AOZ18101DI-03/04

14 V 20 mΩ Over-Voltage Protection Efuse

General Description

AOZ18101DI-03/04 is a current-limiting over-voltage protection Efuse targeting applications that require front end protection at the input line. Both VIN and VOUT terminals are rated at 22 V absolute maximum. There is a programable soft-start feature that controls the inrush current for highly capacitive loads. It also has Input Under-Voltage Lock Out (UVLO), Input Over-Voltage Output Clamp (OVC), and Thermal Shut Down Protection (TSD).

AOZ18101DI-03/04 features an internal current-limiting circuit that protects the supply from large load current. The current limit threshold can be set externally with a resistor.

AOZ18101DI-03 is auto-restart version after fault condition. AOZ18101DI-04 is latch-off version after fault is detected. Both are available in small 3 mm x 3 mm 10-pin DFN package.

Features

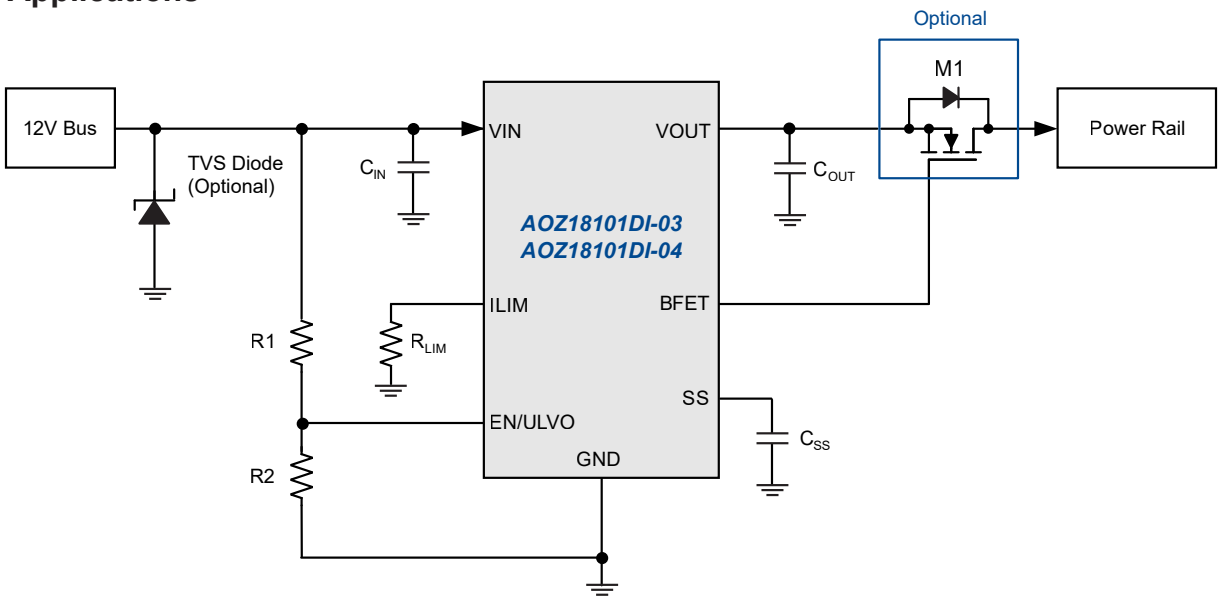
- 3.5 V to 14 V input voltage operating range
- 22 V abs max voltage rating on VIN and VOUT pin
- Typical R_{ON}: 20 mΩ
- 1 A to 5 A programmable current limit
- Programmable output soft start time
- Fast Over Current Protection (OCP)
- Input Over-Voltage Output Clamp (OVC)
- Input Under-Voltage Lock Out (UVLO)
- Thermal Shut Down Protection (TSD)
- ±2 kV HBM ESD rating
- ±1 kV CDM ESD rating
- IEC 61000-4-2: ±8 kV on VIN and VOUT
- IEC 61000-4-5: ± 40 V on VIN, No cap

Applications

- Servers
- HDD and SSD drivers
- PCI cards
- Networking

Green Product

Typical Applications

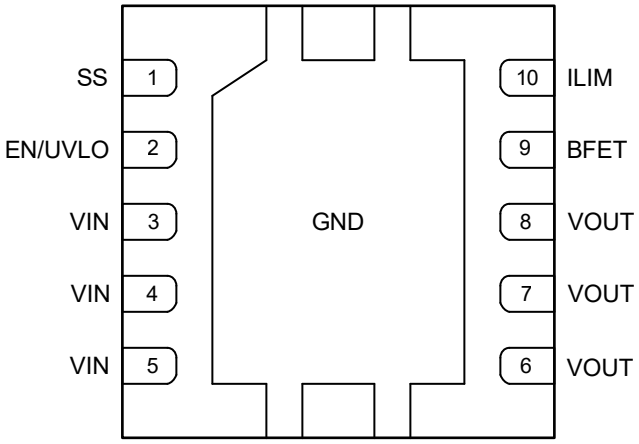


Ordering Information

Part Number	Fault Recovery	Operating Voltage Range	Package	Environmental
AOZ18101DI-03	Auto-Restart	3.5 V – 14 V	DFN3x3-10L	RoHS
AOZ18101DI-04	Latch-Up	3.5 V – 14 V	DFN3x3-10L	RoHS

AOS products are offered in packages with Pb-free plating and compliant to RoHS standards.
Please visit www.aosmd.com/media/AOSGreenPolicy.pdf for additional information.

Pin Configuration



DFN3x3-10L
(Top Transparent View)

Pin Description

Pin Number	Pin Name	Pin Function
1	SS	Soft-start control. Connect a capacitor C_{SS} from SS to GND to set the soft-start time.
2	EN/UVLO	Enable input. Active high. It can be used as UVLO by connecting resistor divider from VIN.
3, 4, 5	VIN	Supply input. Connected to main power supply. They are internally connected together.
6, 7, 8	VOUT	Power output. They are internally connected together.
9	BFET	External blocking FET gate control. This pin can be left open when it is not used. When external blocking FET is used, connect this pin to the gate of the blocking FET.
10	ILIM	Current limit set pin. Connect a 1% resistor RLIM from ILIM to GND to set the current limit threshold.
EXP	GND	Ground. Connect to GND. For best thermal performance make the ground copper pads as large as possible and connect to EXP to the ground plane through multiple thermal VIAs.

