

Rev.27.01  
2010.2.2

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# Renesas Power MOS FETs, IGBTs, Triacs, and Thyristors General Presentation

# **Renesas Power MOS FETs, IGBTs, Triacs, and Thyristors General Presentation January 2010**

Renesas Technology Corp.  
Standard Product Business Group

2/2/2010 Rev.27.01

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# Power MOS FETs

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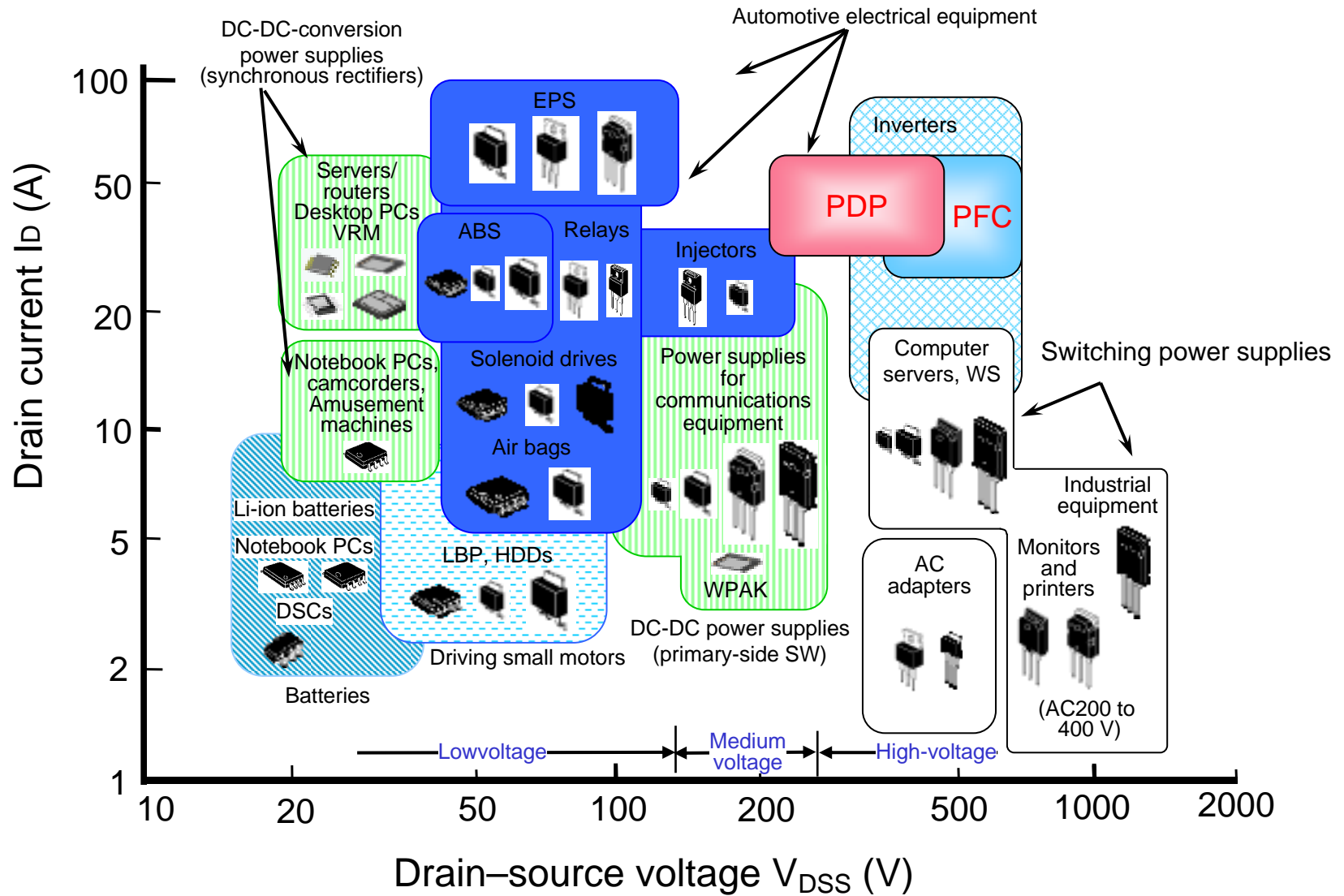
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# Power MOS FETs

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## Applications, Development Trends

# Power MOS FET and IGBT Application Map



# Power MOS FET Trend by Applications

| Field                    | Applications   | Technical trend  | How the power MOS FET suits the task  |
|--------------------------|--|--|---|
| AV                       | PDP  | <ul style="list-style-type: none"> <li>Low power consumption, high brightness</li> <li>Sustained trend for compact modules, bridge method (HIC)</li> </ul>   | <ul style="list-style-type: none"> <li>Medium, high-voltage of 200 to 600 V: Low input capacitance, development of 6th gen. high-voltage series</li> <li>Wafer supply</li> </ul>  |
| Switching power supplies | Network-related devices, AC-DC power supplies                            | <ul style="list-style-type: none"> <li>Harmonic regulation supported Power-factor correction (PFC) circuit included</li> <li>Soft-switching method (ZVS)</li> <li>Secondary synchronous rectification</li> </ul> | <ul style="list-style-type: none"> <li>Medium, high-voltage of 250 to 600 V: Low input capacitance, development of 6th gen. high-voltage series</li> <li>Avalanche tolerance guaranteed, built-in high-speed diode (UPS)</li> <li>Ultra-low on-resistance, low Qg, low Qgd, development of 11th gen. low-voltage series</li> <li>Low-voltage of 30 to 100 V</li> </ul>                                      |
|                          | Servers, routers, Telecom., communications devices, DC-DC power supplies | Isolated type <ul style="list-style-type: none"> <li>2-device/4-device bridge method</li> <li>Active clamp method</li> <li>Secondary synchronous rectification</li> </ul>  | <ul style="list-style-type: none"> <li>Development of 10th gen. power MOS FETs for low/medium voltage of 80 to 100 V, driven by 7 to 10 V. Trench-power MOS FETs for medium voltage of 150 to 250 V, low Ron and low Qgd series.</li> <li>Ultra-low on-resistance, low Qg, low Qgd, development of 10th gen. low-voltage of 30 to 100 V series.</li> </ul>  |
|                          | Distributed power-supply systems   | Non-isolated type <ul style="list-style-type: none"> <li>Synchronous rectification converter</li> <li>Multi-phase adopted</li> <li>Small and thin</li> <li>POL (point of load)</li> </ul>                        | <ul style="list-style-type: none"> <li>Low-voltage of 12 to 30 V, driven by 2.5 to 10 V</li> <li>Ultra-low on-resistance, low Qg, development of 11th gen. low-voltage series</li> <li>Development of Composite and integration (built-in SBD and driver IC circuit)</li> <li>MOS FET (SOP-8, WPAK, QFN56, QFN40)</li> <li>Small, thin, low-resistance, thermal-resistance Package (LFPAK, WPAK)</li> </ul> |
| Batteries                | Mobile phones, Notebook PCs, DSCs  | <ul style="list-style-type: none"> <li>Li-ion battery used</li> <li>Highly functional → Increased current capacity</li> <li>Quick response →</li> <li>Small and thin</li> </ul>                                  | <ul style="list-style-type: none"> <li>P-ch 8th gen. Ultra-low Ron, two devices in one chip (WPAK)</li> <li>Low-voltage drive: 1.8 to 2.5 V ultra-small and thin Package (CMFPAK-6)</li> <li>Wafer supply</li> <li>Dual-type ultra-small and-thin package (CMFPAK-6)</li> </ul>   |
| Motor control            | Small motors (PPCs, printers, HDDs), inverters, high-functional robots   | <ul style="list-style-type: none"> <li>Small, low power consumption</li> <li>High precision, quick response</li> <li>Low noise</li> <li>Directly driven by microcomputer</li> </ul>                              | <ul style="list-style-type: none"> <li>Medium, high-voltage: 150 to 600 V, DP-8, development of TO-92M series</li> <li>Development of 8th gen. low-voltage SOP-8 (including 2-device packages) series</li> <li>Built-in high-speed diode</li> <li>Development of 6th gen. high-voltage series</li> </ul>  |



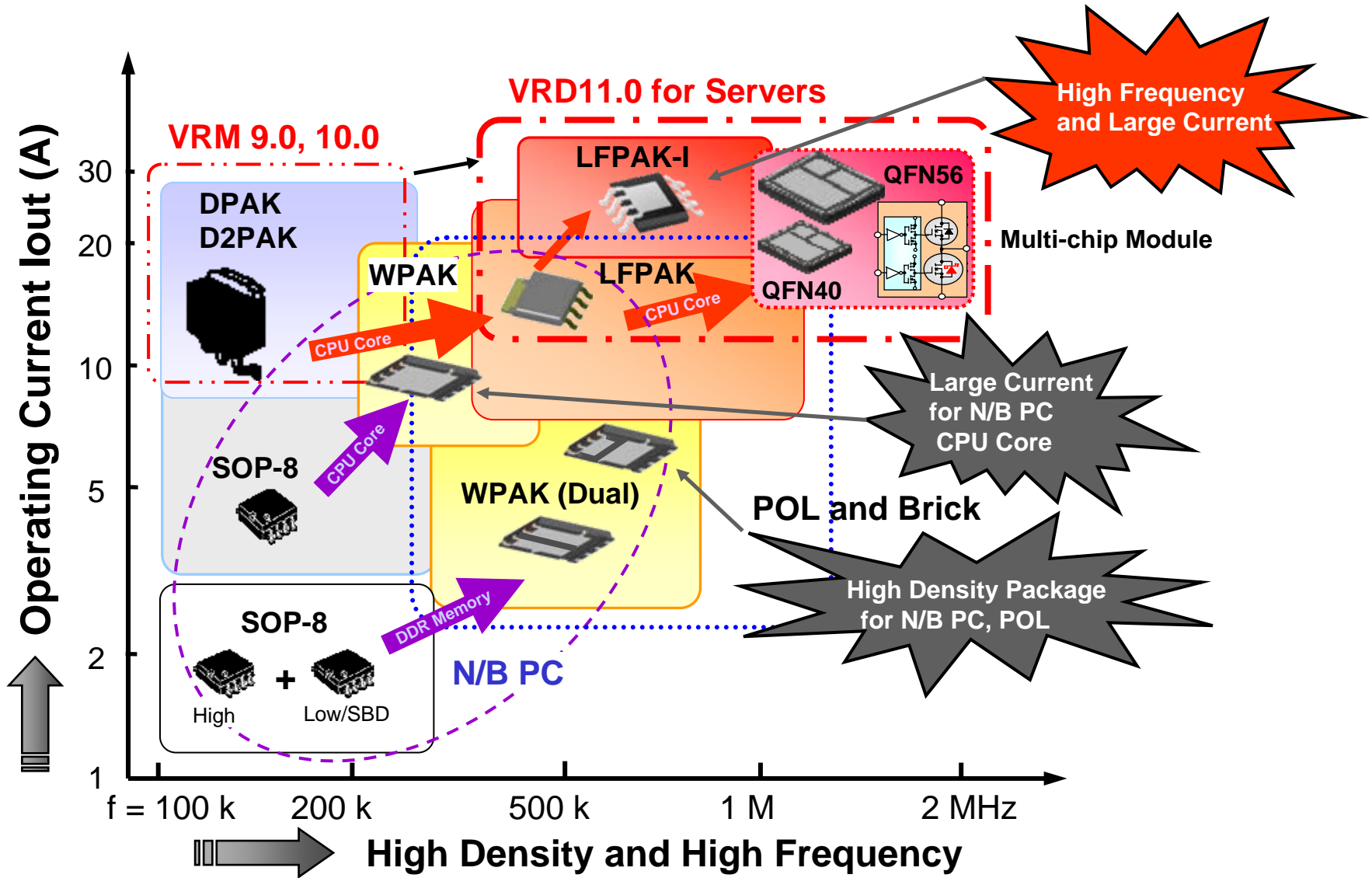
# Power MOS FETs

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## Low-Voltage Power MOS FETs

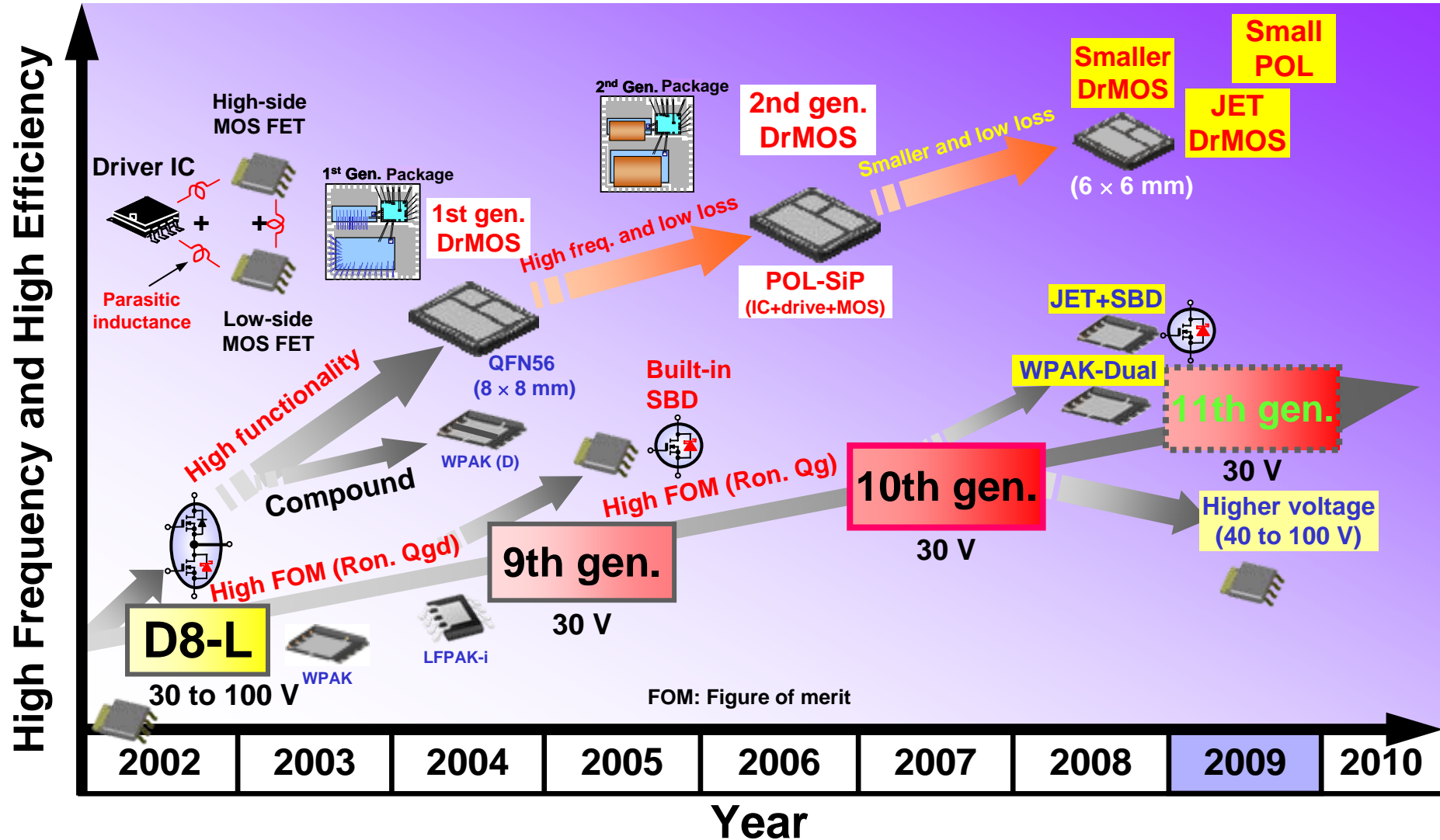
$V_{DSS} = 12\text{ V to }100\text{ V}$

# Low-Voltage MOS FET Package Trend



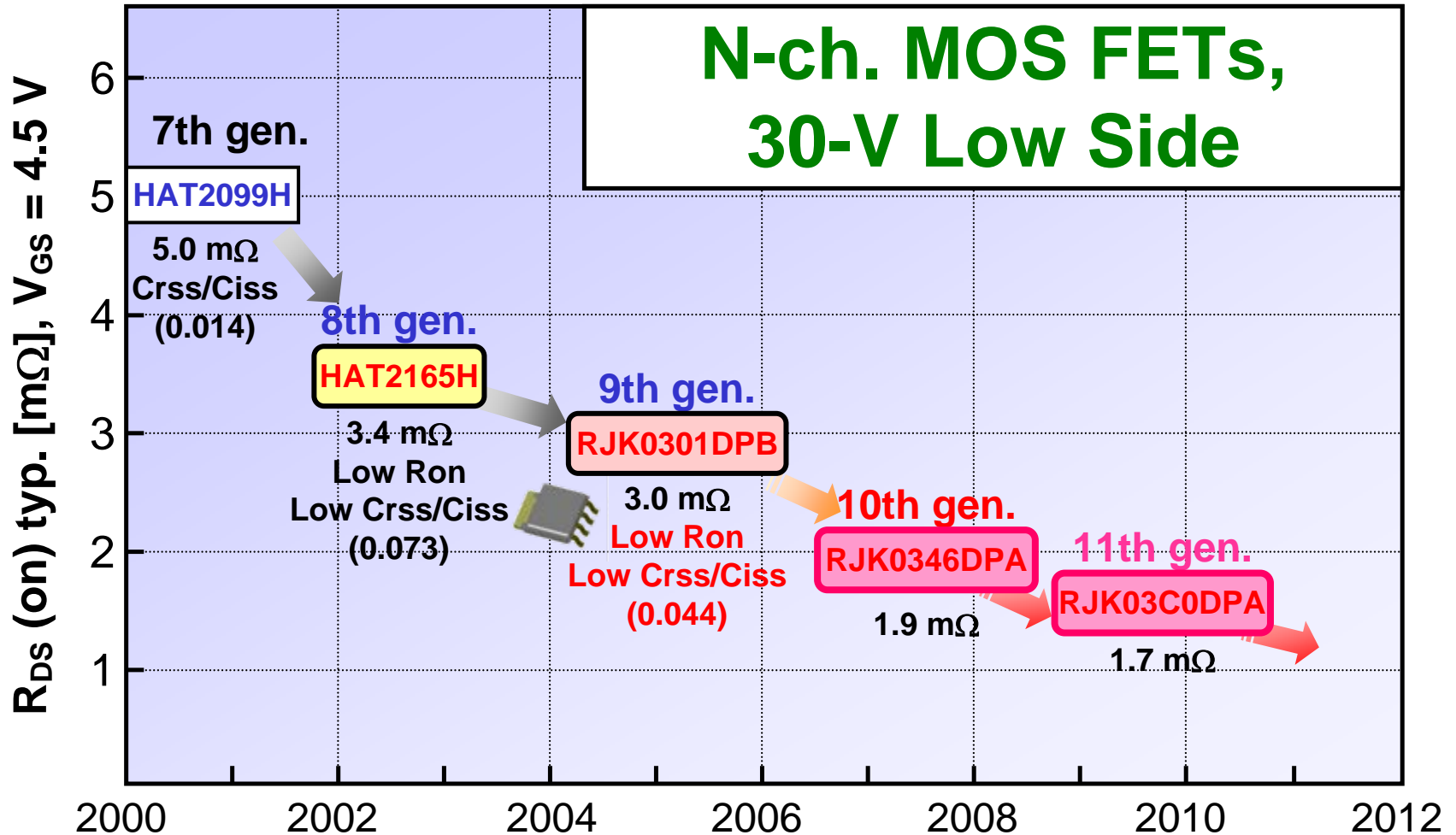
# Roadmap of Power MOS FETs for Highly Efficient Power Supplies

- For Low Loss and More Compact Products -



# Roadmap of On-Resistance for Low-Voltage Power MOS FETs

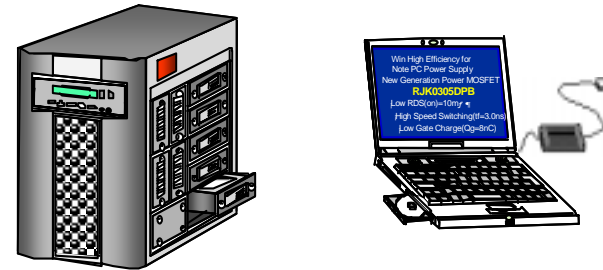
## Power MOS FET Technologies and Trend in $R_{DS(on)}$



# Recommended Applications of Low-Voltage MOS FETs for Highly Efficient Power Supplies

- DC-DC **voltage regulators** for driving CPUs, GPUs, memory, etc.

Servers, other network, telecommunications, notebook PCs, VGA



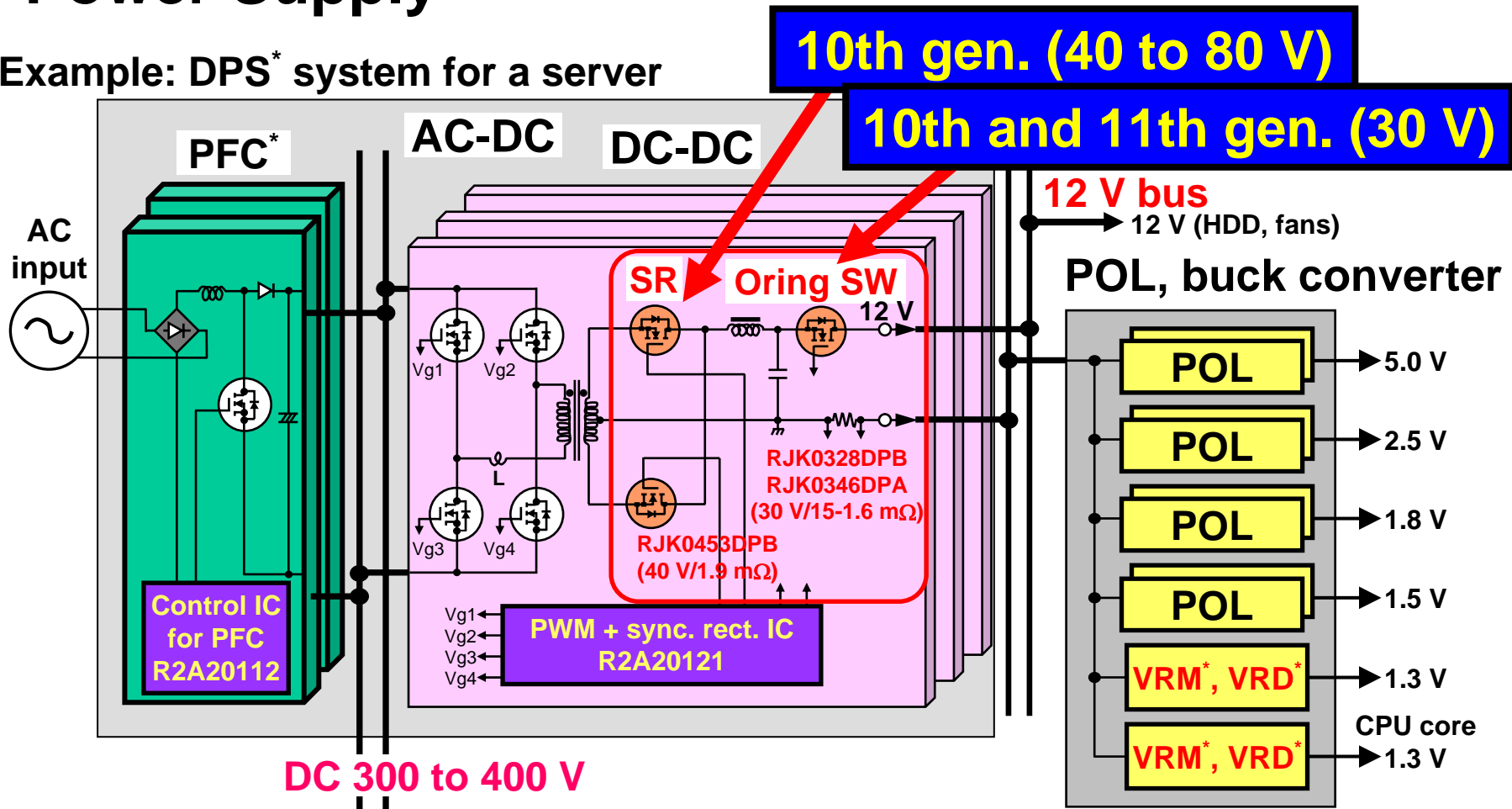
- Isolating **bus converters in brick casings** (primary and secondary sides)  
**Secondary-side synchronous rectifiers** for AC-DC power supplies, **ORing switches**

Servers, routers, telecommunications

- Power management switches (Li-ion battery protection for notebook PCs, etc.)

