# NCV8401, NCV8401A

## Self-Protected Low Side Driver with Temperature and Current Limit

NCV8401/A is a three terminal protected Low-Side Smart Discrete device. The protection features include overcurrent, overtemperature, ESD and integrated Drain-to-Gate clamping for overvoltage protection. This device offers protection and is suitable for harsh automotive environments.

### Features

- Short Circuit Protection
- Thermal Shutdown with Automatic Restart
- Over Voltage Protection
- Integrated Clamp for Inductive Switching
- ESD Protection
- dV/dt Robustness
- Analog Drive Capability (Logic Level Input)
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- These Devices are Pb−Free and are RoHS Compliant

### Typical Applications

- Switch a Variety of Resistive, Inductive and Capacitive Loads
- Can Replace Electromechanical Relays and Discrete Circuits
- Automotive / Industrial

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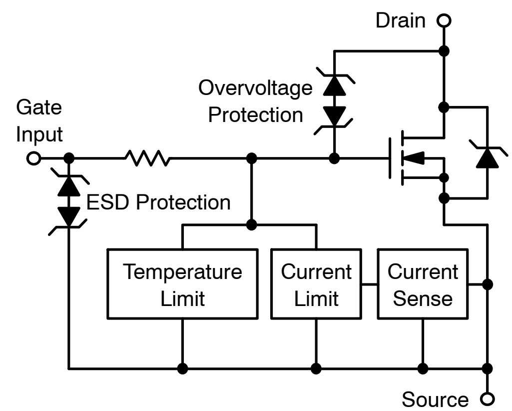
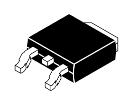
| $V_{DSS}$ (Clamped) | $R_{DS(ON)}$ TYP | $I_D$ MAX (Limited) |
|---|---|---|
| 42 V | 23 mΩ @ 10 V | 33 A* |

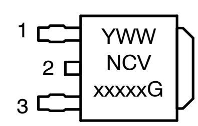
*Max current may be limited below this value depending on input conditions.



**DPAK**
**CASE 369C**
**STYLE 2**

**MARKING DIAGRAM**




| | |
|---|---|
| Y | = Year |
| WW | = Work Week |
| xxxxx | = 8401 or 8401A |
| G | = Pb−Free Package |

1 = Gate
2 = Drain
3 = Source

### ORDERING INFORMATION

| Device | Package | Shipping† |
|---|---|---|
| NCV8401DTRKG | DPAK (Pb−Free) | 2500/Tape & Reel |
| NCV8401ADTRKG | DPAK (Pb−Free) | 2500/Tape & Reel |

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specification Brochure, BRD8011/D.

**MAXIMUM RATINGS** ($T_J$ = 25°C unless otherwise noted)

| Rating | Symbol | Value | Unit |
|---|---|---|---|
| Drain−to−Source Voltage Internally Clamped | $V_{DSS}$ | 42 | V |
| Drain−to−Gate Voltage Internally Clamped ($R_{GS}$ = 1.0 MΩ) | $V_{DGR}$ | 42 | V |
| Gate−to−Source Voltage | $V_{GS}$ | ±14 | V |
| Drain Current − Continuous | $I_D$ | Internally Limited | |
| Total Power Dissipation<br>@ $T_A$ = 25°C (Note 1)<br>@ $T_A$ = 25°C (Note 2) | $P_D$ | <br>1.1<br>2.0 | W |
| Thermal Resistance, Junction−to−Case<br>Junction−to−Ambient (Note 1)<br>Junction−to−Ambient (Note 2) | $R_{\theta JC}$<br>$R_{\theta JA}$<br>$R_{\theta JA}$ | 1.6<br>110<br>60 | °C/W |
| Single Pulse Drain−to−Source Avalanche Energy ($V_{DD}$ = 25 Vdc, $V_{GS}$ = 5.0 Vdc, $I_L$ = 3.65 Apk, L = 120 mH, $R_G$ = 25 Ω, $T_{Jstart}$ = 150°C) (Note 3) | $E_{AS}$ | 800 | mJ |
| Load Dump Voltage ($V_{GS}$ = 0 and 10 V, $R_I$ = 2.0 Ω, $R_L$ = 3.0 Ω, $t_d$ = 400 ms) | $V_{LD}$ | 65 | V |
| Operating Junction Temperature | $T_J$ | −40 to 150 | °C |
| Storage Temperature | $T_{stg}$ | −55 to 150 | °C |

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Minimum FR4 PCB, steady state.
2. Mounted onto a 2″ square FR4 board (1″ square, 2 oz. Cu 0.06″ thick single−sided, t = steady state).
3. Not subject to production testing.

