AOZ1321DI

Load Switch with Controlled Slew Rate

General Description

The AOZ1321DI is a P-channel high-side load switch with controlled slew rate. Three slew rate options are available. The AOZ1321DI-01L and AOZ1321DI-04L have slew rates of 800us. The AOZ1321DI-02L and AOZ1321DI -05L feature fast Slew Rate (less than 1µs). The slew rate of AOZ1321DI-03L and AOZ1321DI-06L is 100µs. The AOZ1321DI-03L, AOZ1321DI-04L, and AOZ1321DI-05L provide an output discharge circuit to quickly discharge the output when the switch is disabled.

The P-channel MOSFET has typical on resistance of 60mΩ. The very low $R_{DS(ON)}$ significantly reduces the power path dissipation. The input voltage range of AOZ1321DI is from 1.6V to 5.5V. The control input is compatible with both TTL and CMOS logic. Ultra low quiescent current makes this product suitable for any portable applications.

The AOZ1321DI is available in 4-pin 1.2x1.6 DFN package and is rated over the -40°C to +85°C ambient temperature range.

Features

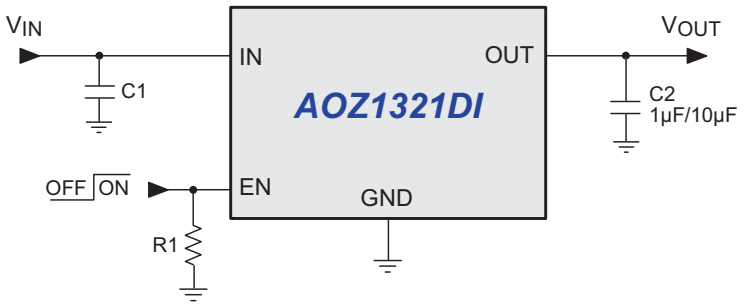
- 1.6V to 5.5V input voltage range
- Low $R_{DS(ON)}$ (60mΩ typical at 5V)
- Controlled turn-on slew rate
  - 800µs (AOZ1321DI-01L, -04L)
  - 100µs (AOZ1321DI-03L, -06L)
  - 1µs (AOZ1321DI-02L, -05L)
- Output discharge function (-03L, -04L, -05L)
- Low quiescent current (1.0µA typical)
- Low shutdown current (<1µA)
- 4kV ESD Rating
- Tiny 1.2x1.6 DFN package

Applications

- Cellular phones
- MP3 players
- Personal media players
- Notebook computers
- Digital still cameras
- Hot-swap applications

Green Product

Typical Application



Ordering Information

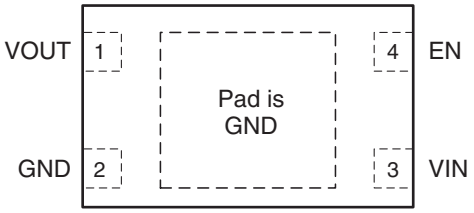
Part Number	Slew Rate	Output Discharge	Package	Environmental
AOZ1321DI-04L	800µs	Yes	1.2 x 1.6 DFN-4	Green Product
AOZ1321DI-01L	800µs	No		
AOZ1321DI-05L	1µs	Yes		
AOZ1321DI-02L	1µs	No		
AOZ1321DI-03L	100µs	Yes		
AOZ1321DI-06L	100µs	No		

• All AOS products are offered in packages with Pb-free plating and compliant to RoHS standards.

• Parts marked as Green Products (with "L" suffix) use reduced levels of Halogens, and are also RoHS compliant.

Please visit www.aosmd.com/web/quality/rohs_compliant.jsp for additional information.

Pin Configuration



DFN-4 1.2mm x 1.6mm
(Top View)

Pin Description

Pin Name	Pin Number	Pin Function
IN	3	Input. IN is the drain of the P-channel MOSFET. It is the supply input of the IC.
GND	2	Ground.
OUT	1	Output. OUT is the source of the P-channel MOSFET.
EN	4	Enable. The P-channel MOSFET turns on when EN is logic HIGH.

Absolute Maximum Ratings

Exceeding the Absolute Maximum ratings may damage the device.

Parameter	Rating
Input Voltage (V_{IN})	6V
Enable Voltage (V_{IN})	6V
Continuous Drain Current (I_D) T_A = 25°C T_A = 85°C	 ±2A ±1.4A
Pulsed Drain Current (I_{DP})	±6A
Continuous Diode Current (I_S)	–50mA
Storage Temperature (T_S)	–55°C to +150°C
ESD Rating(1)	4kV

Note:

1. Devices are inherently ESD sensitive, handling precautions are required. Human body model is a 100pF capacitor discharging through a 1.5kΩ resistor.

Recommend Operating Ratings

The device is not guaranteed to operate beyond the Maximum Operating Ratings.

Parameter	Rating
Input Voltage (V_{IN})	1.6V to 5.5V
Junction Temperature (T_J)	-40°C to +125°C
Package Thermal Resistance 1.2 x 1.6 DFN-4 (Θ_{JA}) 1.2 x 1.6 DFN-4 (Θ_{JC})	 143.17°C/W 128.1°C/W

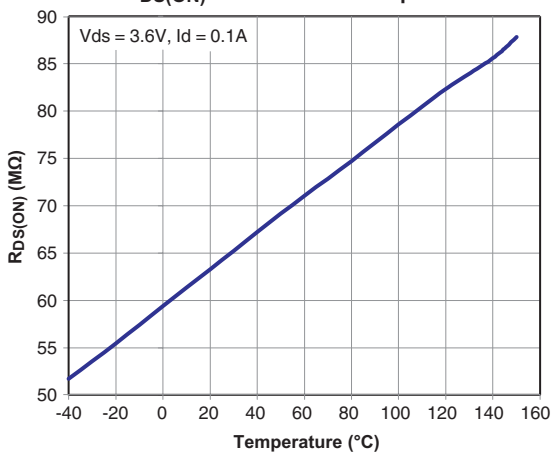
Electrical Characteristics

T_A = 25°C, V_{IN} = V_{EN} = 5V, unless otherwise specified.

