WS4666D

6A, 19mΩ，Dual Channel Load Switch with Quick Output Discharge and Adjustable Rise Time

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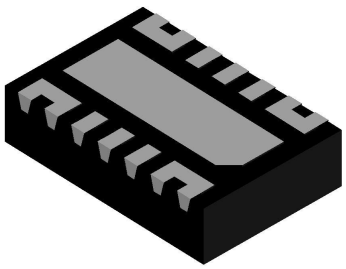
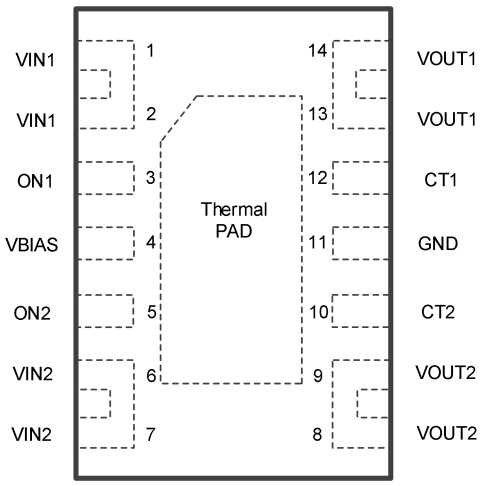
Descriptions

The WS4666D is a dual channel load switch that provides configurable rise time to minimize inrush current. The device contains two N-channel MOSFETs that can operate over an input voltage range of 0.6V 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 WS4666D, a 54Ω on-chip load resistor is added for quick output discharge when the switch is turned off.

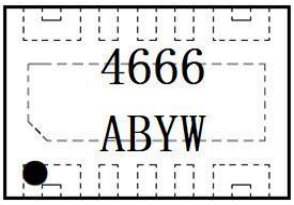
The WS4666D is available in a small, space-saving DFN3x2-14L package.Standard product is Pb-free and Halogen-free.



DFN3X2-14L



Pin configuration (Top view)



DFN3x2-14L

For detail order information, please see page 2.

Features

- Integrated Dual Channel Load Switch
- Input Voltage Range: 0.6V to 5.5V
- Ultra-Low On Resistance （R_{ON}）
  R_{ON} = 19mΩ at V_{IN} = 5V (V_{BIAS} = 5V)
- 6 A Maximum Continuous Switch Current
- Low Control Input Threshold Enables Use of 1.2V, 1.8V, 2.5V and 3.3V Logic
- Configurable Rise Time
- Quick Output Discharge (QOD)
- DFN3x2-14L Package
- ESD Performance Tested per JESD 22
  2kV HBM and 1kV CDM

Applications

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

Order Information

For detail order information, please see page 2.

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Order Information

Ordering No.	Continuous Current	Rise Time	Enable	Output Shutdown Resistor	Package	Operating Temperature	Marking	Shipping
WS4666DAB-14/TR	6A	Adjustable	Active High	54Ω	DFN3x2-14L	-40~105°C	4666 ABYW	3000/Reel &Tape

Marking Information

4666 = Device code

**** = Special code**

Y = Year code

W = Week code

Marking

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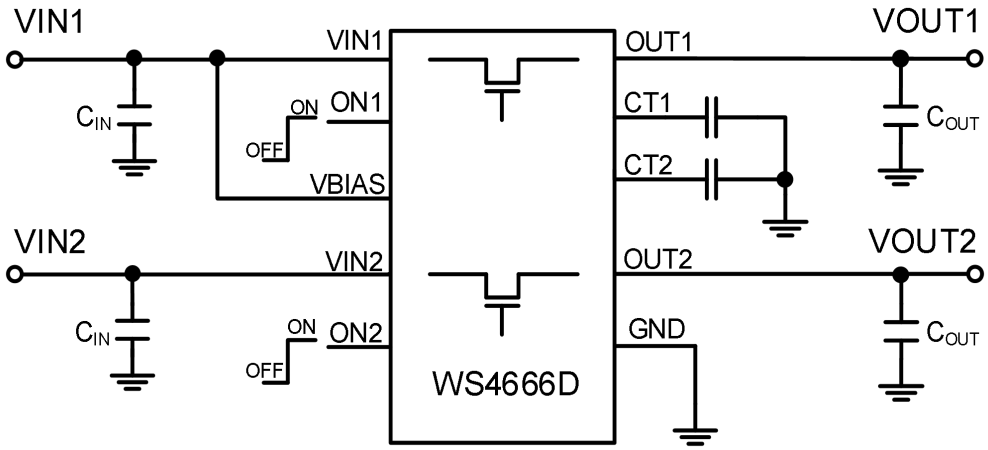
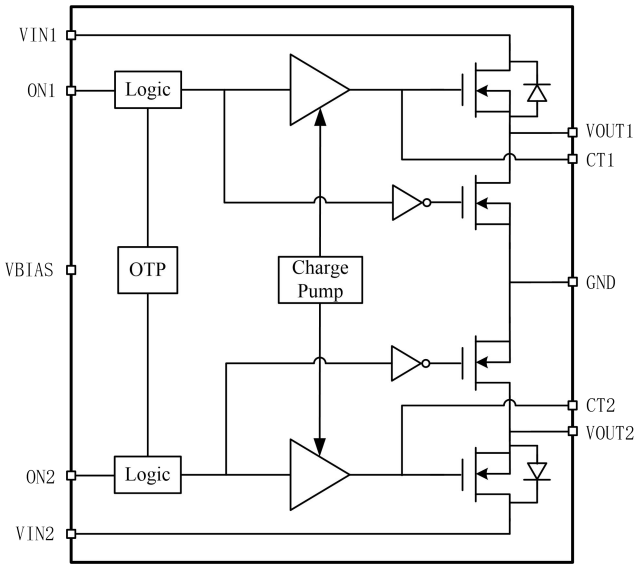
Typical Application



Pin Description

PIN No.	Symbol	I/O	Description
1,2	VIN1	I	Switch1 input. Input bypass capacitor recommended for minimizing V_{IN} dip.
3	ON1	I	Active high switch1 control input. Do not leave floating.
4	VBIAS	I	Bias voltage. Power supply to the device. Recommended voltage range for this pin is 2.7V to 5.5V.
5	ON2	I	Active high switch2 control input. Do not leave floating.
6,7	VIN2	I	Switch2 input. Input bypass capacitor recommended for minimizing V_{IN} dip.
8,9	VOUT2	O	Switch2 output.
10	CT2	O	Switch2 slew rate control. Can be left floating.
11	GND	--	Ground
12	CT1	O	Switch1 slew rate control. Can be left floating.
13,14	VOUT1	O	Switch1 output.
--	Thermal PAD	--	Thermal PAD. Tie to GND