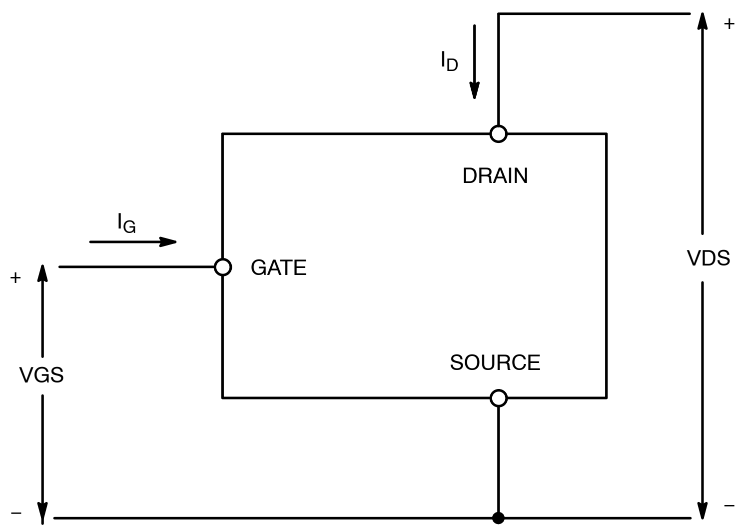



**Figure 1. Voltage and Current Convention**

**MOSFET ELECTRICAL CHARACTERISTICS** ($T_J$ = 25°C unless otherwise noted)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| **OFF CHARACTERISTICS** | | | | | |
| Drain−to−Source Clamped Breakdown Voltage<br>($V_{GS}$ = 0 Vdc, $I_D$ = 250 μAdc)<br>($V_{GS}$ = 0 Vdc, $I_D$ = 250 μAdc, $T_J$ = 150°C) (Note 4) | $V_{(BR)DSS}$ | <br>42<br>42 | <br>46<br>44 | <br>50<br>50 | Vdc |
| Zero Gate Voltage Drain Current<br>($V_{DS}$ = 32 Vdc, $V_{GS}$ = 0 Vdc)<br>($V_{DS}$ = 32 Vdc, $V_{GS}$ = 0 Vdc, $T_J$ = 150°C) (Note 4) | $I_{DSS}$ | | <br>1.5<br>6.5 | <br>5.0 | μAdc |
| Gate Input Current<br>($V_{GS}$ = 5.0 Vdc, $V_{DS}$ = 0 Vdc) | $I_{GSSF}$ | | 50 | 100 | μAdc |
| **ON CHARACTERISTICS** | | | | | |
| Gate Threshold Voltage<br>($V_{DS}$ = $V_{GS}$, $I_D$ = 1.2 mAdc)<br>Threshold Temperature Coefficient | $V_{GS(th)}$ | <br>1.0 | <br>1.8<br>5.0 | <br>2.0 | <br>Vdc<br>−mV/°C |
| Static Drain−to−Source On−Resistance (Note 5)<br>($V_{GS}$ = 10 Vdc, $I_D$ = 5.0 Adc, $T_J$ @ 25°C)<br>($V_{GS}$ = 10 Vdc, $I_D$ = 5.0 Adc, $T_J$ @ 150°C) (Note 4) | $R_{DS(on)}$ | | <br>23<br>43 | <br>29<br>55 | mΩ |
| Static Drain−to−Source On−Resistance (Note 5)<br>($V_{GS}$ = 5.0 Vdc, $I_D$ = 5.0 Adc, $T_J$ @ 25°C)<br>($V_{GS}$ = 5.0 Vdc, $I_D$ = 5.0 Adc, $T_J$ @ 150°C) (Note 4) | $R_{DS(on)}$ | | <br>28<br>50 | <br>34<br>60 | mΩ |
| Source−Drain Forward On Voltage<br>($I_S$ = 5 A, $V_{GS}$ = 0 V) | $V_{SD}$ | | 0.80 | 1.1 | V |

**SWITCHING CHARACTERISTICS** (Note 4)

| Characteristic | Conditions | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Turn−ON Time (10% $V_{IN}$ to 90% $I_D$) | $V_{IN}$ = 0 V to 5 V, $V_{DD}$ = 25 V<br>$I_D$ = 1.0 A, Ext $R_G$ = 2.5 Ω | $t_{ON}$ | | 41 | 50 | μs |
| Turn−OFF Time (90% $V_{IN}$ to 10% $I_D$) | | $t_{OFF}$ | | 129 | 150 | |
| Turn−ON Time (10% $V_{IN}$ to 90% $I_D$) | $V_{IN}$ = 0 V to 10 V, $V_{DD}$ = 25 V,<br>$I_D$ = 1.0 A, Ext $R_G$ = 2.5 Ω | $t_{ON}$ | | 16 | 25 | |
| Turn−OFF Time (90% $V_{IN}$ to 10% $I_D$) | | $t_{OFF}$ | | 164 | 180 | |
| Slew−Rate ON (80% $V_{DS}$ to 50% $V_{DS}$) | $V_{in}$ = 0 to 10 V, $V_{DD}$ = 12 V,<br>$R_L$ = 4.7 Ω | $-dV_{DS}/dt_{ON}$ | | 1.27 | 2.0 | V/μs |
| Slew−Rate OFF (50% $V_{DS}$ to 80% $V_{DS}$) | | $dV_{DS}/dt_{OFF}$ | | 0.36 | 0.75 | |

**SELF PROTECTION CHARACTERISTICS** ($T_J$ = 25°C unless otherwise noted)

| Characteristic | Conditions | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Current Limit | $V_{GS}$ = 5.0 V, $V_{DS}$ = 10 V<br>$V_{GS}$ = 5.0 V, $T_J$ = 150°C (Note 4) | $I_{LIM}$ | 25<br>11 | 30<br>16 | 35<br>21 | Adc |
| | $V_{GS}$ = 10 V, $V_{DS}$ = 10 V<br>$V_{GS}$ = 10 V, $T_J$ = 150°C (Note 4) | | 30<br>18 | 35<br>25 | 40<br>28 | |
| Temperature Limit (Turn−off) | $V_{GS}$ = 5.0 V (Note 4) | $T_{LIM(off)}$ | 150 | 175 | 200 | °C |
| Thermal Hysteresis | $V_{GS}$ = 5.0 V | $\Delta T_{LIM(on)}$ | | 15 | | °C |
| Temperature Limit (Turn−off) | $V_{GS}$ = 10 V (Note 4) | $T_{LIM(off)}$ | 150 | 165 | 185 | °C |
| Thermal Hysteresis | $V_{GS}$ = 10 V | $\Delta T_{LIM(on)}$ | | 15 | | °C |

**GATE INPUT CHARACTERISTICS** (Note 4)

| Characteristic | Conditions | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Device ON Gate Input Current | $V_{GS}$ = 5 V $I_D$ = 1.0 A | $I_{GON}$ | | 50 | 100 | μA |
| | $V_{GS}$ = 10 V $I_D$ = 1.0 A | | | 400 | 700 | |
| Current Limit Gate Input Current | $V_{GS}$ = 5 V, $V_{DS}$ = 10 V | $I_{GCL}$ | | 0.1 | 0.5 | mA |
| | $V_{GS}$ = 10 V, $V_{DS}$ = 10 V | | | 0.7 | 1.0 | |
| Thermal Limit Fault Gate Input Current | $V_{GS}$ = 5 V, $V_{DS}$ = 10 V | $I_{GTL}$ | | 0.6 | 1.0 | mA |
| | $V_{GS}$ = 10 V, $V_{DS}$ = 10 V | | | 2.0 | 4.0 | |

