1.5A SINGLE SLEW RATE CONTROLLED LOAD SWITCH

Description

The AP22908 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 low $R_{DS(ON)}$ of 28mΩ at 3.6V, allowing increased load current handling capacity with a low forward voltage drop. The turn-on slew rate of the device is controlled internally to avoid inrush current.

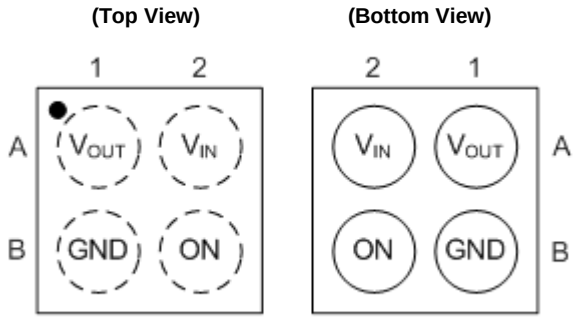
The AP22908 load switch is designed to operate from 1.08V to 3.6V, making it ideal for 1.2V, 1.8V, 2.5V, 3.3V and 3.6V systems. The typical quiescent supply current is only 0.05µA.

The AP22908 is available in the wafer level chip scale 4-pin, X1-WLB0909-4 0.5mm pitch, U-WLB0909-4 0.5mm pitch, and standard SOT26 packages.

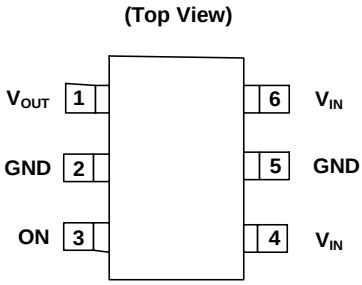
Features

- Wide Input Voltage Range: 1.08V to 3.6V
- Low On-Resistance:
  - 69mΩ Typical @1.2V
  - 41mΩ Typical @1.8V
  - 33mΩ Typical @2.5V
  - 28mΩ Typical @3.6V
- High DC Current Capability up to 1.5A
- Quick Discharging by Output Discharge Resistance
- Ultra-Low Quiescent Current 0.05µA
- Active-High Control Pin
  - Minimum 0.9V V_{IH} of ON
- ESD Protection:
  - Human Body Model: 2kV
  - Charged Device Model: 1kV
- Package:
  - X1-WLB0909-4 with Backside Laminate
  - U-WLB0909-4 with Backside Laminate
  - 0.87mm × 0.87mm, 0.5mm Ball Pitch
  - Standard Green SOT26
- Solder Ball Material: SnAgCu
- **Totally Lead-Free and 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-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative.**
  https://www.diodes.com/quality/product-definitions/

Pin Assignments



X1-WLB0909-4 & U-WLB0909-4



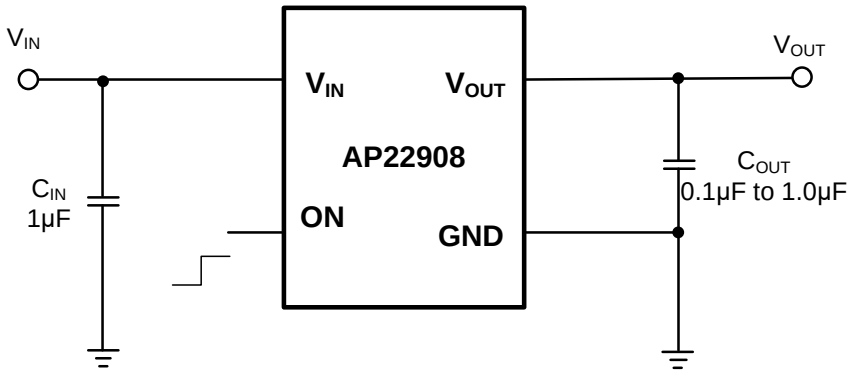
SOT26

Applications

- Mobile devices and smart phones
- Portable media devices
- Wearable devices
- Advanced notebooks, UMPC, and MID
- Portable medical devices
- GPS and navigation equipment
- Portable instrumentation

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.

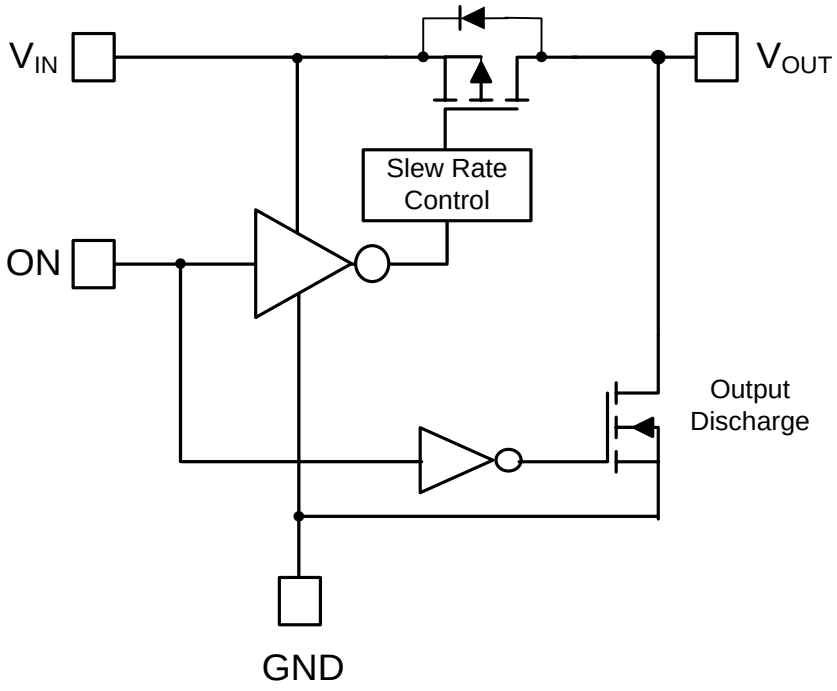
Typical Applications Circuit



Pin Descriptions

Pin Name	Pin Number		Function
	SOT26	X1-WLB0909-4 U-WLB0909-4	
V_{OUT}	1	A1	Voltage output pin. This is the pin to the P-channel MOSFET drain connection. Bypass to ground through a 0.1µF to 1µF capacitor.
V_{IN}	4, 6	A2	Voltage input pin. This is the pin to the P-channel MOSFET source. Bypass to ground through a 1µF capacitor.
GND	2, 5	B1	Ground
ON	3	B2	Enable input, active high

Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Ratings		Unit
ESD HBM	Human Body Model ESD Protection	2		kV
ESD CDM	Charged Device Model ESD Protection	1		kV
V_{IN}	Input Voltage	-0.3 to 4		V
V_{OUT}	Output Voltage	-0.3 to 4		V
V_{ON}	ON Voltage	-0.3 to 4		V
I_{OUT}	Maximum Continuous Output Current (V_{IN} ≥ 1.2V)	1.5		A
I_{OUT}	Maximum Pulse Output Current, Pulse <300μs, 2% Duty Cycle	2.5		A
T_J	Maximum Junction Temperature	-40 ~+125		°C
T_{STG}	Storage Temperature Range	-65 to +150		°C
P_D	Power Dissipation	X1-WLB0909-4 U-WLB0909-4	735	mW
		SOT26	606	mW
$R_{\theta JA}$	Thermal Resistance, Junction to Ambient (Note 4)	X1-WLB0909-4 U-WLB0909-4	136	°C/W
		SOT26	165	°C/W
$R_{\theta JC}$	Thermal Resistance, Junction to Case (Note 5)	X1-WLB0909-4 U-WLB0909-4	31	°C/W
		SOT26	30	°C/W

Notes: 4. The JEDEC high-K (2s2p) board used to derive this data was a 3 inch × 3 inch, multilayer board with 1oz internal power and ground planes with 2oz copper traces on top and bottom of the board.
5. Thermal resistance from junction to case.

