# WS4665

**6A, 14mΩ Load Switch with Quick Output Discharge and Adjustable Rise Time**

**http//:www.ovt.com**

## DESCRIPTION

The WS4665 is a single channel load switch that provides configurable rise time to minimize inrush current. The device contains an N-channel MOSFET that can operate over an input voltage range of 0.8V to 5.5V and can support a maximum continuous current of 6A. The switch is controlled by an on/off input (ON), which is capable of interfacing directly with low-voltage control signals. In the WS4665, a 230 Ω on-chip load resistor is added for quick output discharge when switch is turned off.

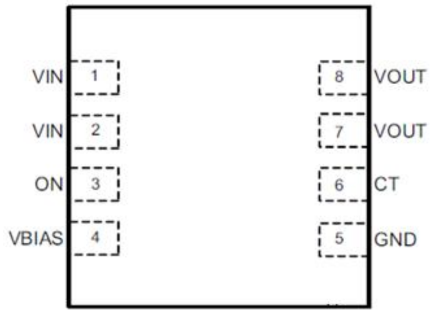
The WS4665 is available in a small, space-saving 2.00mm x 2.00mm 8-pin DFN package. Standard Products are Pb-free and halogen-free.

## FEATURES

- Integrated Single Channel Load Switch
- Input Voltage Range: 0.8V to 5.5V
- Ultra-Low On Resistance （$R_{ON}$）
  - $R_{ON}$ = 14mΩ at VIN = 5V (VBIAS = 5V)
- 6-A Maximum Continuous Switch Current
- Low Control Input Threshold Enables Use of 1.2-V, 1.8-V, 2.5-V and 3.3-V Logic
- Configurable Rise Time
- Quick Output Discharge (QOD)
- DFN8 2x2 8L Package
- ESD Performance Tested per JESD 22
  - 2000V HBM and 1000V CDM

## APPLICATIONS

- Ultrabook TM
- Notebooks/Netbooks
- Tablet PC
- Consumer Electronics
- Set-top Boxes/Residential Gateways
- Telecom Systems




**Pin configuration (Top view)**


DFN2x2-8L

**4665** = **Device code**
**DA** = **Package code**
**Y** = **Year code**
**W** = **Week code**

**Marking**

## Order information

| Device | Package | Shipping |
|---|---|---|
| WS4665D-8/TR | DFN2x2-8L | 3000/Reel&Tape |

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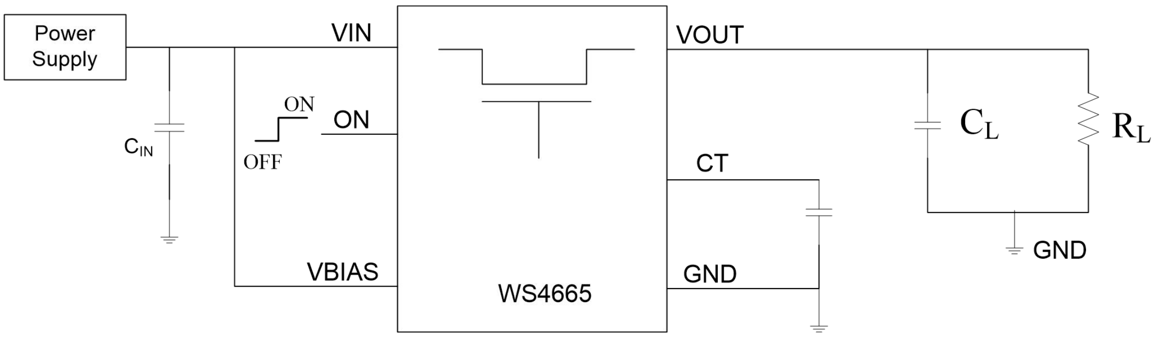
## TYPICAL APPLICATION

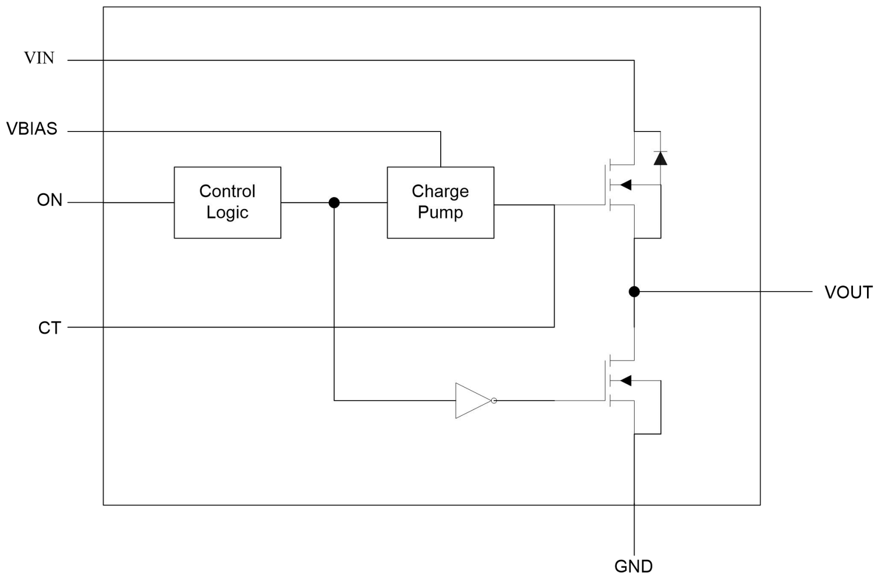



Typical Application

## PIN DESCRIPTION

| PIN No. | PIN NAME | I/O | DESCRIPTION |
|---|---|---|---|
| 1 | VIN | I | Switch input. Input bypass capacitor recommended for minimizing $V_{IN}$ dip. |
| 2 | VIN | I | Switch input. Input bypass capacitor recommended for minimizing $V_{IN}$ dip. |
| 3 | ON | I | Active high switch control input. Do not leave floating. |
| 4 | VBIAS | I | Bias voltage. Power supply to the device. Recommended voltage range for this pin is 2.5V to 5.5V. |
| 5 | GND | - | Device ground. |
| 6 | CT | O | Switch slew rate control. Can be left floating. |
| 7 | VOUT | O | Switch output. |
| 8 | VOUT | O | Switch output. |

## BLOCK DIAGRAM



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## ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | | Value | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Input voltage range | | -0.3 to 6 | V |
| $V_{OUT}$ | Output voltage range | | -0.3 to 6 | V |
| $V_{BIAS}$ | Bias voltage range | | -0.3 to 6 | V |
| $V_{ON}$ | Input voltage range | | -0.3 to 6 | V |
| $I_{MAX}$ | Maximum continuous switch current | | 6 | A |
| $I_{PLS}$ | Maximum pulsed switch current, pulse < 300uS, 2% duty cycle | | 8 | A |
| $T_A$ | Operating free-air temperature range (Note1) | | -40 to 85 | °C |
| $T_J$ | Maximum junction temperature | | 150 | °C |
| $T_{STG}$ | Storage temperature range | | -60 to 150 | °C |
| $T_{LEAD}$ | Maximum lead temperature (10-s soldering time) | | 300 | °C |
| ESD | Electrostatic discharge protection | Human-Body Model (HBM) | 2000 | V |
| | | Charged-Device Model (CDM) | 1000 | |

These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

**Note 1:** In applications where high power dissipation and/or poor package thermal resistance is present, the maximum ambient temperature may have to be de-rated. Maximum ambient temperature （$T_{A(max)}$） is dependent on the maximum operating junction temperature [TJ(max)], the maximum power dissipation of the device in the application [PD(max)], and the junction-to-ambient thermal resistance of the part/package in the application($q_{JA}$), as given by the following equation: $T_A(\max) = T_J(\max) - (q_{JA} \times P_D(\max))$

