Description

The AP221448 is a 17mΩ, 2.5A, load switch that switches a power rail ranging from 1.0V to 5.5V. It contains protection features for enhanced operation and reliability.

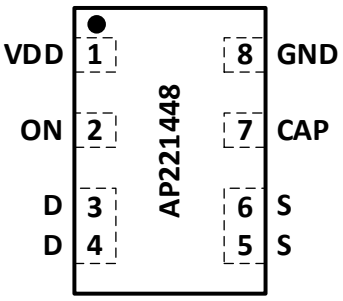
The product is packaged in a small 1.6mm x 1.0mm package. See *Package Outline Dimensions* for details.

Features

- Operating Voltage: 2.5V to 5.5V
- Operating Temperature: -40°C to 85°C
- 1.6mm x 1.0mm x 0.55mm U-DFN1610-8 (Type AX) Package
- 17mΩ RDS_{ON} While Supporting 2.5A
- Discharges Load When Off
- Two Overcurrent Protection Modes
  - Short-Circuit Current Limit
  - Active Current Limit
- Overtemperature Protection
- **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-Q100/101/104/200, 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

(Top View)



U-DFN1610-8 (Type AX)

Applications

- Smartphones
- Tablets
- Notebooks

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 Application Circuit

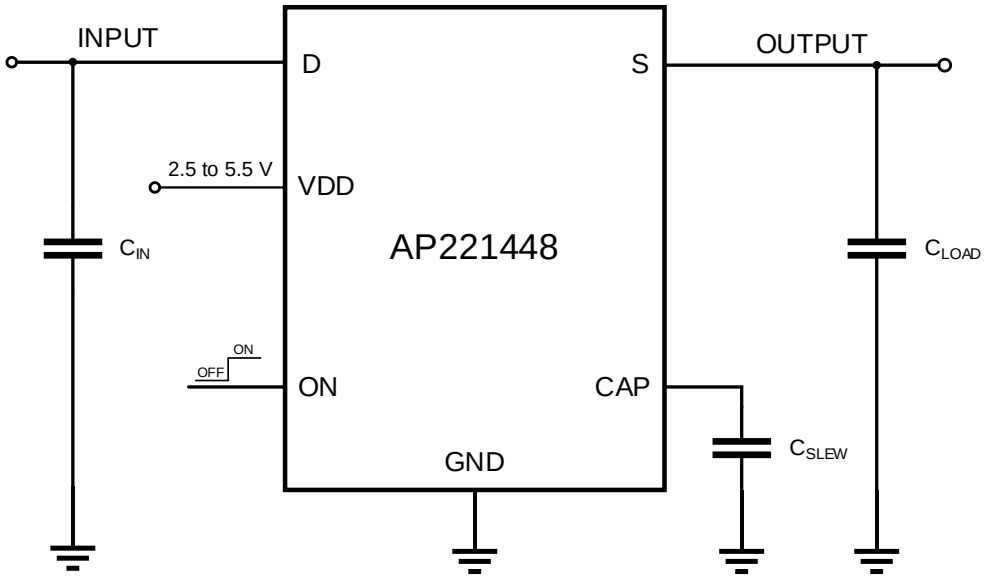


Figure 1. Typical AP221448 Application Circuit

Pin Descriptions

Pin Name	Pin Number	Type	Function
VDD	1	Power	Power supply. Assumes a 0.1µF or larger decoupling capacitor.
ON	2	Input	Turns on load switch, active HI.
D	3, 4	MOSFET	Drain terminal connection for the load switch.
S	5, 6	MOSFET	Source terminal connection for the load switch.
CAP	7	Input	Connects to a low-ESR ceramic capacitor to set the V_S slew rate.
GND	8	GND	Ground

Functional Block Diagram

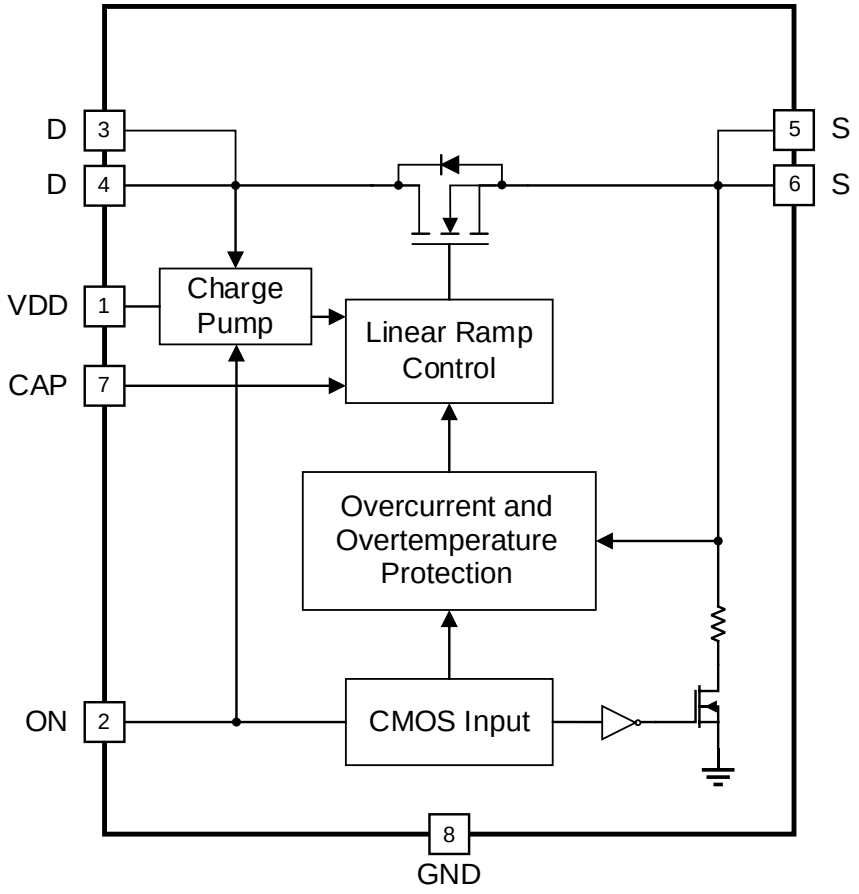


Figure 2. Functional Block Diagram

Absolute Maximum Ratings (Note 4) (@ T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Rating	Unit
V_{DD}	Power Supply (per TSMC process)	+7	V
W_{DIS}	Package Power Dissipation	+0.4	W
MOSFET $I_{OUT(PK)}$	Peak Current from Drain to Source	+3.5 (For no more than 1ms with 1% duty cycle)	A
T_{ST}	Storage Temperature	-65 to +140	°C
ESD Susceptibility (Note 5)			
HBM	Human Body Model, per JEDEC Standard	±2000	V

