

## General Description

The AOZ1360 is a member of Alpha and Omega Semiconductor's high-side load switch family intended for applications that require circuit protection. The device operates from a source voltage between 5.5V and 28V. The internal current limiting circuit protects the input supply voltage from large current load. The current limit can be set with an external resistor. The AOZ1360 provides thermal protection function that limits excessive power dissipation. The device employs internal soft-start circuitry to control in-rush current due to highly capacitive loads associated with hot-plug events. It features low quiescent current of 220  $\mu$ A and the supply current reduces to less than 1  $\mu$ A at shutdown.

The AOZ1360 is available in either an SO-8 or a DFN-10 4 mm x 4 mm package which can operate over a -40°C to +85°C temperature range.

## Features

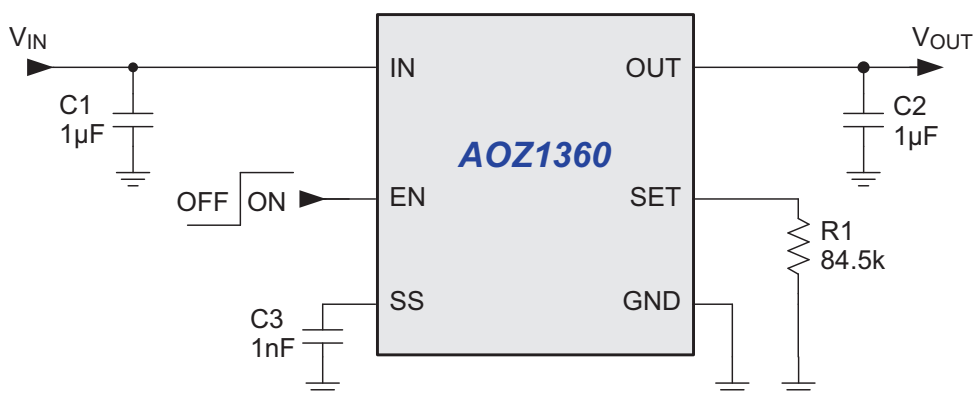
- 35m $\Omega$  maximum on resistance
- Programmable current limit
- 5.5V to 28V operating input voltage
- Low quiescent current
- Under-voltage lockout
- Thermal shutdown protection
- 2.5kV ESD rating
- Available in SO-8 or DFN-10 package

## Applications

- Notebook PCs
- Hot swap supplies



## Typical Application



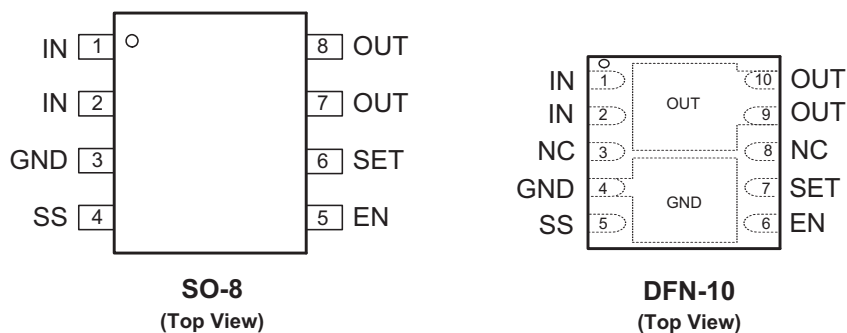
## Ordering Information

| Part Number | Package    | Temperature Range | Environmental |
|-------------|------------|-------------------|---------------|
| AOZ1360AIL  | SO-8       | -40 °C to +85 °C  | Green Product |
| AOZ1360DIL  | DFN-10 4x4 |                   |               |



AOS Green Products use reduced levels of Halogens, and are also RoHS compliant. Please visit [www.aosmd.com/media/AOSGreenPolicy.pdf](http://www.aosmd.com/media/AOSGreenPolicy.pdf) for additional information.

