

# Integration of Internet of Thing Technology in Digital Energy Network with Dispersed Generation

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## Abstract

IoT technology becomes an important issue for boosting the competitiveness of industrializations and it can make our daily life more comfortable. The electricity is also not only a backbone of the country's economy but also a key factor for the development of human's life. Therefore, the integration of IoT in power sector is one of the solution to solve the electricity interruption problem and for the reliability issue. For a better performance and reliable supply to customers, the digital energy network is required to operate. In this paper, the impact of the integration of IoT technology with dispersed generation on power system reliability is analyzed. The amount of energy not supplied to the customer is used to determine the reliability condition. Roybillinton Test System, RBTS bus 2 is used as a test system. According to the results, IoT can enhance the system reliability clearly because of fast and reliable data management.

**Keywords:** IoT; SCADA; Power System Reliability; Energy Not Supply; Digital Energy Network.

## 1. Internet of Thing

The Internet of Things (IoT) is the inter-networking of physical devices, vehicles (also referred to as "connected devices" and "smart devices"), buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to collect and exchange data[1]. IoT is an advanced trend of current and future developments in technology which can make today's age better in many sectors.

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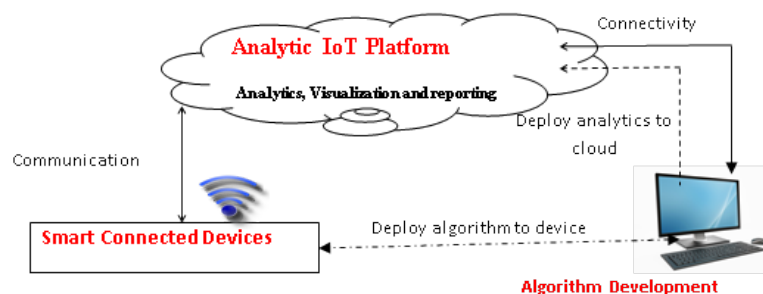
For power sector, digital energy network can make more reliable power supply to the customers as the smart grid technology. As a concept, the smart grid is a combination of an energy generation, transmission and distribution network enhanced by digital control, monitoring and telecommunications capabilities[2]. The performance of a smart grid is measuring the ability of each device and system's components for interconnecting and sharing the information with each other in a fast respond and reliable condition. However, dispersed generation (DG) or embedded generation become popular, no universally agreed definition of what constitutes embedded or dispersed generation and how it differs from conventional or central generation. Some common attributes of embedded or dispersed generation may be listed as [3]. It is

- (1) not centrally planned (by the utility)
- (2) not centrally despatched
- (3) normally smaller than 50–100 MW
- (4) usually connected to the distribution system.

The distribution system is taken to be those networks to which customers are connected directly and which are typically of voltages from 230/400 V up to 145 kV. By installing DGs, it is sure that the system reliability will be improved. However, it is necessary to disconnect the faulted sections as quickly as possible to supply to the healthy sections from DGs. Therefore, it is necessary to use automated protections devices controlled by SCADA system to improve the reliability of the system. Working principle of IoT is shown in figure1.

The major area where IoT deals with energy management systems is the smart grid. IOT extends the benefits of smart grid beyond the automation, distribution and monitoring being done by the utilities[4]. The task of the IoT in the field of electrical energy includes

- (1) Advanced Metering Infrastructure (AMI)
- (2) SCADA (Supervisory Control and Data Acquisition)
- (3) Smart Inverters
- (4) Remote control operation of energy consuming devices



**Figure 1:** Working principle of IoT

By using conventional switch gears in distribution systems, it takes too much time to know fault locations and to disconnect the faulted lines. By using Distribution Automation System (DAS), the problem can be solved in

short time. . Therefore, it is necessary to use automated protections devices controlled by SCADA system to improve the reliability of the system. And IOT technology is used in SCADA system. In SCADA system, Remote Telemetry Unit (RTU) is a device that collects transmits the data to Mater Terminal Unit (MTU). RTUs are equipped with input channels for sensing or metering, output channels for control. The working principle of each protection devices such as disconnector and circuit breaker (CB) are monitored by programmable logic controller (PLC)[5]. In this paper, the integration of IoT and dispersed generation on power system reliability is analyzed.

## 2. Reliability Indices

Distribution system is responsible for transferring electrical energy to the end users. The outage in the distribution system has a localized effect compared with generation and transmission sectors. However, analysis of the customer failure statistics indicates that the distribution system has the greatest contribution to the unavailability of supply to a customer.