Notes: 4. Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability.
5. Semiconductor devices are ESD sensitive and can be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

Recommended Operating Conditions (Note 6) (@ T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
V_{DD}	Supply Voltage	2.5	5.5	V
V_D	Drain Voltage	1.0	V_{DD}	V
T_A	Operating Ambient Temperature	-40	+85	°C
I_{OUT}	Output Current (Continuous)	0	2.5	A
V_{IH}	High Input Voltage on ON pin	0.85	V_{DD}	V
V_{IL}	Low Input Voltage on ON pin	-0.3	0.3	V

Note: 6. The device performance is not guaranteed outside of the recommended operating conditions.

Electrical Characteristics (@ T_A = -40°C to +85°C, unless otherwise specified. Min/Max limits apply across the recommended operating and input voltage range, 2.5V to 5.5V, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{SHDN}	Input Shutdown Current	Disabled, I_{OUT} = 0A	—	—	0.1	μA
I_Q	Input Quiescent Current	Enabled, I_{OUT} = 0A	—	25	50	μA
RDS_{ON}	Switch On-Resistance	T_A = +25°C, I_{OUT} = 100mA	—	16.8	19	mΩ
		T_A = +70°C, I_{OUT} = 100mA	—	18.7	20	
		T_A = +85°C, I_{OUT} = 100mA	—	19.6	23	
t_{ON_Delay}	ON Delay Time	50% ON to V_S Ramp Start	—	250	500	μs
t_{ON}	Total Turn On Time	50% ON to 90% V_S	Configurable (Note 7)			ms
		Example: C_{SLEW} = 3.9nF, V_{DD} = V_D = 5V C_{LOAD} = 10μF, I_{OUT} = 100mA	—	1.55	—	
$V_{S(SR)}$	Slew Rate	10% V_S to 90 % V_S	Configurable (Note 7)			V/ms
		Example: C_{SLEW} = 3.9nF, V_{DD} = V_D = 5V C_{LOAD} = 10μF, I_{OUT} = 100mA	—	3.35	—	
C_{LOAD}	Output Load Capacitance	C_{LOAD} connected from S to GND	—	—	500	μF
R_{DIS}	Discharge Resistance	—	180	215	250	Ω
I_{LIMIT}	Active Current Limit (Note 8)	V_S > 250mV and I_{OUT} > 4.25A	—	4.2	—	A
	Short-Circuit Current Limit (Note 8)	V_S < 250mV	—	1.1	—	
OTP	Overtemperature Protection (Note 8)	Threshold	—	+125	—	°C
		Hysteresis	—	+25	—	°C
		Shutoff Time	—	—	1	ms
t_{OFF}	OFF Delay Time	50% ON to V_S Fall Start, V_{DD} = V_D = 5V R_{LOAD} = 20Ω, no C_{LOAD}	—	6.5	—	μs
t_{FALL}	V_S Fall Time	90% V_S to 10% V_S, V_{DD} = V_D = 5V R_{LOAD} = 20Ω, no C_{LOAD}	—	4.5	—	μs
$R_{Pull-Down}$	ON Pull-Down Resistance	V_{DD} = V_D = 5V	—	4.8	—	MΩ

Notes: 7. Refer to Figure 3 for additional information.
8. Compliance to the datasheet limits is assured by one or more methods: production test, characterization, and/or design.

Typical Performance Characteristics (AP221448 @ T_A = +25°C, unless otherwise specified.)