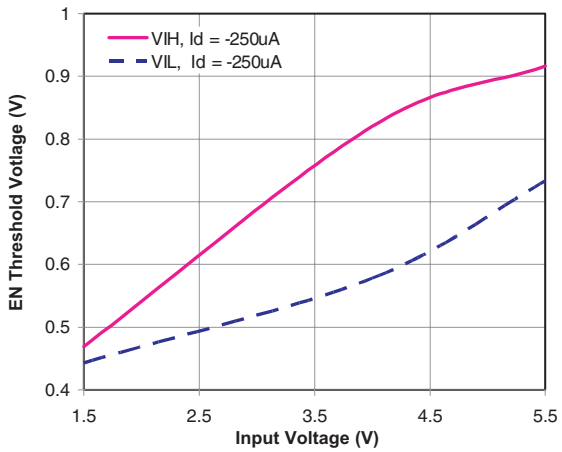
Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_{EN_TH}	Enable Threshold Voltage	V_{IN} = 1.6V to 4.5V, I_D = –250uA	0.3		1.2	V
I_{IN}	Quiescent Supply Current AOZ1321DI -02L/05L	V_{IN} = V_{EN} = 5.5V		1	3	µA
	AOZ1321DI -01L/03L/04L/06L			1.6	3	
I_{OFF}	OFF State Leakage Current	V_{IN} = +5.5V, V_{EN} = 0V			1	µA
$R_{DS(ON)}$	Switch On-Resistance	V_{IN} = 5.0V, I_D = –100mA, V_{EN} = 1.5V		60	85	mΩ
		V_{IN} = 4.5V, I_D = –100mA, V_{EN} = 1.5V		62	90	
		V_{IN} = 3.6V, I_D = –100mA, V_{EN} = 1.5V		65	95	
		V_{IN} = 2.5V, I_D = –100mA, V_{EN} = 1.5V		75	120	
		V_{IN} = 1.8V, I_D = –100mA, V_{EN} = 1.5V		95	180	
		V_{IN} = 1.7V, I_D = –100mA, V_{EN} = 1.5V		101	195	
		V_{IN} = 1.6V, I_D = –100mA, V_{EN} = 1.5V		114	223	
$R_{SHUTDOWN}$	Turn-Off Resistance	V_{IN} = 3.6V, I_{TEST} = 1mA, V_{EN} = 0V		162	220	Ω
AOZ1321DI–05L (T_R = 1µs with Output Discharge)						
$T_{D(ON)}$	Output Turn-on delay	V_{IN} = 3.6V, I_D = –100mA, V_{EN} = 1.5V		1.3	2.5	µs
T_R	Output Rise-time		0.5	1.7	4.0	µs
$T_{D(OFF)}$	Output Turn-off delay			100	200	ns
T_F	Output Fall-time			20	100	ns
AOZ1321DI–02L (T_R = 1µs without Output Discharge)						
$T_{D(ON)}$	Output Turn-On Delay	V_{IN} = 3.6V, I_D = –100mA, V_{EN} = 1.5V		1.3	2.5	µs
T_R	Output Rise-time		0.5	1.7	4.0	µs
$T_{D(OFF)}$	Output Turn-Off Delay			100	200	ns
T_F	Output Fall-time			20	100	ns
AOZ1321DI–04L (T_R = 800µs with Output Discharge)						
$T_{D(ON)}$	Output Turn-On Delay	V_{IN} = 3.6V, I_D = –100mA, V_{EN} = 1.5V		320	700	µs
T_R	Output Rise Time		500	800	1500	µs
$T_{D(OFF)}$	Output Turn-Off Delay			60	200	ns
T_F	Output Fall-time			20	100	ns
AOZ1321DI–01L (T_R = 800µs without Output Discharge)						
$T_{D(ON)}$	Output Turn-On Delay	V_{IN} = 3.6V, I_D = –100mA, V_{EN} = 1.5V		320	700	µs
T_R	Output Rise Time		500	800	1500	µs
$T_{D(OFF)}$	Output Turn-Off Delay			60	200	ns
T_F	Output Fall-time			20	100	ns
AOZ1321DI–03L (TR = 100µs with Output Discharge)						
$T_{D(ON)}$	Output Turn-On Delay	V_{IN} = 3.6V, I_D = –100mA, V_{EN} = 1.5V		120	220	µs
T_R	Output Rise Time		50	100	200	µs
$T_{D(OFF)}$	Output Turn-Off Delay			110	200	ns
T_F	Output Fall-time			20	100	ns
AOZ1321DI–06L (T_R = 100µs without Output Discharge)						
$T_{D(ON)}$	Output Turn-On Delay	V_{IN} = 3.6V, I_D = –100mA, V_{EN} = 1.5V		120	220	µs
T_R	Output Rise Time		50	100	200	µs
$T_{D(OFF)}$	Output Turn-Off Delay			110	200	ns
T_F	Output Fall-time			20	100	ns

