# 50 mΩ, Slew Rate Controlled Load Switch in WCSP

## DESCRIPTION

The SiP32467 and SiP32468 are slew rate controlled integrated high side load switches that operate in the input voltage range from 1.2 V to 5.5 V.

This series of design features slew rate control, reverse blocking when switch is off, output discharge, and control logic pull up. The devices are logic low enabled.

The SiP32467 and SiP32468 are available in compact wafer level WCSP package, WCSP4 0.76 mm x 0.76 mm with 0.4 mm pitch.

## FEATURES

- Low input voltage, 1.2 V to 5.5 V
- Low $R_{on}$, 54 mΩ/typ. at 3 V
- Slew rate control
- Compatible with 1.2 V to 3.3 V logic
- Reverse current blocking when switch is off
- Integrated output discharge switch (SiP32468)
- Integrated pull up resistor at "EN"
- For enable "High" see SiP32460, SiP32461, and SiP32462
- 4-bump WCSP package
- Material categorization: For definitions of compliance please see www.vishay.com/doc?99912

Pb-free

RoHS COMPLIANT

HALOGEN FREE Available

## APPLICATIONS

- Smart phones
- GPS and portable media players
- Tablet computers
- Medical and healthcare equipment
- Industrial and instrumentation
- Game consoles

## TYPICAL APPLICATION CIRCUIT

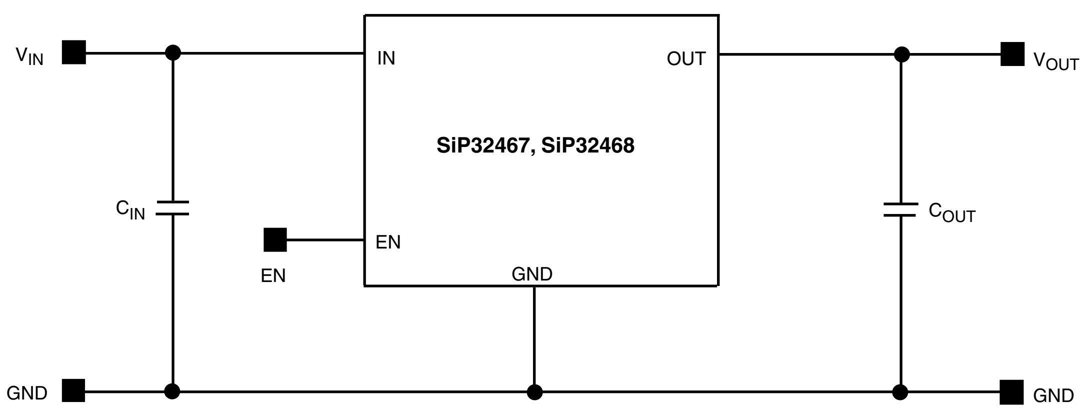


Fig. 1 - Typical Application Circuit



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| ORDERING INFORMATION | | | | | |
|---|---|---|---|---|---|
| PART NUMBER | PACKAGE | $t_{on}$ (µs) | $R_{DISCHARGE}$ | MARK CODE | TEMPERATURE RANGE |
| SiP32467DB-T2-GE1 | WCSP4 (2x2) 0.4 mm Pitch | 300 | No | AJ | -40 °C to +85 °C |
| SiP32468DB-T2-GE1 | WCSP4 (2x2) 0.4 mm Pitch | 300 | Yes | AK | -40 °C to +85 °C |

## PIN CONFIGURATION

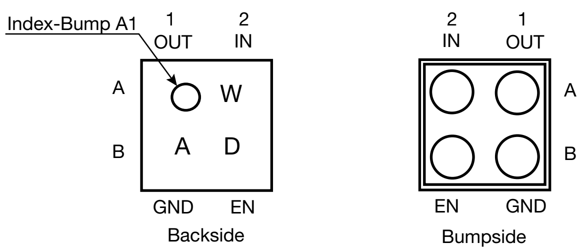


Fig. 2 - WCSP 2 x 2 Package

| DEVICE MARKING | | |
|---|---|---|
| Row 1 | **Dot + W** | : Dot is A1 locator plus week code |
| Row 2 | **AB** | : Mark code for part number |

SiP32467 = AJ

SiP32468 = AK

**PIN DESCRIPTION** (WSCP Package)

| PIN# | NAME | FUNCTION |
|---|---|---|
| A1 | OUT | Switch output |
| A2 | IN | Switch input |
| B1 | GND | Ground connection |
| B2 | EN | Switch on/off control. A pull up resistor is integrated |

## TRUTH TABLE

| EN | SWITCH |
|---|---|
| 1 | OFF |
| 0 | ON |


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| ABSOLUTE MAXIMUM RATINGS | | | |
|---|---|---|---|
| **PARAMETER** | **CONDITIONS** | **LIMIT** | **UNIT** |
| Supply Input Voltage $V_{IN}$ | Reference to GND | -0.3 to 6.5 | V |
| Output Voltage $V_{OUT}$ | Reference to GND | -0.3 to 6.5 | |
| Output Voltage $V_{OUT}$ | Pulse at 1 ms reference to GND [(1)] | -1.6 | |
| Enable Input Voltage EN | Reference to GND | -0.3 to 6.5 | |
| Maximum Continuous Switch Current | | 1.2 | A |
| Maximum Pulse Switch Current | Pulse at 1 ms, 10 % duty cycle | 2 | |
| ESD Rating (HBM) | | 4000 | V |
| Thermal Resistance | | 205 | °C/W |
| Maximum Power Dissipation | $T_A$ = 25 °C | 300 | mW |
| **TEMPERATURE** | | | |
| Operating Temperature | | -40 to 85 | °C |
| Operating Junction Temperature | | 125 | |
| Storage Temperature | | -65 to 150 | |