Caution: Stresses greater than the '*Absolute Maximum Ratings*' specified above, can 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 can be affected by exposure to absolute maximum rating conditions for extended periods of time.

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
V_{IN}	Input Voltage	1.08	3.6	V
V_{ON}	ON Voltage Range	0	3.6	V
V_{OUT}	Output Voltage	0	3.6	V
I_{OUT}	Output Current	0	1.5	A
V_{IH}	ON High-Level Input Voltage	0.9	3.6	V
V_{IL}	ON Low-Level Input Voltage	0	0.38	V
T_A	Operating Ambient Temperature	-40	+85	°C

Electrical Characteristics

(T_A = -40ºC to +85ºC, V_{IN} = 1.08V to 3.6V, V_{ON} = V_{IN}(enabled), V_{ON} = 0V(disabled), C_{IN} = 1µF, C_{OUT} = 0.1µF, typical values are at T_A = +25°C, unless otherwise specified.) (Note 6)

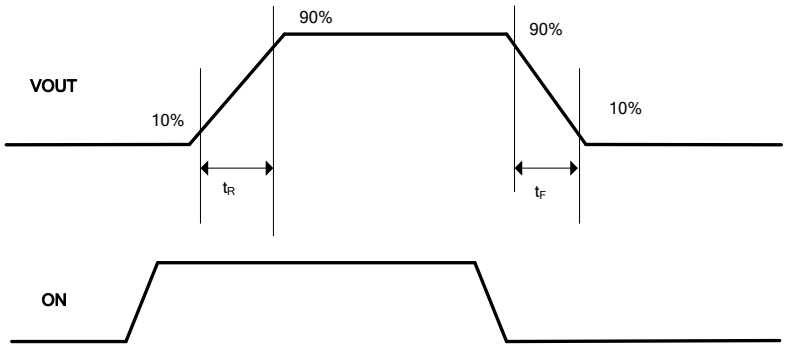
Symbol	Parameters	Test Conditions		Min	Typ	Max	Unit
I_Q	Input Quiescent Current	I_{OUT} = 0mA, V_{ON} = V_{IN}(Enabled)	T_A = -40ºC to +85ºC	—	0.05	1	µA
I_{SHDN}	Input Shutdown Current	R_L = 1MΩ, V_{ON} = Disabled	T_A = -40ºC to +85ºC	—	0.04	0.5	µA
I_{IN_LEAK}	Input Leakage Current	V_{OUT} = 0V, V_{ON} = Disabled	T_A = -40ºC to +85ºC	—	0.04	0.5	µA
I_{ON}	ON Input leakage	V_{ON} = 1.1V to 3.6V or V_{ON} = V_{IN}	T_A = -40ºC to +85ºC	—	0.01	0.1	µA
$R_{DS(ON)}$	X1-WLB0909-4 & U-WLB0909-4 Package, Switch On-Resistance, I_{OUT} = -200mA	V_{IN} = 3.6V	T_A = +25°C	—	28	32	mΩ
			T_A = -40ºC to +85ºC	—	—	40	
		V_{IN} = 2.5V	T_A = +25°C	—	33	38	
			T_A = -40ºC to +85ºC	—	—	45	
		V_{IN} = 1.8V	T_A = +25°C	—	41	50	
			T_A = -40ºC to +85ºC	—	—	54	
		V_{IN} = 1.2V	T_A = +25°C	—	69	87	
			T_A = -40ºC to +85ºC	—	—	91	
		V_{IN} = 1.08V	T_A = +25°C	—	112	155	
			T_A = -40ºC to +85ºC	—	—	165	
	SOT26 Package, Switch On-Resistance, I_{OUT} = -200mA	V_{IN} = 3.6V	T_A = +25°C	—	40	43	mΩ
			T_A = -40ºC to +85ºC	—	—	55	
		V_{IN} = 2.5V	T_A = +25°C	—	45	49	
			T_A = -40ºC to +85ºC	—	—	59	
		V_{IN} = 1.8V	T_A = +25°C	—	53	62	
			T_A = -40ºC to +85ºC	—	—	69	
		V_{IN} = 1.2V	T_A = +25°C	—	91	110	
			T_A = -40ºC to +85ºC	—	—	120	
		V_{IN} = 1.08V	T_A = +25°C	—	120	175	
			T_A = -40ºC to +85ºC	—	—	185	
R_{DIS}	Discharge FET On-Resistance	V_{IN} = 3.3V, V_{ON} = 0V, I_{OUT} = 30mA, T_A = +25°C		—	80	100	Ω

Note: 6. Specifications are over -40ºC to +85ºC and are guaranteed by characterization and design.

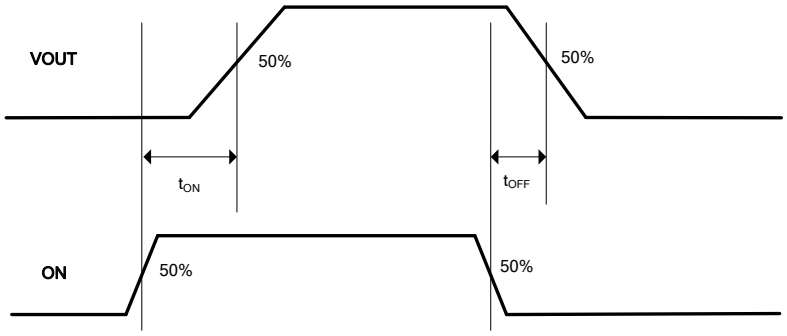
Timing Characteristics (Note 7)

Symbol	Parameters	Test Conditions	Min	Typ	Max	Unit
t_{ON}	Output Turn-On Time	V_{IN} = 3.6V, R_L = 10Ω, C_{OUT} = 0.1μF, T_A = +25ºC	—	110	—	μs
t_{OFF}	Output Turn-Off Time		—	5	—	μs
t_R	Output Rise Time		—	105	—	μs
t_F	Output Fall Time		—	2	—	μs
t_{ON}	Output Turn-On Time	V_{IN} = 1.08V, R_L = 10Ω, C_{OUT} = 0.1μF, T_A = +25ºC	—	900	—	μs
t_{OFF}	Output Turn-Off Time		—	5	—	μs
t_R	Output Rise Time		—	442	—	μs
t_F	Output Fall Time		—	2	—	μs

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



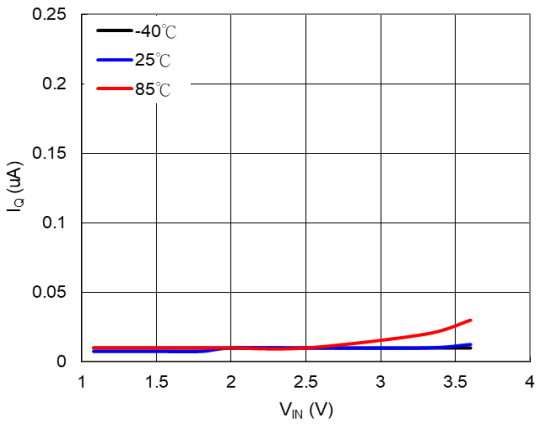
Output Rise (t_R) and Fall (t_F) Time



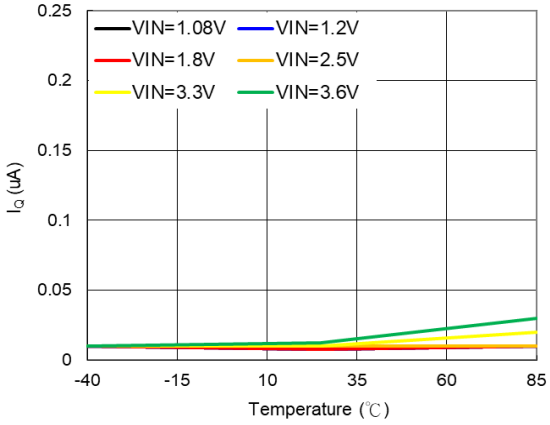
Output Turn On (t_{ON}) and Turn Off (t_{OFF}) time

Typical Performance Characteristics (C_{IN} = 1μF, C_{OUT} = 0.1μF, unless otherwise specified.)