Typical Operating Characteristics

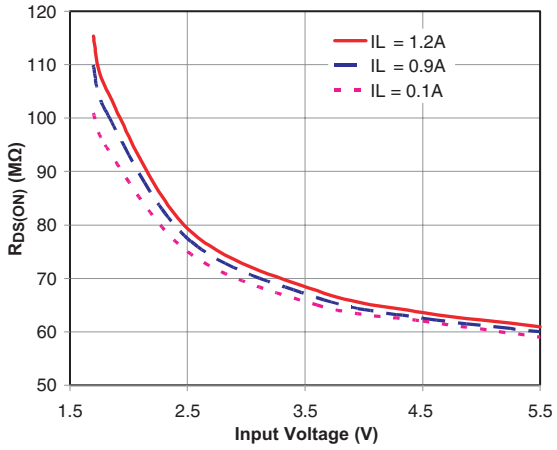
$R_{DS(ON)}$ Variance with Temperature



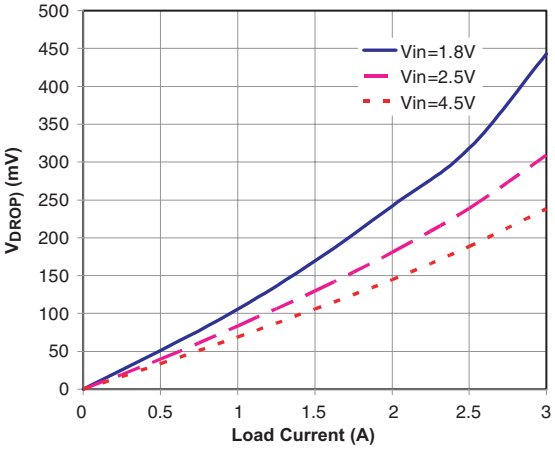
EN Threshold Voltage vs. Input Voltage



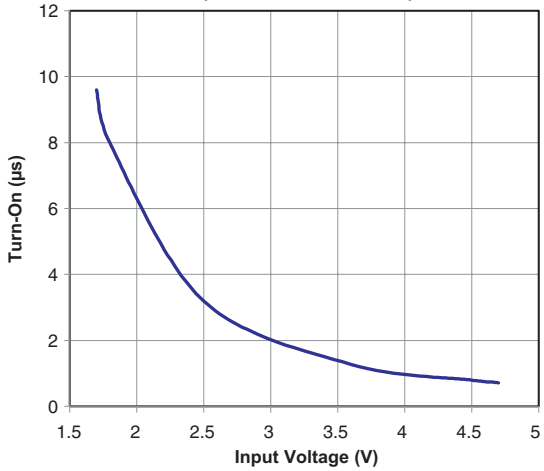
ON Resistance vs. Input Voltage



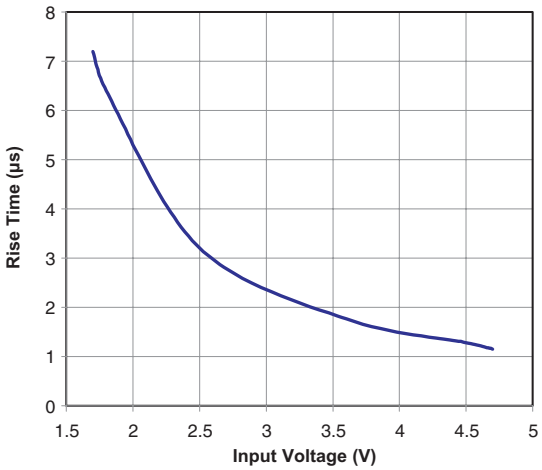
ON Resistance vs. Input Voltage



Turn-on Delay vs. Input Voltage (AOZ1321DI-02L/05L)

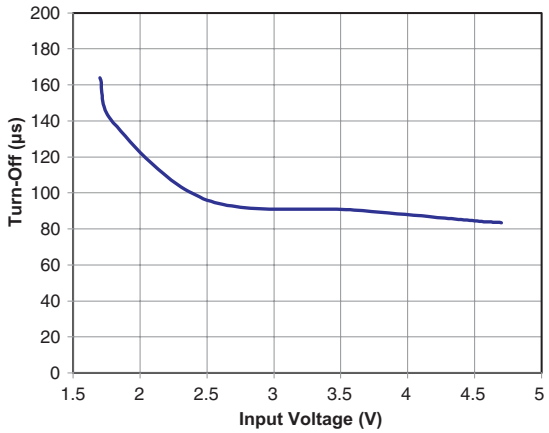


Rise Time vs. Input Voltage (AOZ1321DI-02L/05L)

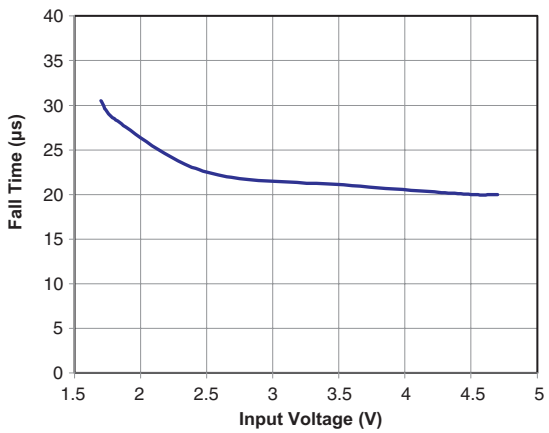


Typical Operating Characteristics (Continued)

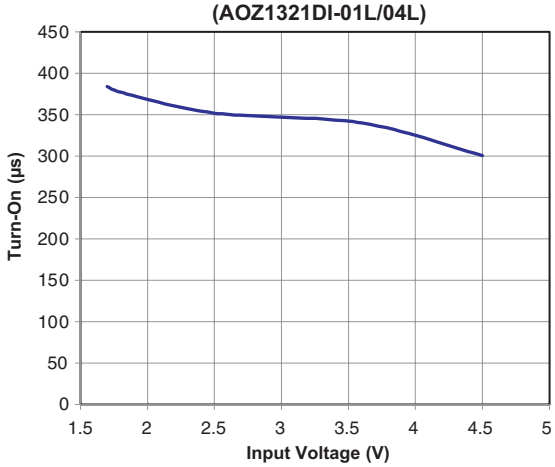
Turn-off Delay vs. Input Voltage (AOZ1321DI-02L/05L)



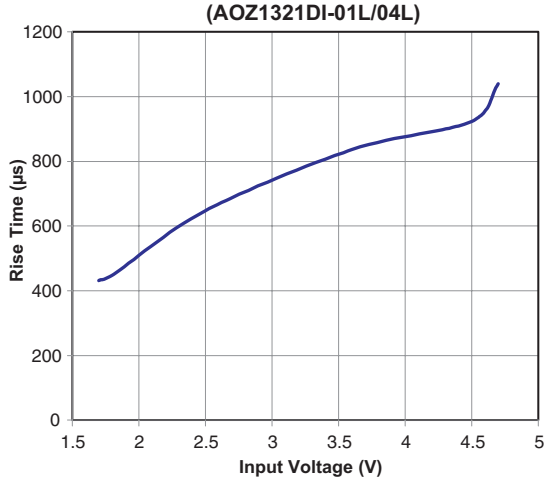
Fall Time vs. Input Voltage (AOZ1321DI-02L/05L)



