

## Description

The AP22913 slew rate controlled load switch is a single P-channel MOSFET power switch designed for high-side load-switching applications. The MOSFET has a typical  $R_{DS(on)}$  of 54mΩ at 5V (X1-WLB0909-4), allowing increased load current handling capacity with a low forward voltage drop. The turn-on slew rate of the device is controlled internally.  $V_{IN}$  and  $V_{OUT}$  are isolated during the OFF state with a TRCB (True Reverse Current Blocking) feature.

The AP22913 load switch is designed to operate from 1.4V to 5.5V, making it ideal for 1.8V, 2.5V, 3.3V, and 5V systems. The typical quiescent supply current is only 1μA.

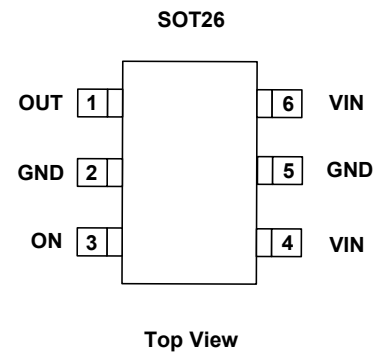
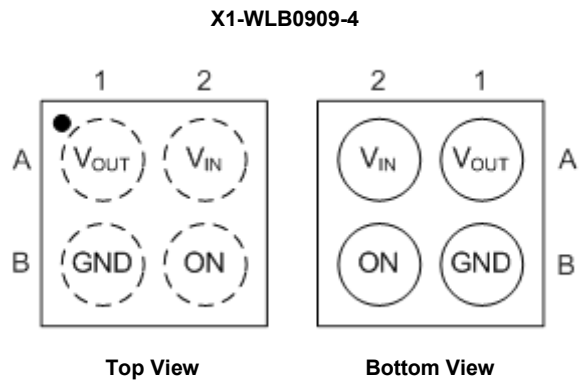
The AP22913 is available in the wafer level chip scale 4-pin, X1-WLB0909-4 0.5mm pitch and standard SOT26 package.

## Features

- Wide Input Voltage Range: 1.4V to 5.5V
- Low On-Resistance (X1-WLB0909-4):
  - 92mΩ Typical @1.5V
  - 76mΩ Typical @1.8V
  - 56mΩ Typical @3.3V
  - 54mΩ Typical @5.0V
- High DC Current Capability up to 2A
- Truly Reverse Current Block (TRCB)
- Discharging Resistor on  $V_{OUT}$  When Disabled
- Ultra-Low Quiescent Current 1μA
- Active-High Control Pin
  - Minimum 1.1V  $V_{IH}$  of ON
- ESD Protection:
  - Human Body Model: 2kV
  - Charged Device Model: 1kV
- Package:
  - SX1-WLB0909-4 with Backside Laminate
  - Standard Green SOT26
  - 0.9mm x 0.9mm, 0.5mm Ball Pitch
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please [contact us](https://www.diodes.com/quality/product-definitions/) or your local Diodes representative. <https://www.diodes.com/quality/product-definitions/>**

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.  
 2. See <https://www.diodes.com/quality/lead-free/> for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.  
 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

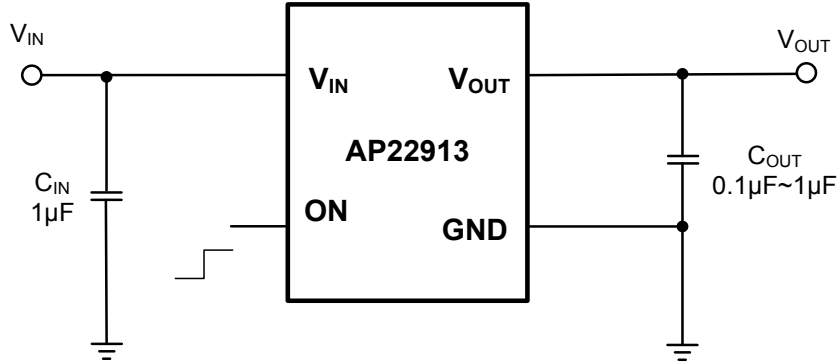
## Pin Assignments



## Applications

- Mobile Device and Smart Phones
- Portable Media Devices
- Wearable Devices
- Advanced Notebooks, UMPC and MID
- Portable Medical Devices
- GPS and Navigation Equipment

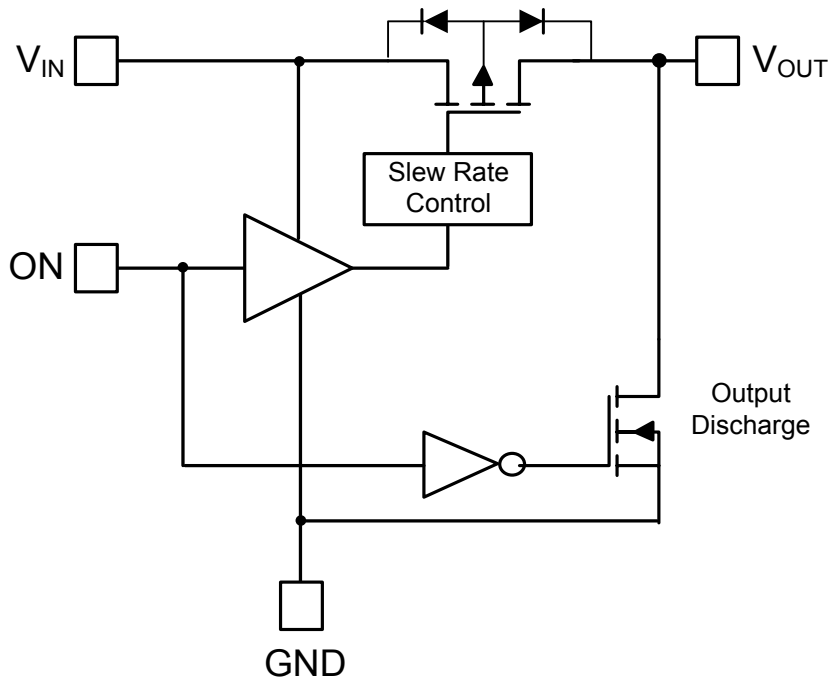
**Typical Applications Circuit**



**Pin Descriptions**

Pin Name	Pin Number	Function
	WLCSP	
V <sub>OUT</sub>	A1	Voltage output pin. This is the pin to the P-channel MOSFET drain connection. Bypass to ground through a 0.1µF or 1µF capacitor.
V <sub>IN</sub>	A2	Voltage input pin. This is the pin to the P-channel MOSFET source. Bypass to ground through a 1µF capacitor.
GND	B1	Ground.
ON	B2	Enable input, active high

**Functional Block Diagram**



### Absolute Maximum Ratings (@ $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

Symbol	Parameter	Ratings		Unit
ESD HBM	Human Body Model ESD Protection	6		kV
ESD CDM	Charged Device Model ESD Protection	2		kV
$V_{IN}$	Input Voltage	-0.3 to 6		V
$V_{OUT}$	Output Voltage	-0.3 to 6		V
$V_{ON}$	ON Voltage	-0.3 to 6		V
$I_{LOAD}$	Maximum Continuous Load Current	2		A
$I_{LOAD}$	Maximum Pulse Load Current, Pulse <300 $\mu\text{s}$ , 2% Duty Cycle	2.5		A
$T_J$	Maximum Junction Temperature	+125		$^\circ\text{C}$
$T_{ST}$	Storage Temperature Range	-65 to +150		$^\circ\text{C}$
$P_D$	Power Dissipation	WLB0909-4	930	mW
		SOT-26	760	
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient (Note 4)	WLB0909-4	136	$^\circ\text{C/W}$
		SOT-26	165	
$R_{\theta JC}$	Thermal Resistance, Junction to Case (Note 5)	WLB0909-4	31	$^\circ\text{C/W}$
		SOT-26	30	

- Notes:
- The JEDEC high-K (2s2p) board used to derive this data was a 3 inch x 3 inch, multilayer board with 1oz internal power and ground planes with 2oz copper traces on top and bottom of the board.
  - Thermal resistance from junction to case.