## THERMAL INFORMATION

| Thermal Metric | | WS4665 DFN2*2-8L(FC) | Units |
|---|---|---|---|
| $q_{JA}$ | Junction-to-ambient thermal resistance | 62 | °C/W |

## RECOMMENDED OPERATING CONDITIONS

| Symbol | Parameter | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| VIN | Input voltage range | | 0.8 | VBIAS | V |
| VBIAS | Bias voltage range | | 2.5 | 5.5 | V |
| VON | ON voltage range | | 0 | 5.5 | V |
| VOUT | Output voltage range | | | VIN | V |
| VIH | High-level input voltage, ON | VBIAS=2.5V to 5.5V | 1.2 | 5.5 | V |
| VIL | Low-level input voltage, ON | VBIAS=2.5V to 5.5V | 0 | 0.4 | V |
| CIN | Input capacitor | | 1 | | μF |



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## ELECTRICAL CHARACTERISTICS

Unless otherwise noted, the specification in the following table applies over the operating ambient temperature -40°C ≤ $T_A$ ≤ 85°C and $V_{BIAS}$=**5.0V**. Typical values are for $T_A$=25°C.

| Parameter | Test Conditions | | $T_A$ | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Power Supplies and Currents** | | | | | | | |
| $I_{IN(VBIAS-ON)}$ $V_{BIAS}$ quiescent current | $I_{OUT}$ = 0mA, $V_{IN}$ = $V_{ON}$ = 5.0V | | Full | | 66 | 75 | μA |
| $I_{IN(VBIAS-OFF)}$ $V_{BIAS}$ shutdown current | $V_{ON}$ = GND, $V_{OUT}$ = 0V | | Full | | | 0.01 | μA |
| $I_{IN(VIN-OFF)}$ $V_{IN}$ off-state supply current | $V_{ON}$ = GND, $V_{OUT}$ = 0V | VIN = 5.0V | Full | | 0.002 | 0.7 | μA |
| | | VIN = 3.3V | | | 0.001 | 0.5 | |
| | | VIN = 1.8V | | | 0 | 0.4 | |
| | | VIN = 0.8V | | | 0 | 0.3 | |
| $I_{ON}$ ON pin input leakage current | $V_{ON}$ = 5.5V | | Full | | | 0.01 | μA |
| **Resistance Characteristics** | | | | | | | |
| $R_{ON}$ ON-state resistance | $I_{OUT}$ = -200mA, $V_{BIAS}$ = 5.0V | $V_{IN}$ = 5.0V | 25°C | | 14.2 | | mΩ |
| | | | Full | | | 22 | |
| | | $V_{IN}$ = 3.3V | 25°C | | 14.2 | | mΩ |
| | | | Full | | | 21.5 | |
| | | $V_{IN}$ = 1.8V | 25°C | | 14.2 | | mΩ |
| | | | Full | | | 21.5 | |
| | | $V_{IN}$ = 1.5V | 25°C | | 14.2 | | mΩ |
| | | | Full | | | 21 | |
| | | $V_{IN}$ = 1.2V | 25°C | | 14.2 | | mΩ |
| | | | Full | | | 21 | |
| | | $V_{IN}$ = 0.8V | 25°C | | 14.2 | | mΩ |
| | | | Full | | | 21 | |
| $R_{PD}$ Output pull-down resistance | $V_{IN}$ = 5.0V, $V_{ON}$ = 0V, $I_{OUT}$ = 15mA | | Full | | 230 | 250 | Ω |



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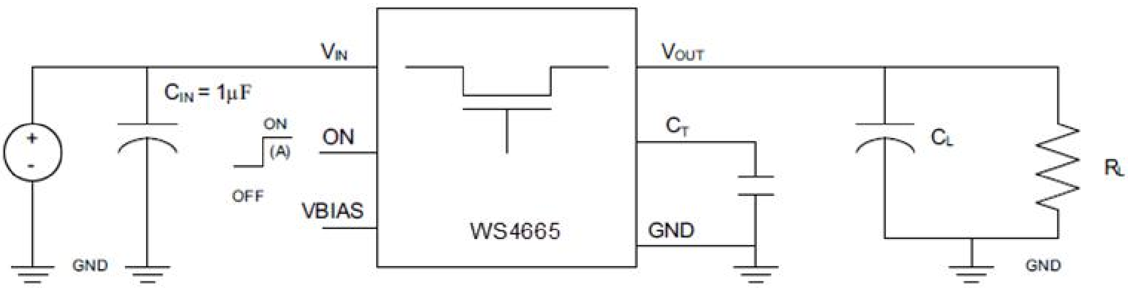
## ELECTRICAL CHARACTERISTICS (Continuous)

Unless otherwise noted, the specification in the following table applies over the operating ambient temperature -40°C ≤ $T_A$ ≤ 85°C and $V_{BIAS}$=**2.5V**. Typical values are for $T_A$=25°C.

| Parameter | Test Conditions | | $T_A$ | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Power Supplies and Currents** | | | | | | | |
| $I_{IN(VBIAS-ON)}$ $V_{BIAS}$ quiescent current | $I_{OUT}$ = 0mA, $V_{IN}$ = $V_{ON}$ = 2.5V | | Full | | 35 | 45 | µA |
| $I_{IN(VBIAS-OFF)}$ $V_{BIAS}$ shutdown current | $V_{ON}$ = GND, $V_{OUT}$ = 0V | | Full | | | 0.01 | µA |
| $I_{IN(VIN-OFF)}$ $V_{IN}$ off-state supply current | $V_{ON}$ = GND, $V_{OUT}$ = 0V | VIN = 2.5V | Full | | 0.001 | 0.5 | µA |
| | | VIN = 1.8V | | | 0.001 | 0.47 | |
| | | VIN = 1.2V | | | 0 | 0.41 | |
| | | VIN = 0.8V | | | 0 | 0.4 | |
| $I_{ON}$ ON pin input leakage current | $V_{ON}$ = 5.5V | | Full | | | 0.01 | µA |
| **Resistance Characteristics** | | | | | | | |
| $R_{ON}$ ON-state resistance | $I_{OUT}$ = -200mA, $V_{BIAS}$ = 2.5V | $V_{IN}$ = 2.5V | 25°C | | 16 | | mΩ |
| | | | Full | | | 22 | |
| | | $V_{IN}$ = 1.8V | 25°C | | 15.7 | | mΩ |
| | | | Full | | | 21.7 | |
| | | $V_{IN}$ = 1.5V | 25°C | | 15.6 | | mΩ |
| | | | Full | | | 21.5 | |
| | | $V_{IN}$ = 1.2V | 25°C | | 15.6 | | mΩ |
| | | | Full | | | 21.4 | |
| | | $V_{IN}$ = 0.8V | 25°C | | 15.5 | | mΩ |
| | | | Full | | | 21.3 | |
| $R_{PD}$ Output pull-down resistance | $V_{IN}$ = 2.5V, $V_{ON}$ = 0V, $I_{OUT}$ = 1mA | | Full | | 255 | 270 | Ω |

