N0412N
N-channel MOSFET
40 V, 100 A, 3.7 mΩ

Features
- Low on-state resistance : \( R_{\text{DS(on)}} = 3.7 \text{ mΩ} \text{ MAX. (} V_{\text{GS}} = 10 \text{ V, } I_D = 50 \text{ A}) \)
- Low \( C_{\text{iss}} \) : \( C_{\text{iss}} = 5550 \text{ pF TYP. (} V_{\text{DS}} = 25 \text{ V, } V_{\text{GS}} = 0 \text{ V}) \)
- High current : \( I_{\text{D(DC)}} = \pm 100 \text{ A} \)
- RoHS Compliant
- Quality Grade : Standard
- Applications : For high current switching

Ordering Information

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Package</th>
<th>Packing</th>
</tr>
</thead>
<tbody>
<tr>
<td>N0412N-S19-AY</td>
<td>TO-220AB, Pb-free Note1</td>
<td>50 pcs / Magazine (Tube)</td>
</tr>
</tbody>
</table>

Note: 1. Pb-free means that this product does not contain lead in the external electrode.

Absolute Maximum Ratings (\( T_A = 25°C \))

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Ratings</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drain to Source Voltage (( V_{\text{GS}} = 0 \text{ V} ))</td>
<td>( V_{\text{DSS}} )</td>
<td>40</td>
<td>V</td>
</tr>
<tr>
<td>Gate to Source Voltage (( V_{\text{DS}} = 0 \text{ V} ))</td>
<td>( V_{\text{GSS}} )</td>
<td>±20</td>
<td>V</td>
</tr>
<tr>
<td>Drain Current (DC) (( T_C = 25°C ))</td>
<td>( I_{\text{D(DC)}} )</td>
<td>±100</td>
<td>A</td>
</tr>
<tr>
<td>Drain Current (pulse) Note2</td>
<td>( I_{\text{D(pulse)}} )</td>
<td>±400</td>
<td>A</td>
</tr>
<tr>
<td>Total Power Dissipation (( T_C = 25°C ))</td>
<td>( P_{T1} )</td>
<td>119</td>
<td>W</td>
</tr>
<tr>
<td>Total Power Dissipation (( T_A = 25°C ))</td>
<td>( P_{T2} )</td>
<td>1.5</td>
<td>W</td>
</tr>
<tr>
<td>Channel Temperature</td>
<td>( T_{\text{ch}} )</td>
<td>150</td>
<td>°C</td>
</tr>
<tr>
<td>Storage Temperature</td>
<td>( T_{\text{stg}} )</td>
<td>−55 to +150</td>
<td>°C</td>
</tr>
<tr>
<td>Single Avalanche Current Note3</td>
<td>( I_{\text{AS}} )</td>
<td>55</td>
<td>A</td>
</tr>
<tr>
<td>Single Avalanche Energy Note3</td>
<td>( E_{\text{AS}} )</td>
<td>300</td>
<td>mJ</td>
</tr>
</tbody>
</table>

Note: Continuous heavy condition (e.g. high temperature/voltage/current or high variation of temperature) may affect a reliability even if it is within the absolute maximum ratings. Please consider derating condition for appropriate reliability in reference Renesas Semiconductor Reliability Handbook (Recommendation for Handling and Usage of Semiconductor Devices) and individual reliability data.

Notes:
2. \( \text{PW} \leq 10 \text{ µs}, \text{Duty Cycle} \leq 1\% \)
3. Starting \( T_{\text{ch}} = 25°C, R_G = 25 \text{ Ω}, V_{\text{DD}} = 25 \text{ V, } V_{\text{GS}} = 20 \rightarrow 0 \text{ V, } L = 100 \text{ µH} \)

Thermal Resistance

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>Max. Value Note4</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel to Case Thermal Resistance</td>
<td>( R_{\text{th(ch-C)}} )</td>
<td>1.05</td>
<td>°C/W</td>
</tr>
<tr>
<td>Channel to Ambient Thermal Resistance</td>
<td>( R_{\text{th(ch-A)}} )</td>
<td>83.3</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

Notes: 4. This data is the designed target maximum value on Renesas’s measurement condition. (Not tested)
## Electrical Characteristics (TA = 25°C)

