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DEVELOPMENT OF ON-SITE FUEL CELL POWER UNITS : INVERTER

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1. FOREWORD

To be installed in buildings, hospitals, restaurants, and other places, on-site fuel cell power units must be quiet, small, and lightweight. As for the inverter used in fuel cell power units to convert the DC power generated by the fuel cell to AC power, low noise, small size, and light weight are, required. High efficiency is also important in reducing the size and cost of the entire fuel cell power plant.

However, the output of fuel cell is different from that of a general power plant and has such characteristics as:
(1) the output voltage change by load change is large
(2) the voltage is low and the current is high.

These are inconvenient conditions in reducing the size and weight and increasing the efficiency of the inverter.
inverter.

Fuji Electric has recently developed a third generation 50kW on-site inverter with high-speed semiconductor devices for on-site use to reduce noise, increase efficiency, and make the total system smaller. The specifications, features, circuit configuration, structure, characteristics, etc. of this inverter are introduced below.

2. FEATURES

2.1 Low noise

The magnetic noise of the transformer, reactor, etc. of the third generation inverter was reduced substantially by using high frequency switching elements. This reduces the noise generated by the inverter to only the cooling fan operating sound and clears the target noise value (55dB).

2.2 High efficiency

The efficiency of the third generation inverter was improved by simplifying the conversion circuit by using a direct inverter system with new high capacity, low loss MOSFET. Efficiency was also improved by eliminating the reactor at the output section AC filter by utilizing the impedance of the transformer.

2.3 High performance

The inverter was developed to allow following operation of fuel cell power plant.
(1) Both grid independent operation and grid connected operation.
(2) Switching between grid independent and grid connected operation without interruption.
(3) P (active power)/Q (reactive power) control.

Of the above, the control function which switches between grid independent operation and grid connected operation without interruption is an important factor which improves the reliability of the fuel cell power plant.

3. SPECIFICATIONS

The specifications and main circuit configuration of the first generation to third generation inverters are shown in *Table 1*.

The features of the second generation inverter were lower voltage and higher current than the first generation

Table 1 Specification of 50kW inverter for fuel cell power plant

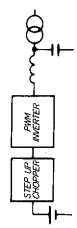
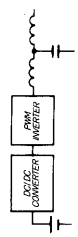
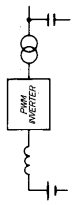
	First generation	Second generation	Third generation
Configuration of circuit			
Feature	High efficiency	Compact Low cost Low noise Low distortion	Hight efficiency Low cost Low noise Low distortion
Rated input	480A, 123V	600A, 102V	600A, 98V
Rated output	53.5kW, 62.9kVA	53.5kW, 62.9kVA	53.5kW, 62.9kVA
Efficiency	91%	88%	91%
Element	BJT	MOSFET, IGBT	MOSFET
Volume	100%	44%	83%
Weight	100%	33%	67%
Noise	60dB	55dB	55dB