## SWITCHING CHARACTERISTICS MEASUREMENT INFORMATION




**TEST CIRCUIT**



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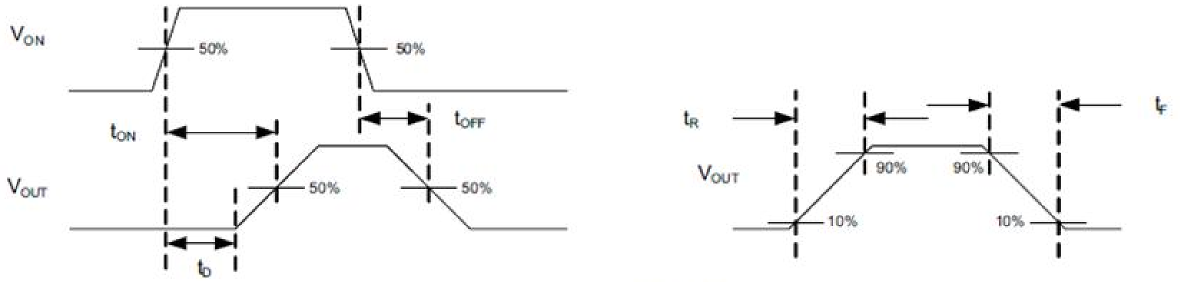


$t_{ON}/t_{OFF}$ WAVEFORMS

## SWITCHING CHARACTERISTICS

| PARAMETER | | TEST CONDITION | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| **$V_{IN}$ = $V_{ON}$ = $V_{BIAS}$ = 5V, $T_A$ = 25 °C (unless otherwise noted)** | | | | | | |
| $t_{ON}$ | Turn-on time | RL = 10Ω, CL = 0.1uF, CT = 1000pF | | 1380 | | μs |
| $t_{OFF}$ | Turn-off time | | | 15 | | |
| $t_R$ | $V_{OUT}$ rise time | | | 2236 | | |
| $t_F$ | $V_{OUT}$ fall time | | | 5 | | |
| $t_D$ | ON delay time | | | 322 | | |
| **$V_{IN}$ = 0.8V, $V_{ON}$ = $V_{BIAS}$ = 5V, $T_A$ = 25 °C (unless otherwise noted)** | | | | | | |
| $t_{ON}$ | Turn-on time | RL = 10Ω, CL = 0.1uF, CT = 1000pF | | 550 | | μs |
| $t_{OFF}$ | Turn-off time | | | 76 | | |
| $t_R$ | $V_{OUT}$ rise time | | | 290 | | |
| $t_F$ | $V_{OUT}$ fall time | | | 6 | | |
| $t_D$ | ON delay time | | | 363 | | |
| **$V_{IN}$ = 2.5V, $V_{ON}$ = 5V, $V_{BIAS}$ = 2.5V, $T_A$ = 25 °C (unless otherwise noted)** | | | | | | |
| $t_{ON}$ | Turn-on time | RL = 10Ω, CL = 0.1uF, CT = 1000pF | | 2226 | | μs |
| $t_{OFF}$ | Turn-off time | | | 22 | | |
| $t_R$ | $V_{OUT}$ rise time | | | 2544 | | |
| $t_F$ | $V_{OUT}$ fall time | | | 4.9 | | |
| $t_D$ | ON delay time | | | 720 | | |
| **$V_{IN}$ = 0.8V, $V_{ON}$ = 5V, $V_{BIAS}$ = 2.5V, $T_A$ = 25 °C (unless otherwise noted)** | | | | | | |
| $t_{ON}$ | Turn-on time | RL = 10Ω, CL = 0.1uF, CT = 1000pF | | 1200 | | μs |
| $t_{OFF}$ | Turn-off time | | | 72 | | |
| $t_R$ | $V_{OUT}$ rise time | | | 856 | | |
| $t_F$ | $V_{OUT}$ fall time | | | 6.1 | | |
| $t_D$ | ON delay time | | | 736 | | |



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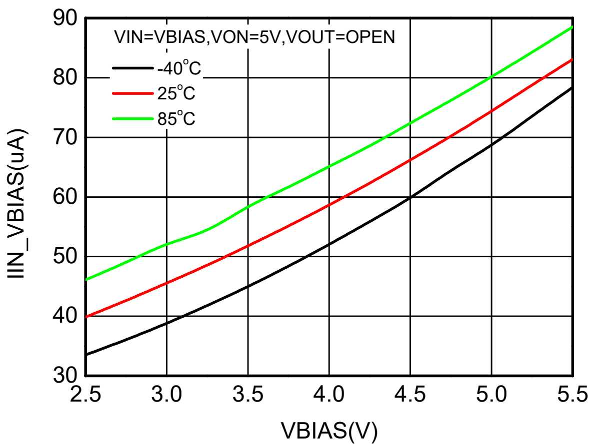
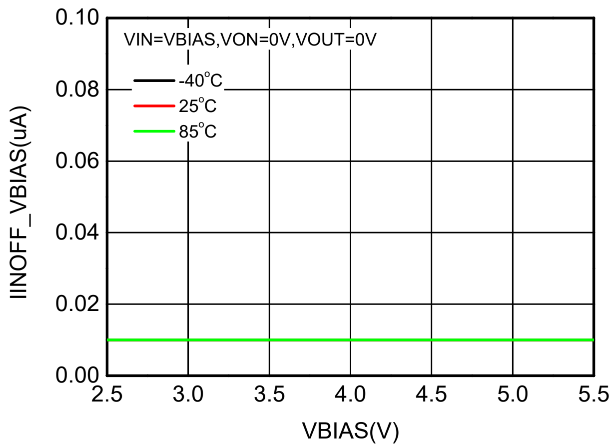
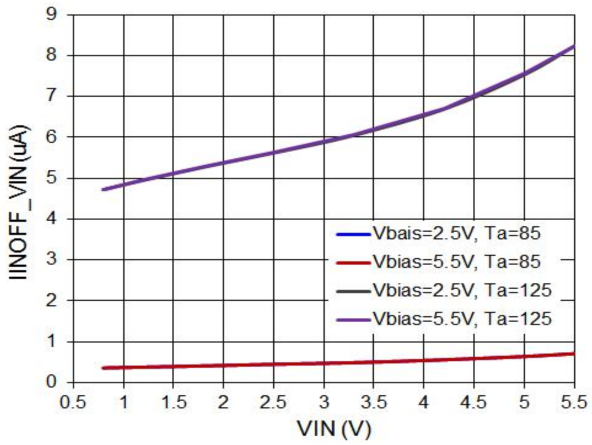
## TYPICAL CHARACTERISTICS (Ta=25°C, unless otherwise noted)