Absolute Maximum Ratings

Exceeding the Absolute Maximum ratings may damage the device.

Parameter	Rating
VIN, VOUT to GND	-0.3 V to 22 V
VOUT to GND Transient <1 µs	-1.2 V
EN/UVLO, ILIM, SS to GND	-0.3 V to 6 V
BFET to GND	-0.3 V to 22 V
Junction Temperature (T_J)	+150 °C
Storage Temperature (T_S)	-65 °C to +150 °C
ESD Rating HBM All Pins	±2 kV
IEC 61000-4-2: VOUT and VIN	±8 kV

Recommended Operating Conditions

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

Parameter	Rating
Supply Voltage VIN, VOUT to GND	3.5 V to 14 V
BFET to GND	0 V to VOUT +6 V
EN/UVLO, ILIM, SS to GND	0 V to 5.5 V
Switch DC Current (I_{SW})	0 A to 5A
Junction Temperature (T_J)	-40 °C to +125 °C
Package Thermal Resistance DFN3x3-10L (Θ_{JA})	65 °C/W

Electrical Characteristics[1]

T_A = 25 °C, VIN = 12 V, EN = 5 V, R_{LIM} = 100 kΩ, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
General						
V_{VIN}	Input Supply Voltage		3.5		14	V
V_{UVLO_R}	Under-voltage Lockout Threshold	VIN rising	2.9		3.4	V
V_{UVLO_HYS}	Under-voltage Lockout Hysteresis	VIN falling		250		mV
I_{VIN_ON}	Input Quiescent Current	IOUT = 0 A		500		µA
I_{VIN_OFF}	Input Shutdown Current	EN/UVLO = 0 V		125		µA
V_{OVC}	Output Over-Voltage Clamp	VIN = 17 V, I_{OUT} = 10 mA	14.0	15.0	16.5	V
R_{ON}	Switch ON-Resistance	VIN = 12 V, I_{OUT} = 1A		20		mΩ
		VIN = 5 V, I_{OUT} = 1A		21		
V_{EN_H}	EN Input Logic High Threshold	EN/UVLO rising	1.3	1.40	1.45	V
V_{EN_L}	EN Input Logic Low Threshold	EN/UVLO falling	1.2	1.35	1.4	V
I_{EN_BIAS}	EN Input Pull-down Resistance	EN/UVLO = 1.8 V	-100		100	nA
Dynamic Timing Characteristics						
t_{D_ON}	Turn-On Delay Time	From EN/UVLO > V_{EN_H} to VOUT = 0.1 V. C_{SS} = open	420	600	780	µs
t_{ON}	Turn-On Time (VOUT from 0.1 V to 11.7 V)	C_{SS} = open	420	700	980	µs
		C_{SS} = 1 nF		12		ms
t_{D_OFF}	Turn-off Delay Time	From EN/UVLO < V_{EN_L} to BFET = falling down to 12V, C_{BFET} = open		0.5		µs
t_{BFET_ON}	BFET Turn-On Time	From EN/UVLO > V_{EN_H} to BFET = rising above to 12V, C_{BFET} = 1 nF		1.3		ms
		From EN/UVLO > V_{EN_H} to BFET = rising above to 12V, C_{BFET} = 10 nF		2.3		ms

Electrical Characteristics[1]

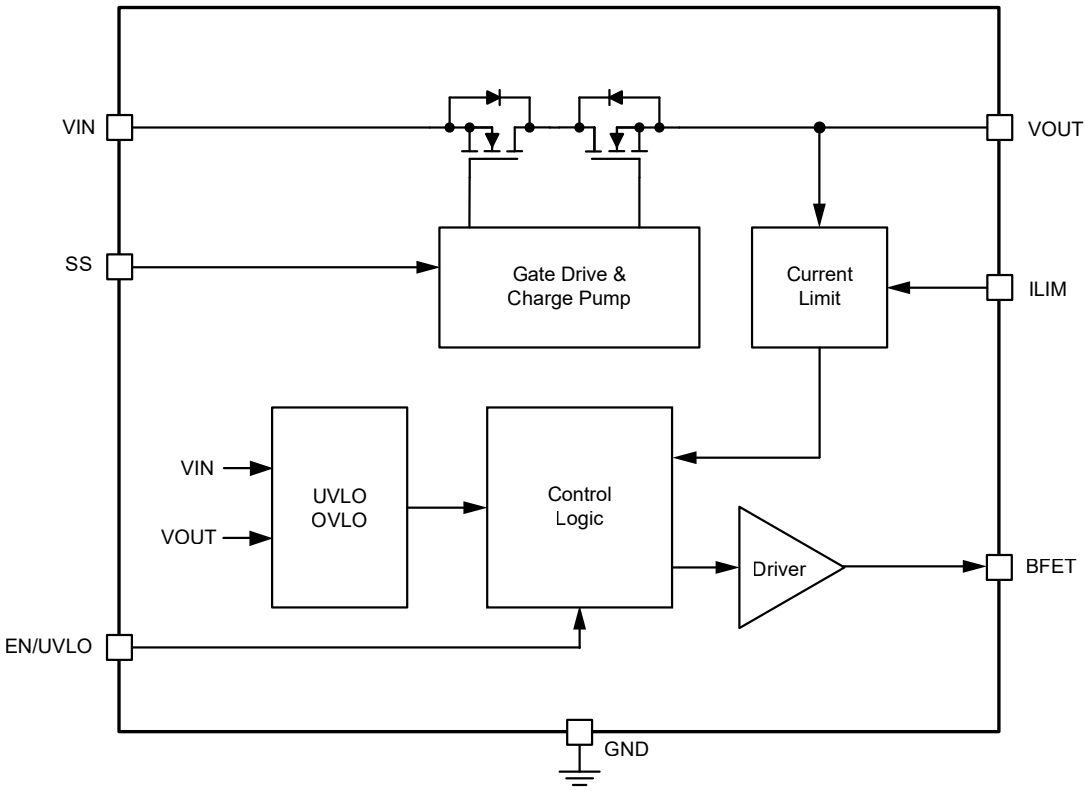
T_A = 25°C, VIN = 12V, EN = 5V, R_{LIM} = 100kΩ, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
Dynamic Timing Characteristics						
t_{BFET_OFF}	BFET Turn-Off Time	From EN/UVLO < V_{EN_L} to BFET = falling down to 12V, C_{BFET} = 1nF		6		µs
		From EN/UVLO < V_{EN_L} to BFET = falling down to 12V, C_{BFET} = 10nF		50		µs
Over Current Protection (OCP)						
I_{LIM}	Current Limt Threshold	R_{LIM} = 150kΩ	4.50	5.10	5.70	A
		R_{LIM} = 100kΩ	3.46	3.75	4.03	
		R_{LIM} = 45.3kΩ	1.79	2.10	2.42	
		R_{LIM} = 10kΩ		1.00		
		R_{LIM} = 0 or Open		0.75		
I_{OCP_FAST}	Fast OCP Threshold for Current Spike	Based on I_{LIM} value		160		%
t_{OCP_FAST}	Fast OCP Response Time	From IOUT > (I_{LIM} x 160%)		300		ns
Blocking FET Driver						
I_{BFET}	BFET Driving Current	BFET = VOUT		10		µA
R_{BFET_DIS}	BFET Discharge Resistance			29		kΩ
Thermal Shutdown (TSD)						
T_{SD}	Thermal Shutdown Threshold	Temperature rising		140		°C
T_{SD_HYS}	Thermal Shutdown Hysteresis	Temperatsure falling		30		°C