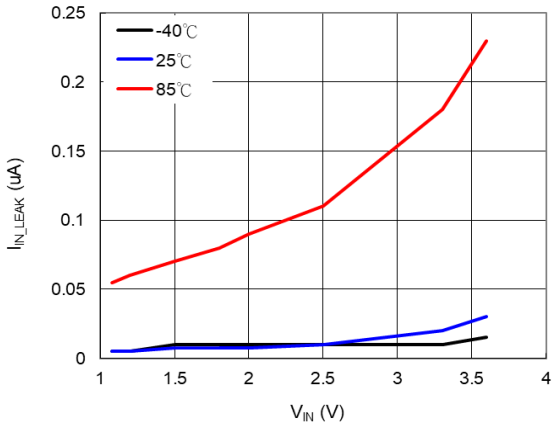
Quiescent Current vs. Input voltage



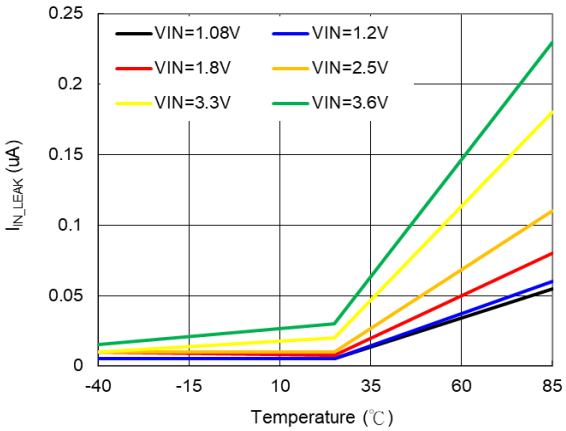
Quiescent Current vs. Temperature



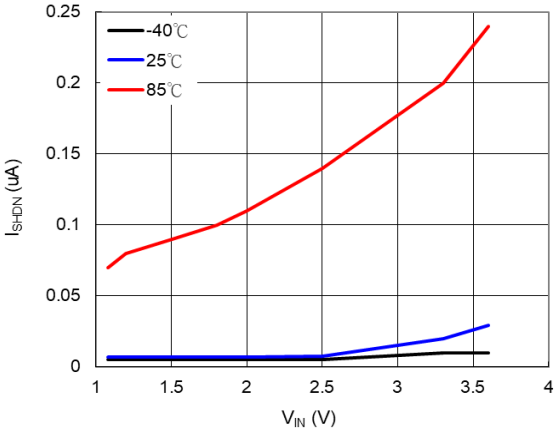
Leakage Current vs. Input voltage



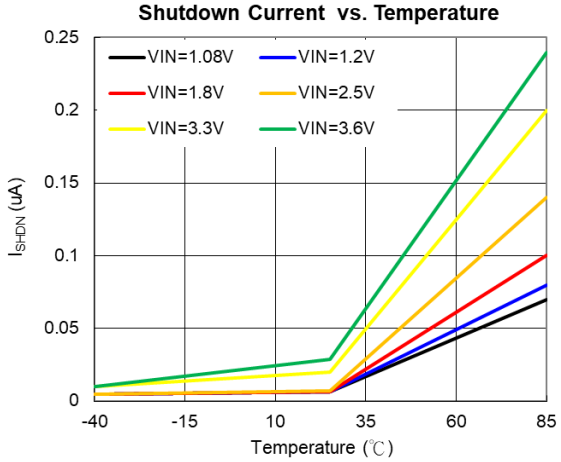
Leakage Current vs. Temperature



Shutdown Current vs. Input voltage

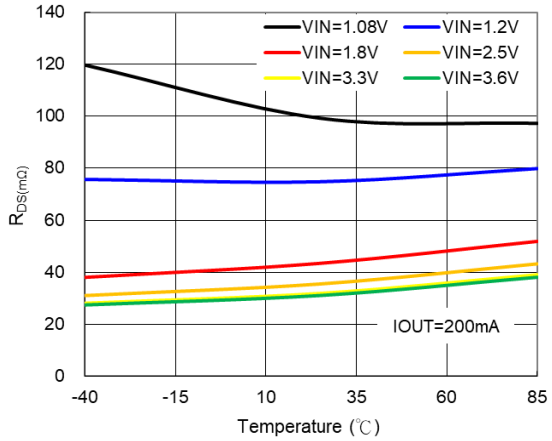


Shutdown Current vs. Temperature

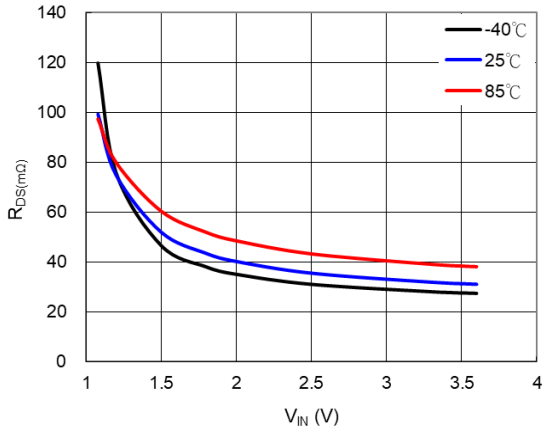


Typical Performance Characteristics (C_{IN} = 1μF, C_{OUT} = 0.1μF, unless otherwise specified.)