Fig. 1 Configuration of the 50kW Inverter for fuel cell power plant

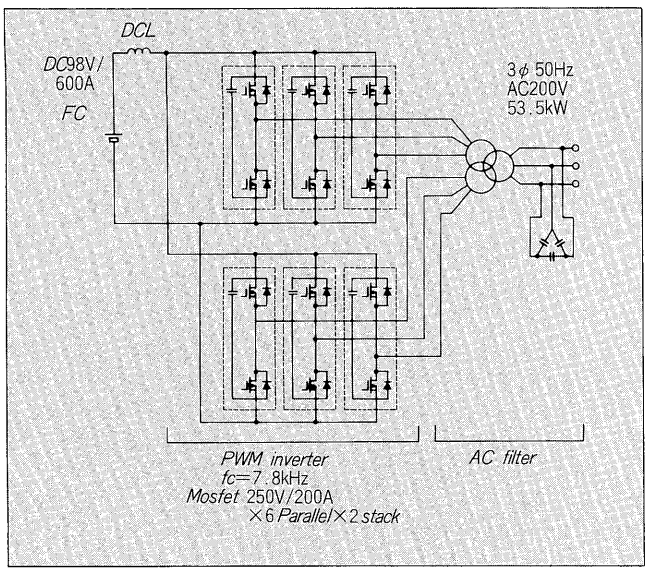


Fig. 2 Stack of the inverter

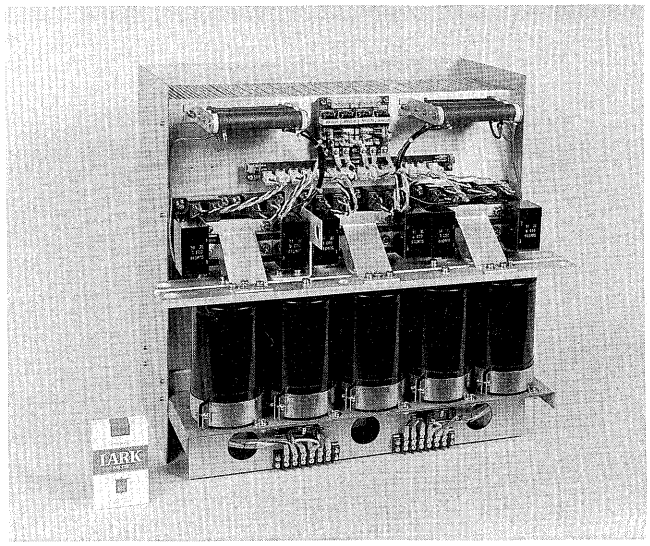
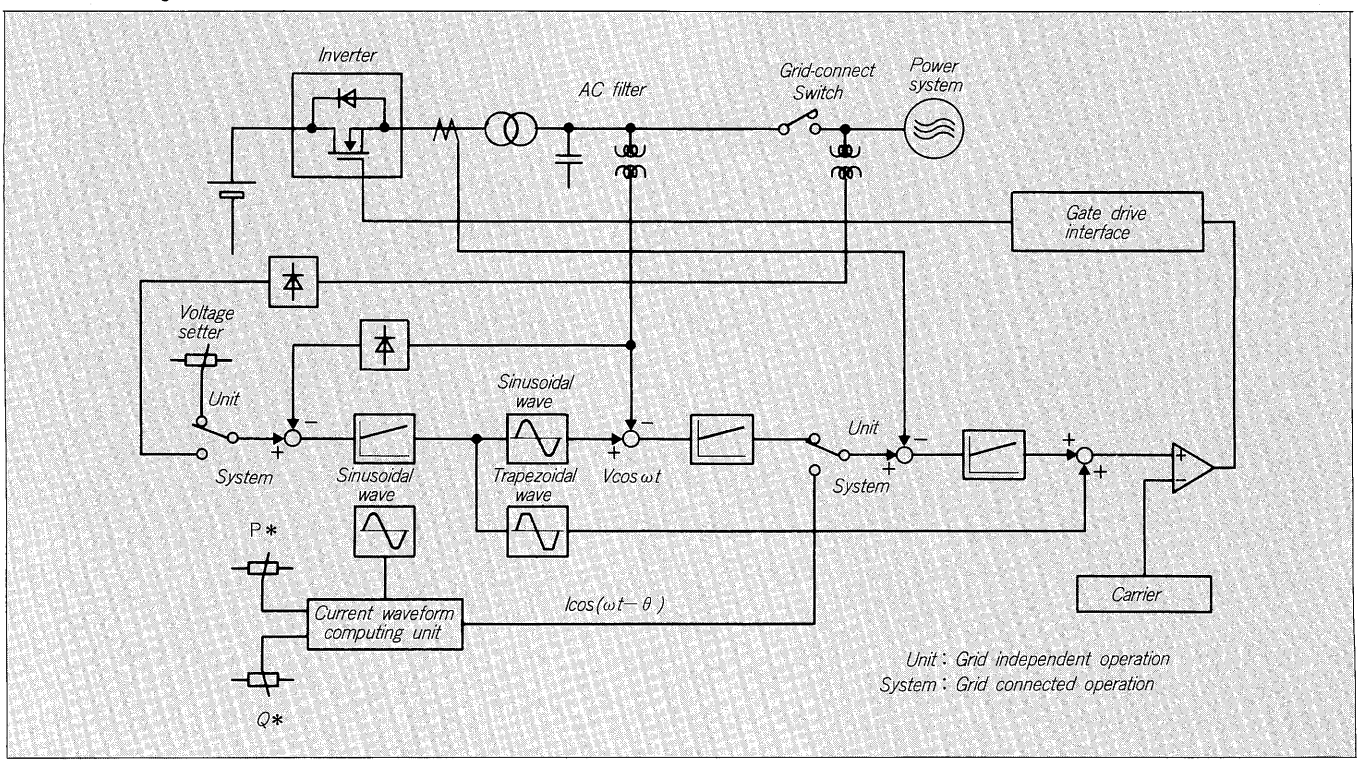


Fig. 3 Block diagram for HF PWM inverter



inverter accompanying the increase of fuel cell performance.

The features of the third generation inverter are making reduction of the number of fuel cell stacks and the cost of the entire plant by increased efficiency.

4. MAIN CIRCUIT CONFIGURATION AND CONTROL

4.1 Main circuit configuration

The configuration of the main circuit is shown in *Fig. 1*. The main circuit consists of a DC reactor + HF PWM inverter + AC filter. A step-up transformer is used as the AC filter reactor.

