

# Development of IoT Device for Monitoring Emergency Generator

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## Abstract

Emergency generator sets (gensets) are one of the vital electrical facilities and such standby power is mandated by law for installation in certain buildings and facilities. In the event of a disaster, the emergency gensets must start up quickly and reliably supply power to run disaster prevention equipment and emergency equipment. However, recently there are many cases where malfunctions such as fuel depletion or internal component failures caused emergency genset failure to operate when needed. To ensure smooth operation of these facilities, it is essential to prevent malfunctions and problems with internal components. Furthermore, challenges related to maintenance, such as equipment aging and a shortage of qualified personnel for electrical safety, are also emerging.

Our company is developing and testing a monitoring system that utilizes Internet of Things (IoT) technology to periodically collect data on the status of the starting battery and fuel levels, primarily for cubicle-type (packaged) emergency generators.

## 1 Preface

In recent years, with the increasing awareness of disaster prevention due to Business Continuity Plans (BCPs) and frequent natural disasters in Japan, the importance of emergency generators and their inspection and maintenance has become more recognized. Among these, the role of the starting battery for powering the generator is crucial since if the battery deteriorates, the generator may fail to start when needed. According to a survey by the Japan Engine Generator Association<sup>(1)</sup>, fuel depletion was the cause of more than half of all engine failures and shutdowns, while poor maintenance (such as battery discharge) was the most common cause of engine failure to start. Even in the 2024 Noto Peninsula Earthquake (a magnitude 7.6 earthquake), although the number of failures was lower than in the Great East Japan Earthquake in 2011 (a magnitude of 9.0 to 9.1), similar malfunctions and anomalies were reported.

Our company has developed and is testing a monitoring system that utilizes Internet of Things (IoT) technology to periodically collect data on the status of the starting battery and fuel levels,

primarily for cubicle-type (packaged) generator sets (gensets).

This system periodically monitors and transmits data to the cloud on battery voltage level and remaining fuel level necessary for the start-up process (battery) and sufficient fuel during the time for establishing stable operation of emergency gensets. This monitoring allows for early detection of battery degradation and efficient fuel management. Our company is developing this system as a part of a joint project with Sankosha Corporation, a leading manufacturer of high-quality and reliable surge arresters, and Nishiyama Corporation, a technology-oriented trading company specializing in product development and offering solutions proposal. This paper introduces this system.

## 2 Regulations and Maintenance

Emergency gensets are subject to regulations that specify the standards, frequency, and types of maintenance and inspection, which are mandatory. The Fire Service Act of Japan stipulates that “Stand-alone power generation equipment and battery systems must comply with the standards set by the

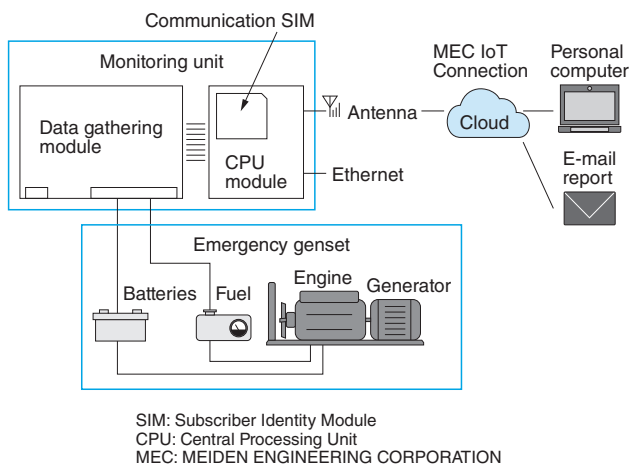
Director-General of the Fire and Disaster Management Agency.” The start-up time is defined as the time from receiving the start signal to achieving stable operation. For typical emergency generators, the standard start-up time is within 40 seconds, and for immediate-start types, within 10 seconds. This system focuses on monitoring the start-up time on a regular basis.

As a maintenance service provider of the genset manufacturer, we perform inspections and repairs of emergency gensets. Issues include generator failure to start due to battery discharge, as mentioned earlier, and we often receive customer requests for fuel replenishment before typhoons approaching period. Battery discharge is often caused by deterioration.

By using this system to detect early signs of problems, our experienced field service engineers can perform a more accurate condition assessment, leading to more high-precision maintenance service.

### 3 System Configuration and Function

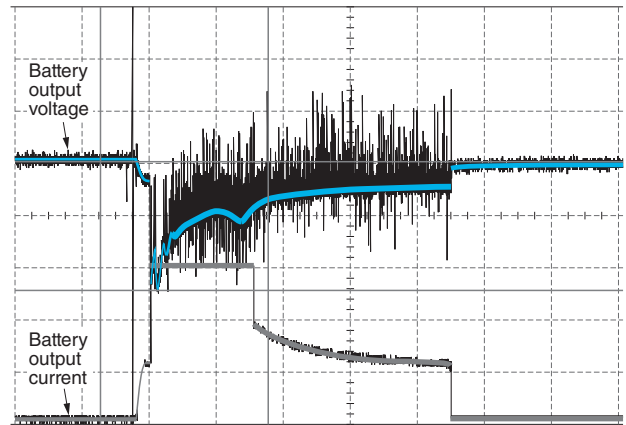
This system utilizes the “MEC IoT Connection” cloud service, allowing for a minimal hardware configuration with low initial investment. The data collected includes battery voltage, time to stable operation, and remaining fuel level. Fig. 1 shows an example of the system configuration. The battery voltage temporarily drops when the start signal is received and the engine starts. This voltage and the generator output data are measured and stored until stable operation is achieved.