# Sample Application: Secondary-Side Synchronous Rectification and ORing Switch for AC-DC Power Supply

Example: DPS\* system for a server



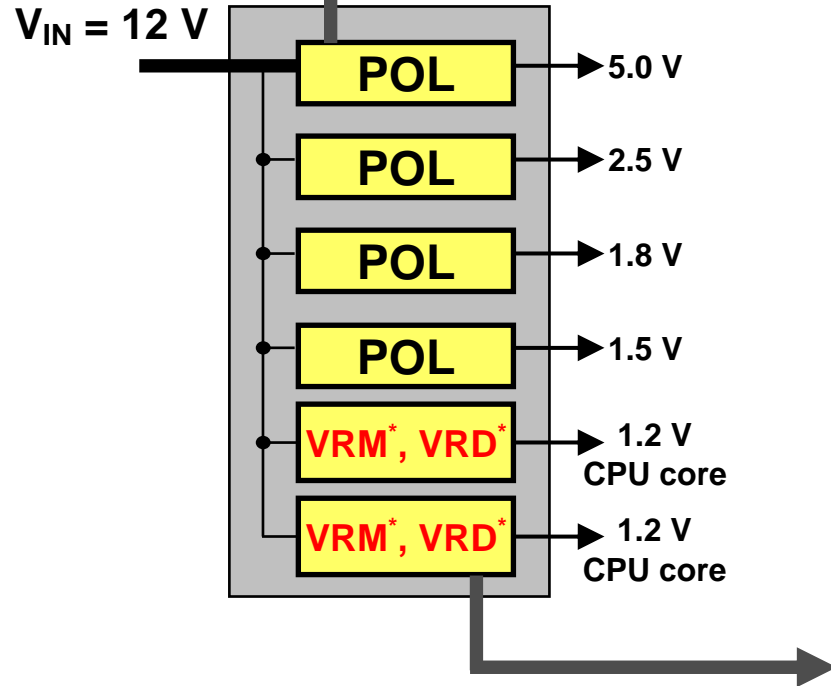
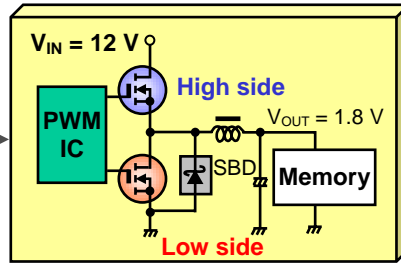
\*SR: Synchronous rectifier  
 \*DPS: Distributed power supply  
 \*PFC: Power factor correction circuit

\*POL: Point of load  
 \*VRM: Voltage regulator module  
 \*VRD: Voltage regulator down

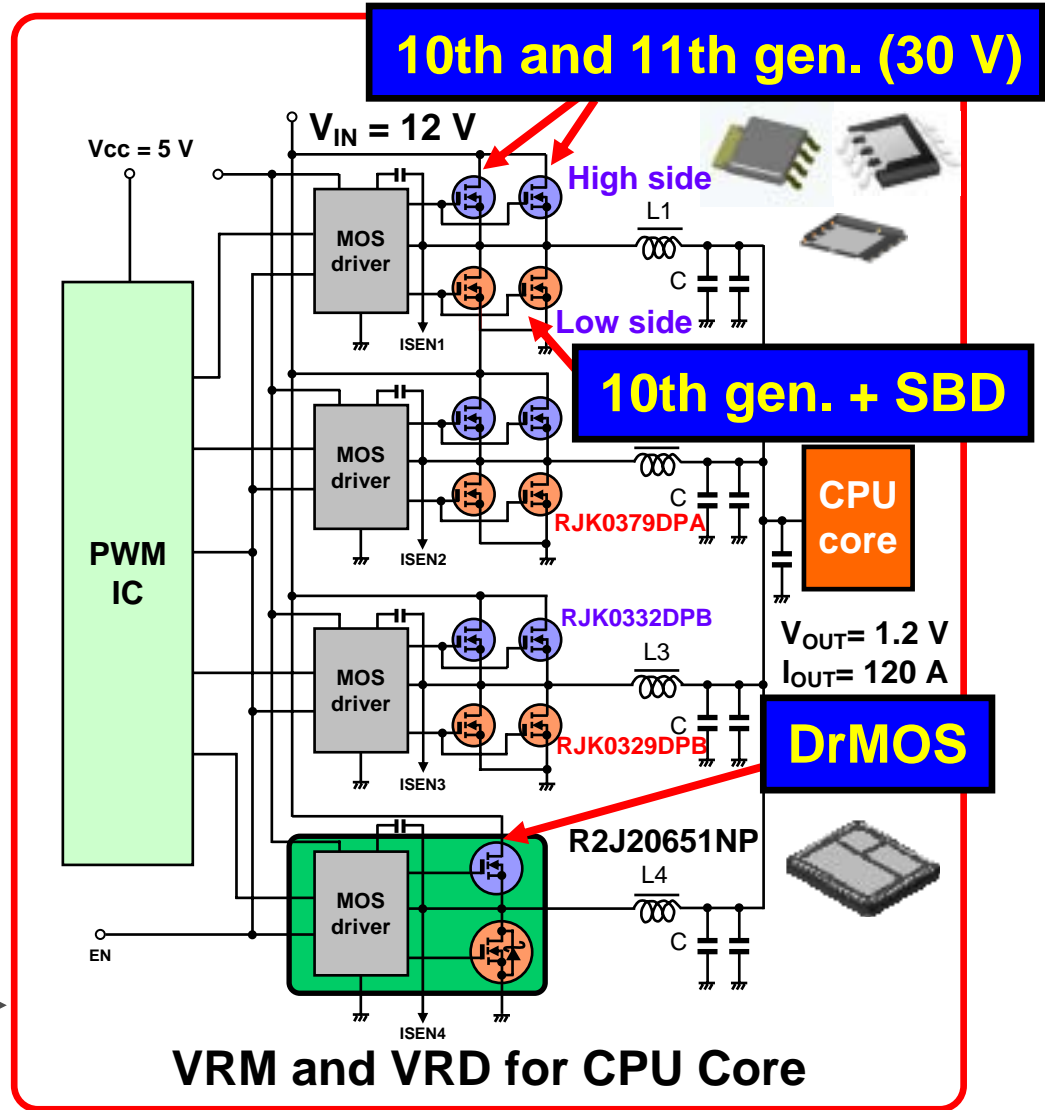
# Sample Application: Power Voltage Regulator

- \*POL: Point of load
- \*VRM: Voltage regulator module
- \*VRD: Voltage regulator down

POL



Buck converter

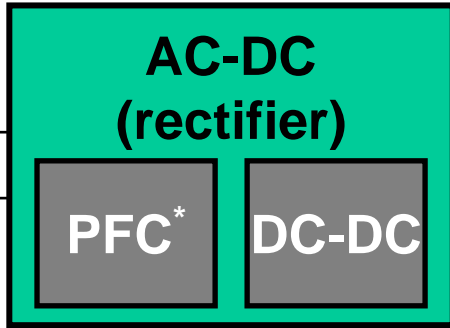


VRM and VRD for CPU Core

# Sample Application: Isolating Bus Converters in Brick Casings

**10th gen. (40 to 100 V)**

AC input

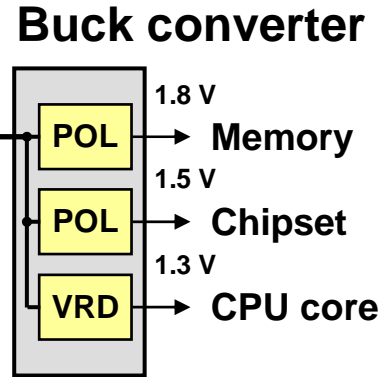
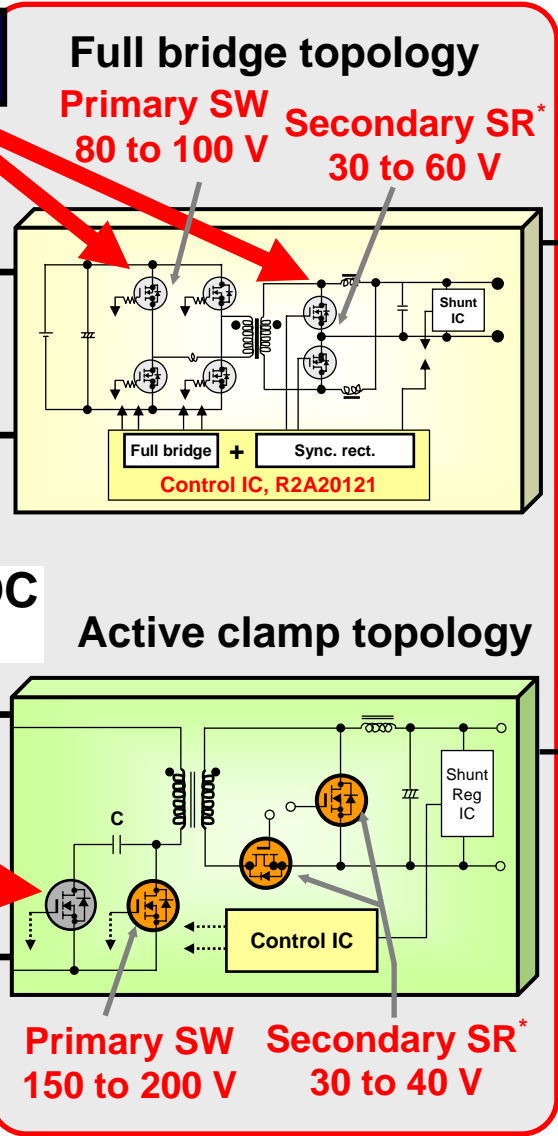


Power supply system for networks and telecommunications

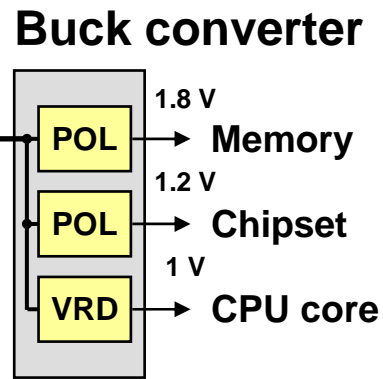
**New product Trench structure (150 to 250 V)**

\*PFC: Power factor correction Circuit  
\*SR: Synchronous rectifier

48-VDC bus



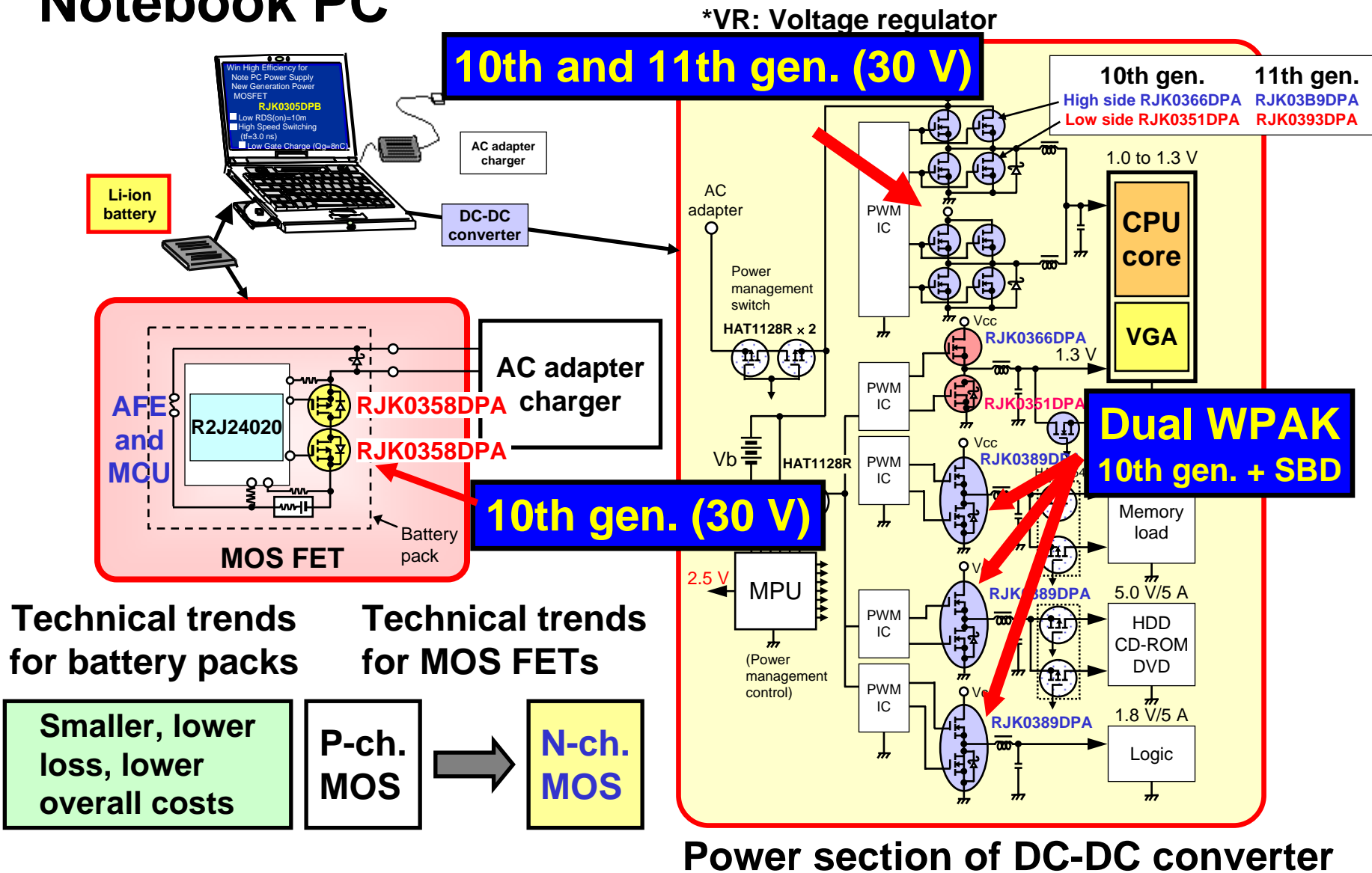
3.3- to 12-V bus



3.3- to 5-V bus



# Sample Application: Li-ion Battery for Notebook PC



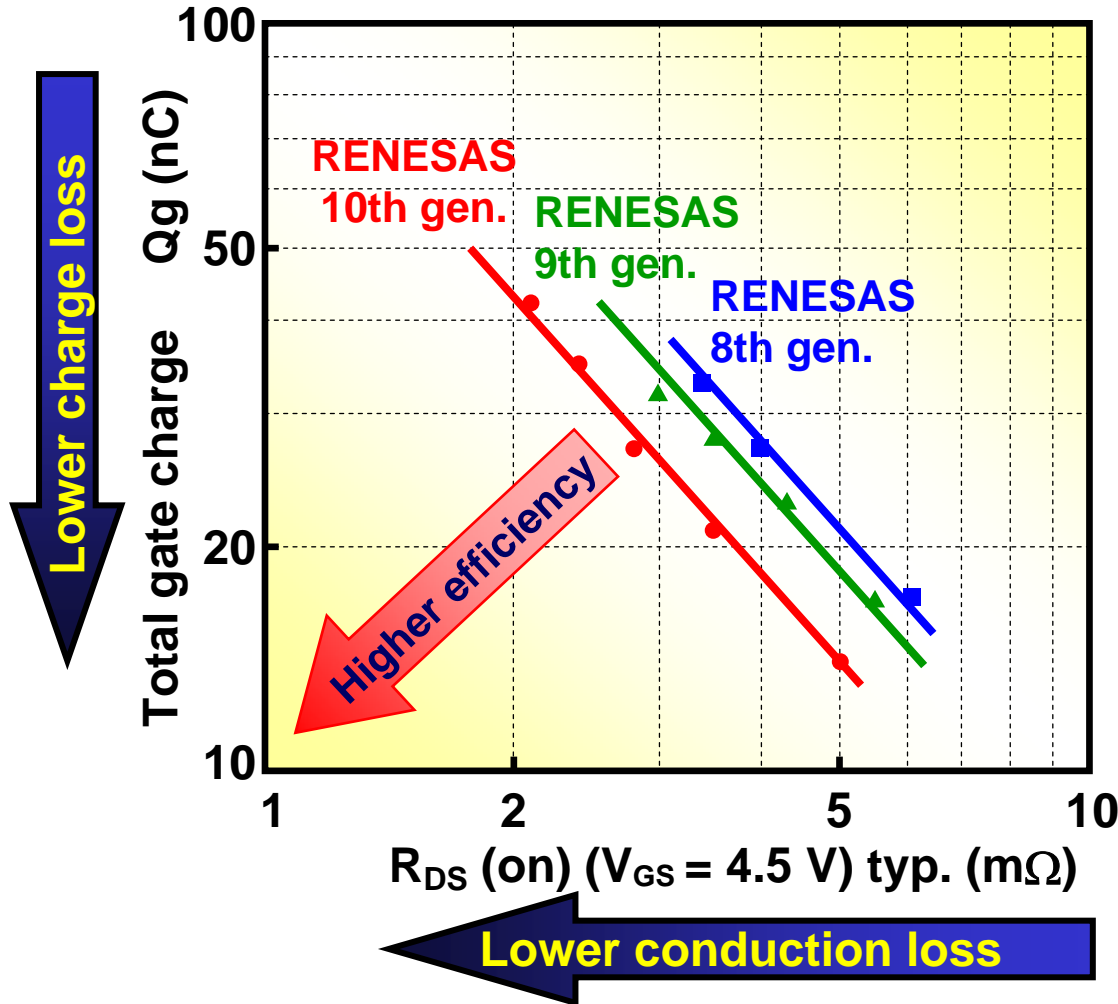
# Power MOS FETs

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## 10th Generation Power MOS FETs ( $V_{DSS}= 30 \text{ V}$ )

# Performance of 10th Generation Power MOS FETs ( $V_{DSS} = 30\text{ V}$ )

● Figure of merit: FOM ( $R_{on} \cdot Q_g$ ) at  $V_{GS} = 4.5\text{ V}$



9th gen. series  
97  $m\Omega$  (nC)



20% cut  
(improved)

10th gen. series  
78  $m\Omega$  (nC)

# Features of 10th Gen. Power MOS FETs

**30% Cut in  $R_{DS(on)}$**   
**Ultra low  $R_{DS(on)}$**

Comparison with  
9th generation

Lower loss leads to less heat  
generation from the package.

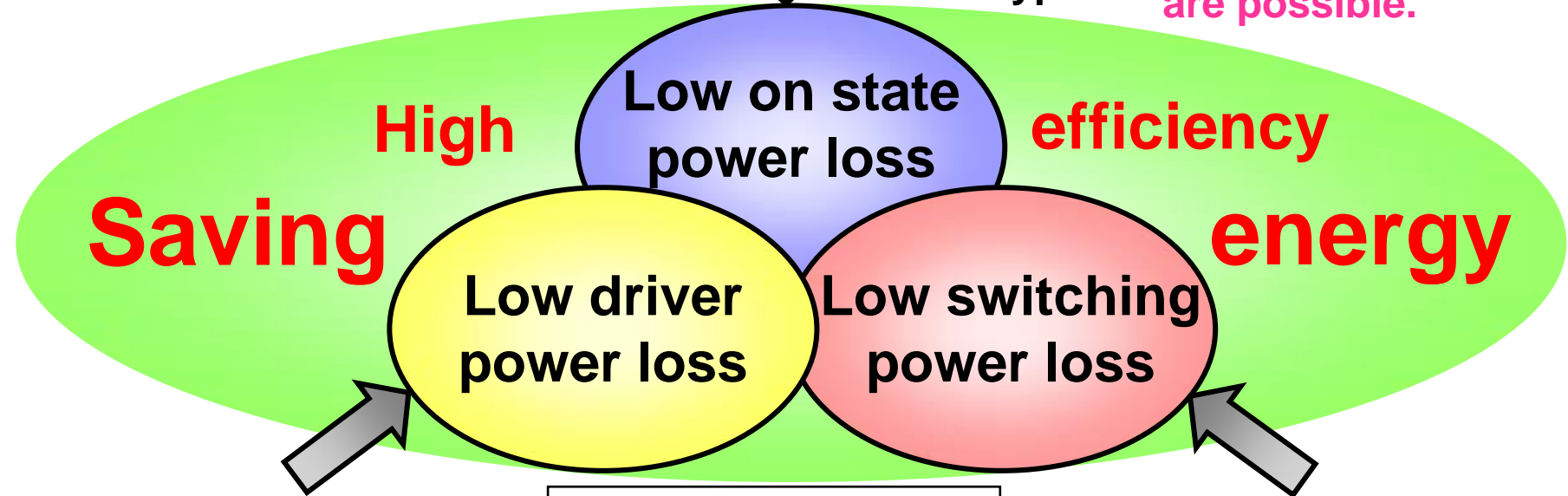
LFPAK  
WPAK  
SOP-8

↓

1.6 mΩ typ.  
1.5 mΩ typ.  
2.6 mΩ typ.

Lower Ron: lower voltage  
for a given current

- Larger currents  
are possible.



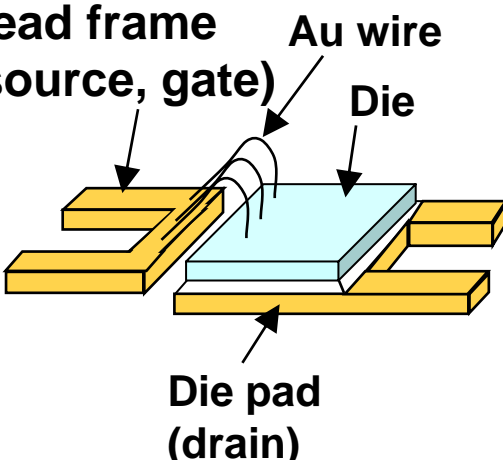
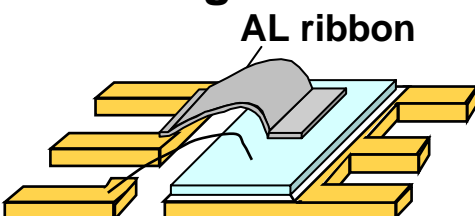
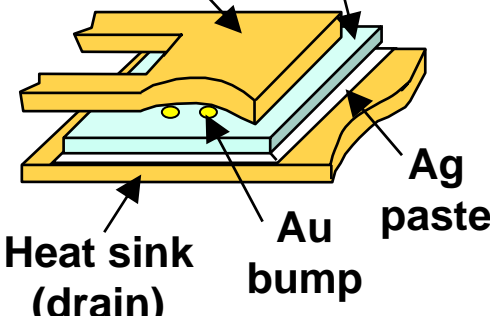
**27% Cut in  $Q_g$**   
**Low  $Q_g$**

Higher frequency and  
faster response  
characteristics for  
power supplies

**30% Cut in  $Q_{gd}$**   
**Low  $Q_{gd}$**

**Making possible smaller and thinner in size**

# Package Structures for the 10th Generation

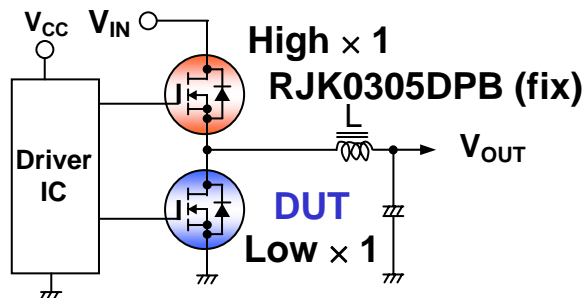
| To the 9th generation<br>SOP-8, WPAK (Au-wire)   | 10th generation series  |   |
|--|---|---|
|  | SOP-8, WPAK (AL ribbon)   | LFPACK (Au Bump)  |
|  <p>Lead frame (source, gate)<br/>Au wire<br/>Die<br/>Die pad (drain)</p> |  <p>Aluminum ribbon bonding<br/>AL ribbon</p> |  <p>Lead (source, gate) Die<br/>Heat sink (drain)<br/>Au bump<br/>Ag paste</p> |

Up to 1.0 mΩ 

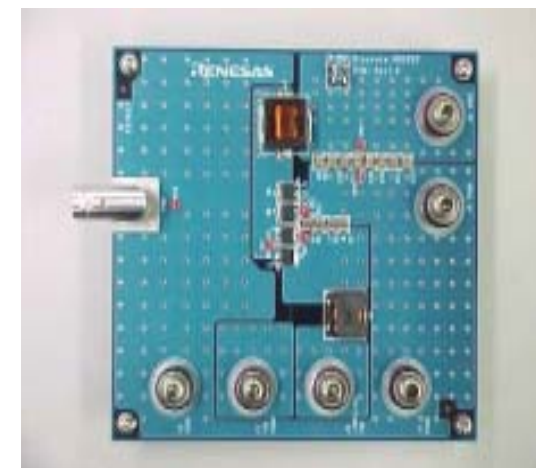
Up to 0.5 mΩ

Resistance of package wires is halved  
(contributing to lower on-resistance).

# Data from Efficiency Evaluation of 10th Generation Products



Renesas discrete evaluation board  
 $T_a = 25 \text{ }^\circ\text{C}$ , no air flow  
 $L = 0.45 \mu\text{H}$

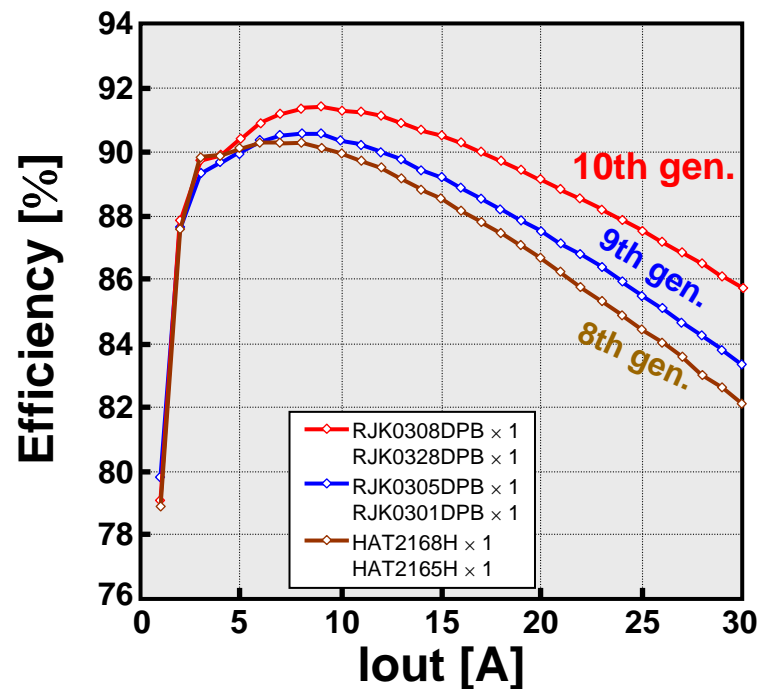
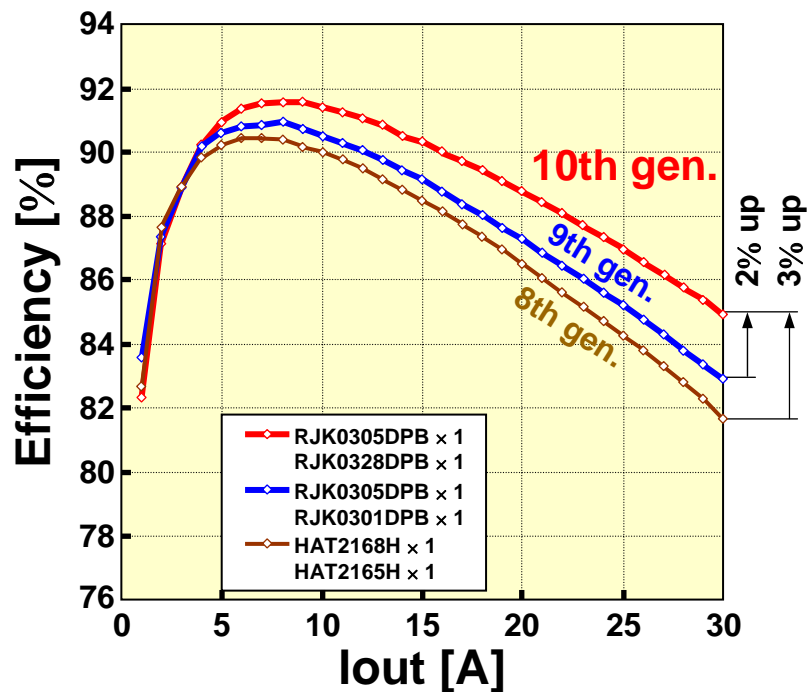


## Test conditions

$V_{IN} = 12 \text{ V}$ ,  $V_{OUT} = 1.2 \text{ V}$   
 $V_{DR} = 5 \text{ V}$ ,  $f_{sw} = 500 \text{ kHz}$

## Test conditions

$V_{IN} = 19 \text{ V}$ ,  $V_{out} = 1.2 \text{ V}$   
 $V_{DR} = 5 \text{ V}$ ,  $f_{sw} = 300 \text{ kHz}$



# Lineup of 10th Generation Products in LFPAK Package

for low-side switch and synchronous rectifier  
 for high-side switch

| No. | Part No.   | Maximum Rating       |                      |                    |          | R <sub>DS</sub> (on) (mΩ) |      |                        |      | Qgd (nC) | Qg (nC) | Schedule |    |
|-----|------------|----------------------|----------------------|--------------------|----------|---------------------------|------|------------------------|------|----------|---------|----------|----|
|     |            | V <sub>DSS</sub> (V) | V <sub>GSS</sub> (V) | I <sub>D</sub> (A) | P-ch (W) | V <sub>GS</sub> = 4.5 V   |      | V <sub>GS</sub> = 10 V |      |          |         | ES       | MP |
|     |            |                      |                      |                    |          | typ.                      | max. | typ.                   | max. |          |         |          |    |
| 1   | RJK0328DPB | 30                   | +20/-20 V            | 60                 | 65       | 2.1                       | 2.9  | 1.6                    | 2.1  | 8.8      | 42      | OK       | OK |
| 2   | RJK0329DPB |                      |                      | 55                 | 60       | 2.4                       | 3.4  | 1.8                    | 2.3  | 7.3      | 35      | OK       | OK |
| 3   | RJK0330DPB |                      |                      | 45                 | 55       | 2.8                       | 3.9  | 2.1                    | 2.7  | 5.8      | 27      | OK       | OK |
| 4   | RJK0331DPB |                      |                      | 40                 | 50       | 3.5                       | 4.9  | 2.6                    | 3.4  | 4.6      | 21      | OK       | OK |
| 5   | RJK0332DPB |                      |                      | 35                 | 45       | 5.0                       | 7.0  | 3.6                    | 4.7  | 3.0      | 14      | OK       | OK |

