WS4665

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

http//:www.sh-willsemi.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.

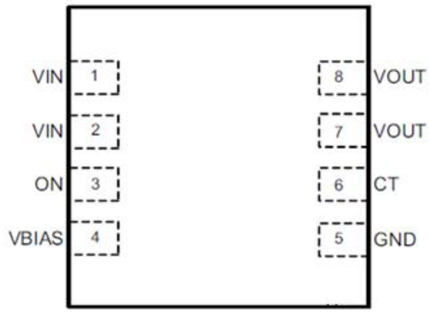
The WS4665 is available in a small, space-saving 2.00mm x 2.00mm 8-pin DFN package. Standard Products are Pb-free and halogen-free.

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



Pin configuration (Top view)

DFN2x2-8L

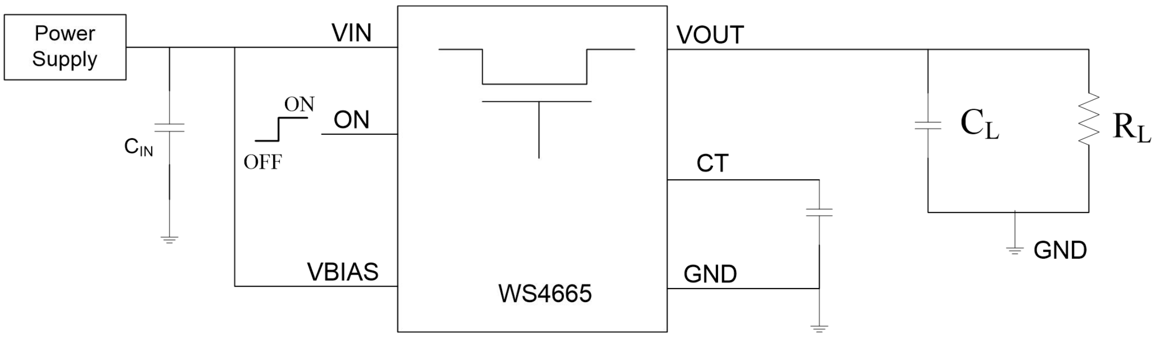
4665 = Device code
DA = Package code
Y = Year code
W = Week code

Marking

Order information

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

TYPICAL APPLICATION

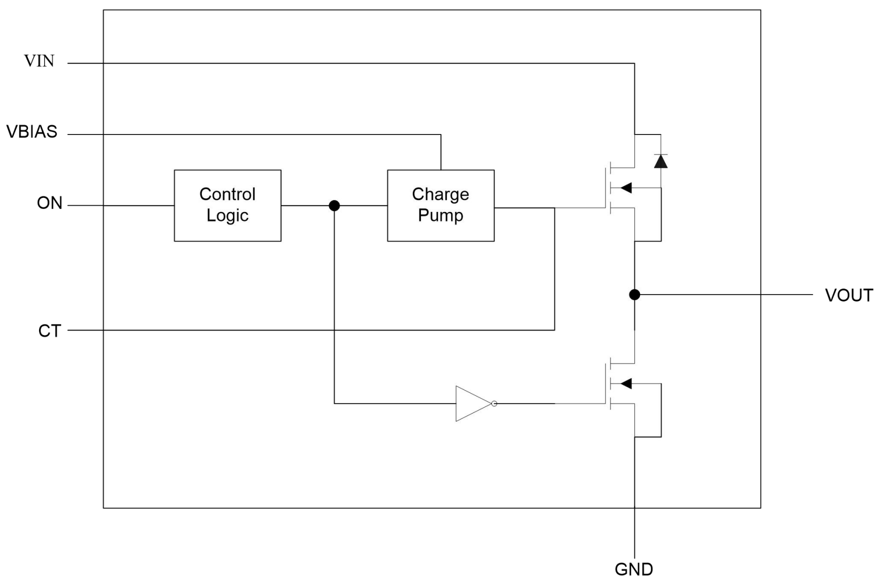


Typical Application

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



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
	Electrostatic discharge protection: Charged-Device Model (CDM)	1000	V

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

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.

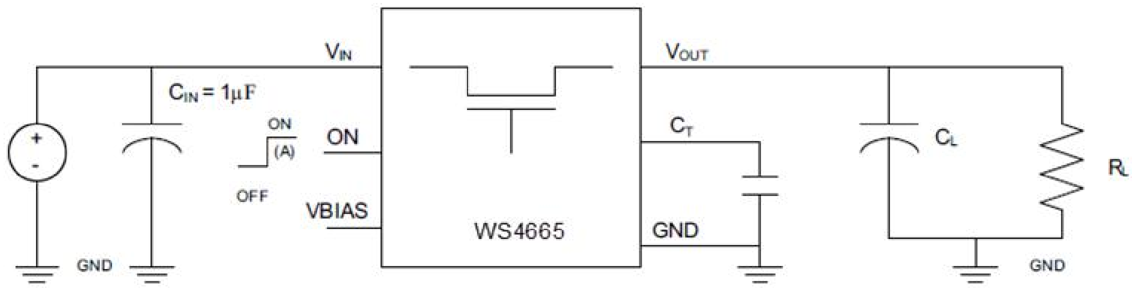
Parameter	Test Conditions		T_A	Min	Typ	Max	Unit
Power Supplies and Currents							
$I_{IN(VBIAS-ON)}$ V_{BIAS} quiescent current	I_{OUT} = 0mA, V_{IN} = V_{ON} = 5.0V		Full		66	75	μA
$I_{IN(VBIAS-OFF)}$ V_{BIAS} shutdown current	V_{ON} = GND, V_{OUT} = 0V		Full			0.01	μA
$I_{IN(VIN-OFF)}$ V_{IN} off-state 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