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

### Recommended Operating Conditions (@ $T_A = +25^\circ\text{C}$ , unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit	
$V_{IN}$	Input Voltage	1.4	5.5	V	
$V_{ON}$	ON Voltage Range	0	5.5	V	
$V_{OUT}$	Output Voltage	1.4	5.5	V	
$I_{OUT}$	Output Current	0	2.0	A	
$V_{IH}$	ON High-Level Input Voltage	1.1	5.5	V	
$V_{IL}$	ON Low-Level Input Voltage	$V_{IN} = 3.6\text{V to } 5.5\text{V}$	0	0.6	V
		$V_{IN} = 1.4\text{V to } 3.6\text{V}$	0	0.4	V
$T_A$	Operating Ambient Temperature	-40	+85	$^\circ\text{C}$	

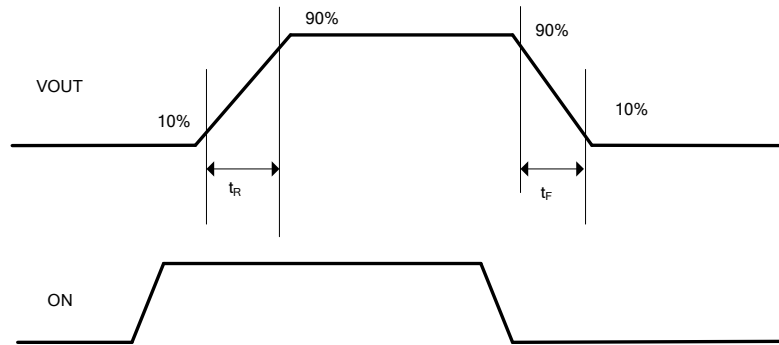
**Electrical Characteristics** ( $T_A = -40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ ,  $V_{IN} = 1.4$  to  $5.5\text{V}$ ,  $V_{ON} = V_{IN}$  (Enabled),  $V_{ON} = 0\text{V}$  (Disabled),  $C_{IN} = 1\mu\text{F}$ ,  $C_{OUT} = 0.1\mu\text{F}$ , unless otherwise specified.) (Note 6)

Symbol	Parameters	Test Conditions	Min	Typ	Max	Unit		
$I_Q$	Input Quiescent Current	$I_{OUT} = 0\text{mA}$ , $V_{ON} = \text{Enabled}$	$V_{IN} = 5.25\text{V}$	—	1.4	7	$\mu\text{A}$	
			$V_{IN} = 4.2\text{V}$	—	1	5		
			$V_{IN} = 3.6\text{V}$	—	0.7	5		
			$V_{IN} = 2.5\text{V}$	—	0.5	3.5		
			$V_{IN} = 1.5\text{V}$	—	0.3	3.5		
$I_{SHDN}$	Input Shutdown Current	$R_L = 1\text{M}\Omega$ , $V_{ON} = \text{Disabled}$	$V_{IN} = 5.25\text{V}$	—	0.1	1	$\mu\text{A}$	
			$V_{IN} = 4.2\text{V}$	—	0.1	1		
			$V_{IN} = 3.6\text{V}$	—	0.1	1		
			$V_{IN} = 2.5\text{V}$	—	0.1	1		
			$V_{IN} = 1.5\text{V}$	—	0.1	1		
$I_{IN\_LEAK}$	Input Leakage Current	$V_{OUT} = 0\text{V}$ , $V_{ON} = \text{Disabled}$	$V_{IN} = 5.25\text{V}$	—	0.1	2	$\mu\text{A}$	
			$V_{IN} = 4.2\text{V}$	—	0.1	2		
			$V_{IN} = 3.6\text{V}$	—	0.1	2		
			$V_{IN} = 2.5\text{V}$	—	0.1	2		
			$V_{IN} = 1.5\text{V}$	—	0.1	2		
$R_{DS(on)}$	Switch On-resistance, $I_{OUT} = -200\text{mA}$ at X1-WLB0909-4 package	$V_{IN} = 5.0\text{V}$	$+25^{\circ}\text{C}$	—	54	70	$\text{m}\Omega$	
			Full	—	—	95		
		$V_{IN} = 4.2\text{V}$	$+25^{\circ}\text{C}$	—	55	70		
			Full	—	—	95		
		$V_{IN} = 3.3\text{V}$	$+25^{\circ}\text{C}$	—	56	80		
			Full	—	—	95		
		$V_{IN} = 2.5\text{V}$	$+25^{\circ}\text{C}$	—	60	85		
	Full		—	—	115			
	$V_{IN} = 1.8\text{V}$	$+25^{\circ}\text{C}$	—	76	100			
		Full	—	—	130			
	$V_{IN} = 1.5\text{V}$	$+25^{\circ}\text{C}$	—	92	120			
		Full	—	—	150			
	Switch On-resistance, $I_{OUT} = -200\text{mA}$ at SOT26 package	$V_{IN} = 5.0\text{V}$	$25^{\circ}\text{C}$	—	84	100		$\text{m}\Omega$
			Full	—	—	125		
$V_{IN} = 4.2\text{V}$		$25^{\circ}\text{C}$	—	85	100			
		Full	—	—	125			
$V_{IN} = 3.3\text{V}$		$25^{\circ}\text{C}$	—	86	100			
		Full	—	—	125			
$V_{IN} = 2.5\text{V}$		$25^{\circ}\text{C}$	—	90	115			
	Full	—	—	145				
$V_{IN} = 1.8\text{V}$	$25^{\circ}\text{C}$	—	106	130				
	Full	—	—	160				
$V_{IN} = 1.5\text{V}$	$25^{\circ}\text{C}$	—	122	150				
	Full	—	—	180				
$R_{DIS}$	Discharge FET On-resistance	$V_{IN} = 3.3\text{V}$ , $V_{ON} = 0\text{V}$ , $I_{OUT} = 30\text{mA}$ , $T_A = +25^{\circ}\text{C}$	—	150	200	$\Omega$		
UVLO	Undervoltage Lockout	$V_{IN}$ increasing	—	—	1.2	$\text{V}$		
		$V_{IN}$ decreasing	0.5	—	—			
$V_{T\_RCB}$	TRCB Trigger Point	$V_{OUT} - V_{IN}$	—	44	—	$\text{mV}$		
$V_{R\_RCB}$	TRCB Release Point	$V_{IN} - V_{OUT}$	—	0	—	$\text{mV}$		
$t_{T\_RCB}$	TRCB Response Time	$V_{IN} = 5\text{V}$ , $V_{ON} = V_{IN}$	—	10	—	$\mu\text{s}$		
$I_{RCB}$	TRCB Reverse Leakage Current (Current from $V_{IN}$ )	$V_{OUT} - V_{IN} > V_{T\_RCB}$ , $V_{ON} = \text{Enabled}$	—	0.3	—	$\mu\text{A}$		
		$V_{IN} = 0\text{V}$ , $V_{OUT} = 5.5\text{V}$ , $V_{ON} = \text{Disabled}$	—	—	—			
$I_{ON}$	ON Input Leakage	$V_{ON} = 0\text{V}$ , $5.25\text{V}$ or $V_{ON} = V_{IN}$	—	—	1	$\mu\text{A}$		

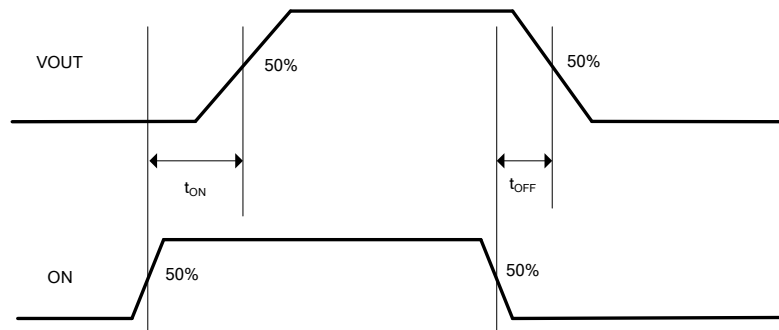
Note: 6. Specifications are over  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  and are guaranteed by characterization and design.