# Lineup of 9th Generation Products in LFPAK Package

| No. | Part No.   | Maximum Rating       |                      |                    |          | R <sub>DS</sub> (on) (mΩ) |      |                        |      | Qgd (nC) | Qg (nC) | Schedule |    |
|-----|------------|----------------------|----------------------|--------------------|----------|---------------------------|------|------------------------|------|----------|---------|----------|----|
|     |            | V <sub>DSS</sub> (V) | V <sub>GSS</sub> (V) | I <sub>D</sub> (A) | P-ch (W) | V <sub>GS</sub> = 4.5 V   |      | V <sub>GS</sub> = 10 V |      |          |         | ES       | MP |
|     |            |                      |                      |                    |          | typ.                      | max. | typ.                   | max. |          |         |          |    |
| 1   | RJK0301DPB | 30                   | +16/-12 V            | 60                 | 65       | 3.0                       | 4.0  | 2.3                    | 2.8  | 7.0      | 32      | OK       | OK |
| 2   | RJK0302DPB |                      |                      | 50                 | 60       | 3.5                       | 4.6  | 2.6                    | 3.1  | 6.0      | 28      | OK       | OK |
| 3   | RJK0303DPB |                      |                      | 40                 | 55       | 4.3                       | 5.6  | 3.1                    | 3.7  | 5.2      | 23      | OK       | OK |
| 4   | RJK0304DPB |                      |                      | 35                 | 50       | 5.5                       | 7.2  | 4.0                    | 4.8  | 3.7      | 17      | OK       | OK |
| 5   | RJK0305DPB |                      |                      | 30                 | 45       | 10.0                      | 13.0 | 6.7                    | 8.0  | 1.5      | 8       | OK       | OK |

# Lineup of 10th Generation Products in WPAK Package

for low-side switch and synchronous rectifier  
 for high-side switch

| No. | Part No.   | Maximum Rating          |                         |                       |             | R <sub>DS</sub> (on) (mΩ) |      |                        |      | Qgd<br>(nC) | Qg<br>(nC) | Schedule |    |
|-----|------------|-------------------------|-------------------------|-----------------------|-------------|---------------------------|------|------------------------|------|-------------|------------|----------|----|
|     |            | V <sub>DSS</sub><br>(V) | V <sub>GSS</sub><br>(V) | I <sub>D</sub><br>(A) | P-ch<br>(W) | V <sub>GS</sub> = 4.5 V   |      | V <sub>GS</sub> = 10 V |      |             |            | ES       | MP |
|     |            |                         |                         |                       |             | typ.                      | max. | typ.                   | max. |             |            |          |    |
| 1   | RJK0346DPA | 30                      | +20/-20 V               | 60                    | 65          | 1.9                       | 2.7  | 1.5                    | 2.0  | 10.5        | 49         | OK       | OK |
| 2   | RJK0348DPA |                         |                         | 50                    | 55          | 2.5                       | 3.5  | 1.9                    | 2.5  | 7.0         | 34         | OK       | OK |
| 3   | RJK0349DPA |                         |                         | 45                    | 50          | 3.1                       | 4.3  | 2.4                    | 3.1  | 5.3         | 25         | OK       | OK |
| 4   | RJK0351DPA |                         |                         | 40                    | 45          | 4.3                       | 6.0  | 3.2                    | 4.2  | 3.7         | 17         | OK       | OK |
| 5   | RJK0353DPA |                         |                         | 35                    | 40          | 5.4                       | 7.6  | 4.0                    | 5.2  | 3.0         | 14         | OK       | OK |
| 6   | RJK0355DPA |                         |                         | 30                    | 25          | 11.8                      | 16.5 | 8.2                    | 10.7 | 1.4         | 6.3        | OK       | OK |
| 7   | RJK0364DPA |                         |                         | 35                    | 35          | 8.0                       | 11.2 | 6.0                    | 7.8  | 2.2         | 10         | OK       | OK |
| 8   | RJK0365DPA |                         |                         | 30                    | 30          | 9.6                       | 13.4 | 7.0                    | 9.1  | 1.7         | 7.6        | OK       | OK |
| 9   | RJK0366DPA |                         |                         | 25                    | 30          | 12.0                      | 16.8 | 8.5                    | 11.1 | 1.5         | 6.8        | OK       | OK |
| 10  | RJK0368DPA |                         |                         | 20                    | 25          | 16.0                      | 22.4 | 11.0                   | 14.3 | 1.3         | 6.2        | OK       | OK |



# Lineup of 10th Generation Products in SOP-8 Package

for low-side switch and synchronous rectifier  
 for high-side switch

| No. | Part No.   | Maximum Rating       |                      |                    |          | R <sub>DS</sub> (on) (mΩ) |      |                        |      | Qgd (nC) | Qg (nC) | Schedule |    |
|-----|------------|----------------------|----------------------|--------------------|----------|---------------------------|------|------------------------|------|----------|---------|----------|----|
|     |            | V <sub>DSS</sub> (V) | V <sub>GSS</sub> (V) | I <sub>D</sub> (A) | P-ch (W) | V <sub>GS</sub> = 4.5 V   |      | V <sub>GS</sub> = 10 V |      |          |         | ES       | MP |
|     |            |                      |                      |                    |          | typ.                      | max. | typ.                   | max. |          |         |          |    |
| 1   | RJK0348DSP | 30                   | +20/-20 V            | 22                 | 2.5      | 3.2                       | 4.5  | 2.6                    | 3.4  | 7.0      | 34      | OK       | OK |
| 2   | RJK0349DSP |                      |                      | 20                 | 2.5      | 3.6                       | 5.0  | 2.9                    | 3.8  | 5.3      | 25      | OK       | OK |
| 3   | RJK0351DSP |                      |                      | 20                 | 2.5      | 5.0                       | 6.9  | 4.0                    | 5.2  | 3.7      | 17      | OK       | OK |
| 4   | RJK0352DSP |                      |                      | 18                 | 2.0      | 5.5                       | 7.0  | 4.3                    | 5.6  | 3.4      | 16      | OK       | OK |
| 5   | RJK0353DSP |                      |                      | 18                 | 2.0      | 5.9                       | 8.3  | 4.5                    | 5.9  | 3.0      | 15      | OK       | OK |
| 6   | RJK0354DSP |                      |                      | 16                 | 2.0      | 7.5                       | 10.5 | 5.4                    | 7.0  | 2.5      | 12      | OK       | OK |
| 7   | RJK0355DSP |                      |                      | 12                 | 1.8      | 12.0                      | 16.8 | 8.5                    | 11.1 | 1.4      | 6.0     | OK       | OK |
| 8   | RJK0366DSP |                      |                      | 11                 | 2.0      | 12.5                      | 17.5 | 9.0                    | 11.7 | 1.5      | 6.5     | OK       | OK |
| 9   | RJK0369DSP |                      |                      | 9                  | 1.8      | 16.0                      | 22.5 | 12.0                   | 15.6 | 1.2      | 5.6     | OK       | OK |
| 10  | RJK0371DSP |                      |                      | 8                  | 1.8      | 19.0                      | 27.0 | 14.0                   | 19.0 | 1.0      | 3.8     | OK       | OK |

# **Power MOS FETs**

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## **New Products: 10th Generation + SBD (Single/Dual)**

**SBD: Schottky barrier diode**

# 10th Generation MOS FET Plus On-Chip SBD (Single/Dual)

SBD: Schottky barrier diode

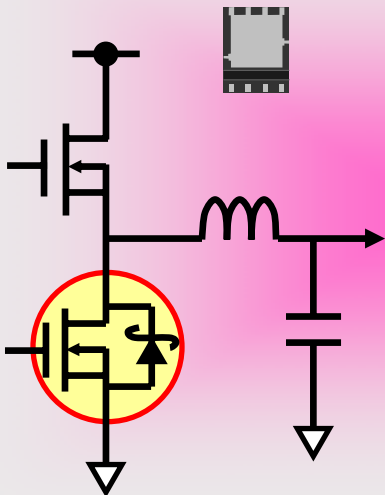
WPAK

New  
Products

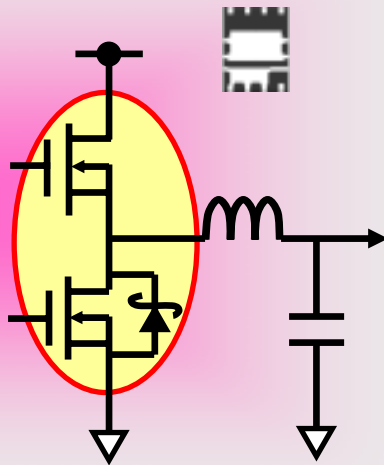
## Main Applications

- Servers/PCs (CPU/memory)
- Graphics cards (VGA/MXM)
- Telecomms (secondary-side synchronous rectification)

### Single (WPAK)



### Dual (WPAK)



## Features (Single)

- On-chip SBD between source and drain
  - Achieve higher power efficiency  
Lower  $V_{DF}$  loss during dead time
  - Reduced EMI noise: Lower spike voltage between low-side D and S when high-side switch is turned on

## Features (Dual)

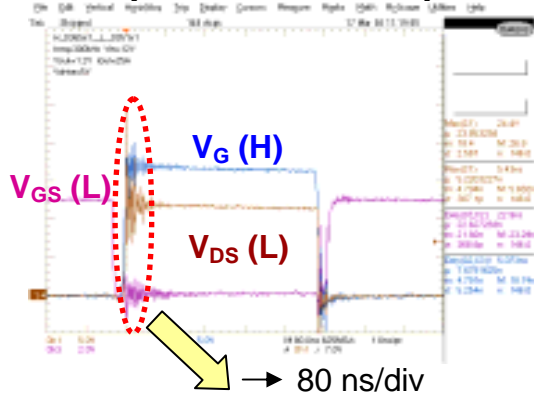
- Inclusion of 2 switching devices for high and low sides in one package
  - Reduces PCB footprint by **50%**, enabling more compact designs
- On-chip SBD for low-side switching device
  - Achieve higher power efficiency  
Lower  $V_{DF}$  loss during dead time
  - Reduced EMI noise: Lower spike voltage between low-side D and S when high-side switch is turned on

# Reduction of Spike Voltages (Comparison of Operating Frequency)

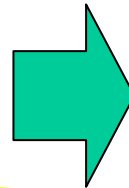
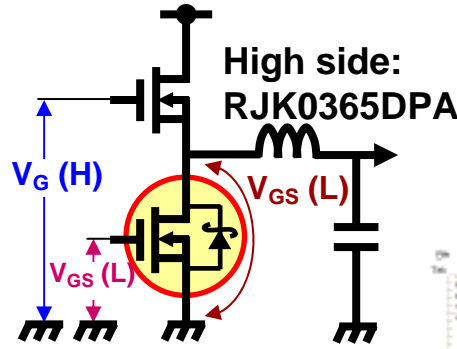
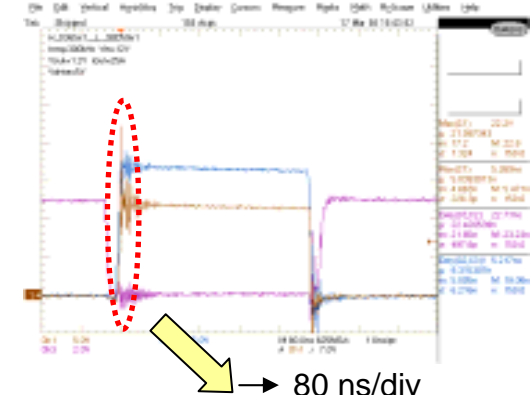
The waveforms in ○ are those when the high-side switching device turned on.

$V_{IN} = 12\text{ V}$ ,  $V_{OUT} = 1.2\text{ V}$ ,  
 $V_{DR} = 5\text{ V}$ ,  $f_{sw} = 300\text{ kHz}$ ,  
 $L = 0.45\text{ }\mu\text{H}$ ,  $I_{OUT} = 25\text{ A}$

Low: RJK0351DPA  
(without SBD)



Low side: RJK0381DPA  
(on-chip SBD)



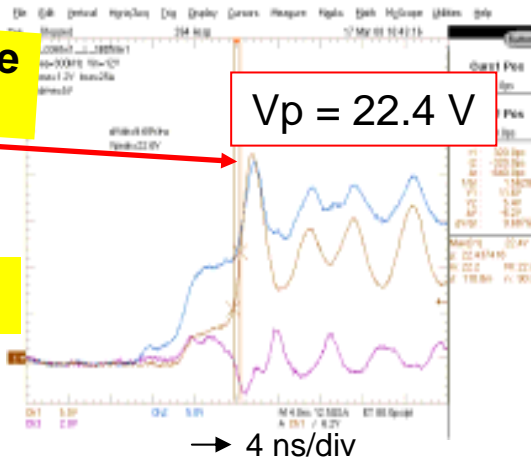
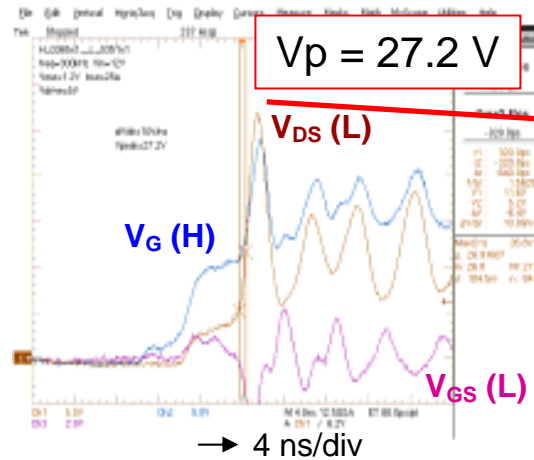
$V_p = 27.2\text{ V}$

Reduction in low-side  
spike voltage

$V_p = 22.4\text{ V}$

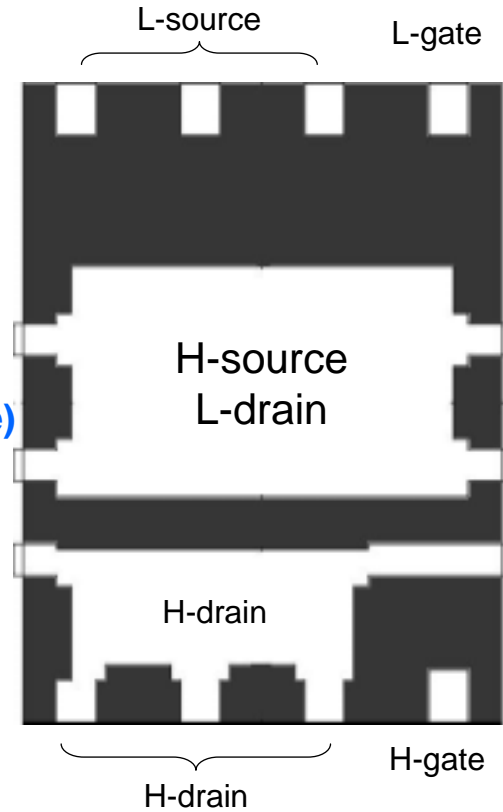
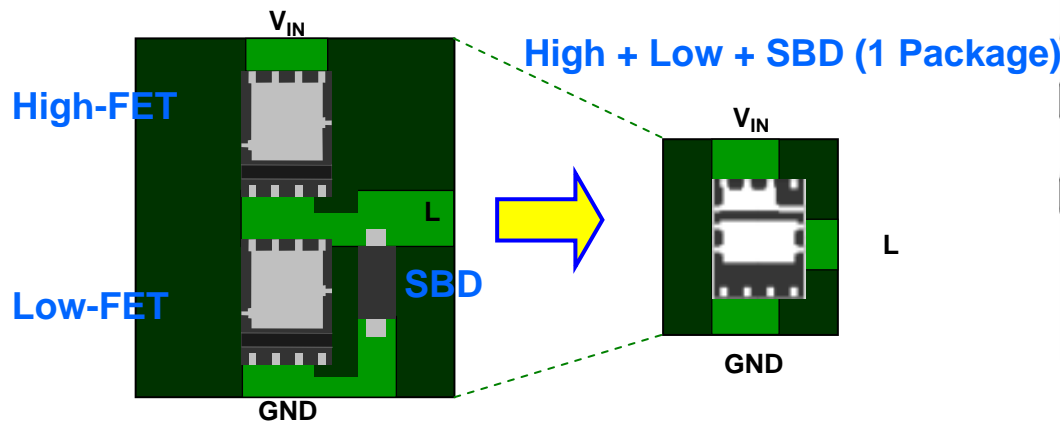
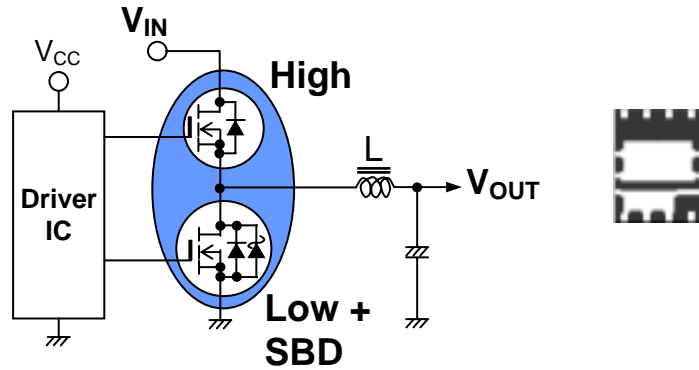
-17%

Reduced EMI noise



# New Product: 10th Generation in WPAK (Dual)

New Product



Back of the package

Reduction of PCB mounting area;  
more compact

# Lineup of 10th Generation Power MOS FET Plus On-Chip SBD Products

WPAK

## WPAK Single



| No | Part No.   | Max. ratings         |                      |                    |                     | R <sub>DS</sub> (on) (mΩ) |      |                        |      | Qgd (nC) | Qg (nC) | Schedule |    |
|----|------------|----------------------|----------------------|--------------------|---------------------|---------------------------|------|------------------------|------|----------|---------|----------|----|
|    |            | V <sub>DSS</sub> (V) | V <sub>GSS</sub> (V) | I <sub>D</sub> (A) | P <sub>ch</sub> (W) | V <sub>GS</sub> = 4.5 V   |      | V <sub>GS</sub> = 10 V |      |          |         | ES       | MP |
|    |            |                      |                      |                    |                     | typ.                      | max. | typ.                   | max. |          |         |          |    |
| 1  | RJK0379DPA | 30 V                 | +20/-20              | 50                 | 55                  | 2.4                       | 3.4  | 1.8                    | 2.3  | 10.7     | 37      | OK       | OK |
| 2  | RJK0380DPA |                      |                      | 45                 | 50                  | 3.3                       | 4.7  | 2.4                    | 3.2  | 6.7      | 24      | OK       | OK |
| 3  | RJK03A4DPA |                      |                      | 42                 | 45                  | 4.3                       | 6.0  | 2.9                    | 3.8  | 5.2      | 17      | OK       | OK |
| 4  | RJK0381DPA |                      |                      | 40                 | 45                  | 4.7                       | 6.6  | 3.4                    | 4.5  | 4.3      | 15      | OK       | OK |

## WPAK Dual



| No | Part No.   | FET  | Max. ratings         |                      |                    |                     | R <sub>DS</sub> (on) (mΩ) |      |                        |      | Qgd (nC) | Qg (nC) | Schedule |    |
|----|------------|------|----------------------|----------------------|--------------------|---------------------|---------------------------|------|------------------------|------|----------|---------|----------|----|
|    |            |      | V <sub>DSS</sub> (V) | V <sub>GSS</sub> (V) | I <sub>D</sub> (A) | P <sub>ch</sub> (W) | V <sub>GS</sub> = 4.5 V   |      | V <sub>GS</sub> = 10 V |      |          |         | ES       | MP |
|    |            |      |                      |                      |                    |                     | typ.                      | max. | typ.                   | max. |          |         |          |    |
| 1  | RJK0389DPA | High | 30                   | +20/-20              | 15                 | 10                  | 11.8                      | 16.5 | 8.2                    | 10.7 | 1.4      | 6       | OK       | OK |
|    |            | Low  |                      |                      | 20                 | 10                  | 10.5                      | 14.7 | 6.8                    | 8.9  | 2.2      | 7.2     |          |    |

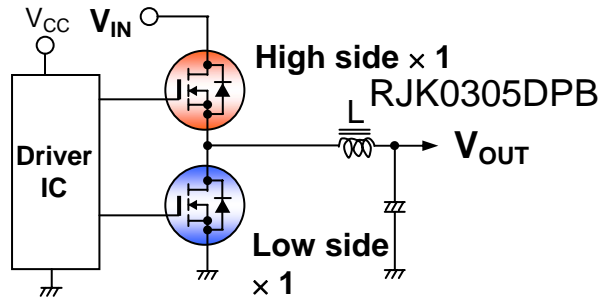
Attention: This product is under development. The electrical characteristics or schedule may be subject to change without notice.

# **Power MOS FETs**

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## **Next Generation Products: 11th Generation Power MOS FETs**

# Data From Efficiency Evaluation of 11th Generation Products

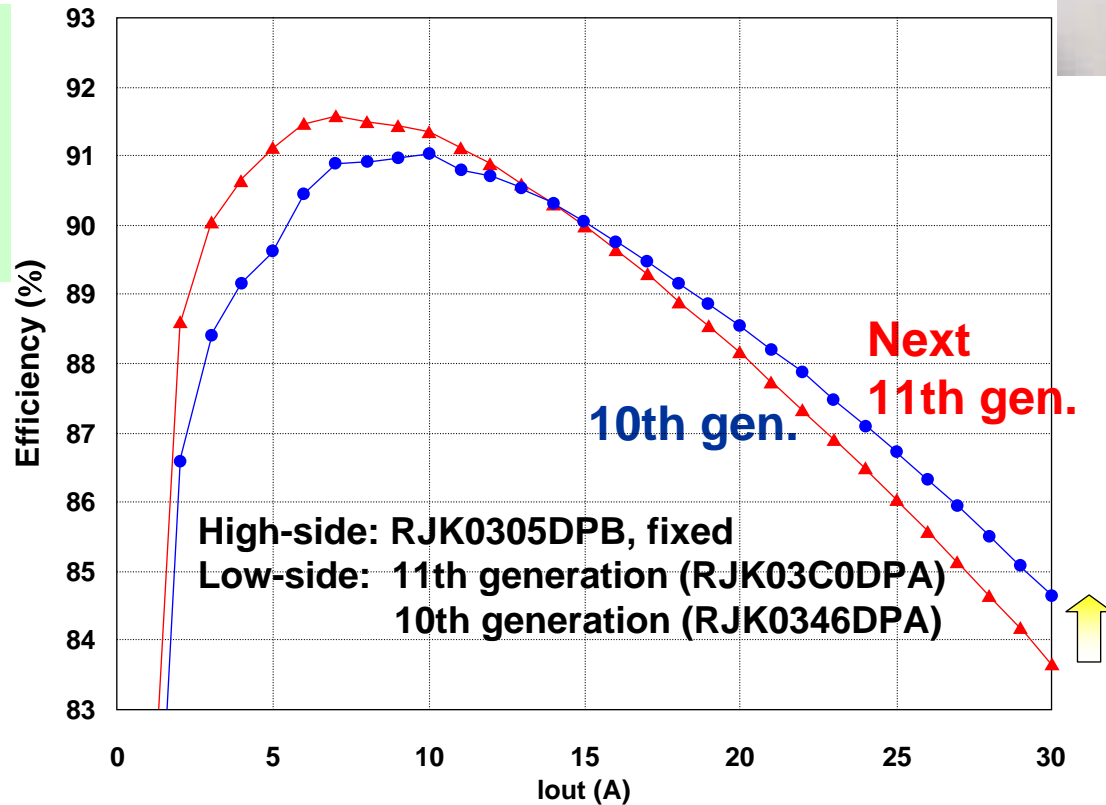


**Renesas discrete evaluation board**  
**T<sub>a</sub> = 25 °C, no air flow**  
**L = 0.45 μH**



## Test conditions

$V_{IN} = 12\text{ V}$ ,  
 $V_{OUT} = 1.2\text{ V}$   
 $V_{DR} = 5\text{ V}$ ,  
 $f_{sw} = 350\text{ kHz}$



1% up



# Development Schedule for Next (11th) Generation Products

 for low-side switch and synchronous rectification

 for high-side switch

## Package: WPAK

| No | Part No.   | Max. ratings         |                      |                    |         | R <sub>DS</sub> (on) (mΩ) |      |                        |      | Qgd (nC) | Qg (nC) | Rg (Ω) | Schedule |    | Current Products (JET Series) |
|----|------------|----------------------|----------------------|--------------------|---------|---------------------------|------|------------------------|------|----------|---------|--------|----------|----|-------------------------------|
|    |            | V <sub>DSS</sub> (V) | V <sub>GSS</sub> (V) | I <sub>D</sub> (A) | Pch (W) | V <sub>GS</sub> = 4.5 V   |      | V <sub>GS</sub> = 10 V |      |          |         |        | ES       | MP |                               |
|    |            |                      |                      |                    |         | typ.                      | max. | typ.                   | max. |          |         |        |          |    |                               |
| 1  | RJK03C0DPA | 30                   | +20<br>/-20 V        | 70                 | 65      | 1.8                       | 2.5  | 1.5                    | 2.0  | 13.7     | 66      | 0.75   | OK       | OK | -                             |
| 2  | RJK0390DPA |                      |                      | 65                 | 60      | 2.1                       | 2.9  | 1.7                    | 2.2  | 11.3     | 54      | 0.8    | OK       | OK | RJK0346DPA                    |
| 3  | RJK0391DPA |                      |                      | 50                 | 50      | 2.8                       | 3.9  | 2.2                    | 2.9  | 7.4      | 34      | 0.95   | OK       | OK | RJK0348DPA                    |
| 4  | RJK0392DPA |                      |                      | 45                 | 45      | 3.4                       | 4.8  | 2.7                    | 3.5  | 5.9      | 26      | 0.8    | OK       | OK | RJK0349DPA                    |
| 5  | RJK0393DPA |                      |                      | 40                 | 40      | 4.2                       | 5.9  | 3.3                    | 4.3  | 4.7      | 21      | 1.4    | OK       | OK | RJK0351DPA                    |
| 6  | RJK0394DPA |                      |                      | 35                 | 35      | 5.3                       | 7.4  | 4.1                    | 5.3  | 3.7      | 15.5    | 1.4    | OK       | OK | RJK0353DPA                    |
| 7  | RJK0395DPA |                      |                      | 30                 | 30      | 7.6                       | 10.6 | 5.9                    | 7.7  | 2.6      | 11.0    | 2.2    | OK       | OK | RJK0364DPA                    |
| 8  | RJK0396DPA |                      |                      | 30                 | 28      | 9.0                       | 12.6 | 6.9                    | 9.0  | 2.2      | 9       | 2.5    | OK       | OK | RJK0365DPA                    |
| 9  | RJK0397DPA |                      |                      | 30                 | 25      | 10.4                      | 14.6 | 7.8                    | 10.1 | 1.9      | 7.4     | 2.5    | OK       | OK | RJK0355, 66DPA<br>RJK0368DPA  |
| 10 | RJK03B7DPA |                      |                      | 30                 | 30      | 7.7                       | 10.7 | 6.0                    | 7.8  | 2.6      | 11.0    | 1.0    | OK       | OK | RJK0364DPA                    |
| 11 | RJK03B8DPA |                      |                      | 30                 | 28      | 9.3                       | 12.9 | 7.0                    | 9.3  | 2.2      | 9       | 1.2    | OK       | OK | RJK0365DPA                    |
| 12 | RJK03B9DPA |                      |                      | 30                 | 25      | 10.9                      | 15.1 | 8.3                    | 10.6 | 1.9      | 7.4     | 1.2    | OK       | OK | RJK0355, 66DPA<br>RJK0368DPA  |

**Attention: This product is under development. The electrical characteristics or schedule may be subject to change without notice.**



**New  
Products**

# **Power MOS FETs**

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**New Products: Middle Voltage (40 V to 100 V)  
JET-MV Low Qg Series**