Note:

1. Guaranteed by characterization and design.

Functional Block Diagram



Timing Diagrams

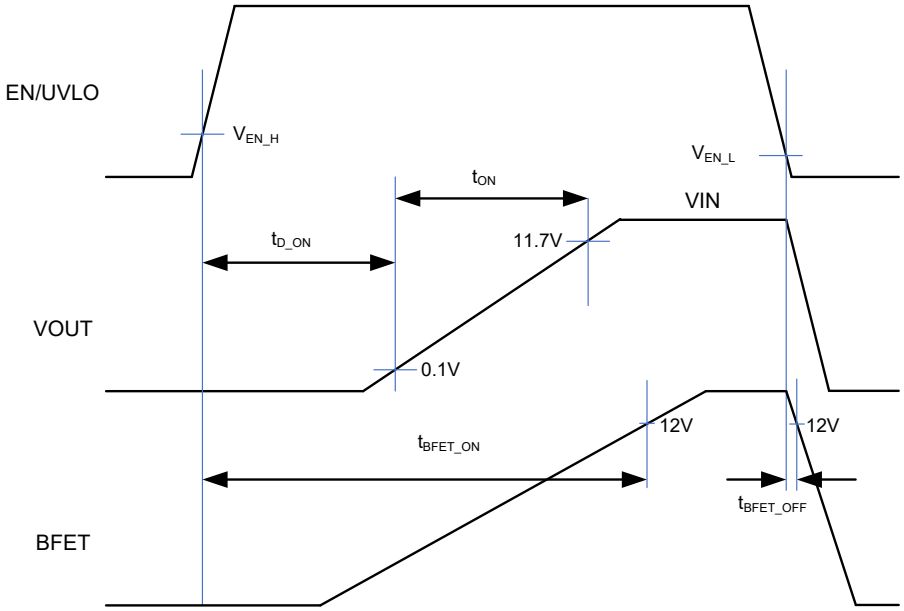


Figure 1. Turn-on Delay, Turn-on and Turn-off Time

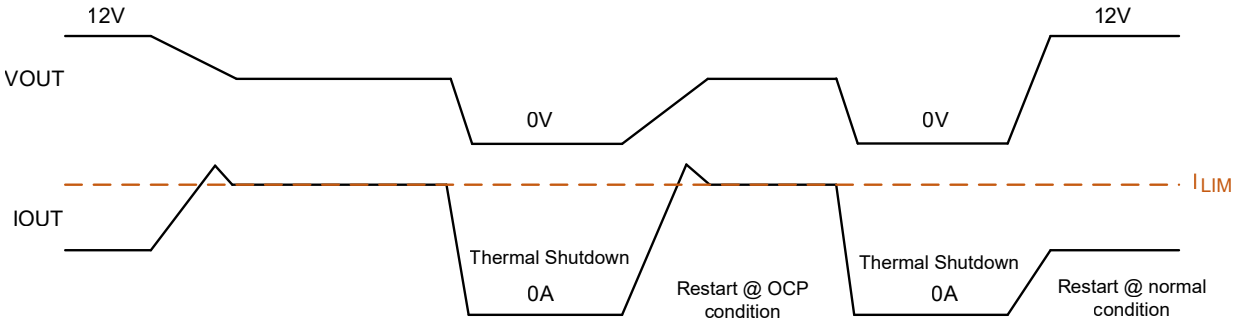


Figure 2. Current Limit Operation (AOZ18101-03 Auto-Restart)