**Note**

(1) Negative current injection up to 300 mA

*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.*

| RECOMMENDED OPERATING RANGE | | | | |
|---|---|---|---|---|
| **ELECTRICAL PARAMETER** | **MINIMUM** | **TYPICAL** | **MAXIMUM** | **UNIT** |
| Input Voltage ($V_{IN}$) | 1.2 | - | 5.5 | V |
| Output Voltage ($V_{OUT}$) | 1.2 | - | 5.5 | |

| SPECIFICATIONS | | | | | | |
|---|---|---|---|---|---|---|
| **PARAMETER** | **SYMBOL** | **TEST CONDITION UNLESS OTHERWISE SPECIFIED** $V_{IN}$ = 1.2 V to 5.5 V, $T_A$ = -40 °C to 85 °C | **LIMITS** | | | **UNIT** |
| | | | **MIN.** | **TYP.** | **MAX.** | |
| **POWER SUPPLY** | | | | | | |
| Quiescent Current | $I_Q$ | $V_{IN}$ = 3.3 V, $I_{OUT}$ = 0 mA | - | 6 | 8 | µA |
| Shutdown Current | $I_{SD}$ | OUT = GND | - | 0.01 | 2 | |
| Off Switch Current | $I_{DS(off)}$ | EN = $V_{IN}$, OUT = GND | - | 0.01 | 2 | |
| Reverse Blocking Current | $I_{(in)RB}$ | Out = 5 V, IN = 1.2 V, EN = 1.2 V, (Measured at IN pin) | - | 0.01 | 1 | |
| | | Out = 5 V, IN = 0 V, EN = open, (Measured at IN pin) | - | 0.01 | 1 | |
| **SWITCH RESISTANCE** | | | | | | |
| On Resistance | $R_{DS(on)}$ | $I_{OUT}$ = 500 mA, $V_{IN}$ = 1.2 V, $T_A$ = 25 °C | - | 95 | 150 | mΩ |
| | | $I_{OUT}$ = 500 mA, $V_{IN}$ = 1.5 V, $T_A$ = 25 °C | - | 80 | 120 | |
| | | $I_{OUT}$ = 500 mA, $V_{IN}$ = 1.8 V, $T_A$ = 25 °C | - | 70 | 100 | |
| | | $I_{OUT}$ = 500 mA, $V_{IN}$ = 3 V, $T_A$ = 25 °C | - | 54 | 65 | |
| | | $I_{OUT}$ = 500 mA, $V_{IN}$ = 5 V, $T_A$ = 25 °C | - | 50 | 65 | |
| Discharge Switch On Resistance | $R_{PD}$ | When $V_{IN}$ = 3 V at 25 °C | - | 80 | - | Ω |
| | | When $V_{IN}$ = 1.8 V at 25 °C | - | < 200 | - | |
| EN Pin Pull Up Resistor | $R_{EN}$ | EN = 1.2 V | 1 | 2.6 | 5 | MΩ |
| On Resistance Temperature Coefficient | $TC_{RDS}$ | | - | 2800 | | ppm/°C |


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| SPECIFICATIONS | | | | | | |
|---|---|---|---|---|---|---|
| PARAMETER | SYMBOL | TEST CONDITION UNLESS OTHERWISE SPECIFIED $V_{IN}$ = 1.2 V to 5.5 V, $T_A$ = -40 °C to 85 °C | LIMITS | | | UNIT |
| | | | MIN. | TYP. | MAX. | |
| **ON/OFF LOGIC** | | | | | | |
| EN Input Low Voltage | $V_{IL}$ | $V_{IN}$ = 1.5 V | 0.4 | - | - | V |
| EN Input High Voltage | $V_{IH}$ | $V_{IN}$ = 5.5 V | - | - | 1 | |
| **SWITCHING SPEED** | | | | | | |
| Switch Turn-ON Delay Time | $t_{on\_DLY}$ | $R_{LOAD}$ = 500 Ω , $C_L$ = 0.1 µF $V_{IN}$ = 5 V | - | 130 | - | µs |
| Switch Turn-ON Rise Time | $t_r$ | $R_{LOAD}$ = 500 Ω , $C_L$ = 0.1 µF $V_{IN}$ = 5 V | - | 170 | - | |
| Switch Turn-OFF Delay Time | $t_{off}$ | $R_{LOAD}$ = 500 Ω, $C_L$ = 0.1 µF, (50 % $V_{IN}$ to 90 % $V_{OUT}$) | - | 2 | - | |

## BLOCK DIAGRAM

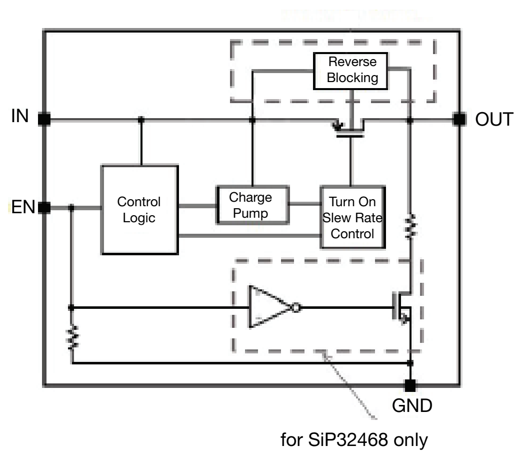


Fig. 3 - Functional Block Diagram


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**TYPICAL CHARACTERISTICS** ($T_J$ = 25 °C, unless otherwise noted)