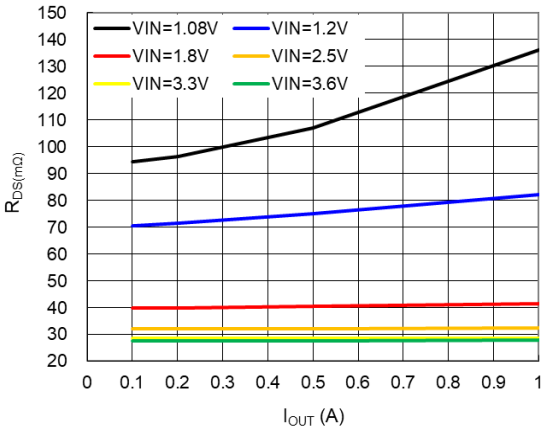
Switch on-resistance vs. Temperature



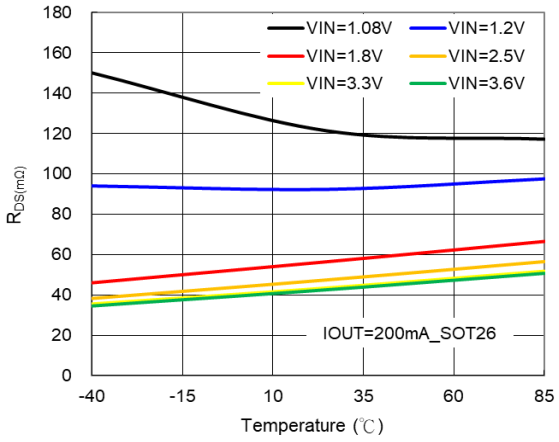
Switch on-resistance vs. Input voltage



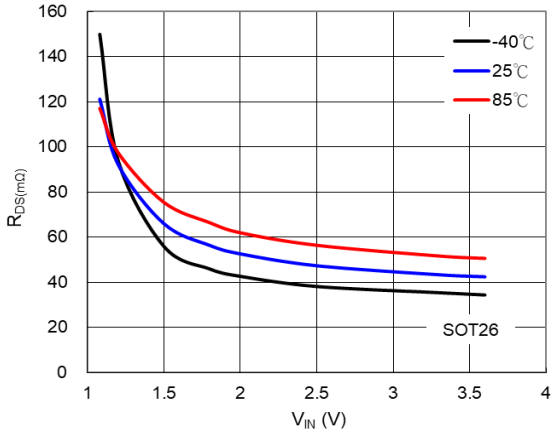
Switch on-resistance vs. Output Current



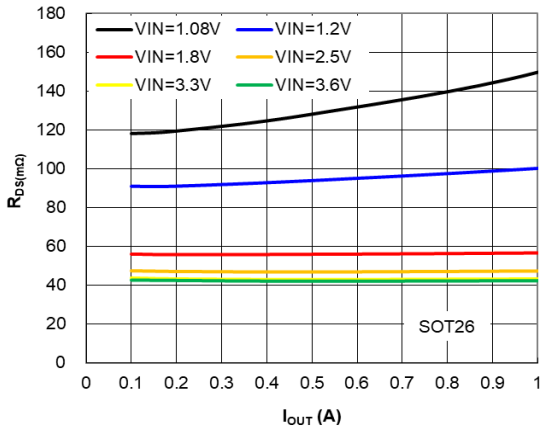
Switch on-resistance vs. Temperature



Switch on-resistance vs. Input voltage

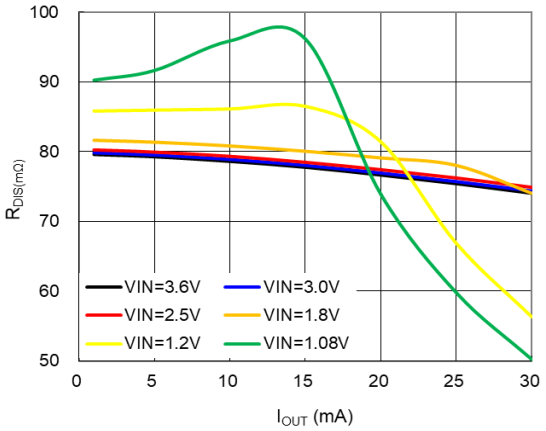


Switch on-resistance vs. Output Current

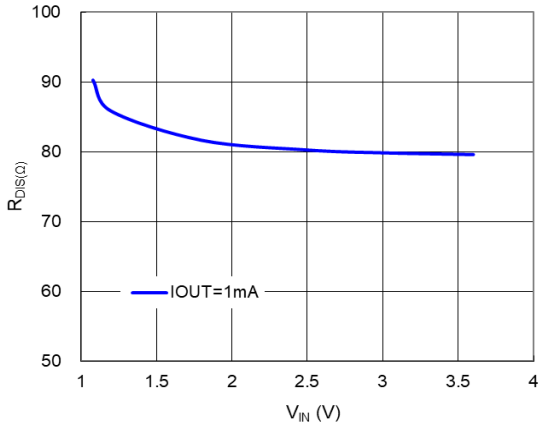


Typical Performance Characteristics (C_{IN} = 1µF, C_{OUT} = 0.1µF, unless otherwise specified.)

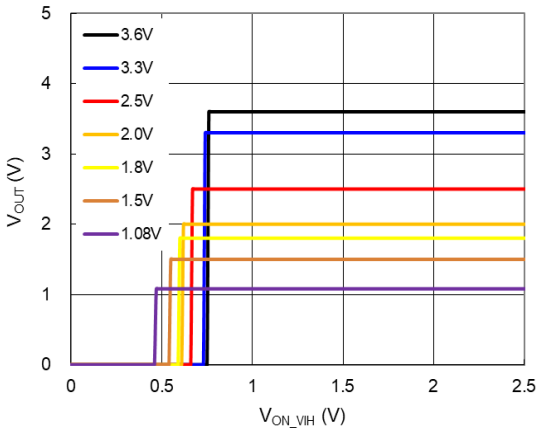
Discharge Resistance vs. Output Current



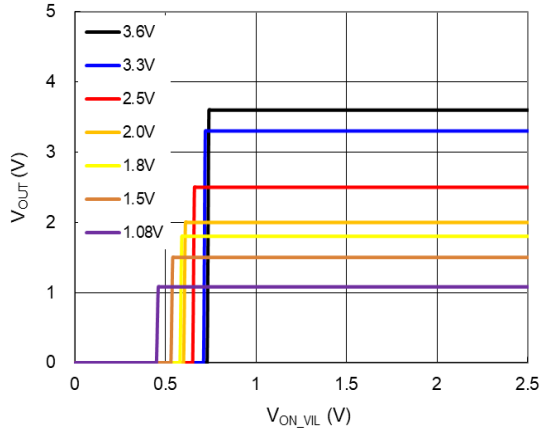
Discharge Resistance vs. Input voltage



ON Input Threshold Voltage (Increasing)

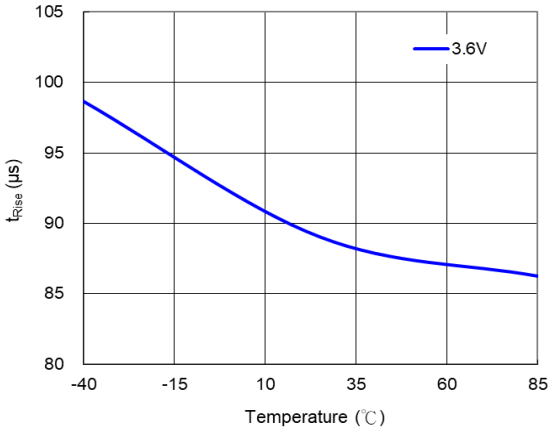


ON Input Threshold Voltage (Decreasing)

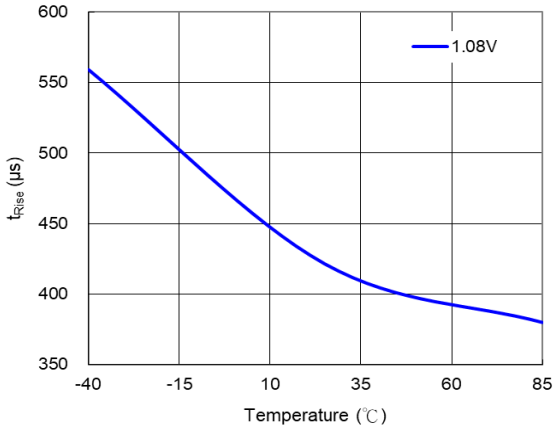


Typical Performance Characteristics (C_{IN} = 1μF, C_{OUT} = 0.1μF, R_L = 10Ω, unless otherwise specified.)