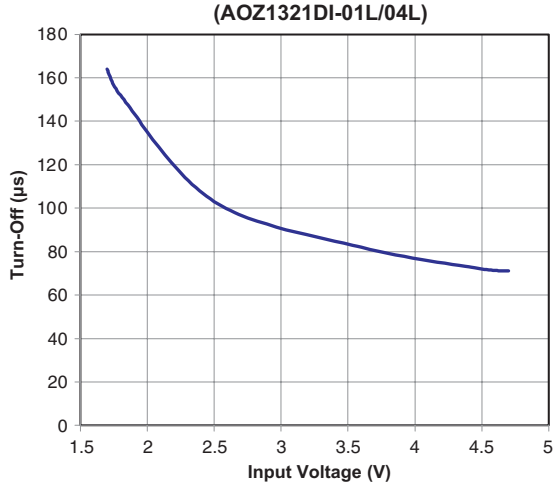
Turn-on Delay vs. Input Voltage (AOZ1321DI-01L/04L)



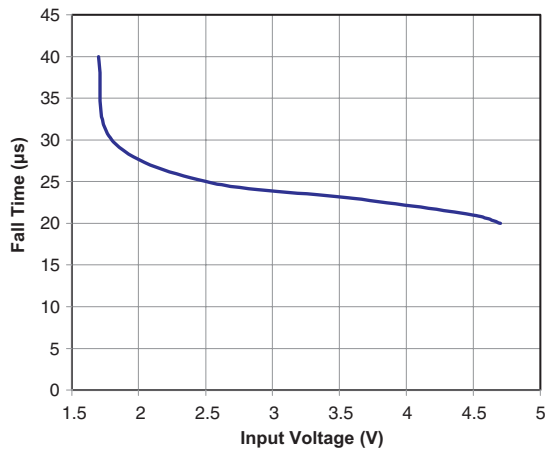
Rise Time vs. Input Voltage (AOZ1321DI-01L/04L)



Turn-off Delay vs. Input Voltage (AOZ1321DI-01L/04L)

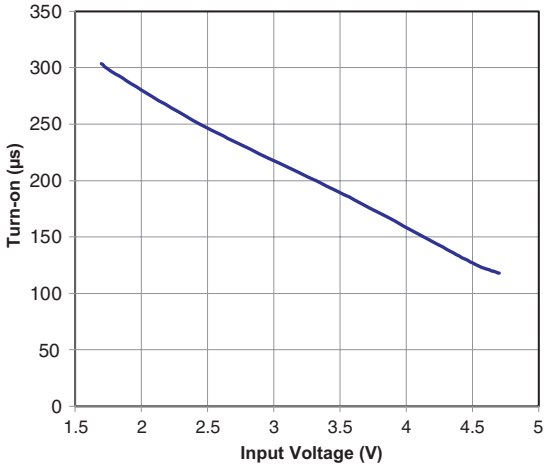


Fall Time vs. Input Voltage (AOZ1321DI-01L/04L)

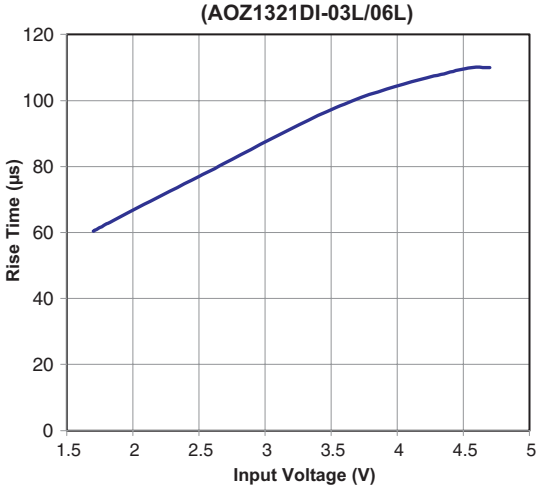


Typical Operating Characteristics (Continued)

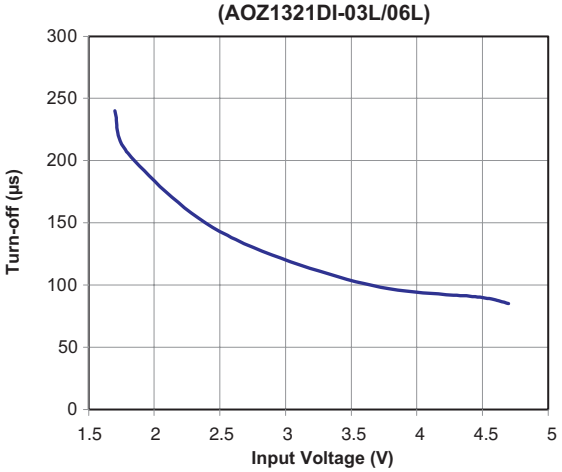
Turn-on Delay vs. Input Voltage (AOZ1321DI-03L/06L)



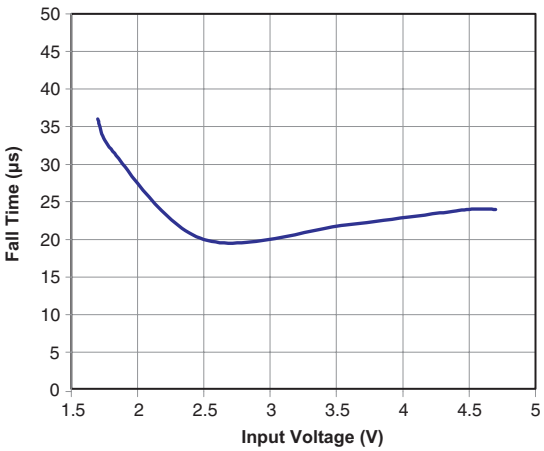
Rise Time vs. Input Voltage (AOZ1321DI-03L/06L)



Turn-off Delay vs. Input Voltage (AOZ1321DI-03L/06L)



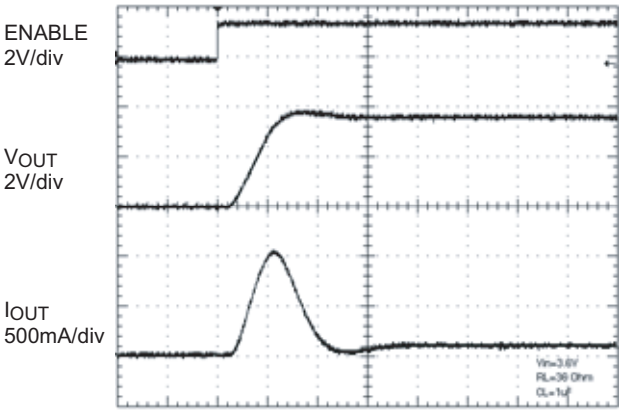
Fall Time vs. Input Voltage (AOZ1321DI-03L/06L)