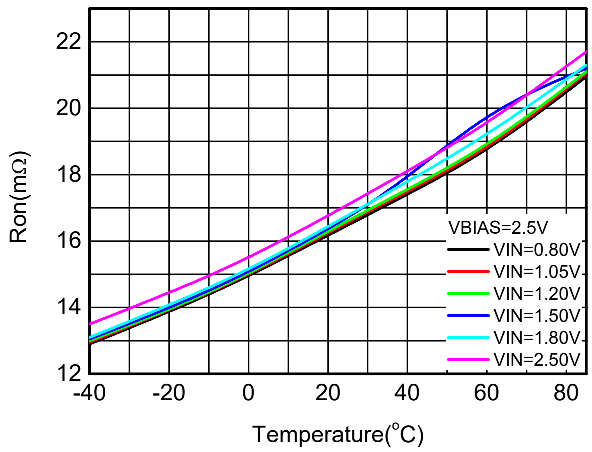

**Quiescent Current vs. $V_{BIAS}$**



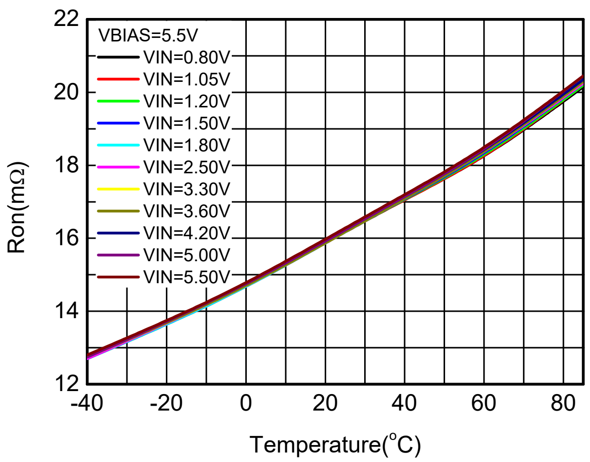

**Shutdown Current vs. $V_{BIAS}$**



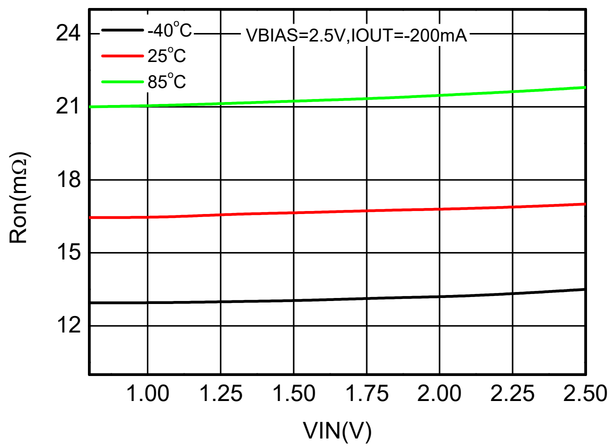

**OFF-State $V_{IN}$ Current vs. $V_{IN}$**




**$R_{ON}$ vs. TEMPERATURE ($V_{BIAS}$ = 2.5V)**




**$R_{ON}$ vs. TEMPERATURE ($V_{BIAS}$ = 5.5V)**




**$R_{ON}$ vs. TEMPERATURE ($V_{BIAS}$ = 5.5V)**



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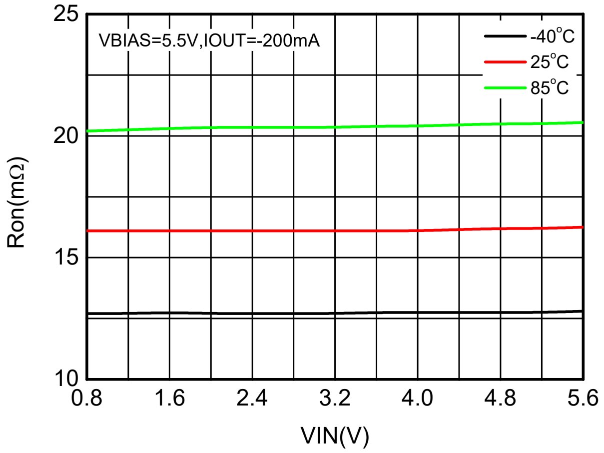
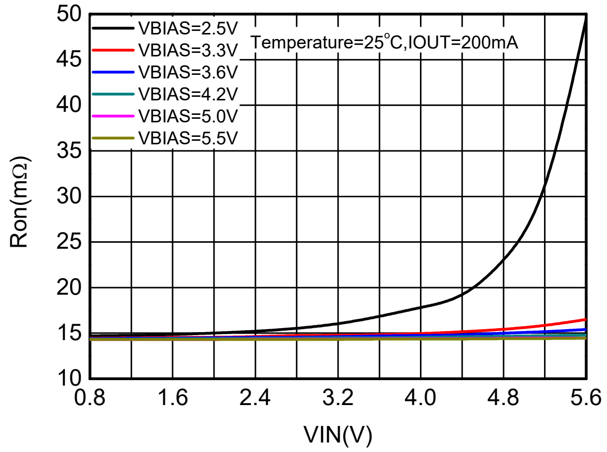
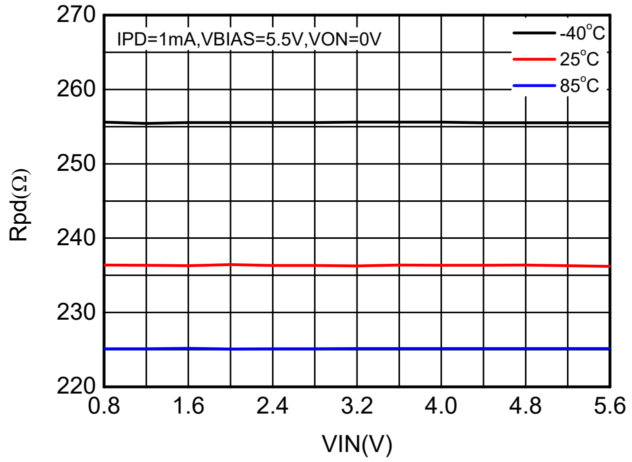