**Timing Characteristics** (Note 7)

Symbol	Parameters	Test Conditions	Min	Typ	Max	Unit
$t_{ON}$	Output Turn-on Time	$V_{IN} = 5V, R_L = 10\Omega, C_{OUT} = 0.1\mu F$	—	720	—	$\mu s$
$t_{OFF}$	Output Turn-off Time		—	5	—	$\mu s$
$t_R$	Output Rise Time		—	660	—	$\mu s$
$t_F$	Output Fall Time		—	2.5	—	$\mu s$
$t_{ON}$	Output Turn-on Time	$V_{IN} = 3.3V, R_L = 10\Omega, C_{OUT} = 0.1\mu F$	—	1050	—	$\mu s$
$t_{OFF}$	Output Turn-off Time		—	6.5	—	$\mu s$
$t_R$	Output Rise Time		—	770	—	$\mu s$
$t_F$	Output Fall Time		—	3.0	—	$\mu s$
$t_{ON}$	Output Turn-on Time	$V_{IN} = 1.5V, R_L = 10\Omega, C_{OUT} = 0.1\mu F$	—	2300	—	$\mu s$
$t_{OFF}$	Output Turn-off Time		—	18	—	$\mu s$
$t_R$	Output Rise Time		—	1400	—	$\mu s$
$t_F$	Output Fall Time		—	5.0	—	$\mu s$



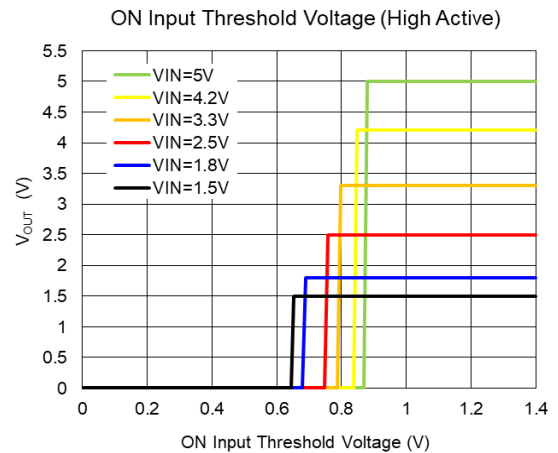
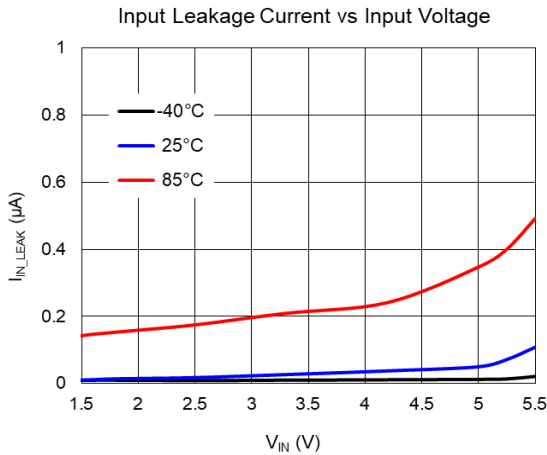
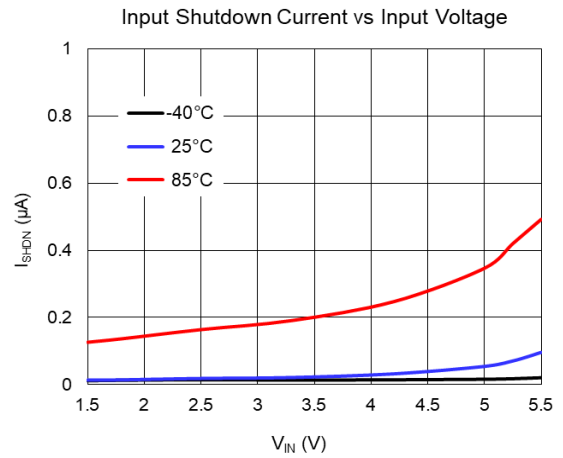
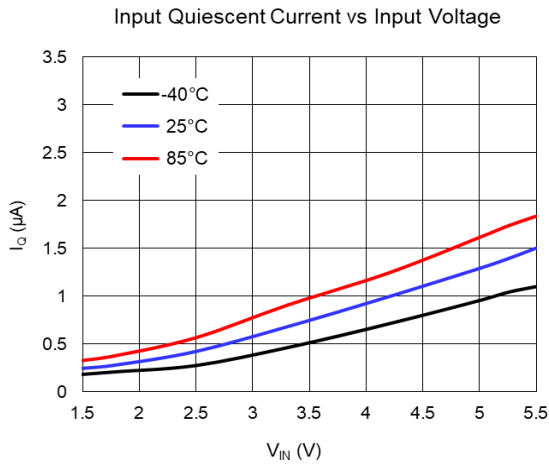
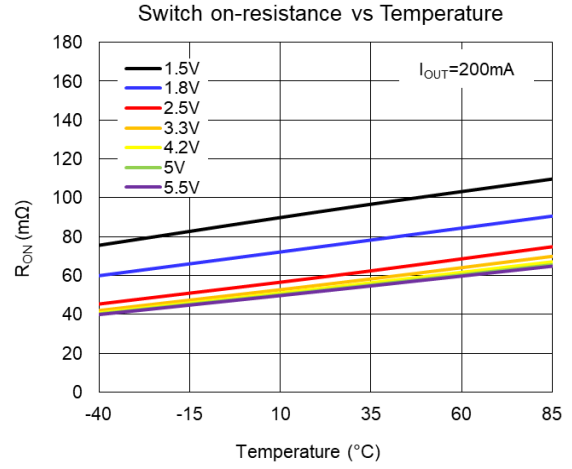
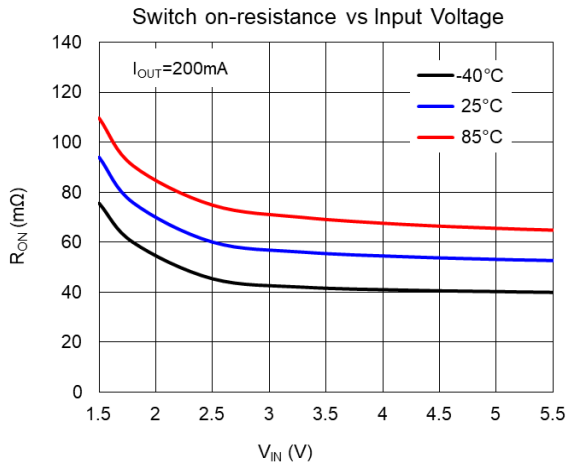
Output Rise ( $t_R$ ) and Fall ( $t_F$ ) Time