Block Diagram



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Absolute Maximum Ratings

Symbol	Parameter		Value	Unit
$V_{IN1,2}$	Input voltage range		-0.3 ~ 6	V
$V_{OUT1,2}$	Output voltage range		-0.3 ~ 6	V
V_{BIAS}	Bias voltage range		-0.3 ~ 6	V
$V_{ON1,2}$	ON pin voltage range		-0.3 ~ 6	V
I_{MAX}	Maximum continuous switch current		6	A
I_{PLS}	Maximum pulsed switch current, pulse < 300μs, 3% duty cycle		8	A
T_A	Operating free-air temperature range		-40 ~ 105	°C
T_J	Maximum junction temperature		125	°C
T_{STG}	Storage temperature range		-40 ~ 125	°C
T_{LEAD}	Maximum lead temperature (10-s soldering time)		260	°C
ESD	Electrostatic discharge protection	Human-Body Model (HBM)	±2000	V
		Charged-Device Model (CDM)	±1000	

Thermal Information

Symbol	Parameter	WS4666D DFN3*2-14L	Unit
$R_{\theta JA}$	Junction-to-Ambient thermal resistance*1	73	°C/W
$R_{\theta JC(top)}$	Junction-to-Case (Top) Thermal Resistance	62	°C/W
$R_{\theta JC(bottom)}$	Junction-to-Case (Bottom) Thermal Resistance	17	°C/W
$R_{\theta JB}$	Junction-to-Board Thermal Resistance	41	°C/W

*1:Surface mounted on FR-4 Board using 2 oz, 1 square inch Cu area, PCB board size 1.5*1.5 square inches

Recommended Operating Ratings

Symbol	Parameter		Min	Max	Unit
$V_{IN1,2}$	Input voltage range		0.6	V_{BIAS}	V
V_{BIAS}	Bias voltage range		2.7	5.5	V
$V_{ON1,2}$	ON voltage range		0	5.5	V
$V_{OUT1,2}$	Output voltage range			V_{IN}	V
V_{IH}	High-level input voltage, ON	V_{BIAS}=2.7V to 5.5V	1.2	5.5	V
V_{IL}	Low-level input voltage, ON	V_{BIAS}=2.7V to 5.5V	0	0.4	V
$C_{IN1,2}$	Input capacitor		1		μF

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Electrical Characteristics

V_{BIAS}=5.0V, Cin=1μF, T_A=25°C, unless otherwise noted.

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
V_{BIAS} Quiescent Current (Both Channels)	$I_{Q,VBIAS}$	I_{OUT1} =I_{OUT2} =0mA, $V_{IN1,2}$ = $V_{ON1,2}$ = 5.0V			49	66	μA
V_{BIAS} Quiescent Current (Single Channel)		I_{OUT1} =I_{OUT2} =0mA, V_{ON2} = 0V $V_{IN1,2}$ = V_{ON1} = 5.0V			39	56	μA
V_{BIAS} Shutdown Current	$I_{SD,VBIAS}$	$V_{ON1,2}$ = 0V , $V_{OUT1,2}$ = 0V			0.3	1	μA
V_{IN} Shutdown Current (Per Channel)	$I_{SD,VIN}$	V_{ON} = 0V , V_{OUT} = 0V	VIN = 5.0V		0.08	1	μA
			VIN = 3.3V		0.025	0.4	
			VIN = 1.8V		0.015	0.3	
			VIN = 0.6V		0.01	0.15	
ON Pin Input Leakage Current	I_{ON}	V_{ON} = 5.5V				0.1	μA
ON-state Resistance (Per Channel)	R_{ON}	I_{OUT} = -200mA, V_{BIAS} = 5.0V	V_{IN} = 5.0V		19	28	mΩ
			V_{IN} = 3.3V		19	28	
			V_{IN} = 1.8V		19	28	
			V_{IN} = 1.2V		19	28	
			V_{IN} = 1.05V		19	28	
			V_{IN} = 0.6V		19	28	
ON Pin Hysteresis	$V_{ON,HYS}$	V_{IN} =5.0V			90		mV
Output Pull-down Resistance	R_{PD}	V_{IN} = V_{OUT}=5.0V, V_{ON} = 0V			54	80	Ω
Thermal Shutdown	T_{SD}	Junction temperature rising			160		°C
Thermal Shutdown Hysteresis	$T_{SD,HYS}$	Junction temperature falling			25		°C

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Electrical Characteristics (Continued)

V_{BIAS}=2.7V, Cin=1μF, T_A=25°C, unless otherwise noted.

Parameter	Symbol	Test Conditions		Min	Typ	Max	Unit
V_{BIAS} Quiescent Current (Both Channels)	$I_{Q,VBIAS}$	I_{OUT1} =I_{OUT2} =0mA, $V_{IN1,2}$ = $V_{ON1,2}$ = 2.5V			27	40	μA
V_{BIAS} Quiescent Current (Single Channel)		I_{OUT1} =I_{OUT2} =0mA, V_{ON2} = 0V $V_{IN1,2}$ = V_{ON1} = 2.5V			24	35	μA
V_{BIAS} Shutdown Current	$I_{SD,VBIAS}$	$V_{ON1,2}$ = 0V , $V_{OUT1,2}$ = 0V			0.1	1	μA
V_{IN} Shutdown Current (Per Channel)	$I_{SD,VIN}$	V_{ON} = 0V , V_{OUT} = 0V	V_{IN} = 2.5V		0.02	0.36	μA
			V_{IN} = 1.8V		0.015	0.3	
			V_{IN} = 1.05V		0.015	0.25	
			V_{IN} = 0.6V		0.01	0.15	
ON Pin Input Leakage Current	I_{ON}	V_{ON} = 5.5V				0.1	μA
ON-state Resistance (Per Channel)	R_{ON}	I_{OUT} = -200mA, V_{BIAS} = 2.7V	V_{IN} = 2.5V		20	28	mΩ
			V_{IN} = 1.8V		20	28	
			V_{IN} = 1.5V		20	28	
			V_{IN} = 1.2V		20	28	
			V_{IN} = 1.05V		20	28	
			V_{IN} = 0.6V		19	28	
ON Pin Hysteresis	$V_{ON,HYS}$	V_{IN} =2.5V			50		mV
Output Pull-down Resistance	R_{PD}	V_{IN} = V_{OUT}=2.5V, V_{ON} = 0V			51	80	Ω
Thermal Shutdown	T_{SD}	Junction temperature rising			160		°C
Thermal Shutdown Hysteresis	$T_{SD,HYS}$	Junction temperature falling			25		°C