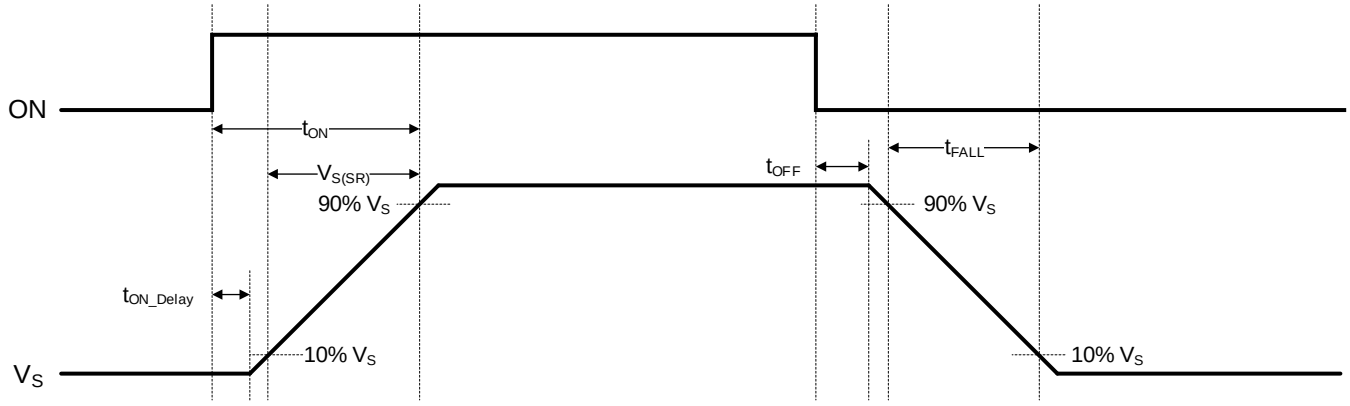


Figure 3. t_{ON_Delay}, $V_{S(SR)}$, and t_{ON} Timing Details

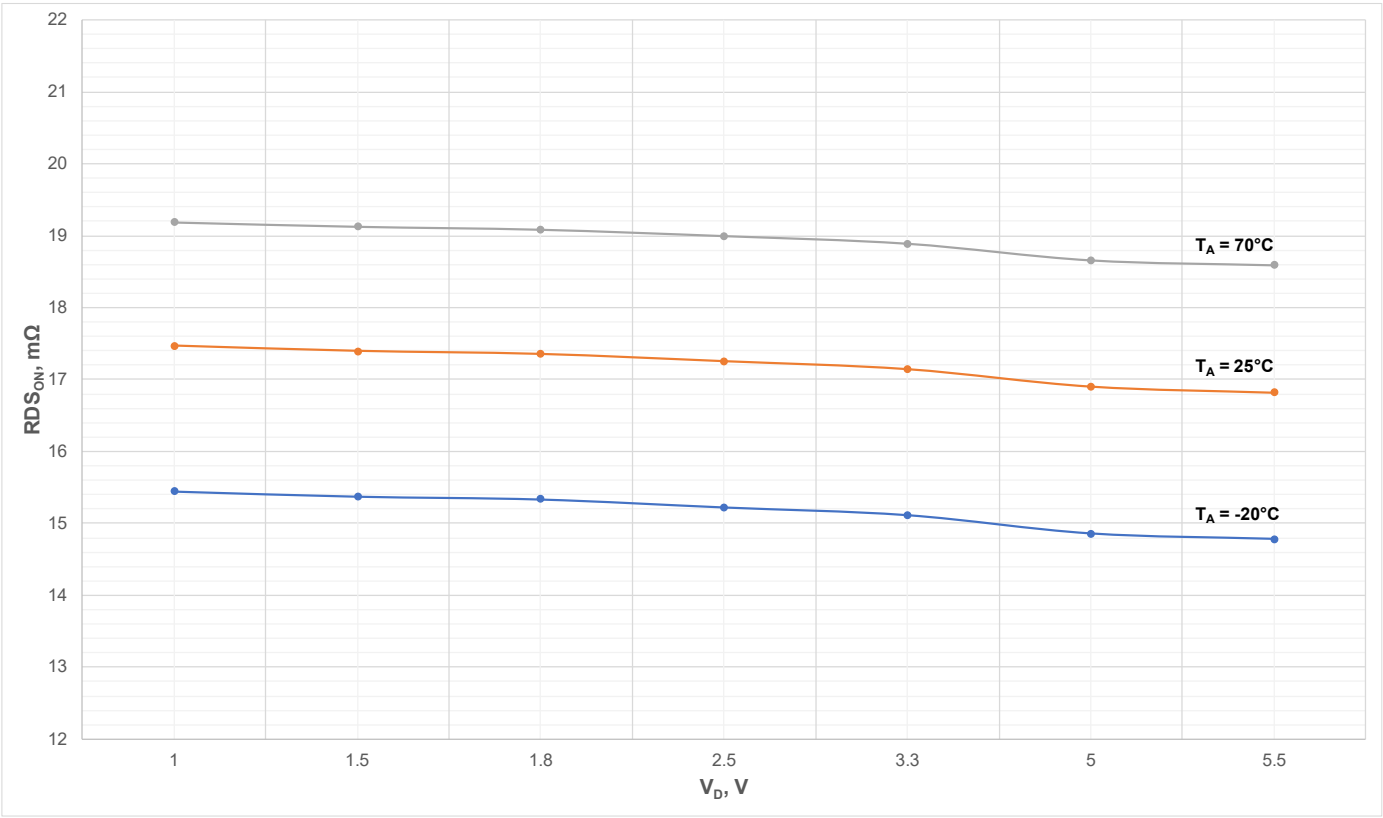


Figure 4. RDS_{ON} vs. V_D and Temperature at V_{DD} = 5.5V and 100mA

Typical Performance Characteristics (AP221448 @ T_A = +25°C, unless otherwise specified.) (continued)