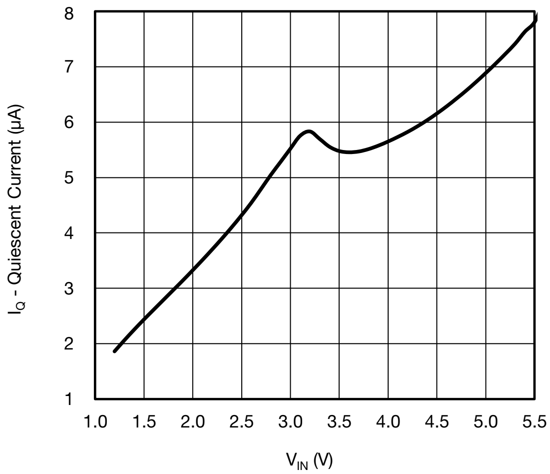


Fig. 4 - Quiescent Current vs. Input Voltage

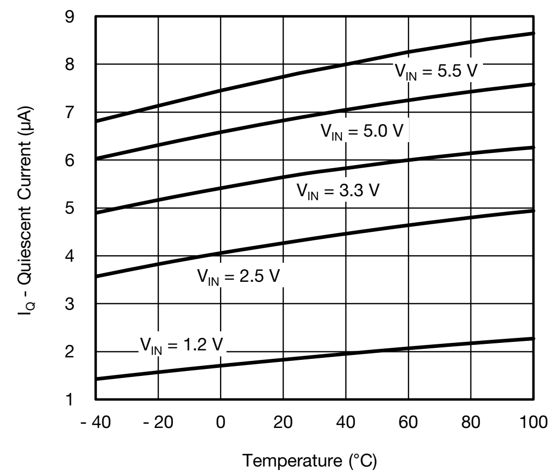


Fig. 7 - Quiescent Current vs. Temperature

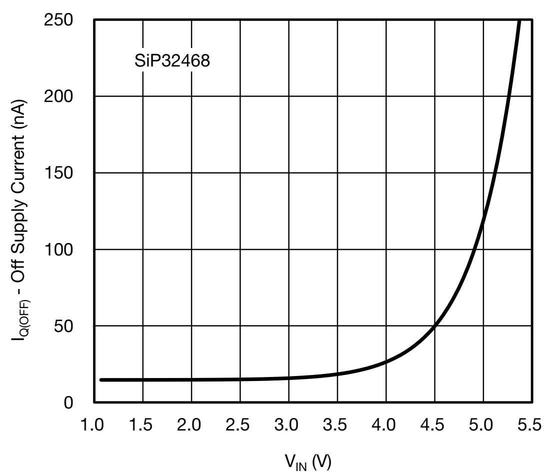


Fig. 5 - Off Supply Current vs. Input Voltage

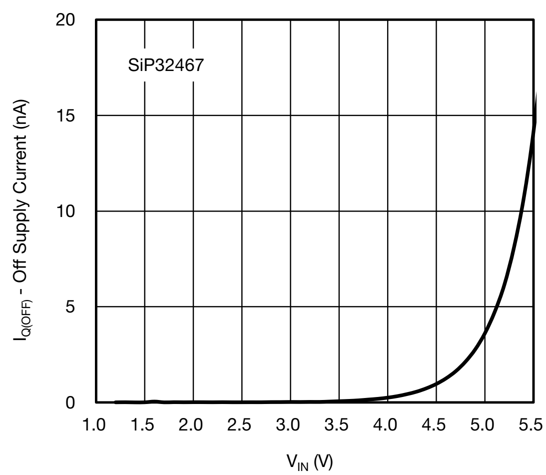


Fig. 8 - Off Supply Current vs. Input Voltage

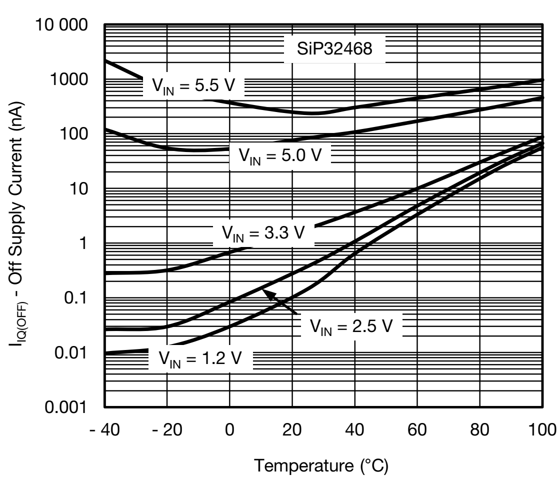


Fig. 6 - Off Supply Current vs. Temperature

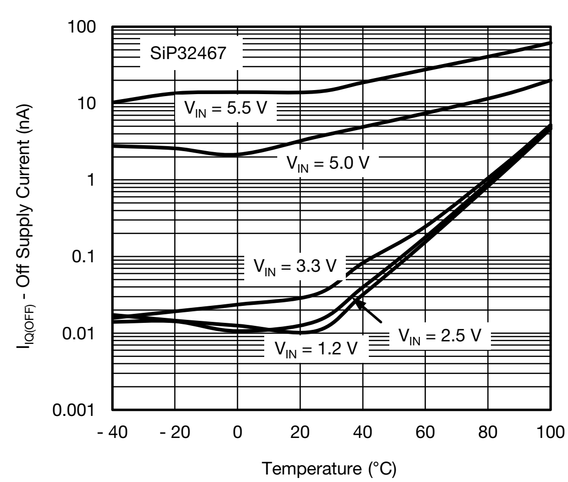


Fig. 9 - Off Supply Current vs. Temperature


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## TYPICAL CHARACTERISTICS ($T_J$ = 25 °C, unless otherwise noted)