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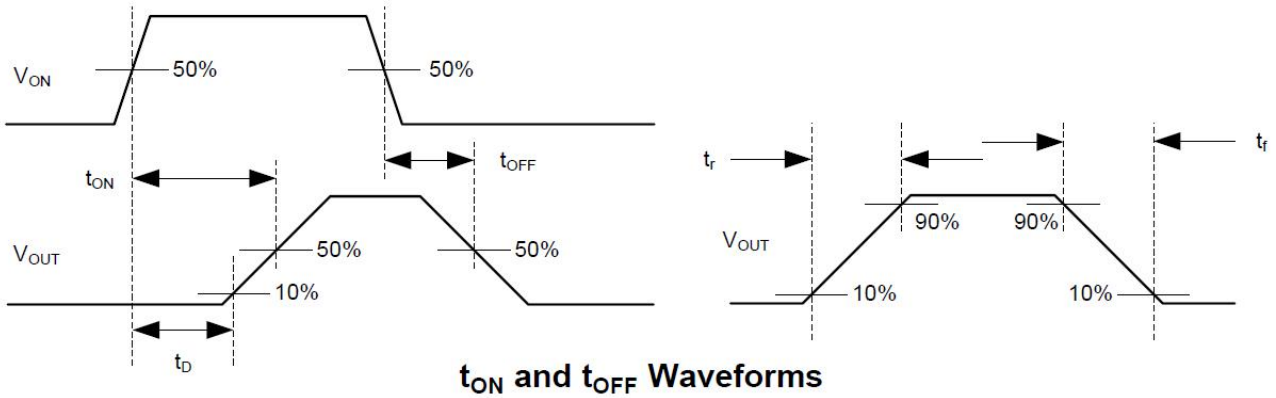
Switching Characteristics Measurement Information



t_{ON} and t_{OFF} Waveforms

Switching Characteristics

Parameter		Test Conditions	Min	Typ	Max	Unit
V_{IN} = V_{ON} = V_{BIAS} = 5V, T_A = 25 °C (unless otherwise noted)						
t_{ON}	Turn-on time	R_L = 10Ω, C_L = 0.1uF, C_T = 1000pF		1800		µs
t_{OFF}	Turn-off time			0.85		
t_R	V_{OUT} rise time			2300		
t_F	V_{OUT} fall time			1.75		
t_D	ON delay time			800		
V_{IN} = 0.6V, V_{ON} = V_{BIAS} = 5V, T_A = 25 °C (unless otherwise noted)						
t_{ON}	Turn-on time	R_L = 10Ω, C_L = 0.1uF, C_T = 1000pF		725		µs
t_{OFF}	Turn-off time			1.15		
t_R	V_{OUT} rise time			360		
t_F	V_{OUT} fall time			1.6		
t_D	ON delay time			540		
V_{IN} = 2.5V, V_{ON} = 5V, V_{BIAS} = 2.7V, T_A = 25 °C (unless otherwise noted)						
t_{ON}	Turn-on time	R_L = 10Ω, C_L = 0.1uF, C_T = 1000pF		1750		µs
t_{OFF}	Turn-off time			1.05		
t_R	V_{OUT} rise time			2065		
t_F	V_{OUT} fall time			2		
t_D	ON delay time			820		
V_{IN} = 0.6V, V_{ON} = 5V, V_{BIAS} = 2.7V, T_A = 25 °C (unless otherwise noted)						
t_{ON}	Turn-on time	R_L = 10Ω, C_L = 0.1uF, C_T = 1000pF		1050		µs
t_{OFF}	Turn-off time			1.2		
t_R	V_{OUT} rise time			560		
t_F	V_{OUT} fall time			1.3		
t_D	ON delay time			740		

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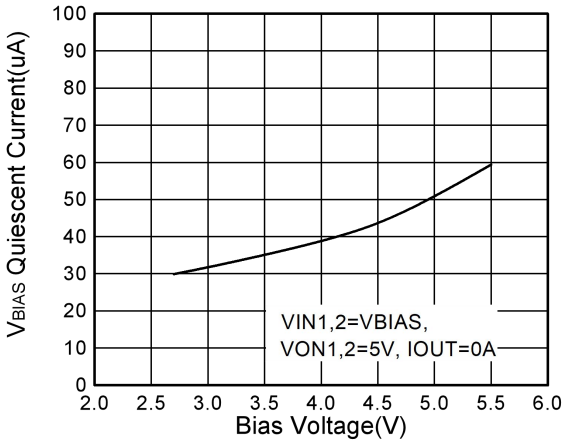
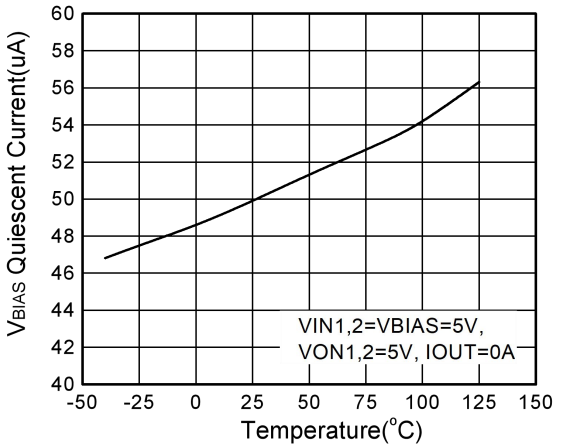
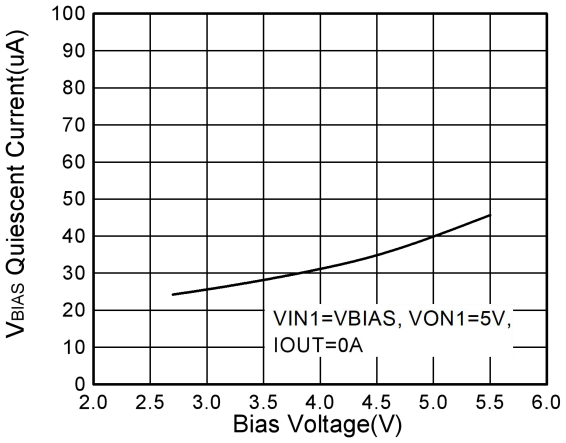
Typical DC Characteristics



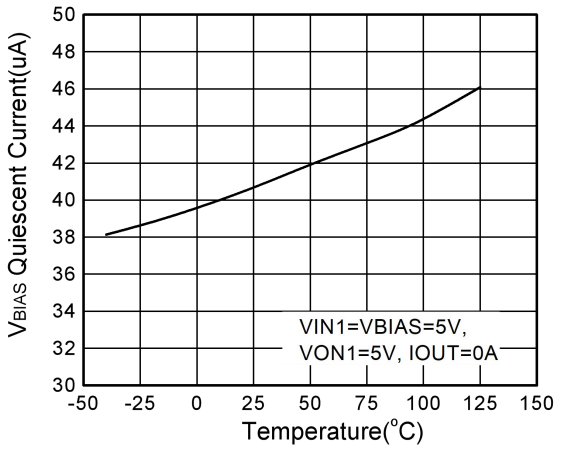
VBIAS Quiescent Current VS. Bias Voltage Both Channels