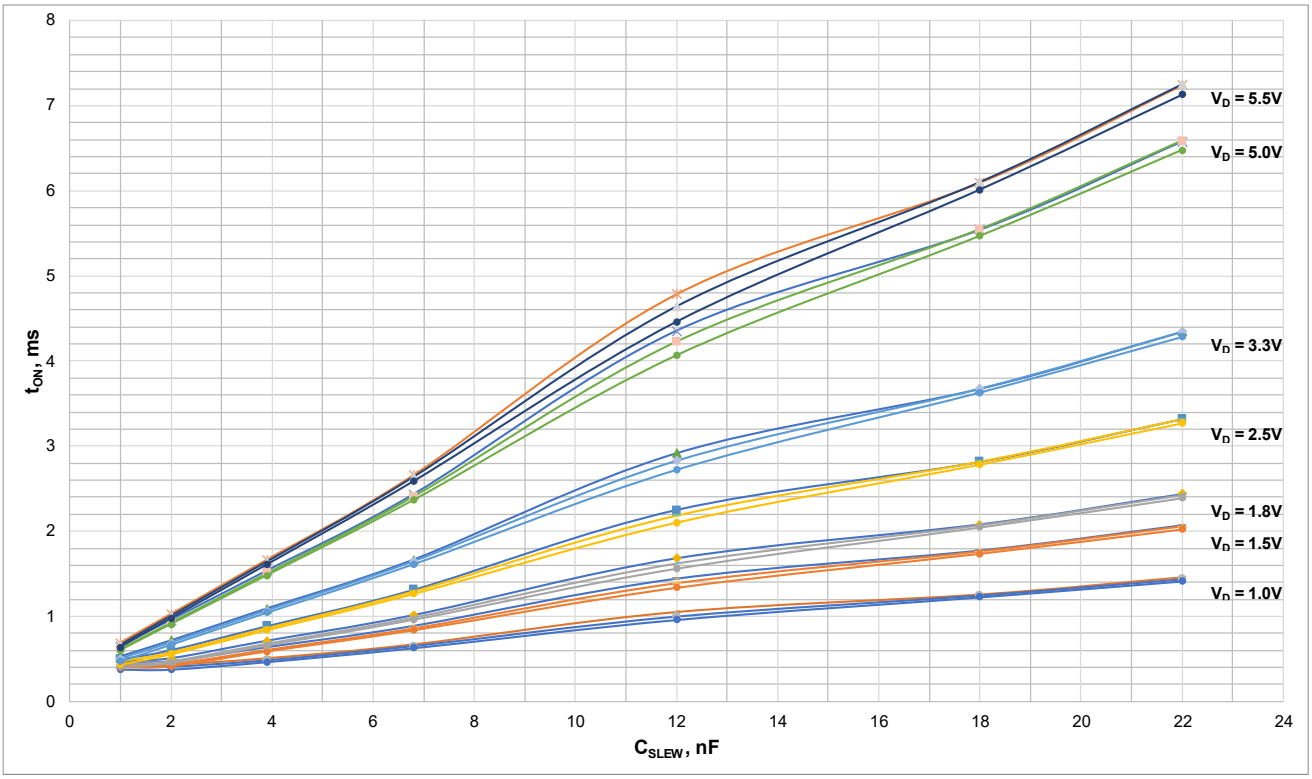


Figure 5. t_{ON} vs. C_{SLEW}, V_D and Temperature at V_{DD} = 5.5V

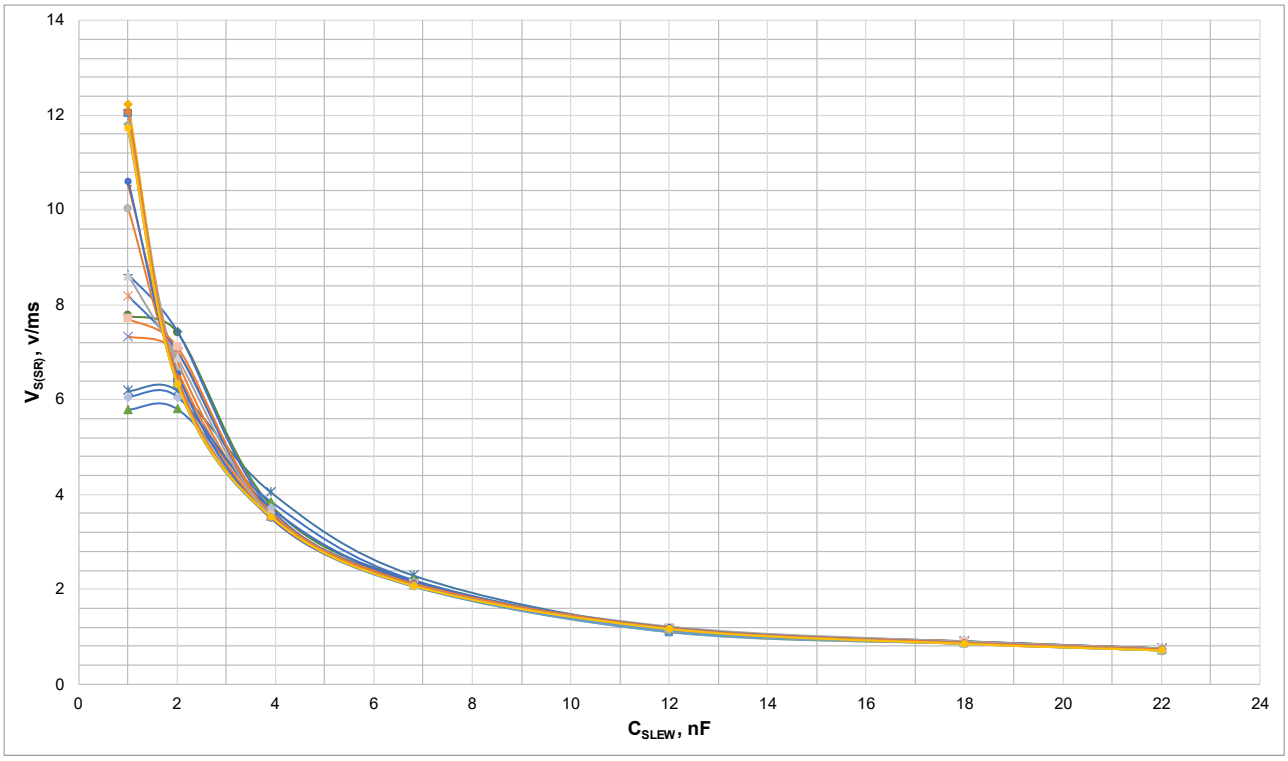


Figure 6. V_S Slew Rate vs. C_{SLEW} and Temperature

Application Information

1 Typical Operation

For correct operability, per the AP221448 EC table, a proper power-up sequence must be applied. Apply V_{DD} first, followed by V_D, then ON signal to power-up the device. In order to control the inrush current from capacitive loads, set a desired linear output slew rate by placing a corresponding C_{SLEW} capacitor between CAP pin and GND. The greater capacitor value at CAP pin, the slower the output ramp.

During operation, should a system fault occur, V_{IN} should be returned to Recommended Operating Conditions before the load switch is transitioned between its on and off states to reduce out-of-spec transitional stress on the MOSFET, discharge resistor, and charge pump.

The AP221448 protection features are not intended for port/live-insertion applications, such as USB ports. The protection features have been designed primarily to protect against initial manufacturing defects and for product development safety.

Some typical operation waveforms are illustrated below.