<table>
<thead>
<tr>
<th>Item</th>
<th>Symbol</th>
<th>MIN.</th>
<th>TYP.</th>
<th>MAX.</th>
<th>Unit</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero Gate Voltage Drain Current</td>
<td>IDSS</td>
<td></td>
<td>1</td>
<td></td>
<td>µA</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 40 V, V&lt;sub&gt;GS&lt;/sub&gt; = 0 V</td>
</tr>
<tr>
<td>Gate Leakage Current</td>
<td>IGSS</td>
<td>±100</td>
<td></td>
<td></td>
<td>nA</td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = ±20 V, V&lt;sub&gt;DS&lt;/sub&gt; = 0 V</td>
</tr>
<tr>
<td>Gate to Source Cut-off Voltage</td>
<td>V&lt;sub&gt;DS(Off)&lt;/sub&gt;</td>
<td>2.0</td>
<td>4.0</td>
<td></td>
<td>V</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 1 mA</td>
</tr>
<tr>
<td>Forward Transfer Admittance Note5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drain to Source On-state Resistance Note5</td>
<td>R&lt;sub&gt;DS(on)&lt;/sub&gt;</td>
<td>2.7</td>
<td>3.7</td>
<td></td>
<td>mΩ</td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V, I&lt;sub&gt;D&lt;/sub&gt; = 50 A</td>
</tr>
<tr>
<td>Input Capacitance</td>
<td>Css</td>
<td>5550</td>
<td></td>
<td></td>
<td>pF</td>
<td>V&lt;sub&gt;DS&lt;/sub&gt; = 25 V,</td>
</tr>
<tr>
<td>Output Capacitance</td>
<td>Coss</td>
<td>580</td>
<td></td>
<td></td>
<td>pF</td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 0 V,</td>
</tr>
<tr>
<td>Reverse Transfer Capacitance</td>
<td>C&lt;sub&gt;rss&lt;/sub&gt;</td>
<td>320</td>
<td></td>
<td></td>
<td>pF</td>
<td>f = 1 MHz</td>
</tr>
<tr>
<td>Turn-on Delay Time</td>
<td>t&lt;sub&gt;on&lt;/sub&gt;</td>
<td>29.0</td>
<td></td>
<td></td>
<td>ns</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 20 V, I&lt;sub&gt;D&lt;/sub&gt; = 50 A,</td>
</tr>
<tr>
<td>Rise Time</td>
<td>tr</td>
<td>15.0</td>
<td></td>
<td></td>
<td>ns</td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V,</td>
</tr>
<tr>
<td>Turn-off Delay Time</td>
<td>t&lt;sub&gt;off&lt;/sub&gt;</td>
<td>64.0</td>
<td></td>
<td></td>
<td>ns</td>
<td>R&lt;sub&gt;G&lt;/sub&gt; = 0 Ω</td>
</tr>
<tr>
<td>Fall Time</td>
<td>tf</td>
<td>13.0</td>
<td></td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Total Gate Charge</td>
<td>Q&lt;sub&gt;G&lt;/sub&gt;</td>
<td>100</td>
<td></td>
<td></td>
<td>nC</td>
<td>V&lt;sub&gt;DD&lt;/sub&gt; = 32 V,</td>
</tr>
<tr>
<td>Gate to Source Charge</td>
<td>Q&lt;sub&gt;GS&lt;/sub&gt;</td>
<td>26</td>
<td></td>
<td></td>
<td>nC</td>
<td>V&lt;sub&gt;GS&lt;/sub&gt; = 10 V,</td>
</tr>
<tr>
<td>Gate to Drain Charge</td>
<td>Q&lt;sub&gt;GD&lt;/sub&gt;</td>
<td>32</td>
<td></td>
<td></td>
<td>nC</td>
<td>I&lt;sub&gt;D&lt;/sub&gt; = 100 A</td>
</tr>
<tr>
<td>Body Diode Forward Voltage Note5</td>
<td>V&lt;sub&gt;F(S-D)&lt;/sub&gt;</td>
<td>1.5</td>
<td></td>
<td></td>
<td>V</td>
<td>I&lt;sub&gt;D&lt;/sub&gt; = 100 A, V&lt;sub&gt;GS&lt;/sub&gt; = 0 V</td>
</tr>
<tr>
<td>Reverse Recovery Time</td>
<td>t&lt;sub&gt;rr&lt;/sub&gt;</td>
<td>40</td>
<td></td>
<td></td>
<td>ns</td>
<td>I&lt;sub&gt;D&lt;/sub&gt; = 50 A, V&lt;sub&gt;GS&lt;/sub&gt; = 0 V,</td>
</tr>
<tr>
<td>Reverse Recovery Charge</td>
<td>Q&lt;sub&gt;rr&lt;/sub&gt;</td>
<td>44</td>
<td></td>
<td></td>
<td>nC</td>
<td>di/dt = 100 A/µs</td>
</tr>
</tbody>
</table>

Notes: 5. Pulsed test

---

**TEST CIRCUIT 1 AVALANCHE CAPABILITY**

- PG: 50 Ω
- D.U.T.: 25 Ω
- V<sub>DS</sub> = 20 to 0 V

**TEST CIRCUIT 2 SWITCHING TIME**

- PG: 50 Ω
- D.U.T.: 25 Ω
- V<sub>DD</sub> Wave Form

**TEST CIRCUIT 3 GATE CHARGE**

- PG: 50 Ω
- D.U.T.: 2 mA
Typical Characteristics

DERATING FACTOR OF FORWARD BIAS SAFE OPERATING AREA

TOTAL POWER DISSIPATION vs. CASE TEMPERATURE

FORWARD BIAS SAFE OPERATING AREA

TRANSIENT THERMAL RESISTANCE vs. PULSE WIDTH

Notes:
6. Designed target value on Renesas measurement condition. ($T_C = 25^\circ C$, unless otherwise specified)
7. This data is the designed value on Renesas’s measurement condition. Renesas recommends that operating conditions are designed according to a document “Power MOSFET/IGBT Attention of Handling Semiconductor Devices (R07ZZ0010)”. 
8. This data is the designed target maximum value on Renesas’s measurement condition.
**DRAIN TO SOURCE ON-STATE RESISTANCE vs. CHANNEL TEMPERATURE**