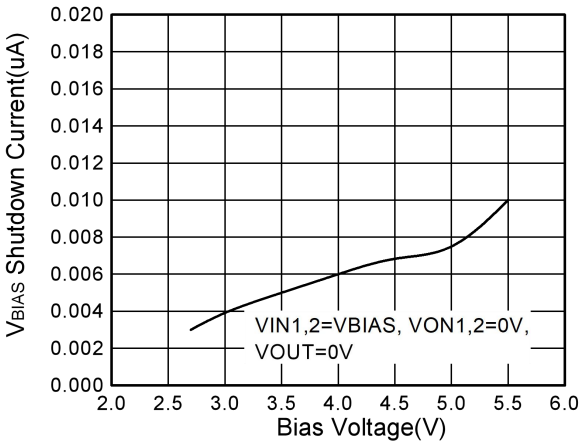
VBIAS Quiescent Current VS.Temperature Both Channels



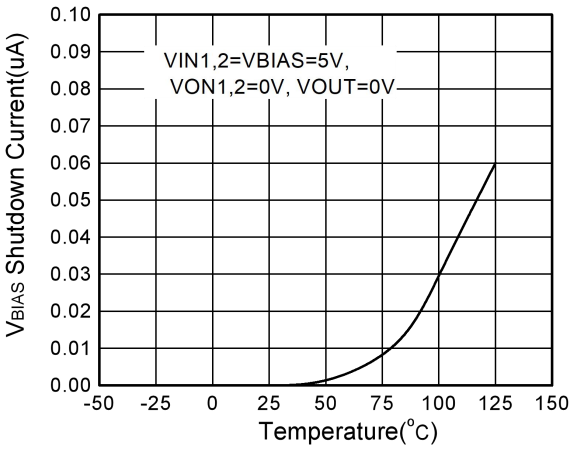
VBIAS Quiescent Current VS. Bias Voltage Single Channel



VBIAS Quiescent Current VS.Temperature Single Channel



VBIAS Shutdown Current VS. Bias Voltage Both Channels



VBIAS Shutdown Current VS.Temperature Both Channels

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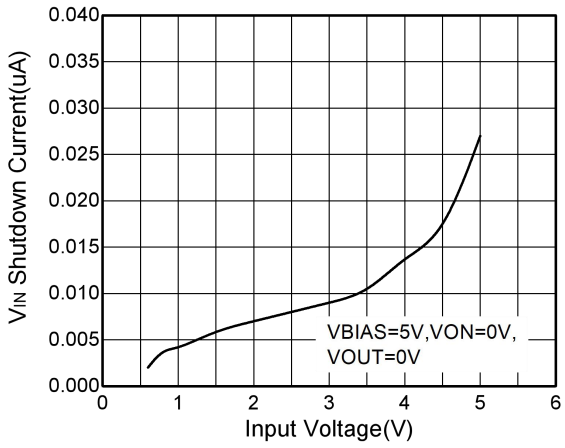
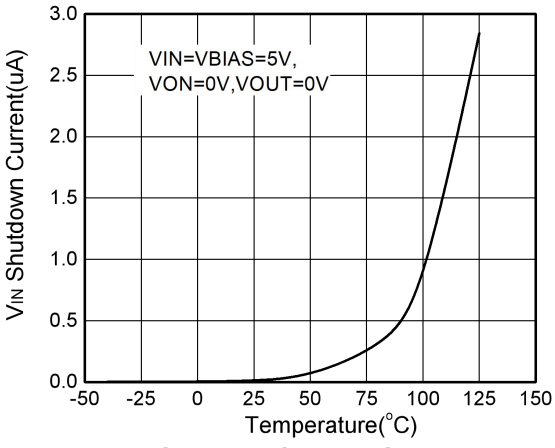
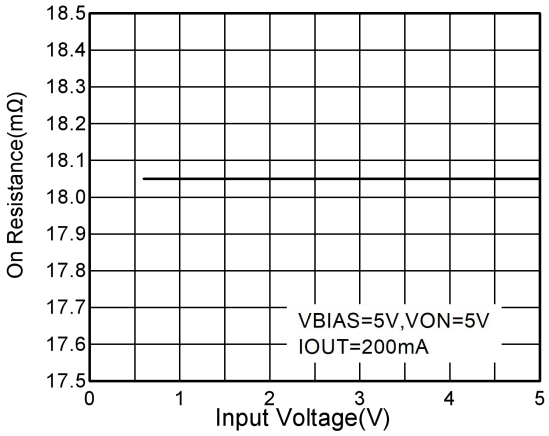
Typical DC Characteristics (Continued)



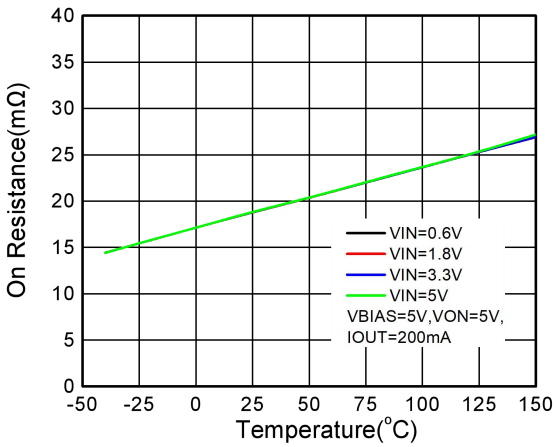
VIN Shutdown Current VS. Input Voltage
Single Channel



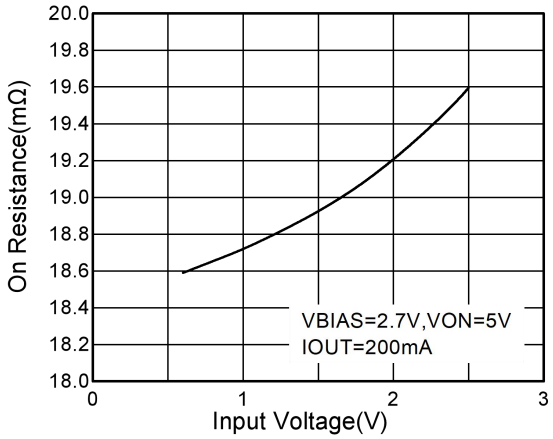
VIN Shutdown Current VS.Temperature
Single Channel