Figure 7. AP221448 Typical Power-Up Operation Waveform. V_{DD} = V_D = 5V, R_{LOAD} = 20Ω, C_{LOAD} = 10μF, C_{SLEW} = 3.9nF

Application Information (continued)

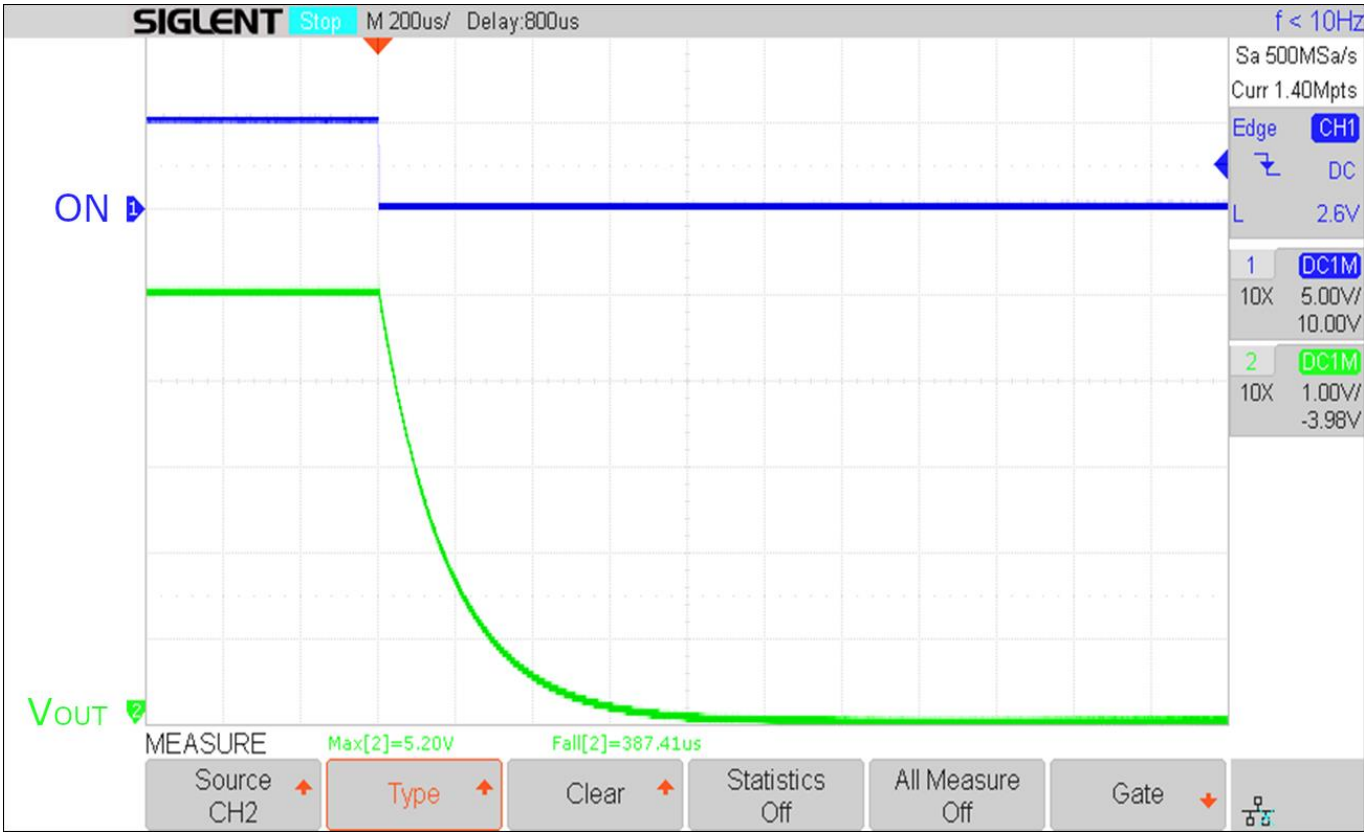


Figure 8. AP221448 Typical Power-Down Operation Waveform. V_{DD} = V_D = 5V, R_{LOAD} = 20Ω, C_{LOAD} = 10μF, C_{SLEW} = 3.9nF

Application Information (continued)

