also shows GOOSE monitoring panel. In Simple Tester, set the Network adapter as our own laptop address. Then click on Start, the Value displays "F, F, and T". These three Boolean values stand for the digital input 1, virtual input 1 and virtual output 6 which have been added in the GOOSE Control Block. This result also gives detailed explanation in Wireshark by receiving GOOSE message.

Connect Disconnect Host 192 , 168 , 65 , 2	Create ICD About	Exit
Reload data model		
ead		
N DI01GGI045 - Obj Ind - Attr stVal	Value True	Read
ontrol		
N Obj1CSW11 💌 Obj Pos 💽 Attr Oper	▼ Value False	Execute
eport		
	* Value	Enable RC
		Disable RC
DOSE		
twork adapter Adapter 3 MAC: 00:16:36:28:81:25 💌Refre	sh	Start
AC 01:0C:CD:01:00:00 AppID 0004 StNum 51	Values F,F,T	Stop
🔽 Any 🖾 Any	Latch on change	Continue

Figure 3.17 Reaction shown in Simple Tester

Figure 3.17 shows the AppID, StNum and Values in GOOSE menu. AppID (application identifier) shows the setting of AppID in Vampset. (StNume (Status Number) records the accounts of changing the status during the configuration. The values correspond to the activated LNs in Vampset. The status of any LN changes will reload the values and the status number.

Open Wireshark to look for the GOOSE transmission.



Figure 3.18 Select Interface

In the menu shown on figure 3.18, click the button capture interfaces,

start the Ethernet interface

Following Figure list the frames of GOOSE in the trip transmission.

No	Tine			Sour	ce	Destinatio	n	Protocol
95	89.187	522		Vamp	0_00:19:97	Iec-Tc57	_01:00:00	GOOSE
954	89.197	516		Vamp	0_00:19:97	Iec-Tc57	_01:00:00	GOOSE
95	\$ 89.207	511		Vamp	0_00:19:97	Iec-Tc57	Iec-Tc57_01:00:00	GOOSE
951	5 89.217	534		Vamp	00:19:97	Iec-Tc57	_01:00:00	GOOSE
957	89.237	506		Vamp	0_00:19:97	Iec-Tc57	_01:00:00	GOOSE
958	8 89.277	505		Vamp	0_00:19:97	Iec-Tc57	_01:00:00	GOOSE
95	89.347	491		Vamp	0_00:19:97	Iec-Tc57	_01:00:00	GOOSE
960	89.477	499		Vamp	0_00:19:97	Iec-Tc57	_01:00:00	GOOSE
969	89.737	4.54		Vamp	0_00:19:97	IEC-TC57	_01:00:00	GOOSE
972	90.257	449		Vamp	0_00:19:97	Iec-Tc57	_01:00:00	GOOSE
98	91.290	308		Vamp	0_00:19:97	Iec-Tc57	_01:00:00	GOOSE
1004	5 93.340	073		Vamp	0_00:19:97	IEC-TC57	_01:00:00	GOOSE
1049	97.439	522		Vamp	0_00:19:97	Iec-Tc57	01:00:00	GOOSE
110.	102.43	9006		Vamp	0_00:19:97	Iec-Tc57	_01:00:00	GOOSE
	107.43	8357		vamp	0_00:14:41	IEC-IC5/	_01:00:00	GOOSE
+ Frame + Ether + GOOSE	e 1049 (net II,	107 byte Src: Va	s on wir mp_00:19	e, 107 by :97 (00::	ytes capture la:d3:00:19:	d) 97), Dst: Iec-'	rc57_01:00:0	00 (01:0c
E Frame E Ether GOOSI	1049 (net II,	107 byte Src: Va	s on wir mp_00:19	e, 107 b 97 (00:	ytes capture la:d3:00:19:	d) 97), Dst: Iec-'	rc57_01:00:0	00 (01:0c:
+ Frame + Ether + GOOSE	1049 (net II,	01 00 00	s on wir mp_00:19	e, 107 b)	ytes capture 1a:d3:00:19: 97 88 b8 00	d) 97), Dst: Iec- 0 04	rc57_01:00:0	00 (01:0c:
+ Frame + Ether + GOOSI + GOOSI 0000 0 0010 0 0020 6 0030 6	1049 (net II, 1 0c cd 0 5d 00 3 62 31 5 6c 61	01 00 00 00 00 00 01 02 27 79 2f 40	s on wir mp_00:19 0 00 1a 0 61 53 10 82 4 4 4 4	e, 107 by :97 (00:: 97 09 40 80 09 40 15 56 44 30 24 44	ytes capture la:d3:00:19: 97 88 b8 00 4c 4e 30 24 6d 70 5f 32 53 47 31 83	d) 97), Dst: Iec- 97), Dst: Iec- 67 .]as 52 cblas 04 elay/LLN	LLNO\$g .Vamp_2R 0\$DSG1	00 (01:00
+ Fram + Ether + GOOSE + GO	1049 (net II, 1 0c cd 0 5d 00 3 62 31 6 41 4d	01 00 00 01 00 00 00 00 00 81 02 27 79 2f 4 50 84 08	s on wir mp_00:19 0 00 1a 0 61 53 7 10 82 4 4 6 8 4b bb	e, 107 by 97 (00: 97 (00: 80 09 4c 15 56 61 30 24 44 56 76 by	ytes capture 1a:d3:00:19: 4 97 88 b8 00 4 4 4 8 30 24 6 4 70 5f 32 5 3 47 48 00 85 9 37 48 00 85	d) 97), Dst: Iec- 67 .]aS 52 cb1 04 elay/LLN 01 VAMPK.		00 (01:0c:
0000 0 0000 0 0000 0 0010 0 0020 6 030 6 030 6 030 3 050 3	1 049 (net II, 1 0c cd 0 5d 00 3 62 31 5 6c 61 4 86 01 4 86 01	01 00 00 81 02 27 79 2f 40 00 87 00 90 80 87 00	s on wir mp_00:19 0 00 1a 0 61 53 10 82 4c 4e 8 4b bb 00 88 00 88	e, 107 b) :97 (00:: 97 (00:: 97 (00:: 197 (00:	ytes capture la:d3:00:19: 97 88 b8 00 4 4 8 30 24 6 70 5f 32 53 47 31 83 37 48 00 8a 01	d) 97), Dst: Iec- 67 .]aS 52 cb1 04 elay/LLN 01 vAMP.K. 03 4	rc57_01:00:0 LLNO\$g .Vamp_2R 0\$D5G1]v.7H	00 (01:0c

