"Mobile Power Supply System"

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1. Introduction

The stable supply of electric power is vital in a highly developed information society. The largest earthquake to hit directly a major city, the Hanshin-Awaji earthquake that struck Kobe in Japan, showed that early restoration and stable supply of lifeline services are critical when the power fails over a wide area. Mobile power supply systems were found to be effective due to their excellent mobility and emergency service functions.

We market two types of "Mobile Power Supply System": a one-box-car type and a truck type. The one-box-car type carries a power generator having a maximum output capacity of 100 kVA, while the truck type has a maximum output capacity of 500 kVA. "Mobile Power Supply System" has an operational guidance function that we have newly developed, and is a low noise, environmentally friendly system that is easy to operate by almost anyone. We describe the details of this new "Mobile Power Supply System" below.

2. Outline of the System

An outside view of "Mobile Power Supply System" is shown in Fig. 1, the internal layout in Fig. 2, the skeleton diagram in Fig. 3, and the main installation and specifications in Table 1. The features are described below.

- This is a low noise system that carries a 30 kVA generator that can be used for non-linear loads (allowable equivalent negative phase sequence current of 30% or more) and a diesel engine mounted on a two-ton vehicle that can be driven by someone possessing an ordinary driver's license.
- The fuel tank and rechargeable starter battery are used by both the diesel engine and the vehicle to reduce weight.
- The load output voltage supplies two output voltages of 210 V and 100 V for various load conditions.
- The entire system can easily and surely be operated by using the operation guidance (touch-key) system.
- For charging the starter battery, an external AC input connector allows the starter battery to be charged even during standby. Switching between the commercial power source and engine generator is automatic.
- In order to improve the efficiency of cable connection work, the power output is equipped with a connector that enables the output power to be connected at a single touch.
Table 1 Installation and specifications

<table>
<thead>
<tr>
<th>Items</th>
<th>Units</th>
<th>Specifications</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated output</td>
<td>kVA</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td>V</td>
<td>210</td>
<td></td>
</tr>
<tr>
<td>Number of phases</td>
<td>-</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Frequency</td>
<td>Hz</td>
<td>50 or 60</td>
<td>Note1</td>
</tr>
<tr>
<td>Power factor</td>
<td>-</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Allowable equivalent negative phase sequence current</td>
<td>%</td>
<td>30 or more</td>
<td></td>
</tr>
<tr>
<td>phase sequence current</td>
<td>rpm</td>
<td>1,500</td>
<td></td>
</tr>
<tr>
<td>Continuous operating hours</td>
<td>Hr</td>
<td>3 or more</td>
<td>Note2</td>
</tr>
<tr>
<td>Maximum sequence operating hours</td>
<td>Hr</td>
<td>30 or more</td>
<td>Note3</td>
</tr>
<tr>
<td>Noise value</td>
<td>dB(A)</td>
<td>65 or less</td>
<td>Note4</td>
</tr>
<tr>
<td>Supplied cables (with drum)</td>
<td>-</td>
<td>15m×2drums</td>
<td>Note5</td>
</tr>
</tbody>
</table>

Vehicle

<table>
<thead>
<tr>
<th>Items</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum payload</td>
<td>tons</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>crew</td>
<td>persons</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Drive system</td>
<td>-</td>
<td>Four-wheel drive</td>
<td></td>
</tr>
<tr>
<td>Hill climbing ability</td>
<td>tanθ</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>Minimum turning radius</td>
<td>m</td>
<td>5.1</td>
<td></td>
</tr>
<tr>
<td>Driver's license required</td>
<td>-</td>
<td>Normal driver's license</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Both 50 Hz and 60 Hz systems are available.
Note 2: Continuous operating hours when the fuel tank is full and the vehicle operates at the rated load.
Note 3: The maximum continuous operating hours without maintenance such as replacing the oil filter, etc., with refueling only.
Note 4: The average noise value in the four directions measured at 1 m from the vehicle and 1.2 m above ground.
Note 5: The standard specification is 2PNCT-3 wire cable.

3. Noise Reduction

Demand is increasing for quieter equipment in urban areas at night, irrespective of whether the power supply system is mobile or not.
Reducing noise and maintaining a good heat balance are mutually contradictory, thus making it difficult to design compact power supply.
To reduce noise, we have reviewed the structure of "Mobile Power Supply System", and have developed a unique sound-proof structure that uses a sound absorption
material for the equipment packaging, and features a sound-absorption duct structure for the air intake and exhaust openings. The noise level is reduced to 65 dB (A)/1 m or less against the standard noise level of 75 dB.

4. Measures for Harmonics

Semiconductor products such as rectifiers, AC power supply system, inverter air conditioners, inverter lighting equipment and so forth are becoming more widespread as the loads on "Mobile Power Supply System". Since distorted current flows through such equipment, the harmonic currents contained therein generate heat and distort the voltage waveform. As a countermeasure for harmonics, the number of damper windings of the generator rotor is increased to reduce the impedance. As a result, 30% or more of the allowable equivalent negative-phase sequence current is permissible as its yield strength against the standard strength of 20%. This raises the reliability of the system.

