Novel High Efficiency UPS System

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Agenda

1. Background

2. Trend of Fuji UPS Technology

3. Series Parallel Processing Topology
   >Principal
   >Realization

4. New Products: 8000 Series (Three-phase, Large Capacity)

5. New Products: GX Series (Single-phase, Small Capacity)

6. Conclusion
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Background

1997: Kyoto Protocol

1998: Promotion of the Measures to Cope with Global Warming

2008: Law Regarding the Rationalization of Energy Use

2007: The Green Grid (DCD, PUE)

Climate Savers Computing Initiative (High Efficiency)

The function and the performance were important so far. Hereafter, efficiency becomes the most important.

Fuji Electric has worked on the development of high efficiency UPS since 2000.
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## Trend of Fuji UPS Technology

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power Device</strong></td>
<td>Thyristors</td>
<td>GTO Power Transistors</td>
<td>MOSFET</td>
<td>IGBT</td>
<td>IPM</td>
<td>Compact, High efficiency, More reliability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Self arc-suppression, Rapid Switching, Low Loss, Low Drive Power]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Topologies</strong></td>
<td>Online Double conversion</td>
<td>Line Interactive</td>
<td>New Conversion</td>
<td></td>
<td></td>
<td>Low cost, High Efficiency, (Energy Saving)</td>
<td></td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td>Contact</td>
<td>Serial Port</td>
<td></td>
<td></td>
<td></td>
<td>High Reliability, User Friendly</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1st. Gen. LAN Applicable (network OS)</td>
<td></td>
<td></td>
<td>2nd. Gen. LAN (SNMP etc)</td>
<td>Auto Shutdown at Blackout, Scheduled Operation, Total Managing System</td>
<td></td>
</tr>
<tr>
<td><strong>Inverter</strong></td>
<td>Multiplied Inverter</td>
<td>Low Freq. PWM (Carrier F ≤ 1kHz)</td>
<td>High Freq. PWM (Carrier F ≥ 5kHz)</td>
<td></td>
<td></td>
<td>Compact in size</td>
<td></td>
</tr>
<tr>
<td><strong>Rectifier</strong></td>
<td>6 Pulse, 12 Pulse Rectifier</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low THDi, Higher Spec (High Pf-in)</td>
<td></td>
</tr>
<tr>
<td><strong>Controller Control Dev. Control Top.</strong></td>
<td>Discrete IC, LSI</td>
<td>Microprocessor, DSP, ASIC</td>
<td>Digital Control</td>
<td></td>
<td></td>
<td>High Reliability, User Friendly, Higher Spec, Non-linear load</td>
<td></td>
</tr>
<tr>
<td><strong>Storage Batteries</strong></td>
<td>Catalytic Plug</td>
<td>Valve Regulated Lead Acid</td>
<td>Capacitors, FW</td>
<td></td>
<td></td>
<td>Maintenance, Lifetime Downsizing, Environment, RoHS</td>
<td></td>
</tr>
</tbody>
</table>
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### Series Parallel Processing Topology

**What is Suitable Principal for High Efficiency?**

<table>
<thead>
<tr>
<th></th>
<th>Voltage Stability</th>
<th>Reduce Volume</th>
<th>Efficiency</th>
<th>Suitable for UPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double Conversion</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Parallel Processing</td>
<td>Low</td>
<td>Mid</td>
<td>High</td>
<td>Mid</td>
</tr>
<tr>
<td>SMR+Inv.</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Mid</td>
</tr>
<tr>
<td>Direct Conversion</td>
<td>High</td>
<td>Mid</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Line Interactive</td>
<td>Mid</td>
<td>Low</td>
<td>Mid</td>
<td>Mid</td>
</tr>
<tr>
<td>Series Processing</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

We need new Topology!!

---

Series Parallel Processing Topology
Series Parallel Processing Topology

Why do we choose Series Parallel Processing Topology?

Double Conversion

High Performance
Low Efficiency

Parallel Processing

Low Performance
High Efficiency

Series Parallel Processing

High Performance
High Efficiency
Series Parallel Processing Topology

Principal

Series Processing

Parallel Processing

Voltage Compensator

Active Filter

Series Parallel Processing

Series Conv. : Voltage Compensator Function

Parallel Conv. : Active Filter & Parallel Inverter Function
Series Parallel Processing Topology

Realization: Three-Phase System

How did we achieve smooth changing operation?