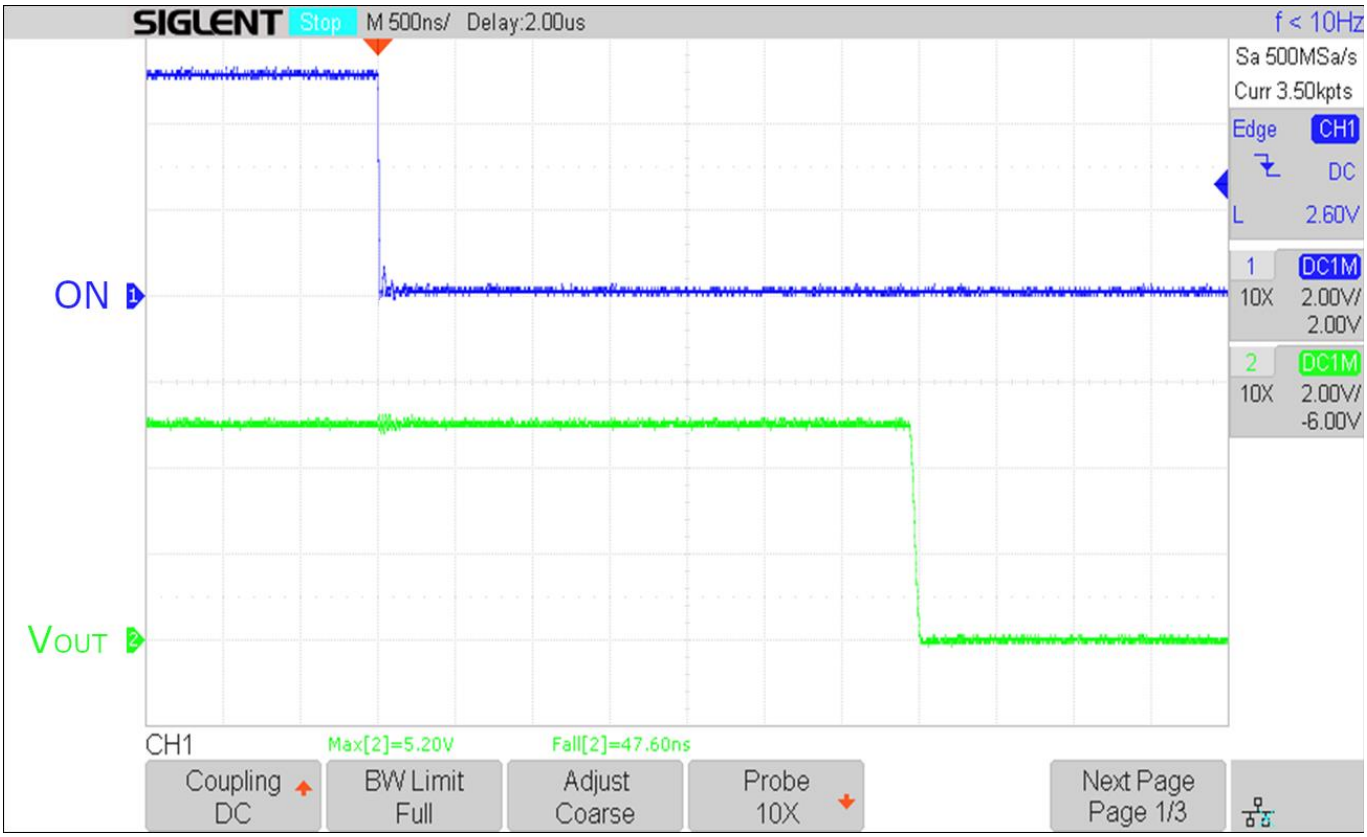


Figure 9. AP221448 Typical Power-Down Operation Waveform. V_{DD} = V_D = 5V, R_{LOAD} = 20Ω, no C_{LOAD}, C_{SLEW} = 3.9nF

2 Overtemperature Protection

The AP221448 contains an overtemperature protection. If the internal junction temperature of the AP221448 reaches +135°C, such as during an overcurrent event, the FET is shut off completely so the die can cool. Once the die temperature reaches approximately +100°C, overtemperature protection will be disabled and the FET will again be capable of conducting. This event will repeat for as long as the condition that causes the die to overheat exists.

3 Current Limiting Operation

3A Active Current Limiting Mode (With Overtemperature Protection)

In the event the current delivered from the drain to source in the AP221448 exceeds the I_{ACL} maximum current limit in the *Electrical Characteristics* table (roughly 50% greater than the maximum sustained current) for more than a few microseconds, the AP221448 will limit the current to the I_{ACL} threshold by increasing the FET resistance. If this current is sustained, the device will overheat and trigger the overtemperature protection.

Application Information (continued)

3A Active Current Limiting Mode (With Overtemperature Protection) (continued)

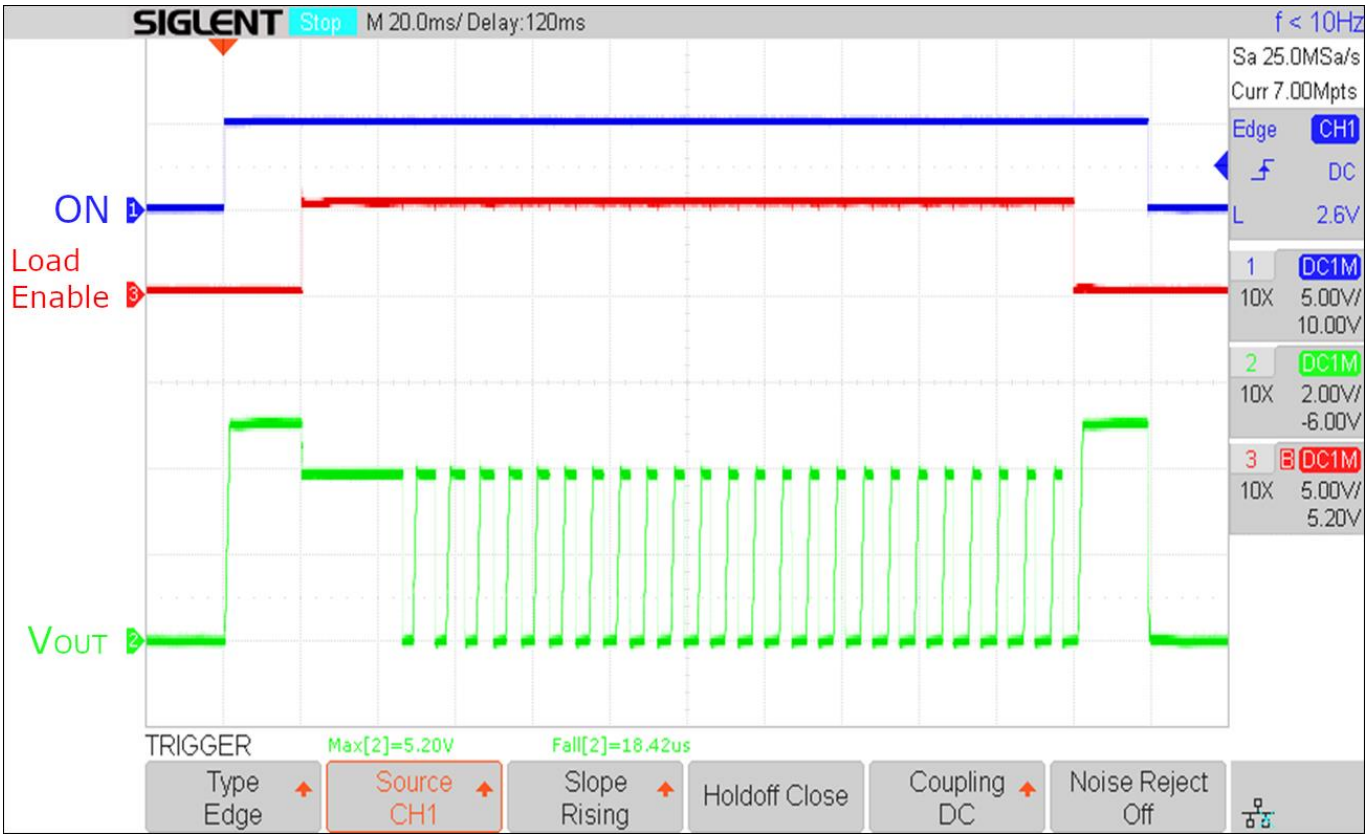


Figure 10. AP221448 ACL+TSD Operation Waveform. V_{DD} = V_D = 5V, R_{LOAD} = 20Ω, C_{LOAD} = 10μF, C_{SLEW} = 3.9nF. *Load Enable* signal applies additional 1Ω of load.

