A new design of generator set controller in cloud service system based IoT technology

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Abstract. To solve the existing technical problems in quality management, distributed control, maintenance and monitoring management faced by traditional diesel generator set (GenSet), this paper summarizes the development status of traditional diesel generator set technology, and analyzes the business requirements of end users for distributed cloud control. Through the integration of traditional diesel generator cloud technology with internet of things technologies (IOT), a new design scheme of cloud GenSet controller is proposed based on IoT technology, which simplifies the logic hierarchy of diesel generator cloud control. Then this paper puts forward the key network hardware design, and applies the new cloud GenSet controller to the enterprise new GenSet system, which verifies the feasibility and stability of the new design.

1. Application of GenSet controller

GenSets are widely used in actual production process and life. The electric energy produced by generator is one of the most important energy sources in modern society[1]. Generators are widely used in Industry, Agriculture, National Defense, Science and Technology, even in daily life where the grid is not available. Firstly, it is applied to large and medium-sized power plants to supply industrial and civil power. Power plants mainly in the possible form of thermal power station, water conservancy power station, Nuclear power station, wind power station, solar power station, etc; Secondly, GenSets are widely used in small power station, acting as on-board generators, oil drilling generators; Thirdly, GenSets can be back-up powers applied in hospitals, banks, shopping malls, etc[1-4].

Although GenSets are widely used, on-site operation and maintenance of the GenSets are difficult and high-cost, which brings some obstacles to the actual production. On the one hand, the GenSet may be in a natural environment with high salt fog concentration and high humidity, which is very unfavourable to the long-term operation of machinery and GenSet equipment[5]; on the other hand, the on-site inspection and maintenance costs of the operation and maintenance personnel of the GenSet are too high[6]. With the help of various effective management measures, all manufacturing enterprises and scientific research institutions have made some achievements, but still lack of effective comprehensive management methodology, as follows[2-7].

1) Management mode is not high-efficient. The existing order management mainly relies on manual record, and needs to inquire about orders through telephone and supplier management system (SMS). It is difficult to track orders, and it is also difficult to obtain the quality guarantee money.
2) The quality control level is not high. Quality indicators need to be recorded manually, data storage is not professional, and data statistical analysis is difficult.

3) Maintenance information of GenSet needs to be improved. Due to historical factors and the fast updating speed of operation and maintenance data of existing GenSet equipment, some equipment inspection, maintenance, and other status information cannot be updated in time, which affects the timeliness and controllability of equipment maintenance management.

4) It is difficult to discover the potential value of failure maintenance cases. For the production and manufacturing process of typical complex equipment such as generator set equipment, the case of equipment failure maintenance is a valuable management wealth of enterprises and industries. As long as we use certain information technology means to analyse and discover the evolutionary law of various maintenance cases, we can timely alert the existing production management and production line operation, and integrate it into the maintenance and training work of employees, and become a kind of corporate culture. However, there is still a lack of information support for sorting out and mining the filed fault maintenance cases nowadays.

2. Market requirement analysis of GenSet controller

According to the construction goal of the FPSS (Fortrust Power Service System) power GenSet industry production, operation and intelligent service internet platform project, as well as the current production management standards and specifications of the company, starting from the daily management requirements, the market demands in three aspects are as follows.

2.1 State monitoring

State monitoring includes equipment monitoring, configuration view display, real-time data display and GenSet data. After authorization, the user can select a set through a mobile APP or web station, click the set menu, and the set management interface will jump to the set monitoring interface to view the real-time operation video of the GenSet, and control the start and stop of the set through the button. After being authorized to enter the system, the data of the engine of the generator set can be viewed through the configuration view display function of the generator set, such as speed, temperature, oil pressure, liquid (fuel or coolant) level, battery voltage, cumulative operation time and other information. This information can be displayed in real time and dynamically through the dashboard, bar graph and so on, so that the user can watch the operation status of the GenSets in real time.

The real-time data display module can display the sampling time interval, last sampling time, last start-up, shutdown time and other information. The real-time collected data of mains voltage, line voltage and frequency, as well as the data information of power line voltage and frequency, as well as the current, active power, reactive power, apparent power, power factor and accumulated power of the load. The display module also can display data information such as engine speed, battery, coolant water temperature, lubrication oil temperature, oil pressure, liquid level, cumulative operation time and cumulative start-up times. The GenSet state data module can view the set management data information interface, including the GenSet name, collector identification, set longitude and latitude, installation location (GPS coordinates), factory number, model, manufacturer, manufacturer brand, specification, production date, rated speed, rated voltage and rated current of the GenSets.