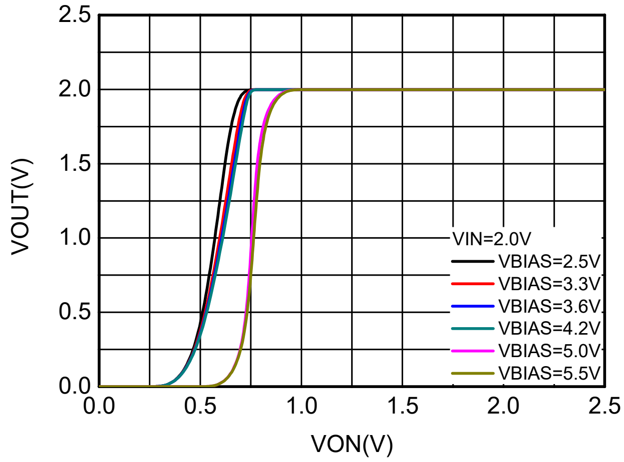

**RON vs. VIN (VBIAS = 5.5V)**



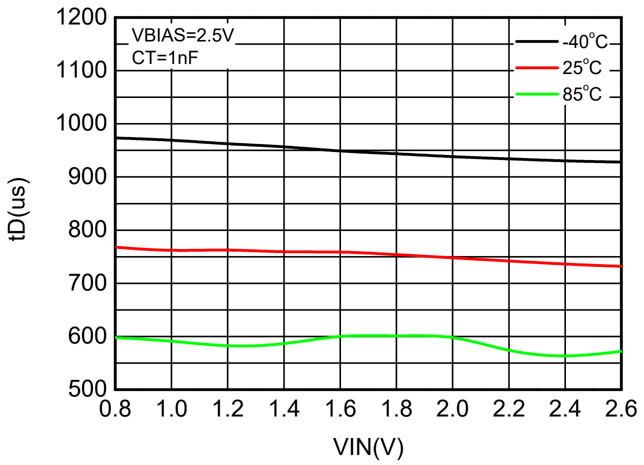

**RON vs. VIN (TA= 25℃)**



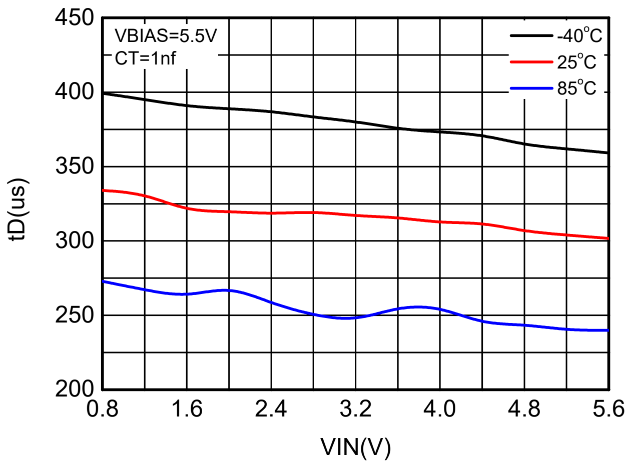

**RPD vs. VIN (VBIAS = 5.5V)**




**VOUT vs. VON (TA= 25℃)**




**tD vs. VIN (VBIAS = 2.5V, CT=1nF)**




**tD vs. VIN (VBIAS = 5.5V, CT=1nF)**



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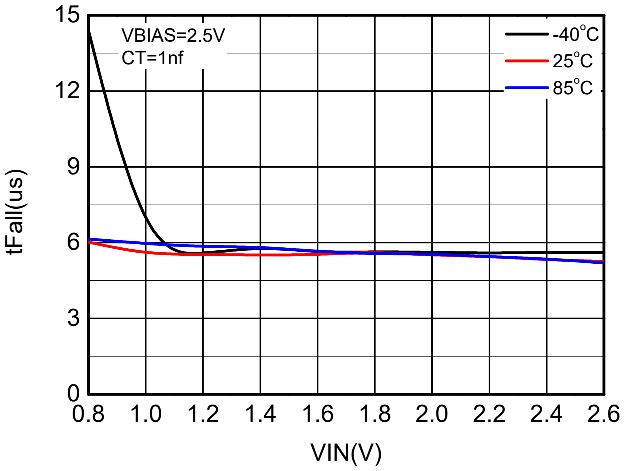
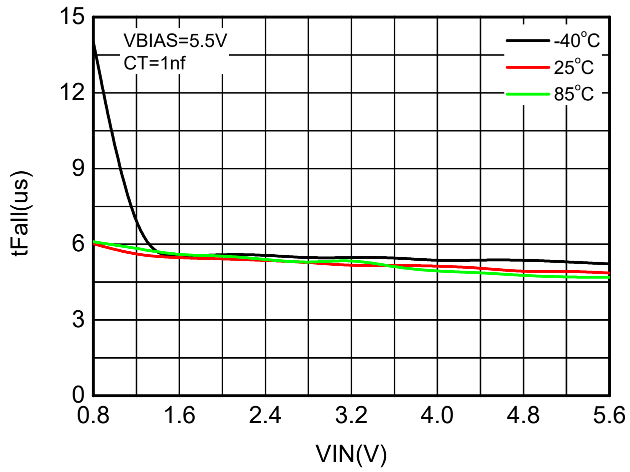
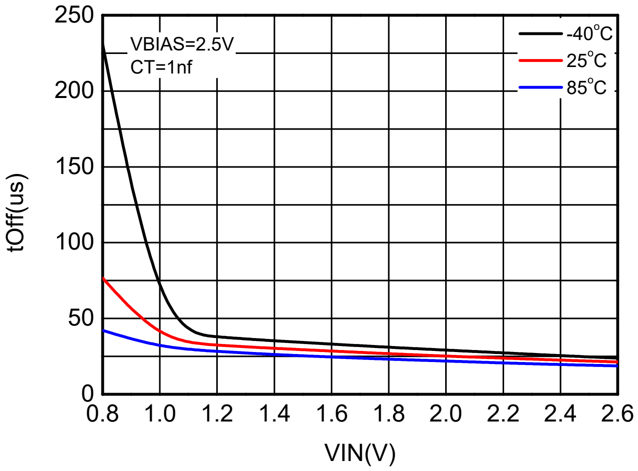


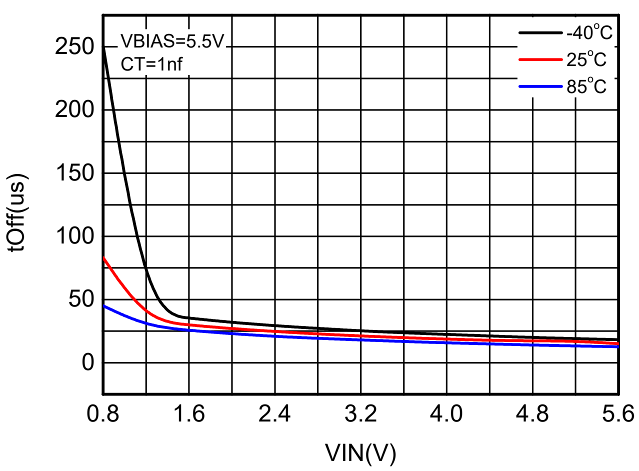

$t_F$ vs. $V_{IN}$ ($V_{BIAS}$ = 2.5V, CT=1nF)



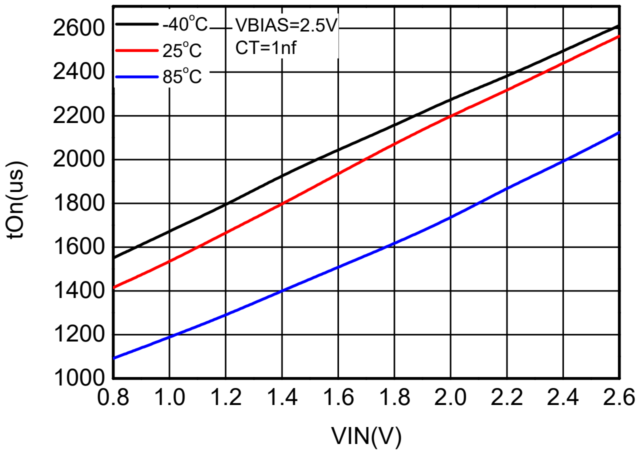

$t_F$ vs. $V_{IN}$ ($V_{BIAS}$ = 5.5V, CT=1nF)



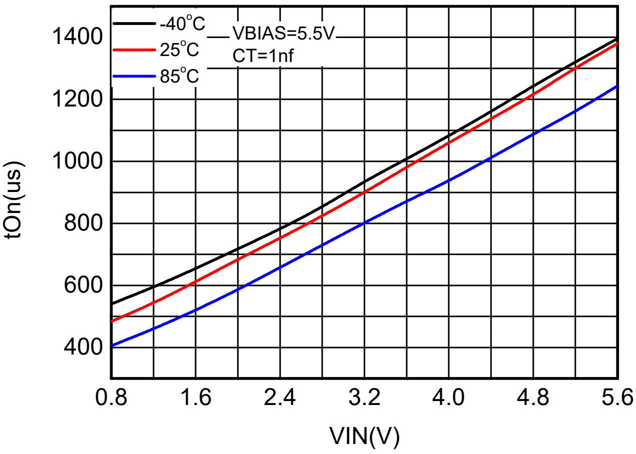

$t_{OFF}$ vs. $V_{IN}$ ($V_{BIAS}$ = 2.5V, CT=1nF)




$t_{OFF}$ vs. $V_{IN}$ ($V_{BIAS}$ = 5.5V, CT=1nF)




$t_{ON}$ vs. $V_{IN}$ ($V_{BIAS}$ = 2.5V, CT=1nF)




$t_{ON}$ vs. $V_{IN}$ ($V_{BIAS}$ = 5.5V, CT=1nF)