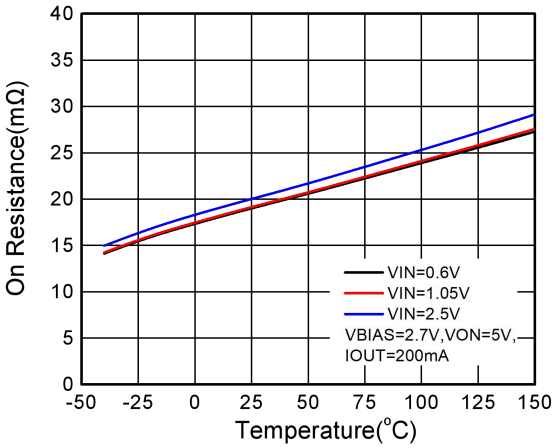
On Resistance VS.Input Voltage
Single Channel



On Resistance VS.Temperature
Single Channel



On Resistance VS.Input Voltage
Single Channel



On Resistance VS. Temperature
Single Channel

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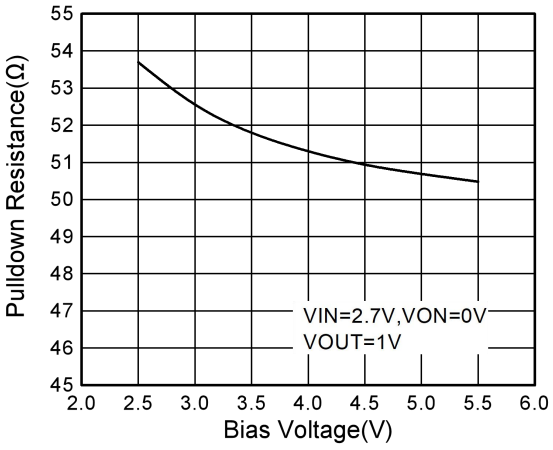
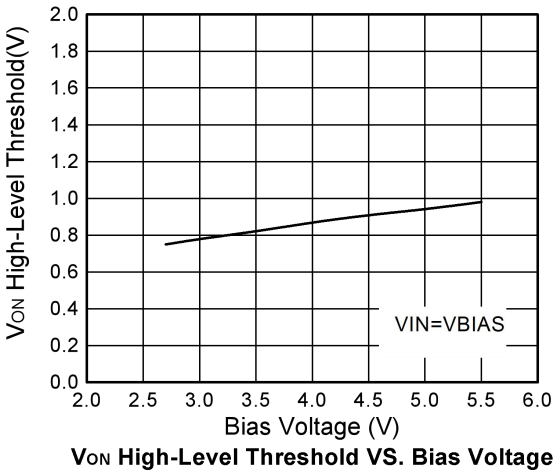
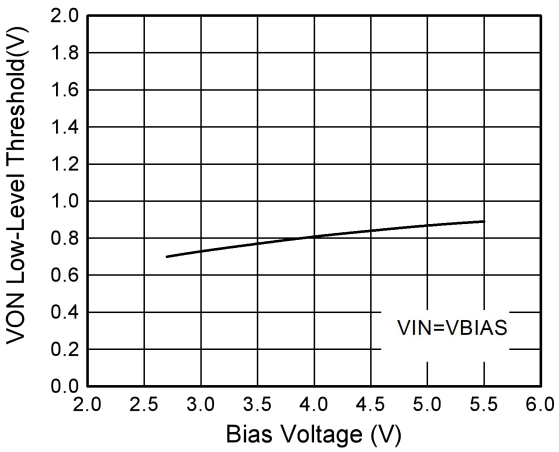
Typical DC Characteristics (Continued)



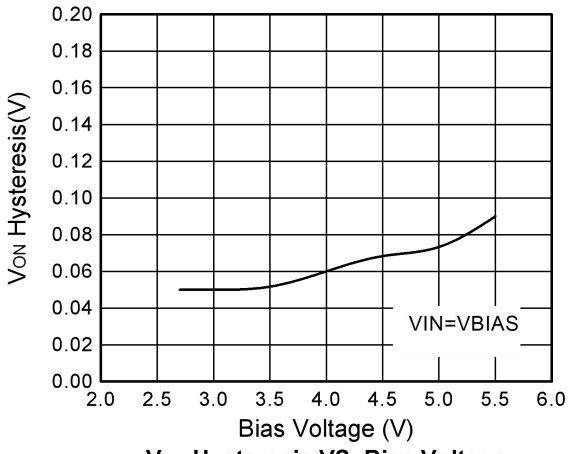
Pulldown Resistance VS.Bias Voltage
Single Channel



VON High-Level Threshold VS. Bias Voltage



VON Low-Level Threshold VS. Bias Voltage



VON Hysteresis VS. Bias Voltage

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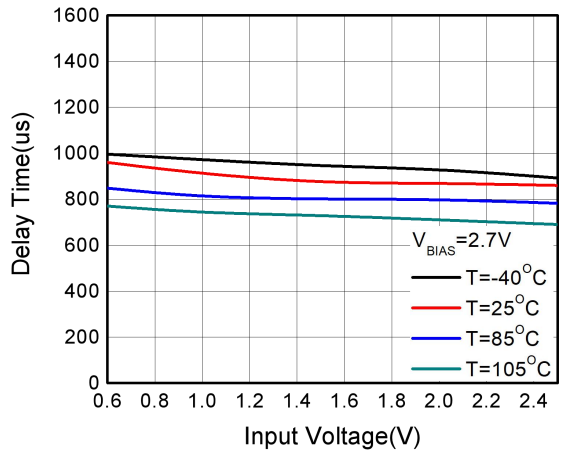
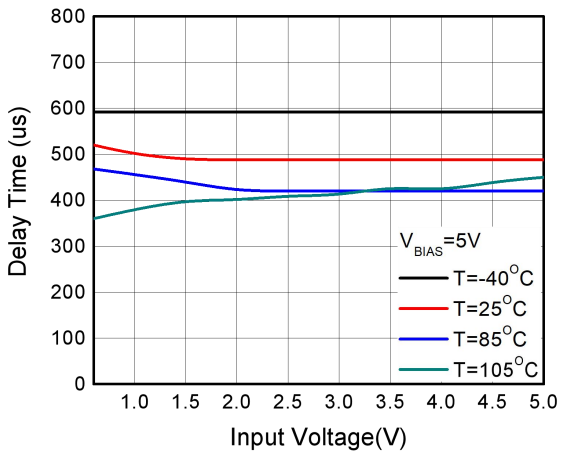
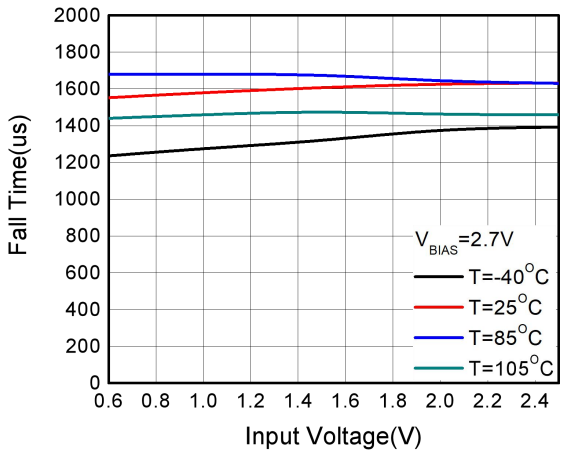
Typical AC Characteristics