An example of the AP221448 Active Current Limit is shown above. At initial turn-on of the IC, the active current limit is sustained for longer before reaching the overtemperature limit. As the package is heated in subsequent ACL events, the time held at the ACL level before triggering the overtemperature protection continues to decrease until it reaches a steady state.

3B Short-Circuit Current Limiting Mode (With Overtemperature Protection)

The AP221448 also contains a short-circuit limit, which will be triggered in the event that V_S is externally limited to 250mV or less due to an improper solder connection or similar defect on the same node as the S pin. During this event, the AP221448 will maintain the resistivity of the FET so as to limit the output current of the device to a typical value of 1.1A.

If the short-circuit event is resolved, the AP221448 will continue its voltage ramp per the slew rate set by the capacitor on the CAP pin.

Application Information (continued)

3B Short-Circuit Current Limiting Mode (With Overtemperature Protection) (continued)

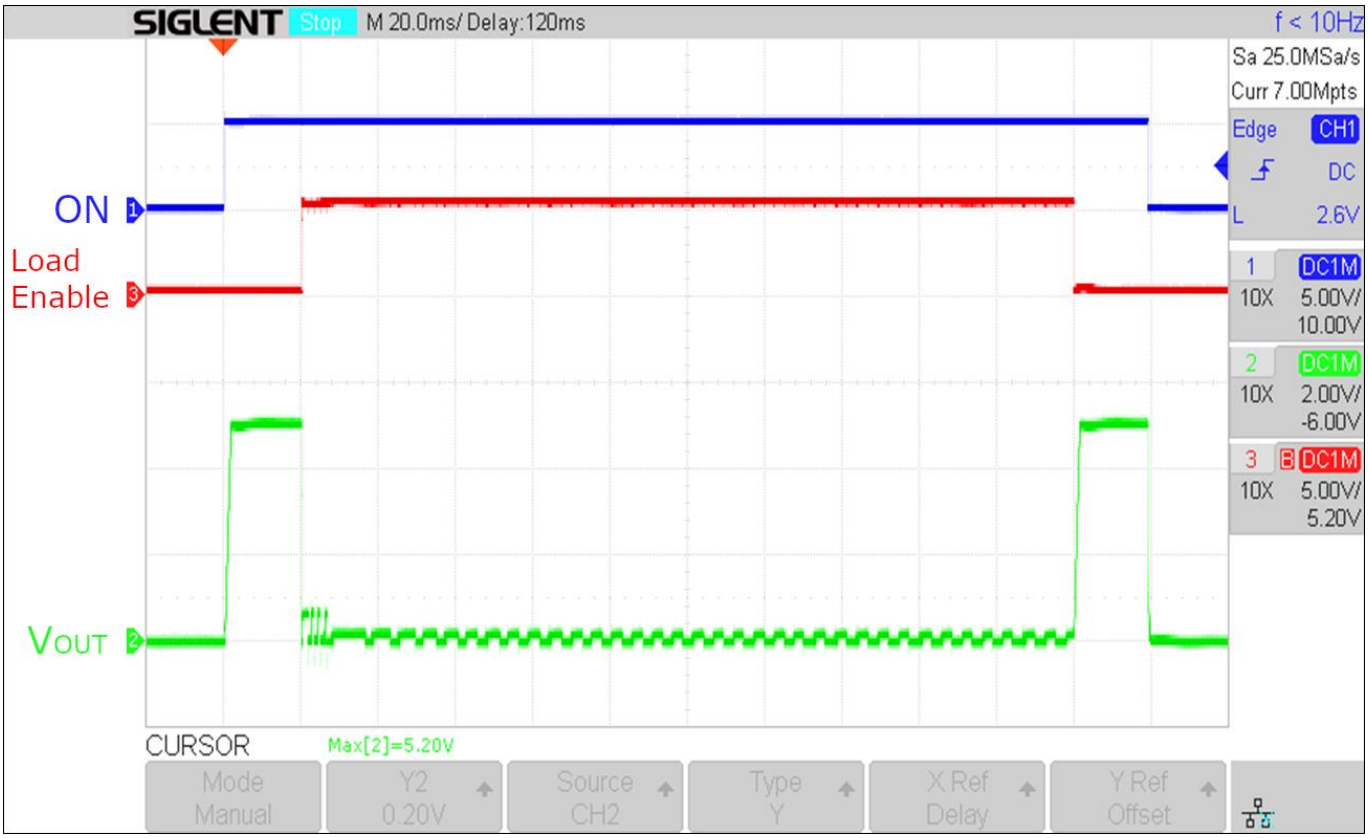


Figure 11. AP221448 SCL+TSD Operation Waveform. V_{DD} = V_D = 5V, R_{LOAD} = 20Ω, C_{LOAD} = 10μF, C_{SLEW} = 3.9nF. *Load Enable* signal applies additional 0.25Ω of load.

Note: 9. Depending upon factors such as V_D, the shorted value of V_S, and the ambient temperature, the AP221448 may or may not dissipate enough power to trigger the overtemperature protection within the circuit. If the overtemperature protection occurs, the part will shut down and retry per the Overtemperature Detection description above.

Recommended Layout

It is important to have a proper PCB layout for high-performance device operation. The list below provides some basic rules for PCB layout.

- Connect a 0.1µF capacitor from VDD pin to GND. It should be placed as closes to device as possible.
- Place high-quality low-ESR input C_{IN} and output C_{OUT} capacitors close to the device Drain and Source pins to minimize the effects of parasitic inductance.
- Make sure to have a solid Ground connection.
- All traces should be as short, wide, and direct as possible.
- Drain and Source pins have the most heat dissipation during high-current operations. Use polygon planes and/or 2oz. copper for Drain and Source connections.