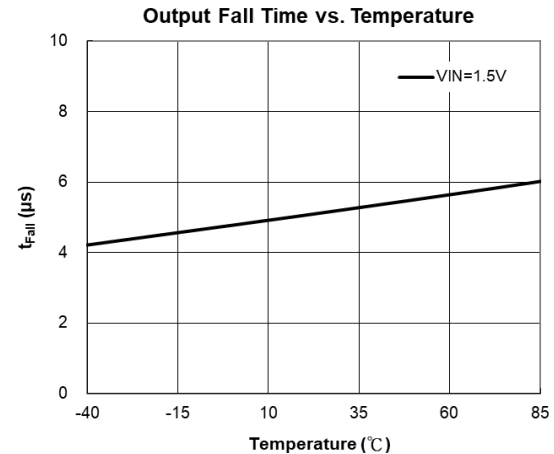
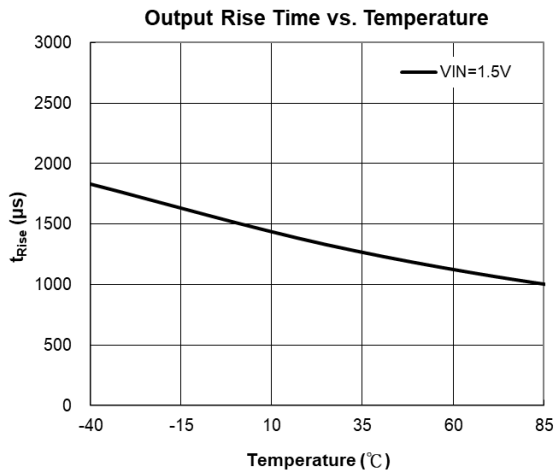
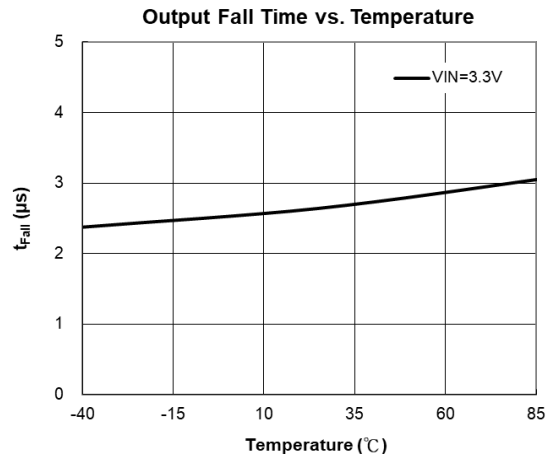
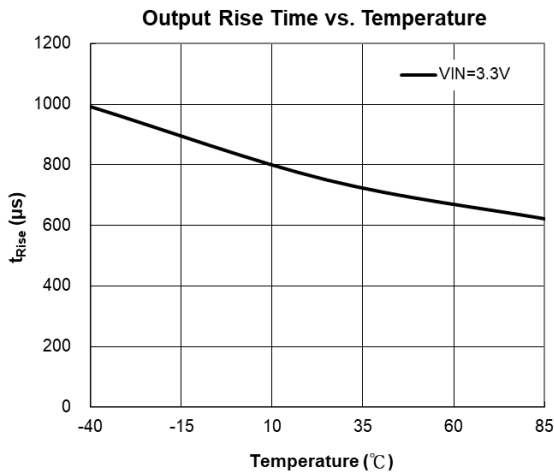
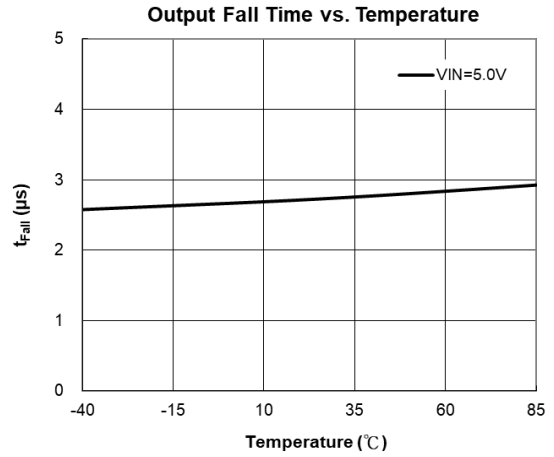
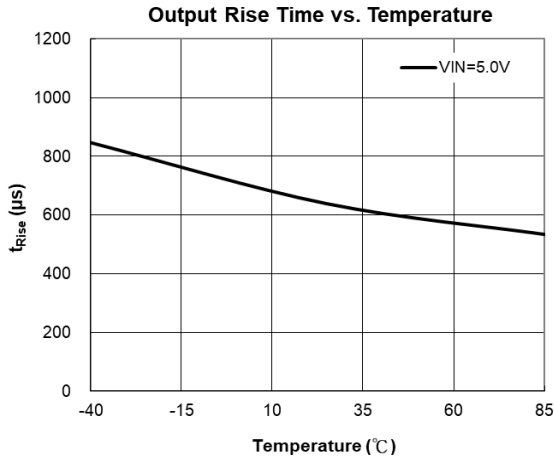
Output Turn On ( $t_{ON}$ ) and Turn Off ( $t_{OFF}$ ) Time

Note: 7. Rise and fall time of the control signal are less than 100ns.

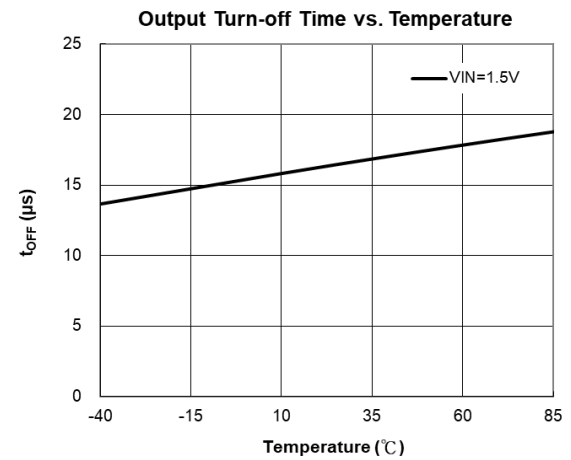
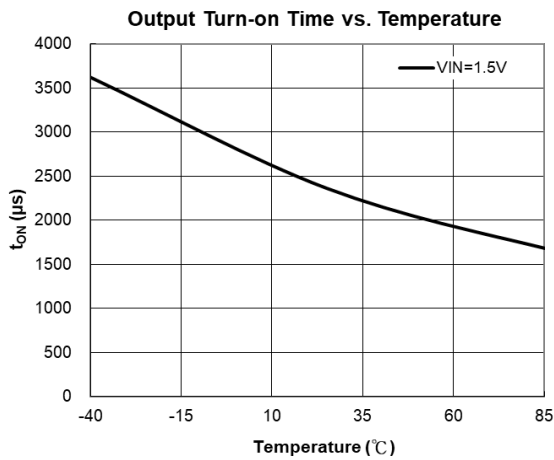
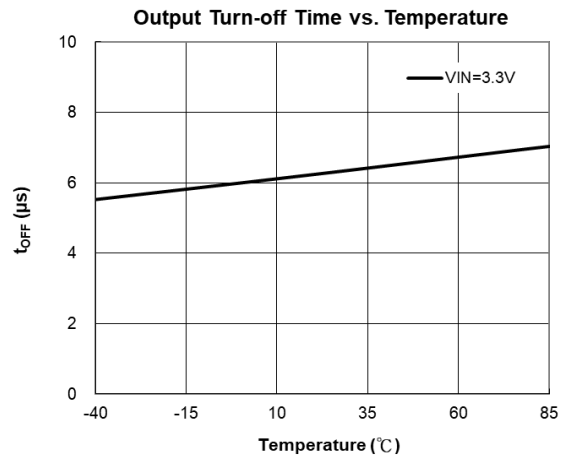
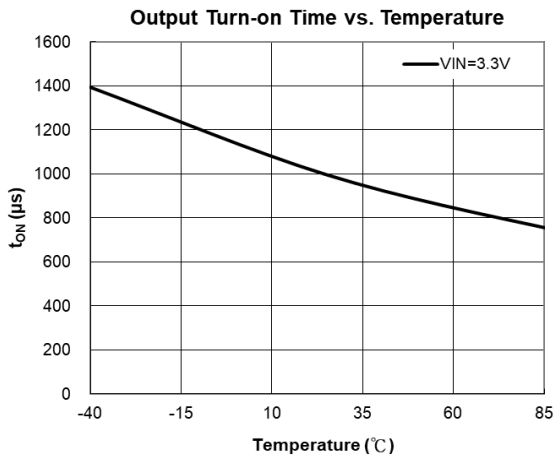
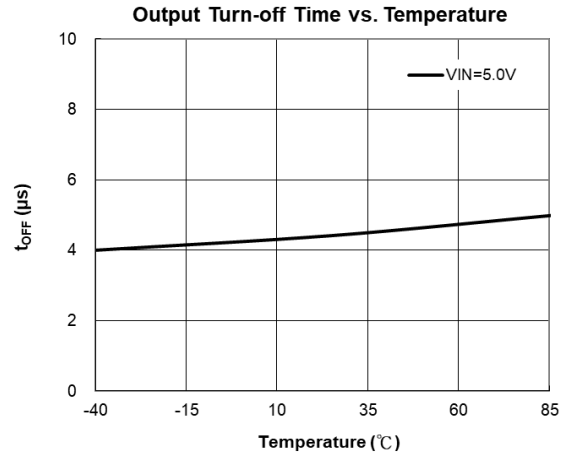
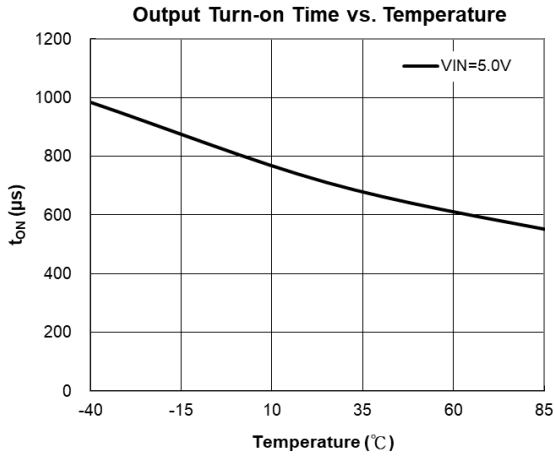
**Typical Performance Characteristics** ( $C_{IN} = 1\mu F$ ,  $C_{OUT} = 0.1\mu F$ , unless otherwise specified.)