Figure 3.19 Frames in Wireshark



sending during the transmission. The destination address "01-0c-cd-01-00-00", "01-0c-cd" is assigned by IEEE; the forth byte "00" shows it is transmitted with GOOSE; the last two bytes "00 00" are the starting address number in GOOSE message.

4. GOOSE messages Analysis

GOOSE message is reflected from application layer to data link layer. It is not across the transmission layer and network layer. The messages contain information that allows the receiving device to know the changed status and the time when it changed. The changed time allows receiving devices to set the relating local time to the receiving events. Even if there's no change of the status value, GOOSE messages keep sending message in a cycle time. This ensures the activated devices know the current status values of the peer devices. From the data in our exercises, there are many attributes included in GOOSE Control Block: GOOSE Control Block name, GOOSE Control Block reference, Application ID, Data Set, Configuration Revision, Needs Commission and Services. The attributes are mentioned in the analysis. Every GOOSE message contains attributes they need. All of GOOSE messages use the same GOOSE structure. But the time to live and Boolean values are different among the messages of these laboratories because of we enable different numbers of digital nodes. Figure 4.1, 4.2 and the specification following will explain more details in GOOSE examples.

NO.	GOOSE message	Description
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12.	01 0c cd 01 00 00 00 1a d3 00 19 97 88 b8 00 04 00 59 00 00 61 4f 80 09 4c 4c 4e 30 24 67 63 62 31 81 01 14 92 15	Destination Address for GOOSE Source Address for Relay Ether type Values (GOOSE) Application ID 4 Length 89 Reserved 1 Reserved 2 Implicit Sequence, APDU length 79 bytes GOOSE Control Block Reference, 9 bytes LLNO\$gcbl (Logic node0 GOOSE control block) Time to Live, 1 byte 20 ms
13. 14. 15. 16. 17. 18. 19.	82 15 56 61 6d 70 5f 32 52 65 6c 61 79 2f 4c 4c 4e 30 24 44 53 47 31 83 04 56 41 4d 50 84 08 4b bb 5d 76 b9 37 48 00	Data Set, 21 bytes Vamp_Relay /LLN0\$DSG1 GOOSE ID, 4 bytes VAMP Time and Quality, 8 bytes date: 03, 03, 2010, time: 18: 43: 33.1644999981 Ounlity, 00
20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35.	85 01 Oe 86 01 06 87 01 00 88 01 01 89 01 00 8a 01 02 ab 06 83 01 00 83 01 00	Status Number, 1 byte 14 Sequence Number, 1 byte 6 test, 1byte 0 Configuration Revision, 1 byte 1 needs Commission, 1 byte 0 Number of Data Set Entries, 1 byte 2 Boolean Value, 6 bytes Boolean Value=0 Boolean Value=0

Figure 4.1 GOOSE message detected from exercise 2

 Destination Address (01 0c cd 01 00 00); Source Address (01 1a d3 00 19 97); Ethertype (88 b8):

In Destination address, "01 0c cd" is assigned by IEEE, "01" means this message is transmitted with GOOSE, "00 00" is the starting address number of the GOOSE message, the end address numbered with "01 ff". Source MAC address is the MAC

address for the laptop which connected to VAMP Feeder Manager. "88 b8" is the Ethertype values for GOOSE.

