Indian Journal of Science and Technology, *Vol 9(44), DOI: 10.17485/ijst/2016/v9i44/105160, November 2016*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Smart Emergency Generator Monitoring System through IoT using IEC 61850

Hyun Sung Lim[1], In Ho Ryu[2*] and Jun Ho Bang[2]

[1]Department of Future Technology Research, Electrical Safety Institute, Wanju, 55365, Korea; hslim@kesco.or.kr

[2]Department of IT Applied System Engineering, University of Chonbuk, Jeonju, 54896, Korea; toto00@jbnu.ac.kr, jhbang@jbnu.ac.kr

Abstract

Objectives: The energy consumption increased day by day. To reduce the peak power demand, there are many studies of Distributed Energy Resource like emergency generator and renewable energy. **Methods/Statistical Analysis**: In Korea, emergency generator capacity is 21GW. If some of emergency generators utilize, it efficiently reduces peak demand. However, the emergency generator is spread all over the country, it need to monitoring and integrating technology by remote site. **Findings**: IEC 61850 is standard of integrating automation substation and IEC 61850-7-420 describes LNs of Distributed Energy Resources. So, we check up the selection and installation regulation of emergency generator by KOSHA CODE and sort the check list like temperature, pressure in system. So, we installed the various sensors (oil temperature, coolant temperature, oil pressure, fuel level). The sensor value output is 4 to 20mA analog data. The controller coverts analog to digital data with Modbus protocol and IEC 61850 gateway creates IED mapping Modbus to IEC 61850. The data transfer VPN with TCP/IP protocol and it can monitor the remote site. **Improvements/Applications**: The proposed system can supply smart service to users with IoT technology and they can predict generator fault and reduce the accident. Furthermore, this system can adapt other Distributed Energy Resources.

Keywords: Distributed Energy Resources, Emergency Generator, IEC 61850, IoT, Sensor network

1. Introduction

Electrical power demand is increasing rapidly in this modern world and energy consumption is increasing parallel. However, power plant construction is delayed and transmission line capacity has been saturated. So, there has been an attempt to find new way of diminish peak power by internally covering a portion of the power demand through the operation of Distributed Energy Resource (DER). Smart Grid enables and empowers DERs in distribution networks through advanced technologies[1]. Emergency Generator is an example of DERs with reliability, high electrical quality, much capacity in Korea. According to the Korea Electrical Safety Corporation's statistics dated June 2013, the country had 69,986 emergency generators with a total capacity of 21GW, which is equivalent to the capacity of approximately 20 nuclear power generating unit. If some of emergency generators are utilized ad demand resources, they might significantly decrease peak power. To utilize the emergency generators, we need integrated system because the resources are dispersed. The integrated system will help reducing the energy wastage by continuously monitoring and controlling the emergency generators. Since the system has TCP/IP protocol with Ethernet modem in order to implement IoT. The values from sensors can be continuously monitored and alarmed over/under values for electrical

**Author for correspondence*

safety. Automation system online makes user to operate the system even when user is not in vicinity of the automation system[2]. IEC 61850 is standard communication of power system and integrated devices of different type into the system. This paper represents smart monitoring system of emergency generators through Internet of Tings technology based on IEC 61850. The proposed smart electrical safety system is introduced in Section 2. The implement of Hardware and Software is described in Section 3. Section 4 is result of experiment. Section 5 concludes this paper.

2. Proposed Smart Electrical Safety System

For establishing Smart Electrical Safety System, we must review the regulation of selection and installation of emergency generator by KOSHA CODE E-84-2011[3]. Emergency generator management lists are as shown in Table 1.

Emergency generator maintenance lists by KOSHA CODE are fuel system, lubrication system, cooling system, exhaust system. Maintenance steps divided visual inspection, inspection, replacement, cleaning, test and R is replacement if necessary. Inspection period is separated every week (W), every month(M), every quarter(Q), every half(S), everssy year(A). The user should make a plan to manage emergency generator and operate the system. However, it needs a remote monitoring and controlling technology due to field manager do not reside.