DCL suppresses the ripple of the input current (FC output current) to the HF PWM inverter. After the HF PWM inverter converts the fuel cell DC output voltage to AC voltage, a 3-phase low distortion AC voltage is obtained via the AC filter. Since the specified AC voltage output

Fig. 4 Output waveform of inverter (100% R load)

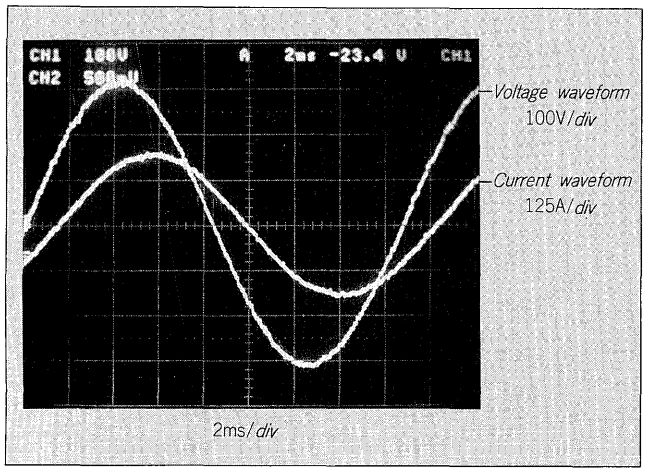
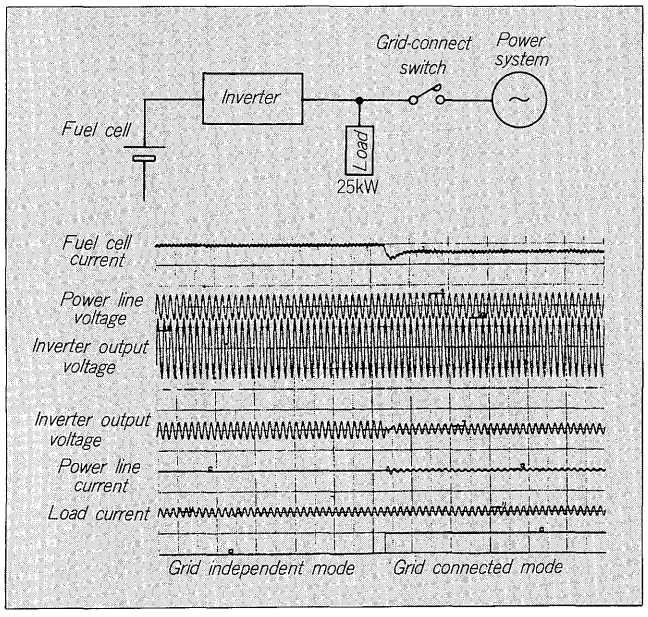


Fig. 5 Change oscillogram between grid independent operation and grid connected operation with noninterruption (25 kW→15 kW)



cannot be obtained by merely converting the DC voltage to an AC voltage, the AC voltage is stepped up by a transformer.

The inverter stack for one phase is shown in *Fig. 2*. The inverter uses this stack in a 3-phases, 2-parallel configuration.

4.2 Control

The control block diagram of the HF PWM inverter is shown in *Fig. 3*.

In grid independent operation, the output end line voltage is detected and constant voltage control is performed. The control system has a 3-stage configuration consisting of average value voltage control, voltage waveform control, and instantaneous current waveform control. A low distortion output voltage waveform is obtained by means of this, even when a rectification load is connected.

On the other hand, in grid connected operation, the current waveform necessary for active power control and reactive power control is computed and instanteneous current waveform control based on the waveform is percontrolled so that the amplitude and phase of the grid voltage and output end voltage match, the grid connected switch is closed and instantaneous current waveform control based on P/Q control is performed.

At switching from grid connected operation to grid independent operation, after P/Q control is switched to voltage control, the grid connected switch is opened. Switching without interrupt is realized with the system above.

4.3 Display and external interface

This inverter has a close relationship with the entire fuel cell power plant system. To improve operability and maintainability, a Fuji programmable controller (MICREX-F) and programmable operation display are used and operation, status display, metering display, and trouble guidance are performed.

5. TEST RESULTS

5.1 AC output voltage waveform

The AC output voltage waveform is shown in *Fig. 4*. A low distortion AC voltage waveform is obtained by means of a high performance HF PWM inverter.

5.2 Noninterruption grid independent operation/grid connected operation switching

The oscillogram for noninterruption switching between grid independent operation and grid connected operation is shown in *Fig. 5*.

6. CONCLUSION

Currently, fuel cell power plants are moving from the development stage to the practical stage. In the practical stage, low noise, high efficiency, and small size are required, as mentioned in the Foreword.

This 50kW on-site HF inverter can amply meet these needs. One-hundred kilowatt and 500kW HF inverters are being developed and tested based on this development. Since ample use of the characteristics of the fuel cell and control which flexibly corresponds to the state of the AC load are required of both of these inverters, improvements and development will also be undertaken in the future. The guidance and cooperation of all concerned parties are requested.