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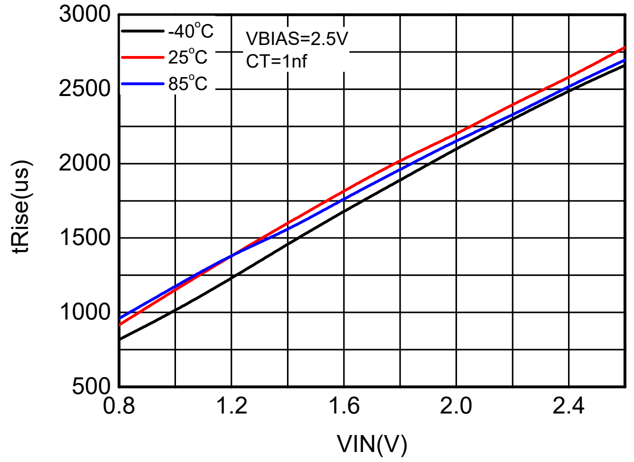
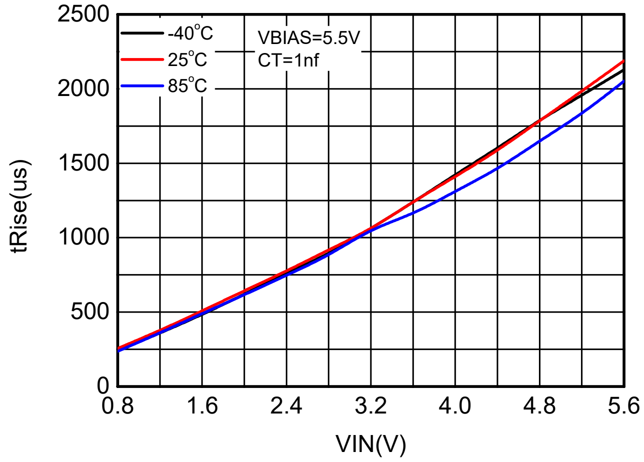
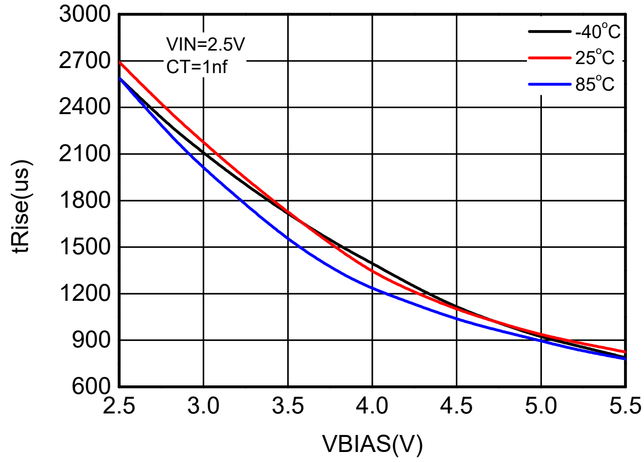



**$t_R$ vs. $V_{IN}$ ($V_{BIAS}$ = 2.5V, CT=1nF)**




**$t_R$ vs. $V_{IN}$ ($V_{BIAS}$ = 5.5V, CT=1nF)**




**$t_R$ vs. $V_{BIAS}$ ($V_{IN}$ = 2.5V, CT=1nF)**



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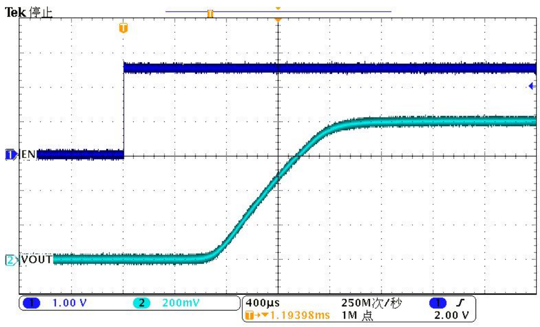
## TYPICAL AC SCOPE CAPTURES （at TA=25℃， CT=1nF（CH1=ON， CH2=VOUT）

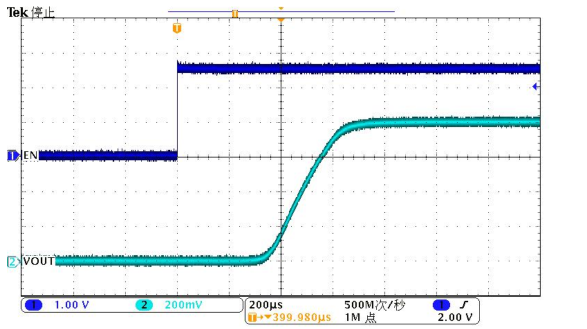
TURN-ON RESPONSE TIME

($V_{IN}$=0.8V,$V_{BIAS}$=2.5V,$C_{IN}$=1uF,$C_L$=0.1uF,$R_L$=10Ω)



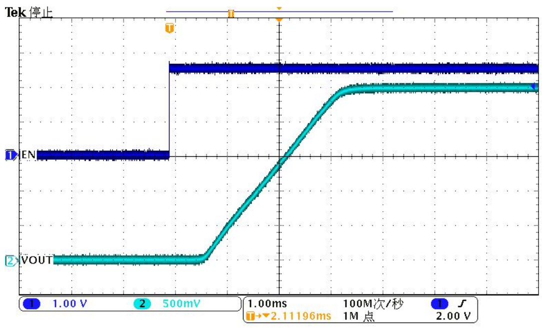

TURN-ON RESPONSE TIME

($V_{IN}$=0.8V,$V_{BIAS}$=5.0V,$C_{IN}$=1uF,$C_L$=0.1uF,$R_L$=10Ω)



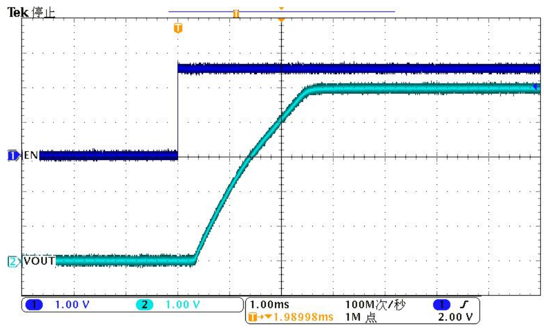

TURN-ON RESPONSE TIME

($V_{IN}$=2.5,$V_{BIAS}$=2.5V,$C_{IN}$=1uF,$C_L$=0.1uF,$R_L$=10Ω)



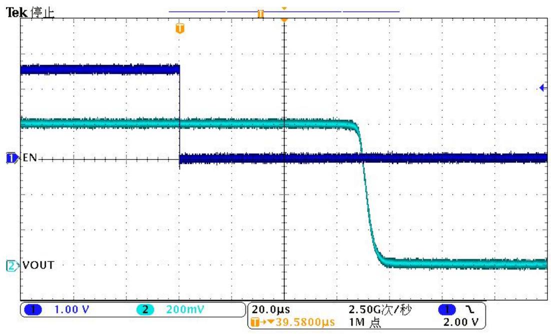

TURN-ON RESPONSE TIME

($V_{IN}$=5.0V,$V_{BIAS}$=5.0V,$C_{IN}$=1uF,$C_L$=0.1uF,$R_L$=10Ω)



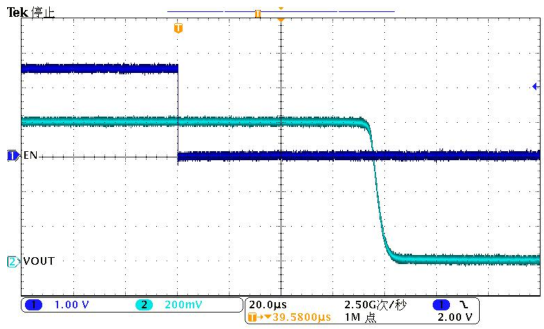

TURN-OFF RESPONSE TIME

($V_{IN}$=0.8V,$V_{BIAS}$=2.5V,$C_{IN}$=1uF,$C_L$=0.1uF,$R_L$=10Ω)