In this paper, to analyze the impact of protection system on reliability, following reliability indices are used: system average interruption frequency index (SAIFI), system average interruption duration index (SAIDI), customer average interruption duration index (CAIDI), energy not supplied index (ENS) and average energy not supplied index (AENS) The equations of reliability indices are equation (1)-(5) [6].

Reliability indices are typically computed by utilities at the end of each year by using historical outage data recorded in distribution outage reports. This is important because utilities know how their systems are performing. However, it is less useful when the specific impact of various design improvement options wish to be quantified and compared. To make such comparisons, a model must be developed which is capable of predicting.

$$\begin{aligned} \text{SAIFI} &= \frac{\text{total number of customer interruptions}}{\text{total number of customer sserved}} \\ &= \frac{\sum \lambda_i N_i}{\sum N_i} \text{ per/year} \end{aligned} \quad (1)$$

$$\begin{aligned} \text{SAIDI} &= \frac{\text{sum of customer interruption duration}}{\text{total number of customer}} \\ &= \frac{\sum U_i N_i}{\sum N_i} \text{ hr/year} \end{aligned} \quad (2)$$

$$CAIDI = \frac{\text{sum of customer interruption duration}}{\text{total number of customer interruptions}}$$

$$= \frac{\sum U_i N_i}{\lambda_i N_i} \quad \text{hr/year} \quad (3)$$

$$ENS = \sum L_{a(i)} U_i \quad \text{MWh/yr} \quad (4)$$

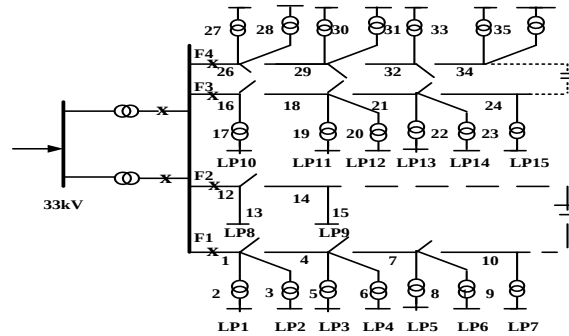
$$AENS = \frac{\text{total energy not supplied}}{\text{total number of customers served}}$$

$$= \frac{\sum L_{a(i)} U_i}{\sum N_i} \quad (5)$$

Where  $L_{a(i)}$  is average load demand at load point  $i$  and  $U_i$  is outage time at load point  $i$ . Reliability indices are useful for determining what a customer can expect in terms of interruption frequencies and durations [6].

### 3. Test System

The test system used in this paper is RBTS Bus 2 system shown in Figure 2 [7]. The single 11 kV supply point for RBTS Bus 2 system is justified by the 20 MW load. The feeders are operated as radial feeders although they can be connected as a mesh through normally open sectionalizing points



**Figure 2:** Distribution system for RBTS bus 2

**Table 1:** Feeder types and lengths

| Feeder Type | Length (km) | Feeder section numbers              |
|-------------|-------------|-------------------------------------|
| 1           | 0.6         | 2,6,10,14,17,21,28,30,34            |
| 2           | 0.75        | 1,4,7,9,12,16,19,22,24,27,29,32,35  |
| 3           | 0.8         | 3,5,8,11,13,15,18,20,23,26,31,33,36 |

The test system has four feeders and thirty six feeder sections. Feeder types and lengths are mentioned in Table 1. For calculation of indices, the failure of breaker and bus bar can be neglected because the failure ration is so small. The tie line effect is also neglected. The load data and system reliability data is shown in Table 2 and 3.

**Table 2:** Loading data

| Feeder | Average Load<br>(MW) | Peak Load<br>(MW) | Numbers of customers |
|--------|----------------------|-------------------|----------------------|
| 1      | 3.645                | 5.934             | 652                  |
| 2      | 2.15                 | 3.5               | 2                    |
| 3      | 3.106                | 5.057             | 632                  |
| 4      | 3.39                 | 5.509             | 622                  |
| Total  | 12.291               | 20                | 1908                 |

**Table 3:** Reliability and system data

| Component   | $\lambda$ | r   | $r_p$ | s |
|-------------|-----------|-----|-------|---|
| 33/11       | 0.015     | 200 | 15    | 1 |
| Transformer |           |     |       |   |
| 11/0.4      | 0.015     | 200 | 10    | 1 |
| Transformer |           |     |       |   |
| 11kv        | 0.065     | 5   |       | 1 |
| Lines       |           |     |       |   |

The  $\lambda$  is failure rate per year per kilometer for lines and failure rate per year for transformers. The  $r$  is repair time in hour. The  $r_p$  is replacement time by a spare in hour. The  $s$  is switching time in hour.