Functional Characteristics

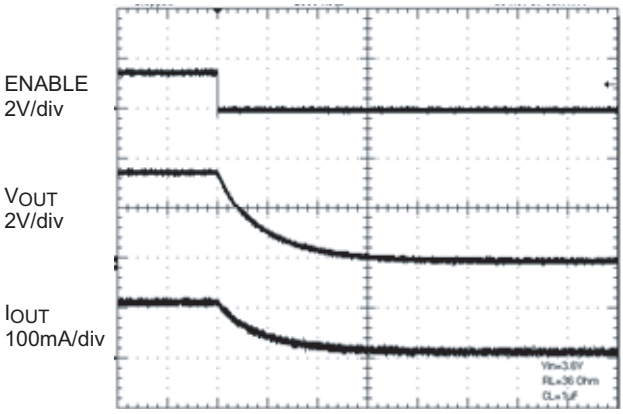
AOZ1321DI-02L, AOZ1321DI-05L

Turn-On Timing



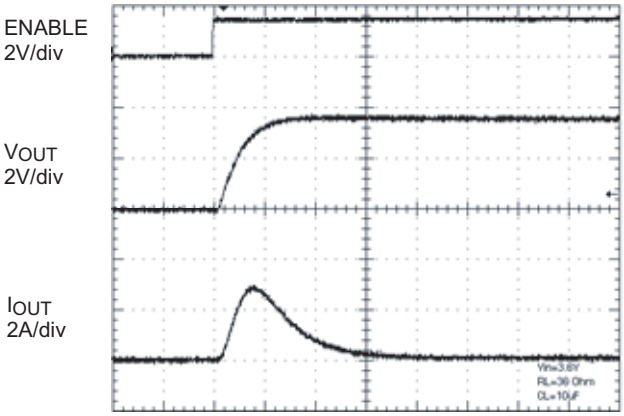
Time: 4µs/div

Turn-Off Timing



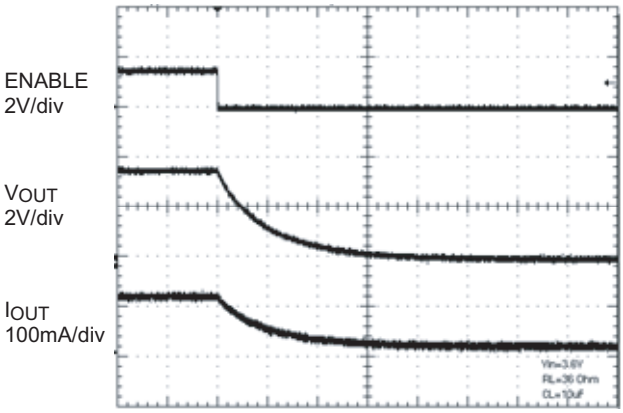
Time: 40µs/div

Turn-On Timing



Time: 10µs/div

Turn-Off Timing

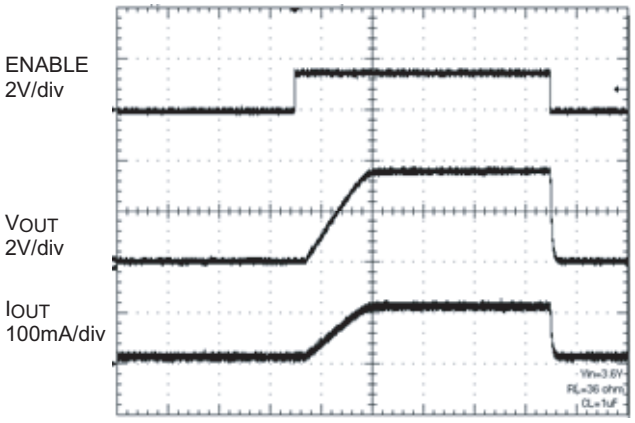


Time: 400µs/div

Functional Characteristics (Continued)