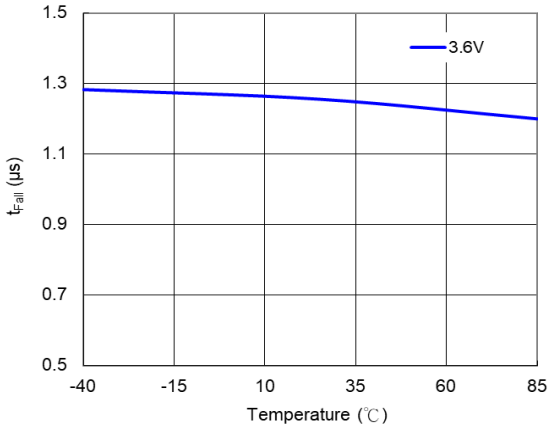
Output Rise Time vs. Temperature



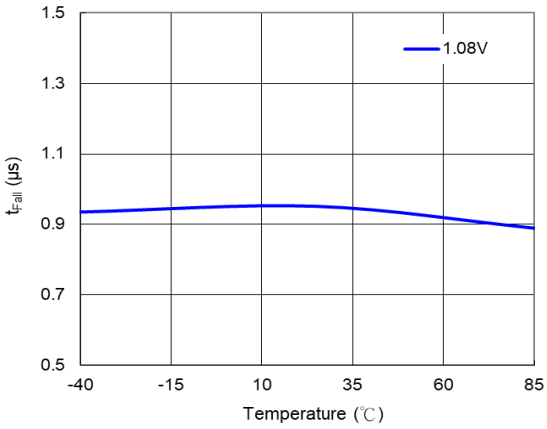
Output Rise Time vs. Temperature



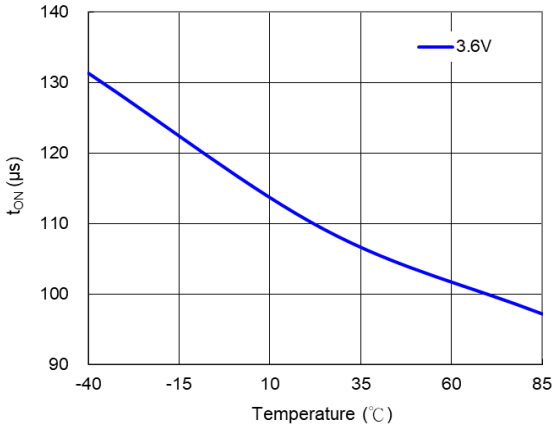
Output Fall Time vs. Temperature



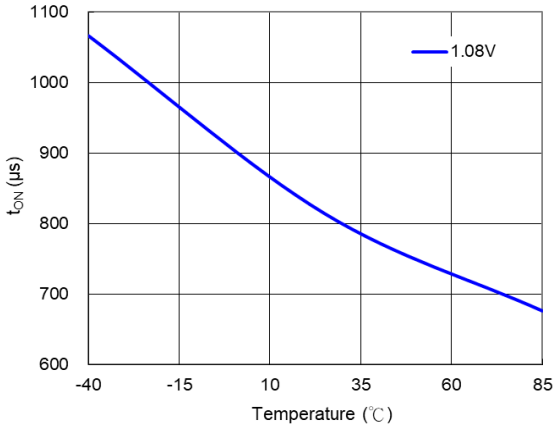
Output Fall Time vs. Temperature



Output Turn-on Time vs. Temperature

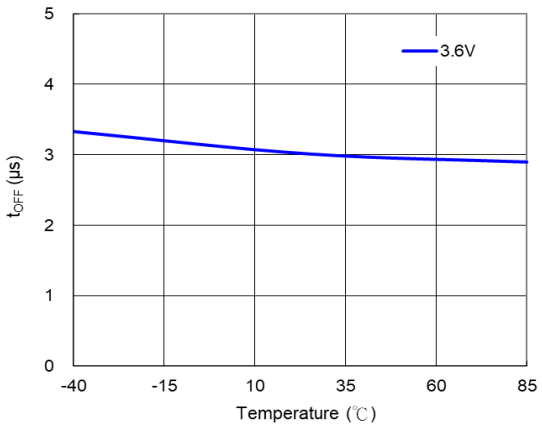


Output Turn-on Time vs. Temperature

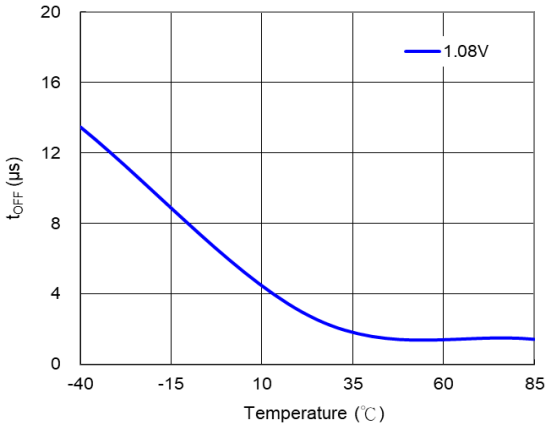


Typical Performance Characteristics (C_{IN} = 1μF, C_{OUT} = 0.1μF, R_L = 10Ω, unless otherwise specified.)