#### 4. Impact of IoT technology on power system reliability

According to the recent researches, it improves reliability to install DG at the most downstream area. Therefore, 2.5 MW DG is installed in the tie line of feeder 1 and 2. 3 MW DG is also installed in the tie line of feeder 3 and 4. The test system is considered with disconnecting switches and fuses to protect feeders and lateral lines. In automation system using IoT technology, the switching time is decreased 1hr to 1 minutes. Repaired time is also

decreased 5 hours to 0.5hour[4]. Assume that transformer replacing time is reduced 10 hours to 5 hours. A following four cases are considered.

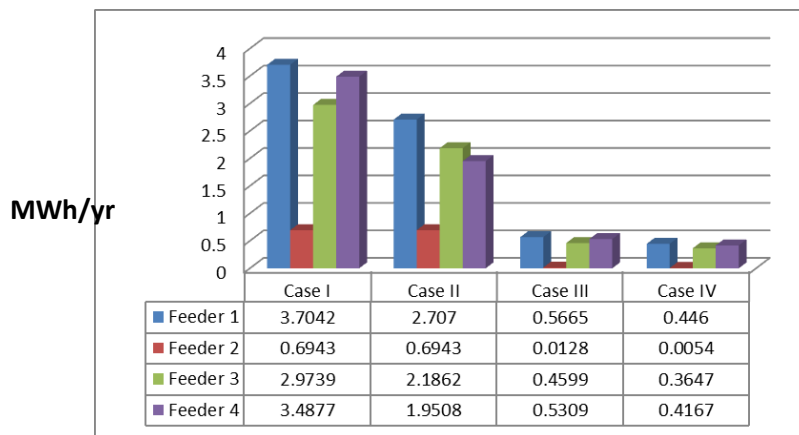
Case I: Conventional system.

Case II: Conventional system and dispersed generation (DG)

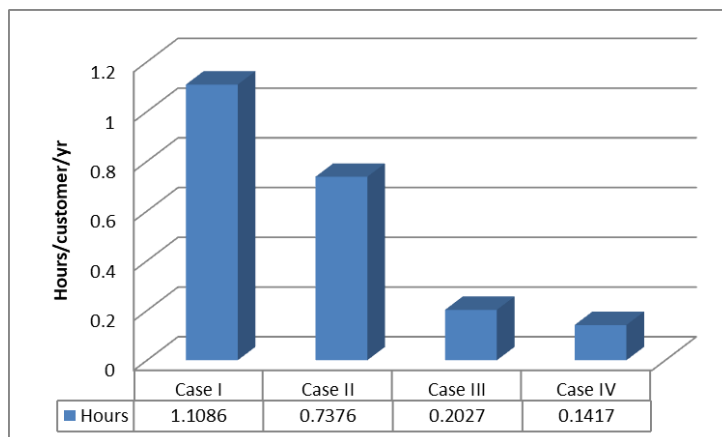
Case III: IoT and without dispersed generation (DG).

Case IV: IoT and with dispersed generation (DG).

In figure 3, the impact of IoT on ENS for each feeder is described in four cases. By comparing case I & III, the impact of IoT can be seen clearly. By applying IoT in case III, the amount of energy not supply is decreased for all feeders. In case II and IV, the integration of IoT and DG can be analyzed. In both case, DG is installed. However, IoT is not applied in case II. In case IV, the amount of energy not supply to the customer is the lowest and the reliability is the highest with the integration of IoT and DG .



**Figure 3:** Impact of IoT on ENS for each feeder



**Figure 4:** Impact of IoT on SAIDI for system

In figure 4, the impact of Iot on System average interruption duration is analyzed for the whole test system. In case III and IV, the duration of interruption per customer is reduced to 0.2027 and 0.1417 respectively. Using IoT, the operation of switching devices and control system is time saving and more reliable.

## **5. Conclusion**

From the results, using the integration of DGs and IoT system has great impact on distribution system reliability. IoT reduce the time for switching, restoration, management and control of the system. Consequently, it can provide more reliable digital energy market for customers. The interruption duration and the amount of energy not supply can be reduced clearly. In this paper, an overview of IoT technology used in the smart grid technology is described. By applying Internet of Things (IoT) technologies, various intelligent services can be provided safely and reliably. Moreover, it is one of the most necessary parts of the smart grid and it would be better by IoT technology. IoT will a solution to change from conventional power grid system to smart grid system because it is advantaged and effective technology for control and data management system.

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