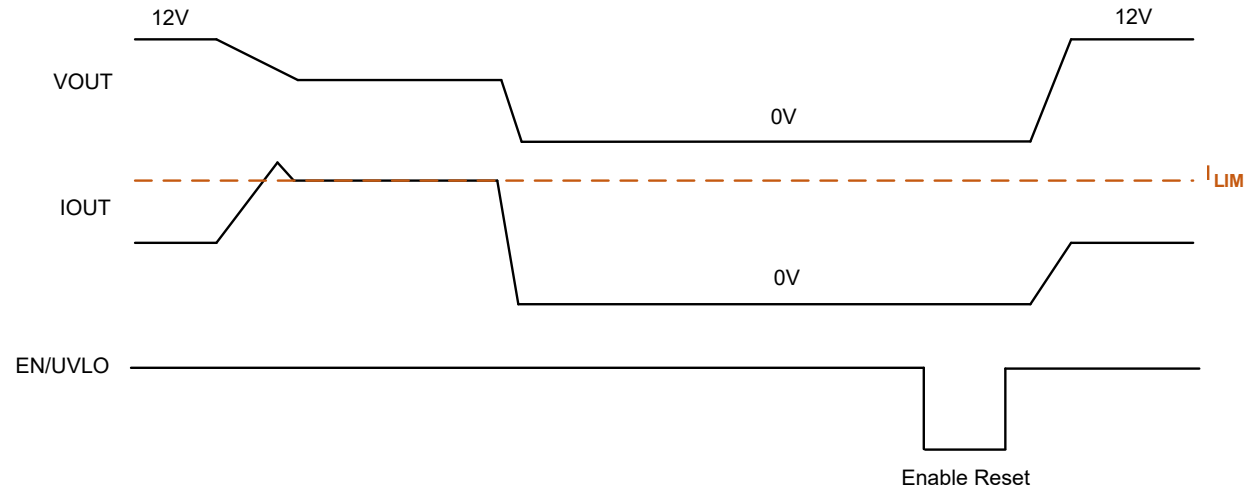
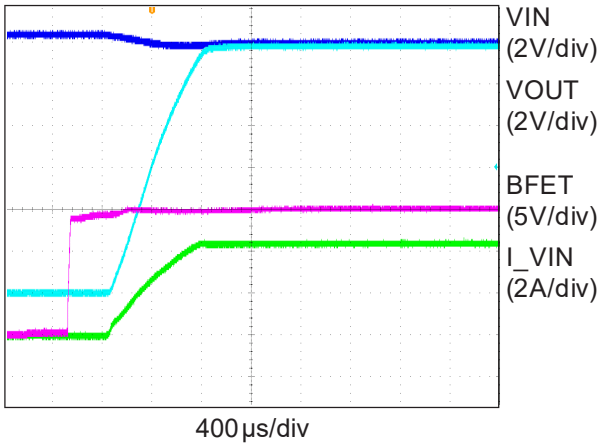


Figure 3. Current Limit Operation (AOZ18101-04 Latch-off)

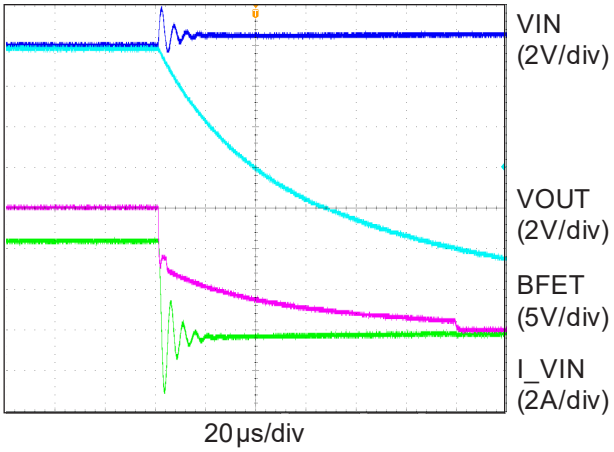
Typical Characteristics

T_A = 25°C, VIN = 12V, EN = 5V, C_{IN} = 10µF, C_{OUT} = 10µF, C_{SS} = 1nF, R_{LIM} = 150kΩ, unless otherwise specified.

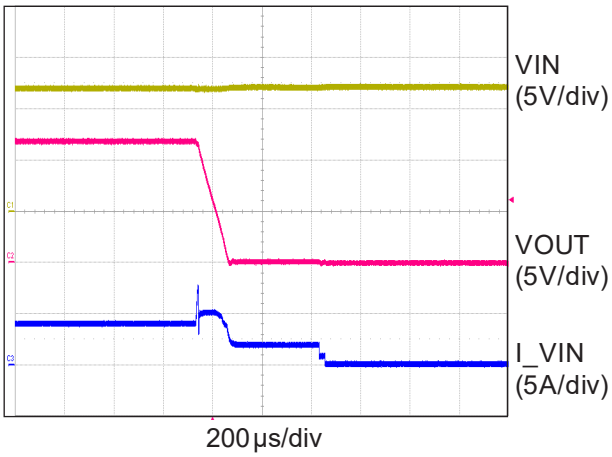
Start Up (Load = 5A)



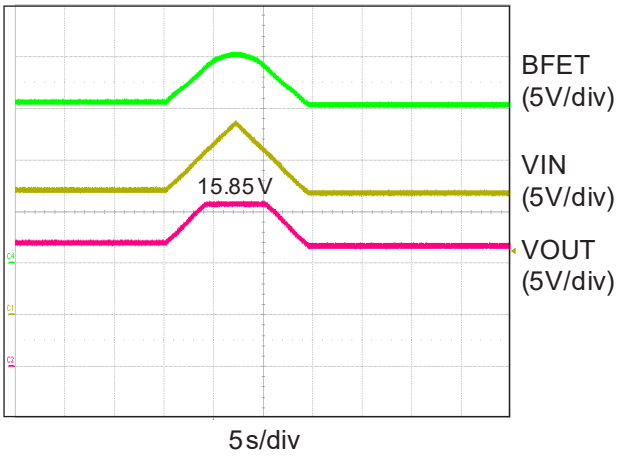
Shutdown



Over-Current Protection



Output Over-Voltage Clamp



Typical Characteristics

T_A = 25 °C, VIN = 12 V, EN = 5 V, C_{IN} = 10 µF, C_{OUT} = 10 µF, C_{SS} = 1 nF, R_{LIM} = 150 kΩ, unless otherwise specified.

