Test facility for determining the performance of storage batteries for photovoltaic applications*

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Abstract

Equipment has been developed for testing batteries of up to 2500 A h capacity under regimes that simulate operation in photovoltaic (PV) systems Parameters that can be monitored include battery voltage and current, specific gravity, temperature, and level of electrolyte The equipment is being used to evaluate batteries developed by NEDO for PV applications

Basic design concept

Many types of storage batteries can be used in photovoltaic (PV) systems according to the intended application. Previous studies have indicated, however, that it is sufficient to consider only two types of batteries: one for stand-alone power supplies with large capacity and low discharge rates, and one for grid-connected systems with relatively low capacity and high discharge rates. Therefore, a test facility has been designed with the capability for performance evaluation of these two types of batteries Emphasis has been placed on a charge/discharge cycle test at a partial state-of-charge (PSOC) This simulates operations in PV systems.

Major test and evaluation parameters to be monitored by the facility are· capacity, storage efficiency at PSOC; charge/discharge cycle test at PSOC with low and high current rates, respectively. Other tests are excluded because they are adequately covered by general testing procedures applied to conventional storage batteries

The design and size of the test facility allows for the testing and evaluation of the operational characteristics of both sealed and vented types of batteries with capacities up to 2500 A h These units have been developed by NEDO for PV applications

Configuration of test facility

The configuration of the test facility is shown in Fig. 1. There are three independent circuits that consist of charge/discharge control units and test

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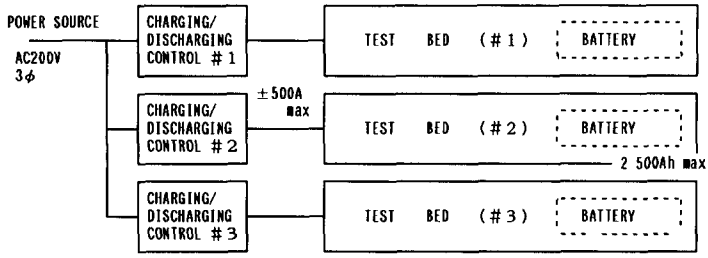

Fig 1 Basic configuration of battery test and evaluation facility

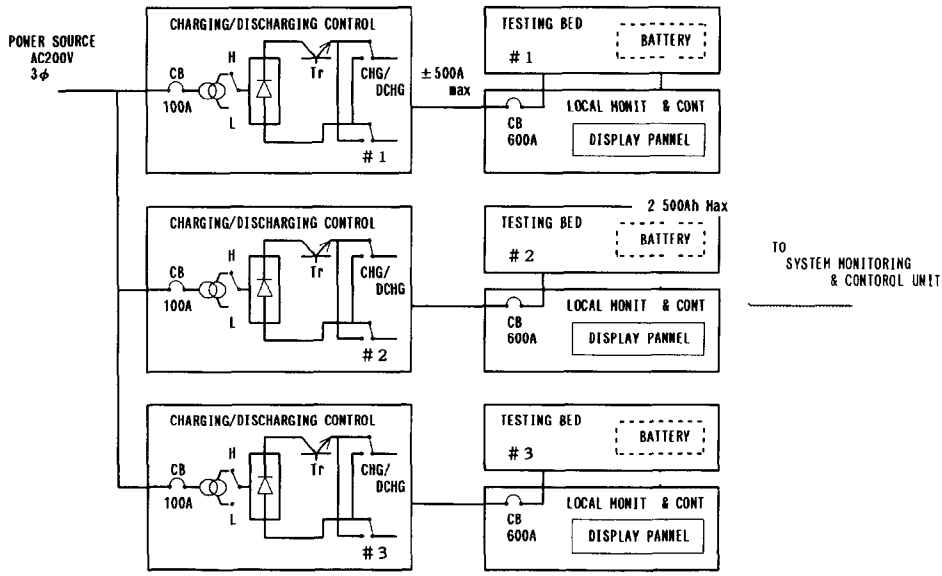

Fig 2 Detailed configuration of battery test and evaluation facility

beds. Each circuit can accommodate batteries of up to six cells with capacities up to 2500 A h. Two of the circuits are used for long-term cycle tests of two types of storage batteries under development by NEDO The remaining circuit is employed for short-term tests of capacity, partial charging and discharging efficiency, and endurance to over-charging or over-discharging These tests are similar to those conducted on conventional storage batteries

A more detailed configuration of the test facility is given in Fig. 2 The two forms of PSOC test profiles used for evaluating batteries for PV applications are presented in Fig 3 The function and performance of each device is as follows