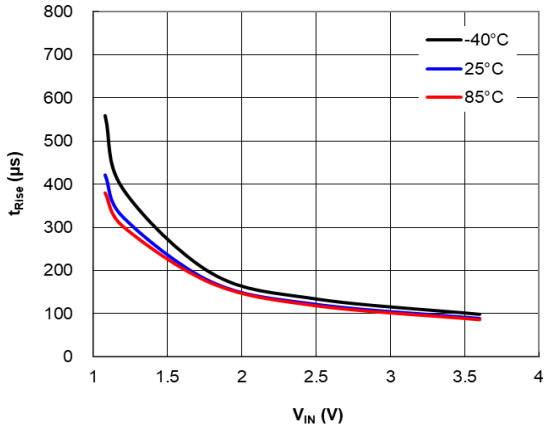
Output Turn-off Time vs. Temperature



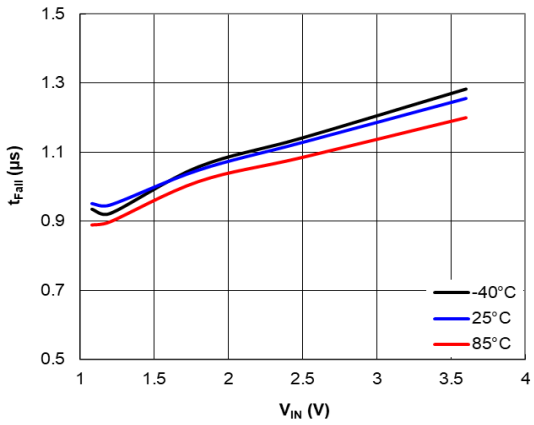
Output Turn-off Time vs. Temperature



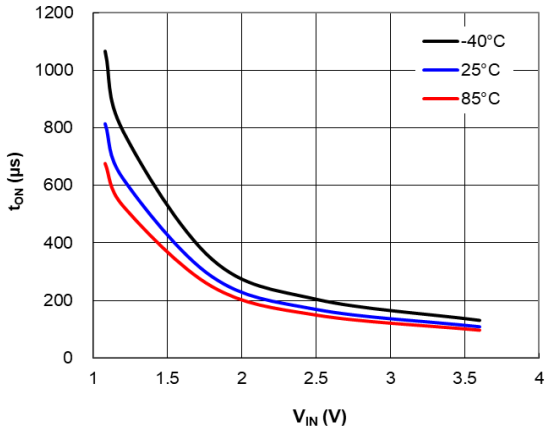
Output Rise Time vs. Input voltage



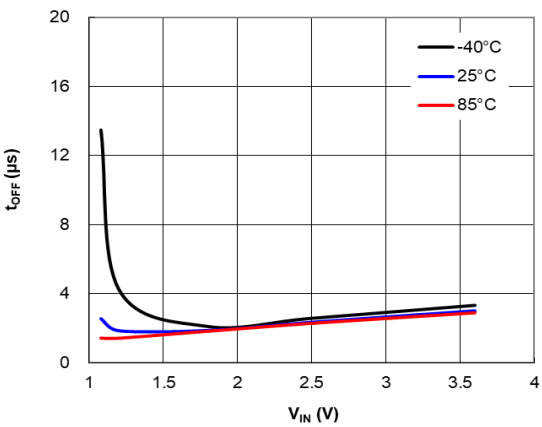
Output Fall Time vs. Input voltage



Output Turn-on Time vs. Input voltage



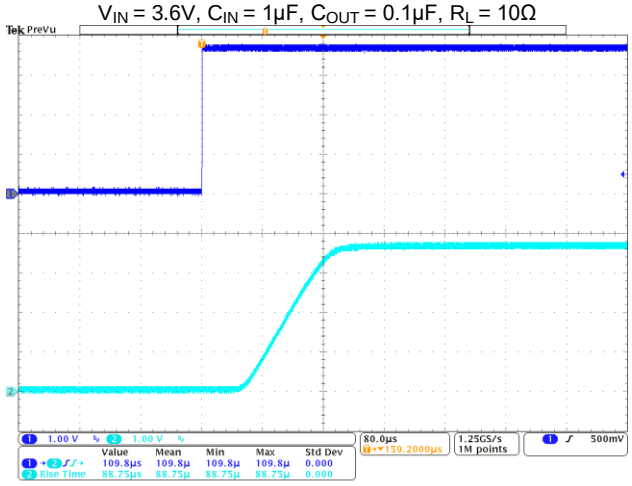
Output Turn-off Time vs. Input voltage



Typical Performance Characteristics (C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω, unless otherwise specified.)

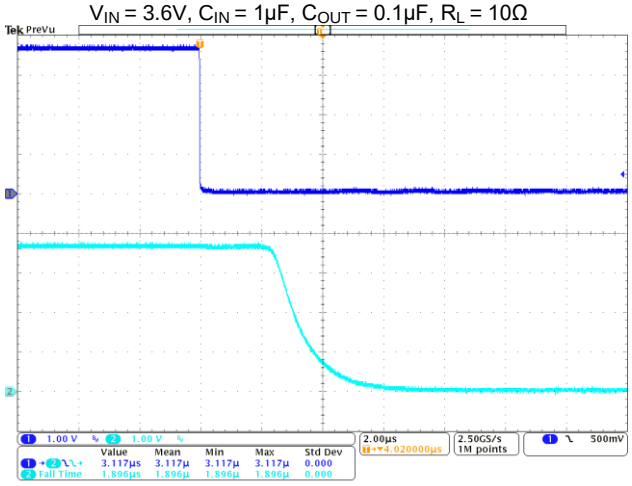
Output Turn On Response

V_{IN} = 3.6V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



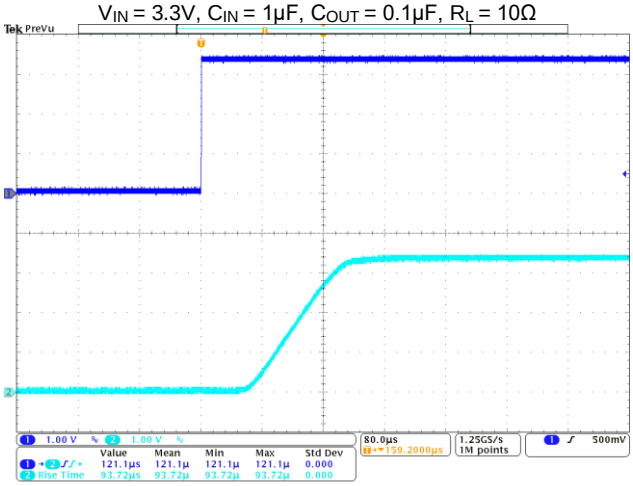
Output Turn Off Response

V_{IN} = 3.6V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



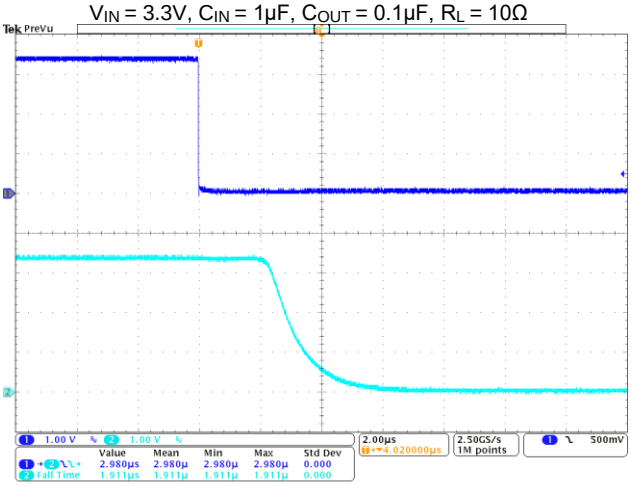
Output Turn On Response

V_{IN} = 3.3V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



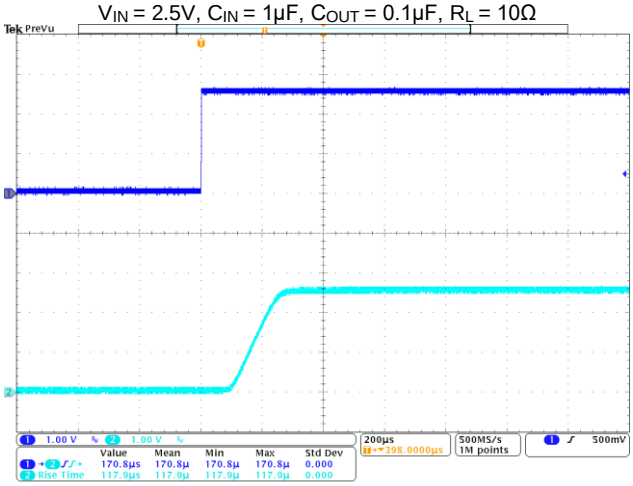
Output Turn Off Response

V_{IN} = 3.3V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



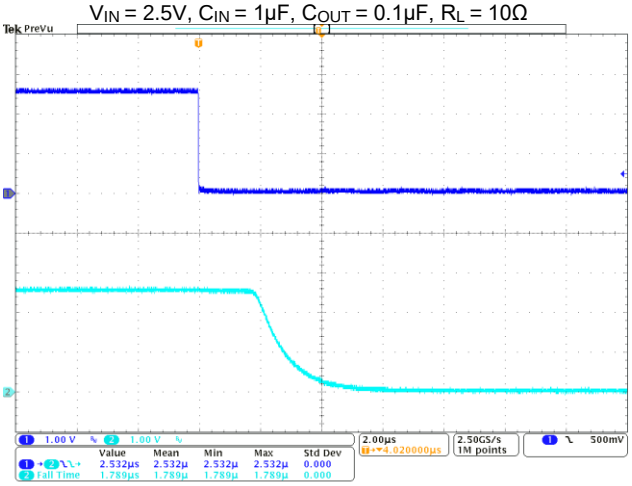
Output Turn On Response

V_{IN} = 2.5V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



Output Turn Off Response

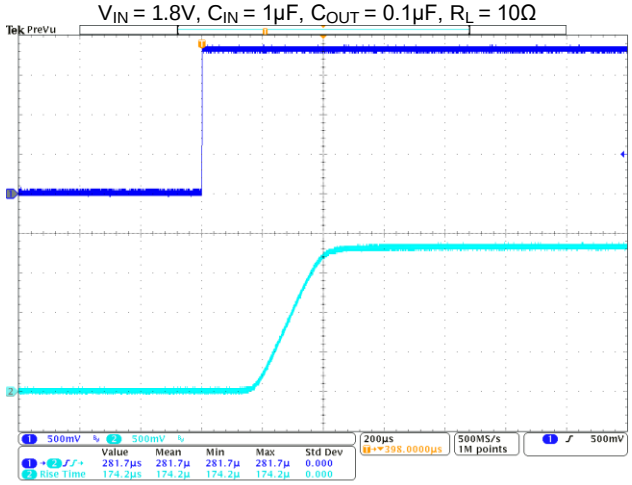
V_{IN} = 2.5V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



Typical Performance Characteristics (C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω, unless otherwise specified.)