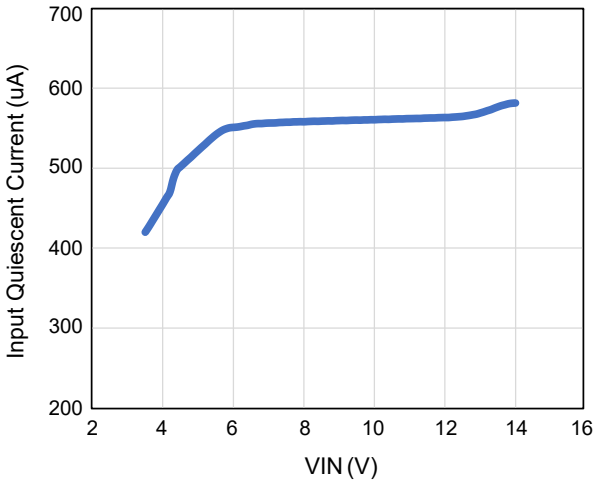


Figure 4. Input Quiescent Current vs. VIN

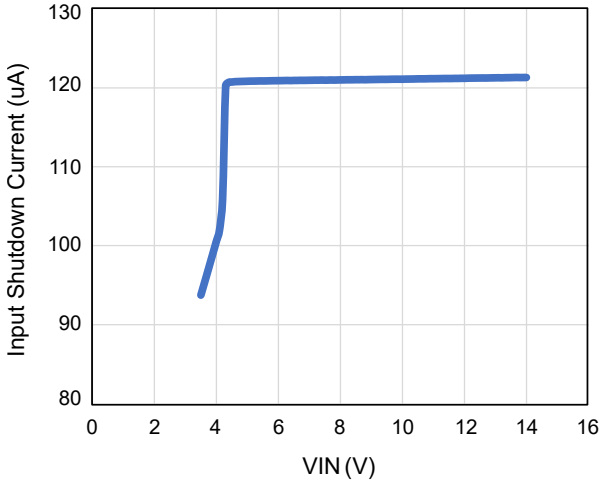


Figure 5. Input Shutdown Current vs. VIN

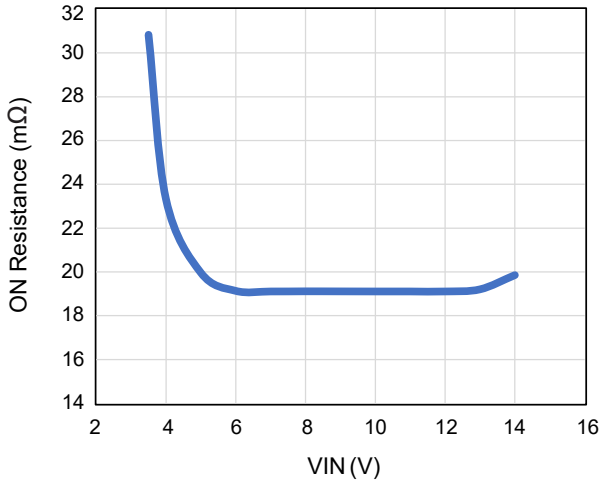


Figure 6. ON Resistance vs. VIN

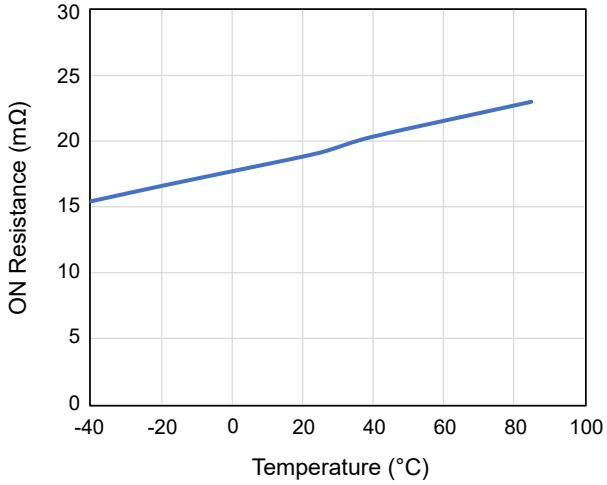


Figure 7. ON Resistance vs. Temperature (VIN = 12V)

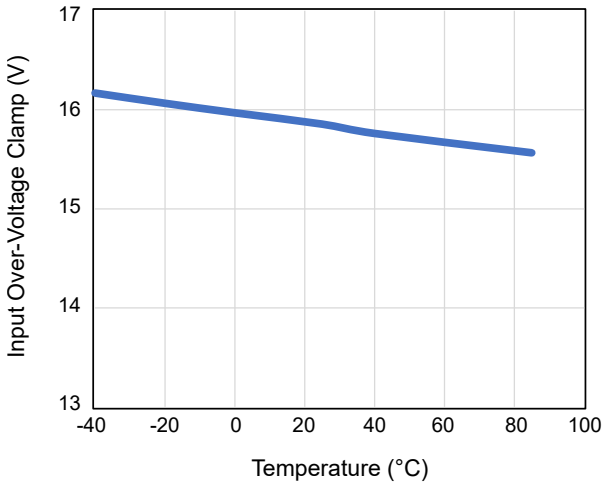


Figure 8. Input Over-Voltage Clamp vs. Temperature

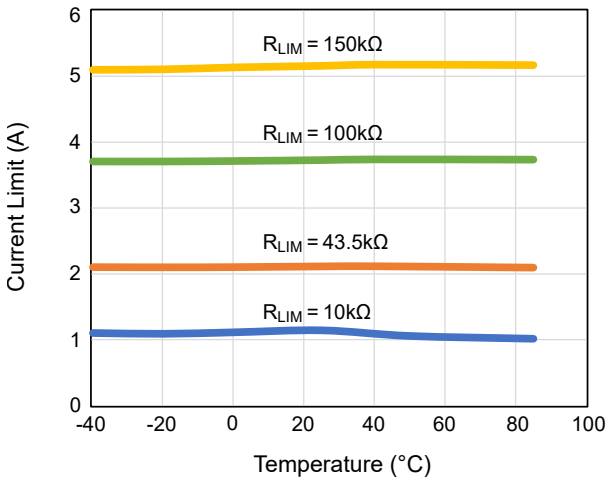


Figure 9. Current Limit vs. Temperature

Detailed Description

AOZ18101DI-03/04 is a current-limiting power switch with under-voltage, over-voltage, over-current and thermal shutdown protections. The VIN and VOUT pins are rated 22 V abs max.

Enable and Under-Voltage Lockout

The EN/UVLO pin is the ON/OFF control for the power switch. The device is enabled when the voltage at EN/UVLO pin is higher than V_{EN_H} and the input voltage is higher than the under-voltage lockout threshold, VIN > V_{UVLO_R}.

EN/UVLO pin can be biased with resistor divider network from VIN so that device enable will be tracking the input voltage. While disabled, the AOZ18101DI-03/04 draws 125 µA from supply. EN/UVLO cannot be left floating.