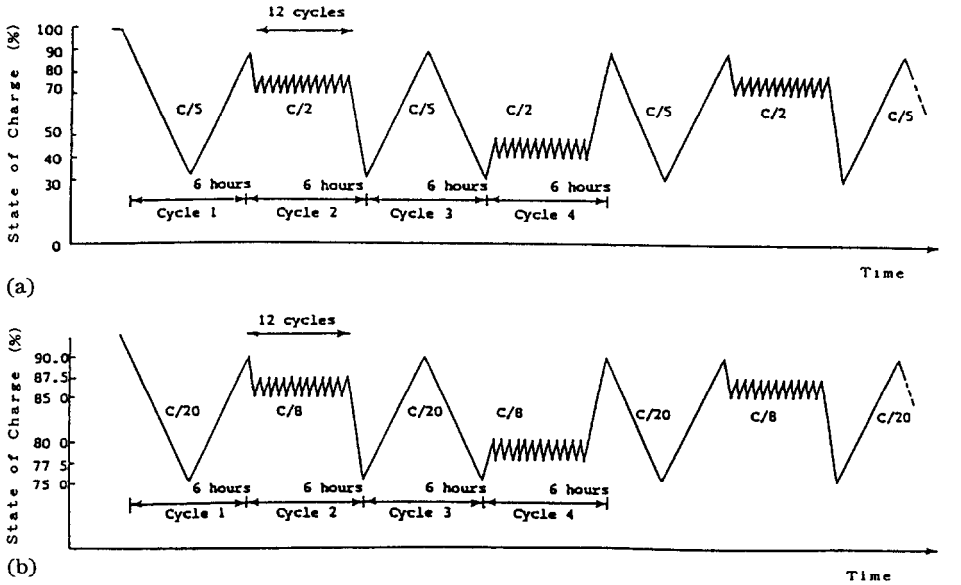

Fig 3 Test profiles for (a) high-rate and (b) low-rate batteries for PV applications

Charging and discharging control unit

Function

The unit supplies charge and discharge current to the storage battery, and is operated in three modes

Capacity

The unit is designed to supply a maximum 0 2 C (or 500 A) of charge and discharge current to storage batteries of up to 2500 A h ($C/10$ rate) in order to determine the performance under the PSOC test profiles

The voltage is 2–12 V so that studies can be undertaken on storage batteries ranging from those developed by NEDO with a single-cell structure to commercial types in the form of multi-cell monoblocs

Operation mode

Charging mode A battery is charged continuously at a specified and constant value of the current The unit can automatically transfer to constant-voltage charging operation at a specified voltage in order to avoid damage to the batteries by overcharging The voltage setting is variable (2–20 V), according to the battery under test.

Discharging mode A battery is discharged at a specific value of the current The unit can automatically transfer to stop mode at a specified voltage to prevent the overdischarge The voltage setting can be varied over the range 0–12 V to suit the battery under test.

Stop mode In the stop mode, charging or discharging is interrupted and the storage battery is electrically separated from the power supply

Accuracy

Accuracy of control is within 0 5% for both voltage and current to give good reliability of test results. Efforts have been made to reduce the integral error in long-duration cycling tests to as low a value as possible

Configuration

The unit has a modular-based design to allow easy extension when necessary (left-hand side, Fig. 2). The unit is composed of a d c power supply and a transistorized current-control circuit.

Although discharged power is generally consumed by resistors or re-generated to an a c power line via an inverter, such methods are impractical with single cells because of the low voltage, viz , 2 V In these cases, therefore, the power is actively absorbed by the current-control circuit

Test bed

Function

The bed has functions that can hold the battery under test, insulate it from ground, and monitor its status. Remote control of the charge/discharge control unit is available

Local monitoring and control

The local monitoring and control unit is equipped with various sensors to measure and control the operating status of the battery at an interval of 1 min. The data are transferred to the system monitoring and control unit via the standard data bus-line

The unit measures the terminal voltage and current of the battery, the specific gravity, temperature, and level of the electrolyte in vented-type batteries, and the temperature of the container with sealed batteries

Local operating switches are located near the main body of the test bed for ease of exchange of batteries and for local operation of the charge/discharge control unit to start and stop a test

There are also facilities to indicate the operating status of the battery, the charge/discharge control unit and other test items, as well as the condition of the test, i e , 'in operation', 'completed', or 'suspended'

Accuracy of monitoring

The accuracy of measurement of the current and voltage is the same as that of the charge/discharge control unit The accuracy of the other items is $\pm 1\%$

Configuration

The unit is again a modular-based structure The configuration is shown on the right-hand side of Fig 2 The unit is designed to accommodate heavy batteries

Present status

A test run was conducted using actual storage batteries in the first half of FY 1989 This established the validity of the test procedures, and identified problems and solved them. Since then, performance tests have been undertaken on new storage batteries under development by NEDO for PV applications.