2.2 Fault diagnosis

Fault diagnosis module consists of fault message push, fault code query, online diagnosis, fault elimination and case warehousing. The fault push module can push the fault code to the generator set end-users or fault diagnosis experts when the machine fails. When troubleshooting technicians diagnose faults in generator sets, they can be removed from memory by manual or external diagnostic devices. Through the corresponding fault information of these codes, the maintenance personnel can quickly cut into the main topic, and avoid the wrong diagnosis. We can use a typewriter or CRT to indicate the diagnosis results of various items and the fault position indicated by a unified number. According to the results of online diagnosis, the equipment maintenance staffs put forward solutions based on the
historical data about location and cause of the fault. After the solution is put forward, implement and verify the solution. If the solution is correct, the next step can be taken. If the solution fails to solve the problem, return to continue online diagnosis. After the equipment maintenance staffs put forward correct solutions to solve the GenSet fault, the service cloud system will automatically store the case of this fault into the database for the next time similar fault occurs.

2.3 Intelligent operation and maintenance
Intelligent operation and maintenance consists of historical data loading, model selection, maintenance prediction and preventive maintenance report. The maintenance records will be stored in the special database of the system as the data source of intelligent operation and maintenance. Intelligent operation and maintenance solves the problem of fault classification, so it is necessary to select classification algorithm, through the training of historical data, to form a stable and efficient model.

After the formation of the intelligent operation and maintenance model, the data of the operation state of the generator set on the site is collected as the input of the model, and the output is the possible failure type of the equipment, so as to prevent the failure of the generator set in advance. Through intelligent operation and maintenance, maintenance prediction and operation and maintenance scheme can be formed. Maintenance scheme will automatically generate as a preventive maintenance report. Maintenance report of each generator set can be viewed or downloaded at any time to make corresponding maintenance.

3. Traditional diesel generator controller
The intelligent control system of the diesel generator set can realize to remotely control. The intelligent controller can improve the operation and maintenance of the diesel generator, and at the same time ensures the stable work of the diesel generator set. The common products of the remote control Gensets on the market are mainly produced by manufacturers such as the DEEPSEA, COMAP, FORTRUST, SMARTGEN and LIXISE, etc. Most of these traditional diesel generator controller and remote control system have three layers [8], as shown in figure 1.

![Figure 1. Traditional diesel generator controller and remote control system](image)

4. New design of Genset controller used for cloud service
To simplify the complex structure from three layers into two layers, the functions of the new cloud set controller can better meet the needs of the distributed cloud-based controller users, as well as the business requirements of the operation, maintenance, and health management of the whole life cycle of
GenSet [9]. For this reason, this paper designs the new cloud GenSet control system, which has the functions including network parameter setting, factory inspection, operation monitoring, GenSet localization for anti-theft, acceptance report, GenSet fault cloud diagnosis, GenSet maintenance management, health management and data statistics analysis. In terms of network structure, the new cloud GenSet controller has built-in network communication module, which is compatible with 4G communication and TCP/IP network cable communication mode. The traditional three-layer structure of Genet monitoring is simplified into two-layer, which realizes the breakthrough of GenSet service cloud organization structure, as shown in figure 2.

**Figure 2. Architecture of the new cloud Genset control system**

5. **Hardware design of cloud set controller**

The performance of cloud controller's built-in cloud cat hardware device is as follows [9-11],

1) GPS accuracy: positioning 2.5Mcep, SBAS 2.0mCEP, capture cold start29s, warm start 29s, auxiliary start < 1s, hot start < 1s, sensitivity, capture −160dBm, tracking −160dBm, cold start−145dBm, multipath suppression, intelligent multipath detection and suppression, A-GPS, support for Assist Now Online and Assist now Offline, operation limitation, speed 515m/s (1000 knots);

2) Interface: 1 UART interface, 1 USB V2.0, full speed 12Mbit / s, 1 DDC interface, 1 SPI interface, serial port and I/O voltage 3V level;

3) Protocol: RS485, NMEA, UBX binary, digital I/O interface configurable time pulse, one EXTINT input interface, voltage 2.7V–3.6V, power consumption < 80mW @ 1.8V, 120mW @ 3.0V, standby power supply 1.3 – 4.8V, 30uA, antenna type active and passive, operating temperature − 40 °C – + 85 °C, storage temperature − 40 °C – + 85 °C.

4) Reference dimension: 170.0 * 108.0 * 50.0mm.
The built-in modem motherboard is designed as a double-sided printed circuit board. The layout of main board components of the controller is shown in figure 3. The new cloud controller, 7800 series types, and final assembly in new GenSet in a factory are shown in figure 4, 5.

Figure 3. The layout of main board components of the controller.

Figure 4. 7800 cloud controller.

Figure 5. FPSS 7800 cloud controller assembled in GenSet in a factory

6. Conclusion
This paper summarizes the development status of traditional diesel generator technology, and analyzes the business requirements of end users for distributed cloud generator control. Through the integration of traditional cloud Genset technology with IoT technologies, a new design scheme of cloud controller is proposed and applied to the new GenSet of manufacturing factories. Considering the technical development trend of road Genset industry, the development of set controller should further meet the
business requirements of production, operation and maintenance and comprehensive service management. Using IOT and cloud computing technologies, and adopting lightweight mobile operation, data sharing and efficient information management of the whole life cycle of Genset can be realized. Further, industries can greatly improve the level of Genset production management and after-sales service.

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