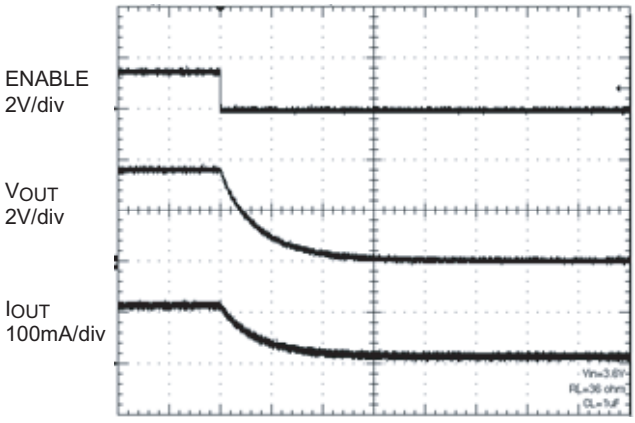
AOZ1321DI-01L, AOZ1321DI-04L

Turn-On/Turn-Off Timing



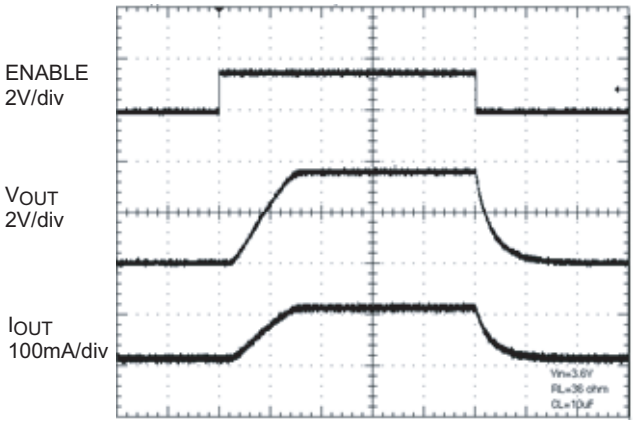
Time: 1ms/div

Turn-Off Timing



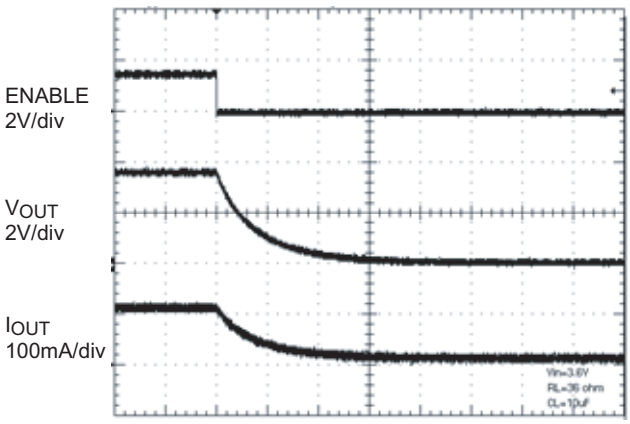
Time: 40µs/div

Turn-On/Turn-Off Timing



Time: 1ms/div

Turn-Off Timing

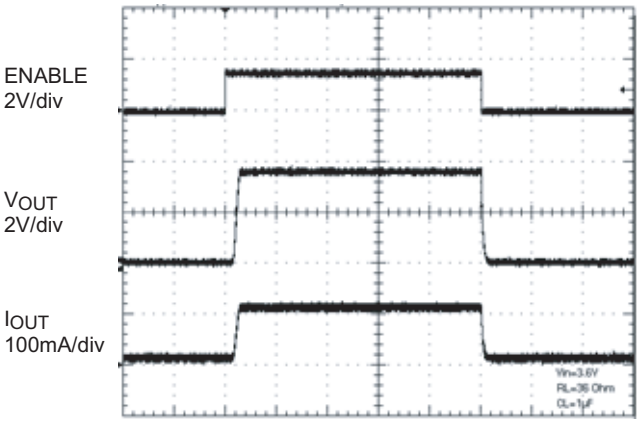


Time: 400µs/div

Functional Characteristics (Continued)