The advances in computer, control and analysis, and communication technologies make new multi-functional universal devices, generally called IEDs (Intelligent Electronic Devices), have been developed to provide an integrated device for measuring, metering, and some basic monitoring and control functionalities. Such IEDs are net worked over high-speed communication networks based on standardized communication protocols. The use of existing communication standards and commonly accepted communication principle jointly with the new standards

Table 1. Emergency generator maintenance lists

Maintenance Lists		Steps					Period	
		Visual Inspection	Inspection	replacement	cleaning	test	LV1	LV2
Fuel System	Liquid level		√				W	M
	Fuel Tank level	√	√				W	M
	Fuel Tank Liquid level switch	√				√	W	Q
	Operation of pump switch	√				√	W	Q
	Operation of Solenoid valve	√				√	W	Q
	Filter	√			√		Q	Q
	Water plant	√	√		√		W	Q
	Flexible hose	√		R			W	M
	Overflow pipe		√		√		A	A
	Pipe	√					A	A
	Gasoline (when using)			R			A	A
Lubricant System	Lubricant level	√	√				W	W
	Exchange Oil			R				
	Oil Filter			√				
	Lubricant Heater		√					
	Crank case air hole	√		R	√			

Cooling System	Cooling System-level	√	√				W	M
	Anti-freeze protection level					√	S	A
	Anti-freeze			√			A	A
	Heat exchanger for cooling water		√				W	M
	Load out heat exchanger				√		A	A
	Fresh air through radiator		√				W	M
	Radiator				√		A	A
	Fan & Belt of alternator	√					M	Q
	Water pump	√					W	Q
	Flexible hose and connection status	√	√				W	M
	Jacket Water Heater		√				W	M
	Check and clean the duct louver	√	√	√			A	A
	Louver motor and controller	√			√	√	A	A
Exhaust System	Exhaust system leak	√	√				W	M
	Multiple drain trap		√				W	M
	Insulation and fire risk	√					Q	Q
	Excessive pressure					√	A	A
	Exhaust system hangers	√					A	A
	Exhaust flexible joint	√					S	S

such as IED 61850 provide information exchange platform between IEDs within a substation and between substation and the control center[4,5]. IEC 61850-7-420 is committed to the principle of standards to support the various DERs[6]. A reciprocating engine is an engine that utilizes one or more pressure-driven pistons in order to convert back-and-forth motion into a rotating motion. The most common form of reciprocating engine used to generate electricity is the diesel engine, which is used in combination with an electric generator to form a diesel generator. Diesel generator can be used as off-grid sources of electricity or as emergency power supplies if the grid fails. Figure 1 illustrates some of the LNs that could be included in a diesel generation system[7].

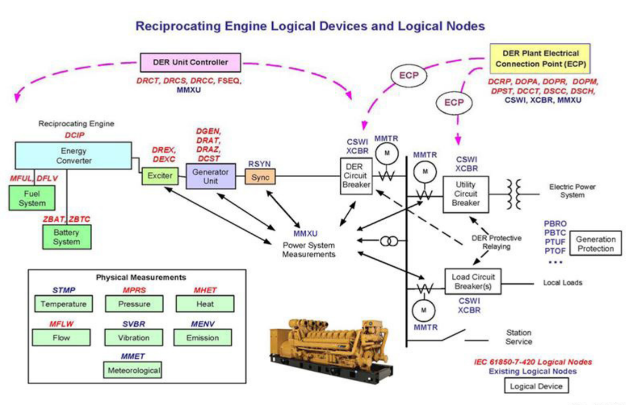

Figure 1. Example of LNs in a reciprocating engine system.

The LNs in emergency generator physical measurements could include:

- STMP : Temperature characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, lubrication (oil), after-cooler
- MPRS : Pressure characteristics, including coolant (e.g. air, water) intake, exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler
- MFLW : Flow characteristics, including coolant, lubrication
- SVBR : Vibration characteristics
- MENV : Emissions characteristics, including coolant (e.g. Air, water) intake, exhaust (outlet), manifold, engine, turbine, lubrication (oil), after-cooler

The proposed system has been designed to provide emergency generator status to the user. The IEC 61850 gateways receive the data from sensors (temperature, pressure, fuel flow) in the emergency generator. Figure 2 represents the block diagram of the system.

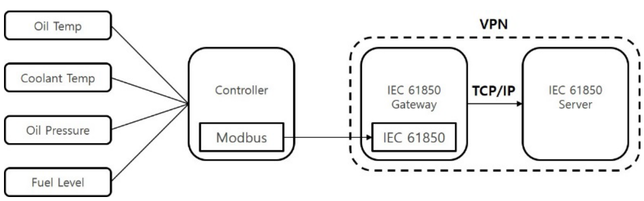

Figure 2. Block diagram of system.

3. System Architecture

3.1 Hardware Components

The hardware of the system includes 4 to 20mA sensors, Controller, IEC61850 gateway, Ethernet Modem

3.1.1 Electricity Sensor

Temperature sensor uses PT 100-ohm type sensor and 0~100°C range. Pressure sensor is 2 wire type sensor and 2~30 bar range. Fuel level sensor measures flow level in the container by using the buoyancy. All sensor output is 4 to 20mA.