**ESD ELECTRICAL CHARACTERISTICS** ($T_J$ = 25°C unless otherwise noted) (Note 4)

| Characteristic | Symbol | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| Electro−Static Discharge Capability<br>Human Body Model (HBM)<br>Machine Model (MM) | ESD | <br>4000<br>400 | | | V |

4. Not subject to production testing.
5. Pulse Test: Pulse Width ≤ 300 μs, Duty Cycle ≤ 2%.

## TYPICAL PERFORMANCE CURVES

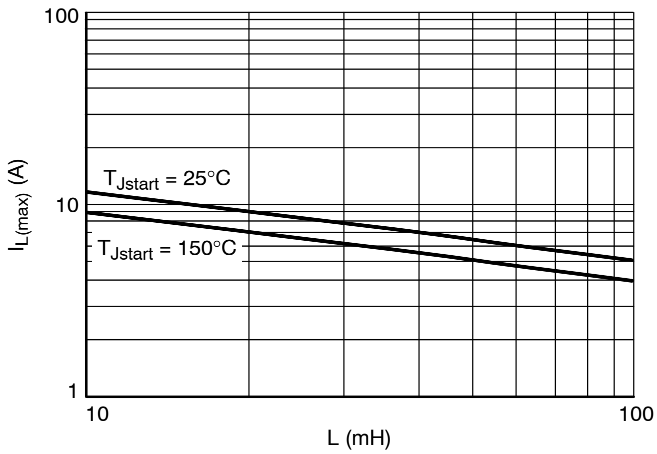



**Figure 2. Single Pulse Maximum Switch−off Current vs. Load Inductance**

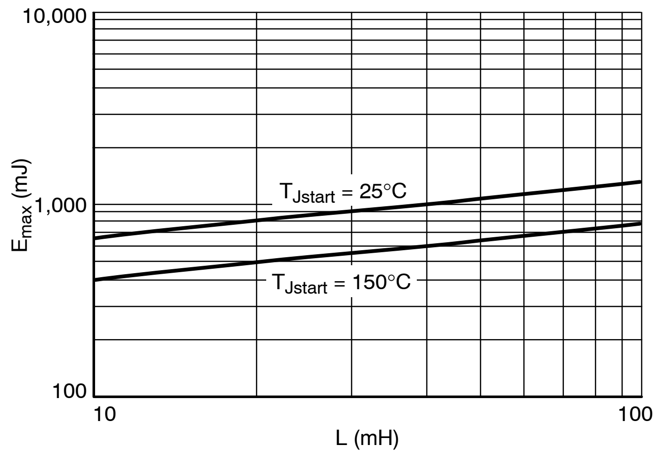



**Figure 3. Single Pulse Maximum Switching Energy vs. Load Inductance**

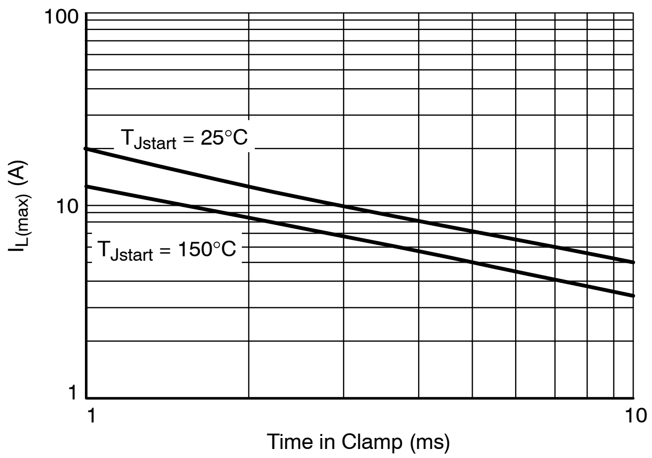



**Figure 4. Single Pulse Maximum Inductive Switch−off Current vs. Time in Clamp**

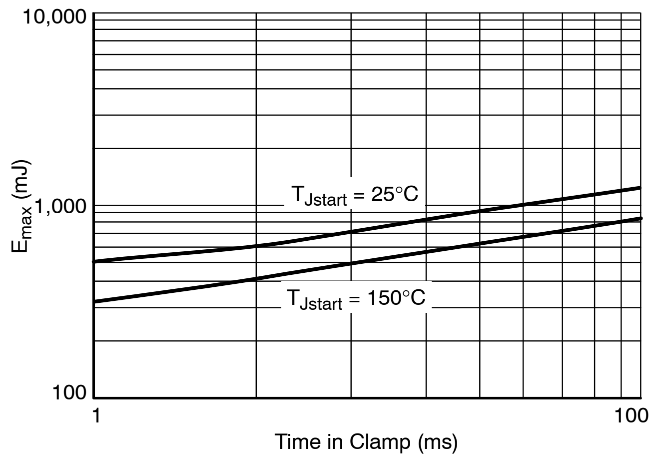



