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Development of Utility Interactive Inverter for Photovoltaic Power System "PMB"

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1. Introduction

Our Technology Center that will be completed in August, 1997 will be partly run by a photovoltaic power (abbreviated as "PV" hereafter) system using our "PMA" utility interactive inverter in combination with the commercial power supply at all times.
Data gained from running this system is then utilized for designing practical, more efficient PV systems. We have been developing a new utility interactive inverter in response to various requests from "PMA" users, and from our experience, data and research, we have developed the new "PMB" utility interactive inverter that enables a low-cost, high-efficiency PV system to be configured.
We introduce here the features of the newly developed "PMB".
For detailed descriptions and the terminology regarding our PV system work and system configuration, please refer to Technical Report No. 3 issued in May 1997.

2. New "PMB" utility interactive inverter

2.1 "PMB" Configuration

"PMB" is a newly designed unit-type utility interactive inverter, and is the successor of our conventional "PMA".
Fig. 1 shows the circuit block diagram of "PMB" utility interactive inverter.
This utility interactive inverter consists of a 10 kW transformer-less unit inverter (abbreviated as "unit" hereafter), input/output circuit breaker, control block, display block and interactive protection block.
The "unit" is the basic building block, and utility interactive inverters ranging from 10 kW to 100 kW can be constructed by adding multiple basic blocks.
The outside view of the "unit" is shown in Fig. 2.
"PMB" utility interactive inverter consists of one master unit and (n-1) slave units.
The control block is located outside the units as the common control unit.

2.2 Features of "PMB"

"PMB" has the following main features.
(1) Unit add-on system
In the conventional model, inverters of specific capacity are designed. In "PMB", the power block features a "unit" add-on structure.
As shown in Fig. 3, the "unit" supplies power from this system to the commercial power source by converting DC power to AC power.
This add-on structure with only one type of 10 kW unit allows mass production and thus reduces the material and labor costs, so an economical utility interactive inverter can be made.
(2) Transformer-less insulation

Insulation between the DC side and AC side of the inverter is maintained by the transformer in the conventional model, whereas in "PMB", the transformer is eliminated by using a DC ground fault detector, DC out-flow current detector, chopper, etc. This improves the efficiency of the inverter by about 2% compared with the conventional model, and also makes the inverter lighter (by 20% on average).

(3) Enlarged solar battery voltage follow-up range

The required number of solar battery modules is connected in series in accordance with the rated input voltage of the inverter.

The voltage follow-up range of the inverter used to be from 250 V to 360 V in the conventional model, but we have extended this range from 200 V to 400 V in "PMB" in order to support different module types and solar batteries of different manufacturers.

When using the amorphous type module that is expected to be the main next-generation type, a high input voltage is required to offset the anticipated initial deterioration of this type of module. "PMB" can accept a maximum input voltage of up to 500 V for the amorphous type module.

(4) Improvement of overall system efficiency (Controlling the number of running "units")

Efficiency during low output is improved by controlling the number of running units, using the unique unit add-on configuration.

In conventional configurations, the loss ratio during no-load running of the inverter when there is a normal running loss cannot be neglected because it lowers the overall efficiency of the system (Fig. 4).

In "PMB", when the output power of the inverter of 20 kW or more falls below the specified value, excess units are stopped in order to increase the overall efficiency of the system (Fig. 5).

As a result, several extra percent of power can be obtained in "PMB" system of 20 kW or more compared with conventional systems.

(5) Improved flexibility with options

The design shapes of panels, frames, and structures had to be changed whenever different measurement specifications were requested by users in the conventional model.

Based on past experience, various option functions have been standardized and can be added in "PMB" system without major modification, thus reducing design cost and delivery time.

2.3 Standard Specifications of "PMB"

The standard specifications of "PMB" are shown in Table 1, with capacity ranging from 10 to 100 kW. This range can be extended by adding options.