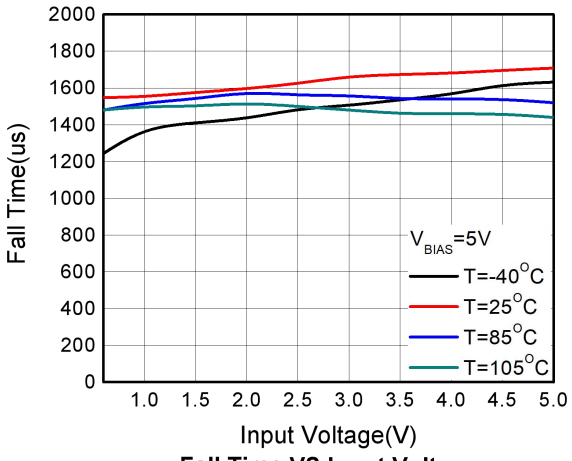
Delay Time VS.Input Voltage



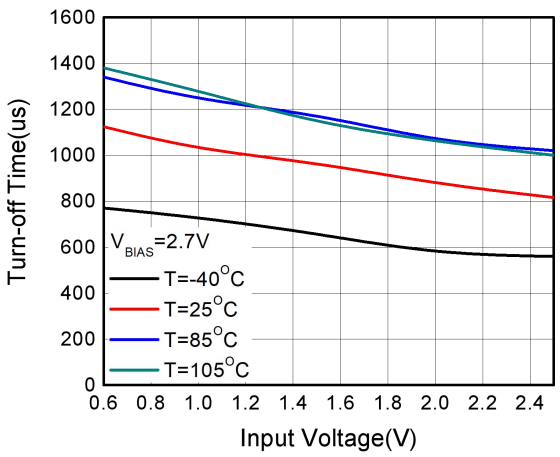
Delay Time VS.Input Voltage



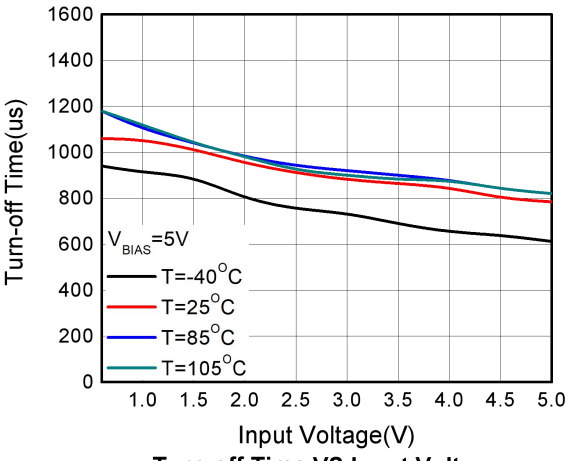
Fall Time VS.Input Voltage



Fall Time VS.Input Voltage



Turn-off Time VS.Input Voltage



Turn-off Time VS.Input Voltage

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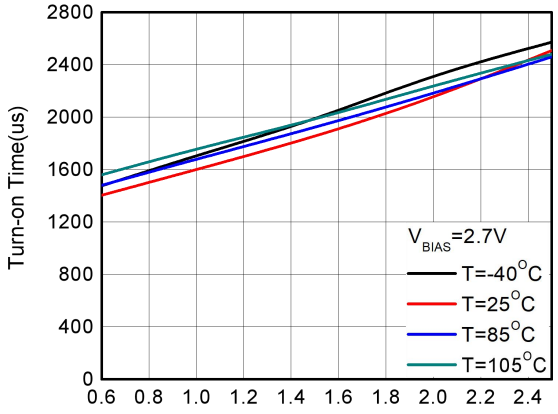
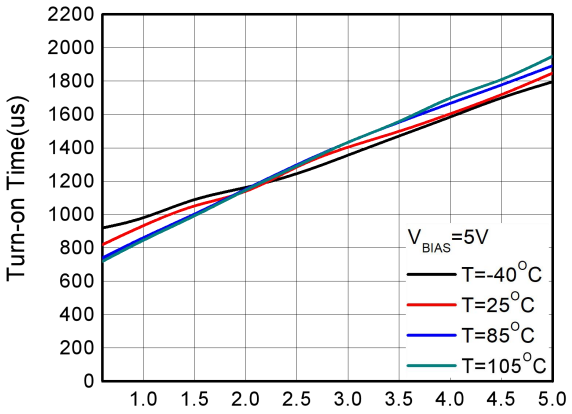
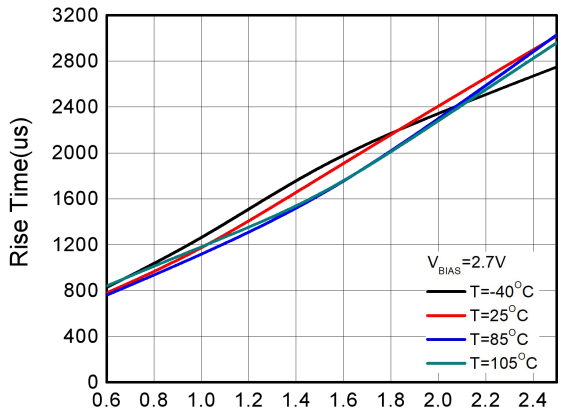