2. Application ID (00 04); Length (00 59):

Application ID is the Application Identify used for distinguishing the GOOSE message in subscriber. In this GOOSE message application ID is 4. The length of this GOOSE message is 89 bytes.

3. APDU length (61 4f):

The 23th byte "61" is signed by APDU. "4f" is the length of APDU command data. The command data length in this message is 79 bytes.

4. GoRef (80 09 4c 4c 4e 30 24 67 63 62 31):

GOOSE Control Block Reference is Logic Node 0 from GOOSE Control Block. This is the route of this message and the reference must be the unique path-name of a GOOSE Control Block within the Logic Node 0.

5. TimeAllowedtoLive (81 01 14):

The time allowed to live is 20ms. Because of the importance of GOOSE messages even if status of device is not changing, the messages should be sent repetitive. This parameter point out to subscriber that the maximum waiting time for next GOOSE message. 6. DataSet (82 15 56 61 6d 70 5f 32 52 65 6c 61 79 2f 4c 4c 4e 30 24 44 53 47 31):

Dataset may have several members called MemberOffset. Each member shall have a Member Reference referencing the data attribute with a specific functional constraint. In this dataset, "Vamp-2Relay" is the logic device, Logic node is logic node 0 and dataset group 1 is the functional constraint.

7. GoID (83 04 56 41 4D 50); Utc time & quality (84 08 4b 83 f6 9e 2a 1c ac 00):

The GOOSE ID is "VAMP" and Utc time is the time when this message is transmitted. For the data which represent time, the time tag is "4b 83 f6 9e 2a 1c ac". The first 4 bytes stand for the amount of time in seconds from the date 01,01,1970 at time 00:00:00 to the time the data is detected. Therefore the date should be calculated by the user. The last 3 bytes calculated for the decimal part of second. Firstly, we change the hex value "4b 83 f6 9e" to decimal value "1266939550" and the unit is "second". For calculating the exact date, we converse the unit to year, month, day, hour and minute.

The calculation of the time is shown below.

1266939550s/60s/60m/24h/365d=40.17...years

(40.17...-40)*12month=2.09... months

(2.09...-2)*30day=2.78...days

(2.78...-2)*24hour=18.72...hours

(18.72...-18)*60=43.56...minutes

(43.56...-43)*60=33.69...seconds

The last 3 bytes "2a 1c ac" was decimal point value: $(0x2a 1c ac) /(2^24) = 0.1644999981$ second.

To the addition of the value that compute to the original date and time, and then calculate the date and time we in the experiment is :

Year: 1970+40=2010

Month: 01+02=03

Day: 01+02=03

Hour: 00+18=18

Minute: 00+43=43

Second: 00+33.2759852=33.1644999981

For all the calculation above, the exact date is: 03,03,2010

Time is: 18:43:33.1644999981

8. StNum (85 01 0e); SeqNum (86 04 06):

Status Number shows how many times status changes. Sequence number of this message is 6. There's no testing during this configuration.

9. ConfRev (88 01 01):

Configuration Revision presents a count of configuration of the dataset has been changed. The count should not include a restart of the IED.

10. NdsCom (89 01 00):

"Needs Commission" have a value of true if the attribute dataset has a value of "null". In this message because the attribute dataset is not null, this value is false.

11. numdatSetEntries (8a 01 02); Boolean Values (ab 06 83 01 00 83 01 00):

The number of dataset entries is 1. The two Boolean values are the values of the inputs applied in exercise 2. The first one is the value of digital input 1 and the other value is for Virtual input 1. So as the result of true setting in exercise 2, this GOOSE message shows the false value which presents in IEC Simple Tester as well.

For the tag Boolean Value, 01 means True, 00 means false. And the corresponded Boolean Value also reacts in IEC Simple Tester. If the value is true with the value "1 0", GOOSE Sender corresponds to be "T, F". If the value was false as "0 0", GOOSE Sender corresponds to be "F, F".