Input Under-Voltage Lockout (UVLO)

The under-voltage lockout (UVLO) circuit monitors the input voltage. The power switch and the BFET for charging the gate of the external FET are only allowed to turn on when input voltage is higher than UVLO threshold (V_{UVLO_R}). Otherwise the switch is off.

Over-Voltage Clamp (OVC)

The voltage at VIN pin is constantly monitored once the device is enabled. In case input voltage exceeds the over-voltage clamp (V_{OVC}), the output voltage will be clamped at the threshold voltage.

Under the over-voltage clamp (OVC) condition, the output voltage is clamped to the V_{OVC} level. The power dissipation in the internal FETs under this condition is P_{FET_OVC} = (VIN – V_{OVC}) x I_{OUT}, which can heat up the device and causes thermal shutdown when the temperature reaches TSD.

Programmable Current Limit and Over-Current Protection (OCP)

The AOZ18101DI-03/04 implements current limit to ensure that the current through the switch does not exceed current limit threshold set by the external resistor RLIM.

The current limit threshold can be estimated using the equation below:

$$I_{LIM} = (0.7 + 3 \times 10^{-5} \times R_{LIM})$$

where R_{LIM} unit is in Ohm and I_{LIM} unit is in Ampere.

AOZ18101DI-03/04 continuously limits the output current when output is overloaded. Under this condition, the part is dissipating excessive power due to higher voltage drop across VIN to VOUT. If over current continues to exist, it will reach thermal shutdown threshold and the switch will be turned off.

For AOZ18101DI-03 Auto-Restart version, the power switch will be turn on again to restart after thermal shutdown is released.

For AOZ18101DI-04 Latch Off version, the power switch will only be turned on after toggling the EN/UVLO input logic to reset the device.

The AOZ18101-03/04 integrates a fast comparator which will trigger to turn off the switch at 160% of the current limit threshold set by ILIM pin. After the fast comparator turns off the switch, the switch will be turned on to regulate the current to the set current limit threshold.

Programming Soft Start

The output soft-start time can be programmed externally through SS pin. The output soft-start time can be estimated using the equations below:

$$t_{ON} = \frac{(C_{SS} + 0.07) \times VIN}{1.067}$$

where C_{SS} unit is in nF and t_{ON} unit is in ms.

The SS pin can be left floating (C_{SS} = open) for the minimum soft-start time (0.75 ms for VIN = 12 V).

The device has internal SOA management to protect the internal FETs. Design Tool is available to select the appropriate C_{SS} based on load and input voltage.

Blocking FET Driver (BFET)

When external blocking FET (N-Channel MOSFET) is used, connect BFET pin to the gate of the blocking FET. The BFET pin charges the gate of the external FET when both the voltage at EN/UVLO pin is higher than V_{EN_H} and the input voltage is higher than the under-voltage lockout threshold, VIN > V_{UVLO_R}. The BFET pin discharges current from the gate of the external FET via a 29 kΩ internal discharge resistor, when either the voltage at EN/UVLO pin is lower than V_{EN_L} or the input voltage is lower than the under-voltage lockout threshold, VIN < (V_{UVLO_R} -V_{UVLO_HYS}).

This driver is available for application compatibility if external FET is already placed.

Thermal Shutdown Protection (TSD)

Thermal shutdown protects device from excessive temperature. The power switch is turned off when the die temperature reaches thermal shutdown threshold of 140 °C. There is a 30 °C hysteresis. The power switch is allowed to turn on again if die temperature drops below approximately 110 °C.

Input Capacitor Selection

The input capacitor prevents large voltage transients from appearing at the input, and provides the instantaneous current needed each time the switch turns on to charge output capacitors and to limit input voltage drop. It also prevents high-frequency noise on the power line from passing through to the output. The input capacitor should be located as close to the pin as possible. A minimum of 10 µF ceramic capacitor should be used. A higher capacitor value is strongly recommended to further reduce the transient voltage drop at the input.

In some applications, a Transient Voltage Suppressor (TVS) can be added on the input side to ensure that the input voltage transients don't exceed the Absolute Maximum Ratings of the device.

Output Capacitor Selection

The output capacitor acts in a similar way. Also, the output capacitor has to supply enough current for a large load that it may encounter during system transient. This bulk capacitor must be large enough to supply fast transient load in order to prevent the output from dropping.

A Schottky diode can be added between the output and ground to absorb negative voltage spikes

Power Dissipation Calculation

Calculate the power dissipation for normal load condition using the following equation:

$$Power\ Dissipation = R_{ON} \times (I_{OUT})^2$$

Layout Guidelines

Good PCB layout is important for improving the thermal and overall performance of AOZ18101DI-03/04. To optimize the switch response time to output short-circuit conditions, keep all traces as short as possible to reduce the effect of unwanted parasitic inductance. Place the input and output bypass capacitors as close as possible to the VIN and VOUT pins. The input and output PCB traces should be as wide as possible. The input and output traces should be sized to carry at least twice the full-load current.

Place a decoupling capacitor as close as possible to the VIN and GND terminals of the device. Minimize the loop area formed by the bypass-capacitor connection, the VIN pins, and the GND pin (EXP) of the IC.

If protective devices such as TVS and Schottky diode are needed, place them physically close to the IC, and route with short traces to reduce inductance.

For the most efficient thermal dissipation, connect the exposed pad to the ground plane with thermal vias as many as possible.

Figure 10 shows example for the AOZ18101DI-03/04 layout. Note that the TVS and the Schoktty diode are optional.