3.1.2 Module Type Controller

The controller has 0~10V input voltage, 50ms sampling period and output data provide RS 232C/RS 485 communication. The system supports PC-link, Modbus protocol.

3.1.3 IEC61850 Gateway

The IEC 61850 gateway has ARM Cortex M5 Series 500Mhz CPU, 512MB Ram, 512MB, Flash memory. It supported IEC 61840 Group 1 MMS protocol and RS 485 based 2 Channel communications (Half Duplex Mode).

3.1.4 Ethernet Modem

The Ethernet modem wireless router is used for LAN connection. It supports 4G LTE gateway and 802.11 b/g/n standard.

3.2 Software Components

The software of system use SCL Forge that can model Markup language based on XML considering Intelligent Electrical Devices characteristic and attributes. Figure 3 is shown the mapping Modbus to IEC 81850 data format and Figure 4 represent the IED modeling of SCL tool using SCL Forge program.

No	Variation	Dimension	Data Type	Modbus Channel	Modbus Address	Modbus Description	IEC 61850 data location
1	sensorFuelLevel	%	float	3	40102	Fuel level	KESCOBIFUEL/MENV1MXFLevelmagf
2	sensorOilPressure	Bar	float	3	40402	Oil press	KESCOBIFUEL/MPRS1MXPresmagf
3	sensorOilTemperature	℃	float	4	40102	Oil temp	KESCOBIFUEL/MTMP1MXOilTempmagf
4	sensorCoolantTemperature	℃	float	4	40202	CW Temp	KESCOBIFUEL/MTMP1MXCWTempmagf

Figure 3. Mapping data Modbus to IEC 61850.

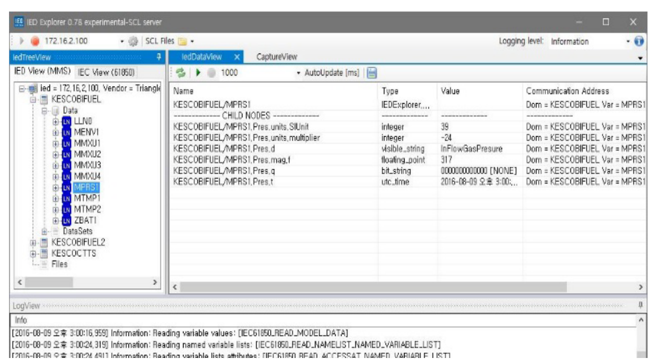

Figure 4. Modeling IED with SCL forge.

4. Results

4.1 Experimental Setup

The system consists 300kW diesel genset (emergency generator), 100kW load and operating time is approximately 10 min. Each sensor (oil temperature, coolant temperature, oil pressure, fuel level) installed part of the generator.

4.2 Monitoring Values

The measured data from the sensors is 4 to 20mA analog data and controller convert analog to digital data with Modbus protocol. Modbus data transfer IEC 61850 gateway with RS 485 communication. And then IEC 61850 gateway processes modeling Modbus to IEC 61850 and send the data to Ethernet modem in VPN. The output data can be seen in Figure 5.

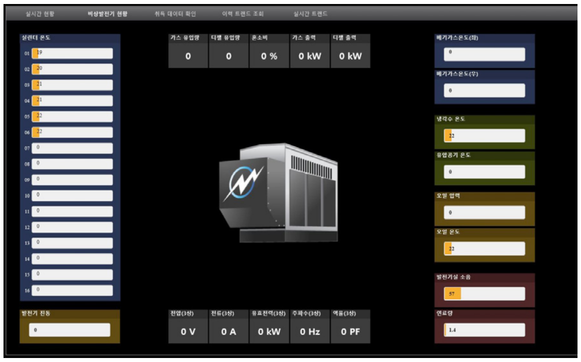

Figure 5. Output data.

4.3 Testing Results

Figure 6 is testing results of operating emergency generator values from each sensor. During the emergency generator operating, fuel level drop from 51% to 50%. Oil pressure values keep over 2 bars. If the oil pressure drops under 2 bars, the generator must stop and need to check the system. Coolant average temperature is 81.8°C and oil average temperature is 79.7 °C. If the coolant and oil temperature is over 90°C, the system must alarm the users and stop the generator over 100°C temperature.

5. Conclusion

This paper proposed smart monitoring system in emergency generator. This system can offer smart service utilizing IoT technology to users which administrate the emergency generator. It can reduce the generator accident and predict the system fault. This technology can be adapted to other Distributed Energy Resource.