## Pin Configuration



## Pin Description

| Pin Name | Pin Number |             | Pin Function                                                                                                                                    |
|----------|------------|-------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
|          | SO-8       | DFN 4x4 10L |                                                                                                                                                 |
| IN       | 1, 2       | 1, 2        | P-channel MOSFET source. Connect a 1 $\mu$ F capacitor from IN to GND.                                                                          |
| GND      | 3          | 4           | Ground.                                                                                                                                         |
| SS       | 4          | 5           | Soft-Start Pin. Connect a capacitor from SS to GND to set the soft-start time. Connect SS to IN to set to the default soft-start time of 100us. |
| EN       | 5          | 6           | Enable Input.                                                                                                                                   |
| SET      | 6          | 7           | Current Limit Set Pin. Connect a resistor from SET to GND to set the switch current limit.                                                      |
| NC       |            | 3, 8        | No Connect                                                                                                                                      |
| OUT      | 7, 8       | 9, 10       | P-channel MOSFET Drain. Connect a capacitor with 0.1 $\mu$ F or above from OUT to GND.                                                          |

## Functional Block Diagram

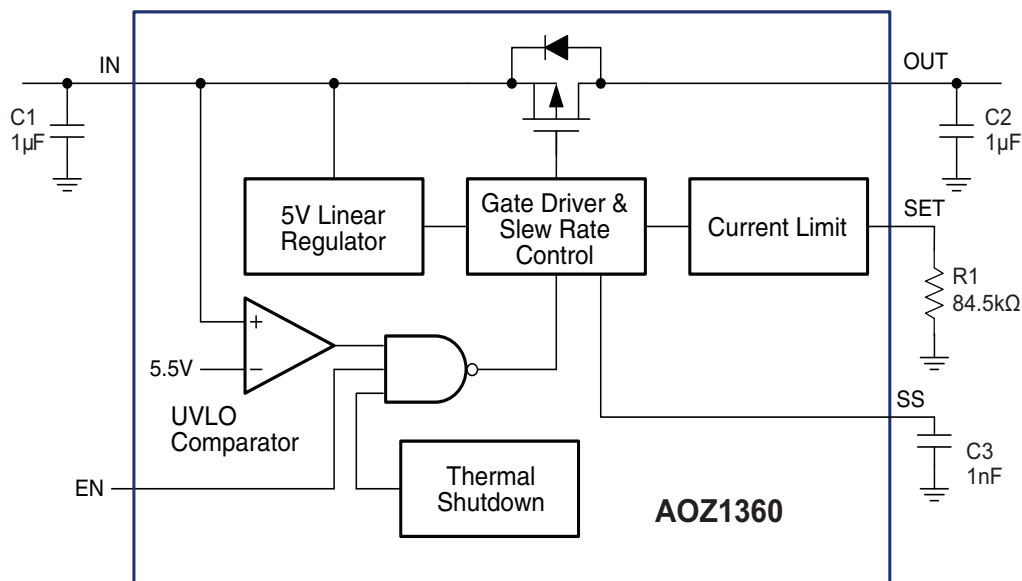


Figure 1. Functional Block Diagram

## Timing Diagram

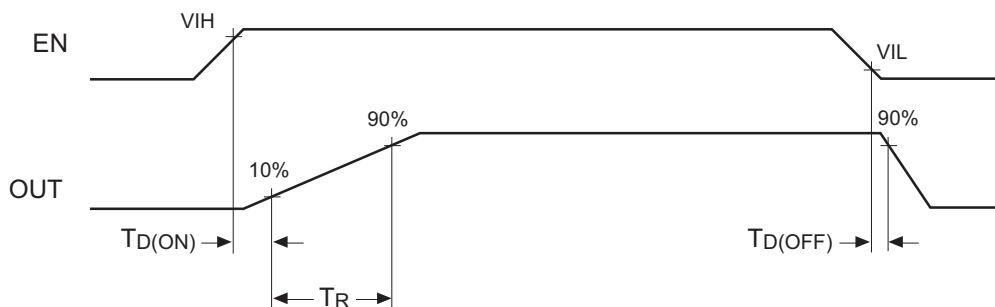


Figure 2. AOZ1360 Timing Diagram

## Absolute Maximum Ratings

Exceeding the Absolute Maximum Ratings may damage the device.