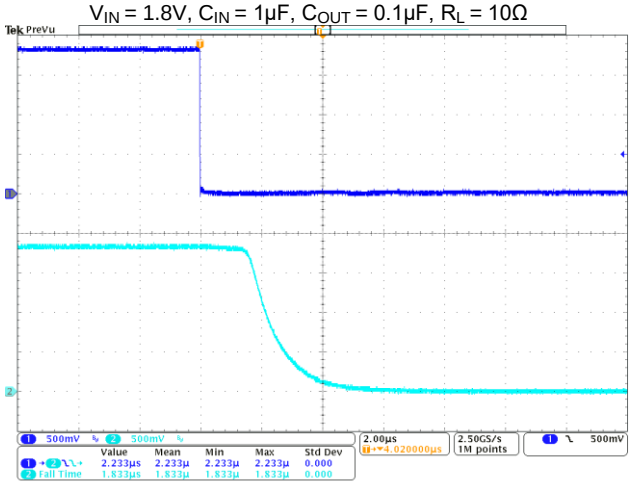
Output Turn On Response

V_{IN} = 1.8V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



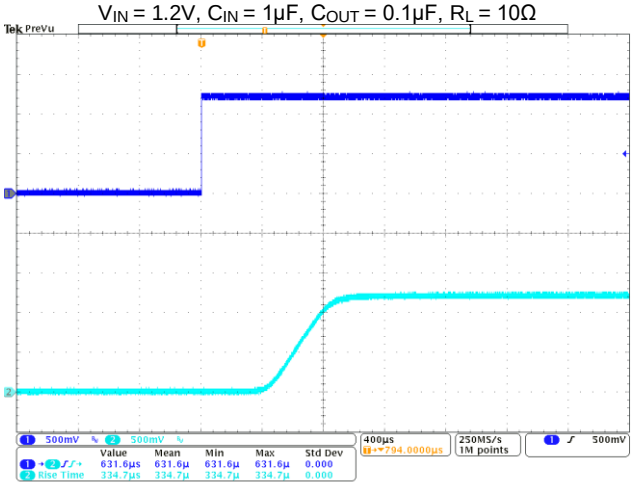
Output Turn Off Response

V_{IN} = 1.8V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



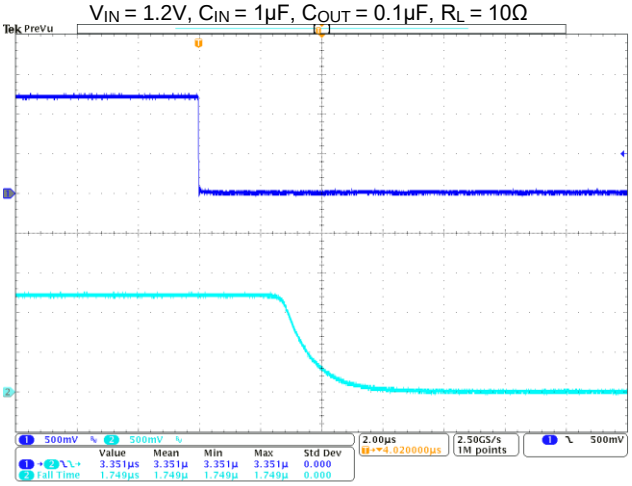
Output Turn On Response

V_{IN} = 1.2V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



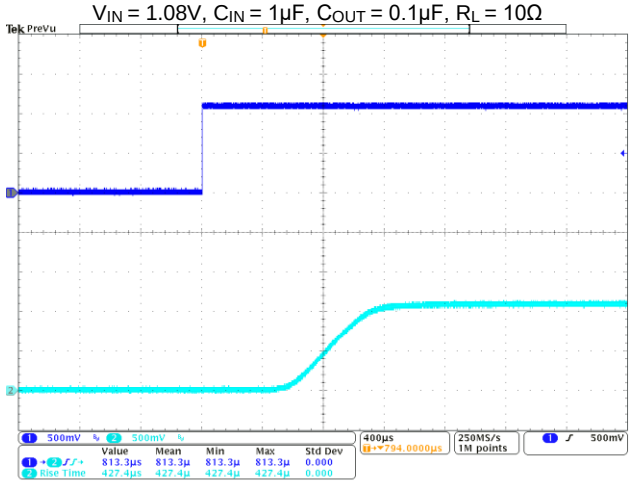
Output Turn Off Response

V_{IN} = 1.2V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



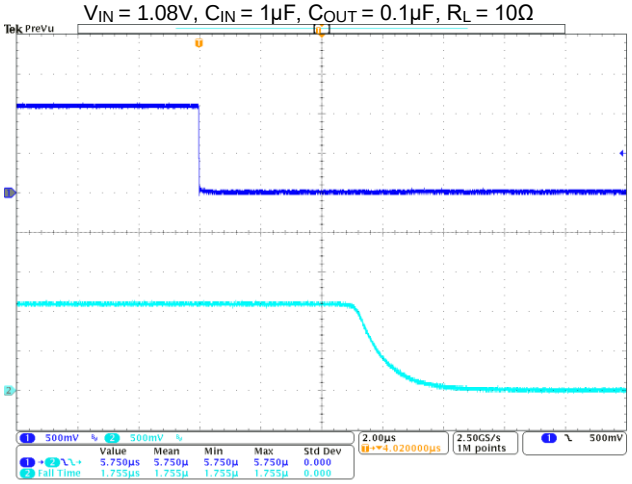
Output Turn On Response

V_{IN} = 1.08V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



Output Turn Off Response

V_{IN} = 1.08V, C_{IN} = 1µF, C_{OUT} = 0.1µF, R_L = 10Ω



Application Information

Input Capacitor

A 1μF capacitor is recommended to connect between V_{IN} and GND pins to decouple input power supply glitch and noise. 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_{IN} and GND.

Output Capacitor

The 0.1μF to 1μF capacitor is recommended to connect between V_{OUT} 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_{OUT} and GND pins, and keep the traces as short as possible.

Enable/Shutdown Operation

The AP22908 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_{IL} and V_{IH}.

Discharge Operation

The AP22908 offers discharge option that helps to discharge the output charge when disabled. The discharge resistance with a typical value of 80Ω is connected between the output and ground.

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:

$$P_D = I_{OUT}{}^2 x R_{DSON} \qquad \textbf{(1)}$$

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:

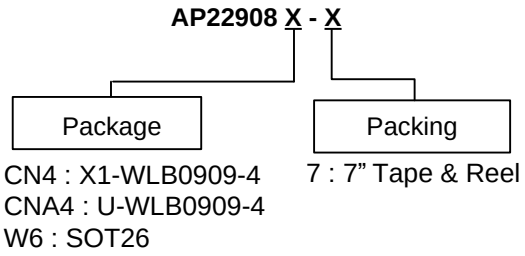
$$P_{D(MAX)} = \frac{(125°C - T_A)}{\theta_{JA}} \qquad \textbf{(2)}$$

Layout Guildline

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_{IN}) and output (V_{OUT}) 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



Orderable Part Number	Package Code	Package	Packing		
			Quantity	Carrier	Part Number Suffix
AP22908CN4-7	CN4	X1-WLB0909-4	3,000	7" Tape & Reel	-7
AP22908CNA4-7	CNA4	U-WLB0909-4	3,000	7" Tape & Reel	-7
AP22908W6-7	W6	SOT26	3,000	7" Tape & Reel	-7