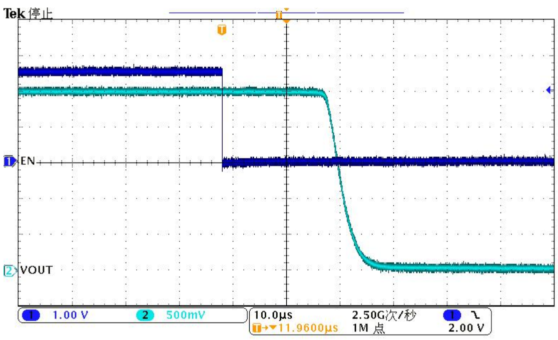

TURN-OFF RESPONSE TIME

($V_{IN}$=0.8V,$V_{BIAS}$=5.0V,$C_{IN}$=1uF,$C_L$=0.1uF,$R_L$=10Ω)



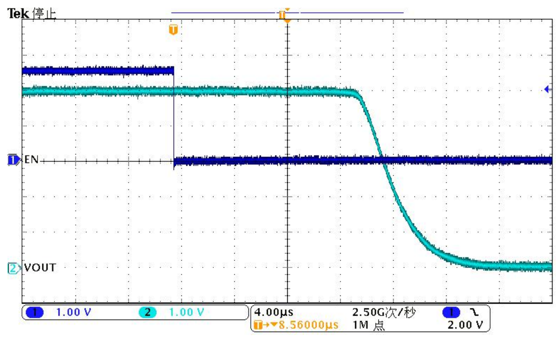

TURN-OFF RESPONSE TIME

($V_{IN}$=0.8V,$V_{BIAS}$=2.5V,$C_{IN}$=1uF,$C_L$=0.1uF,$R_L$=10Ω)




TURN-OFF RESPONSE TIME

($V_{IN}$=0.8V,$V_{BIAS}$=5.0V,$C_{IN}$=1uF,$C_L$=0.1uF,$R_L$=10Ω)



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## APPLICATION INFORMATION

### ON/OFF CONTROL

The ON pin controls the state of the switch. Asserting ON high enables the switch. ON is active high and has a low threshold, making it capable of interfacing with low-voltage signals. The ON pin is compatible with standard GPIO logic thresholds. It can be used with any microcontroller with 1.2V or higher GPIO voltage. This pin cannot be left floating and must be driven either high or low for proper functionality.

### INPUT CAPACITOR ( OPTIONAL)

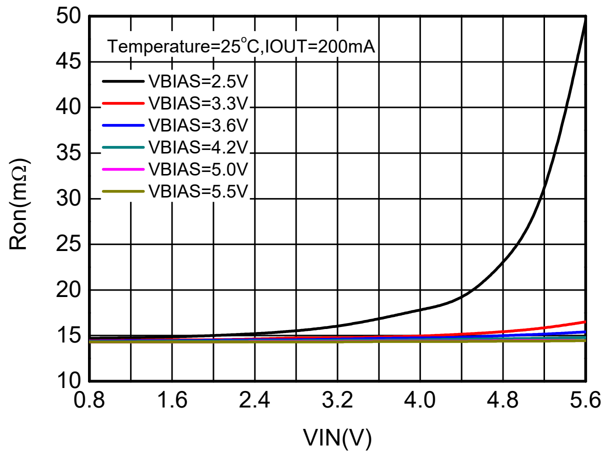
To limit the voltage drop on the input supply caused by transient inrush currents when the switch turns on into a discharged load capacitor or short-circuit, a capacitor needs to be placed between VIN and GND. A 1-uF ceramic capacitor, $C_{IN}$, placed close to the pins, is usually sufficient. Higher values of $C_{IN}$ can be used to further reduce the voltage drop during high current applications. When switching heavy loads, it is recommended to have an input capacitor about 10 times higher than the output capacitor to avoid excessive voltage drop.

### OUTPUT CAPACITOR (OPTIONAL)

Due to the integrated body diode in the NMOS switch, a $C_{IN}$ greater than $C_L$ is highly recommended. A $C_L$ greater than $C_{IN}$ can cause $V_{OUT}$ to exceed $V_{IN}$ when the system supply is removed. This could result in current flow through the body diode from VOUT to VIN. A $C_{IN}$ to $C_L$ ratio of 10 to 1 is recommended for minimizing $V_{IN}$ dip caused by inrush currents during startup, however a 10 to 1 ratio for capacitance is not required for proper functionality of the device. A ratio smaller than 10 to 1 (such as 1 to 1 ) could cause slightly more VIN dip upon turn-on due to inrush currents. This can be mitigated by increasing the capacitance on the CT pin for a longer rise time (see ADJUSTABLE RISE TIME section below).

### VIN AND VBIAS VOLTAGE RANGE

For optimal $R_{ON}$ performance, make sure VIN ≤ VBIAS. The device will still be functional if VIN > VBIAS but it will exhibit RON greater than what is listed in the ELECTRICAL CHARACTERISTICS table. See below Figure for an example of a typical device. Notice the increasing $R_{ON}$ as VIN exceeds VBIAS voltage. Be sure to never exceed the maximum voltage rating for VIN and VBIAS.



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**ADJUSTABLE RISE TIME**

A capacitor to GND on the CT pin sets the slew rate. The voltage on the CT pin can be as high as 11V. Therefore, the minimum voltage rating for the CT cap should be 25V for optimal performance.

The table below contains rise time values measured on a typical device. Rise times shown below only valid for the power-up sequence where VIN and VBIAS are already in steady state condition, and the ON pin is asserted high.

| CT(pF) | RISE TIME(us) 10%-90%, CL=0.1uF, CIN=1uF, RL=10Ω, VBIAS=5V TYPICAL VALUES at 25℃ with a 25V X7R 10% CERAMIC CAPACITOR on CT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | VIN=5V | VIN=4.2V | VIN=3.3V | VIN=2.5V | VIN=1.8V | VIN=1.5V | VIN=1.2V | VIN=1.05V | VIN=0.8V |
| 0 | 195 | 170 | 132 | 107 | 85 | 76 | 67 | 62 | 54 |
| 220 | 410 | 340 | 254 | 193 | 145 | 125 | 106 | 97 | 81 |
| 470 | 1250 | 1000 | 728 | 526 | 376 | 314 | 254 | 224 | 178 |
| 1000 | 2220 | 1760 | 1260 | 928 | 656 | 550 | 440 | 396 | 306 |
| 2200 | 5060 | 4100 | 3020 | 2170 | 1550 | 1290 | 1040 | 910 | 684 |
| 4700 | 10320 | 8360 | 6280 | 4660 | 3320 | 2820 | 2280 | 2040 | 1600 |
| 10000 | 20500 | 16440 | 12120 | 8840 | 6280 | 5300 | 4320 | 3860 | 3040 |



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## BOARD LAYOUT AND THERMAL CONSIDERATIONS

For best performance, all traces should be as short as possible. To be most effective, the input and output capacitors should be placed close to the device to minimize the effects that parasitic trace inductances may have on normal operation. Using wide traces for $V_{IN}$, $V_{OUT}$, and GND helps minimize the parasitic effects along with minimizing the case to ambient thermal impedance.