# JET Middle Voltage Series



New Products

LFPAK

## Target Application

- Server (D2D)
- Telecom (Brick)
- Isolated DC/DC converter

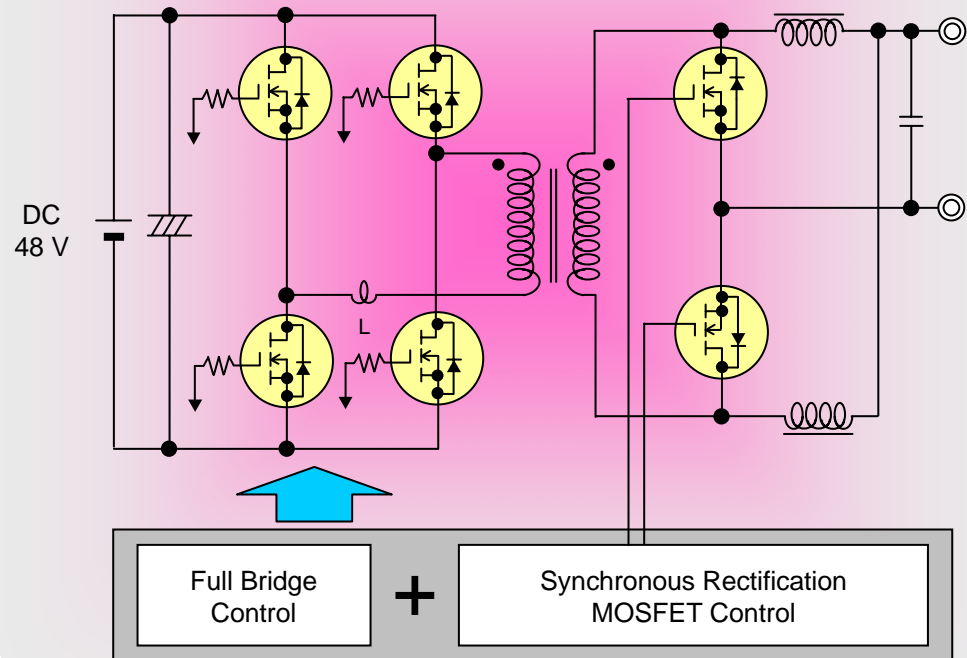
## Feature

- Lineup
- **Low Qg series: Low SW loss.**
- Various  $V_{DSS}$  series
- $V_{DSS}$ : 40 V, 60 V, 80 V, 100 V
- Improving FOM
- $R_{on} \cdot Q_{dg}$ ,  $R_{on} \cdot Q_g$

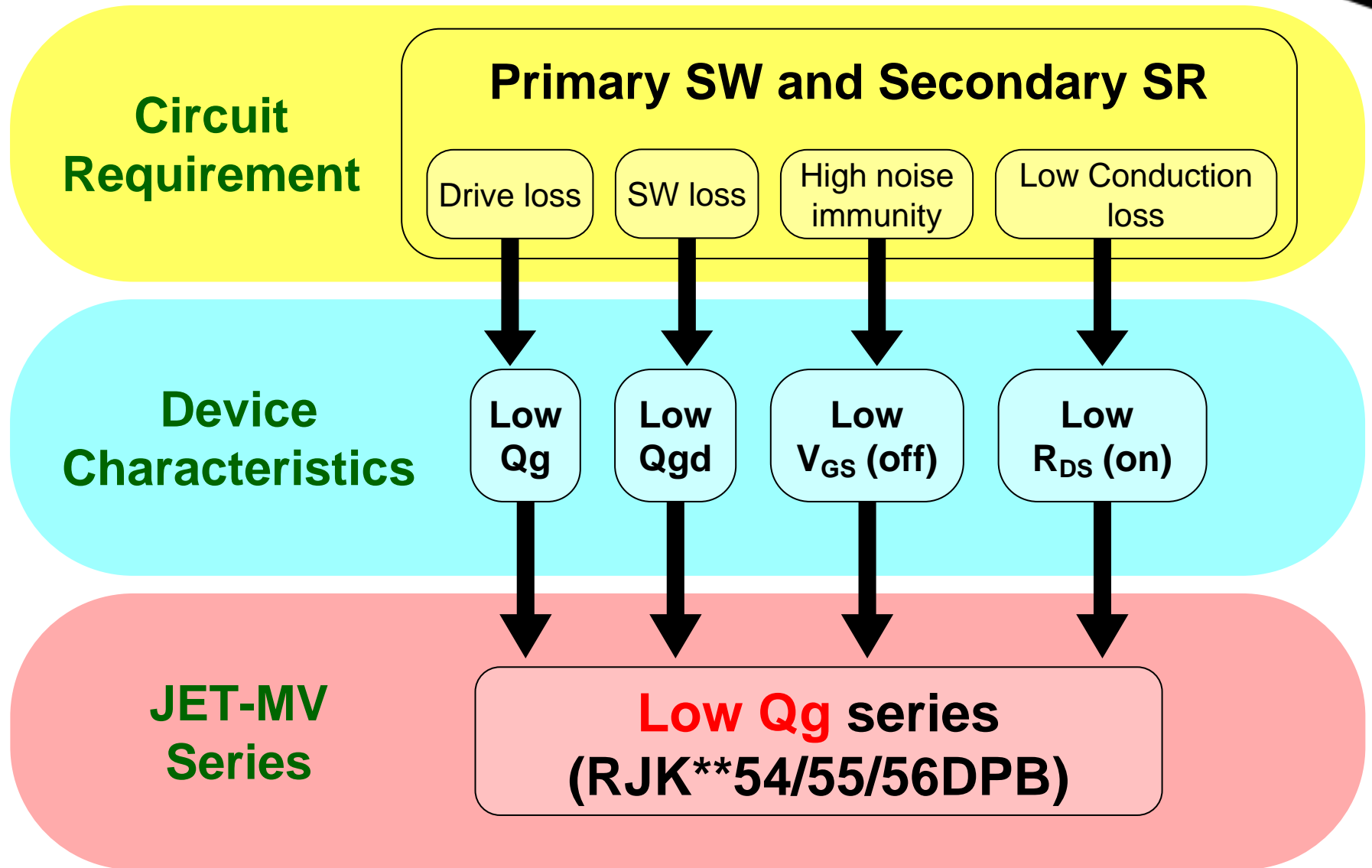
## Isolated DC/DC Converter

Primary:  
for Switching

Secondary:  
for Synchronous Rectifier



# Recommended JET Middle Voltage Series

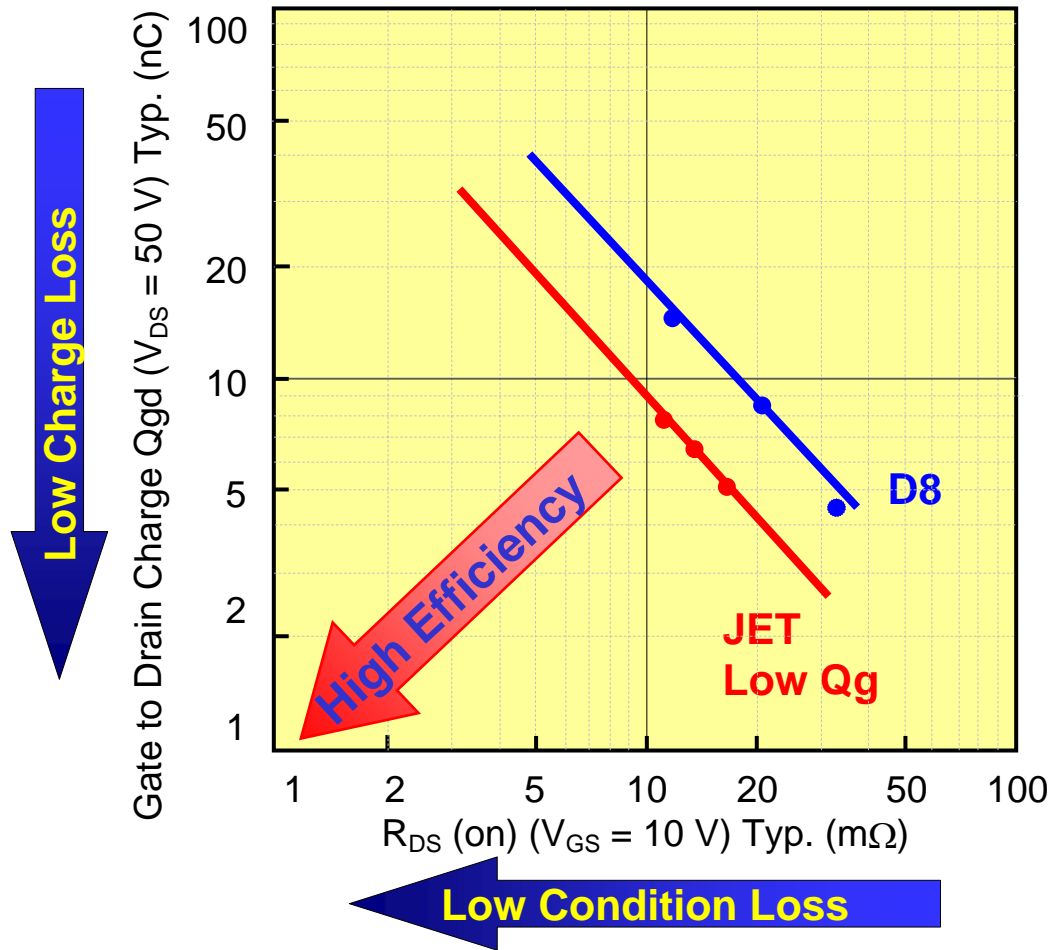


# Low Gate Charge (Qg) JET Middle Voltage. ( $V_{DSS} = 100\text{ V}$ )

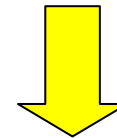


## For Primary SW

- Figure of Merit: FOM ( $R_{on} \cdot Q_{dg}$ ) at  $V_{DS} = 50\text{ V}$



D8  
180  $m\Omega nC$



50% Down

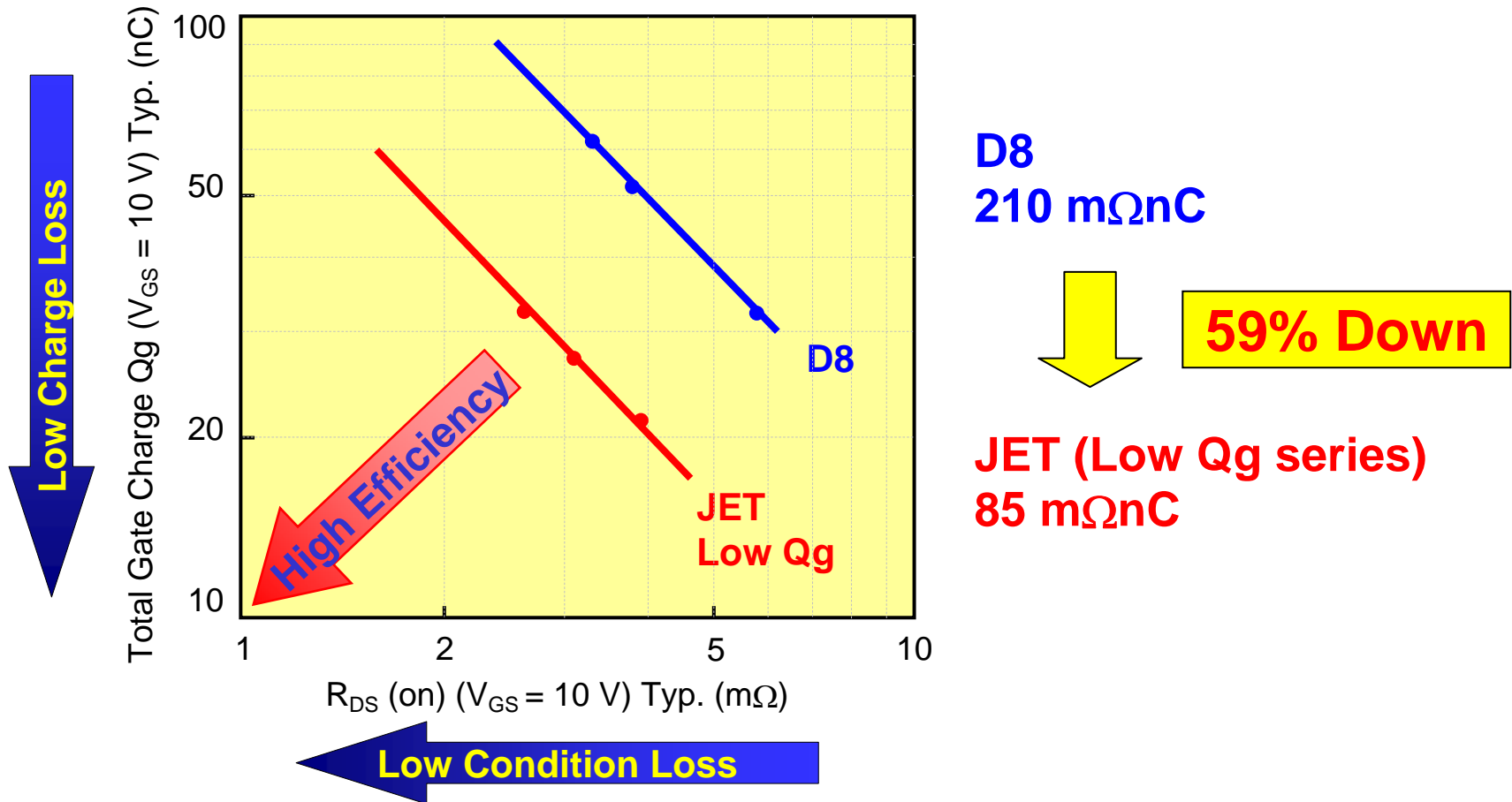
JET (Low Qg series)  
90  $m\Omega nC$

# Low Gate Charge (Qg) JET Middle Voltage. ( $V_{DSS} = 40\text{ V}$ )



## For Secondly SR

- Figure of Merit: FOM ( $R_{on} \cdot Q_g$ ) at  $V_{GS} = 10\text{ V}$



# MOS FET Recommendation for Next Bricks



| Application  | Pout (W)   | Topology             | Primary SW           |                                  | Secondary SR |                                  |
|--|------------|----------------------|----------------------|----------------------------------|--------------|----------------------------------|
|  |            |                      | V <sub>DSS</sub> (V) | V <sub>DSS</sub> (V)             |              |                                  |
| <b>Bus Converter</b><br>V <sub>IN</sub> = 36 to 75 V<br>V <sub>OUT</sub> = 12 V              | 120 to 240 | Half Bridge          | 100                  | RJK1056DPB × 2                   | 60           | RJK0654DPB × 2                   |
|  |            | Full Bridge          |                      | RJK1055DPB × 4                   |              | 80                               |
|  | 300 to 700 | Full Bridge          | 100                  | RJK1056DPB × 4<br>RJK1056DPB × 8 | 60<br>80     | RJK0656DPB × 4<br>RJK0856DPB × 4 |
| <b>Isolated Converter</b><br>V <sub>IN</sub> = 38 to 55 V<br>V <sub>OUT</sub> = 3.3 V, 5.5 V | 30 to 90   | Forward Active Clamp | 150                  | RJK1557DPA × 1                   | 40           | RJK0454DPB × 2                   |
|  | 100 to 200 | Half Bridge          | 80                   | RJK0856DPB × 2                   | 40           | RJK0455DPB × 2<br>RJK0456DPB × 4 |
| <b>PA Converter</b><br>V <sub>IN</sub> = 36 to 75 V<br>V <sub>OUT</sub> = 28 V               | 300 to 500 | Full Bridge          | 100                  | RJK1056DPB × 4<br>RJK1056DPB × 8 | 100          | RJK1055DPB × 4<br>RJK1056DPB × 4 |

Frequency: Forward Active Clamp f = 300 to 500 kHz, Half Bridge f = 250 to 400 kHz, Full Bridge f = 150 to 200 kHz  
 Drive Voltage: Primary V<sub>GS</sub> = 7 to 10 V, Secondary V<sub>GS</sub> = 7 to 8 V

# Low Qg JET Middle Voltage Series Lineup



- Main application : DC/DC Power Supply and Motor Drive, Battery Power Management etc.
- Feature : Low Qg and Qdg (**Low Switching loss**)  
High Threshold Voltage (**High noise immunity**)

**LFPAK**



| Type No.   | Max. ratings            |                         |                       |            | V <sub>GS</sub> (off)<br>[V]<br>min-max | R <sub>DS</sub> (on) (mΩ) |      | Qdg<br>(nC) | Qg<br>(nC) | Schedule               |    |
|------------|-------------------------|-------------------------|-----------------------|------------|---|---------------------------|------|-------------|------------|------------------------|----|
|            | V <sub>DSS</sub><br>(V) | V <sub>GSS</sub><br>(V) | I <sub>D</sub><br>(A) | Pch<br>(W) |   | V <sub>GS</sub> = 10 V    |      |             |            | V <sub>GS</sub> = 10 V | ES |
|            |                         |                         |                       |            |   | typ.                      | max. |             |            |                        |    |
| RJK0454DPB | 40                      | ±20                     | 40                    | 55         | 2.0-4.0                                 | 3.9                       | 4.9  | 3.2         | 22         | OK                     | OK |
| RJK0455DPB |                         |                         | 45                    | 60         | 2.0-4.0                                 | 3.1                       | 3.8  | 4.1         | 27         | OK                     | OK |
| RJK0456DPB |                         |                         | 50                    | 65         | 2.0-4.0                                 | 2.6                       | 3.2  | 4.9         | 33         | OK                     | OK |
| RJK0654DPB | 60                      |                         | 30                    | 55         | 2.0-4.0                                 | 6.5                       | 8.3  | 3.3         | 22         | OK                     | OK |
| RJK0655DPB |                         |                         | 35                    | 60         | 2.0-4.0                                 | 5.3                       | 6.7  | 4.2         | 28         | OK                     | OK |
| RJK0656DPB |                         |                         | 40                    | 65         | 2.0-4.0                                 | 4.5                       | 5.6  | 5.0         | 34         | OK                     | OK |
| RJK0854DPB | 80                      |                         | 25                    | 55         | 2.0-4.0                                 | 10                        | 13   | 5.0         | 30         | OK                     | OK |
| RJK0855DPB |                         |                         | 30                    | 60         | 2.0-4.0                                 | 8.2                       | 11   | 6.3         | 37         | OK                     | OK |
| RJK0856DPB |                         |                         | 35                    | 65         | 2.0-4.0                                 | 6.9                       | 8.9  | 7.6         | 45         | OK                     | OK |
| RJK1054DPB | 100                     |                         | 20                    | 55         | 2.0-4.0                                 | 17                        | 22   | 5.1         | 30         | OK                     | OK |
| RJK1055DPB |                         |                         | 23                    | 60         | 2.0-4.0                                 | 13                        | 17   | 6.5         | 38         | OK                     | OK |
| RJK1056DPB |                         |                         | 25                    | 65         | 2.0-4.0                                 | 11                        | 14   | 7.8         | 45         | OK                     | OK |

**Note)** The development plan and the characteristics of this series may be changed without notice.

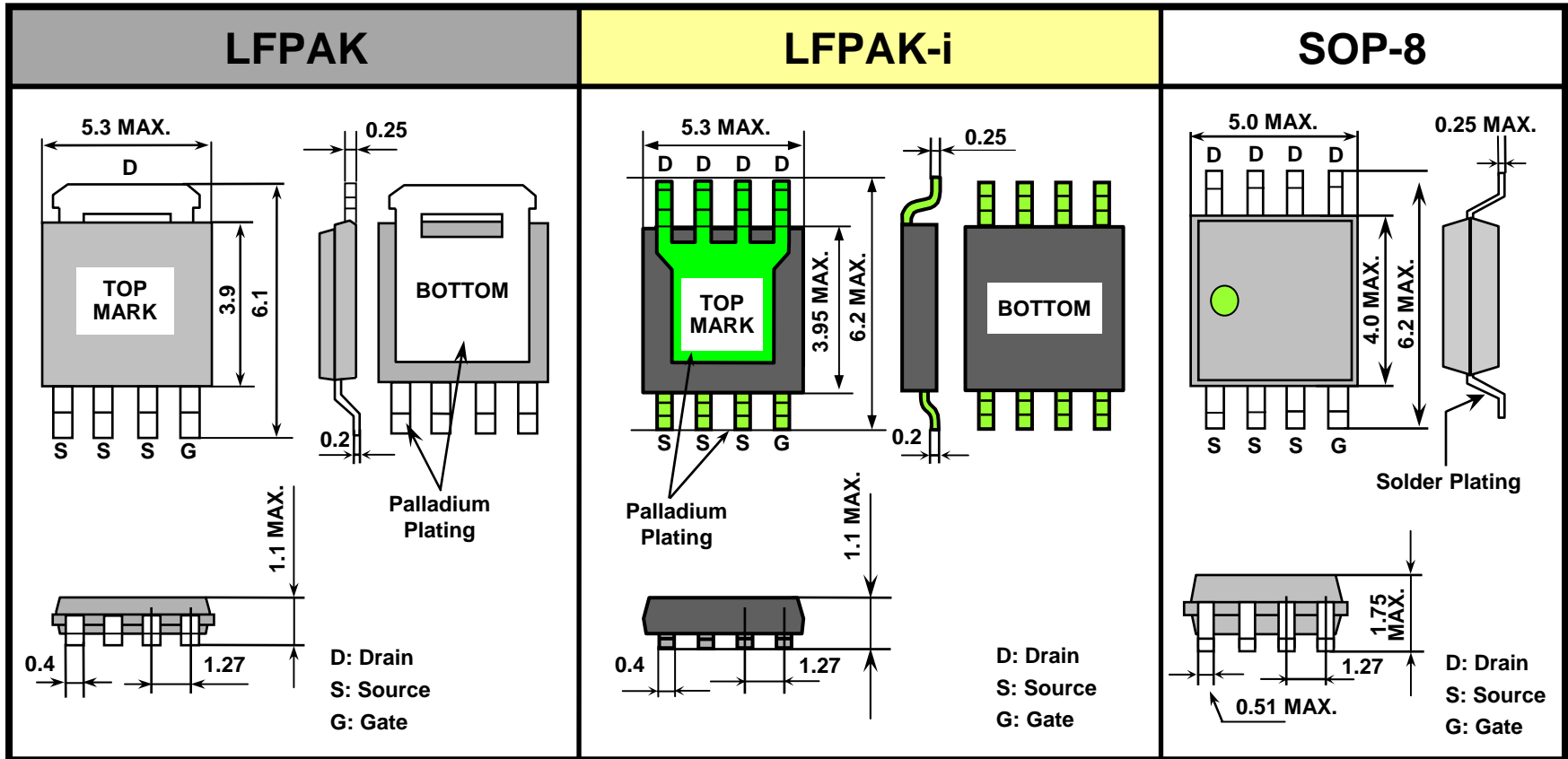


# **Power MOS FETs**

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**LFPAK-i Double-Sided Mounting Packages,  
P-ch. MOS FET Series,  
and Power-Saving Compact Package Series**

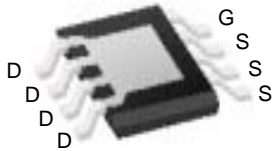
# LFAK and LFAK-i (SOP-8) Comparison of Package Dimensions



UNIT: mm

# LFLPAK-i Package Power MOS FET Series

**New Products**

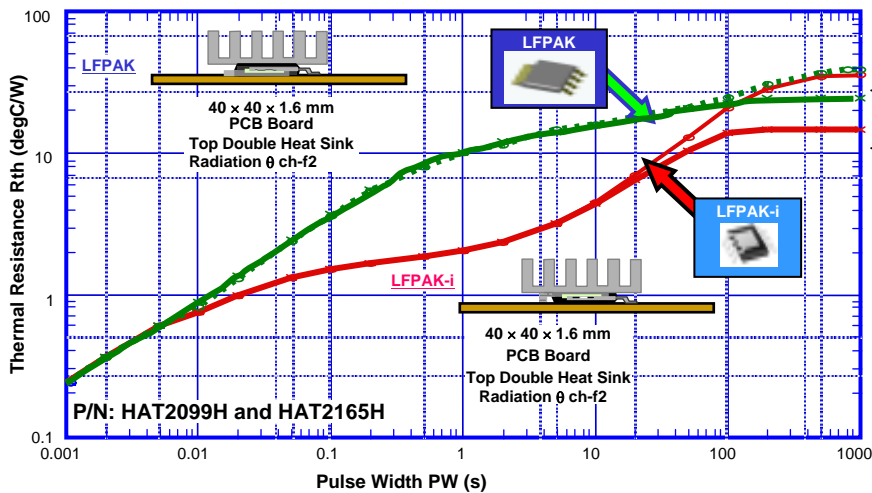


- Features -**
- 40% of mounting thermal resistance is reduced and 30% of current improvement is realized
  - SOP-8 and LFLPAK of substitutions
  - Top side cooling capability

- Application -**
- Server of VR (Voltage Regulator)
  - VR of High-side to HAT2168N  
Low-side to HAT2165N/HAT2166N



**- Comparisons Between LFLPAK and LFLPAK-i Rth -**



Without Air Flow

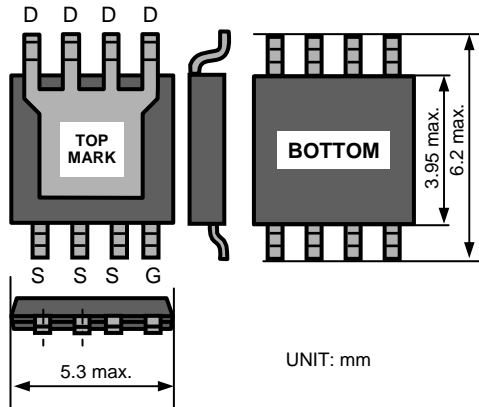
**With Air Flow**

Used Al Heat Sink (25 x 16 x 6 mm)

Lower PCB temperature is achieved by using heat sink with air flow.

Can reduce the conduction loss for the MOS FET.