NO.	GOOSE	mes	ssa	ge							Description
1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11.	01 0c 00 1a 88 b8 00 04 00 59 00 00 00 00 61 53 80 09 4c 4c 81 01 14	cd d3 4e	01 00 30	00 19 24	00 97 67	63	62	31			Destination Address for GOOSE Source Address for Relay Ether type Values (GOOSE) Application ID 4 Length 89 Reserved 1 Reserved 2 Implicit Sequence, APDU length 83 bytes GOOSE Control Block Reference, 9 bytes LLNO\$gcbl (Logic node0 GOOSE control block) Time to Live, 1 byte 20 ms
13.	82 15		_					_			Data Set, 21 bytes
14. 15.	56 61 2f 4c	6d 4 c	70 4e	5† 30	32 24	52 44	65 53	6C 47	61 31	79	Vamp_Relay /LLN0\$DSG1
16.	83 04										GOOSE ID, 4 bytes
18	50 41 84 08	4a	50								VAMP Time and Quality & bytes
19.	4b bb	5d	76	b9	37	48	00				date: 14, 03, 2010, time: 05: 28: 04.41099977493
20. 21. 22. 23. 24. 25. 26. 27.	85 01 34 86 01 0d 87 01 00 88 01 01										Status Number, 1 byte 52 Sequence Number, 1 byte 13 test, 1byte 0 Configuration Revision, 1 byte 1
28.	00 00										0
30. 31. 32.	8a 01 03 ab 09										Number of Data Set Entries, 1 byte 3 Boolean Values, 9 bytes
33. 34. 25	83 01 00 83 01										Boolean Value=0
36.	00										Boolean Value=0
38.	00										Boolean Value=0

Figure 4.2 GOOSE message detected from exercise3

Figure 4.2 illustrates the GOOSE message and description. This message is intercepted in Wireshark in exercise 3. The destination address (01 0c cd 01 00 00), source address (00 1a d3 00 19 97) and ethertype value (88 b8) are the same as the message in exercise 2. The differences between the two messages in 4.1 and 4.2 are the length of the whole message, the length of APDU command, Utc time, Status number, Sequence number and Boolean values. The specification below presents element content which are different from exercise 3.

Line 5(00 59) and Line 8 (61 53) in Figure 4.2 show the length of this message is 89 bytes and the length of APDU is 83 bytes.

1. TimeAllowedtoLive (81 01 14):

Because of the importance of GOOSE message, GOOSE must keep sending even though the state is not changed. Time allowed to live is the longest time for subscribers waiting for the next message. When the waiting time is longer than the time to live and the subscriber still doesn't receive the message. Subscriber thinks the communication is missing. The value should be replaced by the default value defined before. The time allowed to live here is 20 ms.

2. Utc time & quality (84 08 4b bb 5d 76 69 37 48 00)

The method of calculating the Utc time is introduced in last exercise. In this message, the date is 14,03,2010 at the time 05: 28: 04. Quality is satisfied.

3. StNum (85 01 34):

Status number decides whether this message is a new event. Just check if the state number is the same as the value of GOOSE message. If they are the same, this message is not a new event. So in this case, the amount of testing is 52 which is much more than the number in last message. It shows there are several tests during the two exercises.

4. SeqNum (86 01 0d):

The sequence Number of a new event must be 1. But the sequence number of

message retransmitted is steadily increasing.

5. Boolean Values (ab 09 83 01 00 83 01 00 83 01 00):

There are 3 Boolean Values in this message. They are the values of Digital Input 1, Virtual Input 1 and Virtual Output 6. The values react in the result shown in the IEC Simple Tester of exercise 3. In the result, the three values are false which correspond to the Boolean value '00' '00' in the message.

5. Conclusion

This project has focus on creating telecommunication Laboratory exercises about using IEC61850. The three telecommunication Laboratories are designed according to the principle where by the uses are familiar with the idea of the IEC standard, and secondly, with the Vamp Relay. Searching the GOOSE structure and decoding GOOSE message cost a lot of time during the whole procedure.

When the team of three was facing the difficulties typical to similar new technical problems, we encouraged ourselves and never lost faith. We kept looking for interrelated references and generated precious suggestions. These are effective manners to solve the problems.

In the project, we have written pre-laboratories, laboratory instructions to help students and teachers with researching the IEC61850 exercises. Each report presents the purpose, method and request for students who will do the laboratory exercises to understand and figure out problems for themselves. Hopefully, the precious instructions will support and guide through the teachers during the telecommunication Laboratory courses. Maybe our project is still unfinished, due to the limited scope of the final year research project. However, the three of us would eagerly welcome an opportunity to spend more time on further research for this interesting protocol. [1] IEC61850 Interface in Vamp Relays Configuration Guide. Author: Wojciech Kozlowski. Date: 25-11-2009(initial version).

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