GreenFET Load Switch Technology

Renesas’ GreenFET family of high-performance robust load switches are designed and optimized for all high-side power rail control applications from 0.25 V to 25.2 V where the load currents range from 1 A to 9 A. Using Renesas’ proprietary MOSFET design, all GreenFET load switches achieve ultra-stable RDS\textsubscript{ON} across wide input and supply voltage ranges.

CuFET MOSFET TECHNOLOGY
For Achieving Smallest Parts with Lowest RDS\textsubscript{ON}

Combining Renesas’ proprietary MOSFET IP and advanced assembly techniques, these advanced state-of-the-art products are available in ultra-small pcb footprints from 0.56 mm\(^2\) to 4 mm\(^2\) and exhibit low thermal resistances for high-current operation.

All low- and high-voltage GreenFET load switches are designed and fully characterized over the commercial (0 °C to 70 °C), extended commercial (-20 °C to 70 °C), industrial (-40 °C to 85 °C), or extended industrial (-40 °C to 125 °C) temperature ranges.
GreenFET Load Switch Portfolio

GreenFET

- Single-channel nFET & pFET in STDFN & STQFN (1 mm² to 4 mm²)
- Single-channel in WLCSP (1 A to 4 A, 0.56 mm² to 1.5 mm²)
- Dual-channel nFET and pFET in STDFNs (3 mm²)

Operating input voltage range

- Maximum V_{DD} voltage ranges: 2 V, 3.6 V & 5.5 V
- Operating input voltage range: 0.25 V to V_{DD}
- RDS_{ON} range: 4 mΩ to 45 mΩ
- I_{DS} current range: 1 A to 9 A
- UL2367 current-limiter certified (select parts)

High voltage GreenFET

- Single-channel (2.3 mm² to 5 mm²)
- Operating input voltage range: 4.5 V to 25.2 V
- RDS_{ON} range: 13.3 mΩ to 50 mΩ
- I_{DS} current range: 3 A to 6 A
- WLCSP for space-constrained applications
- UL2367 current-limiter certified (select parts)

High side gate drivers

- N-Channel MOSFET drivers

GreenFET products combine high-performance nFET or pFET structures, high current handling capability, charge pumps, as well as multiple protection and control circuits into space-efficient single- and dual-channel products.
GreenFET LOAD SWITCH FEATURES & TARGET APPLICATIONS

Key features
- High-performance Low \( \text{RDS}_{\text{ON}} \) nFET & pFET MOSFETs
  - From as low as 4 m\( \Omega \)
- Internal Protection Features:
  - Built-in supply undervoltage lockout protection
  - Built-in supply overvoltage protection
  - Fast VOUT discharge (VOUT discharge delete options available)
  - Fixed and capacitor/resistor-adjustable inrush current control
  - Fixed and resistor-adjustable current limit protection
  - Built-in short-circuit current protection
  - Built-in thermal shutdown protection with auto restart or latch off
  - Reverse-current blocking using bulk switch or back-to-back FETs
  - Reverse-voltage detection (selected part numbers)
  - Safe operating area protection
- Active HIGH ON-OFF control (Active-LOW ON-OFF control available)
- Open-drain (“FAULT”) signaling (select part numbers)
- Open-drain power good signaling (select part numbers)
- Wafer-level chip-scale packaging (select part numbers)
- UL2367 certified (select part numbers)

Applications
- Smartphones and fitness bands
- Notebook and tablet PCs
- Enterprise networking
- Enterprise multifunction copiers/printers
- Enterprise computing
- Set-top boxes
- HDDs and SSDs
- PCIe/PCI adapter cards
- Portable consumer electronics
- General-purpose, high-side power-rail switching/control
GreenFET LOAD SWITCH USAGE EXAMPLES

Power Distribution Application
Load Switch Example Usage

System Power

- LDO
- Load Switch
- Sub-System
- PMU
- Load Switch
- Sub-System
- LDO
- Load Switch
- Sub-System
- DC-DC
- Load Switch
- Sub-System

Power Control Application
Load Switch Example Usage

System 5 V

- Load Switch
- 5V to 3.3V DC-DC
- Gated +5 V Power
- Gated +3.3 V Power
- 5V to 1.8V DC-DC
- Gated +1.8 V Power
- 5V to 1.5V DC-DC
- Gated +1.5 V Power
- GreenPAK
- Supply Sequencing
- Voltage Supervisory
- Application Processor

- Power
- Signal
GreenFET LOAD SWITCH USAGE EXAMPLES

**Power Sequencing Application**
Load Switch Example Usage

- **5.0 V**
- **3.3 V**
- **1.8 V**
- **1.5 V**

System Mains

![Power Sequencing Application Diagram]

**Multiple Power Source Application**
Load Switch Example Usage

- **Power Supply**
- **Battery**
- **Wireless Charger**
- **Power Control**

![Multiple Power Source Application Diagram]
GreenFET ADVANTAGES

- Highest current per mm². CuFET™ MOSFET technology utilizes a unique architecture, layout, and inverted die packaging to increase circuit packaging density.