**Figure 5. Single Pulse Maximum Inductive Switching Energy vs. Time in Clamp**

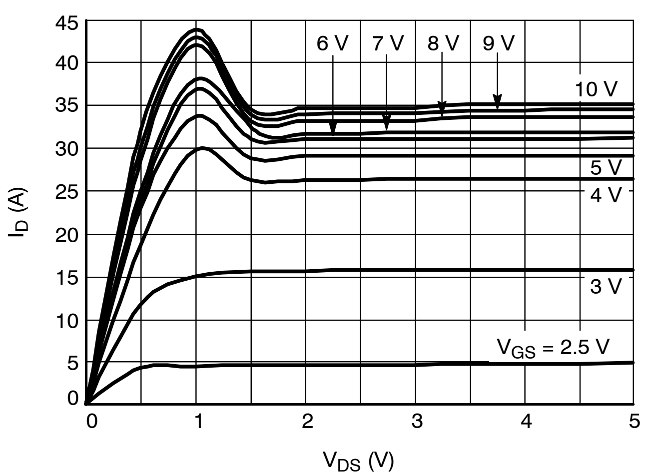



**Figure 6. On−state Output Characteristics at 25°C**

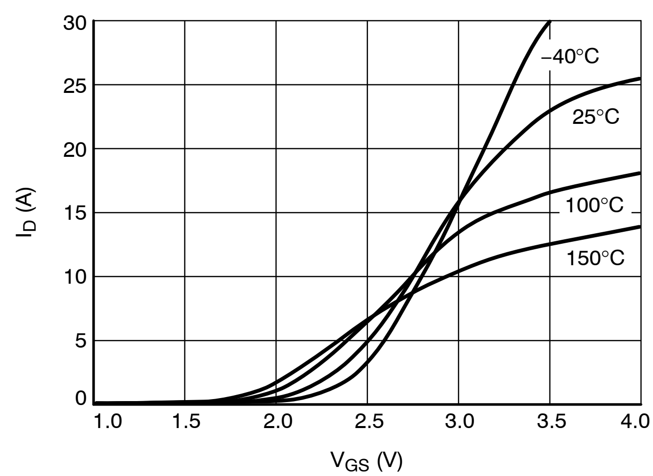



**Figure 7. Transfer Characteristics ($V_{DS}$ = 10 V)**

## TYPICAL PERFORMANCE CURVES

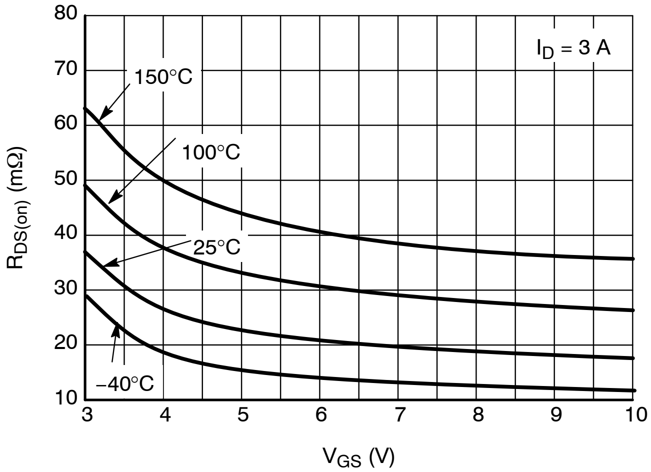



**Figure 8. $R_{DS(on)}$ vs. Gate−Source Voltage**

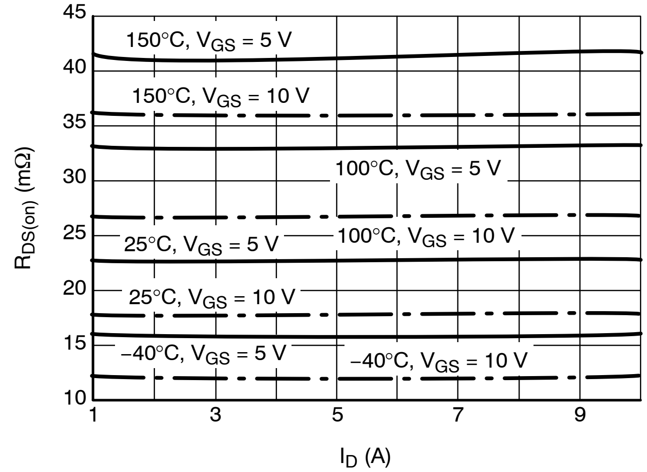



**Figure 9. $R_{DS(on)}$ vs. Drain Current**

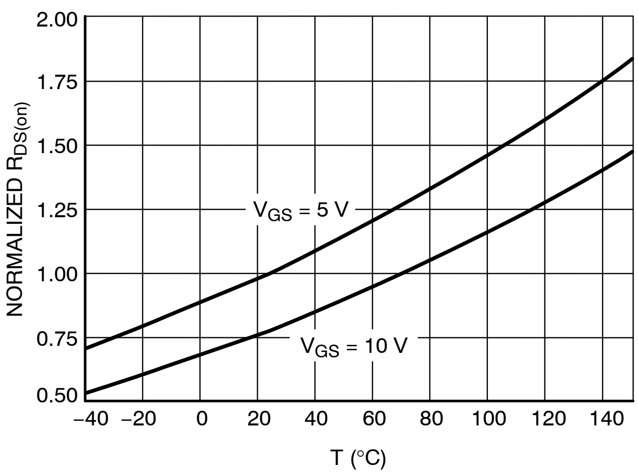



**Figure 10. Normalized $R_{DS(on)}$ vs. Temperature ($I_D$ = 5 A)**

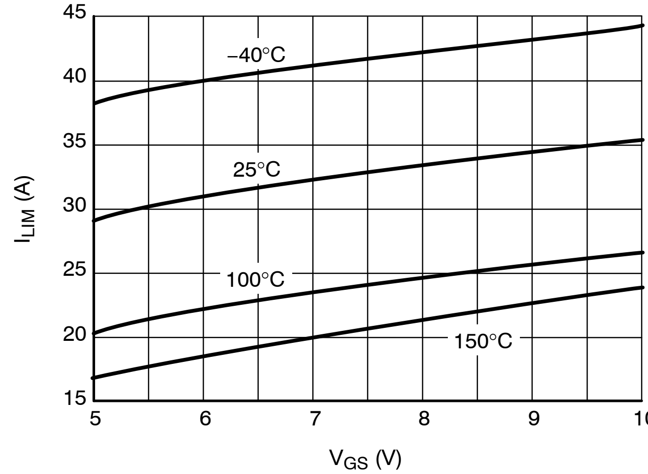



**Figure 11. Current Limit vs. Gate−Source Voltage ($V_{DS}$ = 10 V)**

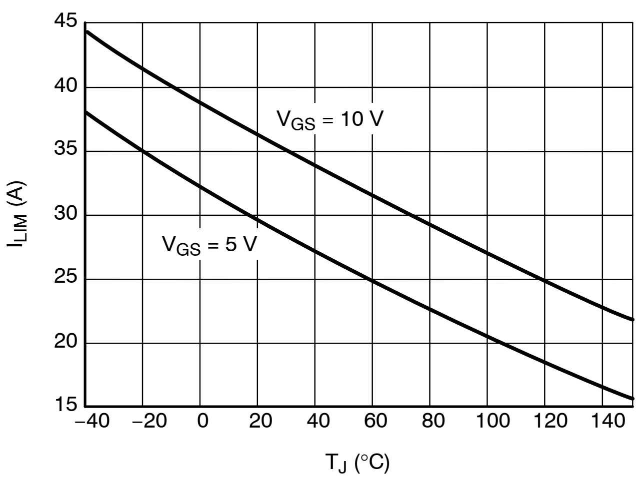