<Normal Mode>

Alternate Switching

Active filter & PFC
Series Parallel Processing Topology

Realization: Three-Phase System

<Back-Up Mode>

Transition Period:
High Gain AVR operation

Non Interruption!
Series Parallel Processing Topology

Realization: Single-Phase System

How did we achieve without using the transformer?

Easy to Compose the Series Converter with a Transformer. However, the miniaturization of the device of small capacity disturbed by the Transformer.

Furthermore we need DC Power Source.
Series Parallel Processing Topology

Realization: Single-Phase System
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New Products: 8000 Series

Features

1. High Efficiency : 98%
2. Non Interruption
3. High reliability : (N+1) Redundant systems

System / Circuit configurations

[Diagram of UPS 8000D system configurations]

Operation Waveforms

[Graphs showing operation waveforms]
## Specifications

<table>
<thead>
<tr>
<th>UPS System</th>
<th>Dual processing method (Standby redundancy operation possible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated output capacity (kVA)</td>
<td>100 150 200 250 300 400 500 600 750 1000 1500 2000</td>
</tr>
<tr>
<td>Switching time on service interruption</td>
<td>No short break</td>
</tr>
<tr>
<td>AC input Number of phases</td>
<td>Three-phase, three-wire</td>
</tr>
<tr>
<td>Voltage</td>
<td>200 V +/-15%</td>
</tr>
<tr>
<td>Frequency</td>
<td>50/60Hz (+/-1 to +/-5% selectable for setting)</td>
</tr>
<tr>
<td>Power factor</td>
<td>0.98 or more (At the rating)</td>
</tr>
<tr>
<td>Direct transmission input Number of phases</td>
<td>Three-phase, three-wire</td>
</tr>
<tr>
<td>Voltage</td>
<td>Same as the AC output voltage</td>
</tr>
<tr>
<td>AC output Voltage</td>
<td>200V or 415V, 3-phase</td>
</tr>
<tr>
<td>Frequency</td>
<td>Same as the input, except for +/-0.01% when operated on battery</td>
</tr>
<tr>
<td>Load power factor</td>
<td>0.8 (lag) to 1.0 (Rated at 1.0)</td>
</tr>
<tr>
<td>Voltage accuracy (When set)</td>
<td>In AVR mode: +/-2% or less</td>
</tr>
<tr>
<td></td>
<td>In ECO mode: +/-5% or less (Selectable for setting)</td>
</tr>
<tr>
<td>Transient voltage fluctuation</td>
<td>+/-5% or less (Load 0 &lt;= 100%)</td>
</tr>
<tr>
<td>Voltage waveform distortion factor</td>
<td>5% or less</td>
</tr>
<tr>
<td>Overload capacity</td>
<td>In normal condition: 125% for 10 minutes, 200% for one minute, 1000% for one cycle.</td>
</tr>
<tr>
<td></td>
<td>During service interruption: 150% for one minute.</td>
</tr>
</tbody>
</table>
New Products: 8000 Series

Example of Parallel Operation System

Max 8-Parallel / Redundancy
New Products: 8000 Series

Example of Parallel Operation Waveforms

Breakdown Mode

![Waveform diagram with parallel operation waveforms and circuit diagrams showing 3-parallel and 2-parallel operations.]

- Out-Put
  - Voltage
- Out-Put
  - Current
- No 1
- No 2
- No 3
- Warning
- No 1 MC3

- No 1-MC3 Opened
- No 1-Fuse Blown

- 3-Parallel Operation
- 2-Parallel Operation

No 1
No 2
No 3
MC3

Loses

- Breakdown Mode
## New Products: 8000 Series

### Comparison in Efficiency and Loss (Example at 80kW)

<table>
<thead>
<tr>
<th>Series</th>
<th>Output (kW)</th>
<th>Efficiency (%)</th>
<th>Loss (kW)</th>
<th>Power Consumption of Air-Conditioning Unit (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional UPS</td>
<td>80</td>
<td>88</td>
<td>10.9</td>
<td>3.9</td>
</tr>
<tr>
<td>8000 Series</td>
<td>80</td>
<td>98</td>
<td>1.6</td>
<td>0.45</td>
</tr>
</tbody>
</table>