- Industry-leading RDS\textsubscript{ON}. Extensive use of all copper layers, interconnect, and lead frame generate extremely low thermal gradients across PCB.

- \( \leq 1 \) Failure incident per 75 Mu shipped. Integrating extensive protection features protect the IC itself and circuits connected to it, making systems more robust and reliable.

GreenFET Safe Operating Area (SOA) Protection

Power Limiting Protection Circuitry

Typical MOSFET

No protection resulting in SOA being violated during turn-on, which can cause long term damage over multiple cycles

\[
P = \frac{(V_{GS} - V_{TH}) \cdot V_{DS}}{R}
\]

\[
P_{th} = \frac{dP}{dV_{DS}} = 6
\]

\[
P_{th} = \frac{V_{DS} \cdot V_{DS}}{2} \quad R = 10 \text{ Q}
\]

GreenFET with SOA Protection

Power Clamp holds output low enough to keep \( \leq 5 \text{ W}, \) or 10 W depending on the part, otherwise IC shuts down FET completely if fault persists and then does auto-retry.
GreenFET LOAD SWITCH PRODUCT CHART

Single-Channel GreenFET Load Switch

<table>
<thead>
<tr>
<th>Package Size</th>
<th>RDSON</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8 x 0.8 x 0.44 mm</td>
<td></td>
<td>Slew Rate Control</td>
</tr>
<tr>
<td>WLCSP</td>
<td></td>
<td>Overtemperature Protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Undervoltage Protection</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Overcurrent Protection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reverse-Current Blocking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reverse-Voltage Detection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Good Signaling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power Monitor Output</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fault Signaling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Current Monitor Output</td>
</tr>
<tr>
<td>0.71 x 1.16 x 0.445 mm</td>
<td></td>
<td>Internal VOUT Discharge</td>
</tr>
<tr>
<td>WLCSP</td>
<td></td>
<td>Internal TVS Protection</td>
</tr>
<tr>
<td>1.0 x 1.0 x 0.55 mm</td>
<td></td>
<td>P-channel Load Switch</td>
</tr>
<tr>
<td>STDFN</td>
<td></td>
<td>N-channel Load Switch</td>
</tr>
</tbody>
</table>

Dual-Channel GreenFET Load Switch

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<tr>
<th>Package Size</th>
<th>RDSON</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 x 1.6 x 0.55 mm</td>
<td></td>
<td>Slew Rate Control</td>
</tr>
<tr>
<td>STDFN</td>
<td></td>
<td>Overtemperature Protection</td>
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<tr>
<td></td>
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<td>Fault Signaling</td>
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<tr>
<td></td>
<td></td>
<td>Current Monitor Output</td>
</tr>
<tr>
<td>1.0 x 3.0 x 0.55 mm</td>
<td></td>
<td>Internal VOUT Discharge</td>
</tr>
<tr>
<td>STDFN</td>
<td></td>
<td>Internal TVS Protection</td>
</tr>
<tr>
<td>1.5 x 2.0 x 0.75 mm</td>
<td></td>
<td>P-channel Load Switch</td>
</tr>
<tr>
<td>TDFN</td>
<td></td>
<td>N-channel Load Switch</td>
</tr>
</tbody>
</table>

Package Size

- 0.8 x 0.8 x 0.44 mm
- 0.71 x 1.16 x 0.445 mm
- 1.0 x 1.0 x 0.55 mm
- 1.5 x 2.0 x 0.75 mm
- 1.0 x 1.6 x 0.55 mm
- 1.6 x 2.5 x 0.55 mm

- 0.8 x 0.8 x 0.44 mm
- 0.71 x 1.16 x 0.445 mm
- 1.0 x 1.0 x 0.55 mm
- 1.5 x 2.0 x 0.75 mm
- 1.0 x 1.6 x 0.55 mm
- 1.6 x 2.5 x 0.55 mm
GreenFET LOAD SWITCH PRODUCT CHART

Reverse-Blocking GreenFET Load Switch

High Voltage GreenFET Load Switch
GreenFET ROBUST LOAD SWITCHES

Visit renesas.com/load-switches for more details on the complete portfolio of products, including the product selector guide, eval boards and samples.