**Figure 12. Current Limit vs. Junction Temperature ($V_{DS}$ = 10 V)**

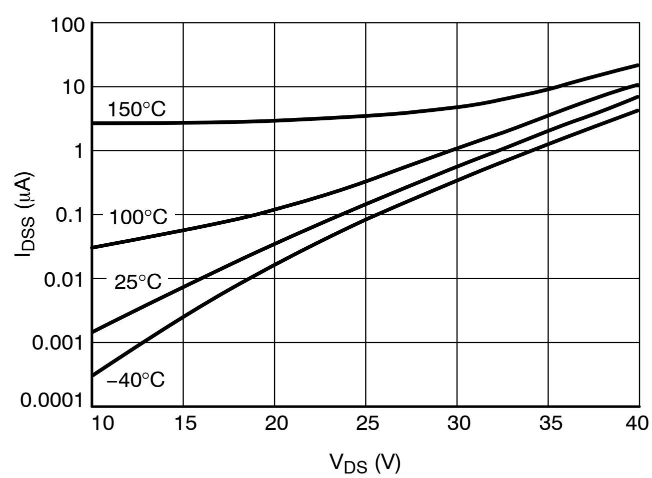



**Figure 13. Drain−to−Source Leakage Current ($V_{GS}$ = 0 V)**

## TYPICAL PERFORMANCE CURVES

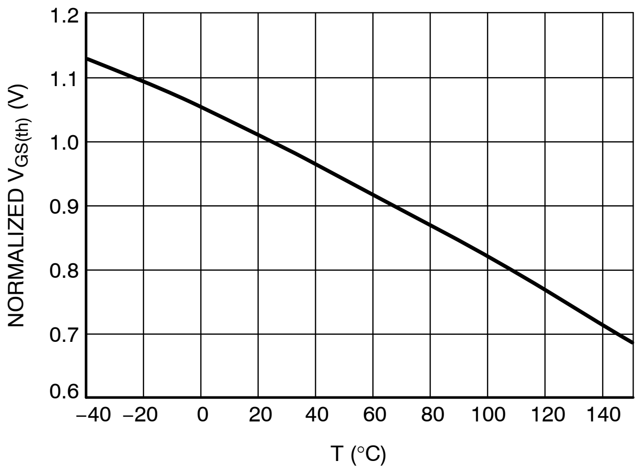



**Figure 14. Normalized Threshold Voltage vs. Temperature ($I_D$ = 1.2 mA, $V_{DS}$ = $V_{GS}$)**

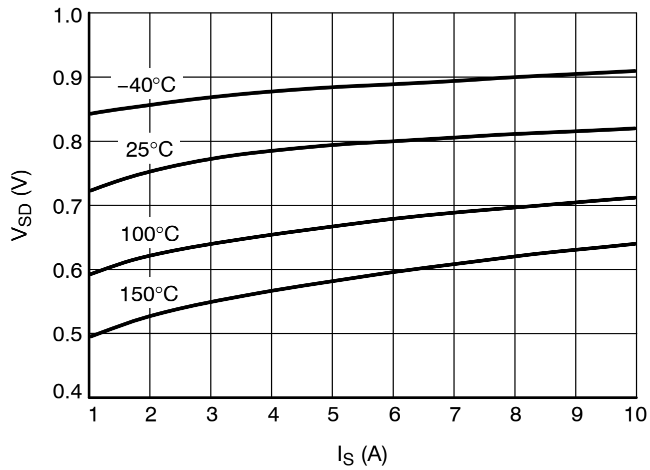



**Figure 15. Source−Drain Diode Forward Characteristics ($V_{GS}$ = 0 V)**

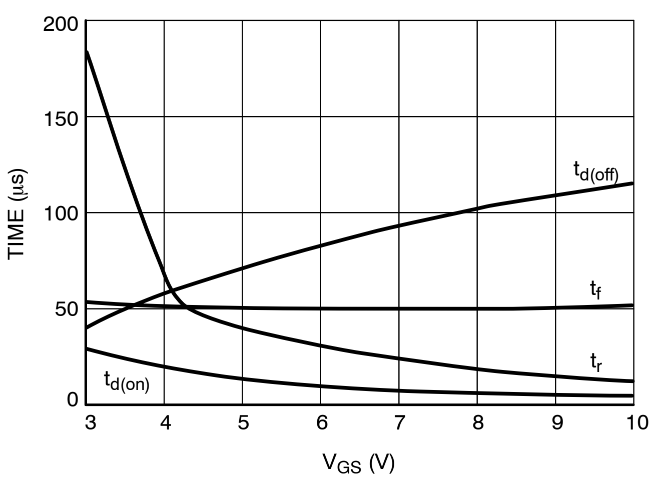



**Figure 16. Resistive Load Switching Time vs. Gate−Source Voltage ($V_{DD}$ = 25 V, $I_D$ = 5 A, $R_G$ = 0 Ω)**

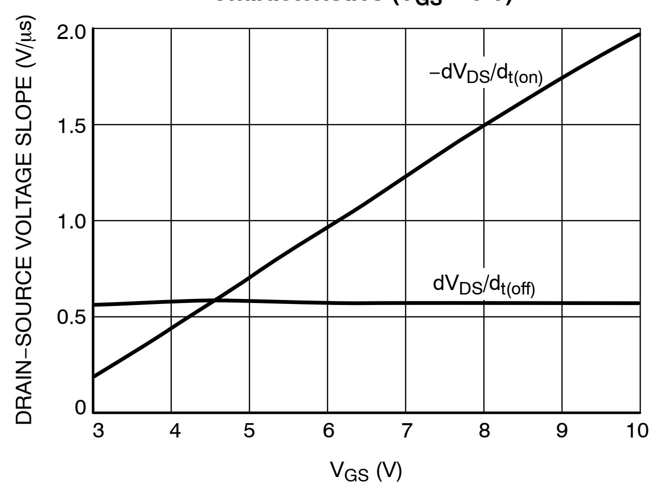



**Figure 17. Resistive Load Switching Drain−Source Voltage Slope vs. Gate−Source Voltage ($V_{DD}$ = 25 V, $I_D$ = 5 A, $R_G$ = 0 Ω)**