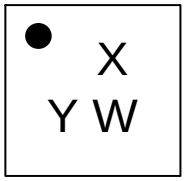
Feature Options:

Orderable Part Number	Rise Time (Typ) at 3.6V	Output Discharge	Enable
AP22908CN4-7	105µs	Yes	Active High
AP22908CNA4-7	105µs	Yes	Active High
AP22908W6-7	105µs	Yes	Active High

Marking Information

(1) X1-WLB0909-4

(Top View)

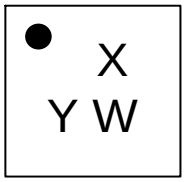


X : Identification Code
Y : Year : 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week

Part Number	Package	Identification Code
AP22908CN4-7	X1-WLB0909-4	$\overline{4}$

(2) U-WLB0909-4

(Top View)

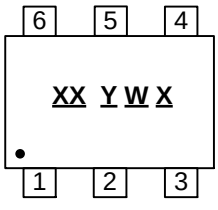


X : Identification Code
Y : Year : 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week

Orderable Part Number	Package	Identification Code
AP22908CNA4-7	U-WLB0909-4	$\overline{8}$

(3) SOT26

(Top View)



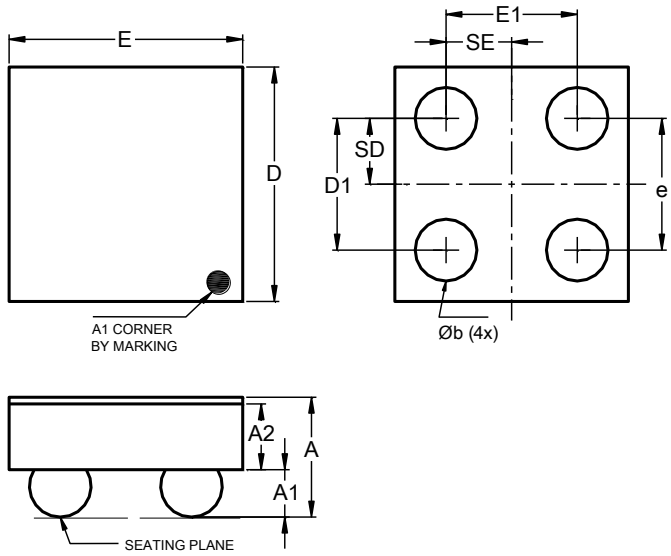
XX : Identification Code
Y : Year 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : Internal Code

Orderable Part Number	Package	Identification Code
AP22908W6-7	SOT26	N8

Package Outline Dimensions

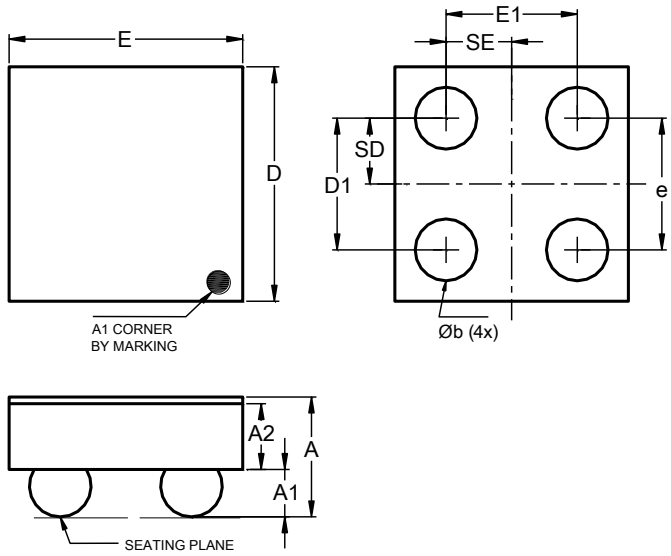
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: 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			

(2) Package Type: U-WLB0909-4

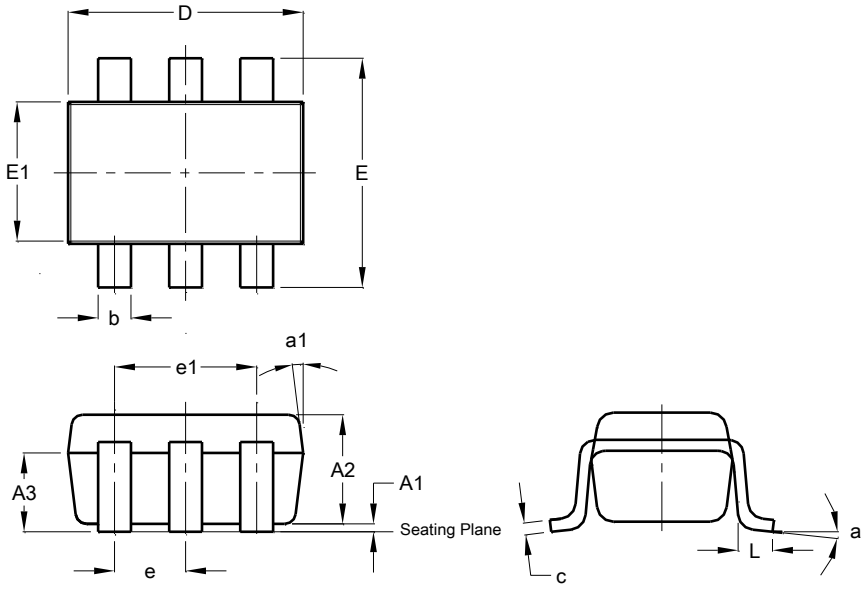


U-WLB0909-4			
Dim	**Min**	**Max**	**Typ**
A	0.540	0.630	0.585
A1	0.160	0.200	0.180
A2	0.355	0.405	0.380
b	0.205	0.265	0.235
D	0.860	0.920	0.880
D1	0.450	0.550	0.500
E	0.860	0.920	0.880
E1	0.450	0.550	0.500
e	0.500 BSC		
SD	0.250 BSC		
SE	0.250 BSC		
All Dimensions in mm			

Package Outline Dimensions (continued)

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

(3) Package Type: SOT26

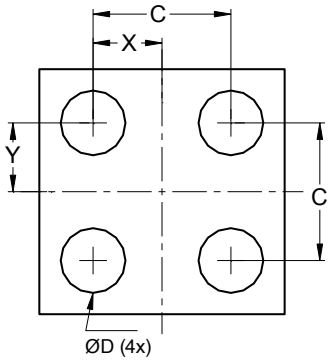


SOT26			
Dim	**Min**	**Max**	**Typ**
A1	0.013	0.10	0.05
A2	1.00	1.30	1.10
A3	0.70	0.80	0.75
b	0.35	0.50	0.38
c	0.10	0.20	0.15
D	2.90	3.10	3.00
e	-	-	0.95
e1	-	-	1.90
E	2.70	3.00	2.80
E1	1.50	1.70	1.60
L	0.35	0.55	0.40
a	-	-	8°
a1	-	-	7°
All Dimensions in mm			

Suggested Pad Layout

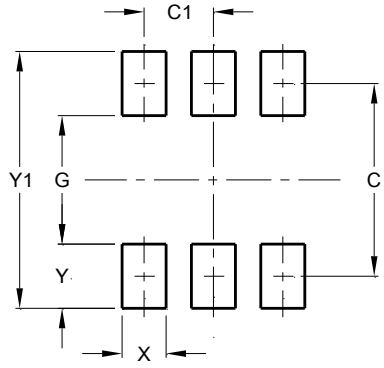
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: X1-WLB0909-4 & U-WLB0909-4



Dimensions	Value (in mm)
C	0.500
D	0.235
X	0.250
Y	0.250

(2) Package Type: SOT26



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

Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3
- Weight: 0.001 grams (Approximate)

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