ELECTRICAL CHARACTERISTICS (Continuous)

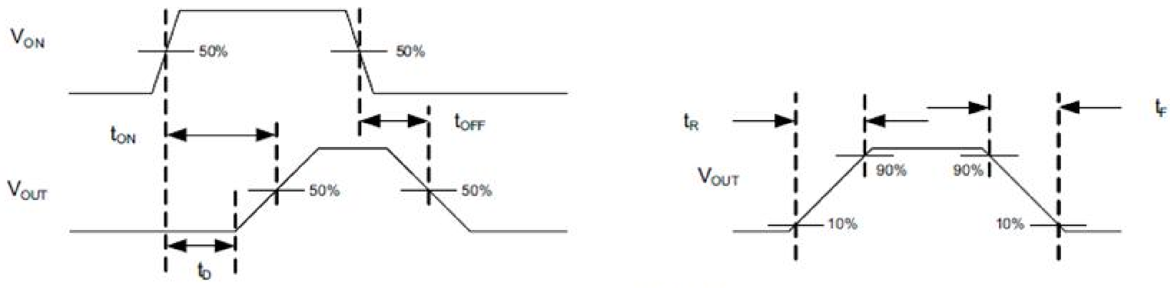
Unless otherwise noted, the specification in the following table applies over the operating ambient temperature -40°C ≤ T_A ≤ 85°C and V_{BIAS}=**2.5V**. Typical values are for T_A=25°C.

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

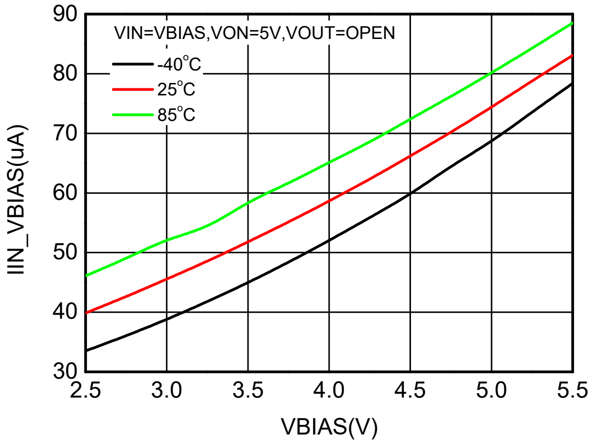


t_{ON}/t_{OFF} WAVEFORMS

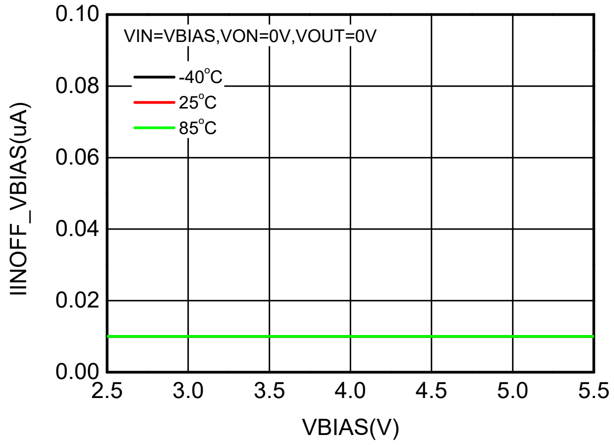
SWITCHING CHARACTERISTICS

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		

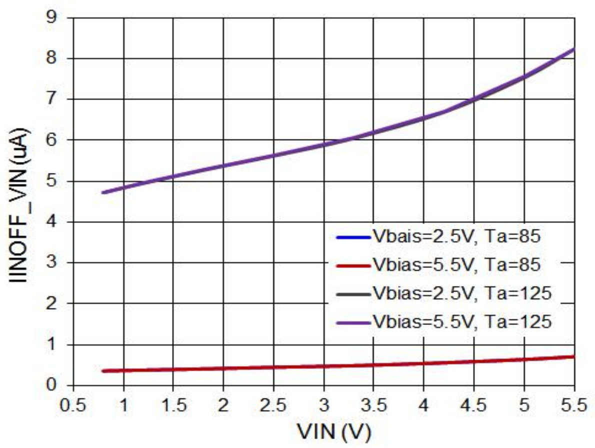
TYPICAL CHARACTERISTICS (Ta=25°C, unless otherwise noted)