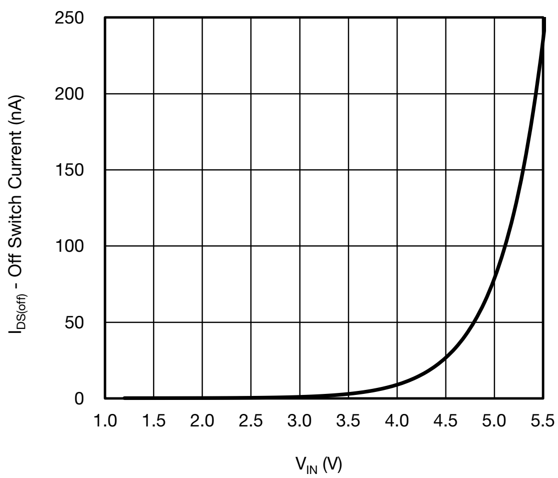


Fig. 10 - Off Switch Current vs. Input Voltage

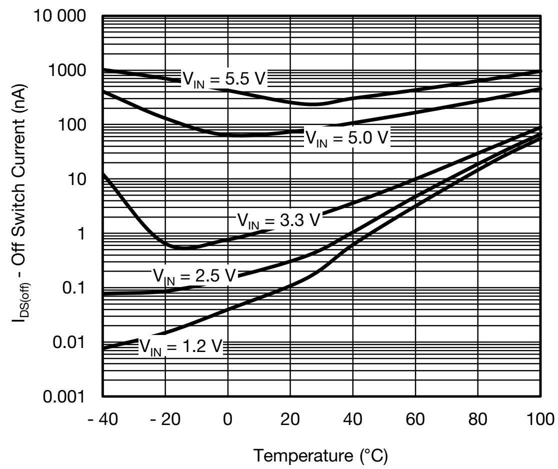


Fig. 13 - Off Switch Current vs. Temperature

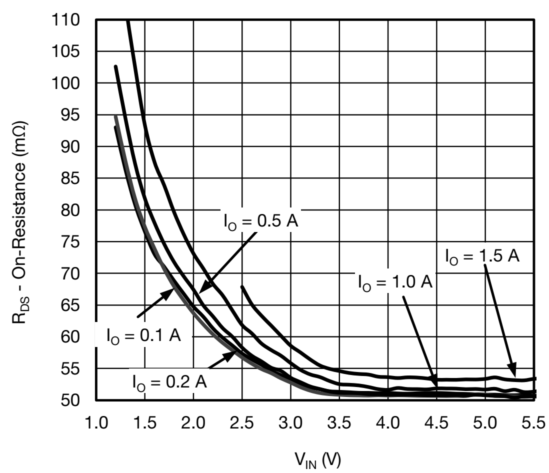


Fig. 11 - $R_{DS(on)}$ vs. Input Voltage

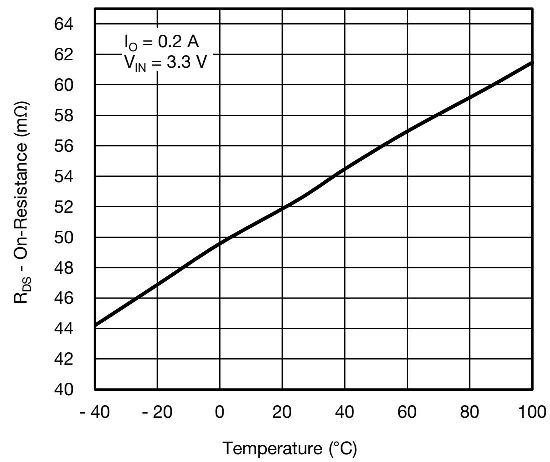


Fig. 14 - $R_{DS(on)}$ vs. Temperature

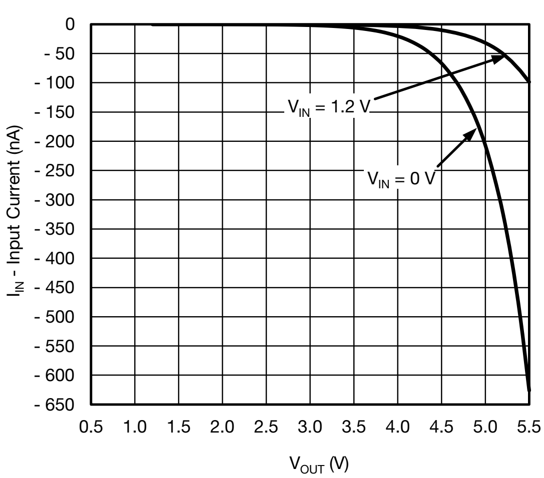


Fig. 12 - Reverse Blocking Current vs. Output Voltage

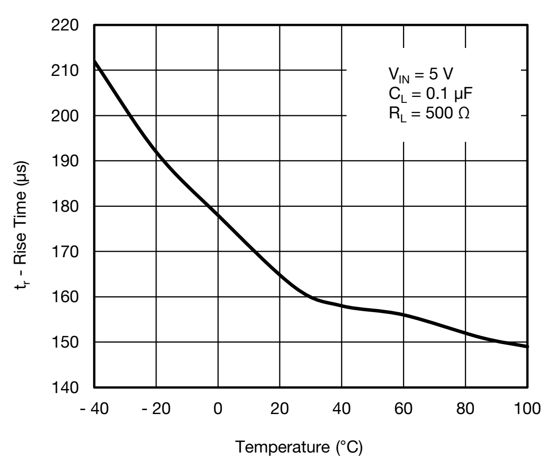


Fig. 15 - Rise Time vs. Temperature


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**TYPICAL CHARACTERISTICS** ($T_J$ = 25 °C, unless otherwise noted)