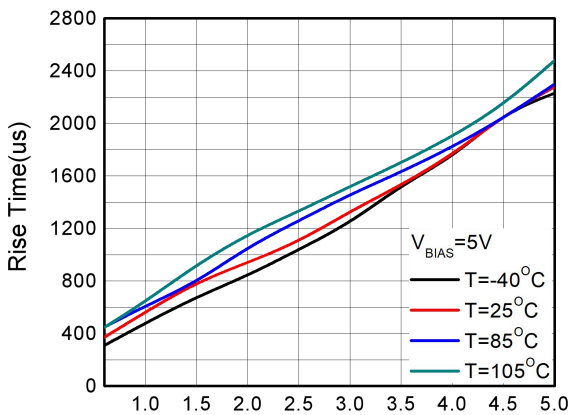
Turn-on Time VS.Input Voltage



Turn-on Time VS.Input Voltage



Rise Time VS.Input Voltage



Rise Time VS.Input Voltage

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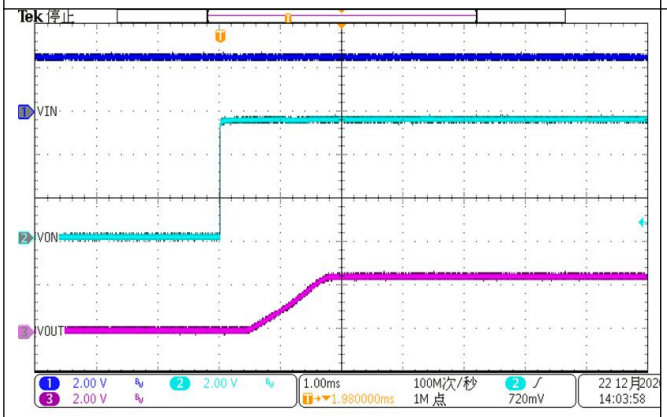
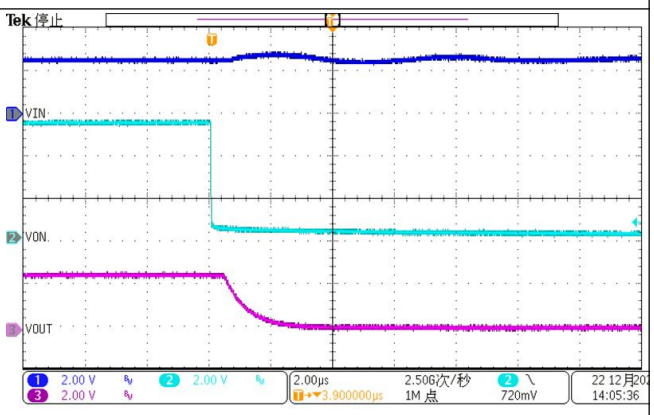
Working Waveforms

Start up by ON



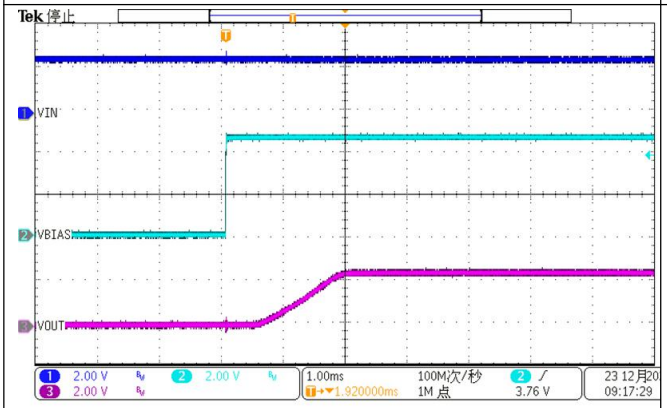
V_{BIAS}=5V,V_{IN}=2.5V,R_L=10Ω,C_L=0.1μF

Shutdown by ON



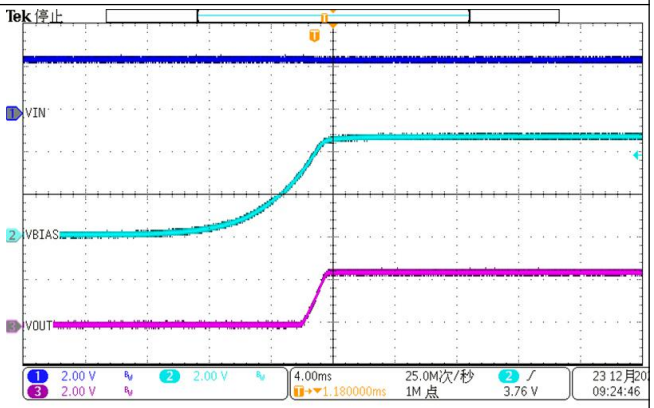
V_{BIAS}=5V,V_{IN}=2.5V,R_L=10Ω,C_L=0.1μF

Start up by VBIAS



V_{ON}=5V,V_{IN}=2.5V,R_L=10Ω,C_L=0.1μF

Shutdown by VBIAS



V_{ON}=5V,V_{IN}=2.5V,R_L=10Ω,C_L=0.1μF

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Detailed Description

Overview

The WS4666D device is a dual channel, 19mΩ load switch in a DFN3x2-14L package.Each channel can support a maximum continuous current of 6 A and is controlled by an on and off GPIO-compatible input. To reduce the voltage drop in high current rails, the device implements N-channel MOSFETs. The device has a configurable slew rate for applications that require a specific rise-time.

The device prevents downstream circuits from pulling high standby current from the supply by limiting the leakage current of the device when it is disabled. The integrated control logic, driver, power supply, and output discharge FET eliminates the need for any external components, which reduces solution size and bill of materials (BOM) count.

Adjustable Rise Time

A capacitor to GND on the CT pin sets the slew rate. To ensure desired performance, a capacitor with a minimum voltage rating of 25 V must be used on either CT pins. This equation accounts for 10% to 90% measurement on VOUT and does not apply for CT < 100 pF.

Use Table 1 to determine rise times for when CT = 0 pF.

$$SR = 0.45 \times C_T + 30$$

where

- SR is the slew rate (in µs/V)
- CT is the capacitance value on the CT pin (in pF)
- The units for the constant 30 are µs/V. The units for the constant 0.45 are µs/(V × pF).

Rise time can be calculated by multiplying the input voltage by the slew rate. Table 1 contains rise time values measured on a typical device. Rise times shown in Table 1 are only valid for the power-up sequence where VIN and VBIAS are already in steady state condition before the ON pin is asserted high.

Table 1. Rise Time tR vs CT Capacitor

CT(pF)	RISE TIME(us) 10%-90% ,C_L=0.1µF,C_{IN}=1µF,R_L=10Ω，V_{BIAS}=5V						
	VIN=5V	VIN=3.3V	VIN=1.8V	VIN=1.5V	VIN=1.2V	VIN=1.05V	VIN=0.6V
0	247	180	110	100	89	84	63
220	645	417	263	234	205	190	138
470	1056	671	421	373	325	298	209
1000	1949	1231	763	672	577	527	364
2200	4032	2523	1545	1351	1150	1049	711
4700	9165	5580	3332	2915	2468	2238	1567
10000	19810	12040	7179	6257	5314	4785	3213

*1:Typical Values at 25℃ with a 25V X7R 10% Ceramic Capacitor on CT.