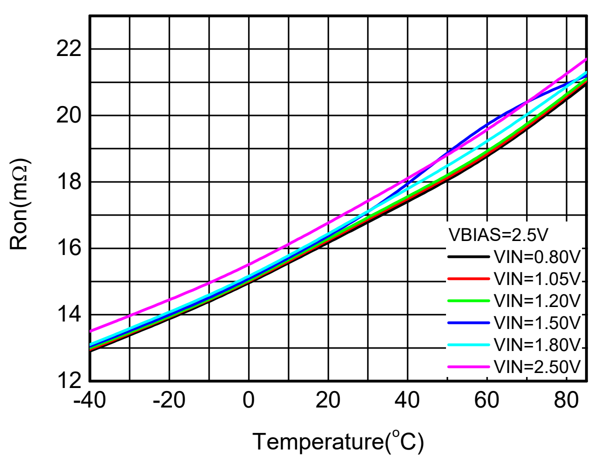
Quiescent Current vs. V_{BIAS}



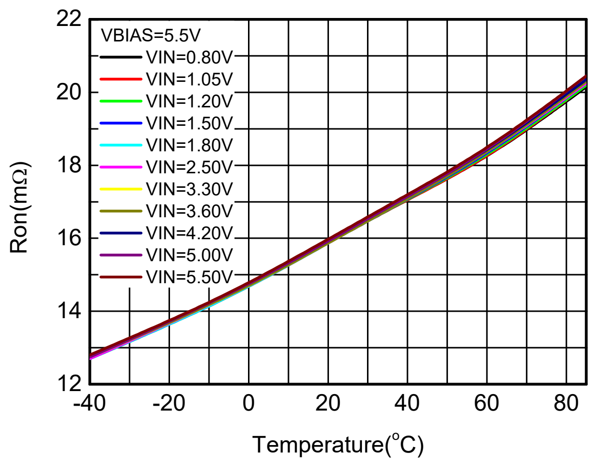
Shutdown Current vs. V_{BIAS}



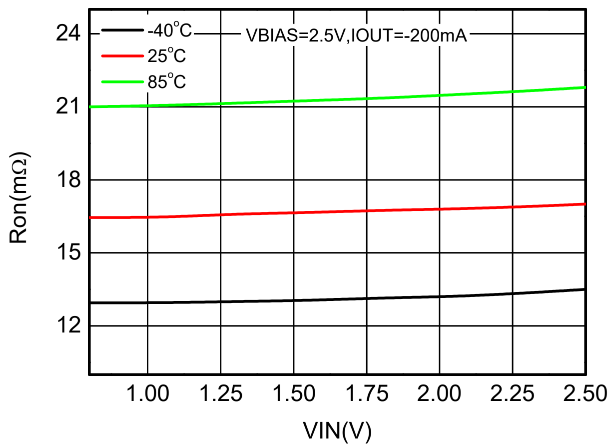
OFF-State V_{IN} Current vs. V_{IN}



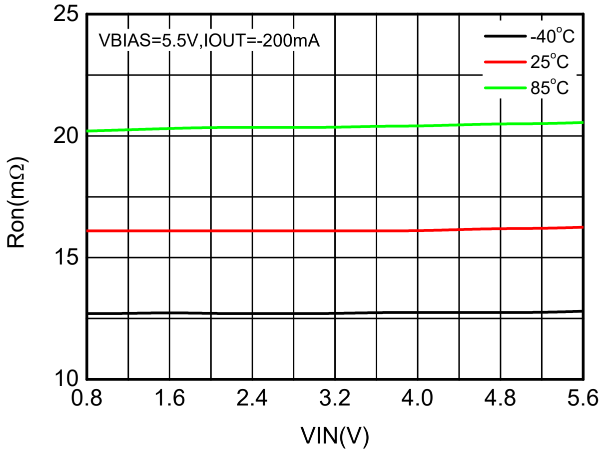
R_{ON} vs. TEMPERATURE (V_{BIAS} = 2.5V)



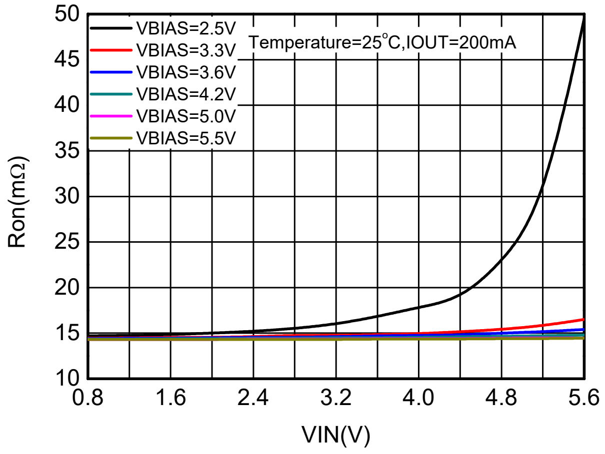
R_{ON} vs. TEMPERATURE (V_{BIAS} = 5.5V)



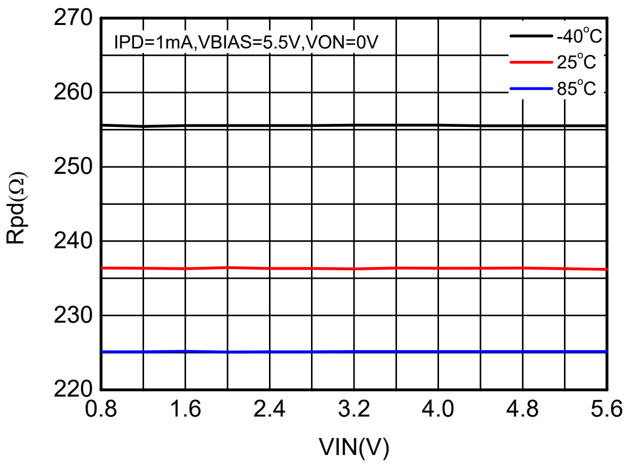
R_{ON} vs. TEMPERATURE (V_{BIAS} = 5.5V)



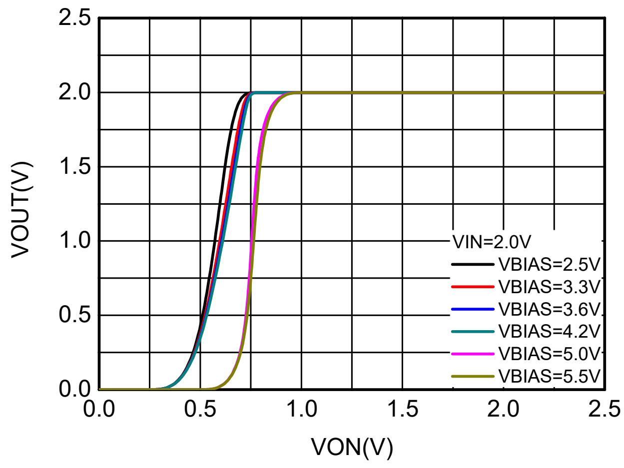
R_{ON} vs. V_{IN} (V_{BIAS} = 5.5V)