### Comparison in Electric Charge (Example at 100kVA)

<table>
<thead>
<tr>
<th>Item</th>
<th>Result</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difference in UPS loss</td>
<td>9.3kW</td>
<td>=10.9kW-1.6kW</td>
</tr>
<tr>
<td>Difference in air-conditioning power consumption</td>
<td>3.45kW</td>
<td>=3.9kW-0.45kW</td>
</tr>
<tr>
<td>Electric power improved</td>
<td>12.75kW</td>
<td>=9.3kW+3.45kW</td>
</tr>
<tr>
<td>Annual electric energy reduced</td>
<td>111,690kWh</td>
<td>=12.75kW x 24h x 365days</td>
</tr>
<tr>
<td>Electric charge saved (Annual)</td>
<td>1.68 million yen / year</td>
<td>Electricity rate of 15 yen/kWh</td>
</tr>
<tr>
<td>Amount of CO₂ cut back</td>
<td>41.4t</td>
<td>CO₂ emission rate of 0.371kg-amount of CO₂/kWh</td>
</tr>
</tbody>
</table>

The 8000 Series leads to a **substantial cutback of running cost** and reduction of CO₂ emissions. It can therefore be termed **environment-friendly and suitable Green-IDC systems**.

*When operated continuously all year around under 100% load.*
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New Products: GX Series

Features

1. High Efficiency
   : 96.7% (3000VA)
2. Non Interruption

System / Circuit configurations

Operation Waveforms

Change from 165V to 235V
Change from 235V to 165V
# New Products: GX Series

## Specifications

<table>
<thead>
<tr>
<th>Series</th>
<th>Input</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capacity ( kVA )</td>
<td>Phase</td>
</tr>
<tr>
<td></td>
<td>0.7, 1.4, 3.0, 5.0, 7.5, 10</td>
<td>Single-Phase / 2-Wire</td>
</tr>
<tr>
<td></td>
<td>220 / 230 ( +25%, -25% )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>85 - 138 ( Wide Range )</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1, 1.5, 2.0, 3.0, 5.0, 7.5, 10</td>
<td>Single-Phase / 2-Wire</td>
</tr>
<tr>
<td></td>
<td>5 - minutes</td>
<td></td>
</tr>
</tbody>
</table>

- 220 / 230 ( +25%, -25% )
- 240 ( +20%, -20% )
- 85 - 138 ( Wide Range )
- 100, 105, 110, 115, 120 ( +2%, -2% )
- Selectable on Dip Switches
## New Products: GX Series

### Comparison in Efficiency and Loss

<table>
<thead>
<tr>
<th>Series</th>
<th>Voltage ( % )</th>
<th>Efficiency ( % )</th>
<th>Loss ( W )</th>
<th>Conversion Loss ( W )</th>
</tr>
</thead>
<tbody>
<tr>
<td>GX: 3000VA</td>
<td>75</td>
<td>92.8</td>
<td>187</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>96.7</td>
<td>83</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>94.9</td>
<td>129</td>
<td>81</td>
</tr>
<tr>
<td>Conventional</td>
<td>85</td>
<td>85.1</td>
<td>426</td>
<td>251</td>
</tr>
<tr>
<td>J: 3000VA</td>
<td>100</td>
<td>87.1</td>
<td>361</td>
<td>190</td>
</tr>
<tr>
<td></td>
<td>115</td>
<td>88.5</td>
<td>316</td>
<td>156</td>
</tr>
<tr>
<td>GX: 700VA</td>
<td>75</td>
<td>90.4</td>
<td>47</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>96.6</td>
<td>16</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>92.8</td>
<td>35</td>
<td>23</td>
</tr>
<tr>
<td>Conventional</td>
<td>85</td>
<td>84.3</td>
<td>151</td>
<td>100</td>
</tr>
<tr>
<td>J: 1000VA</td>
<td>100</td>
<td>86.6</td>
<td>126</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>115</td>
<td>88.3</td>
<td>108</td>
<td>63</td>
</tr>
</tbody>
</table>

The GX Series is a high efficiency UPS. It means a substantial cutback of running cost and environment-friendly and suitable Server systems.
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Conclusion

Fuji Electric has worked on the development of high efficiency UPS since 2000.

New Topology: Series Parallel Processing Topology

8000 Series: Large Capacity (100kVA - 2,000kVA)
High Efficiency and High Performance
Suitable Green-IDC

GX Series: Small Capacity (0.7kVA - 10kVA)
High Efficiency, For Server

Fuji Electric Systems works on strategic development of new circuit topology and further, high efficiency UPS System aiming at the achievement of the Sustainable Society.
Thank You!

Contact: okuma-yasuhiro@fesys.co.jp