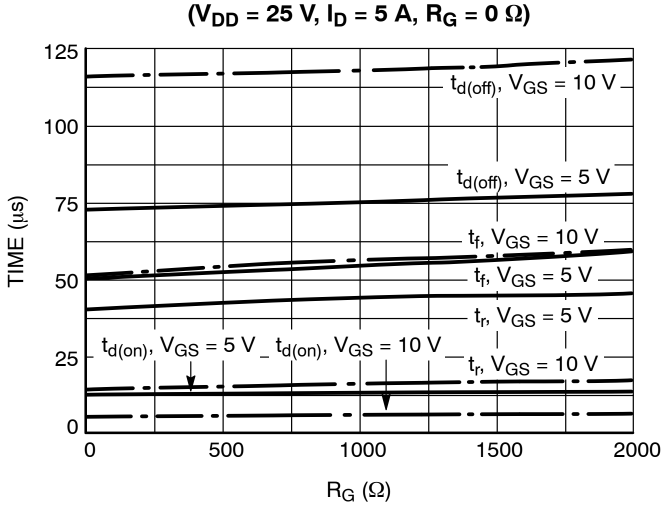



**Figure 18. Resistive Load Switching Time vs. Gate Resistance ($V_{DD}$ = 25 V, $I_D$ = 5 A)**

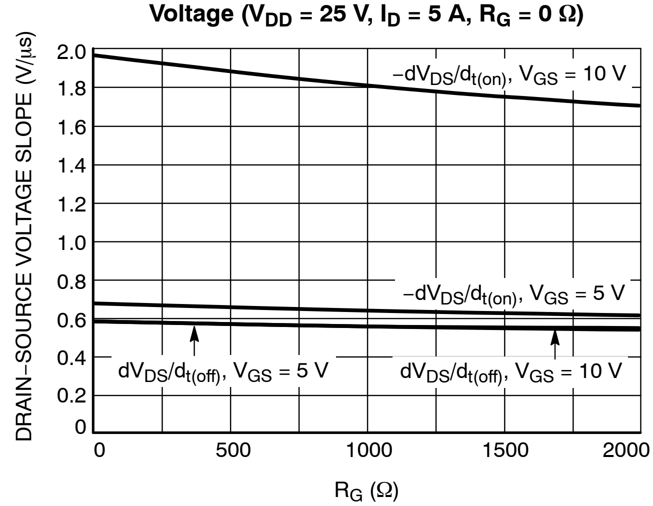



**Figure 19. Drain−Source Voltage Slope during Turn On and Turn Off vs. Gate Resistance ($V_{DD}$ = 25 V, $I_D$ = 5 A)**

## TYPICAL PERFORMANCE CURVES

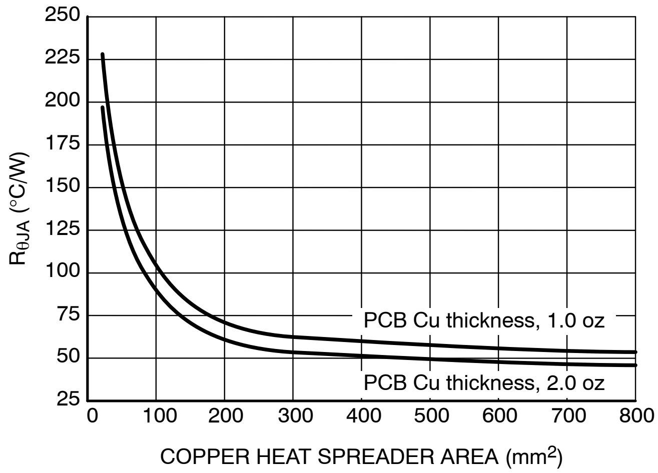



**Figure 20. $R_{\theta JA}$ vs. Copper Area**

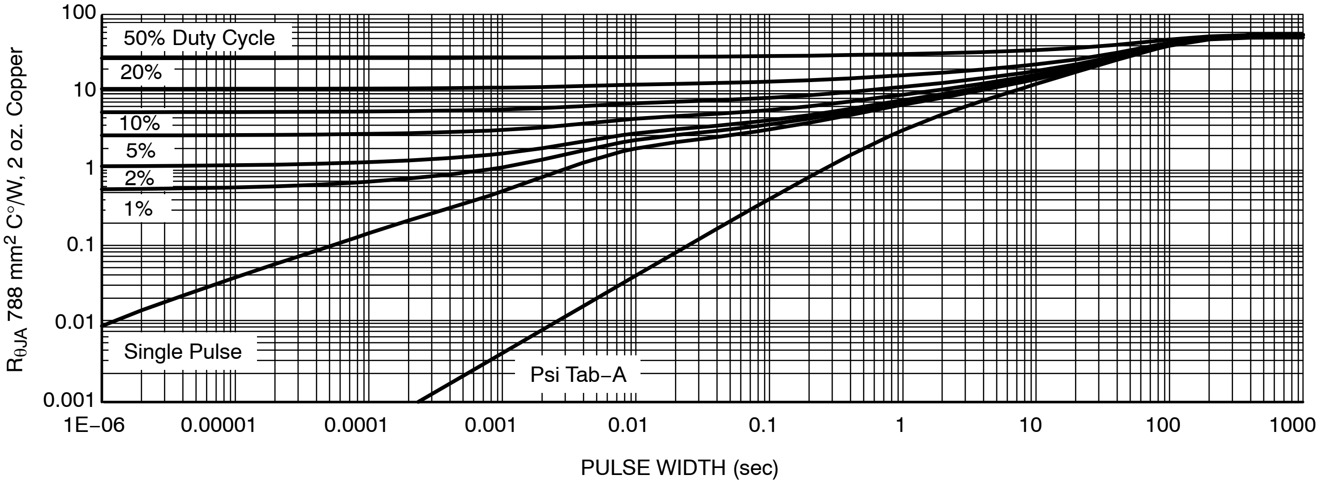



**Figure 21. Transient Thermal Resistance**

## TEST CIRCUITS AND WAVEFORMS

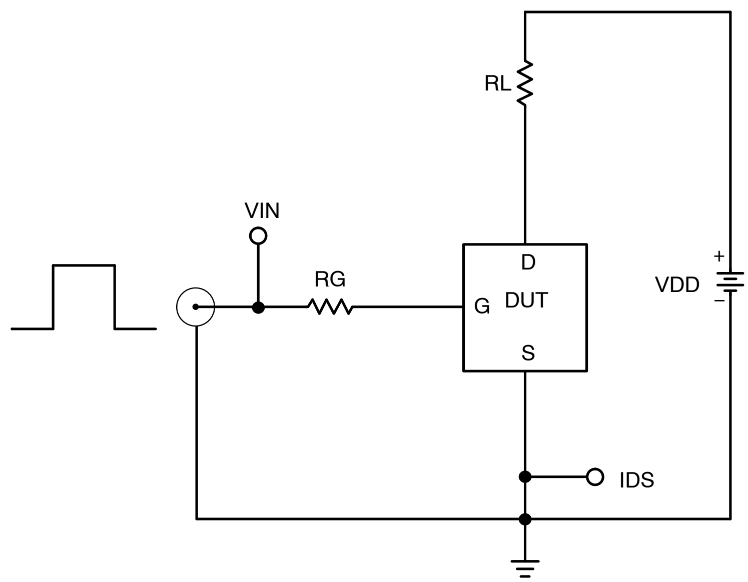



**Figure 22. Resistive Load Switching Test Circuit**

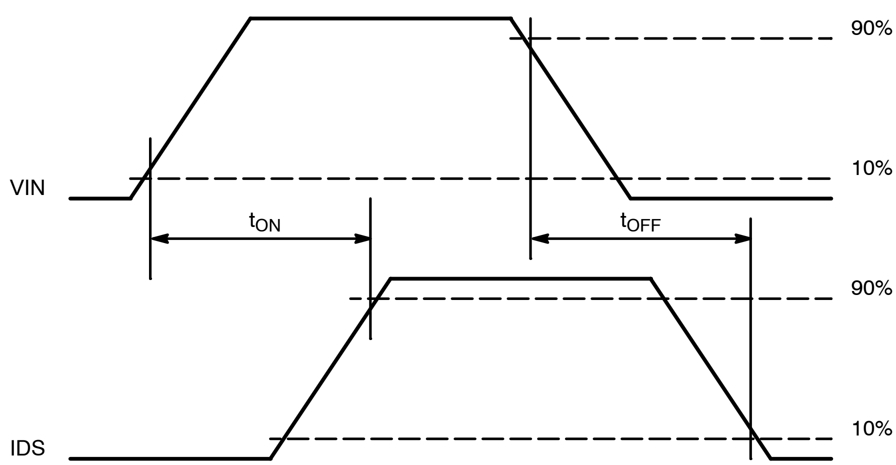



**Figure 23. Resistive Load Switching Waveforms**

## TEST CIRCUITS AND WAVEFORMS

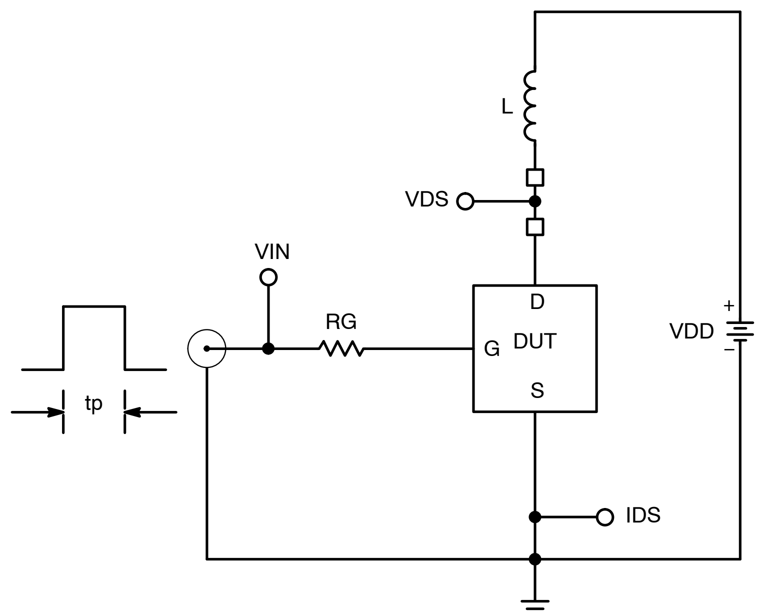



**Figure 24. Inductive Load Switching Test Circuit**

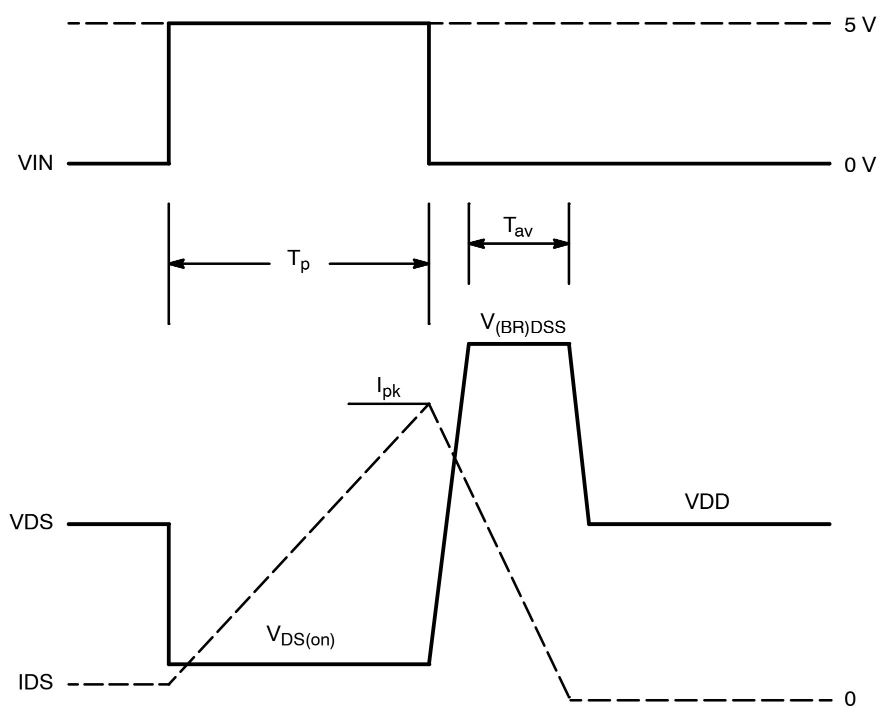
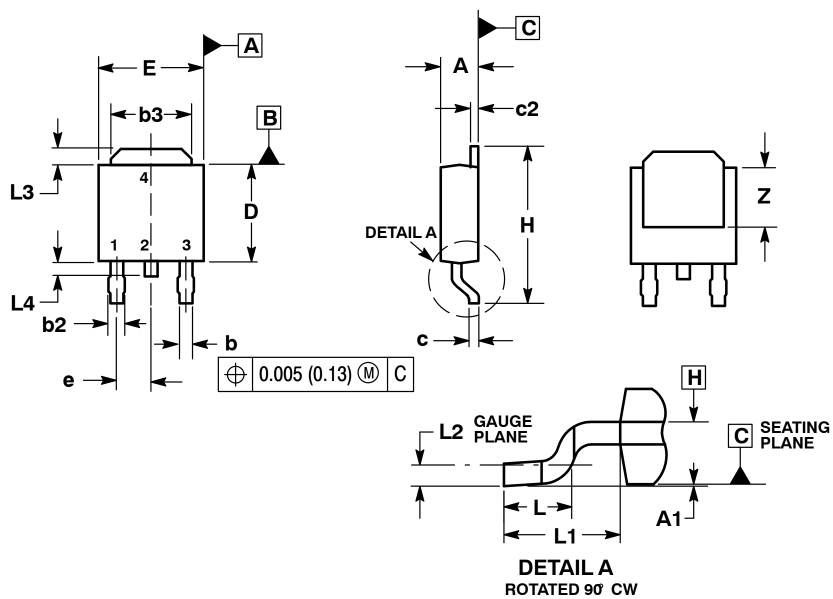



**Figure 25. Inductive Load Switching Waveforms**

## PACKAGE DIMENSIONS

### DPAK
CASE 369C