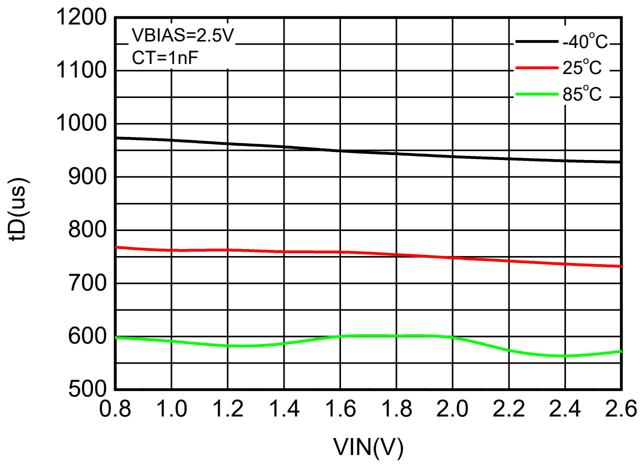
R_{ON} vs. V_{IN} (T_A= 25℃)



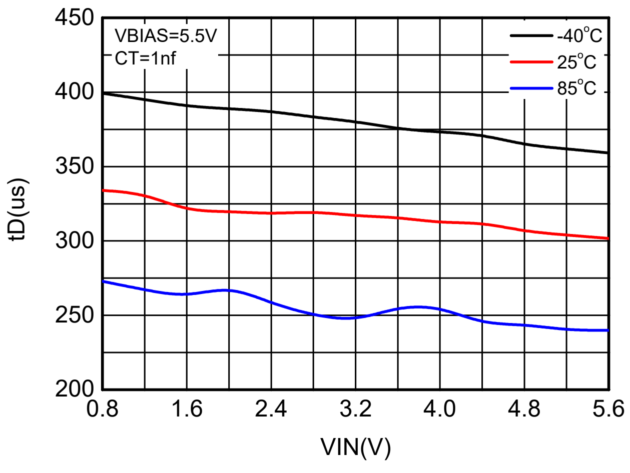
R_{PD} vs. V_{IN} (V_{BIAS} = 5.5V)



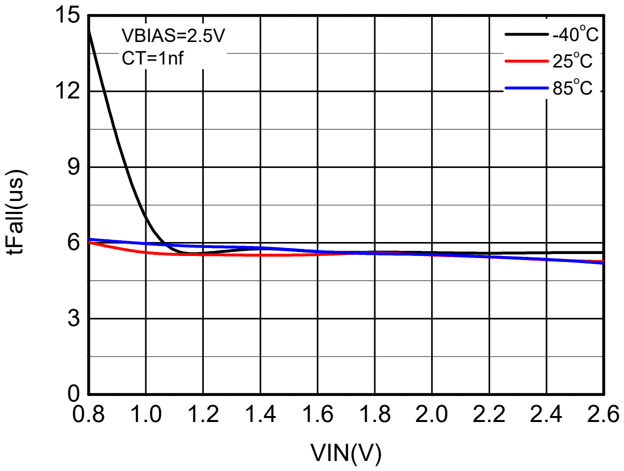
V_{OUT} vs. V_{ON} (T_A= 25℃)



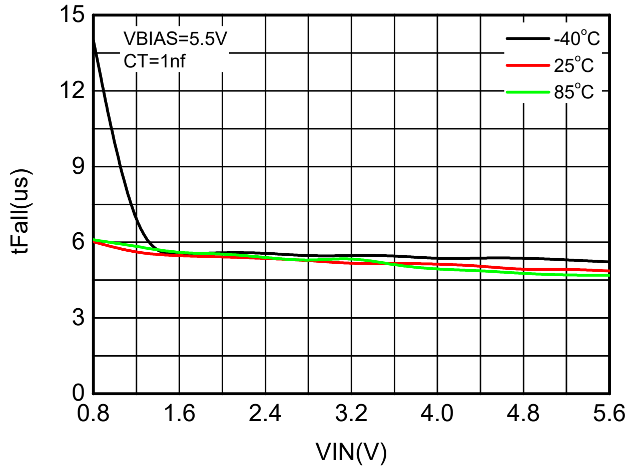
t_D vs. V_{IN} (V_{BIAS} = 2.5V, CT=1nF)



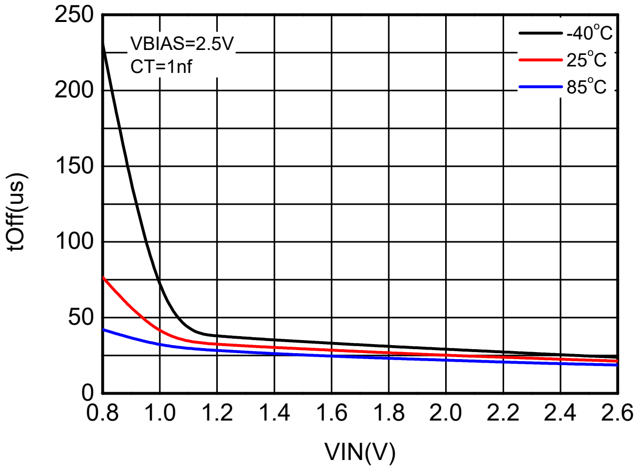
t_D vs. V_{IN} (V_{BIAS} = 5.5V, CT=1nF)