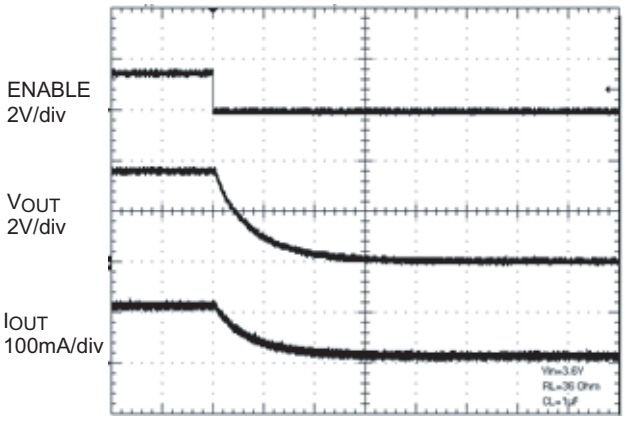
AOZ1321DI-03L, AOZ1321DI-06L

Turn-On/Turn-Off Timing



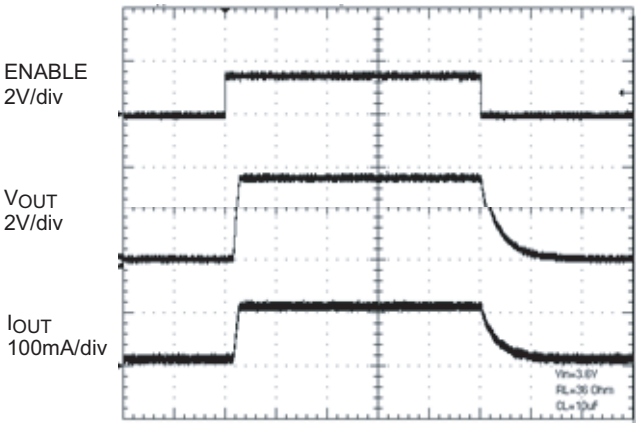
Time: 1ms/div

Turn-Off Timing



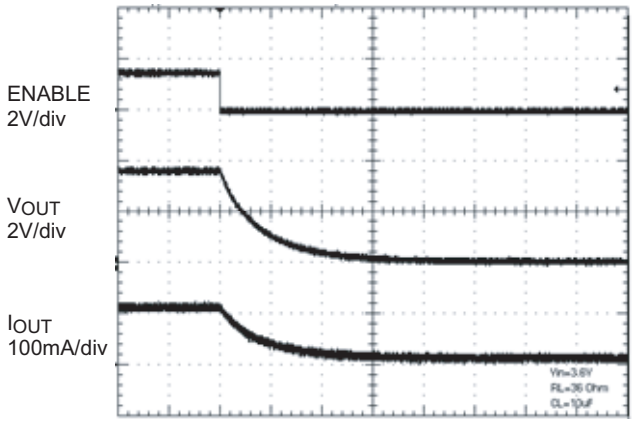
Time: 40µs/div

Turn-On/Turn-Off Timing



Time: 1ms/div

Turn-Off Timing



Time: 400µs/div

Timing Diagram

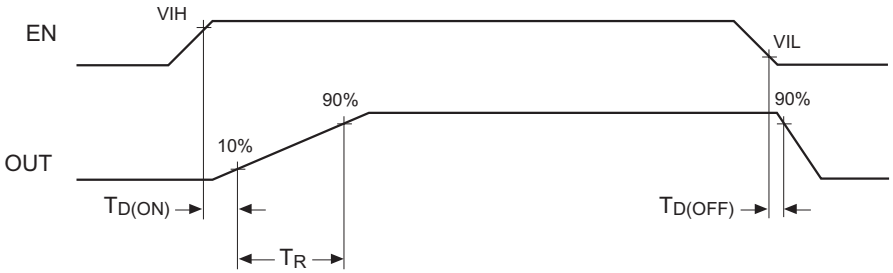


Figure 1. AOZ1321 Timing Diagram

Functional Block Diagram

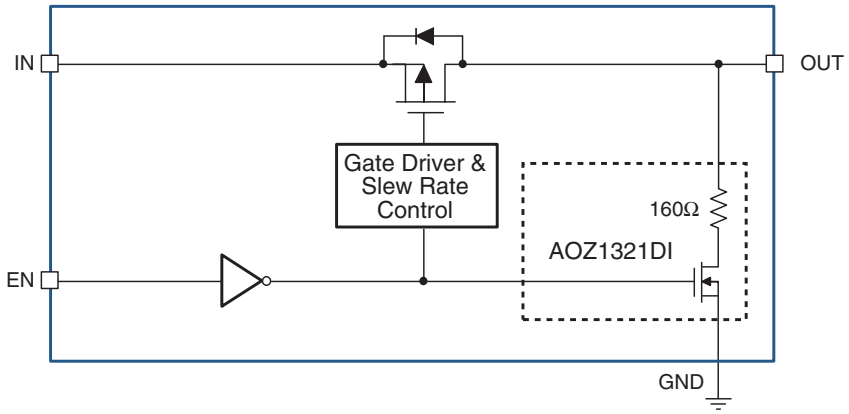


Figure 2. Functional Block Diagram

Detailed Description

Internal Discharge Resistor

The AOZ1321DI has an internal 160Ω resistor to discharge any remaining voltage from the system to the ground that is store in a capacitive load. This provides a safe shutdown of the system to prevent any damages to the devices. This function is controlled from the Enable pin.

Slew Rate Control

The AOZ1321DI is a family of P-channel high-side load switches with controlled slew rate. The device is enabled when the EN pin is high. Once enabled, the gate driver and slew-rate control circuitry immediately raises the source-to-gate voltage of the P-channel MOSFET to its threshold level, and then gradually turns on the MOSFET by linearly increasing the source-to-gate voltage. This slow turn-on action effectively limits the input inrush current and provides a nice ramp for the output voltage. After the MOSFET is fully enhanced, the AOZ1321DI quickly increases the source-to-gate voltage to the full input voltage to minimize on resistance and reduce power dissipation.

Three slew-rate options are available. AOZ1321DI-01L and AOZ1321DI-04L have slew rate of 800us. This option significantly reduces the inrush current when the MOSFET turns on, allowing the use of very small input capacitor. AOZ1321DI-02L and -05L have no slew rate control and the MOSFET can be turned on within 1us. This option is suitable for applications that require very fast switching. AOZ1321DI-03L and -06L have moderate slew rate to 100µs. The AOZ1321DI-03L, -04L and -05L options include an internal output discharge circuit that quickly discharges the output to ground when the device is disabled.

On/Off Control

The AOZ1321DI is enabled when the EN pin is asserted high. The device is disabled when the EN pin is asserted low. The EN input is compatible with both TTL and CMOS logic.

Applications Information

Input Capacitor Selection

Use a 1µF or larger capacitor for input bypassing. Place the capacitor close to the IN pins of AOZ1321DI.

Output Capacitor Selection

Use a 0.1µF or larger capacitor between OUT and GND. The capacitance does not affect the turn-on slew rate. However, a larger capacitor makes the initial turn-on transient smoother.

Layout Guidelines

Good PCB is important for improving the thermal performance of AOZ1321DI. Place the input and output bypass capacitors close to the IN and OUT pins. The input and output PCB traces should be as wide as possible for the given PCB space. Use a ground plane to enhance the power dissipation capability of the device. The AOZ1321DI evaluation board can be used as a layout example. The PCB layout of AOZ1321DI evaluation board is shown in Figure 3.

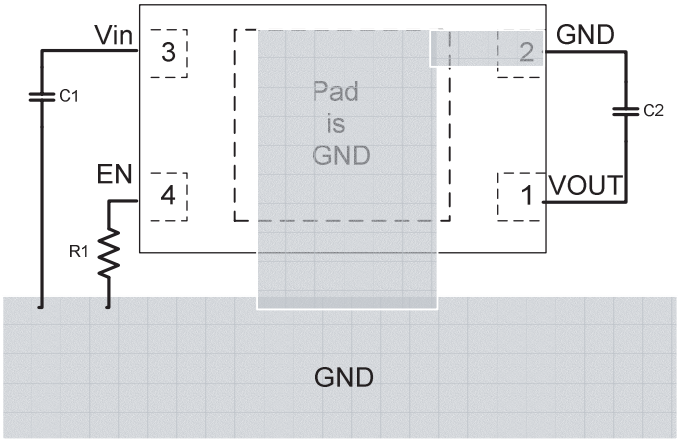
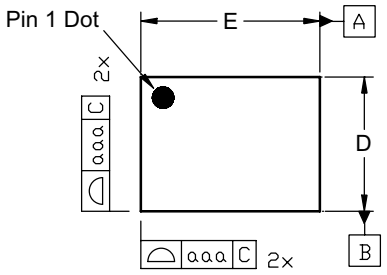
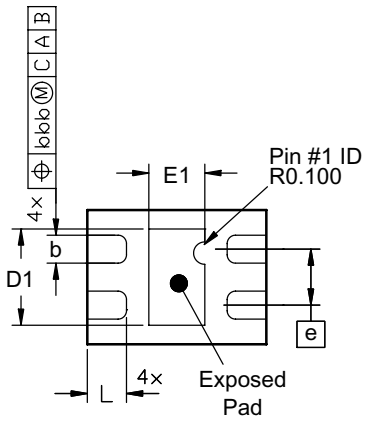


Figure 3. AOZ1321DI PCB Layout

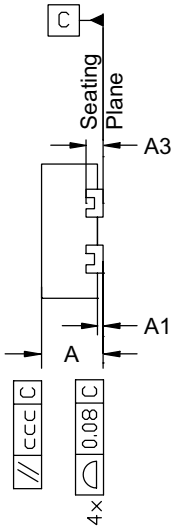
Package Dimensions, DFN 1.2 x 1.6 4L



TOP VIEW

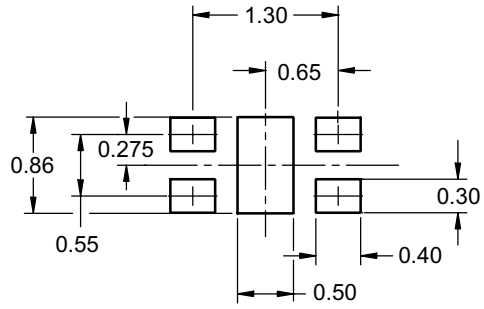


BOTTOM VIEW



SIDE VIEW

RECOMMENDED LAND PATTERN



UNIT: mm

Dimensions in millimeters

Symbols	Min.	Nom.	Max.
A	0.50	0.55	0.60
A1	0	—	0.05
A3		0.152 REF.	
b	0.20	0.25	0.30
E	1.55	1.60	1.65
E1	0.45	0.50	0.55
D	1.15	1.20	1.25
D1	0.81	0.86	0.91
e		0.5 BSC	
L	0.30	0.35	0.40
aaa	—	0.15	—
bbb	—	0.10	—
ccc	—	0.10	—