ISSUE D

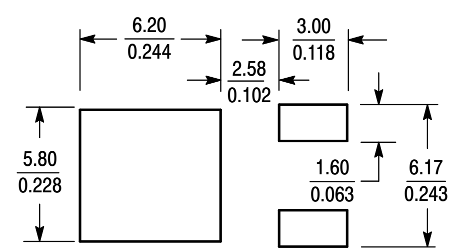



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: INCHES.
3. THERMAL PAD CONTOUR OPTIONAL WITHIN DIMENSIONS b3, L3 and Z.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.006 INCHES PER SIDE.
5. DIMENSIONS D AND E ARE DETERMINED AT THE OUTERMOST EXTREMES OF THE PLASTIC BODY.
6. DATUMS A AND B ARE DETERMINED AT DATUM PLANE H.

| | INCHES | | MILLIMETERS | |
|---|---|---|---|---|
| DIM | MIN | MAX | MIN | MAX |
| A | 0.086 | 0.094 | 2.18 | 2.38 |
| A1 | 0.000 | 0.005 | 0.00 | 0.13 |
| b | 0.025 | 0.035 | 0.63 | 0.89 |
| b2 | 0.030 | 0.045 | 0.76 | 1.14 |
| b3 | 0.180 | 0.215 | 4.57 | 5.46 |
| c | 0.018 | 0.024 | 0.46 | 0.61 |
| c2 | 0.018 | 0.024 | 0.46 | 0.61 |
| D | 0.235 | 0.245 | 5.97 | 6.22 |
| E | 0.250 | 0.265 | 6.35 | 6.73 |
| e | 0.090 BSC | | 2.29 BSC | |
| H | 0.370 | 0.410 | 9.40 | 10.41 |
| L | 0.055 | 0.070 | 1.40 | 1.78 |
| L1 | 0.108 REF | | 2.74 REF | |
| L2 | 0.020 BSC | | 0.51 BSC | |
| L3 | 0.035 | 0.050 | 0.89 | 1.27 |
| L4 | −−− | 0.040 | −−− | 1.01 |
| Z | 0.155 | −−− | 3.93 | −−− |

STYLE 2:
PIN 1. GATE
2. DRAIN
3. SOURCE
4. DRAIN

### SOLDERING FOOTPRINT*




SCALE 3:1 (mm / inches)

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.



**PUBLICATION ORDERING INFORMATION**

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**Fax**: 303−675−2176 or 800−344−3867 Toll Free USA/Canada
**Email**: orderlit@onsemi.com

**N. American Technical Support**: 800−282−9855 Toll Free USA/Canada
**Europe, Middle East and Africa Technical Support:**
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# OCEAN CHIPS
## Океан Электроники
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Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения **«JONHON»**, а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов **«FORSTAR»**.

**«JONHON»** (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

**«FORSTAR»** (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).

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