- **R\(_{\text{DS(on)}}\)** - Drain to Source On-state Resistance - m\(\Omega\)
- \(T_\text{ch}\) - Channel Temperature - °C
- \(V_{\text{GS}} = 10\) V
- \(I_\text{D} = 50\) A
- Pulsed

**CAPACITANCE vs. DRAIN TO SOURCE VOLTAGE**

- **C\(_{\text{iss}}, C\(_{\text{oss}}, C\(_{\text{rss}}\)** - Capacitance - pF
- \(V_{\text{GS}} = 0\) V
- \(f = 1.0\) MHz

**SWITCHING CHARACTERISTICS**

- **\(t_{\text{d(on)}}, t_{\text{r}}, t_{\text{d(off)}}, t_{\text{f}}\)** - Switching Time - ns
- \(V_{\text{DD}} = 20\) V
- \(V_{\text{GS}} = 10\) V
- \(R_G = 0\) Ω

**DYNAMIC INPUT CHARACTERISTICS**

- **\(V_{\text{DD}}\)** - Gate to Source Voltage - V
- **\(Q_G\)** - Gate Charge - nC
- \(I_\text{D} = 100\) A
- \(V_{\text{GS}} = 10\) V

**SOURCE TO DRAIN DIODE FORWARD VOLTAGE**

- **\(I_F\)** - Diode Forward Current - A
- \(V_{\text{GS}} = 10\) V
- \(0\) V
- Pulsed

**REVERSE RECOVERY TIME vs. DIODE FORWARD CURRENT**

- **\(t_r\)** - Reverse Recovery Time - ns
- \(V_{\text{GS}} = 0\) V
- \(\text{di/dt} = 100\) A/µs
Package Drawing (Unit: mm)

<table>
<thead>
<tr>
<th>JEDEC Package Code</th>
<th>RENESAS Code</th>
<th>Previous Code</th>
<th>MASS (Typ) [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO-220AB</td>
<td>PRSS004AU-A</td>
<td>TO-220ABB</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Unit: mm

Equivalent Circuit
Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the design and use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.

2. Renesas Electronics hereby expressly disclaims any warranties against liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.

3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part, Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depend on the product's quality grade, as indicated below.

   - "Standard": Computers; office equipment; communications equipment; audio and video equipment, home appliance equipment, machine tools; personal electronic equipment; industrial robots, etc.
   - "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment, etc.

   Unless expressly designated as a high reliability product or for a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantation equipment; or may cause serious property damage (space systems; ocean research; nuclear power control systems; aircraft control systems; key plant systems; military equipment), etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.) and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operation power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any damages, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.

7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain usage conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures against the possibility of bodily injury, injury or damage caused by fire, and/or damage to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to, redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.

8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that govern the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.

10. Renesas Electronics products are not designed or manufactured for use as a component in medical apparatus (life support apparatus, implant apparatus, artificial life support apparatus, etc.) or any system or apparatus that is intended for use in space systems, or any other system or apparatus in which human life is at risk.

11. Please do not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part, Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

12. “Renesas Electronics product(s)” means any product developed or manufactured by or for Renesas Electronics.

13. Renesas Electronics hereby expressly disclaims any warranty against liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.

14. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

15. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part, Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

16. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depend on the product's quality grade, as indicated below.

   - "Standard": Computers; office equipment; communications equipment; audio and video equipment, home appliance equipment, machine tools; personal electronic equipment; industrial robots, etc.
   - "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment, etc.

   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantation equipment; or may cause serious property damage (space systems; ocean research; nuclear power control systems; aircraft control systems; key plant systems; military equipment), etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

17. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.) and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operation power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any damages, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.

18. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain usage conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures against the possibility of bodily injury, injury or damage caused by fire, and/or damage to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to, redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.

19. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that govern the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

20. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.

21. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depend on the product's quality grade, as indicated below.

   - "Standard": Computers; office equipment; communications equipment; audio and video equipment, home appliance equipment, machine tools; personal electronic equipment; industrial robots, etc.
   - "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment, etc.

   Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantation equipment; or may cause serious property damage (space systems; ocean research; nuclear power control systems; aircraft control systems; key plant systems; military equipment), etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

22. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, “General Notes for Handling and Using Semiconductor Devices” in the reliability handbook, etc.) and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operation power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any damages, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.