**Fig. 1** Example of System Configuration

An example of system configuration for the emergency generator monitoring system is shown.

Fig. 2 shows the battery voltage and current waveforms from start-up to stable operation. While starting batteries require periodic replacement, the rate of deterioration depends on the operating environment (frequency of use, temperature, humidity, and so on). Detecting signs of battery deterioration allows for accurate timing of replacement. Fig. 3 shows a view of the system during verification testing.



**Fig. 2** Waveforms of Battery Voltage and Current from Startup to Stable Operation Establishment

Battery voltage and current from startup to stable operation establishment of the emergency generator are measured to examine the fact that the battery voltage is temporarily lowered.



**Fig. 3** View during Verification Test

A view of the verification test is shown using an emergency genset for in-house technical training program.

**Table 1 CPU Module Hardware Specifications**

Hardware specifications of the CPU module are shown.

Item	Specifications
CPU	Arm Cortex-A7 (528 MHz)
RAM	512 MB (DDR3L-800)
ROM	3.8 GB (eMMC)
LAN	Supporting Ethernet Standards : LAN 100 BASE-TX/10 BASE-T, AUTO-MDIX
USB	USB2.0 (Host) × 2 (High Speed)
SD/MMC	Micro SD slot × 1
External dimensions	W100 × H110 × D45 mm

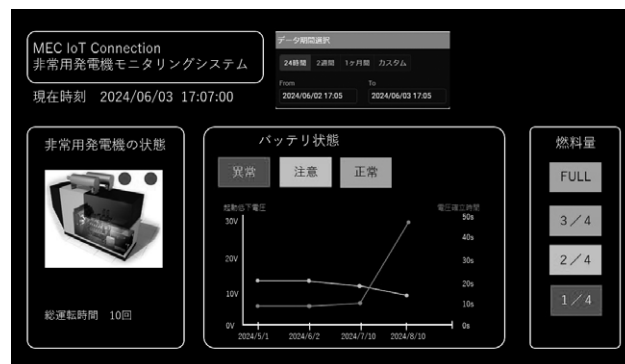
## 4 Hardware Specifications

The CPU board utilizes a low-power IoT gateway equipped with an ARM processor, and the sensor board was jointly developed with Sankosha Corporation. To ensure energy efficiency, the device operates intermittently, only rapidly booting and communicating with the cloud when necessary, such as when receiving a power generator start signal, and then entering sleep mode after data transmission. Additionally, as an option, it can operate using a battery (dry cell), allowing for use in locations with unreliable power supply. **Table 1** shows the hardware specifications of the CPU module.

## 5 Display Screen and Cloud Service

Data collected by the emergency generator monitoring system is transmitted to the cloud service “MEC IoT Connection” via a cellular communication network (LTE) using the MQTT (Message Queuing Telemetry Transport) communication protocol. The cloud stores and visualizes the collected data. A dedicated dashboard is also provided and it displays trend graphs and remaining fuel levels. The dashboard allows for comparison with historical data. When a pre-set threshold is reached, an alert or e-mail notification is sent, and the stored data can be exported in CSV (Comma-Separated Values) format.

The cloud service “MEC IoT Connection” centrally manages data from various IoT sensors on a single dashboard screen, supporting operational management. The dashboard can also be flexibly customized to meet customer requirements. **Fig. 4** shows the MEC IoT Connection dashboard screen, which visualizes the data stored in the cloud.



**Fig. 4 MEC IoT Connection Dashboard Screen**

Battery voltage and the time to establishment of stable operation are shown with trend graphs. For the remaining amount of fuel, there are indications of 1/4, 2/4, 3/4, and full. These indications can be customized.

## 6 Verification Tests

The typical replacement cycle for batteries in emergency generators is generally based on the age of the battery, regardless of the number of starts or the installation environment. However, when we sampled the condition of the replaced batteries, we found that some were severely deteriorated, while others were almost as good as new. By using general measurement data, as well as the voltage at startup and the waveform of the operating characteristics (which we are focusing on this time) as evaluation criteria, we can determine an accurate replacement cycle that takes into account degradation due to the installation environment and the number of starts. Furthermore, by periodically measuring the remaining fuel level, another important monitoring factor, we can detect sudden fuel level drops or other anomalies caused by malfunctions in the typical float sensor. This enables more reliable generator operation. We will continue to focus on various abnormal conditions and degradation factors, and conduct further field verification tests.

## 7 Postscript

We introduced our emergency generator monitoring system that we are currently developing.

In the future, we aim to improve the accuracy of our degradation assessment based on accumulated data, thereby enhancing the maintenance and reliability of power generation equipment. Furthermore, by leveraging our extensive experience and expertise as the maintenance service pro-

vider of the genset manufacturer, we intend to provide IoT and ICT services tailored to a wide range of applications.

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#### 《Reference》

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