Dimensions in inches

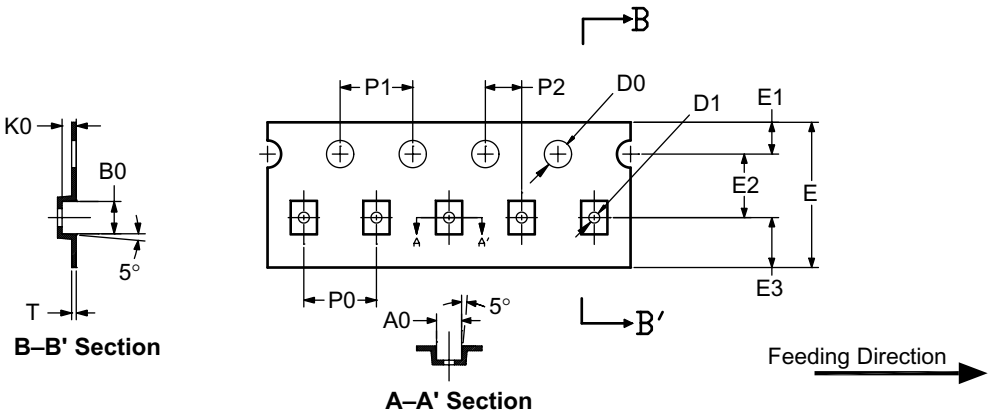
Symbols	Min.	Nom.	Max.
A	0.020	0.022	0.024
A1	0	—	0.002
A3		0.006 REF.	
b	0.008	0.010	0.012
E	0.061	0.063	0.065
E1	0.018	0.020	0.022
D	0.045	0.047	0.049
D1	0.032	0.034	0.036
e		0.020 BSC	
L	0.012	0.014	0.016
aaa	—	0.006	—
bbb	—	0.004	—
ccc	—	0.004	—

Notes:

1. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.
2. Coplanarity ccc applies to the terminals and all other bottom surface metallization.

Tape and Reel Dimensions, DFN 1.2 x 1.6 4L

Carrier Tape



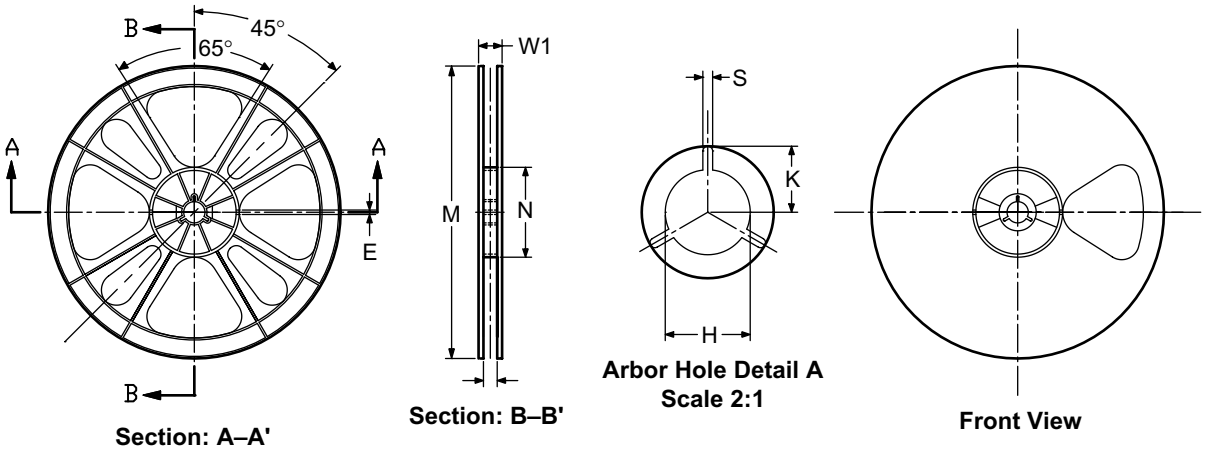
B–B' Section

A–A' Section

UNIT: mm

Package	T	B0	A0	K0	D0	D1	E	E1	E2	P0	P1	P2
DFN 1.2x1.6	0.254 ±0.02	1.78 ±0.05	1.38 ±0.05	0.78 ±0.05	ø1.5 ±0.10	ø0.6 ±0.05	8.00 +0.30/-0.10	1.75 ±0.10	3.50 ±0.05	4.00 ±0.10	4.00 ±0.10	2.00 ±0.05

Reel



Section: A–A'

Section: B–B'

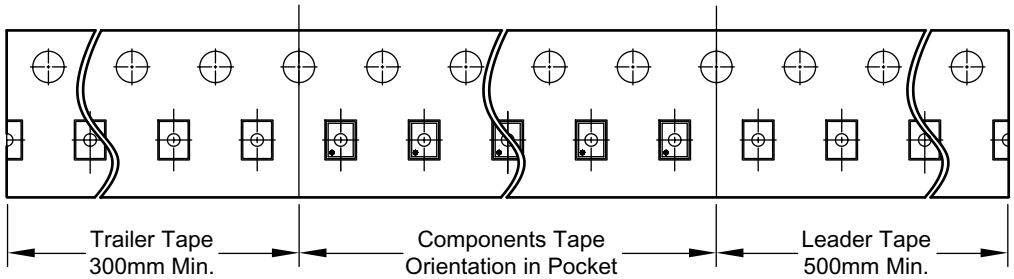
Arbor Hole Detail A
Scale 2:1

Front View

UNIT: mm

Tape Size	Reel Size	M	N	W	W1	H	S	K	E
8mm	ø149	ø179.0 ±0.50	ø55.0 ±0.5	8.4 +1.5/-0.0	14.4 Max.	ø13.0 +0.5/-0.2	1.5 Min.	10.1 Min.	2.70 ±0.2

Leader / Trailer & Orientation



Package Marking

DFN 1.2 x 1.6