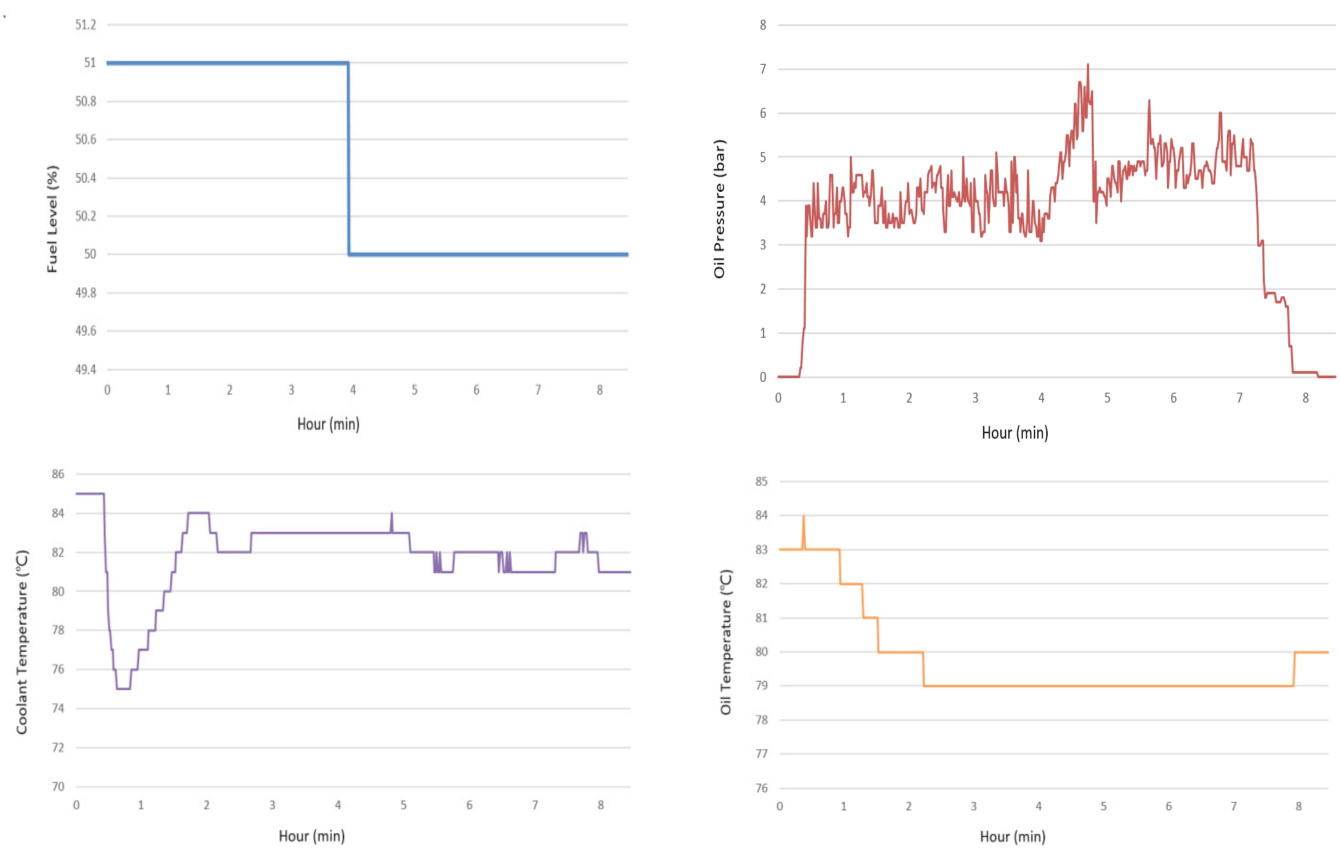

Figure 6. Testing results of each sensor.

6. References

1. Pazouki S, Ardalan S, Haghifam MR. demand response programs in optimal operation of multi-carrier energy networks. Indian Journal of Science and Technology. 2015 Dec; 8(33):1–7.
2. Sindhuja P, Balamurugan MS. Smart power monitoring and control system through internet of tings using cloud data storage. Indian Journal of Science and Technology. 2015 Aug; 8(19):1–7.
3. KOSHA, Selection and Installation of Emergency Generator; 2011
4. Ozansoy CR, Zayegh A, Kalam A. The real-time publisher/subscriber communication model for distributed substation systems. IEEE Transaction on Power Delivery. 2007 Jul; 22(3):1411–23.
5. Calvo OG, Albeniz D, Noguero A, Perez F. Towards a modular and scalable design for the communications of electrical protection relays. IEEE Industrial Electronics; 2009 Nov. p. 3–5
6. Cavalieri S, Regalbuto A. Mapping IEC 61850 SCl to IPC UA for Smart Grid Application. IEEE; 2015.
7. IEC. Communication networks and systems in substation Part 7-420: Basic communication structure; 2011.