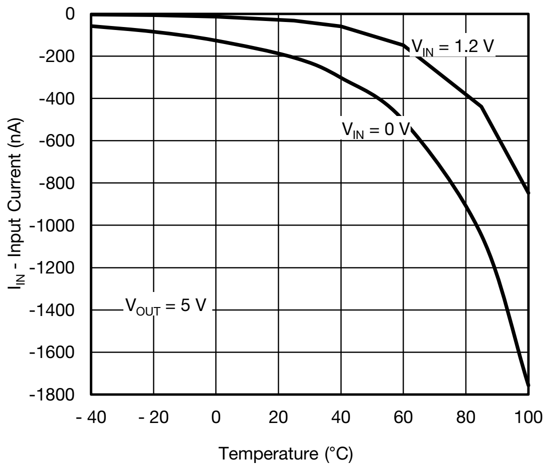


Fig. 16 - Reverse Blocking Current vs. Temperature

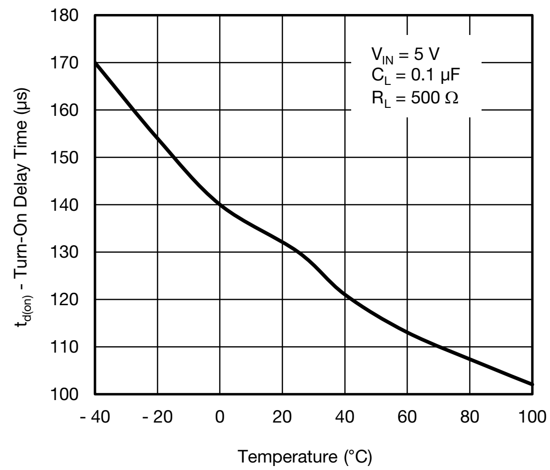


Fig. 19 - Turn-on Delay Time vs. Temperature

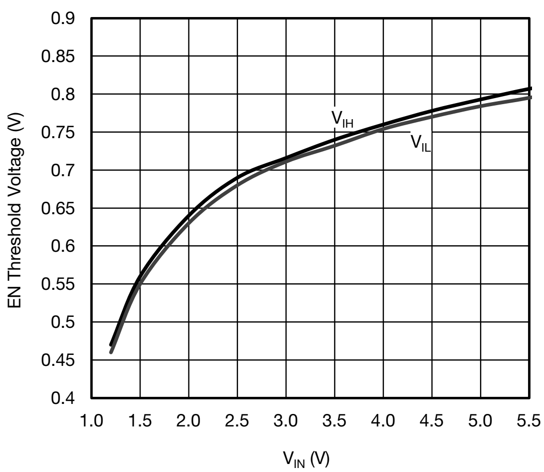


Fig. 17 - EN Threshold Voltage vs. Input Voltage

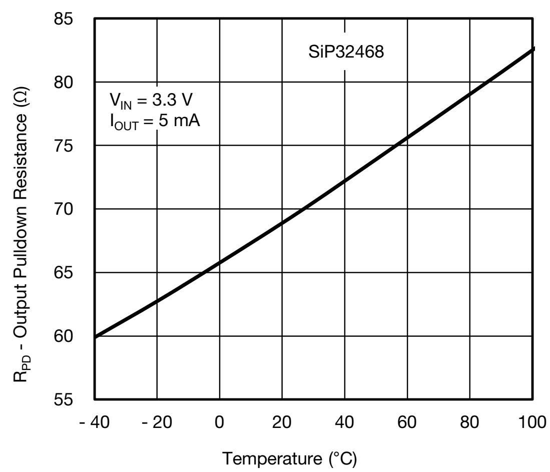


Fig. 20 - Output Pulldown Resistance vs. Temperature

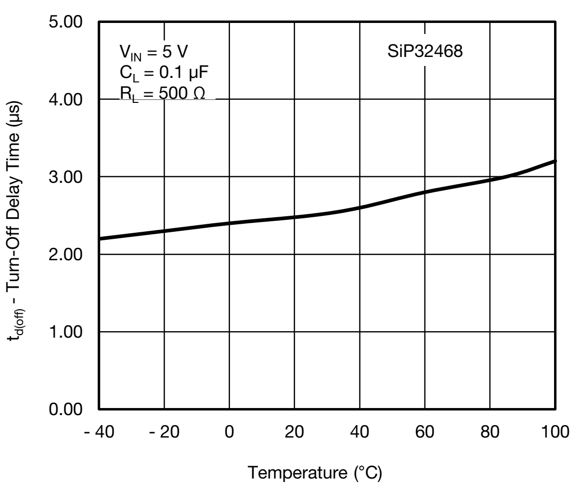


Fig. 18 - Turn-off Delay Time vs. Temperature

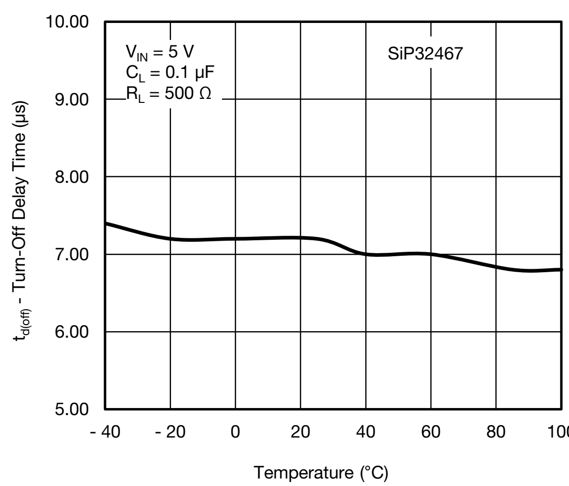


Fig. 21 - Turn-off Delay Time vs. Temperature