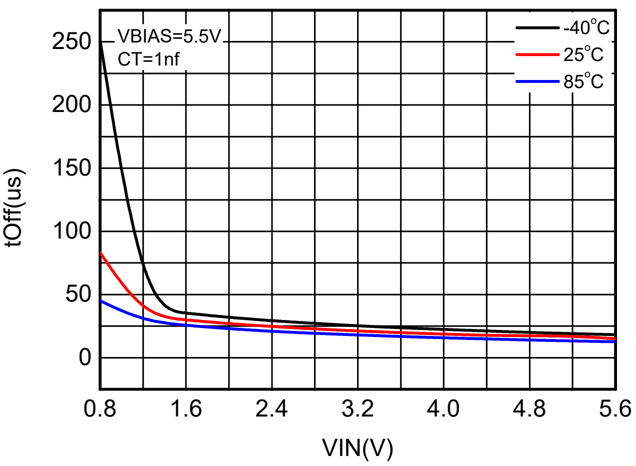
t_F vs. V_{IN} (V_{BIAS} = 2.5V, CT=1nF)



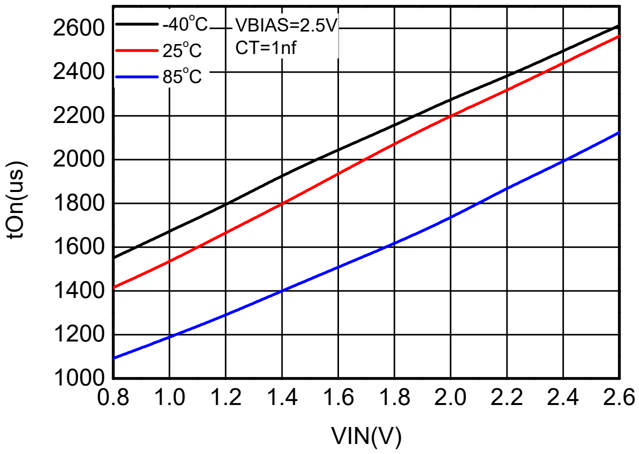
t_F vs. V_{IN} (V_{BIAS} = 5.5V, CT=1nF)



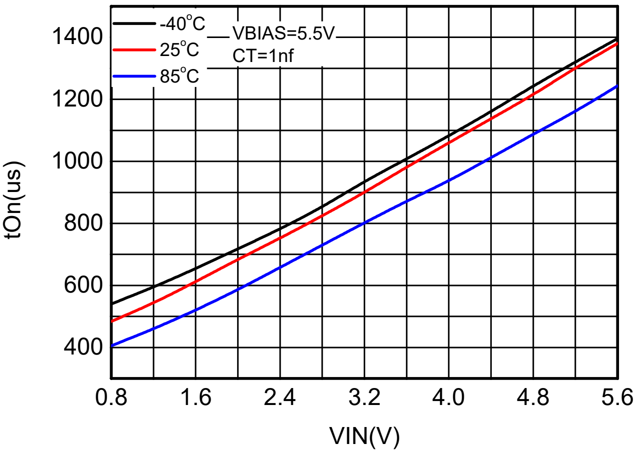
t_{OFF} vs. V_{IN} (V_{BIAS} = 2.5V, CT=1nF)



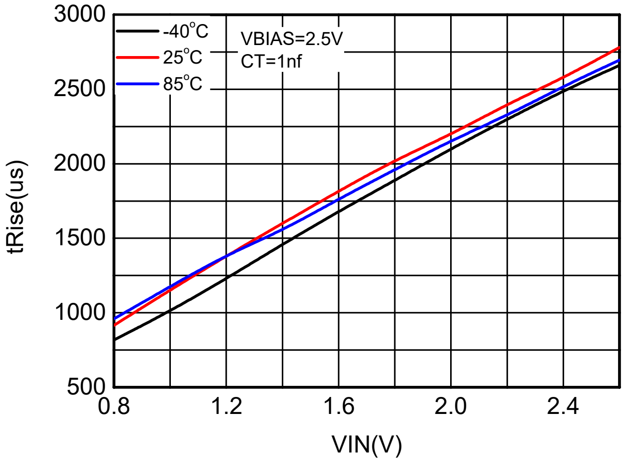
t_{OFF} vs. V_{IN} (V_{BIAS} = 5.5V, CT=1nF)



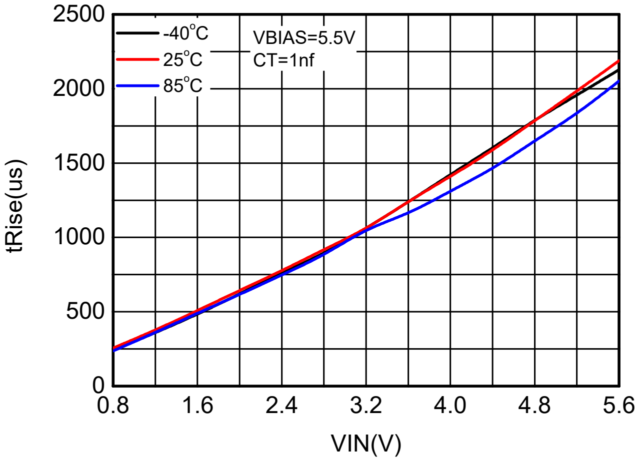
t_{ON} vs. V_{IN} (V_{BIAS} = 2.5V, CT=1nF)