ON and OFF Control

The ON pin controls the state of the switch. ON is active high and has a 1.2 V ON pin enable 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 1.2 V or higher GPIO voltage. This pin cannot be left floating and must be driven either high or low for proper functionality.

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Input Capacitor (C_{IN}) (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 1µF 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 (C_L) to avoid excessive voltage drop.

Output Capacitor (C_L) (Optional)

Because of 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 V_{OUT} to V_{IN}. 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 V_{IN} dip upon turn-on because of inrush currents. This can be mitigated by increasing the capacitance on the CT pin for a longer rise time.

Quick-Output Discharge

When the switch is disabled， an internal discharge resistance is connected between VOUT and GND to remove the remaining charge from the output. This resistance has a typical value of 230 Ω and prevents the output from floating while the switch is disabled. For best results, it is recommended that the device gets disabled before VBIAS falls below the minimum recommended voltage.

Thermal Shutdown

Thermal shutdown protects the part from internally or externally generated excessive temperatures. When the device temperature triggers TSD (typical 160°C), the switch is turned off. The switch automatically turns on again if the temperature of the die drops 20 degrees below the TSD threshold.

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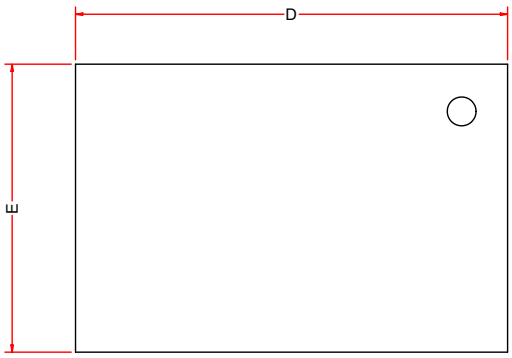
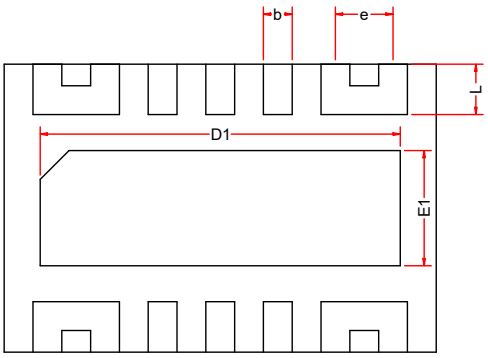
PACKAGE OUTLINE DIMENSIONS

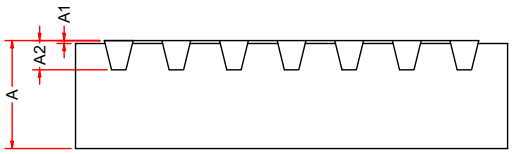
DFN3X2-14L



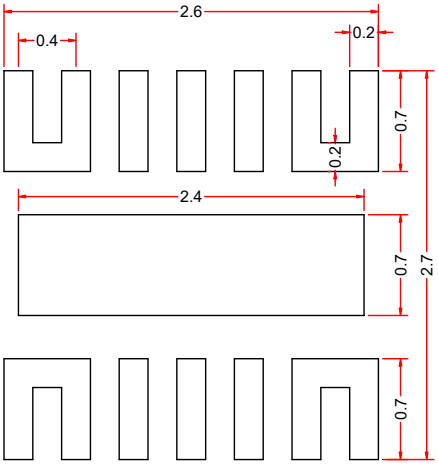
TOP VIEW



BOTTOM VIEW



SIDE VIEW



RECOMMENDED LAND PATTERN(unit:mm)

Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	0.70	0.75	0.80
A1	--	0.02	0.05
A2	0.203REF		
D	3BSC		
E	2BSC		
E1	0.75	0.80	0.85
D1	2.45	2.50	2.55
b	0.15	0.20	0.25
e	0.4BSC		
L	0.30	0.35	0.40

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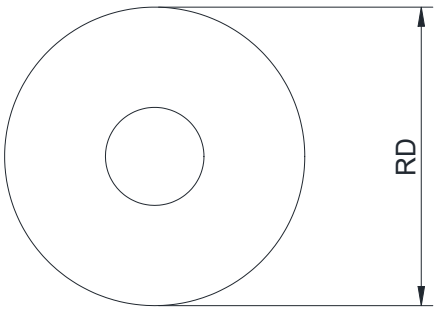
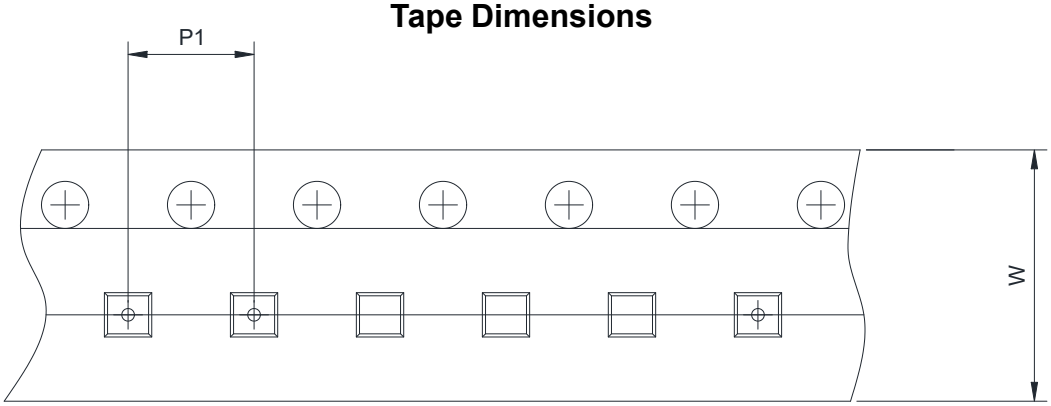
TAPE AND REEL INFORMATION

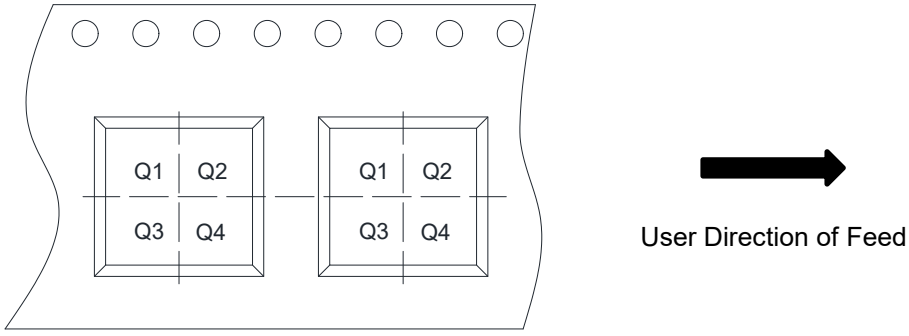
Reel Dimensions



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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