**- Package Dimension -**

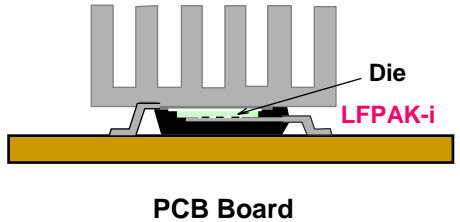


**- Lineup -**

\*[ ]: V<sub>GS</sub> = 8 V

| Part No. | Ratings              |                    | R <sub>DS</sub> (on) (mΩ) |        |                        |      | Q <sub>g</sub> | Q <sub>gd</sub> | Schedule |    |
|----------|----------------------|--------------------|---------------------------|--------|------------------------|------|----------------|-----------------|----------|----|
|          | V <sub>DSS</sub> (V) | I <sub>D</sub> (A) | V <sub>GS</sub> = 4.5 V*  |        | V <sub>GS</sub> = 10 V |      | typ.           | typ.            | WS       | MP |
|          |                      |                    | typ.                      | max.   | typ.                   | max. | (nC)           | (nC)            |          |    |
| HAT2165N | 30                   | 55                 | 3.7                       | 5.6    | 2.8                    | 3.6  | 33             | 7.1             | OK       | OK |
| HAT2166N | 30                   | 45                 | 4.3                       | 6.4    | 3.2                    | 4.1  | 27             | 5.9             | OK       | OK |
| HAT2168N | 30                   | 30                 | 9.1                       | 13.8   | 6.3                    | 8.2  | 11             | 2.4             | OK       | OK |
| HAT2172N | 40                   | 30                 | (6.9)                     | (9.5)  | 6.1                    | 7.8  | 32             | 4               | OK       | OK |
| HAT2173N | 100                  | 25                 | [13.3]                    | [17.8] | 12.3                   | 15.3 | 61             | 14.5            | OK       | OK |
| HAT2174N | 100                  | 20                 | [22]                      | [30]   | 21                     | 27   | 33.5           | 8.4             | OK       | OK |
| HAT2175N | 100                  | 15                 | [34]                      | [46]   | 33                     | 42   | 21             | 4.5             | OK       | OK |

**Top Side Cooling Capability Heat Sink**






# P-channel MOS FET Series

Feature : Super-Low  $R_{DS(on)}$  **HAT1125H  $R_{DS(on)} = 2.7\text{ m}\Omega$**

Application : Li-ion Battery Protect Circuit

Load SW, Charger for Note-Book PC

| No. | Part No.   | Package   | $V_{DSS}$<br>(V) | $V_{GSS}$<br>(V) | $I_D$<br>(A) | 4.5 V $R_{DS(on)}$ |               | 10 V $R_{DS(on)}$ |               | Qg<br>(nC) | Qgd<br>(nC) | Schedule |       |
|-----|------------|---|------------------|------------------|--------------|--------------------|---------------|-------------------|---------------|------------|-------------|----------|-------|
|     |            |   |                  |                  |              | typ.               | max.          | typ.              | max.          |            |             | WS       | MP    |
|     |            |   |                  |                  |              | (m $\Omega$ )      | (m $\Omega$ ) | (m $\Omega$ )     | (m $\Omega$ ) |            |             |          |       |
| 1   | HAT1125H   | LPAK<br>   | -30              | +10/-20          | -45          | 4.1                | 5.9           | 2.7               | 3.6           | 165        | 40          | OK       | OK    |
| 2   | HAT1127H   |   |                  |                  | -40          | 6.0                | 8.6           | 3.6               | 4.5           | 125        | 28          | OK       | OK    |
| 3   | RJK0315DSP | SOP-8<br>  |                  |                  | -16          | 7.2                | 10.5          | 5.2               | 6.5           | 48         | 20          | OK       | OK    |
| 4   | RJK0318DSP |   |                  |                  | -12          | 14.0               | 22.0          | 9.5               | 12.0          | 22         | 10          | OK       | OK    |
| 5   | RJK0319DSP |   |                  |                  | -10          | 19.0               | 28.0          | 12.5              | 15.5          | 17         | 5.5         | OK       | OK    |
| 6   | RJK0315DPA | WPAK<br> |                  |                  | -35          | 6.8                | 10.0          | 4.8               | 5.9           | 48         | 20          | OK       | '10/2 |

# Next Generation Compact Low-Loss Power MOS FET CMFPAK-6 Series

**New Products**



Renesas power MOS FET series in a small package can realize smaller and lighter mobile devices

## Power MOS FET incorporated in CMFPAK-6

- Gate driving voltage: 1.8 to 2.5 V
- P-ch/N-ch products using D8 process
- Suitable for step-up/down DC-DC converters for mobile devices (small set) and power management

## Main applications

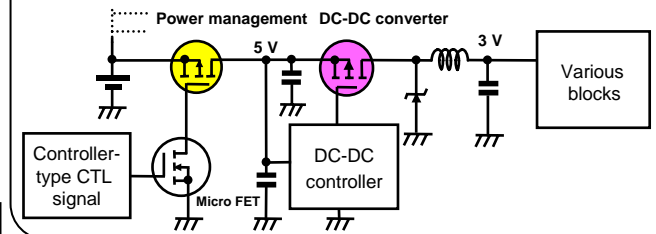
- Digital still cameras
- Mobile phones
- PDAs, etc.

## Product Lineup

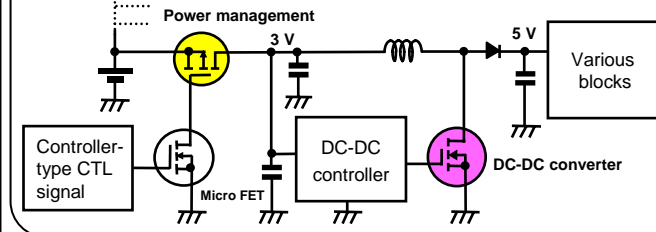
Note 1: Numbers in R<sub>DS(on)</sub> are indicated as typ./max.  
Note 2: Please contact our sales department for delivery date.

| Polarity     | Part No.       | Drive Voltage (V) | Maximum Ratings      |                      | Electrical Characteristics |                                  |                                   |                                   |                                   |                       | Schedule |     |    |
|--------------|----------------|-------------------|----------------------|----------------------|----------------------------|----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------|----------|-----|----|
|              |                |                   | V <sub>BSS</sub> (V) | V <sub>GSS</sub> (V) | I <sub>D</sub> (A)         | R <sub>DS(on)</sub> (mΩ) at 10 V | R <sub>DS(on)</sub> (mΩ) at 4.5 V | R <sub>DS(on)</sub> (mΩ) at 2.5 V | R <sub>DS(on)</sub> (mΩ) at 1.8 V | C <sub>iss</sub> (pF) | Marking  | SPL | MP |
| P            | HAT1069C       | 1.8               | -12                  | ±8                   | -4.0                       | —                                | 38/52                             | 48/70                             | 60/93                             | 1380                  | VY-      | OK  | OK |
|              | HAT1093C       |                   |                      |                      | —                          | —                                | 41/54                             | 54/76                             | 85/128                            | 940                   | VM-      |     |    |
|              | HAT1094C       |                   |                      |                      | —                          | —                                | 67/88                             | 90/126                            | 128/192                           | 530                   | VN-      |     |    |
|              | HAT1095C       |                   |                      |                      | —                          | —                                | 108/140                           | 146/205                           | 225/337                           | 290                   | VP-      |     |    |
|              | NEW RJJ0102DQM |                   |                      |                      | —                          | —                                | 265/315                           | 400/535                           | 625/930                           | 123                   | TBD      |     |    |
|              | HAT1090C       | 2.5               | -20                  | ±12                  | -2.5                       | —                                | 50/65                             | 74/104                            | —                                 | 590                   | VJ-      | OK  | OK |
|              | HAT1089C       |                   |                      |                      | —                          | —                                | 79/103                            | 120/168                           | —                                 | 365                   | VK-      |     |    |
|              | HAT1091C       |                   |                      |                      | —                          | —                                | 134/175                           | 205/287                           | —                                 | 200                   | VL-      |     |    |
|              | HAT1096C       |                   |                      |                      | —                          | —                                | 225/293                           | 380/530                           | —                                 | 155                   | VQ-      |     |    |
|              | HAT1108C       |                   |                      |                      | —                          | —                                | —                                 | —                                 | —                                 | —                     | 160      |     |    |
| NEW HAT1142C | 4.5            | -30               | +20/-10              | -3.0                 | —                          | 50/63                            | 75/109                            | —                                 | 505                               | TBD                   | OK       | OK  |    |
| HAT1111C     |                |                   |                      | —                    | —                          | 245/307                          | 310/450                           | —                                 | 290                               | UA-                   |          |     |    |
| HAT1141C     |                |                   |                      | —                    | —                          | 800/1050                         | 1020/1380                         | —                                 | 170                               | UM-                   |          |     |    |
| N            | HAT2204C       | 1.8               | 12                   | ±8                   | 3.5                        | —                                | 26/34                             | 34/44                             | 45/69                             | 770                   | VU-      | OK  | OK |
|              | HAT2205C       |                   |                      |                      | —                          | —                                | 38/50                             | 48/67                             | 65/97                             | 430                   | VV-      |     |    |
|              | HAT2206C       |                   |                      |                      | —                          | —                                | 65/85                             | 81/114                            | 113/170                           | 260                   | VW-      |     |    |
|              | HAT2202C       | 2.5               | 20                   | ±12                  | 3                          | —                                | 31/40                             | 43/55                             | —                                 | 520                   | VR-      | OK  | OK |
|              | HAT2196C       |                   |                      |                      | —                          | —                                | 45/58                             | 66/93                             | —                                 | 270                   | VS-      |     |    |
|              | HAT2203C       |                   |                      |                      | —                          | —                                | 69/90                             | 107/150                           | —                                 | 165                   | VT-      |     |    |
|              | HAT2207C       |                   |                      |                      | —                          | —                                | 100/130                           | 140/210                           | —                                 | 135                   | VX-      |     |    |
|              | NEW RJK0320DQM |                   |                      |                      | —                          | —                                | 30/39                             | 40/58                             | —                                 | 510                   | TBD      |     |    |
|              | HAT2268C       | 4.5               | 30                   | +20/-10              | 4.0                        | —                                | 27/34                             | 37/54                             | —                                 | 440                   | UN-      | OK  | OK |
|              | HAT2221C       |                   |                      |                      | —                          | —                                | 120/150                           | 160/235                           | —                                 | 110                   | UC-      |     |    |
|              | HAT2240C       | 2.5               | 60                   | ±12                  | 2.5                        | —                                | 75/98                             | 85/119                            | —                                 | 590                   | UK-      | OK  | OK |
|              | HAT2281C       |                   |                      |                      | —                          | —                                | 120/156                           | 140/196                           | —                                 | 350                   | UH-      |     |    |
|              | HAT2282C       |                   |                      |                      | —                          | —                                | 195/254                           | 240/336                           | —                                 | 210                   | UJ-      |     |    |
| HAT2217C     | —              |                   |                      |                      | —                          | 3.0                              | —                                 | 105/132                           | 126/183                           | —                     | 275      |     |    |

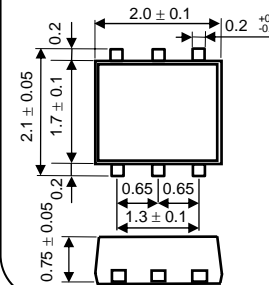
## Mobile devices: DC-DC converter (step-down voltage)



## Mobile devices: DC-DC converter (step-up voltage)



## Package dimension of CMFPAK-6



| Package type    | Size                             |             | Height       |             |
|-----------------|----------------------------------|-------------|--------------|-------------|
|                 | Mounting area (mm <sup>2</sup> ) | Ratio       | Package (mm) | Ratio       |
| TSOP-6          | 9.3                              | 1.00        | 1.10         | 1.00        |
| MPAK (SC-59)    | 8.7                              | 0.94        | 1.35         | 1.23        |
| SOT-23          | 7.6                              | 0.82        | 1.12         | 1.02        |
| <b>CMFPAK-6</b> | <b>4.5</b>                       | <b>0.49</b> | <b>0.80</b>  | <b>0.73</b> |

# CMFPAK-6 Dual Type Power MOS FET

**New Products**

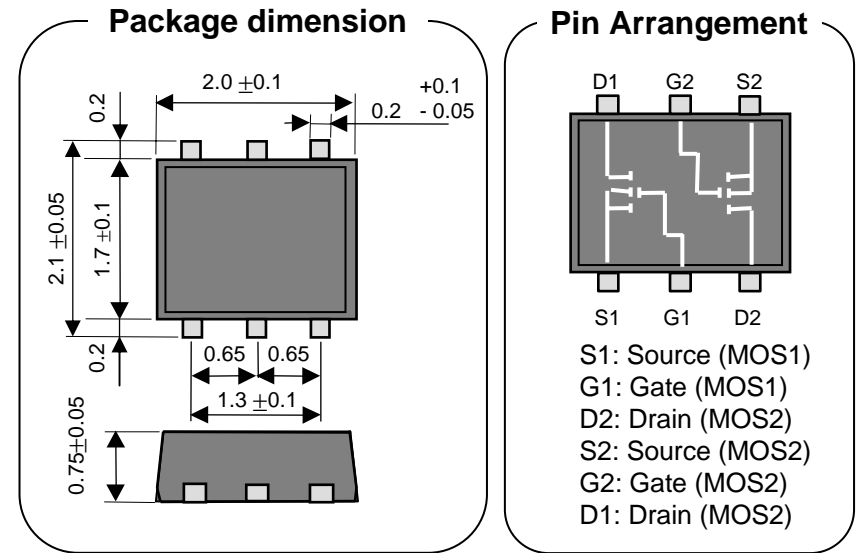
## ● Features

- Dual (N-ch Dual, P-ch Dual, N-ch + P-ch)
- Low-voltage drive (1.8 V, 2.5 V)
- Small package (CMFPAK-6)
- High speed switching

## ● Applications

- DC-DC converter
- Motor drive
- Power Management switch

## ● Lineup



| Polarity    | Part No  | Drive voltage (V) | Maximum Ratings      |                      |                    | Electrical characteristics            |                         |                         |                       | Schedule |    |
|-------------|----------|-------------------|----------------------|----------------------|--------------------|---------------------------------------|-------------------------|-------------------------|-----------------------|----------|----|
|             |          |                   | V <sub>DSS</sub> (V) | V <sub>GSS</sub> (V) | I <sub>D</sub> (A) | R <sub>DS</sub> (on) (mΩ) (typ./max.) |                         |                         | C <sub>iss</sub> (pF) | SPL      | MP |
|             |          |                   |                      |                      |                    | V <sub>GS</sub> = 4.5 V               | V <sub>GS</sub> = 2.5 V | V <sub>GS</sub> = 1.8 V |                       |          |    |
| P-ch (Dual) | HAT1146C | 1.8               | -12                  | ±8                   | -1.2               | 265/330                               | 400/565                 | 625/1130                | 125                   | OK       | OK |
|             | HAT1147C | 2.5               | -20                  | ±12                  | -1.0               | 340/440                               | 575/960                 | -                       | 85                    |          |    |
| N-ch (Dual) | HAT2291C | 1.8               | 12                   | ±8                   | 1.8                | 150/200                               | 200/290                 | 265/440                 | 100                   | OK       | OK |
|             | HAT2292C | 2.5               | 20                   | ±12                  | 1.5                | 165/215                               | 255/370                 | -                       | 73                    |          |    |
|             | HAT2286C |                   | 60                   |                      | 0.9                | 460/595                               | 560/770                 | -                       | 80                    |          |    |
| N-ch + P-ch | HAT3042C | 1.8               | 12                   | ±8                   | 1.8                | 150/200                               | 200/290                 | 265/440                 | 100                   | OK       | OK |
|             |          |                   | -12                  |                      | -1.2               | 265/330                               | 400/565                 | 625/1130                | 125                   |          |    |
|             | HAT3043C | 2.5               | 20                   | ±12                  | 1.5                | 165/215                               | 255/370                 | -                       | 73                    |          |    |
|             |          |                   | -20                  |                      | -1.0               | 340/440                               | 575/960                 | -                       | 85                    |          |    |

# **Power MOS FETs**

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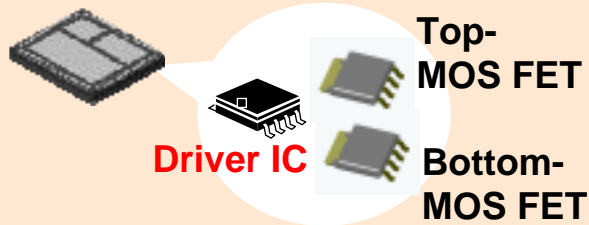
## **Integrated Power Devices: IC and MOS FET**

**Driver IC and MOS FET integrated in SiP: DrMOS**

**PWM controller and MOS FET integrated in SiP: POL-SiP**

# Product Family: IC and MOS FET Integrated in SiP

## DrMOS: Driver IC and MOS FETs



3.3 V PWM,  $I_o = 40$  A

R2J20604NP

Next gen. DrMOS

5 V PWM,  $I_o = 40$  A

R2J20602NP

6 × 6 mm QFN,  $I_o = 40$  A

R2J20651NP

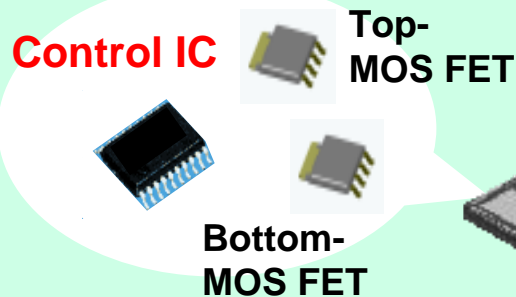
New Product

5 V PWM,  $I_o = 35$  A

R2J20601NP

(to be discontinued)

## POL-SiP: Control IC and MOS FETs



Peak current mode,  
 $I_o = 35$  A

R2J20701NP

(to be discontinued)

Next gen. POL-SiP

R2J20702NP

high power efficiency and  
Low loss,  $I_o = 40$  A

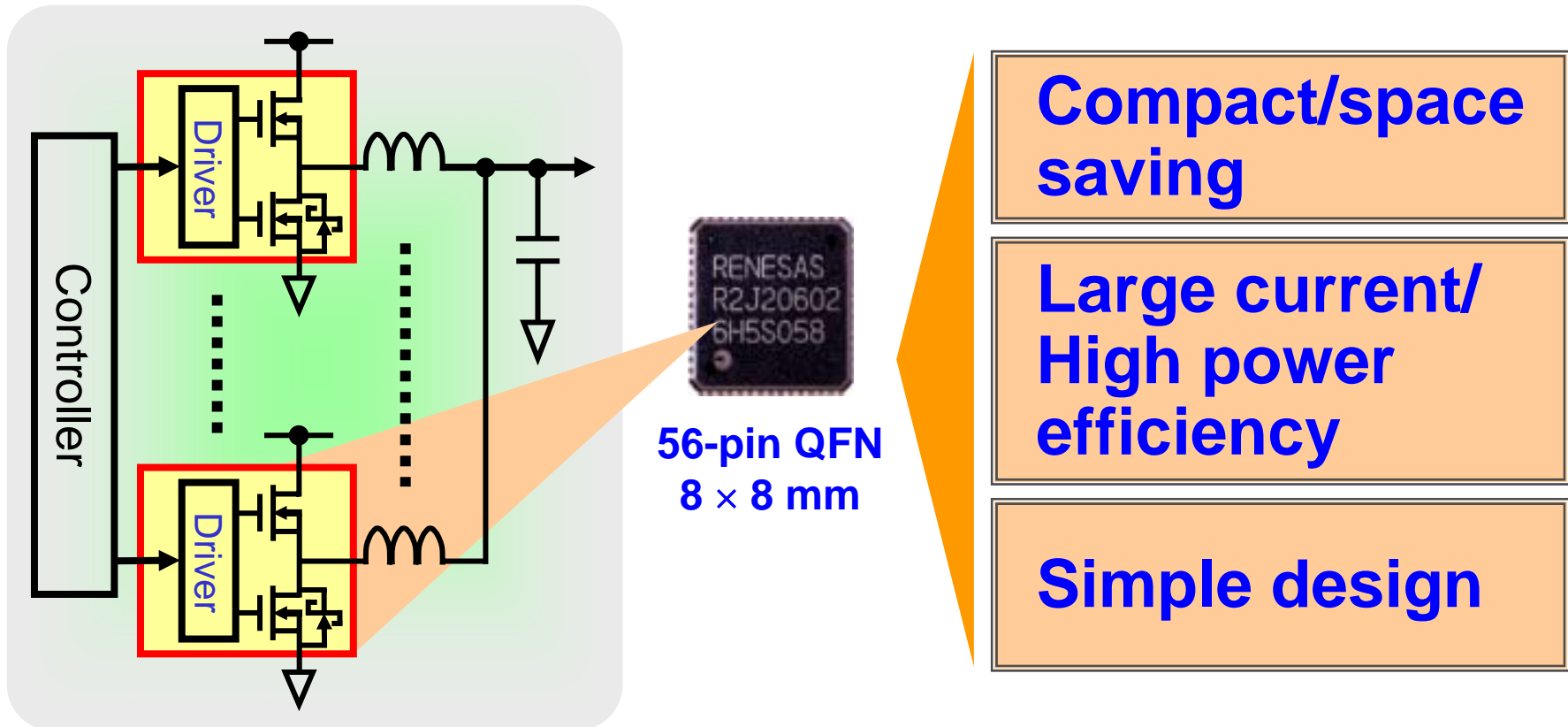
New Product



# DrMOS (R2J20602NP) (1)

**Driver IC, MOS FET × 2 → Incorporated in a single package**

Sample configuration: Multiphase power supply

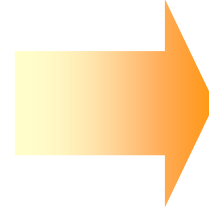
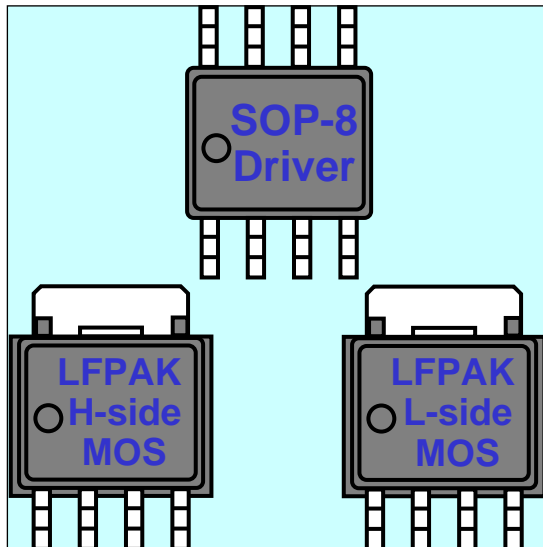


# DrMOS (R2J20602NP) (2)

**Compact package: QFN *saves space.***

Configuration of discrete device

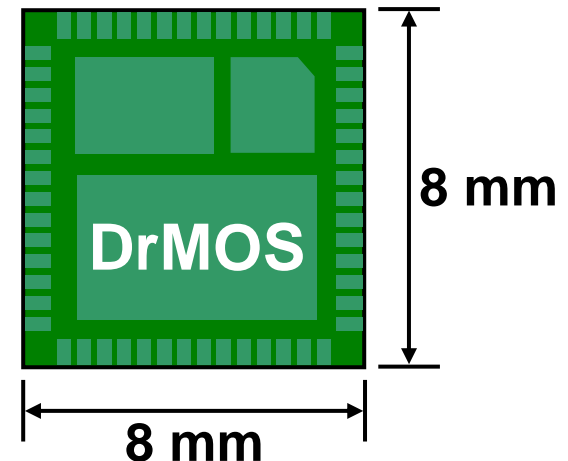
**Mounting area  
= 150 mm<sup>2</sup>**



Configuration of DrMOS

**Mounting area  
= 64 mm<sup>2</sup>**

**43% cut**  
**In mounting area**

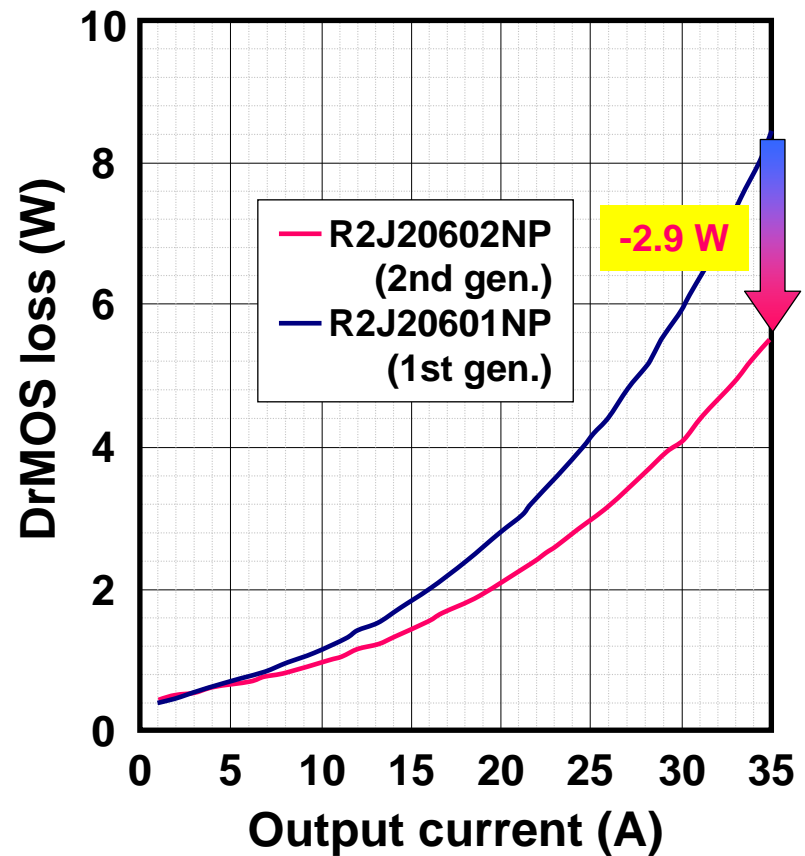
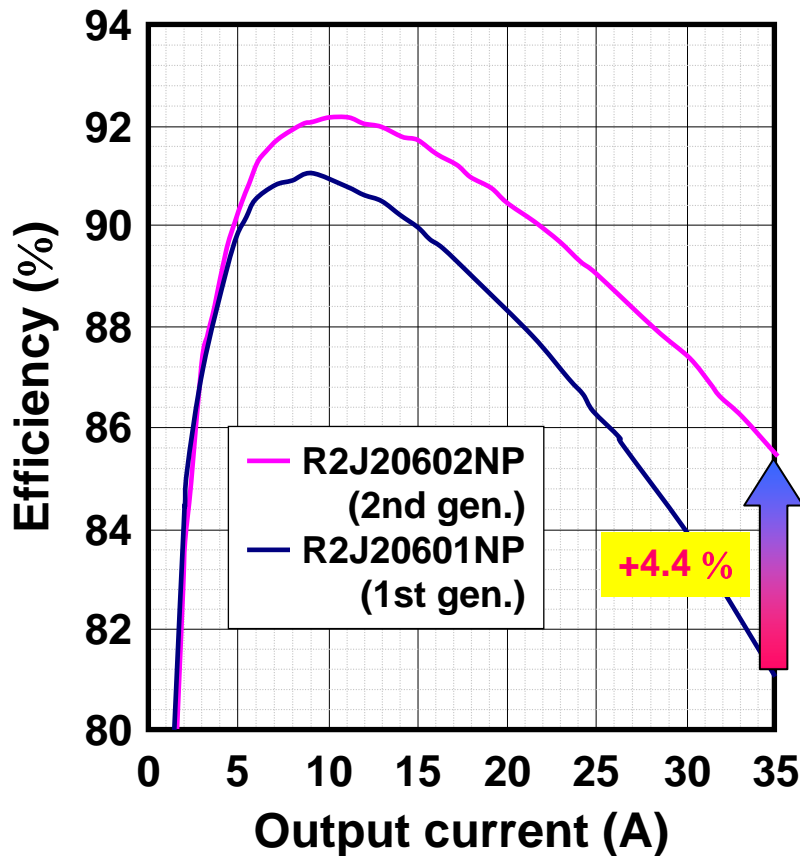


# DrMOS (R2J20602NP) (3)

**Package with wireless structure contributes to better performance.**

**Test conditions**

$V_{IN} = 12\text{ V}$ ,  
 $V_{OUT} = 1.3\text{ V}$ ,  
 $f_{sw} = 600\text{ kHz}$ ,  
No Airflow



# DrMOS (R2J20604NP)

New Product

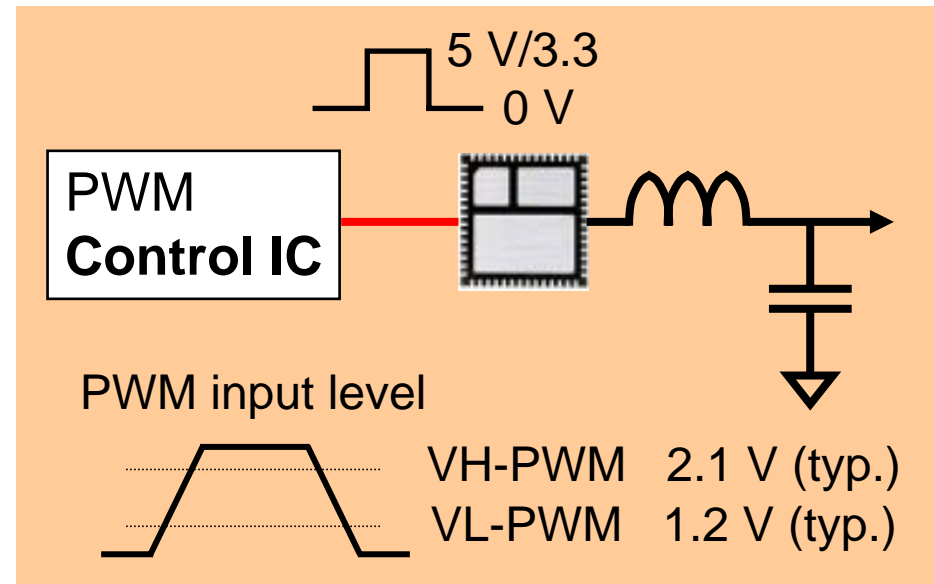
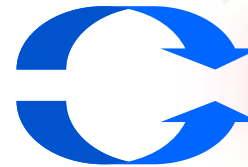
**3.3-V PWM input** covers a wealth of applications.