Examples below illustrate described layout guidelines implementation.

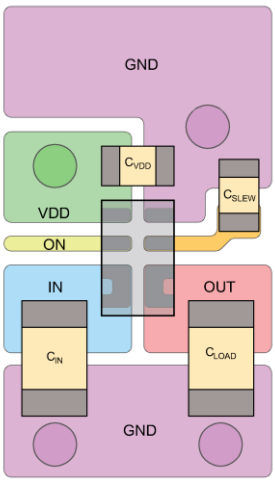


Figure 12. Option 1

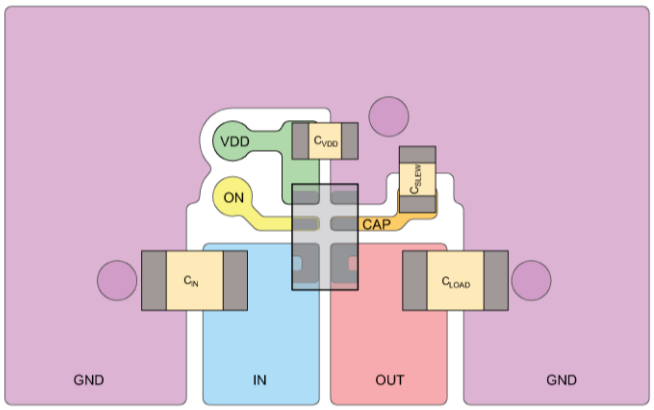
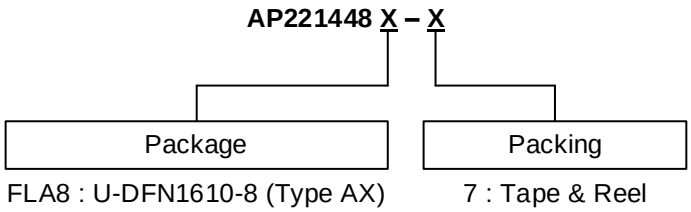


Figure 13. Option 2

Ordering Information

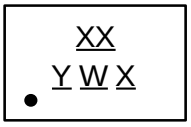


Part Number	Package	Package Code	Packing	
			Qty.	Carrier
AP221448FLA8-7	U-DFN1610-8 (Type AX)	FLA8	3,000	7” Tape and Reel

Marking Information

U-DFN1610-8 (Type AX)

(Top View)



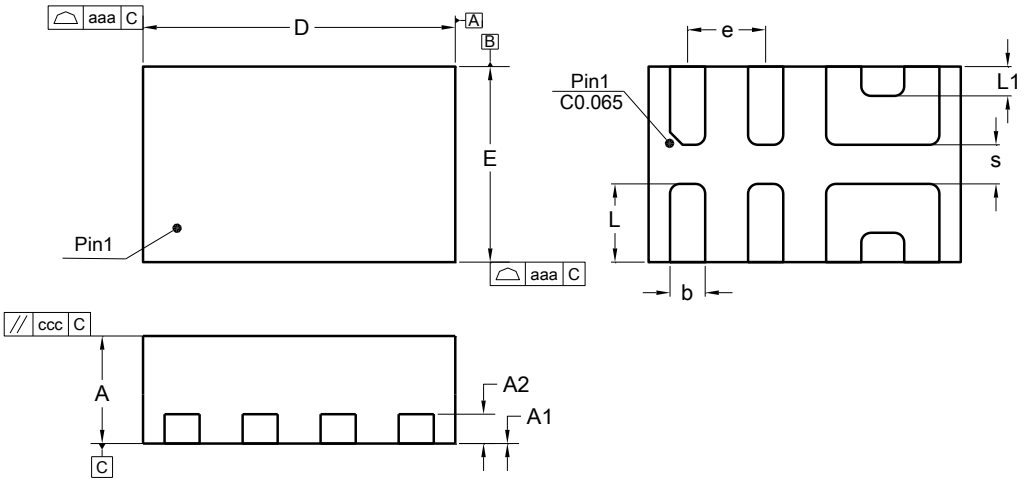
XX : Identification Code
Y : Year : 0 to 9 (ex: 4 = 2024)
W : Week : A to Z : week 1 to 26;
a to z : week 27 to 52; z represents week 52 and 53
X : Internal Code

Part Number	Package	Identification Code
AP221448FLA8-7	U-DFN1610-8 (Type AX)	A2

Package Outline Dimensions

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

U-DFN1610-8 (Type AX)

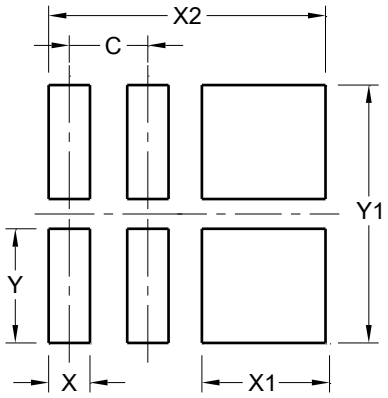


U-DFN1610-8 (Type AX)			
Dim	**Min**	**Max**	**Typ**
A	0.50	0.60	0.55
A1	-0.005	0.03	--
A2	0.225	0.275	0.250
b	0.155	0.205	0.180
D	1.55	1.65	1.60
E	0.95	1.05	1.00
e	--	--	0.40
L	0.375	0.425	0.400
L1	0.125	0.175	0.150
s	--	--	0.20
aaa	0.05		
ccc	0.05		
All Dimensions in mm			

Suggested Pad Layout

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

U-DFN1610-8 (Type AX)



Dimensions	Value (in mm)
C	0.400
X	0.210
X1	0.610
X2	1.410
Y	0.565
Y1	1.300

Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish – NiPdAu. Solderable per MIL-STD-202, Method 208 e4
- Weight: 0.0031 grams (Approximate)

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