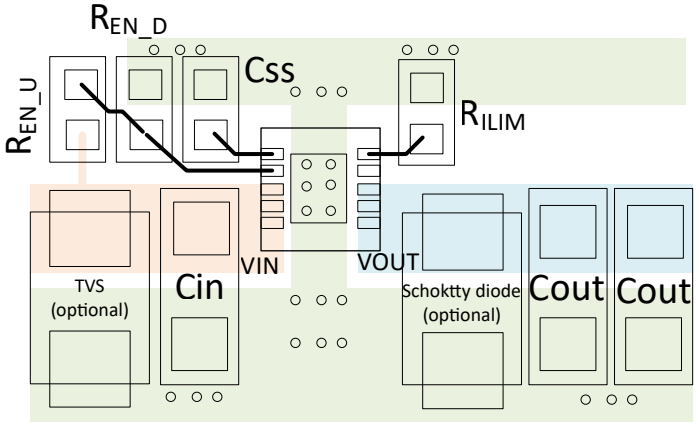
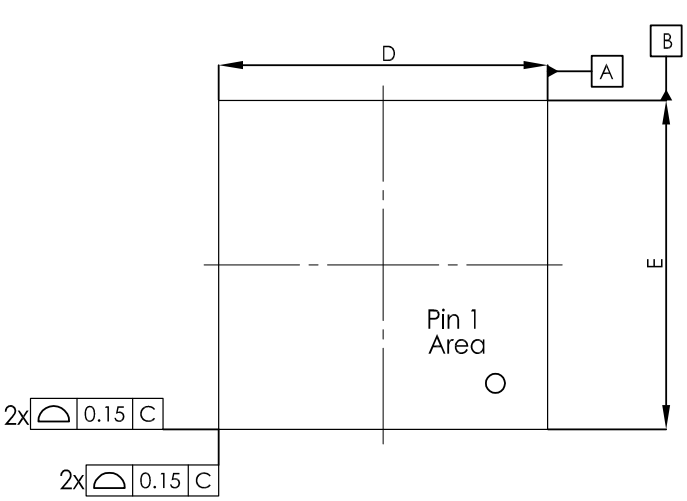
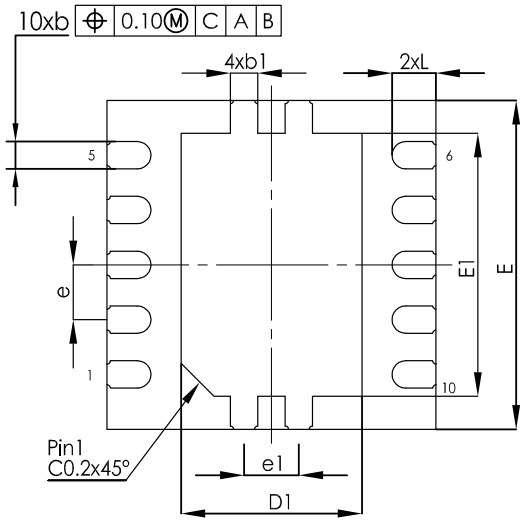


Figure 10. PCB Layout Example

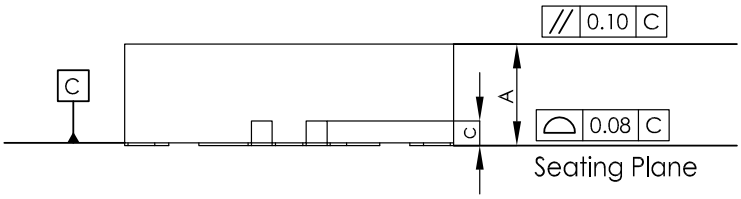
Package Dimensions, DFN3x3-10L



TOP VIEW

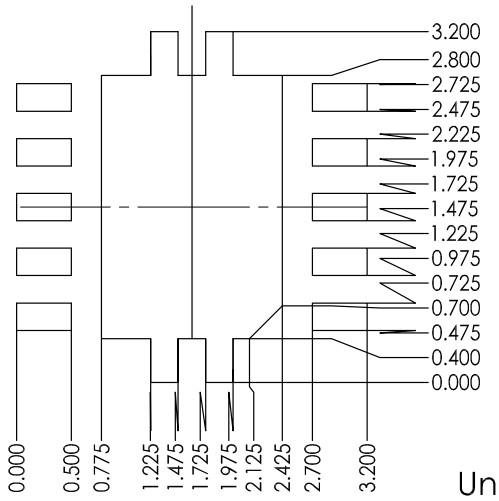


BOTTOM VIEW



SIDE VIEW

RECOMMENDED LAND PATTERN



Unit: mm

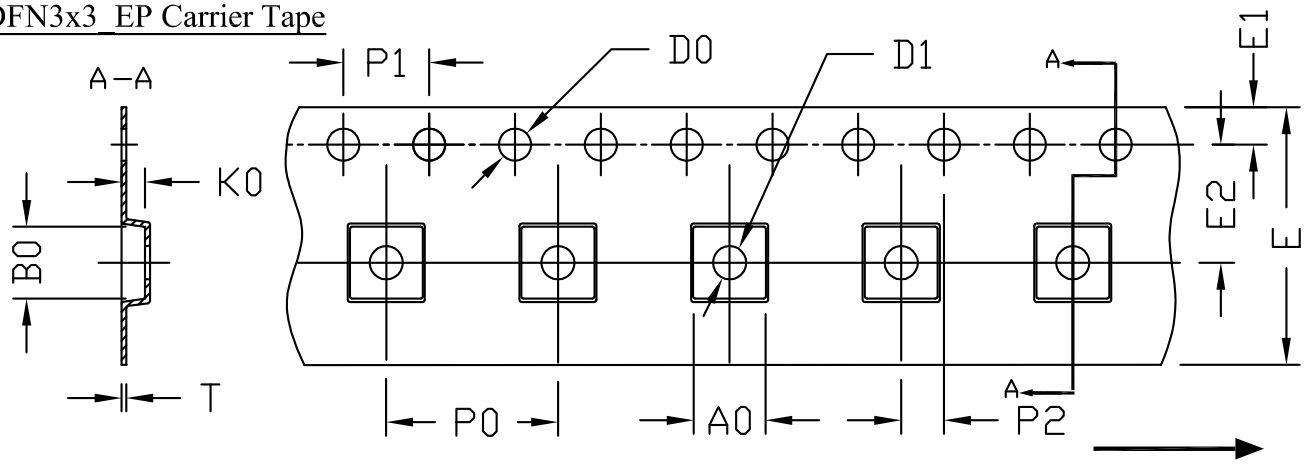
SYMBOLS	DIM. IN MM			DIM. IN INCH		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.80	0.90	1.00	0.031	0.035	0.039
A1	0.00	---	0.05	0.000	0.000	0.002
D	2.90	3.00	3.10	0.114	0.118	0.122
D1	1.55	1.65	1.75	0.061	0.065	0.069
E	2.90	3.00	3.10	0.114	0.118	0.122
E1	2.30	2.40	2.50	0.091	0.094	0.098
L	0.30	0.40	0.50	0.012	0.016	0.020
b	0.18	0.25	0.30	0.007	0.010	0.012
b1	0.25REF			0.010REF		
c	0.20REF			0.008REF		
e	0.50 BSC			0.020 BSC		
e1	0.50REF			0.02REF		

NOTE:

1. Dimensioning and tolerancing comply with ASME Y14.5M 1994.
2. Controlled dimensions are in milimeters.
3. Coplanarity applies to the exposed pad(s) and all termainal leads having metallization.