Table 1 Standard Specifications of "PMB" Inverter Item

Item		Unit	Standard specifications
Output capacity		kW	From 10 to 100 kW in 10kW increments
System	Construction	-	10 kW transformer-less inverter add-on system
	Inverter system	-	Voltage-type current control system
	Switching system	-	Harmonic PWM system
	Cooling system	-	Forced air cooling
DC input	Rated voltage	V	300
	Range of variation	V	0 to 500
	Running voltage	V	200 to 400 (Maximum power point tracking control range)
AC output	Number of phases, Number of wires	-	Three-phase, three-wire
	Rated voltage	V	200
	Rated frequency	Hz	50 or 60
	High harmonics leak-out current	%	Overall current distortion factor: 5 or less Distortion factor of respective harmonic currents: 3 or less
	Output power factor	-	0.95 or more
	Utility interactive	-	Low voltage/High voltage utility interactive system
Interactive protection		-	Over voltage (OV), Under voltage (UV),Over frequency (OF),- Under frequency (UF),(Over voltage ground fault (OVGR)),DC ground fault, DC out-flow current detection
Detection of independent operation		-	Passive system: Voltage phase jump detection Active system: Frequency shift system
Stand-alone operation, Charging function		-	Supported by options

3. Conclusion

The PV system offers benefits as a distributed power supply, namely, power generation without pollution, vibration or noise.
The Government has promoted an aggressive energy policy, and we expect sales to government agencies and commercial enterprises to increase.
We are facing stiff competition in technical aspects at present, but the newly developed "PMB" PV inverter marks a breakthrough, as it realizes a low-cost, high-efficiency system.
We will develop a highly efficient, low cost, long life system and improve the

environmental characteristics from the production phase up to the disposal of the system, in order to encourage use of PV systems.

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Fig.1 Circuit block diagram

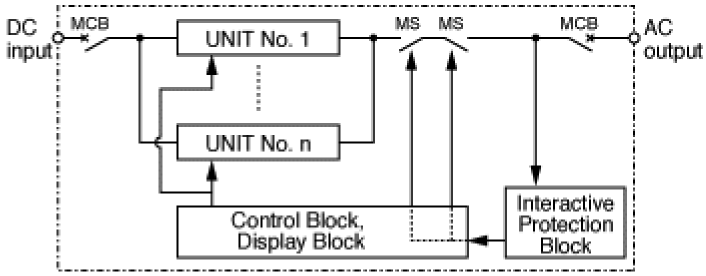

Fig.2 Outside view of the "unit"

Fig.3 Block diagram of "unit"

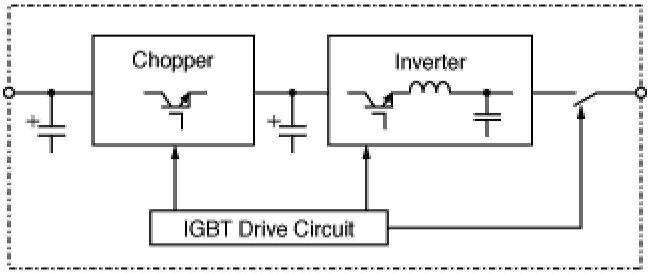

Fig.4 Running efficiency of the conventional model

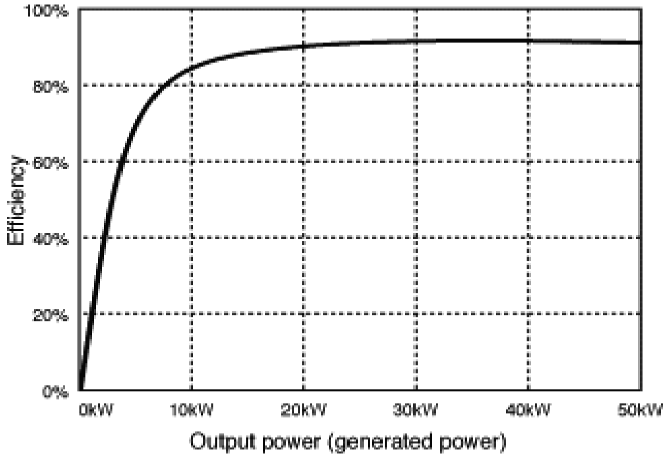

Fig.5 Running efficiency of 50kW "PMB"