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## TYPICAL WAVEFORMS

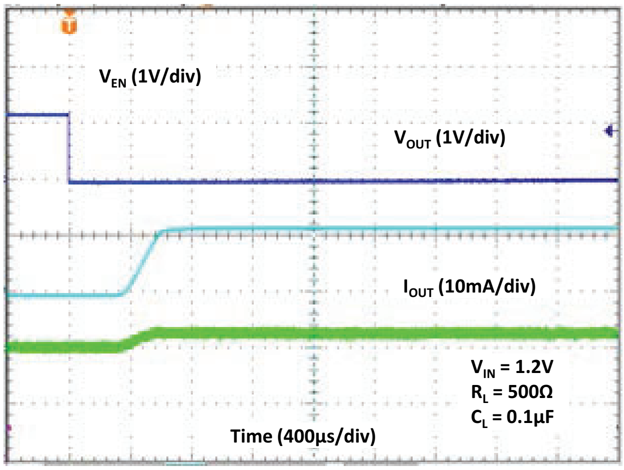


Fig. 22 - Turn-on Time

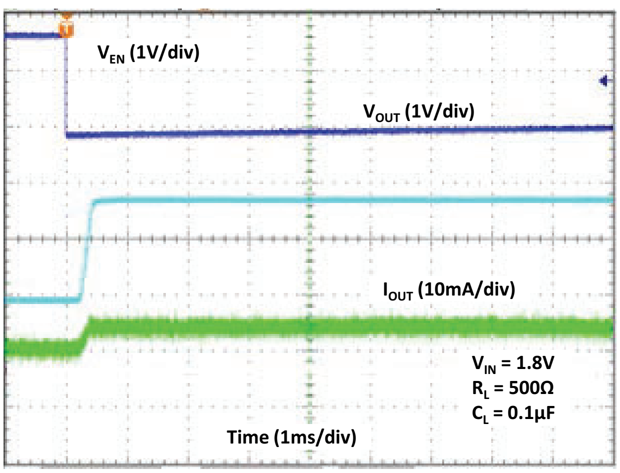


Fig. 23 - Turn-on Time

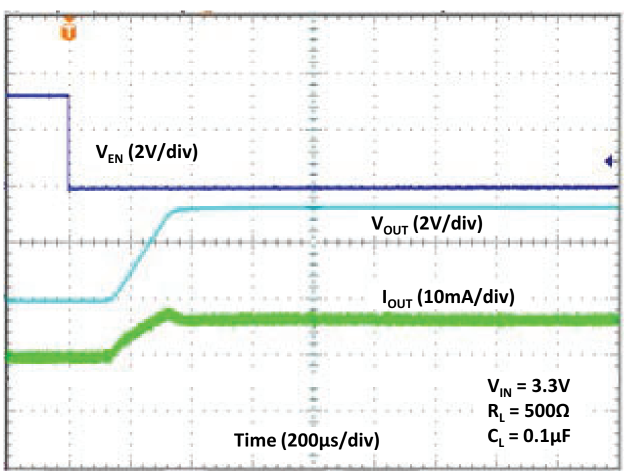


Fig. 24 - Turn-on Time

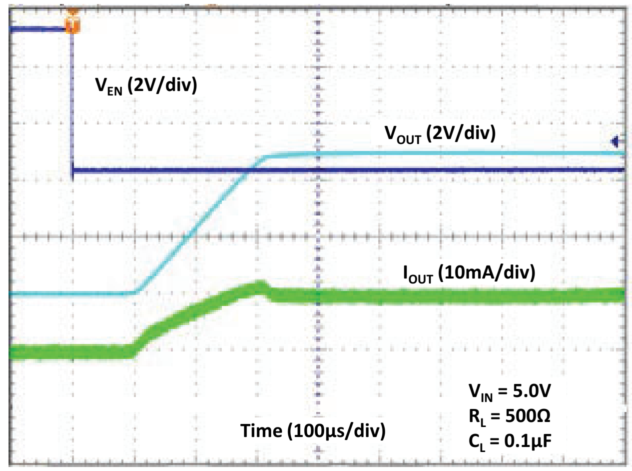


Fig. 25 - Turn-on Time

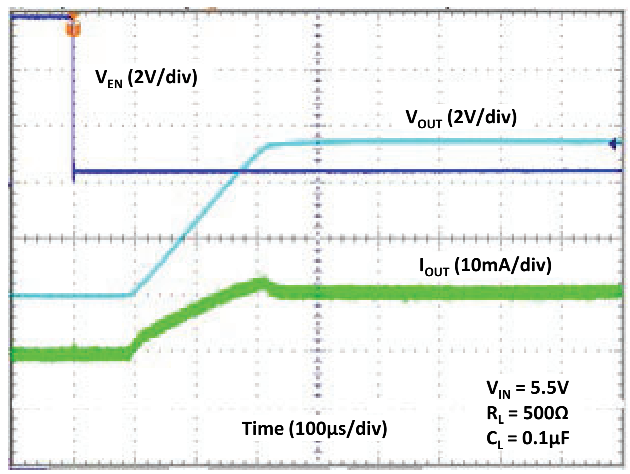


Fig. 26 - Turn-on Time

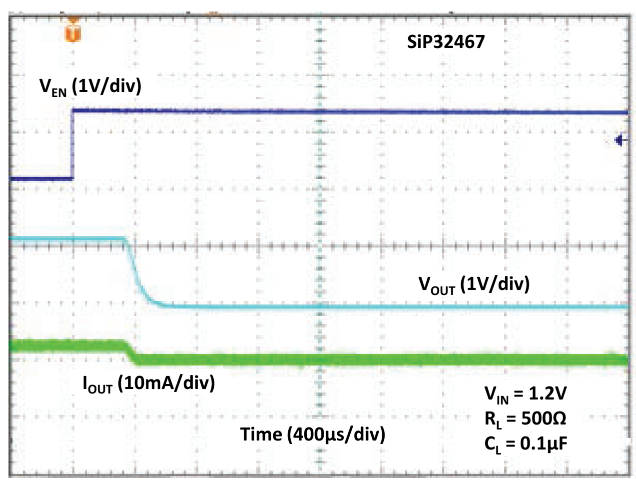


Fig. 27 - Turn-off Time


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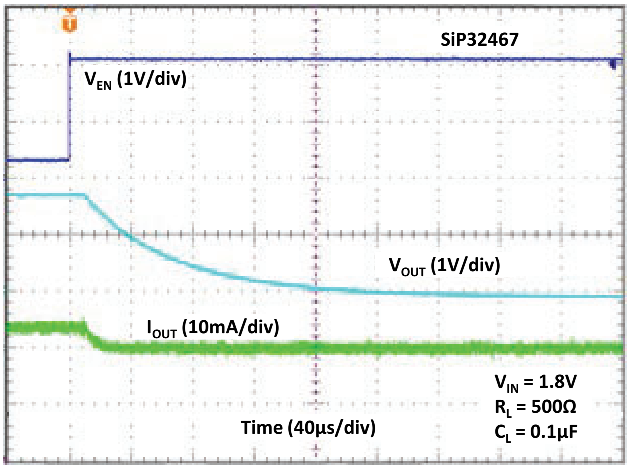