| Parameter                              | Rating                     |
|----------------------------------------|----------------------------|
| IN to GND                              | -0.3 V to +30 V            |
| EN, OUT to GND                         | -0.3 V to $V_{IN} + 0.3$ V |
| SS, SET                                | -0.3 V to +6 V             |
| Maximum Junction Temperature ( $T_J$ ) | +150 °C                    |
| ESD Rating (Human Body Model)          | 2.5 kV                     |

## Recommended Operating Conditions

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

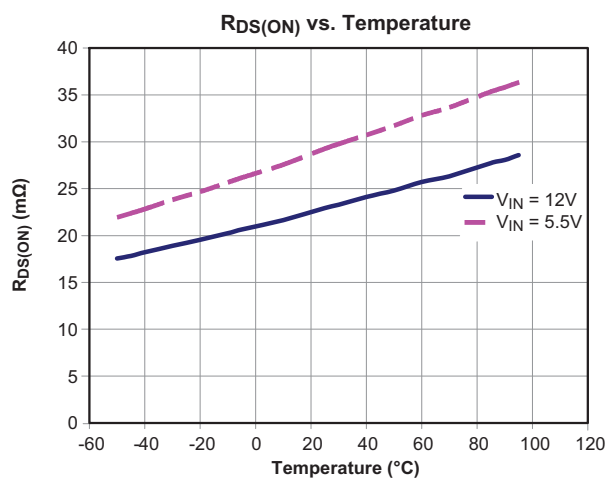
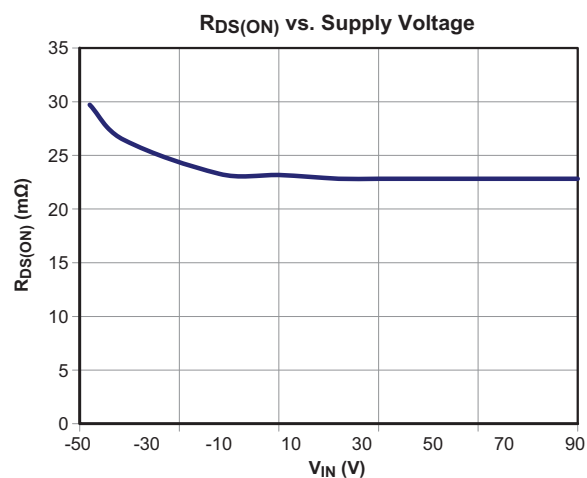
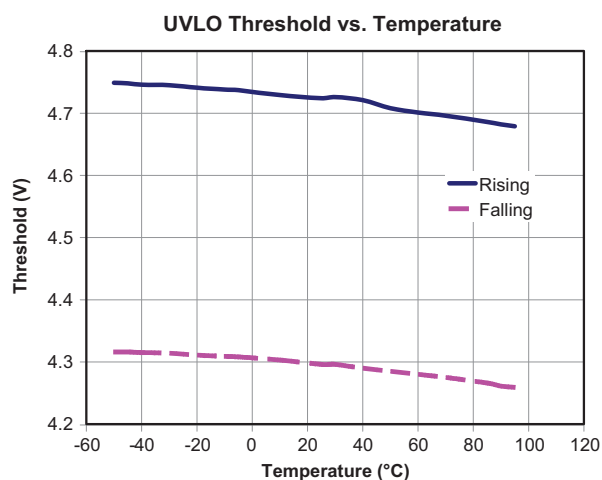
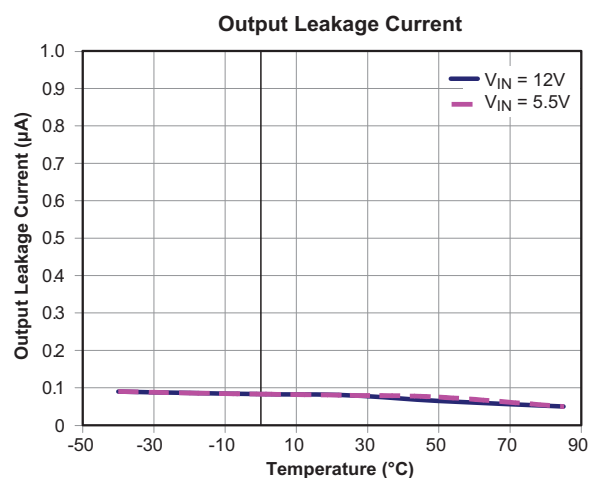
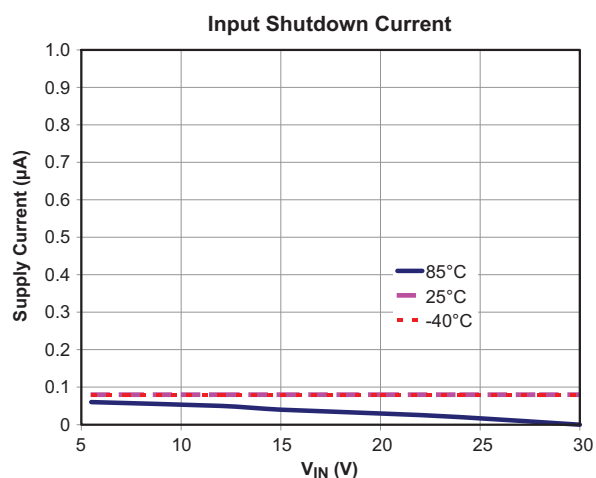