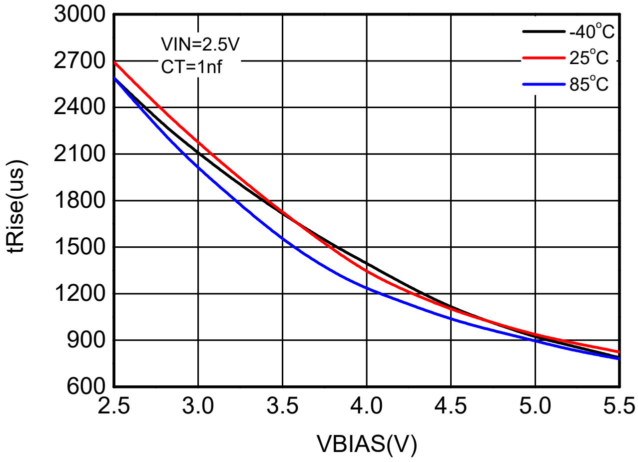
t_{ON} vs. V_{IN} (V_{BIAS} = 5.5V, CT=1nF)



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



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

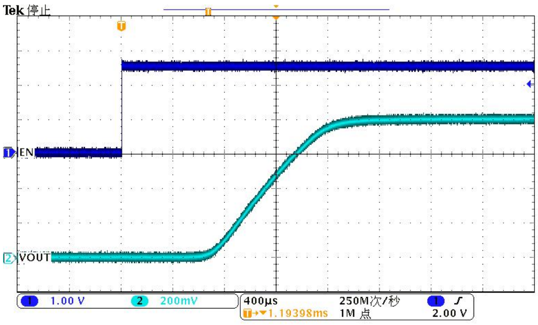


t_R vs. V_{BIAS} (V_{IN} = 2.5V, CT=1nF)