**Typical Performance Characteristics** (continued) ( $C_{IN} = 1\mu F$ ,  $C_{OUT} = 0.1\mu F$ ,  $R_L = 10\Omega$ , unless otherwise specified.)

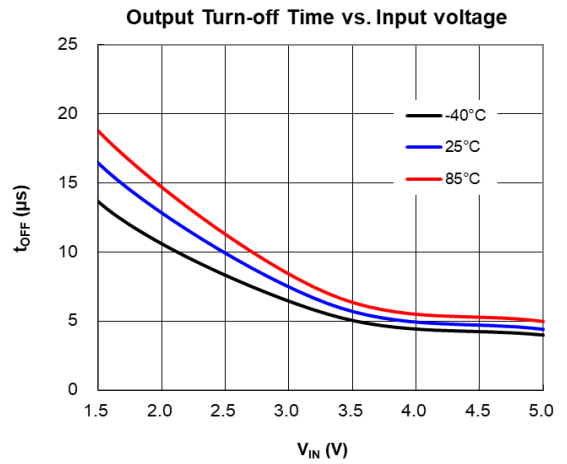
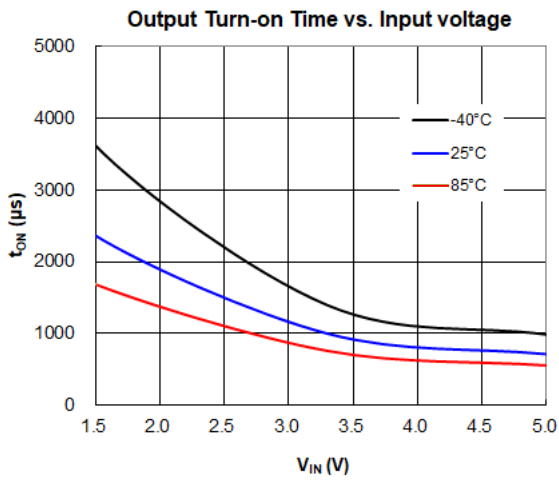
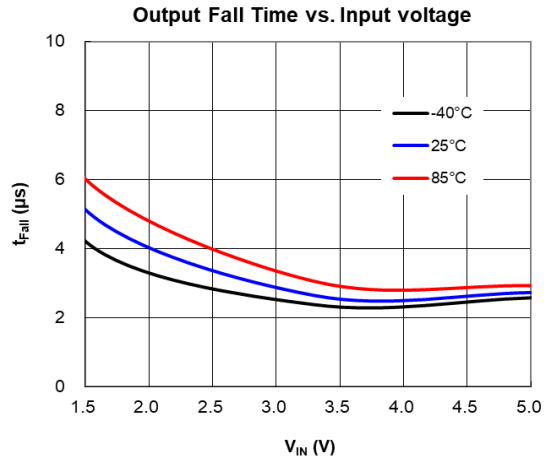
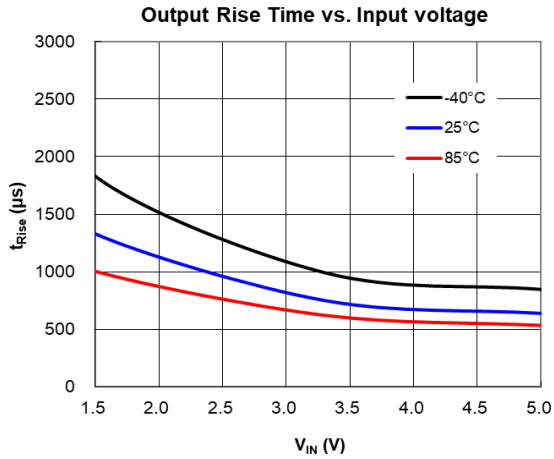


**Typical Performance Characteristics** (continued) ( $C_{IN} = 1\mu F$ ,  $C_{OUT} = 0.1\mu F$ ,  $R_L = 10\Omega$ , unless otherwise specified.)





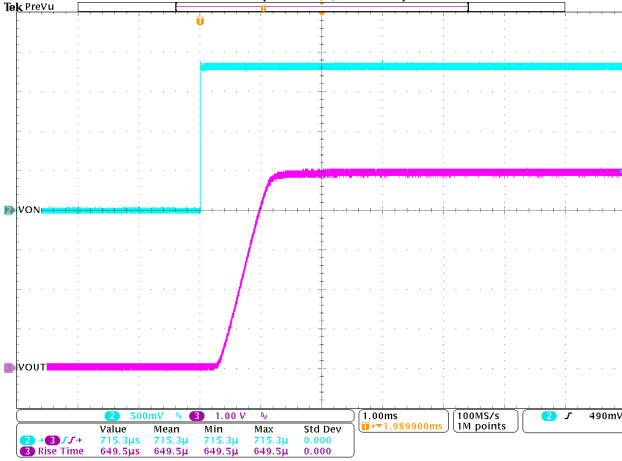
**Typical Performance Characteristics** (continued) ( $C_{IN} = 1\mu F$ ,  $C_{OUT} = 0.1\mu F$ ,  $R_L = 10\Omega$ , unless otherwise specified.)



**Typical Performance Characteristics** (continued) ( $T_A = +25^\circ\text{C}$ ,  $V_{ON} = 1.8\text{V}$ , unless otherwise specified.)