GreenFET Product Selector Guide

GreenFET ULTRA-LOW RDS(ON) LOAD SWITCH SELECTOR GUIDE

Renesas’ GreenFET family of high-performance fast switches are designed and optimized for high risk power-set control applications from 4.5 V to 5.5 V where load currents range from 1 A to 16 A. Using Renesas’ proprietary MOSFET design, all GreenFET load switches achieve ultra-low RDS(on), excess input and output voltages, ruggedness, and high-temperature resistance for high-current operation.

Composed to deliver GreenFET’s superior performance, Renesas’ GreenFET products combine high-performance ESD and FET structure, high-current handling capability, shape area, as well as multiple protection and control circuits in space and power efficient single channel products. The combination of all these advanced features directly results in reduced bill of material components and cost solutions as well as increasing system reliability and reduced board size.

All of Renesas’ GreenFET low voltage load switches are designed and fully characterized over the conventional 0 °C to 70 °C, intended conditions (10 °C to 55 °C), industrial (-40 °C to 85 °C), or extended industrial (-40 °C to 125 °C) temperature ranges. Consistent with generating very low thermal gradients, Renesas’ integrated power control switches are available in four thermal resistance, STUP/STON, RoHS compliant packaging or through hole chip scale package (WQFN). See renesas.com/load-switches for more details on the complete portfolio of products, including the product selector guide, eval boards and samples.

Table 1: Single N-Channel Load Switches

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Min. I</th>
<th>Min. V</th>
<th>Max. I</th>
<th>Max. V</th>
<th>RDS(on)</th>
<th>Tj</th>
<th>Operating Temp.</th>
<th>SOIC</th>
<th>WQFN</th>
<th>QFN</th>
</tr>
</thead>
<tbody>
<tr>
<td>33UGF21N50P</td>
<td>1 N-channel with charge pump, input buffer, output enable, current limit, 500 mA input</td>
<td>0</td>
<td>0</td>
<td>200</td>
<td>5 V</td>
<td>3.8 mΩ</td>
<td>175</td>
<td>-40 to 125 °C</td>
<td>SOIC</td>
<td>WQFN</td>
<td>QFN</td>
</tr>
<tr>
<td>33UGF21N5A0P</td>
<td>1 N-channel with charge pump, input buffer, output enable, current limit, 500 mA input</td>
<td>0</td>
<td>0</td>
<td>200</td>
<td>5 V</td>
<td>3.8 mΩ</td>
<td>175</td>
<td>-40 to 125 °C</td>
<td>SOIC</td>
<td>WQFN</td>
<td>QFN</td>
</tr>
<tr>
<td>33UGF21N75P</td>
<td>1 N-channel with charge pump, input buffer, output enable, current limit, 750 mA input</td>
<td>0</td>
<td>0</td>
<td>200</td>
<td>5 V</td>
<td>3.8 mΩ</td>
<td>175</td>
<td>-40 to 125 °C</td>
<td>SOIC</td>
<td>WQFN</td>
<td>QFN</td>
</tr>
<tr>
<td>33UGF21N7A0P</td>
<td>1 N-channel with charge pump, input buffer, output enable, current limit, 750 mA input</td>
<td>0</td>
<td>0</td>
<td>200</td>
<td>5 V</td>
<td>3.8 mΩ</td>
<td>175</td>
<td>-40 to 125 °C</td>
<td>SOIC</td>
<td>WQFN</td>
<td>QFN</td>
</tr>
</tbody>
</table>

Key features in the GreenFET family of high-performance fast switches products include:
- High performance (low RDS(on) fast FET MOSFETs)
- Fused as fast as 0.1 μs
- Internal protection features:
  - Auto-applied undercut protection
  - Fixed and capacitive/inductive load current control
  - Fast reset and adjustable current limit protection
- Built-in thermal overcurrent protection
- Built-in thermal shutdown protection with a trip level

Applications:
- Notebook and tablet PC
- Digital sub- and main audio system
- Input power switching
- Switch power supply
- Switch power supply
- Input power switching
- Switch power supply
- Input power switching
- Switch power supply

Visit renesas.com/load-switches for more details on the complete portfolio of products, including the product selector guide, eval boards and samples.