Available in combination with various control ICs.

Analog 5.0 V PWM controller

Digital 3.3 V PWM controller

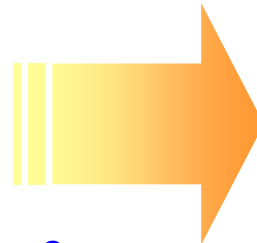
Analog 3.3 V PWM controller



# DrMOS (R2J20651NP) (1)

**40-pin QFN (6×6) saves more space.**

R2J20602NP



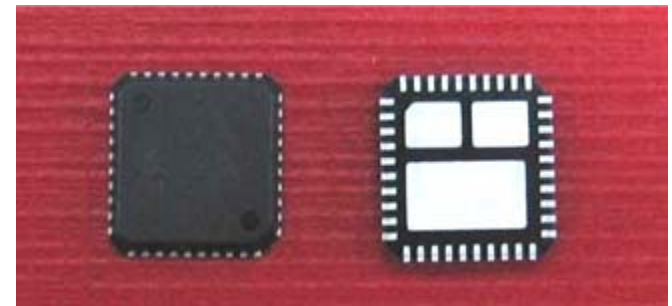
Configuration of DrMOS

Mounting area = **64 mm<sup>2</sup>**

Mounting area = **36 mm<sup>2</sup>**



**56-pin QFN  
(8 × 8 mm)**



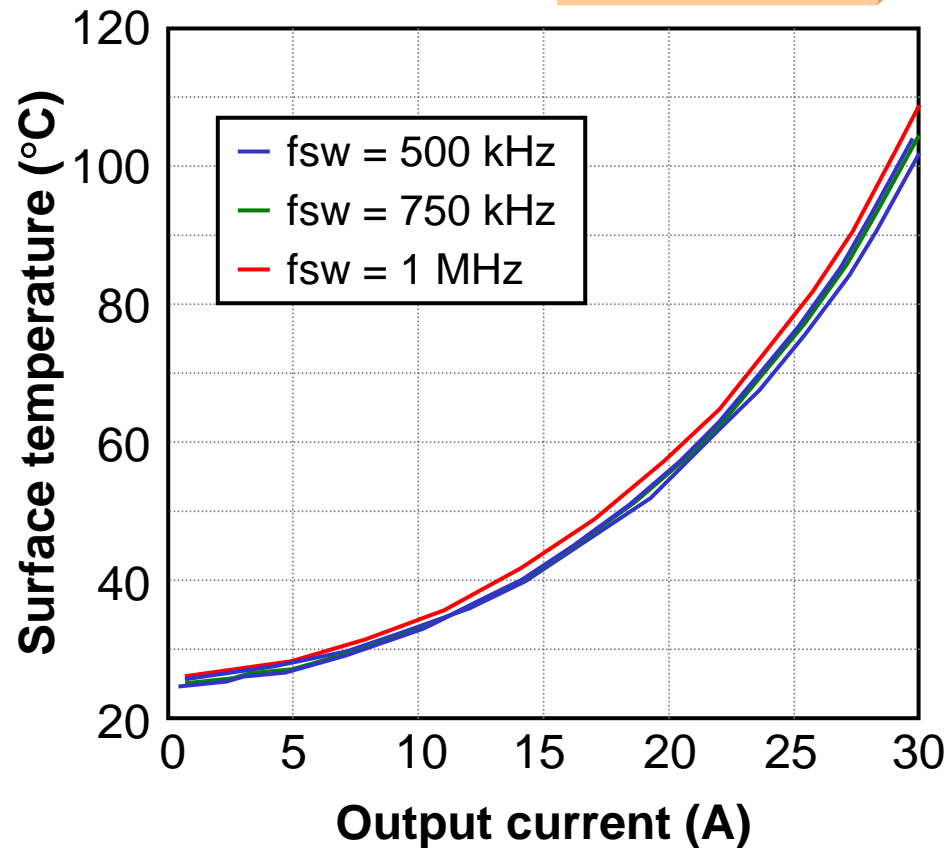
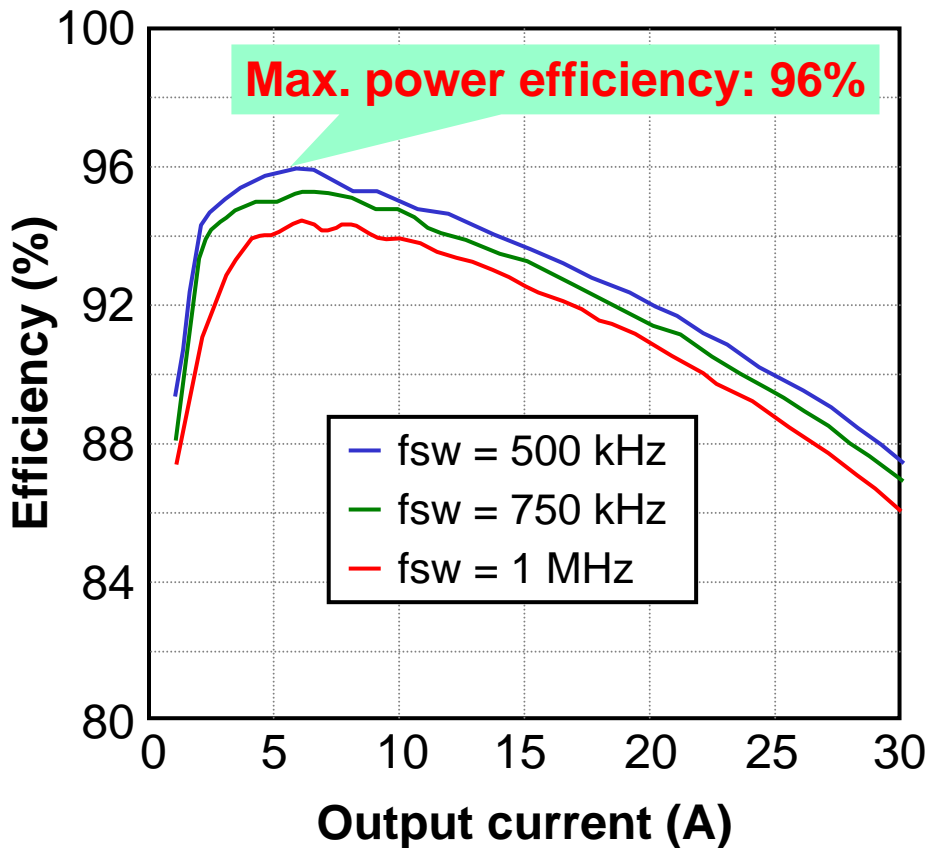
**40-pin QFN  
(6 × 6 mm)**

**44% cut  
in mounting  
area**

# DrMOS (R2J20651NP) (2)

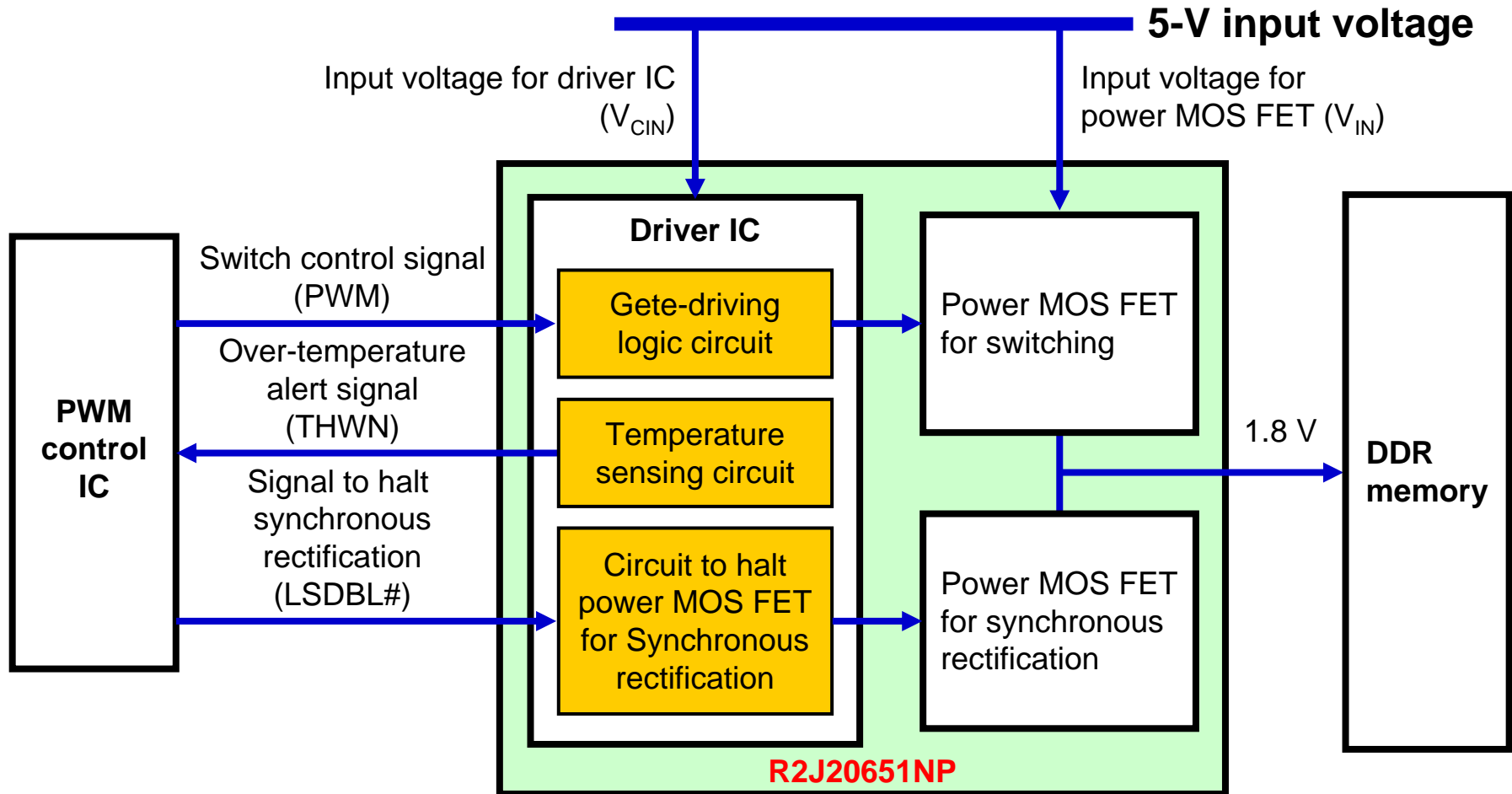
**Low loss and high power efficiency keeps heat generation down.**

Test conditions  
 $V_{IN} = 5\text{ V}$ ,  
 $V_{OUT} = 1.8\text{ V}$ ,  
no air flow,  
no heat sink



# DrMOS (R2J20651NP) (3)

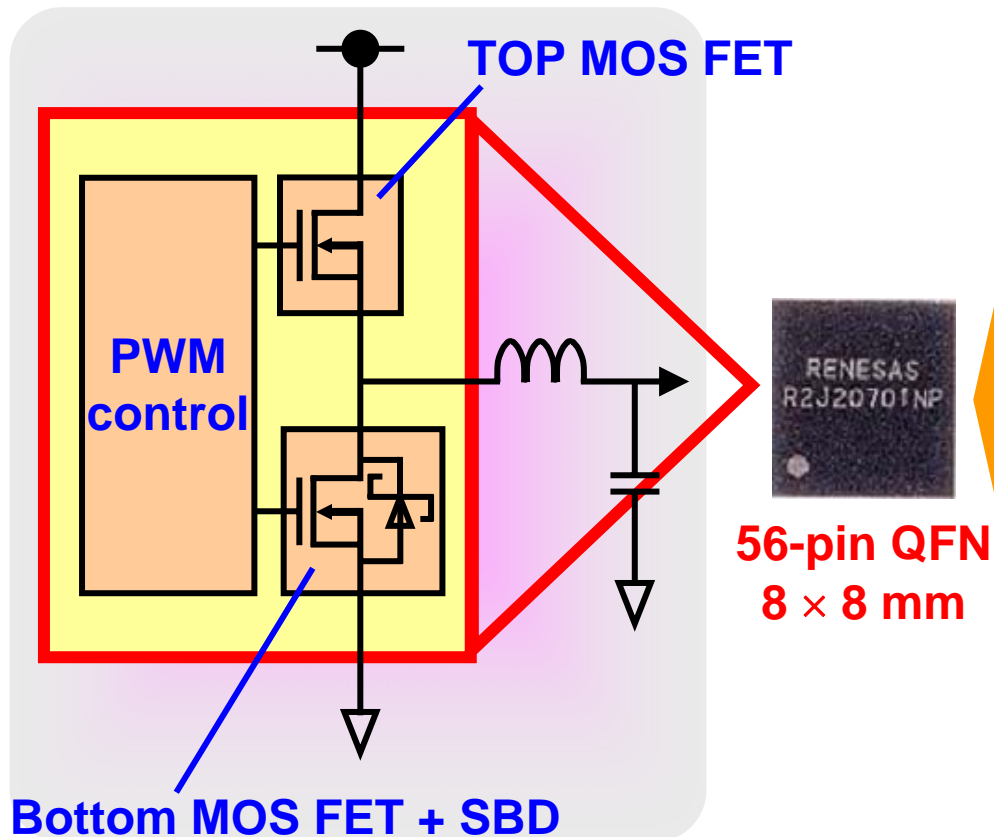
## Sample system configuration: DC-DC power supply for DDR RAM



# POL-SiP (R2J20702NP) (1)

PWM IC, MOS FET × 2 → Incorporated in a single package

Fully compatible with R2J20701NP pin assignment



Compact/space saving

57% cut in mounting area  
(compared to discrete devices)

Large current/  
High power efficiency

High response speed

Multi-functionality



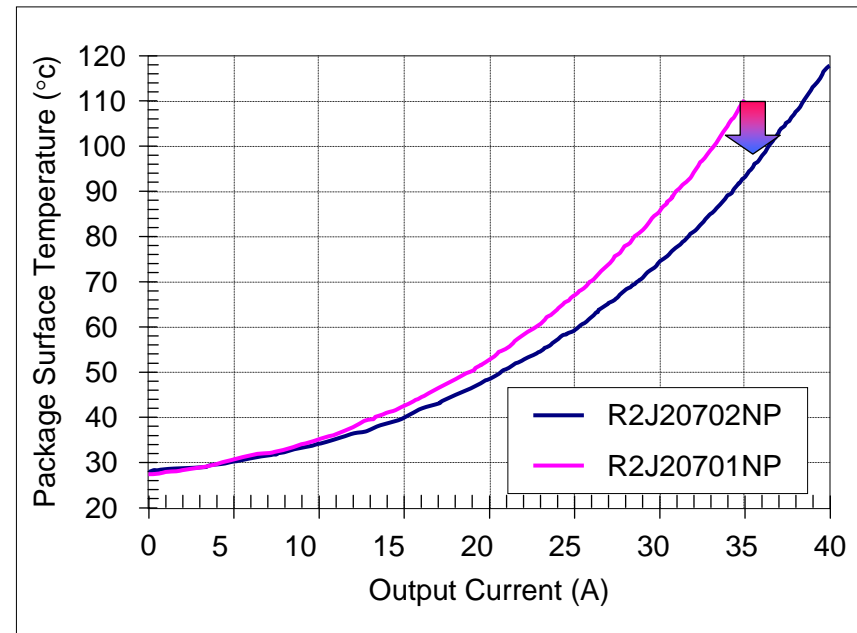
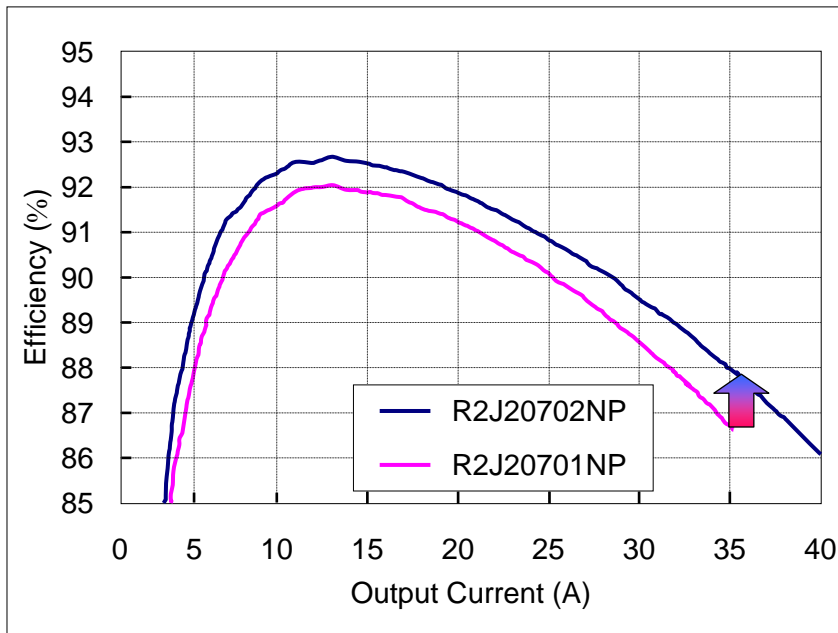
# POL-SiP (R2J20702NP) (2)

**Low loss and high power efficiency  
keeps heat generation down.**

Test conditions  
 $V_{IN} = 12\text{ V}$ ,  
 $V_{OUT} = 1.8\text{ V}$ ,  
fsw = 500 kHz,  
 $L = 0.32\text{ }\mu\text{H}$ ,  
 $C_{OUT} = 600\text{ }\mu\text{F}$ ,  
no air flow

Evaluation data

## ■ Efficiency + Package Surface Temperature



# POL-SiP (R2J20702NP) (3)

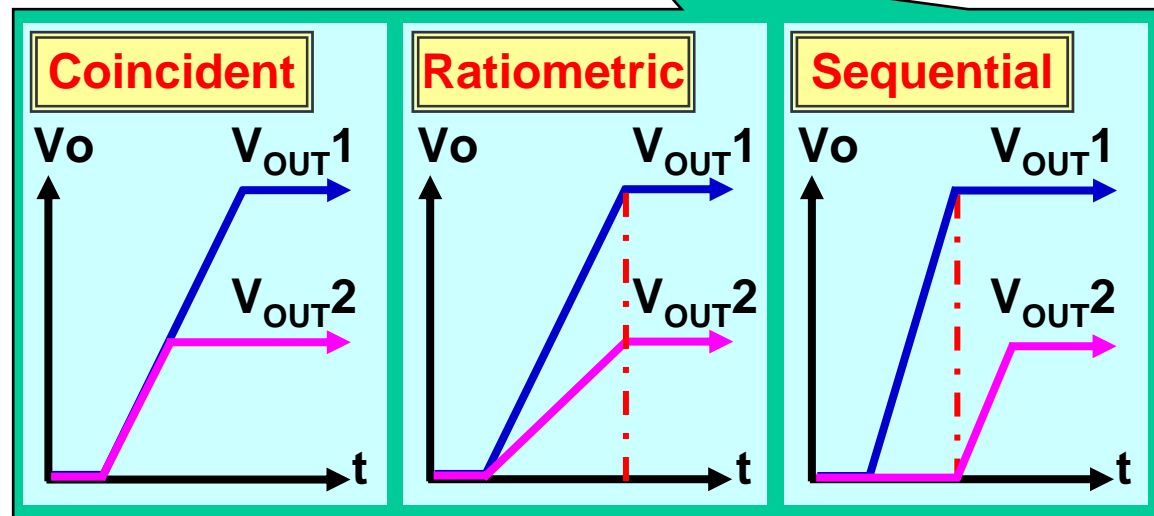
Availability of various styles of parallel driving **simplifies design.**

## 2-phase operation

- Large-current driving (80 A)
- Current sharing
- Automatic phase shifting by  $180^\circ$

## Multi-channel operation

- Parallel synchronous behavior
- Various kinds of tracking start are available.

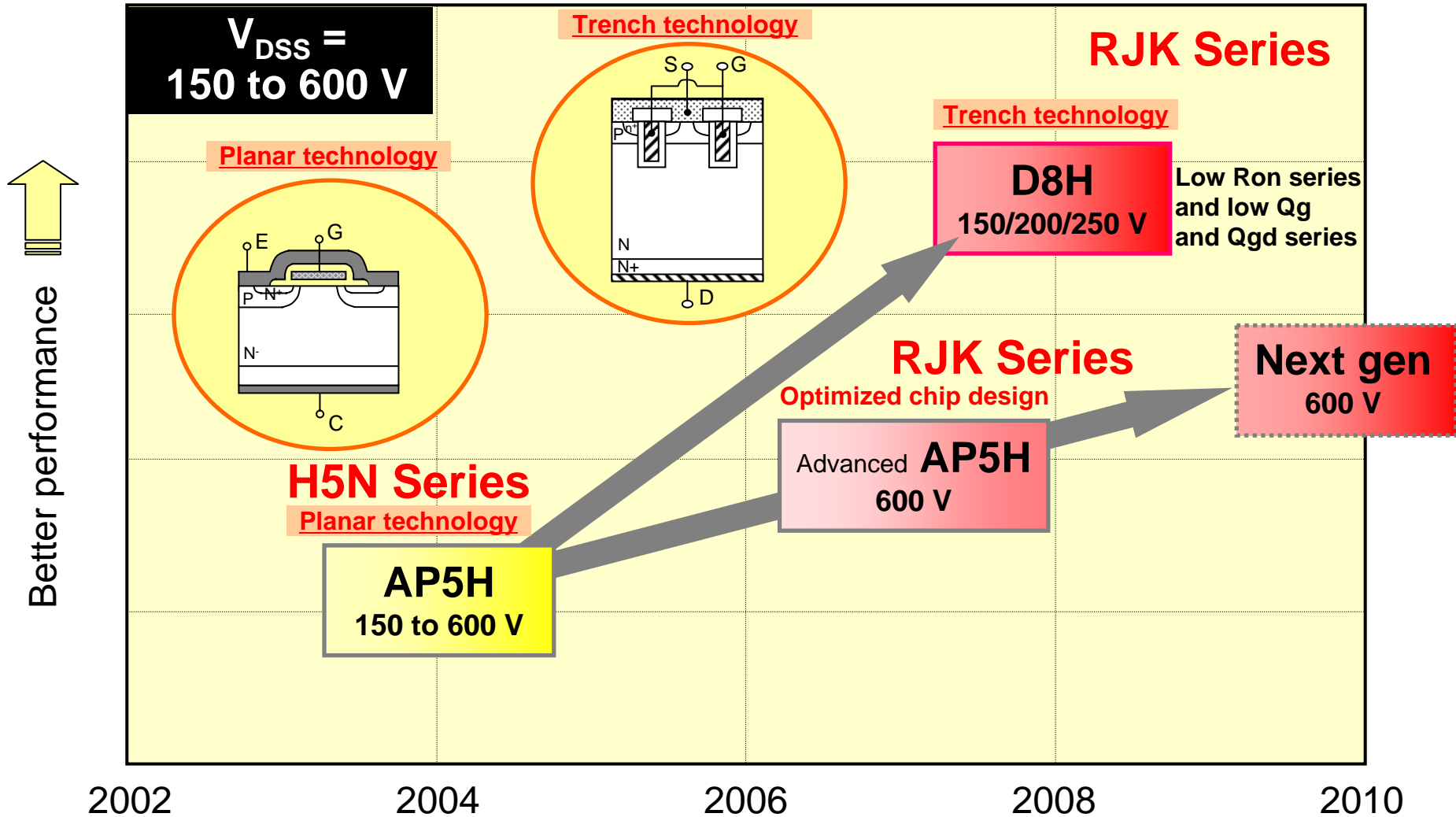


# Power MOS FETs

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**Medium-/High-Voltage Power MOS FETs**  
 **$V_{DSS} = 150\text{ V to }600\text{ V}$**

# Roadmap of Medium-/High-Voltage Power MOS FETs



# Features of Medium-, High-Voltage Power MOS FETs

- Lineup of ultra-low on-resistance, large-current products
  - RJK2511DPK: 250 V, 65 A, 34 m $\Omega$ , TO-3P
  - RJK4018DPK: 400 V, 43 A, 100 m $\Omega$ , TO-3P
  - RJK5020DPK: 500 V, 40 A, 115 m $\Omega$ , TO-3P
  - RJK6020DPK: 600 V, 32 A, 175 m $\Omega$ , TO-3P
- Low gate charge (low Qg)
- Avalanche tolerance guaranteed
- Built-in diode with high breakdown-tolerance

# New Products: 8th Generation Trench-type (150 V- 250 V)

**New Products**

Low on-state resistance

## Low on-state resistance series

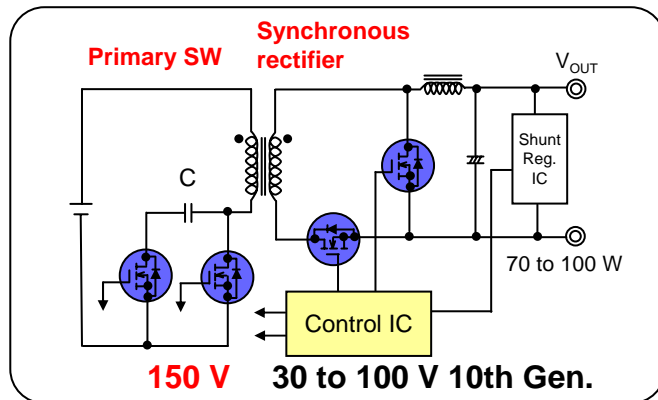
| Package | Part No.   | $V_{DSS}$<br>[V] | $I_D$<br>[A] | $R_{DS(on)}$<br>Max. [ $\Omega$ ] | Ciss<br>Typ. [pF] | Qg<br>Typ. [nC] | Qgd<br>Typ. [nC] | Schedule |    |
|---------|------------|------------------|--------------|-----------------------------------|-------------------|-----------------|------------------|----------|----|
|         |            |                  |              |                                   |                   |                 |                  | ES       | MP |
| WPAK    | RJK1555DPA | 150              | 25           | 0.048                             | 2400              | 38              | 10.2             | OK       | OK |
|         | RJK2055DPA | 200              | 20           | 0.069                             | 2400              | 38              | 9.0              | OK       | OK |
|         | RJK2555DPA | 250              | 17           | 0.104                             | 2400              | 39              | 10.5             | OK       | OK |

High speed switching

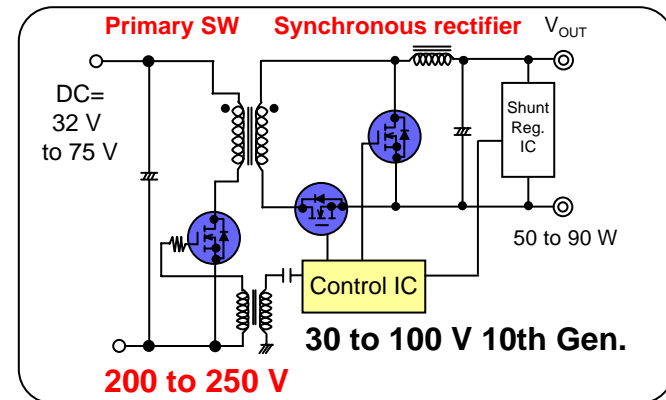
## Low-Capacitance series

| Package | Part No.   | $V_{DSS}$<br>[V] | $I_D$<br>[A] | $R_{DS(on)}$<br>Max. [ $\Omega$ ] | Ciss<br>Typ. [pF] | Qg<br>Typ. [nC] | Qgd<br>Typ. [nC] | Schedule |    |
|---------|------------|------------------|--------------|-----------------------------------|-------------------|-----------------|------------------|----------|----|
|         |            |                  |              |                                   |                   |                 |                  | ES       | MP |
| WPAK    | RJK1557DPA | 150              | 25           | 0.058                             | 1250              | 20              | 5                | OK       | OK |
|         | RJK2057DPA | 200              | 20           | 0.085                             | 1250              | 19              | 5.3              | OK       | OK |
|         | RJK2557DPA | 250              | 17           | 0.128                             | 1250              | 20              | 5.9              | OK       | OK |