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

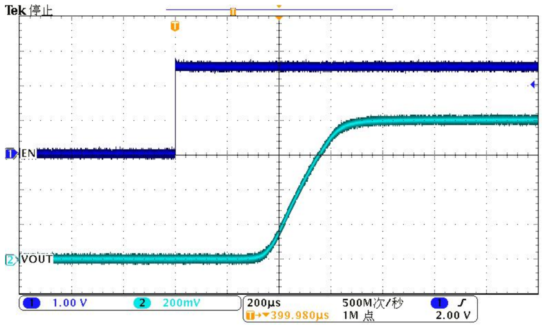
TURN-ON RESPONSE TIME

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



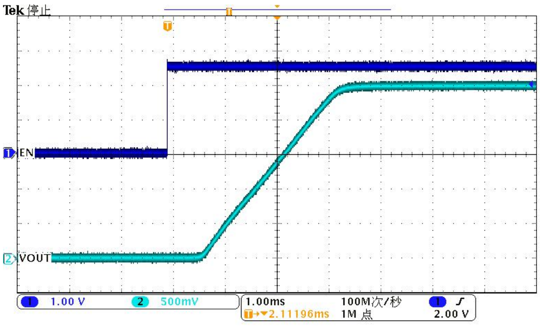
TURN-ON RESPONSE TIME

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



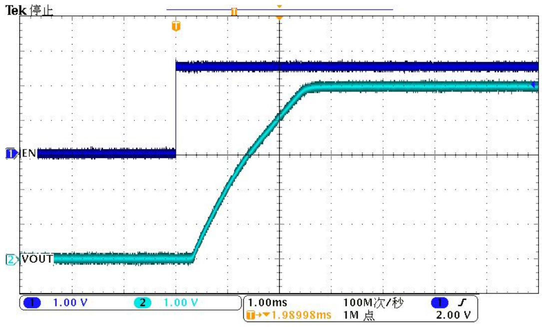
TURN-ON RESPONSE TIME

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



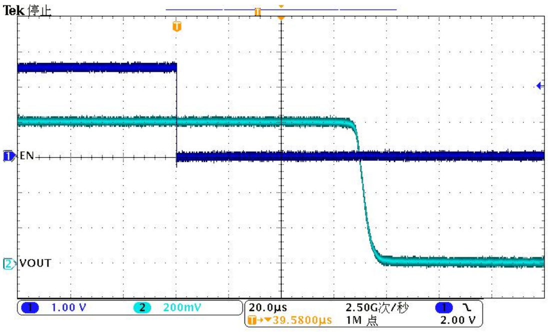
TURN-ON RESPONSE TIME

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



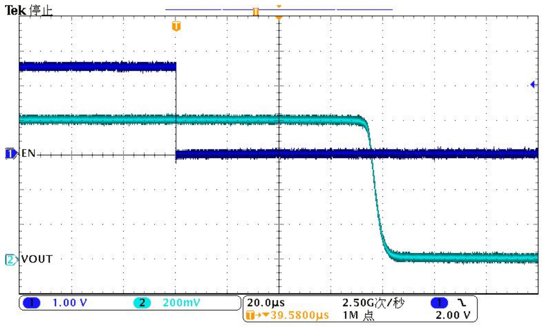
TURN-OFF RESPONSE TIME

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



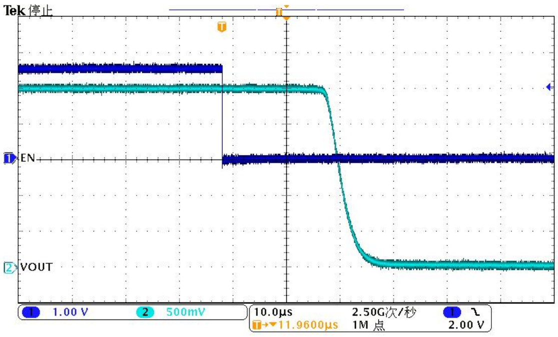
TURN-OFF RESPONSE TIME

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



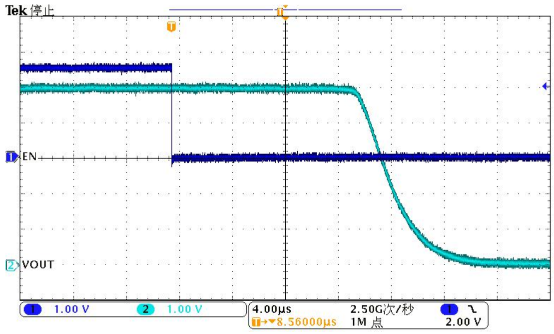
TURN-OFF RESPONSE TIME

(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)



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)

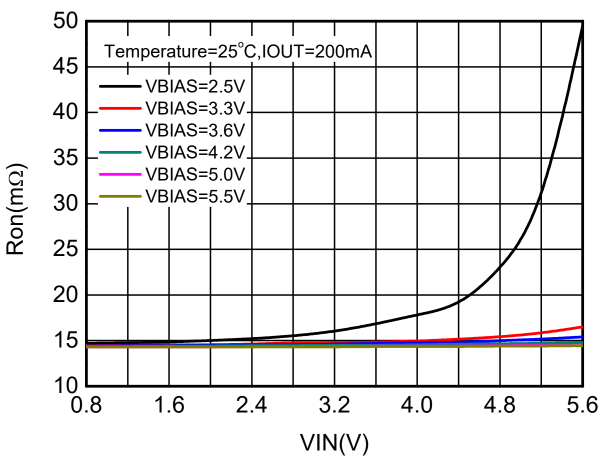
To limit the voltage drop on the input supply caused by transient inrush currents when the switch turns on into a discharged load capacitor or short-circuit, a capacitor needs to be placed between VIN and GND. A 1-uF ceramic capacitor, C_{IN}, placed close to the pins, is usually sufficient. Higher values 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.



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

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

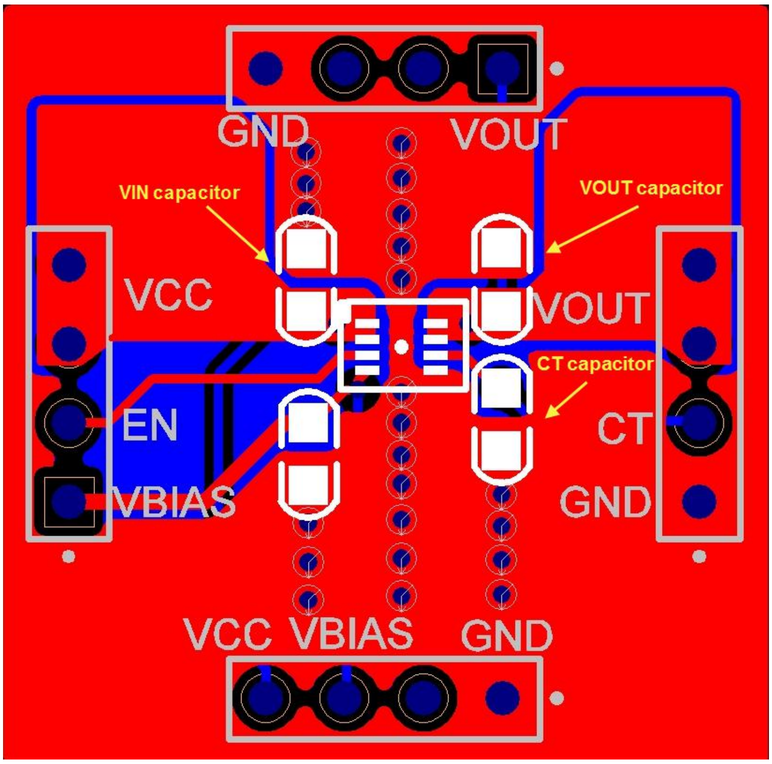
$T_{J(max)}$ = maximum allowable junction temperature (125 ℃ for the WS4665)

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.