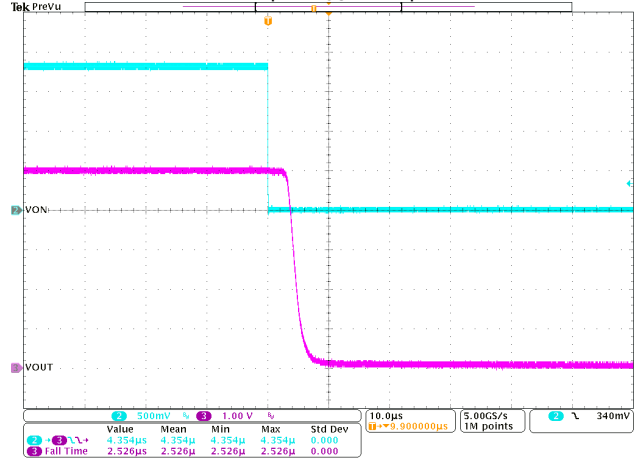
**Output Turn On Response**

$V_{IN} = 5\text{V}$ ,  $C_{IN} = 1\mu\text{F}$ ,  $C_{OUT} = 0.1\mu\text{F}$ ,  $R_L = 10\Omega$



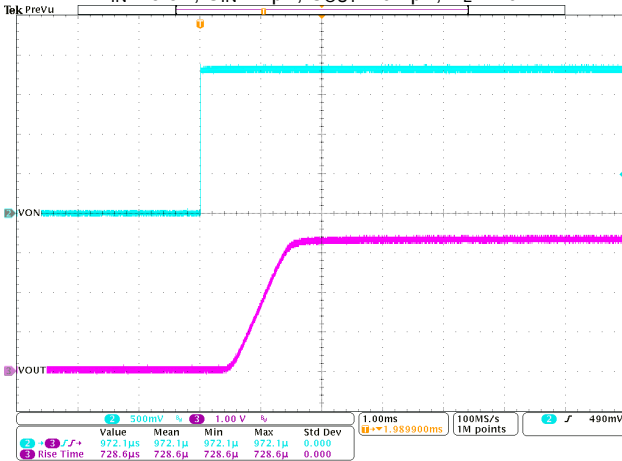
**Output Turn Off Response**

$V_{IN} = 5\text{V}$ ,  $C_{IN} = 1\mu\text{F}$ ,  $C_{OUT} = 0.1\mu\text{F}$ ,  $R_L = 10\Omega$



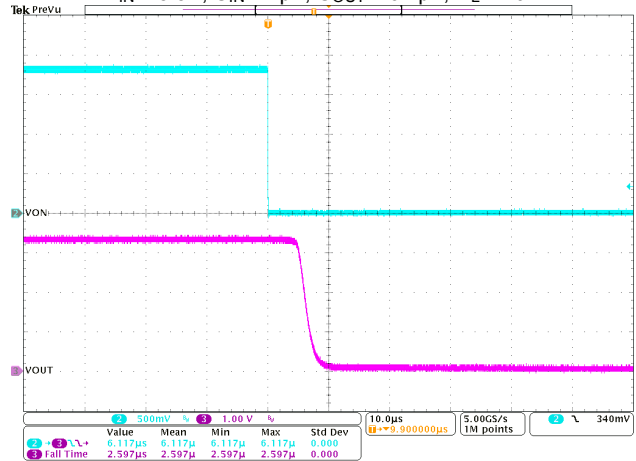
**Output Turn On Response**

$V_{IN} = 3.3\text{V}$ ,  $C_{IN} = 1\mu\text{F}$ ,  $C_{OUT} = 0.1\mu\text{F}$ ,  $R_L = 10\Omega$



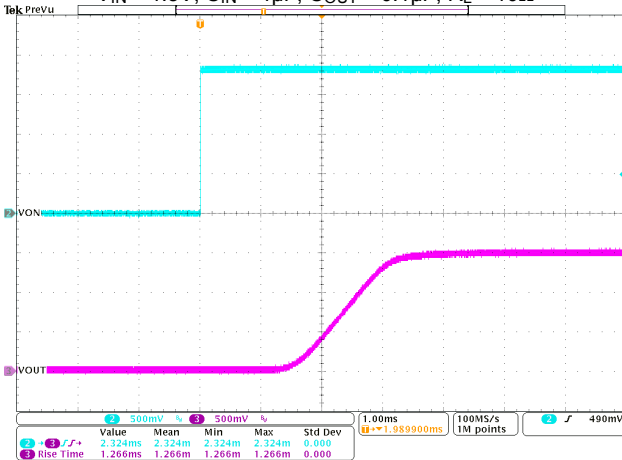
**Output Turn Off Response**

$V_{IN} = 3.3\text{V}$ ,  $C_{IN} = 1\mu\text{F}$ ,  $C_{OUT} = 0.1\mu\text{F}$ ,  $R_L = 10\Omega$



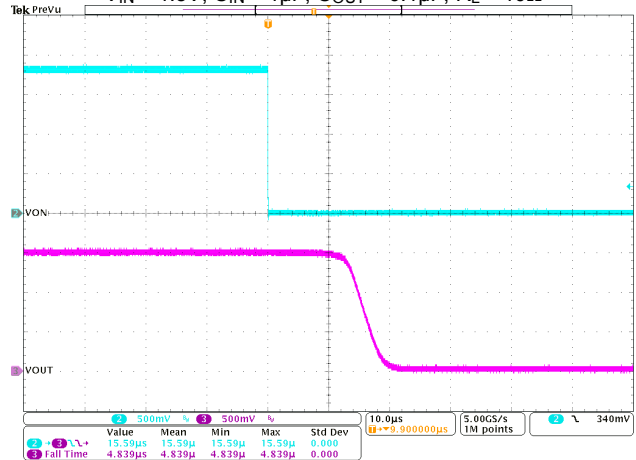
**Output Turn On Response**

$V_{IN} = 1.5\text{V}$ ,  $C_{IN} = 1\mu\text{F}$ ,  $C_{OUT} = 0.1\mu\text{F}$ ,  $R_L = 10\Omega$