**Recommended application: primary-side switches of isolating brick converter**



**Active clamp circuit**



**Single-ended forward converter circuit**

# Lineup of 150- to 600-V Power MOS FETs (Compact Packages for Surface Mounting)

| Package          | Part No.   | V <sub>DSS</sub> [V] | I <sub>D</sub> [A] | R <sub>DS(on)</sub> Max. [Ω] | Ciss [pF] | Schedule  |           |
|------------------|------------|----------------------|--------------------|------------------------------|-----------|-----------|-----------|
|                  |            |                      |                    |                              |           | WS        | MP        |
| TO-92            | 2SK4151    | 150                  | 1                  | 1.95                         | 98        | -         | Available |
|                  | 2SK4150    | 250                  | 0.4                | 5.7                          | 80        | -         | Available |
|                  | HS54095    | 600                  | 0.15               | 25                           | 50        | -         | Available |
|                  | HS54097    |                      | 0.2                | 16.5                         | 66        | -         | Available |
| TO-92MOD         | 2SK4093    | 250                  | 1                  | 2.6                          | 140       | -         | Available |
|                  | RJK6011DJE | 600                  | 0.1                | 52                           | 25        | -         | Available |
|                  | RJK6022DJE |                      | 0.2                | 15                           | 84        | -         | Available |
|                  | HS56021    |                      | 0.2                | 15                           | 84        | -         | Available |
| MP-3A<br>(SMD)   | RJK4006DPD | 400                  | 8                  | 0.8                          | 650       | -         | Available |
|                  | RJK5003DPD | 500                  | 5                  | 1.5                          | 550       | -         | Available |
|                  | RJK5006DPD |                      | 7                  | 1.3                          | 650       | -         | Available |
|                  | RJK6002DPD | 600                  | 2                  | 6.8                          | 160       | -         | Available |
|                  | RJK6023DPD |                      | 0.15               | 25                           | 240       | Available | Available |
|                  | RJK6024DPD |                      | 0.4                | 42                           | TBD       | Available | Available |
|                  | RJK6025DPD |                      | 0.8                | 20                           | TBD       | Available | Available |
| LDBAK-S<br>(SMD) | RJK2006DPE | 200                  | 40                 | 0.059                        | 1800      | -         | Available |
|                  | RJK4012DPE | 400                  | 15                 | 0.41                         | 1120      | -         | Available |
|                  | RJK4013DPE |                      | 17                 | 0.3                          | 1470      | -         | Available |
|                  | RJK4512DPE | 450                  | 14                 | 0.51                         | 1100      | -         | Available |
|                  | RJK4513DPE |                      | 16                 | 0.38                         | 1440      | -         | Available |
|                  | RJK5012DPE | 500                  | 12                 | 0.62                         | 1100      | -         | Available |
|                  | RJK5013DPE |                      | 14                 | 0.465                        | 1470      | -         | Available |
|                  | RJK6026DPE | 600                  | 5                  | 2.4                          | 440       | -         | Available |
|                  | RJK6012DPE |                      | 10                 | 0.92                         | 1100      | -         | Available |
|                  | RJK6024DPE |                      | 0.4                | 42                           | TBD       | Available | Available |
|                  | RJK6025DPE |                      | 0.8                | 20                           | TBD       | Available | Available |
|                  | RJK6013DPE |                      | 11                 | 0.7                          | 1470      | -         | Available |



TP-92



TP-92MOD

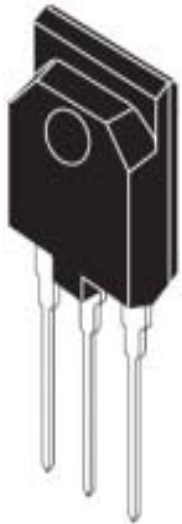


MP-3A



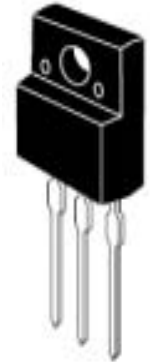
LDBAK-S

# Lineup of 400- to 600-V Power MOS FETs (3-Pin Through-Hole Packages)

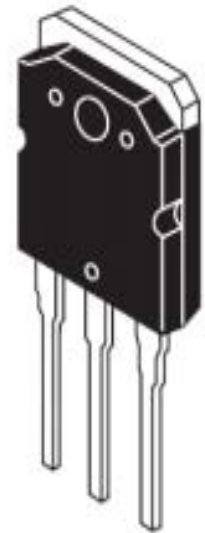


TO-3PFM

| Package                 | Part No.      | V <sub>DSS</sub><br>[V] | I <sub>D</sub><br>[A] | R <sub>DS(on)</sub><br>Max. [Ω] | C <sub>iss</sub><br>[pF] | Schedule  |           |
|-------------------------|---------------|-------------------------|-----------------------|---------------------------------|--------------------------|-----------|-----------|
|                         |               |                         |                       |                                 |                          | WS        | MP        |
| TO-220FN<br>(full mold) | RJK4007DPP    | 400                     | 7.6                   | 0.55                            | 850                      | -         | Available |
|                         | RJK5026DPP    | 500                     | 6                     | 1.75                            | 450                      | -         | Available |
|                         | RJK5012DPP    |                         | 12                    | 0.62                            | 1100                     | -         | Available |
|                         | RJK5013DPP    |                         | 14                    | 0.465                           | 1470                     | -         | Available |
|                         | RJK5014DPP    |                         | 19                    | 0.38                            | 1800                     | -         | Available |
|                         | RJK5009DPP    |                         | 20                    | 0.3                             | 2600                     | -         | Available |
|                         | RJK6026DPP    |                         | 600                   | 5                               | 2.4                      | 440       | -         |
|                         | RJK6012DPP    | 10                      |                       | 0.92                            | 1100                     | -         | Available |
|                         | RJK6013DPP    | 11                      |                       | 0.7                             | 1470                     | -         | Available |
|                         | RJK6014DPP    | 16                      |                       | 0.575                           | 1800                     | -         | Available |
| TO-220FL<br>(full mold) | RJK6066DPP-MO |                         | 5                     | 3                               | TBD                      | Available | '10/Q1    |
|                         | RJK6052DPP-MO |                         | 10                    | 1.15                            | TBD                      | Available | '10/Q1    |
|                         | RJK6053DPP-MO |                         | 11                    | 0.875                           | TBD                      | Available | '10/Q1    |
|                         | RJK6054DPP-MO |                         | 16                    | 0.72                            | TBD                      | Available | '10/Q1    |
| TO-3PFM                 | RJK2009DPM    | 200                     | 40                    | 0.036                           | 2900                     | -         | Available |
|                         | RJK5015DPM    | 500                     | 25                    | 0.24                            | 2600                     | -         | Available |
|                         | RJK6015DPM    | 600                     | 21                    | 0.36                            | 2600                     | -         | Available |
| TO-3P                   | RJK2508DPK    | 250                     | 50                    | 0.064                           | 2600                     | -         | Available |
|                         | RJK2511DPK    |                         | 65                    | 0.034                           | 4900                     | -         | Available |
|                         | RJK4014DPK    | 400                     | 24                    | 0.24                            | 1820                     | -         | Available |
|                         | RJK4015DPK    |                         | 30                    | 0.165                           | 2600                     | -         | Available |
|                         | RJK4018DPK    |                         | 43                    | 0.1                             | 4100                     | -         | Available |
|                         | RJK4514DPK    | 450                     | 22                    | 0.3                             | 1820                     | -         | Available |
|                         | RJK4515DPK    |                         | 27                    | 0.2                             | 2600                     | -         | Available |
|                         | RJK4518DPK    | 500                     | 39                    | 0.13                            | 4100                     | -         | Available |
|                         | RJK5013DPK    |                         | 14                    | 0.465                           | 1470                     | -         | Available |
|                         | RJK5014DPK    | 600                     | 19                    | 0.38                            | 1800                     | -         | Available |
|                         | RJK5015DPK    |                         | 25                    | 0.24                            | 2600                     | -         | Available |
|                         | RJK5018DPK    |                         | 35                    | 0.155                           | 4100                     | -         | Available |
|                         | RJK5020DPK    |                         | 40                    | 0.118                           | 5150                     | -         | Available |
|                         | RJK6014DPK    | 600                     | 16                    | 0.575                           | 1800                     | -         | Available |
| RJK6015DPK              | 21            |                         | 0.36                  | 2600                            | -                        | Available |           |
| RJK6018DPK              | 30            |                         | 0.235                 | 4100                            | -                        | Available |           |
| RJK6020DPK              | 32            |                         | 0.175                 | 5150                            | -                        | Available |           |



TO-220FN  
TO-220FL

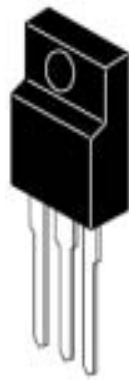


TO-3P



# Lineup of 250- to 600-V Power MOS FET Products Incorporation High-Speed Diodes

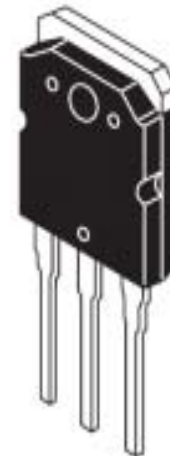
| Package                  | Part No.   | V <sub>DSS</sub><br>[V] | I <sub>D</sub><br>[A] | R <sub>DS(on)</sub><br>Max. [Ω] | C <sub>iss</sub><br>[pF] | Schedule |           |
|--------------------------|------------|-------------------------|-----------------------|---------------------------------|--------------------------|----------|-----------|
|                          |            |                         |                       |                                 |                          | WS       | MP        |
| TO-220CFM<br>(full mold) | H5N2512CF  | 250                     | 18                    | 0.105                           | 2200                     | -        | Available |
|                          | H5N3007CF  | 300                     | 15                    | 0.16                            | 2180                     | -        | Available |
| TO-220FN<br>(full mold)  | H5N2522FN  | 250                     | 12                    | 0.21                            | 1300                     | -        | Available |
|                          | RJL5012DPP |                         | 12                    | 0.7                             | 1050                     | -        | Available |
|                          | RJL5013DPP | 600                     | 14                    | 0.51                            | 1400                     | -        | Available |
|                          | RJL6012DPP |                         | 10                    | 1.1                             | 1050                     | -        | Available |
|                          | RJL6013DPP |                         | 11                    | 0.81                            | 1400                     | -        | Available |
|                          | RJL6014DPP |                         | 15                    | 0.635                           | 1680                     | -        | Available |
| TO-3P                    | H5N2507P   | 250                     | 50                    | 0.055                           | 5000                     | -        | Available |
|                          | H5N3008P   | 300                     | 40                    | 0.069                           | 5150                     | -        | Available |
|                          | RJL5020DPK | 500                     | 38                    | 0.14                            | TBD                      | -        | Available |
|                          | RJL6020DPK | 600                     | 30                    | 0.21                            | TBD                      | -        | Available |



TO-220CFM



TO-220FN



TO-3P

# IGBT

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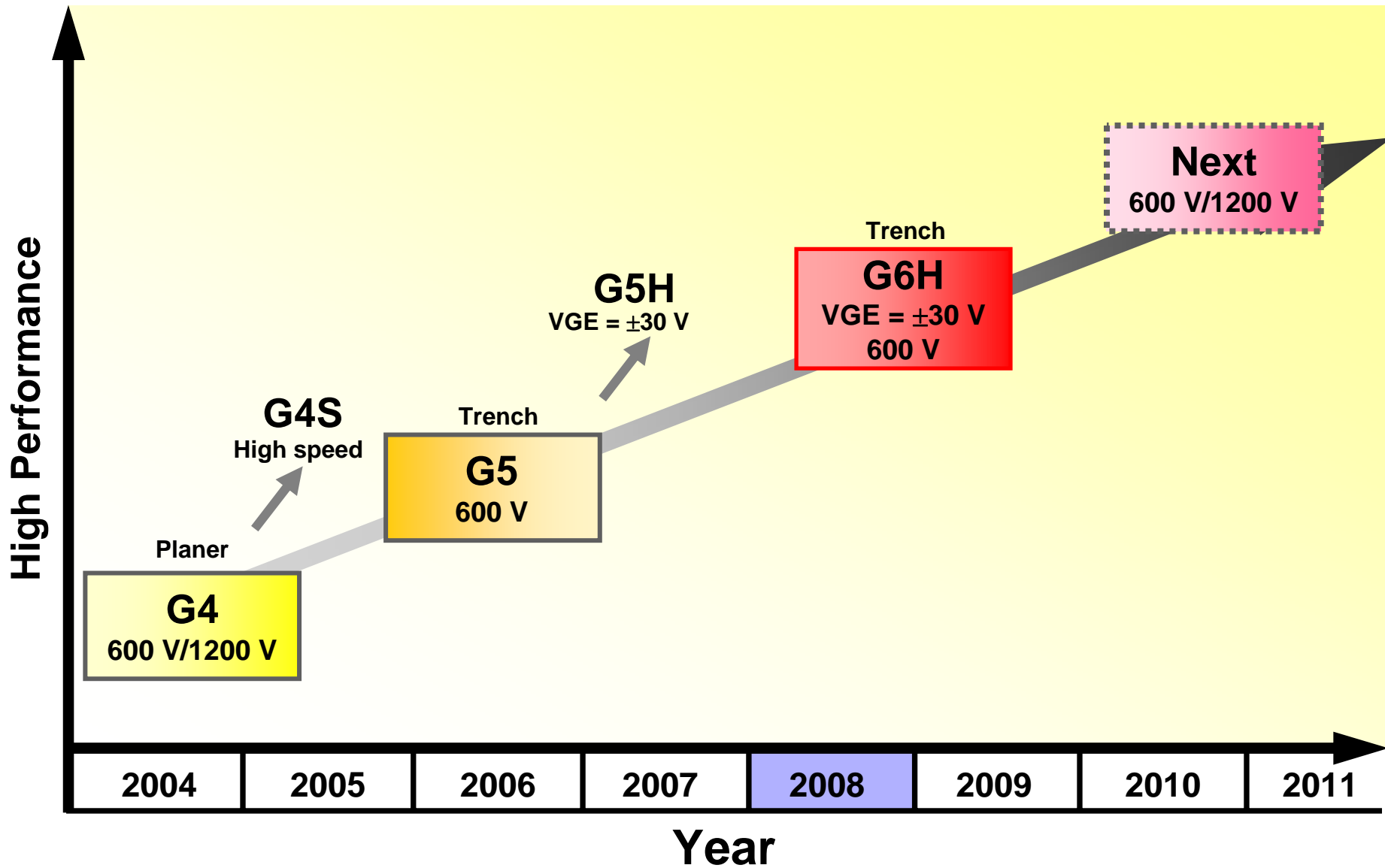
- **IGBTs for Industrial and HA Applications**
- **IGBTs for Strobe Flash**

# IGBT

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## IGBTs for Industrial and HA Applications

# IGBT Road Map



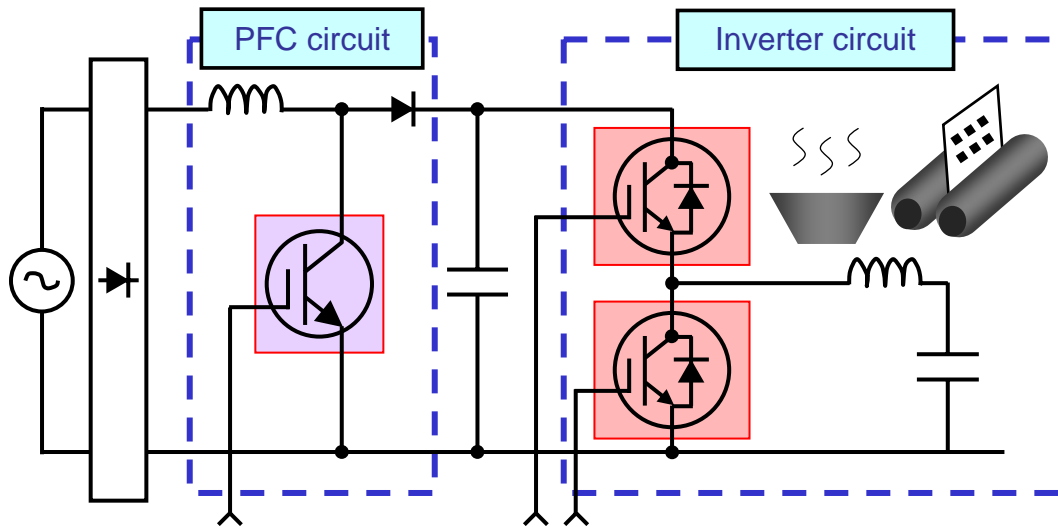
# IGBTs for Cook Top

## ■ Features and Merits

Best support for miniaturization and high efficiency

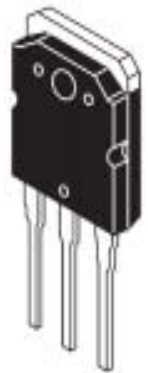
| Circuit                               | Family                               | Part No.   | Feature  | Merit   |
|---------------------------------------|--------------------------------------|------------|--|---|
| current synchronous resonance circuit | Low $V_{CE(sat)}$<br>High Speed type | RJH60F4DPK | Low saturation voltage<br>High speed switching (90 ns) typ.<br>Small package (TO-3P) | For high output, Low ON loss<br>For high frequency, Low switching loss<br>Miniaturization |

## ■ Circuit Examples (Half-bridge current synchronous resonance circuit)



IH: Induction Heating  
A method of pot heating by using electromagnetic induction, spiral current generate at the bottom of pot on heater.

## ■ Package



TO-3P

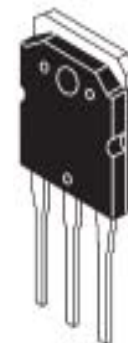
# Low $V_{CE(sat)}$ High Speed IGBT Lineup

**New Products**

## Features

- 600 V class products with Thin wafer and Trench technology
- Low Collector to Emitter saturation voltage  $V_{CE(sat)}$
- Pb free (Lead dip and Chip bonding)

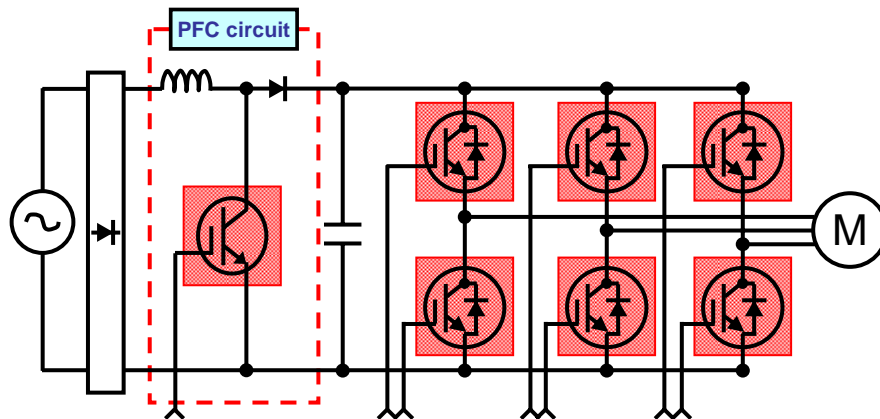
| P/N         | $V_{CES}$<br>[V] | $I_C$<br>[A] | $V_{CE(sat)}$<br>Typ. [V] | Conditions   | tf<br>Typ. [ns] | Diode          |               | Package | Development schedule plan |        |
|-------------|------------------|--------------|---------------------------|--------------|-----------------|----------------|---------------|---------|---------------------------|--------|
|             |                  |              |                           |              |                 | $V_F$ typ. (V) | trr typ. (ns) |         | WS                        | MP     |
| RJH60F0DPK  | 600              | 50           | 1.40                      | $I_C = 25$ A | 90              | 1.6            | 140           | TO-3P   | OK                        | '10/Q1 |
| RJH60F4DPK  | 600              | 60           | 1.40                      | $I_C = 30$ A | 80              | 1.6            | 140           | TO-3P   | OK                        | OK     |
| RJH60F5DPK  | 600              | 80           | 1.37                      | $I_C = 40$ A | 80              | 1.6            | 140           | TO-3P   | OK                        | OK     |
| RJH60F6DPK  | 600              | 85           | 1.35                      | $I_C = 45$ A | 95              | 1.6            | 140           | TO-3P   | OK                        | '10/Q1 |
| RJH60F7ADPK | 600              | 90           | 1.35                      | $I_C = 50$ A | 95              | 1.6            | 140           | TO-3P   | OK                        | OK     |



TO-3P

# IGBTs for Motor Control and Inverter Units

| Device                             | Features                                | Merit                |
|------------------------------------|---|----------------------|
| High Short circuit capability IGBT | Low $V_{CE(sat)}$ (1.6 V) typ.          | Making to high power |
|                                    | Fast recovery diode (100 ns) typ.       | Miniaturization      |
|                                    | Short circuit capability 5 $\mu$ s min. | High reliability     |



Circuit example of Motor control

## Applications

Air conditioner, Refrigerator, Washing machine  
 Photovoltaic generation, UPS, Machine tool,  
 Fan control, and general-purpose inverter unit  
 etc.

# High Short Circuit Capability IGBT Lineup

New Products

Under Development

[tsc] Test condition:  $V_{CE} = 400\text{ V}$ ,  $V_{GE} = 15\text{ V}$ / $T_c = 100^\circ\text{C}$

| IGBT       | $V_{CES}$ (V) | $I_C$ (A)<br>( $25^\circ\text{C}/100^\circ\text{C}$ ) | $V_{CE(sat)}$ (V) |           |              | tf (ns) |           |              | tsc ( $\mu\text{s}$ )<br>min. | Built-in<br>FRD | Package   | Status |        |
|------------|---------------|---|-------------------|-----------|--------------|---------|-----------|--------------|-------------------------------|-----------------|-----------|--------|--------|
|            |               |   | typ.              | $I_C$ (A) | $V_{GE}$ (V) | typ.    | $I_C$ (A) | $V_{CE}$ (V) |                               |                 |           | WS     | MP     |
| RJH60C9DPD | 600           | (10)/(5)  | (1.9)             | 5         | 15           | (100)   | 5         | 300          | (5)                           | Yes             | MP-3A     | OK     | '10/Q1 |
| RJH60D1DPP | 600           | (16)/(8)  | (1.6)             | 8         | 15           | (100)   | 8         | 300          | (5)                           | Yes             | TO-220FL  | OK     | '10/Q1 |
| RJH60D1DPE | 600           | (16)/(8)  | (1.6)             | 8         | 15           | (100)   | 8         | 300          | (5)                           | Yes             | LDBAK (S) | OK     | '10/Q1 |
| RJH60D2DPP | 600           | (20)/(10)   | (1.6)             | 10        | 15           | (100)   | 10        | 300          | (5)                           | Yes             | TO-220FL  | OK     | '10/Q1 |
| RJH60D2DPE | 600           | (20)/(10)   | (1.6)             | 10        | 15           | (100)   | 10        | 300          | (5)                           | Yes             | LDBAK (S) | OK     | '10/Q1 |
| RJH60D3DPP | 600           | (30)/(15)   | (1.6)             | 15        | 15           | (100)   | 15        | 300          | (5)                           | Yes             | TO-220FL  | OK     | '10/Q1 |
| RJH60D3DPE | 600           | (30)/(15)   | (1.6)             | 15        | 15           | (100)   | 15        | 300          | (5)                           | Yes             | LDBAK (S) | OK     | '10/Q1 |
| RJH60D0DPK | 600           | (40)/(20)   | (1.6)             | 20        | 15           | (100)   | 20        | 300          | (5)                           | Yes             | TO-3P     | OK     | '10/Q1 |
| RJH60D5DPK | 600           | (60)/(30)   | (1.6)             | 30        | 15           | (100)   | 30        | 300          | (5)                           | Yes             | TO-3P     | OK     | '10/Q1 |
| RJH60D6DPK | 600           | (80)/(40)   | (1.6)             | 40        | 15           | (100)   | 40        | 300          | (5)                           | Yes             | TO-3P     | OK     | '10/Q1 |
| RJH60D7DPK | 600           | (90)/(50)   | (1.6)             | 50        | 15           | (100)   | 50        | 300          | (5)                           | Yes             | TO-3P     | OK     | '10/Q1 |

## Applications

Solar photovoltaic system,  
air-conditioning, refrigerator,  
washing machine, UPS,  
Eco Cute and other.



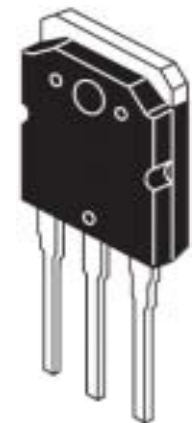
MP-3A



TO-220FL



LDBAK-S



TO-3P

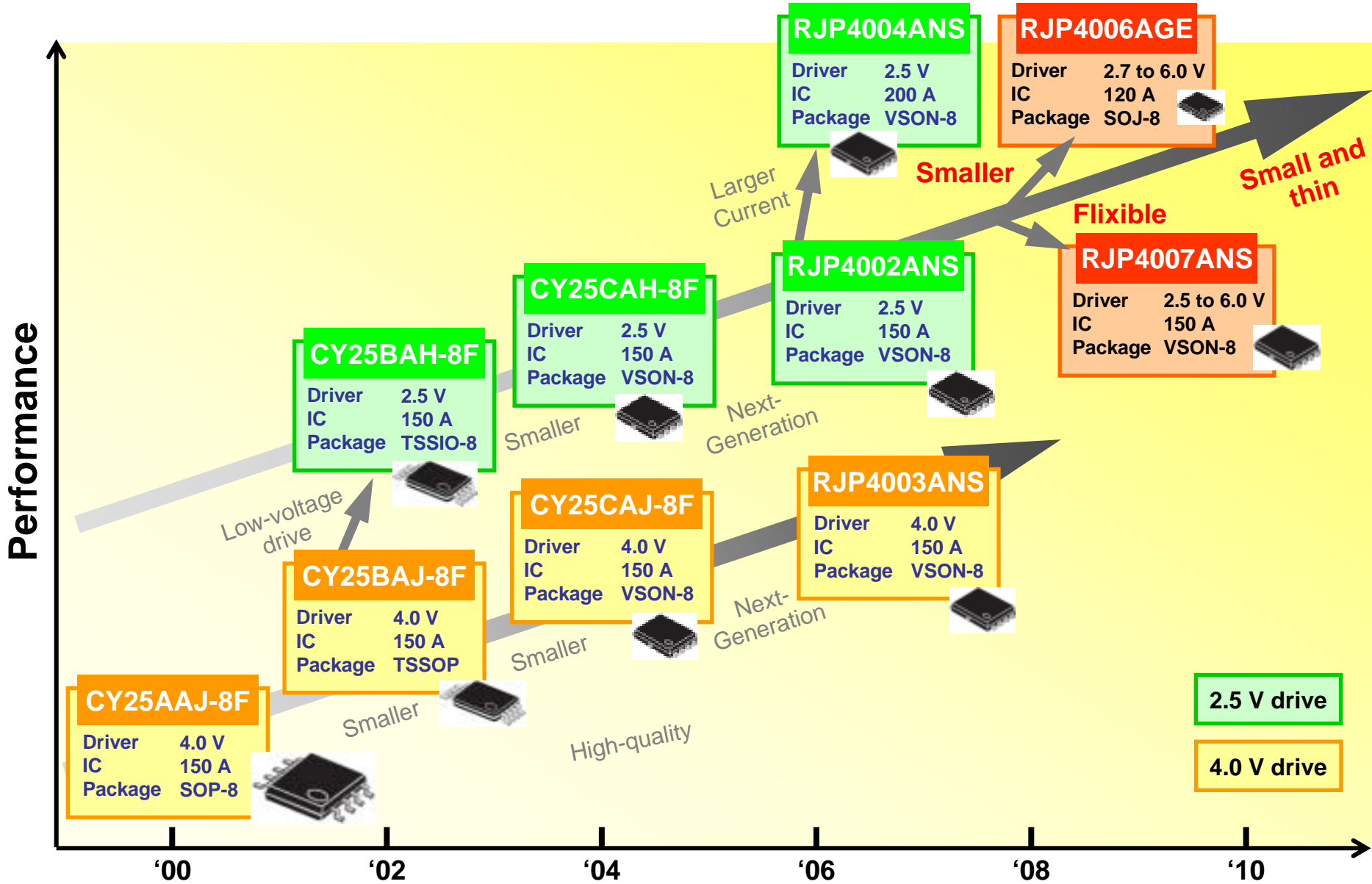


# IGBT

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## IGBTs for Strobe Flash

# Development Roadmap of IGBT for Strobe Use



# Development of Products for Large-Current Control: IGBT for Internal Strobe Use

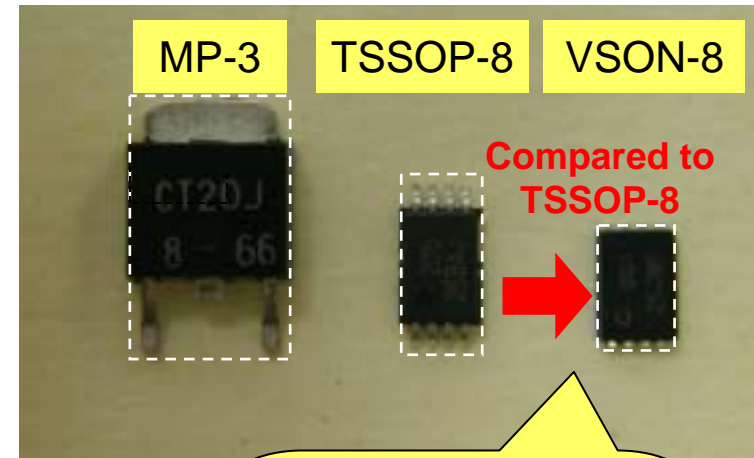
Under Development

- Part No.