Tape and Reel Dimensions, DFN3x3-10L

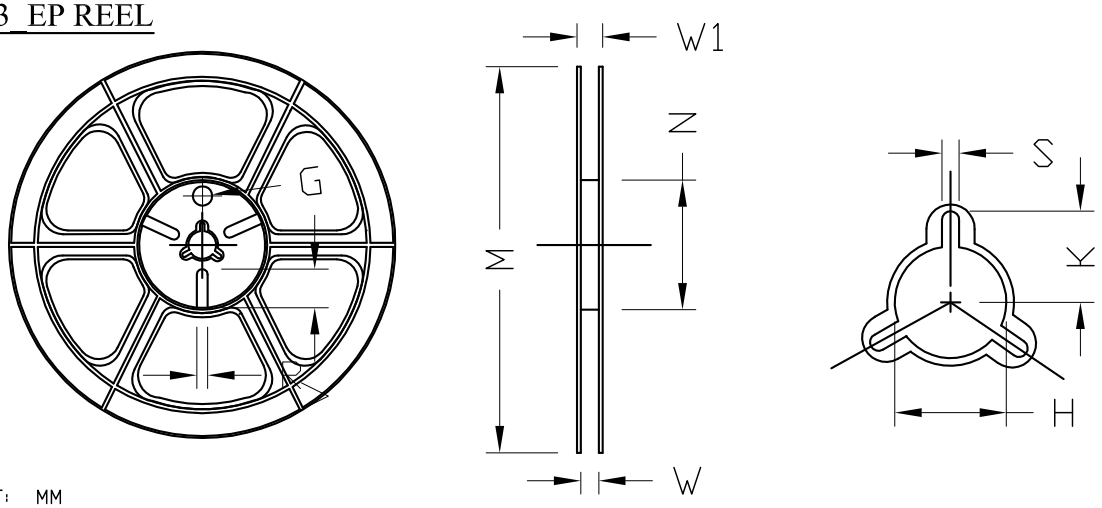
DFN3x3_EP Carrier Tape



UNIT: MM

PACKAGE	A0	B0	K0	D0	D1	E	E1	E2	P0	P1	P2	T
DFN3x3_EP	3.40 ±0.10	3.35 ±0.10	1.10 ±0.10	1.50 +0.10 −0	1.50 +0.10 −0	12.00 ±0.30	1.75 ±0.10	5.50 ±0.05	8.00 ±0.10	4.00 ±0.10	2.00 ±0.05	0.30 ±0.05

DFN3x3_EP REEL

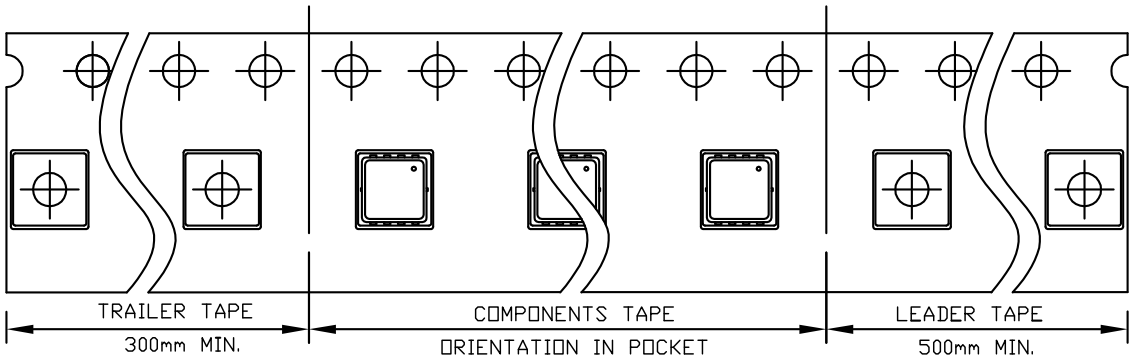


UNIT: MM

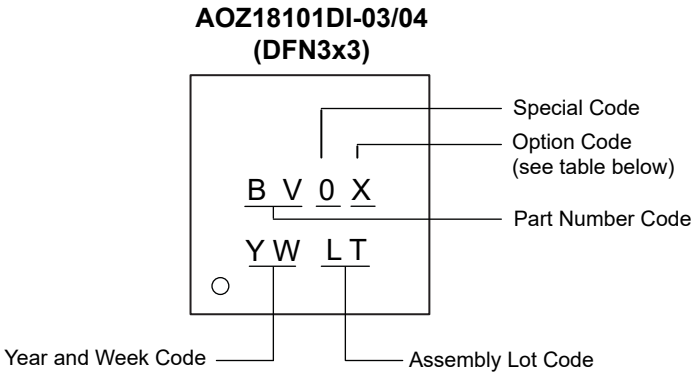
TAPE SIZE	REEL SIZE	M	N	W	W1	H	K	S	G	R	V
12 mm	ø330	ø330.00 ±0.50	ø97.00 ±0.10	13.00 ±0.30	17.40 ±1.00	ø13.00 +0.50 −0.20	10.60	2.00 ±0.50	---	---	---

PIC

Unit Per Reel: 5000pcs



Part Marking



Part Number	Description	Marking Code
AOZ18101DI-03	Auto-Restart	BV03
AOZ18101DI-04	Latch Off	BV04

LEGAL DISCLAIMER

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LIFE SUPPORT POLICY

ALPHA AND OMEGA SEMICONDUCTOR PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS.

As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body or (b) support or sustain life, and (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury of the user.

2. A critical component in any component of a life support, device, or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.