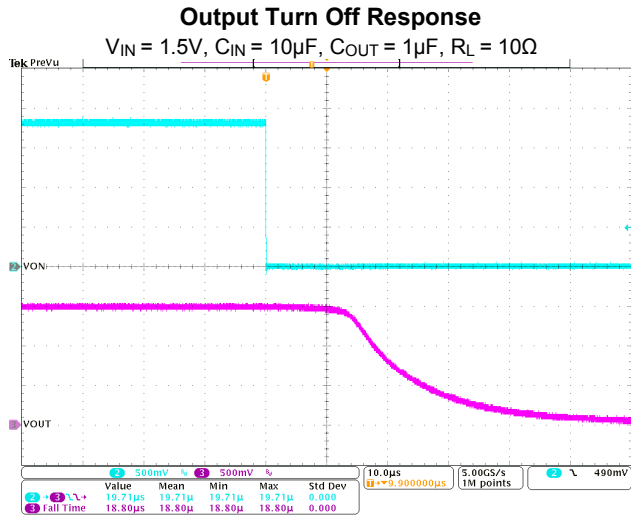
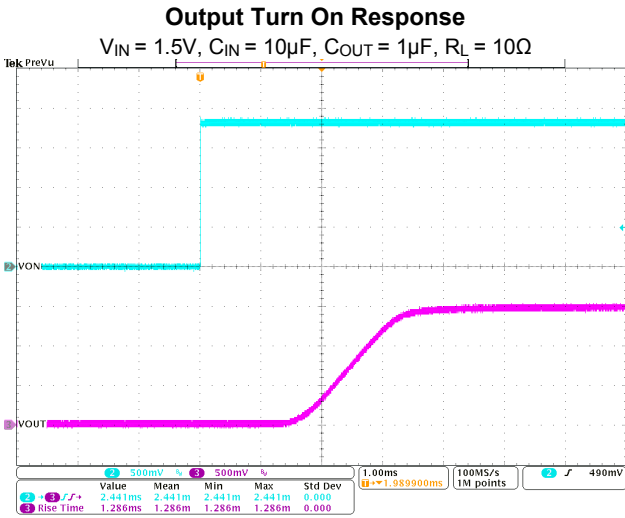
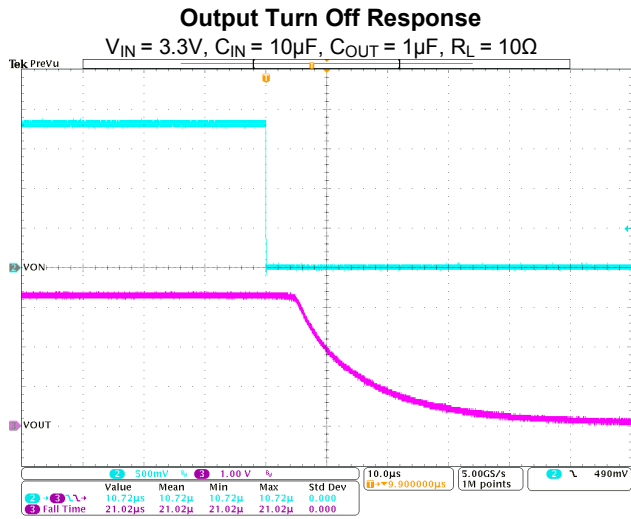
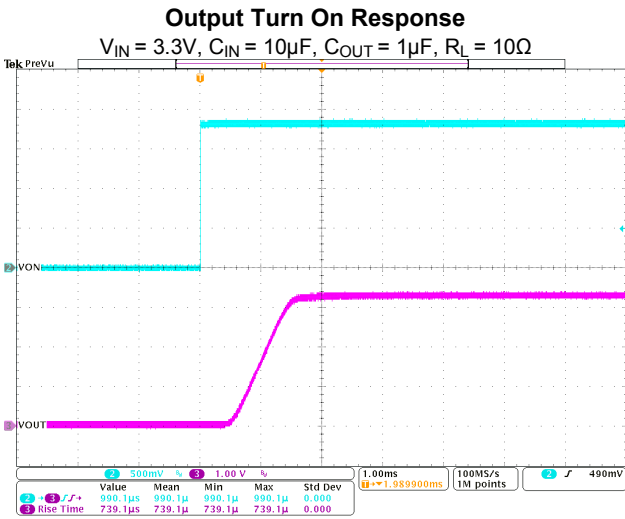
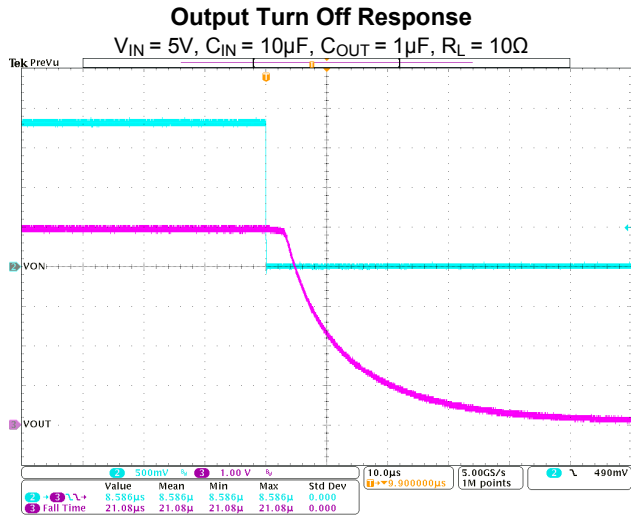
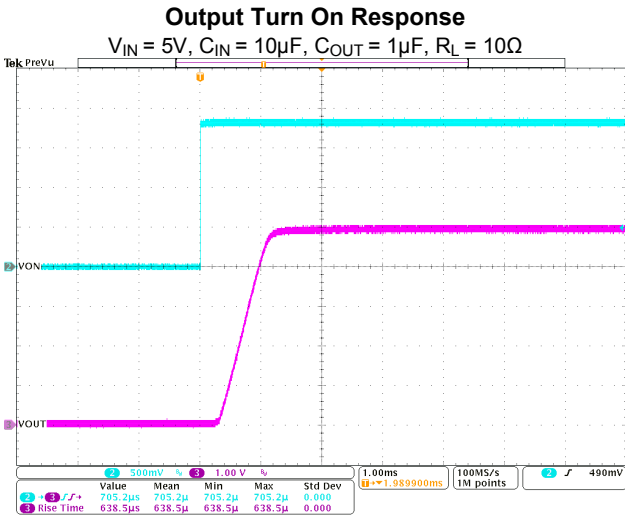


**Output Turn Off Response**

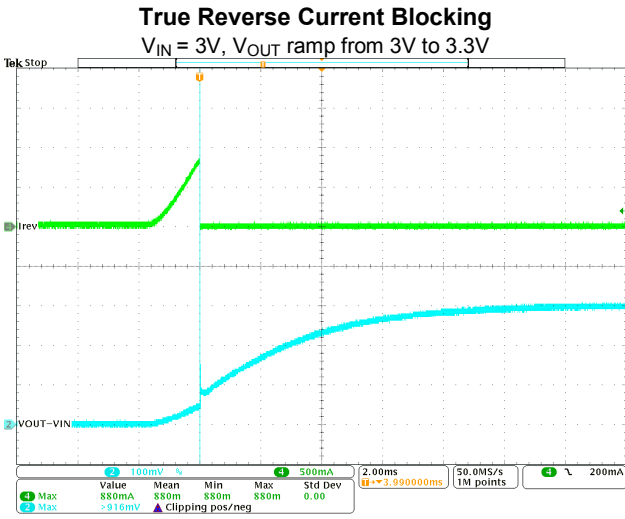
$V_{IN} = 1.5\text{V}$ ,  $C_{IN} = 1\mu\text{F}$ ,  $C_{OUT} = 0.1\mu\text{F}$ ,  $R_L = 10\Omega$



**Typical Performance Characteristics** (continued) ( $T_A = +25^\circ\text{C}$ ,  $V_{ON} = 1.8\text{V}$ , unless otherwise specified.)



**Typical Performance Characteristics** (continued) ( $T_A = +25^\circ\text{C}$ ,  $C_{IN} = 1\mu\text{F}$ ,  $C_{OUT} = 0.1\mu\text{F}$ , unless otherwise specified.)



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## Application Information

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### Input Capacitor

A 1 $\mu$ F capacitor is recommended to connect between the V<sub>IN</sub> and GND pins to decouple glitch and noise of the input power supply. The input capacitor has no specific type or ESR (Equivalent Series Resistance) requirement. However, for higher current application, ceramic capacitors are recommended due to their capability to withstand input current surges from low impedance sources, such as batteries in portable applications. This input capacitor must be located as close as possible to the device to assure input stability and less noise. For PCB layout, a wide copper trace is required for both V<sub>IN</sub> and GND.

### Output Capacitor

The 0.1 $\mu$ F to 1 $\mu$ F capacitor is recommended to connect between the V<sub>OUT</sub> and GND pins to stabilize and accommodate load transient condition. The output capacitor has no specific type or ESR requirement. The amount of the capacitance may be increased without limit. For PCB layout, the output capacitor must be placed as close as possible to V<sub>OUT</sub> and GND pins. The traces must be kept as short as possible.

### Enable/Shutdown Operation

The AP22913 is turned on by setting the ON pin high, and is turned off by pulling it low. To ensure proper operation, the signal source used to drive the ON pin must be able to swing above and below the specified turn-on/off voltage thresholds listed in the Electrical Characteristics section under V<sub>IL</sub> and V<sub>IH</sub>.

### True Reverse Current Blocking

An internal reverse voltage comparator disables the power-switch when the output voltage (V<sub>OUT</sub>) is driven higher than the input voltage (V<sub>IN</sub>), by V<sub>T\_RCB</sub>, to quickly (10 $\mu$ s typ) stop the flow of current towards the input side of the switch.

Reverse current protection is always active, even when the power switch is disabled. Additionally, undervoltage lockout (UVLO) protection turns the switch off if the input voltage is too low.

### Discharge Operation

The AP22913 offers a discharge option that helps to discharge the output charge when disabled.