RJP4004ANS

- Features

1. Large current (200 A)  
Making possible more compact xenon tubes
2. Industry's smallest package (VSON-8: 3044)
3. Low-voltage drive (2.5 V)  
Optimized for 3.3-V power supply
4. High ESD level
5. Full lead-free



Package footprint:  
Reduced to 25%  
Package height:  
Reduced to 15%

- Development Product

| Part No.   | $V_{CES}$<br>[V] | $I_{CP}$<br>[A] | Drive<br>[V] | Package | Schedule |    |    |
|------------|------------------|-----------------|--------------|---------|----------|----|----|
|            |                  |                 |              |         | WS       | CS | MP |
| RJP4004ANS | 400              | 200             | 2.5 V        | VSON-8  | OK       | OK | OK |

# New Products of IGBT for Strobe

## New Products

- Part No.

1. **VSON-8 package:** RJP4007ANS

2. **SOJ-8 package:** RJP4006AGE

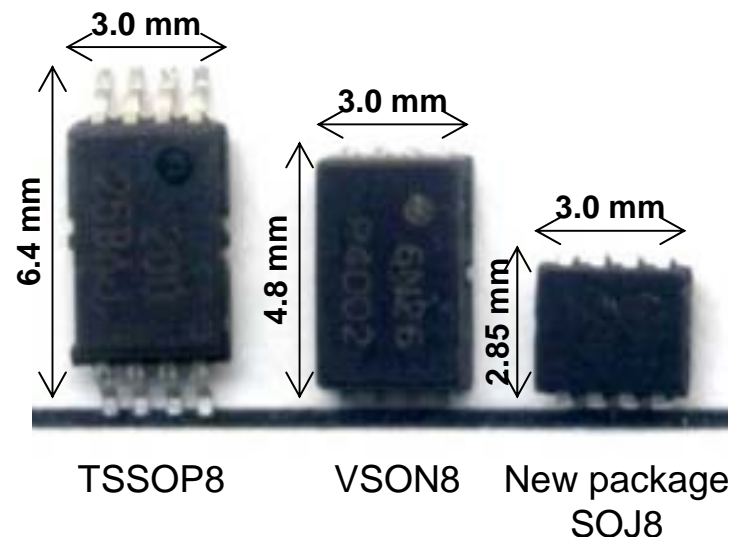
- Features

1. Ultra small package (SOJ-8: size: 3.05 × 2.85 mm)

2. Flexible free (2.5 V (2.7 V) to 6.0 V)

3. High ESD capability (built-in gate zener diode)

4. Completed Pb Free and Halogen Free



- Lineups

| Part No.   | V <sub>CES</sub> [V] | I <sub>CP</sub> [A] | Drive [V]    | Package | Schedule |    |    |
|------------|----------------------|---------------------|--------------|---------|----------|----|----|
|            |                      |                     |              |         | WS       | CS | MP |
| RJP4006AGE | 400                  | 120                 | 2.7 to 6.0 V | SOJ-8   | OK       | OK | OK |
| RJP4007ANS | 400                  | 150                 | 2.5 to 6.0 V | VSON-8  | OK       | OK | OK |

# Lineup of Renesas IGBT for Strobe Use

| Part No.           | Maximum ratings  |                 |              | Package  |
|--------------------|------------------|-----------------|--------------|----------|
|                    | $V_{CES}$<br>[V] | $I_{CP}$<br>[A] | Drive<br>[V] |          |
| CY20AAJ-8H (Note)  | 400              | 130             | 4.0          | SOP-8    |
| RJP4003ASA         | 400              | 150             | 4.0          | TSSOP-8  |
| RJP4002ASA         | 400              | 150             | 2.5          | TSSOP-8  |
| RJP4003ANS         | 400              | 150             | 4.0          | VSON-8   |
| RJP4002ANS         | 400              | 150             | 2.5          | VSON-8   |
| RJP4004ANS*        | 400              | 200             | 2.5          | VSON-8   |
| RJP4301APP* (Note) | 400              | 200             | 30.0         | TO-220FN |
| RJP5001APP* (Note) | 400              | 300             | 12.0         | TO-220FN |
| RJP4006AGE         | 400              | 120             | 2.7-4.0      | SOJ-8    |
| RJP4007ANS         | 400              | 150             | 2.5-4.0      | VSON-8   |

\*: Under Development

(Note): High frequency type

# Triacs and Thyristors

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# Examples of Thyristor and Triac Applications

## Triacs

## Thyristors

Control Alternate current

Control rectifier

Control capacitor  
(LC resonance)

Heaters  
and  
Lamp



Electric Pot



Rice cooker



Printer,  
Copier,  
Fax



Lamp

Solenoid  
Valve



Washing machine



Toilet seat



Dishwasher/dryer

Motor



Electric Fan



Vacuum machine



Electric tool

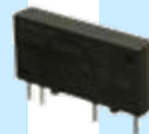
Others



SMPS  
(rush current  
protection)



Inverter Lighting  
(rush current  
prevention circuit)



Solid state relay



Bike (regulator)



Fan heater (igniter)



Boat Jet ski (igniter)



Leakage detector



Camera (strobe)

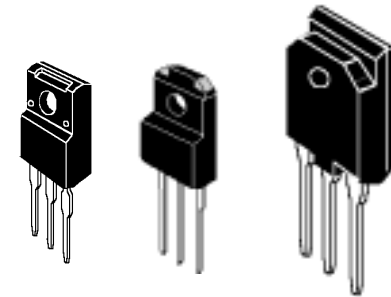
# Features of Renesas Thyristors and Triacs

- Development of guaranteed products against 150°C junction temperature (600 V/700 V/800 V)

- LB/LC/LD/LG Series

- Abundant lineups of products

- TO-220 full-mold type, UL certified
  - TO-3P full-mold type, for products requiring large current
  - Variety of lead-forming packages



- Product development optimized for applications

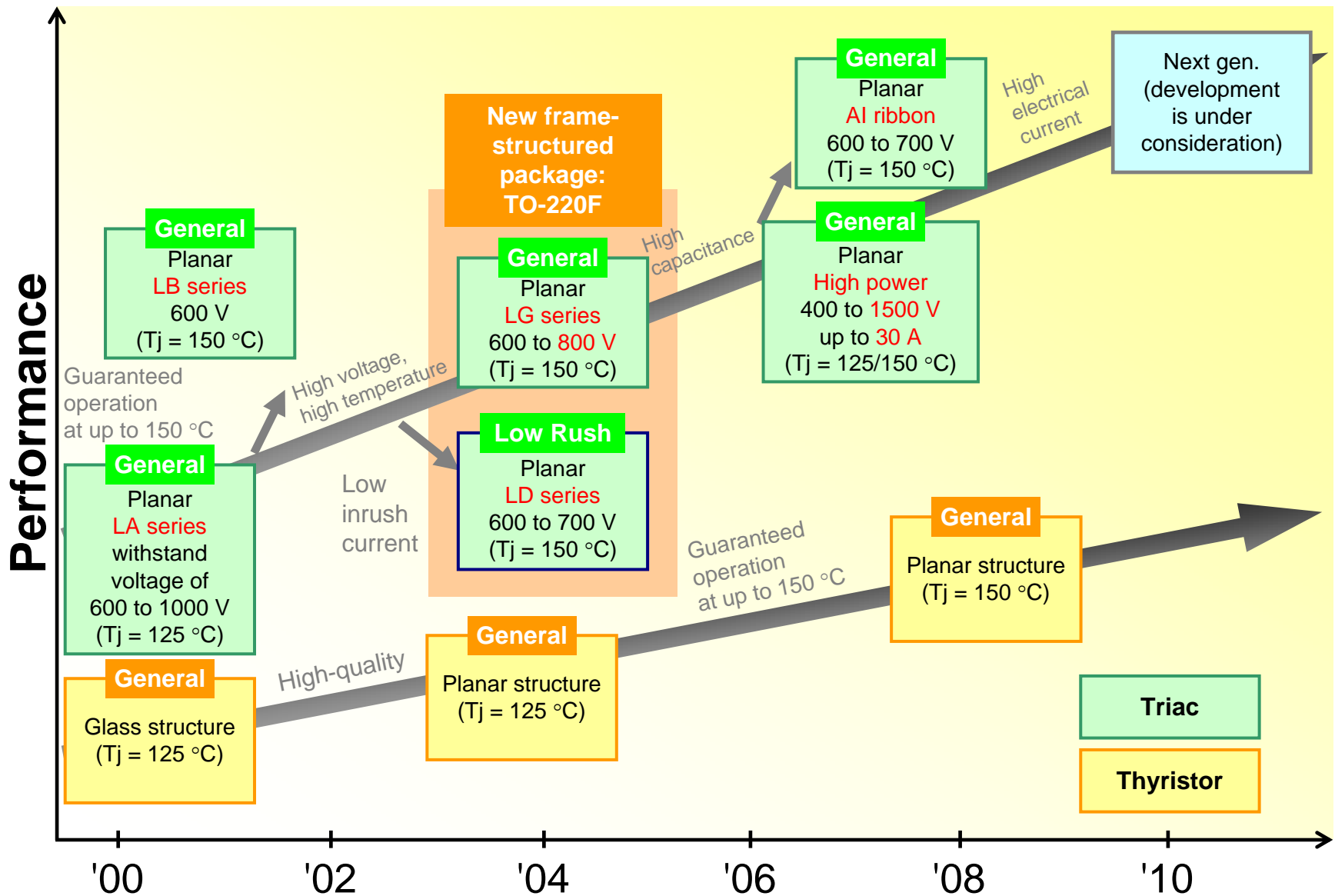
- For applications for low-rush current ••• LC and LD Series, etc.

- Development of high-voltage products

- 700 V, 800 V, 1000 V, 1500 V



# Roadmap of Triac and Thyristor Development



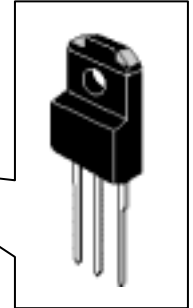
# Development of LG-Series Products: General-Purpose Triacs

- Applications

Control of heaters and motors used for laundry machines, vacuum cleaners, rice cookers, etc

- Features

- 1) High reliability: Adoption of planar structure
- 2) Insulation-type outline: TO-220F(1), dielectric strength of 2000 V, UL certified
- 3) High-withstand voltage: 600 V, 700 V, 800 V
- 4) High temperature guaranteed: 150 °C assured
- 5) Products in lead-forming package available



- Product List

| Part No.     | V <sub>DRMS</sub><br>[V] | I <sub>TRMS</sub><br>[A] | I <sub>TSM</sub><br>[A] | I <sub>GT</sub> (max.)<br>[mA] | Status |    | Note  |
|--------------|--------------------------|--------------------------|-------------------------|--------------------------------|--------|----|---|
|              |                          |                          |                         |                                | CS     | MP |   |
| BCR3PM-12LG  | 600                      | 3                        | 30                      | 20                             | OK     | OK | —   |
| BCR5PM-12LG  |                          | 5                        | 50                      | 20                             | OK     | OK | —   |
| BCR8PM-12LG  |                          | 8                        | 80                      | 30                             | OK     | OK | —   |
| BCR10PM-12LG |                          | 10                       | 100                     | 30                             | OK     | OK | —   |
| BCR12PM-12LG |                          | 12                       | 120                     | 30                             | OK     | OK | —   |
| BCR16PM-12LG |                          | 16                       | 160                     | 30                             | OK     | OK | —   |
| BCR3PM-14LG  | 700                      | 3                        | 30                      | 20                             | OK     | OK | Support V <sub>DRMS</sub><br>= 800 V<br>(@T <sub>j</sub> = 125°C) |
| BCR5PM-14LG  |                          | 5                        | 50                      | 30                             | OK     | OK |   |
| BCR8PM-14LG  |                          | 8                        | 80                      | 30                             | OK     | OK |   |
| BCR12PM-14LG |                          | 12                       | 120                     | 30                             | OK     | OK |   |
| BCR16PM-14LG |                          | 16                       | 160                     | 30                             | OK     | OK |   |
| BCR8PM-16LG  | 800                      | 8                        | 80                      | 30                             | OK     | OK | —   |

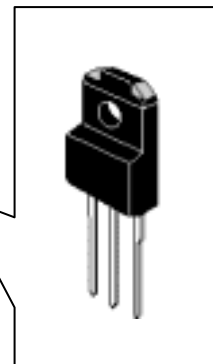
# Development of LD-Series Products: Triacs for Low-Rush Current

- Applications

Low-rush current applications for ceramic heaters, etc.

- Features

- 1) High reliability: Adoption of planar structure
- 2) Insulation-type outline: TO-220F(1), dielectric strength of 2000 V, UL certified
- 3) High-temperature guaranteed: 150 °C assured
- 4) High-noise tolerance:  $I_{GT} \leq 50$  mA
- 5) Products in lead-forming package available



- Product List

| Part No.     | $V_{DRMS}$<br>[V] | $I_{TRMS}$<br>[A] | $I_{TSM}$<br>[A] | $I_{GT}$ (max.)<br>[mA] | Status |    |
|--------------|-------------------|-------------------|------------------|-------------------------|--------|----|
|              |                   |                   |                  |                         | CS     | MP |
| BCR8PM-12LD  | 600               | 8                 | 48               | 50                      | OK     | OK |
| BCR10PM-12LD |                   | 10                | 60               | 50                      | OK     | OK |
| BCR12PM-12LD |                   | 12                | 72               | 50                      | OK     | OK |
| BCR16PM-12LD |                   | 16                | 96               | 50                      | OK     | OK |
| BCR5PM-14LD  | 700               | 5                 | 30               | 50                      | OK     | OK |
| BCR8PM-14LD  |                   | 8                 | 48               | 50                      | OK     | OK |

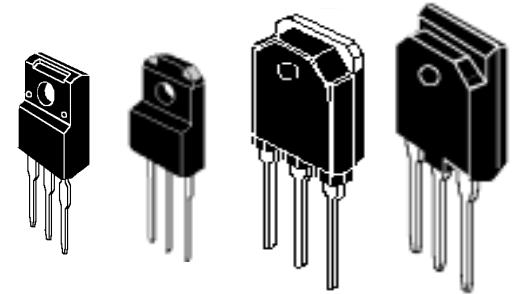
# Development of High-Voltage and High-Capacity Triacs for General Purposes

- Applications

Rush-current protection circuit during power-on, heater control, motor control

- Features

- 1) High reliability: Adoption of planar structure
- 2) Insulation-type outline: TO-220F/TO-220FN/TO-3P/TO-3PF
- 3) High-withstand voltage: 1000 V, 1500 V
- 4) Large current: **25 A/30 A at TO-220FN**
- 5) Products in lead-forming package available



- Product List

| Part No.     | V <sub>DRMS</sub><br>[V] | T <sub>j</sub><br>[°C] | I <sub>TRMS</sub><br>[A] | I <sub>TSM</sub><br>[A] | I <sub>GT</sub> (max.)<br>[mA] | Status |    | Package  |
|--------------|--------------------------|------------------------|--------------------------|-------------------------|--------------------------------|--------|----|----------|
|              |                          |                        |                          |                         |                                | WS     | MP |          |
| BCR30KM-8LB  | 400                      | 150                    | 30                       | 300                     | 30                             | OK     | OK | TO-220FN |
| BCR16RM-12LB | 600                      | 150                    | 16                       | 160                     | 30                             | OK     | OK | TO-3PFN  |
| BCR25KM-12LB |                          | 150                    | 25                       | 250                     | 50                             | OK     | OK | TO-220FN |
| BCR25RM-12LB |                          | 150                    | 25                       | 250                     | 50                             | OK     | OK | TO-3PFM  |
| BCR30AM-12LA |                          | 125                    | 30                       | 300                     | 50                             | OK     | OK | TO-3P    |
| BCR30AM-12LB |                          | 150                    | 30                       | 300                     | 50                             | OK     | OK |          |
| BCR8PM-20LA  |                          | 1000                   | 125                      | 8                       | 80                             | 30     | OK | OK       |
| BCR8KM-20LA  | 125                      |                        | 8                        | 80                      | 30                             | OK     | OK | TO-220FN |
| BCR20RM-30LA | 1500                     | 125                    | 20                       | 200                     | 50                             | OK     | OK | TO-3PFM  |

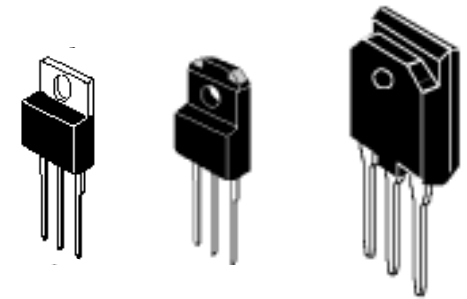
# Development of High-Capacity Thyristors for General Purposes

- Applications

Rush-current protection circuit during power-on, inverters, etc.

- Features

- 1) High reliability: Adoption of planar structure
- 2) Insulation-type outline: TO-220FN/TO-3PF/TO-220
- 3) Large current: **12 A/25 A**
- 4) Products in lead-forming package available
- 5) Junction temperature guaranteed: 150 °C (-12B, -12D)



- Product List

| Part No.       | V <sub>DRMS</sub><br>[V] | T <sub>j</sub><br>[°C] | I <sub>T</sub> (AV)<br>[A] | I <sub>TSM</sub><br>[A] | I <sub>GT</sub> (max.)<br>[mA] | Status |    | Package |
|----------------|--------------------------|------------------------|----------------------------|-------------------------|--------------------------------|--------|----|---------|
|                |                          |                        |                            |                         |                                | WS     | MP |         |
| CR6PM-12A/12B  | 600                      | 125/150                | 6                          | 90                      | 10                             | OK     | OK | TO-220F |
| CR6CM-12A/12B  |                          | 125/150                | 6                          | 90                      | 10                             | OK     | OK | TO-220  |
| CR8PM-12A/12B  |                          | 125/150                | 8                          | 120                     | 15                             | OK     | OK | TO-220F |
| CR8CM-12A/12B  |                          | 125/150                | 8                          | 120                     | 15                             | OK     | OK | TO-220  |
| CR12PM-12A/12B |                          | 125/150                | 12                         | 360                     | 30                             | OK     | OK | TO-220F |
| CR12CM-12A/12B |                          | 125/150                | 12                         | 360                     | 30                             | OK     | OK | TO-220  |
| CR25RM-12D     |                          | 125                    | 25                         | 360                     | 30                             | OK     | OK | TO-3PFM |

# 125°C Guaranteed Triac Lineup

## TO-220 package

| Part No.     | $I_T$ (RMS)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $V_{DSM}$<br>(V) | $I_{GT}$<br>(mA) |
|--------------|--------------------|------------------|------------------|------------------|------------------|
| BCR5AM-12LA  | 5                  | 50               | 600              | 720              | 20               |
| BCR6AM-12LA  | 6                  | 60               | 600              | 720              | 30               |
| BCR8CM-12LA  | 8                  | 80               | 600              | 720              | 30               |
| BCR10CM-12LA | 10                 | 100              | 600              | 720              | 30               |
| BCR12CM-12LA | 12                 | 120              | 600              | 720              | 30               |
| BCR16CM-12LA | 16                 | 170              | 600              | 720              | 30               |
| BCR20AM-12LA | 20                 | 200              | 600              | 720              | 30               |

## TO-220FN package

| Part No.     | $I_T$ (RMS)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $V_{DSM}$<br>(V) | $I_{GT}$<br>(mA) |
|--------------|--------------------|------------------|------------------|------------------|------------------|
| BCR3KM-12LA  | 3                  | 30               | 600              | 720              | 20               |
| BCR5KM-12LA  | 5                  | 50               | 600              | 720              | 20               |
| BCR8KM-12LA  | 8                  | 80               | 600              | 720              | 30               |
| BCR10KM-12LA | 10                 | 100              | 600              | 720              | 30               |
| BCR12KM-12LA | 12                 | 120              | 600              | 720              | 30               |
| BCR16KM-12LA | 16                 | 160              | 600              | 720              | 30               |
| BCR20KM-12LA | 20                 | 200              | 600              | 720              | 30               |
| BCR3KM-14LA  | 3                  | 30               | 700              | 840              | 30               |
| BCR5KM-14LA  | 5                  | 50               | 700              | 840              | 30               |
| BCR8KM-14LA  | 8                  | 80               | 700              | 840              | 30               |
| BCR12KM-14LA | 12                 | 120              | 700              | 840              | 30               |
| BCR8KM-16LA  | 8                  | 80               | 800              | 960              | 30               |
| BCR8KM-20LA  | 8                  | 80               | 1000             | 1200             | 30               |

## TO-220F package (resistance load)

| Part No.    | $I_T$ (RMS)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $V_{DSM}$<br>(V) | $I_{GT}$<br>(mA) |
|-------------|--------------------|------------------|------------------|------------------|------------------|
| BCR2PM-12RA | 2                  | 10               | 600              | 720              | 10 (2, 3)        |

## TO-220FN package (resistance load)

| Part No.    | $I_T$ (RMS)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $V_{DSM}$<br>(V) | $I_{GT}$<br>(mA) |
|-------------|--------------------|------------------|------------------|------------------|------------------|
| BCR3KM-12RA | 3                  | 30               | 600              | 720              | 15               |
| BCR5KM-12RA | 5                  | 50               | 600              | 720              | 15               |

## MP-3A/DPAK (L) package

| Part No.    | $I_T$ (RMS)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $V_{DSM}$<br>(V) | $I_{GT}$<br>(mA) |
|-------------|--------------------|------------------|------------------|------------------|------------------|
| BCR3AS-12LA | 3                  | 30               | 600              | 720              | 15               |
| BCR5AS-12LA | 5                  | 50               | 600              | 720              | 30               |

## TO-220S package

| Part No.     | $I_T$ (RMS)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $V_{DSM}$<br>(V) | $I_{GT}$<br>(mA) |
|--------------|--------------------|------------------|------------------|------------------|------------------|
| BCR8CS-12LA  | 8                  | 80               | 600              | 720              | 30               |
| BCR10CS-12LA | 10                 | 100              | 600              | 720              | 30               |
| BCR12CS-12LA | 12                 | 120              | 600              | 720              | 30               |
| BCR16CS-12LA | 16                 | 170              | 600              | 720              | 30               |

## TO-92 package

| Part No.    | $I_T$ (RMS)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $V_{DSM}$<br>(V) | $I_{GT}$<br>(mA) |
|-------------|--------------------|------------------|------------------|------------------|------------------|
| BCR08AM-12A | 0.8                | 8                | 600              | 720              | 5 (2, 3)         |
| BCR1AM-12   | 1                  | 10               | 600              | 720              | 5 (4 = 10)       |
| BCR1AM-12A  | 1                  | 10               | 600              | 720              | 7 (1, 2, 3)      |
| BCR08AM-14  | 0.8                | 8                | 700              | 840              | 5 (2, 3)         |

## UPAK package

| Part No.    | $I_T$ (RMS)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $V_{DSM}$<br>(V) | $I_{GT}$<br>(mA) |
|-------------|--------------------|------------------|------------------|------------------|------------------|
| BCR08AS-12A | 0.8                | 8                | 600              | 720              | 5 (4 = 10)       |

# Thyristor Lineup

## MP-3A/DPAK (L) package

| Part No. | $I_T$ (AV)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $I_{GT}$<br>(mA) | $V_{GT}$<br>(V) |
|----------|-------------------|------------------|------------------|------------------|-----------------|
| CR3AS-12 | 3                 | 90               | 600              | 0.1              | 0.8             |
| CR5AS-12 | 5                 | 90               | 600              | 0.1              | 0.8             |

## MPAK package

| Part No. | $I_T$ (AV)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $I_{GT}$<br>(mA) | $V_{GT}$<br>(V) |
|----------|-------------------|------------------|------------------|------------------|-----------------|
| CR05BS-8 | 0.1               | 10               | 400              | 0.1              | 0.8             |

## UPAK package

| Part No.  | $I_T$ (AV)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $I_{GT}$<br>(mA) | $V_{GT}$<br>(V) |
|-----------|-------------------|------------------|------------------|------------------|-----------------|
| CR05AS-8  | 0.5               | 10               | 400              | 0.1              | 0.8             |
| CR08AS-12 | 0.8               | 10               | 600              | 0.1              | 0.8             |

## TO-220 package

| Part No.  | $I_T$ (AV)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $I_{GT}$<br>(mA) | $V_{GT}$<br>(V) |
|-----------|-------------------|------------------|------------------|------------------|-----------------|
| CR12CM-12 | 12                | 360              | 600              | 30               | 1.5             |

## TO-92 package

| Part No.  | $I_T$ (AV)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $I_{GT}$<br>(mA) | $V_{GT}$<br>(V) |
|-----------|-------------------|------------------|------------------|------------------|-----------------|
| CR02AM-8  | 0.3               | 10               | 400              | 0.1              | 0.8             |
| CR03AM-12 | 0.3               | 20               | 600              | 0.1              | 0.8             |
| CR05AM-12 | 0.3               | 10               | 600              | 0.1              | 0.8             |
| CR04AM-12 | 0.4               | 10               | 600              | 0.1              | 0.8             |
| CR03AM-16 | 0.3               | 20               | 800              | 0.1              | 0.8             |
| CR05AM-16 | 0.3               | 10               | 800              | 0.1              | 0.8             |

## TO-220FN package

| Part No. | $I_T$ (AV)<br>(A) | $I_{TSM}$<br>(A) | $V_{DRM}$<br>(V) | $I_{GT}$<br>(mA) | $V_{GT}$<br>(V) |
|----------|-------------------|------------------|------------------|------------------|-----------------|
| CR3KM-12 | 3                 | 70               | 600              | 0.1              | 0.8             |
| CR6KM-12 | 6                 | 90               | 600              | 10               | 1.0             |
| CR8KM-12 | 8                 | 120              | 600              | 15               | 1.0             |

## Renesas Power MOS FETs, IGBTs, Triacs, and Thyristors General Presentation

Publication Date: Rev.1.00, July 2003

Rev.27.01, Feb 2, 2010

Published by: Sales Strategic Planning Div.

Renesas Technology Corp.

Edited by: Customer Support Department

Global Strategic Communication Div.

Renesas Solutions Corp.

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REJ13G0003-2701





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