5. Control System with Operation Guidance Function

5.1 Structure and Layout of Control System
The control system has a compact, stand-alone structure. All the connections with external equipment are made by connectors, so the system can be easily installed. All inspection works can be performed from the front by opening the front door; maintenance, inspection and parts replacement can be performed from the front so maintenance engineers do not need to go into the mobile power supply vehicle. The control equipment is installed in the rear side of the mobile power supply vehicle. All controls are concentrated in one location, and can be easily performed by opening the small door of the mobile power supply vehicle. Illuminations above the switchboard enable the meters and indicators to be checked visually from outside the vehicle through the inspection window even in the dark.

5.2 Running and Operation
The running and operation block is shown in Fig. 4. "Mobile Power Supply System" has conventionally had to be operated by experienced staff, or it had need to use operation manuals prepared by maintenance staff. This system has been improved so that it can be used by anyone by using the built-in guidance function. When the small door of the mobile power supply vehicle is opened, the operation block appears, and this block has a color touch-panel LCD of 320×240 dots. After turn on the control power, the operation guide messages prompt the operator to select either YES or NO on the touch keys to operate the system. Safe, simple and secure operation has been ensured by including check items in the guidance, and maintainability has also been improved. An example of the operation guidance is shown in Fig. 5. When an error occurs, the "Display of All Troubles" appears, highlighting where troubles occurred. When the operator touches the highlighted area, the check points of high error probability are displayed in order to locate the cause of trouble swiftly. An example of trouble display is shown in Fig. 6.

5.3 Display Block
The display block has a color touch-panel LCD of 320×240 dots. Various devices of the operation sequence can be checked on the display with their associated data. The eight-color display and the high-lit indication help ensure correct operation of the system. Because of the built-in sequencer, the display items such as number of troubles to be displayed, switches, contents of guidance, etc., can be modified by the software without modifying the hardware, thus flexibly satisfying the various requests of users.

6. Easy Overhaul
Because the useful lifespan of the vehicle and the power supply is different, overhauling and replacement of "Mobile Power Supply System" will become necessary in the future. The vehicle and the power supply are conventionally combined into one structure so that overhaul or replacement work takes a long time. New "Mobile Power Supply System" has the structure in which the vehicle (chassis with cab) and the storage package can be separated to facilitate replacement work. At the same time, all the components in the storage package are fixed by bolts so that they can be pulled out from the rear of the vehicle for easy overhauling, which reduces the overhaul time greatly.

7. Conclusion

We have outlined our "Mobile Power Supply System" that has an operation guidance function. We will continue to develop highly reliable, handy, low-cost systems that help preserve the environment by emitting less exhaust and noise, in order to help restore lifeline services, to supply backup power for many hours, and to assist in case of emergency.

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Fig. 1 Outside view of "Mobile Power Supply System"
Fig. 2 Internal layout

Diesel powered engine generator

Cable drums

Vehicle

Switchboard terminals

Output
Fig. 3 Skeleton diagram
Fig. 4 Running and operation block
Fig. 5 Example of the operation guidance

Display 2
- Wiring
  Is wiring of load side correct?
  YES | NO

Display 3
- Wiring Check
  Correctly wire the load side.
  OK

Display 4
- Startup preparation
  Perform the startup preparation.

Display 5
- Turning on the battery switch
  While pulling the battery switch, turn it on.
  YES | NO

Display 6
- Starting method selection
  Select the starting method

Display 7
- Manual Start
  Insert key into "Start Switch" and turn it to the left, then turn it to the right after the "Preheat Display" changes to red to start.
  Note: If the engine does not start even after the cell starter motor has rotated for about five seconds, wait for about 10 seconds with the switch off, then restart the engine.

Display 8
- Automatic Start
  Press the start switch.

Display 9
- Preheating
  Now preheating.

Display 10
- Voltage Setting
  Adjust voltage with the voltage setting control (0% on the switchboard)

Display 11
- Establishing the voltage
  Is the "Power Generation Under Load" indicator ON?
  YES | NO

Display 12
- Operation Manual
  Refer to the operation manual.

Display 13
- Frequency Setting
  Adjust frequency with engine speed governor

Display 14
- Frequency Adjustment
  Does "Frequency indicator" indicate 50 to 55 Hz?
  YES | NO

Display 15
- Main circuit breaker
  Is the main circuit breaker turned on?
  YES | NO

Display 16
- Stop
  Is the stop operation performed?
  YES | NO
Fig. 6 Example of trouble display

**Overspeed**
- Check point
- Inspect the speed governor or repair it.

**Decrease of lubrication oil pressure**
- Check point
- Amount of lubrication oil
- Leakage of lubrication oil from piping

**Undervoltage**
- Check point
- Check the generator output voltage value.
- Check AVR.
- Voltage adjustment control

**Output overcurrent**
- Check point
- Load limit
- Thermal relay
- Shorting of load, etc.

Trouble Occurs

Display of All Troubles
- Cannot start the engine
- Overvoltage
- Insufficient oil pressure
- Undervoltage
- Check if inlet air is restricted
- Ground fault trouble
- Overspeed
- Output overcurrent
- Circuit has abnormality

Alarm stop switch
Return from trouble

Returning from trouble
Press the return switch after eliminating the cause of trouble.

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