### Power Dissipation

The maximum IC junction temperature should be restricted to +125°C under normal operating conditions. The device power dissipation and proper sizing of the thermal plane is critical to avoid thermal shutdown and ensure reliable operation. Power dissipation of the device depends on input voltage and load conditions and can be calculated by:

$$P_D = I_{OUT}^2 \times R_{DSON} \quad (1)$$

However, the maximum power dissipation that can be handled by the device depends on the maximum junction to ambient thermal resistance, maximum ambient temperature, and maximum device junction temperature, which can be approximated by the equation below:

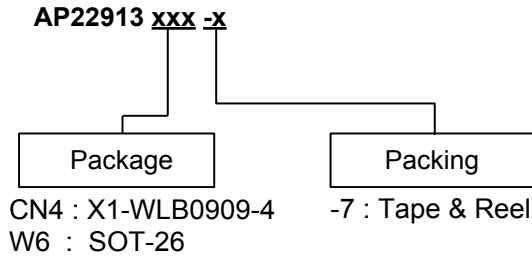
$$P_{D(MAX)} = \frac{(125^\circ\text{C} - T_A)}{\theta_{JA}} \quad (2)$$

### Layout Guidelines

Good PCB layout is important for improving the thermal performance of the device. All trace lengths should be kept as short as possible. The input (V<sub>IN</sub>) and output (V<sub>OUT</sub>) PCB traces should be as wide as possible to reduce stray impedance.

Use a ground plane to enhance the power dissipation capability of the device if applicable. Place input and output capacitors close to the device to minimize the effects of parasitic inductance.

**Ordering Information**

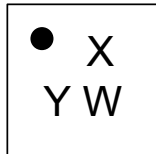


Part Number	Package Code	Packaging	7" Tape and Reel	
			Quantity	Part Number Suffix
AP22913CN4-7	CN4	X1-WLB0909-4	3,000/Tape & Reel	-7
AP22913W6-7	W6	SOT26	3,000/Tape & Reel	-7

**Marking Information**

(1) X1-WLB0909-4

(Top View)

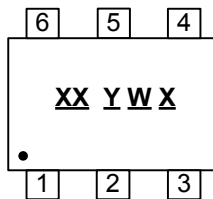


X : Identification Code  
Y : Year : 0~9  
W : Week : A~Z : 1~26 week;  
a~z : 27~52 week; z represents  
52 and 53 week

Part Number	Package	Identification Code
AP22913CN4-7	X1-WLB0909-4	<u>C</u>

(2) SOT-26

( Top View )



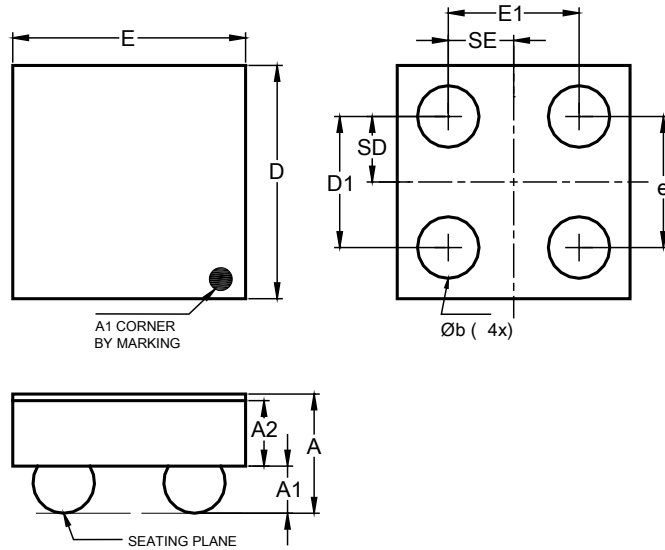
XX : Identification Code  
Y : Year 0~9  
W : Week : A~Z : 1~26 week;  
a~z : 27~52 week; z represents  
52 and 53 week  
X : Internal Code

Part Number	Package	Identification Code
AP22913W6-7	SOT26	N9

**Package Outline Dimensions**

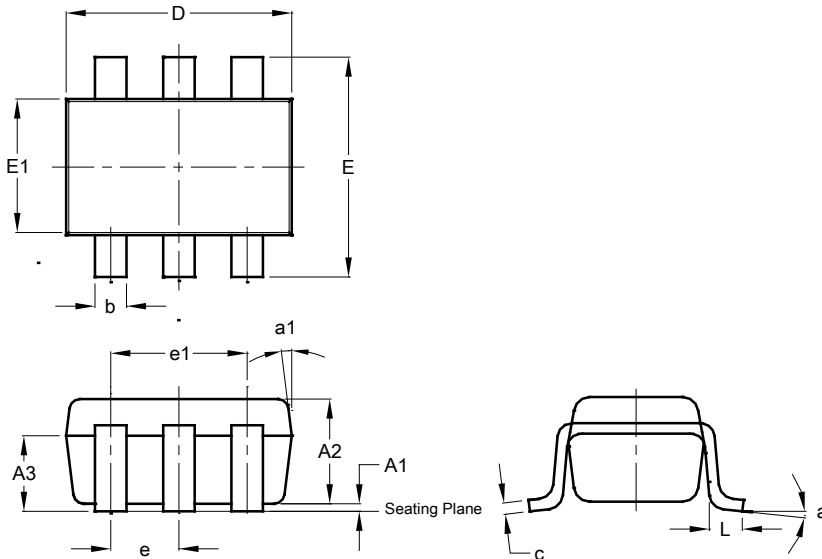
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**X1-WLB0909-4**



X1-WLB0909-4			
Dim	Min	Max	Typ
A	0.410	0.500	0.455
A1	0.160	0.200	0.180
A2	0.225	0.275	0.250
b	0.215	0.255	0.235
D	0.840	0.900	0.870
D1	0.450	0.550	0.500
E	0.840	0.900	0.870
E1	0.450	0.550	0.500
e	0.500 BSC		
SD	0.250 BSC		
SE	0.250 BSC		
All Dimensions in mm			

**SOT26**

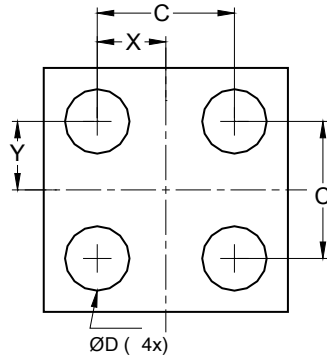


SOT26			
Dim	Min	Max	Typ
A1	0.013	0.10	0.05
A2	1.00	1.30	1.10
A3	0.70	0.80	0.75
b	0.35	0.50	0.38
c	0.10	0.20	0.15
D	2.90	3.10	3.00
e	-	-	0.95
e1	-	-	1.90
E	2.70	3.00	2.80
E1	1.50	1.70	1.60
L	0.35	0.55	0.40
a	-	-	8°
a1	-	-	7°
All Dimensions in mm			

**Suggested Pad Layout**

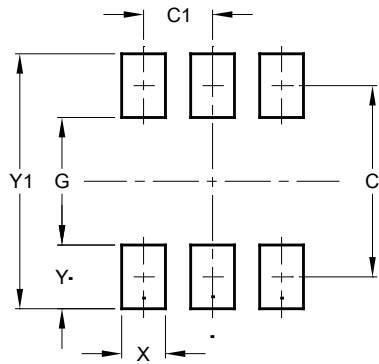
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

**X1-WLB0909-4**



Dimensions	Value (in mm)
<b>C</b>	0.500
<b>D</b>	0.235
<b>X</b>	0.250
<b>Y</b>	0.250

**SOT26**



Dimensions	Value (in mm)
<b>C</b>	2.40
<b>C1</b>	0.95
<b>G</b>	1.60
<b>X</b>	0.55
<b>Y</b>	0.80
<b>Y1</b>	3.20



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