Smart Substation IED Relay Interoperability Simulation Test System

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I. Preface：

In accordance with the government energy policy, Taiwan power company (TPC) is committed to promoting and developing the smart grids. The international standard: IEC 61850 integrating the intelligent electronic devices (IEDs), information engineering and network communication offers the interoperability and flexibility needed in smart grid, because the IEC standard defines the necessary information models in substation automation and unifies the communication protocol of IEDs to make interoperability possible.

In the recent years, the actual substation automation systems complying with the IEC 61850 standard were established piece by piece by the branches of TPC. The key equipment of the newly built-up IEC 61850 smart substation is undoubtedly the IED. Previously the IED was mainly known for its protection function in overcurrent、undervoltage、current differential relay and so on. However, not only protection function but also measuring, controlling and communicating functions are fully utilized in the IEC 61850 smart substation nowadays.

Moreover, in the past, it was almost impossible to integrate multi-vendor IEDs in one substation due to different communication protocols among IEDs. Nowadays, thanks to the IEC standard, enabling IEDs supplied by different vendors to communicate with each other was successfully realized. It means whenever a fault occurs in certain IED in a IEC 61850 substation consisted of several different vendors' IEDs, the fault message could be published to other vendors' IEDs simultaneously. The fault message is transferred through so-called GOOSE (Generic Object Oriented Substation Event). On the other hand, whether the IEDs belong to the same brand or not, as long as the logical nodes of each IED and other equipment are well configured, the SCADA (Supervisory Control And Data Acquisition) can monitor and control all of them via another protocol: MMS (Manufacturing Message Specification) of IEC 61850.

Fig.1 IED interoperability emulation testing system

Fig. 2 IED interoperability emulation test panel

To verify such IEDs with the above new features, the Measuring Instrument (MI) section of Taiwan Power Research Institute(TPRI) had set up a IED interoperability emulation testing system (Fig. 1&2) in TPRI head office. The system can be used to verify the GOOSE messages transferring among IEDs and MMS monitoring and control function between SCADA and IED.

II. Introduction：

6 different brands of IEDs are built in this testing system , all of which have passed the interoperability test conducted by Information and Communication Technology (ICT) research laboratory of TPRI. These IEDs model name and their makers are all shown in Fig. 3. This testing system is mainly designed for IED function

verification, such as GOOSE function evaluation. We are especially interested in how IEDs publish and subscribe GOOSE messages with each other while one of them detects certain fault. This is very useful for verify some GOOSE strategies proposed by transmission system division (TSD) and distribution/service division(DSD) of TPC.

On the other hand, according to the MMS verifying methodology adopted by TSD, we can also verify the IED measuring function and MMS protocols between IED and SCADA at the same time.

ABB-REF620	GE-F650	
		
SIEMENS-7SJ82	SEL-751	
		
ZIV-IRFA	INGETEAM-DA-PT1	
		

Fig.3 6 Multi-vendor IEDs

We used to send analog voltages(V) and currents(I) into IED's analog voltage and current input modules and read the measured values in its front LCD panel. At this testing system, a novel method of measuring analog V/I by the IED and showing the measured values at a computer through MMS communication protocol can be demonstrated.

It is also equipped with signal analyzing instrument, which can detect the source of synchronization clocks and compare the SCL files in the instrument and in the IED while connecting it to the network switch. If the wrong version SCL file is installed in the IED, the orphan GOOSE messages might be found. The orphan messages are the origins of unnecessary data flow and should be avoided.

Finally, we can customize the SCADA human/machine interface to fit our needs (for example: more energy sources). See Fig.4~7 for more examples.

III. Conclusion：

The IED interoperability simulation test system in TPRI can be configured to any desired IEC 61850 substation structure(1 main/ 5 feeders or 2main/ 4feeders etc.) through different settings to simulate the GOOSE and MMS operation in the power system of the current distribution substation (D/S) and secondary substation (S/S). Before a GOOSE protection strategy really being implemented in DS or SS, the system offers a good opportunity to test and verify in advance.

The efforts of debugging and modifying the GOOSE protection strategy can all be done in this system without wasting time on the field.

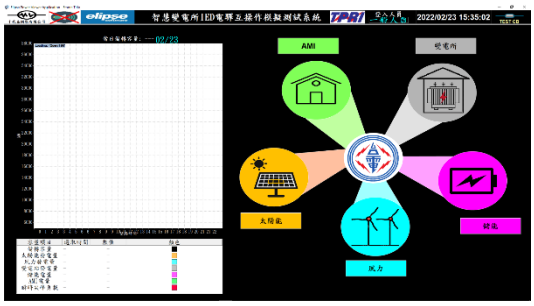

Fig. 4 IEC 61850 SCADA/HMI- Front page

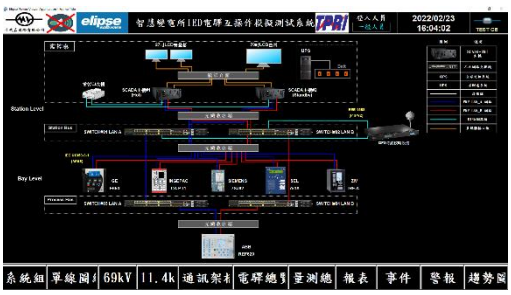

Fig. 5 IEC 61850 SCADA/HMI- Architecture

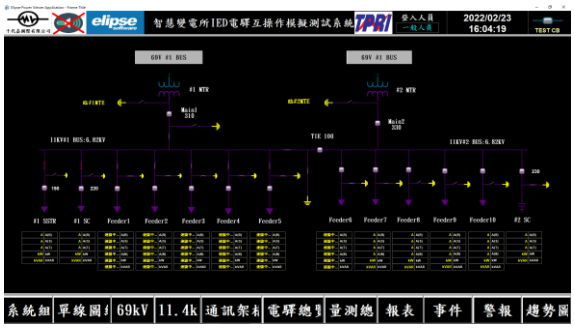

Fig. 6 IEC 61850 SCADA/HMI- One-Line Diagram

Fig. 7 IEC 61850 SCADA/HMI- IED Status

Considering the introduction of merging units (MU) in the substation and the adoption of IEC 61850 standard in the power plants in the future, the system also reserved some spaces and function for the coming equipment expansion. Step by step, we look forward to developing a more powerful system, which can meet all the IED relative verification demand in IEC 61850 standard.