Fig. 28 - Turn-off Time

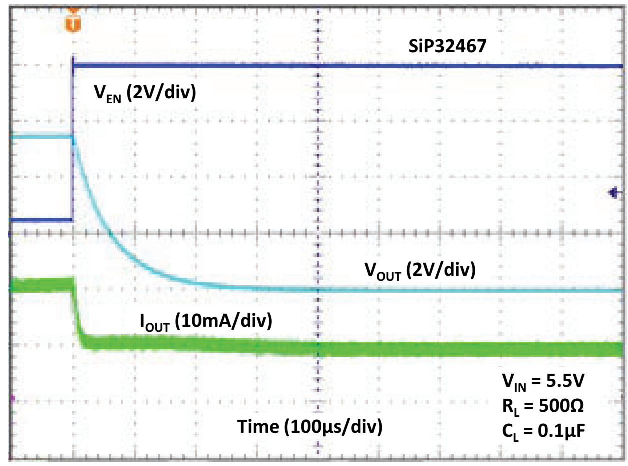


Fig. 31 - Turn-off Time

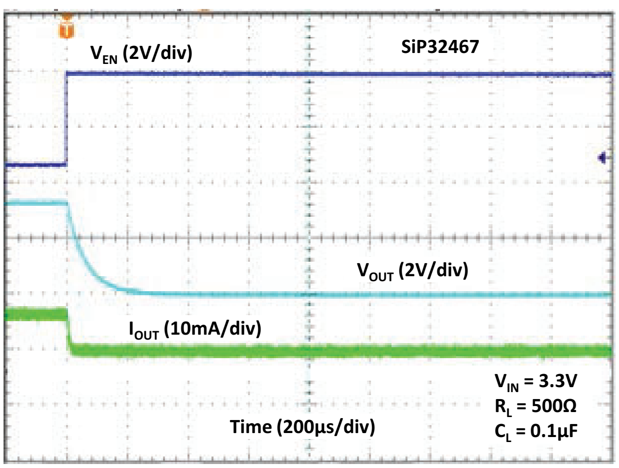


Fig. 29 - Turn-off Time

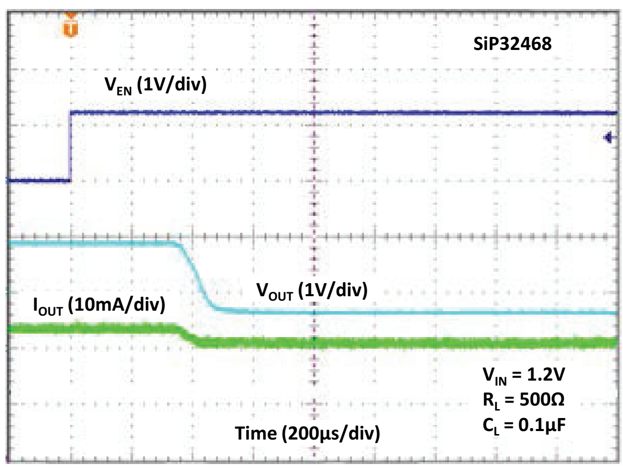


Fig. 32 - Turn-off Time

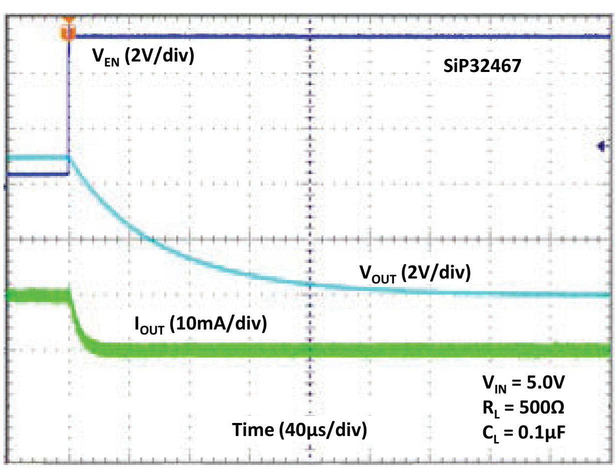


Fig. 30 - Turn-off Time

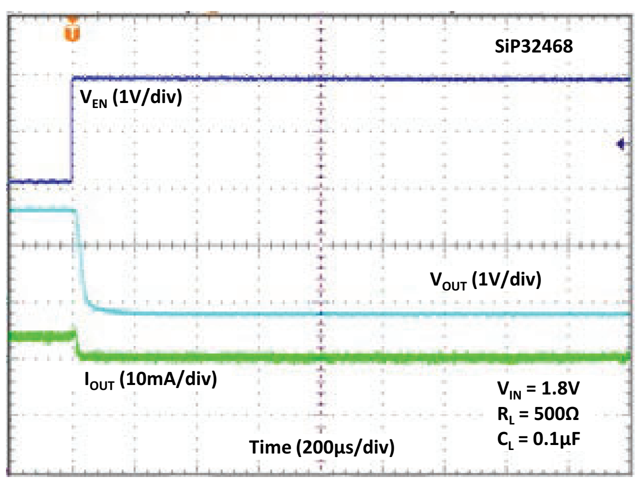


Fig. 33 - Turn-off Time


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**TYPICAL WAVEFORMS**

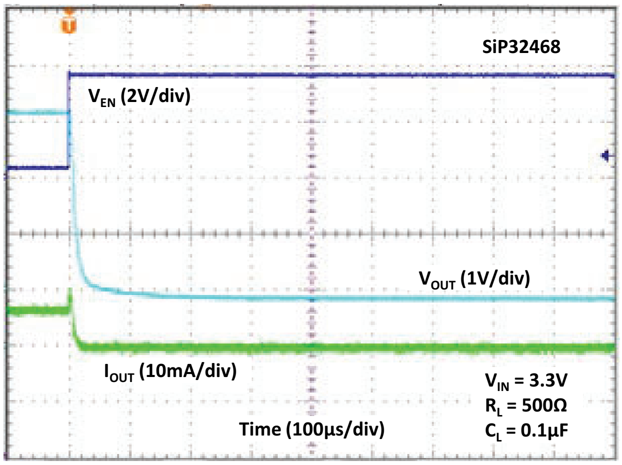


Fig. 34 - Turn-off Time

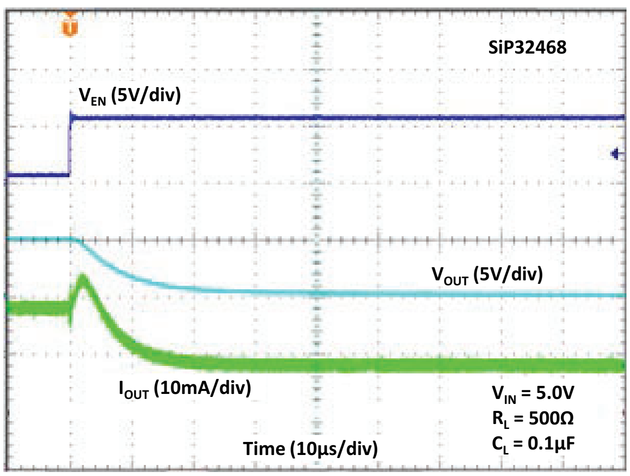


Fig. 35 - Turn-off Time

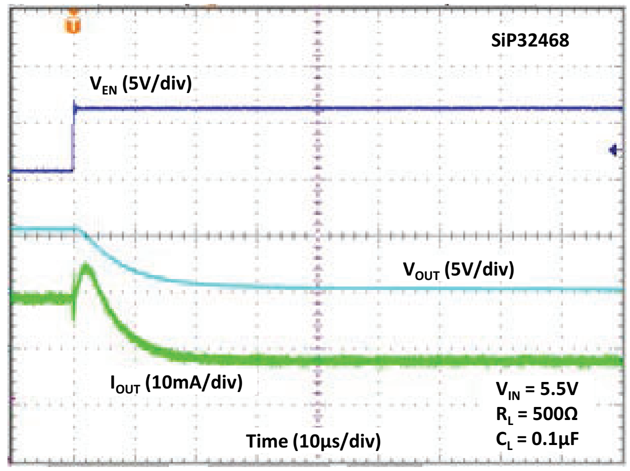


Fig. 36 - Turn-off Time


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## DETAILED DESCRIPTION

SiP32467 and SiP32468 are high side, slew rate controlled, load switches. They incorporate a negative charge pump at the gate to keep the gate to source voltage high when turned on. This keeps the on resistance low at lower input voltages. SiP32467 and SiP32468 are designed with slow slew rate to minimize the inrush current during turn on. These devices have a reverse blocking circuit, when disabled, to prevent the current from going back to the input when the output voltage is higher than the input voltage. The SiP32467 can be used as a bi-directional switch and can be turned ON and OFF when power is at either IN or OUT. The SiP32468 has an output pull down resistor to discharge the output capacitance when the device is off.