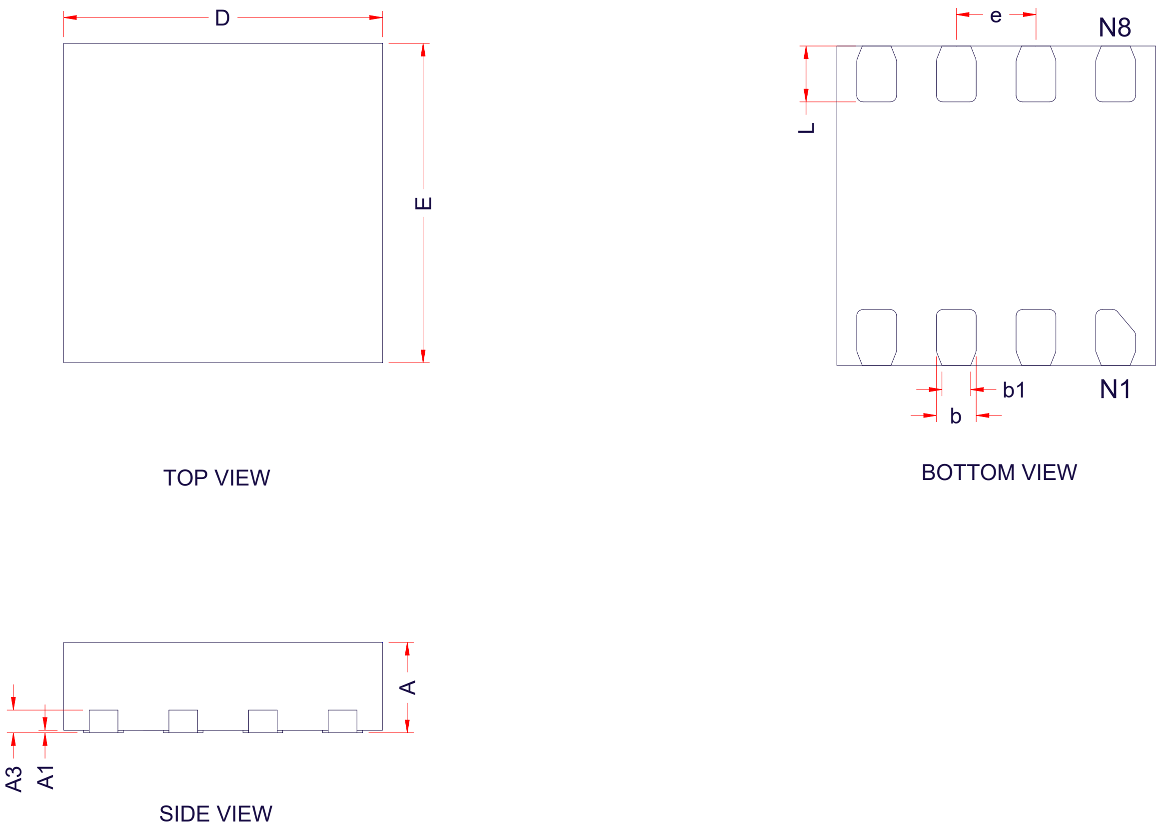
In order to achieve smaller θ_{JA}, the copper area of V_{IN} and V_{OUT} pin on PCB should be as large as possible.

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



PACKAGE OUTLINE DIMENSIONS

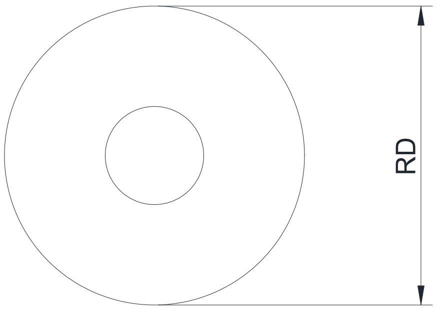
DFN2x2-8L



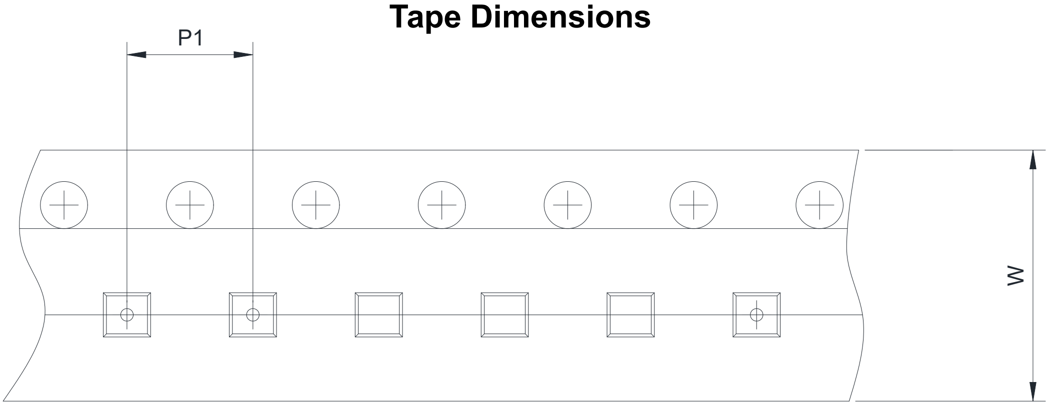
Symbol	Dimensions in Millimeters		
	Min.	**Typ.**	**Max.**
A	0.50	-	0.60
A1	0.00	-	0.05
A3	0.15 Ref.		
D	1.90	2.00	2.10
E	1.90	2.00	2.10
e	0.50 Typ.		
b	0.20	-	0.30
b1	0.13	-	0.23
L	0.30	-	0.40

TAPE AND REEL INFORMATION

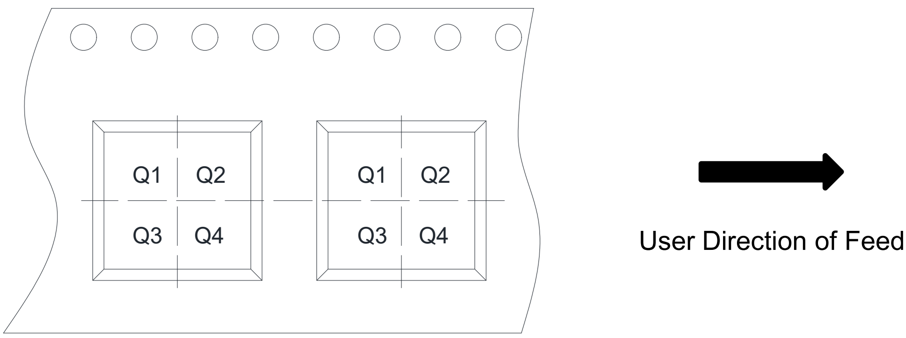
Reel Dimensions



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