The maximum IC junction temperature should be restricted to 125℃ under normal operating conditions. To calculate the maximum allowable dissipation, $P_{D(max)}$ for a given output current and ambient temperature, use the following equation as a guideline:

$$P_{D(\max)} = \frac{T_{J(\max)} - T_A}{q_{JA}}$$

Where:

$P_{D(max)}$ = maximum allowable power dissipation

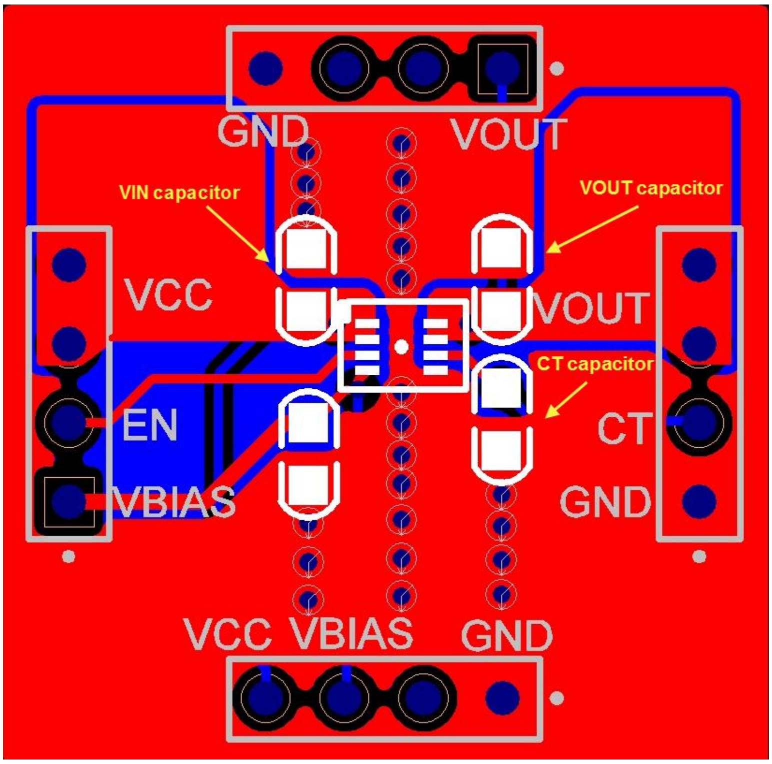
$T_{J(max)}$ = maximum allowable junction temperature (125 ℃ for the WS4665)

$T_A$ = ambient temperature of the device

$q_{JA}$= junction to air thermal impedance. See Thermal Information section. This parameter is highly dependent upon board layout.

**In order to achieve smaller $\theta_{JA}$, the copper area of $V_{IN}$ and $V_{OUT}$ pin on PCB should be as large as possible.**

The figure below shows an example of a layout. Notice that the copper area connected to $V_{IN}$ and $V_{OUT}$ pin is big.



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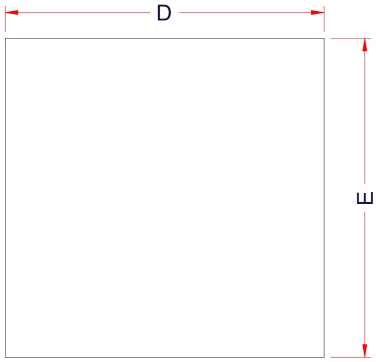
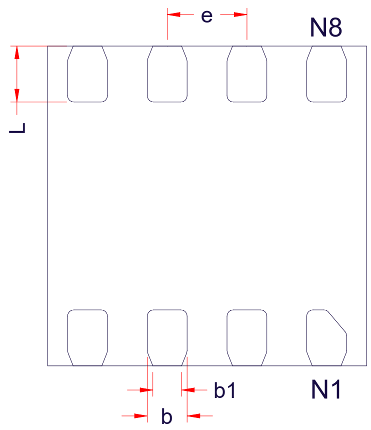
## PACKAGE OUTLINE DIMENSIONS

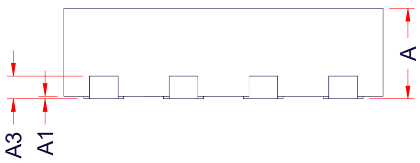
### DFN2x2-8L




TOP VIEW




BOTTOM VIEW




SIDE VIEW

| Symbol | Dimensions in Millimeters | | |
|---|---|---|---|
| | Min. | Typ. | Max. |
| A | 0.50 | - | 0.60 |
| A1 | 0.00 | - | 0.05 |
| A3 | 0.15 Ref. | | |
| D | 1.90 | 2.00 | 2.10 |
| E | 1.90 | 2.00 | 2.10 |
| e | 0.50 Typ. | | |
| b | 0.20 | - | 0.30 |
| b1 | 0.13 | - | 0.23 |
| L | 0.30 | - | 0.40 |



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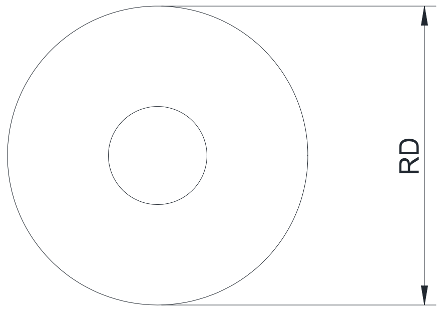
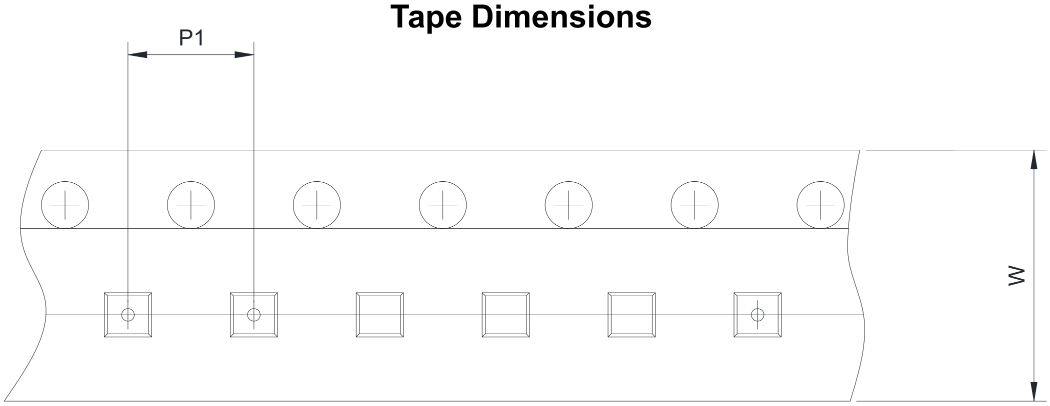
## TAPE AND REEL INFORMATION

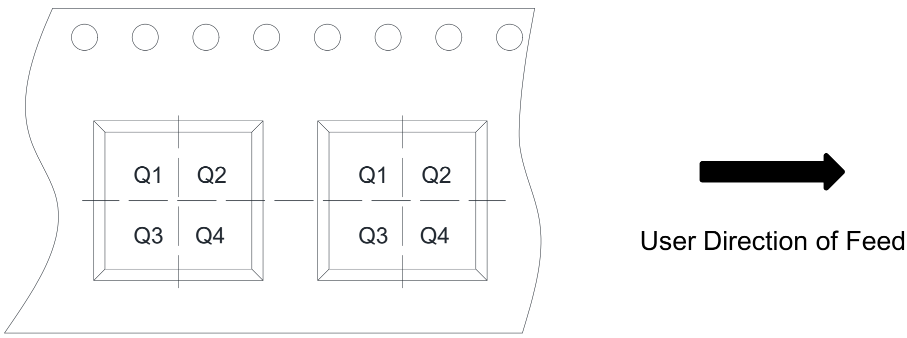
### Reel Dimensions




### Tape Dimensions




### Quadrant Assignments For PIN1 Orientation In Tape




| | | | | | |
|---|---|---|---|---|---|
| RD | Reel Dimension | ☑ 7inch | ☐ 13inch | | |
| W | Overall width of the carrier tape | ☑ 8mm | ☐ 12mm | | |
| P1 | Pitch between successive cavity centers | ☐ 2mm | ☑ 4mm | ☐ 8mm | |
| Pin1 | Pin1 Quadrant | ☑ Q1 | ☐ Q2 | ☐ Q3 | ☐ Q4 |



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