## APPLICATION INFORMATION

### Input Capacitor

While a bypass capacitor on the input is not required, a 4.7 μF or larger capacitor for $C_{IN}$ is recommended in almost all applications. The bypass capacitor should be placed as physically close as possible to the input pin to be effective in minimizing transients on the input. Ceramic capacitors are recommended over tantalum because of their ability to withstand input current surges from low impedance sources such as batteries in portable devices.

### Output Capacitor

A 0.1 μF capacitor across $V_{OUT}$ and GND is recommended to insure proper slew operation. There is inrush current through the output MOSFET and the magnitude of the inrush current depends on the output capacitor, the bigger the $C_{OUT}$ the higher the inrush current. There are no ESR or capacitor type requirement.

### Enable

The EN pin is compatible with CMOS logic voltage levels. It requires at least 1 V or above to fully shut down the device and 0.4 V or below to fully turn on the device. There is a 2.6 MΩ resistor connected between EN pin and IN pin.

### Protection Against Reverse Voltage Condition

This device contains a reverse blocking circuit. When disabled ($V_{EN}$ greater than 1 V) this circuit keeps the output current from flowing back to the input when the output voltage is higher than the input voltage.

### Thermal Considerations

Due to physical limitations of the layout and assembly of the device the maximum switch current is 1.2 A as stated in the Absolute Maximum Ratings table. However, another limiting characteristic for the safe operating load current is the thermal power dissipation of the package.

The maximum power dissipation in any application is dependant on the maximum junction temperature, $T_{J(max.)}$ = 125 °C, the junction-to-ambient thermal resistance, $\theta_{J-A}$ = 205 °C/W, and the ambient temperature, $T_A$, which may be expressed as:

$$P\,(max.) = \frac{T_J\,(max.) - T_A}{\theta_{J-A}} = \frac{125 - T_A}{205}$$

It then follows that, assuming an ambient temperature of 70 °C, the maximum power dissipation will be limited to about 268 mW.

So long as the load current is below the 1.2 A limit, the maximum continuous switch current becomes a function two things: the package power dissipation and the $R_{DS(ON)}$ at the ambient temperature.

As an example let us calculate the worst case maximum load current at $T_A$ = 70 °C. The worst case $R_{DS(ON)}$ at 25 °C is 120 mΩ at $V_{IN}$ = 1.5 V. The $R_{DS(ON)}$ at 70 °C can be extrapolated from this data using the following formula:

$R_{DS(ON)}$ (at 70 °C) = $R_{DS(ON)}$ (at 25 °C) x (1 + $T_C$ x ΔT)

Where $T_C$ is 2800 ppm/°C. Continuing with the calculation we have

$R_{DS(ON)}$ (at 70 °C) = 120 mΩ x (1 + 0.0028 x (70 °C - 25 °C)) = 135 mΩ

The maximum current limit is then determined by

$$I_{LOAD}\,(max.) < \sqrt{\frac{P\,(max.)}{R_{DS(ON)}}}$$

which in this case is 1.99 A. Under the stated input voltage condition, if the 1.99 A current limit is exceeded the internal die temperature will rise and eventually, possibly damage the device.

To avoid possible permanent damage to the device and keep a reasonable design margin, it is recommended to operate the device maximum up to 1.2 A only as listed in the Absolute Maximum Ratings table.

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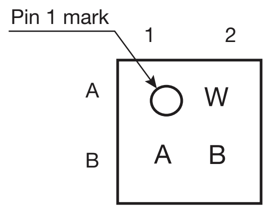
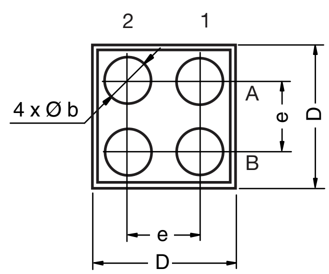
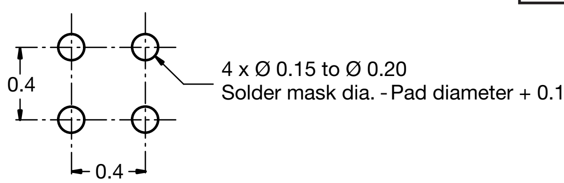
# WCSP4: 4 Bumps

(2 x 2, 0.4 mm pitch, 208 µm bump height, 0.8 mm x 0.8 mm die size)

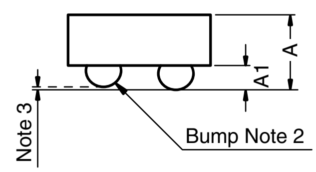
Mark on backside of die




Recommended Land Pattern
All dimensions in millimeters




DWG-No: 6004

**Notes**

(1) Laser mark on the backside surface of die
(2) Bumps are SAC396
(3) 0.05 max. coplanarity

| DIM. | MILLIMETERS [a] | | | INCHES | | |
|---|---|---|---|---|---|---|
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| A | 0.515 | 0.530 | 0.545 | 0.0202 | 0.0208 | 0.0214 |
| A1 | | 0.208 | | | 0.0081 | |
| b | 0.250 | 0.260 | 0.270 | 0.0098 | 0.0102 | 0.0106 |
| e | | 0.400 | | | 0.0157 | |
| D | 0.720 | 0.760 | 0.800 | 0.0182 | 0.0193 | 0.0203 |

**Note**

a. Use millimeters as the primary measurement.



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OCEAN CHIPS
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Поставка электронных компонентов

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- Поставка электронных компонентов под контролем ВП;
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