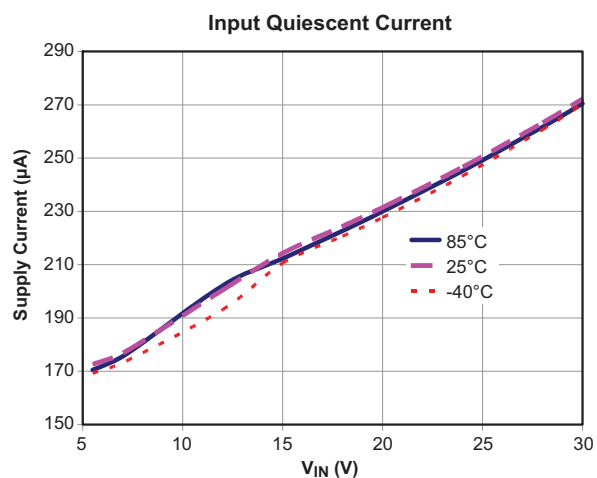
| Parameter                      | Rating            |
|--------------------------------|-------------------|
| Junction Temperature ( $T_J$ ) | -40 °C to +125 °C |
| Thermal Resistance             |                   |
| SO-8 ( $\theta_{JA}$ )         | 82 °C/W           |
| DFN-10 ( $\theta_{JA}$ )       | 63 °C/W           |

## Electrical Characteristics

$V_{IN} = 12V$ ,  $T_A = 25^\circ C$  unless otherwise stated.

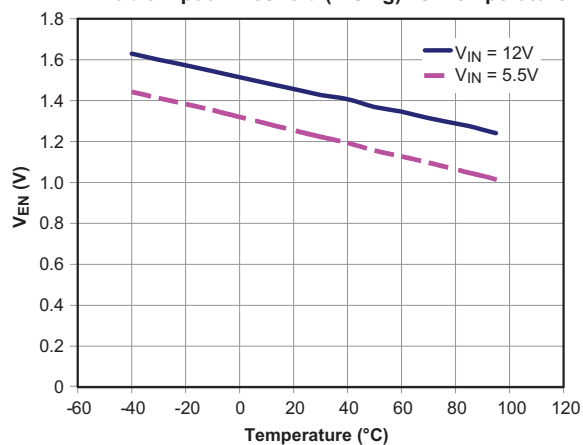
| Symbol         | Parameter                               | Conditions                                          | Min. | Typ. | Max | Units      |
|----------------|-----------------------------------------|-----------------------------------------------------|------|------|-----|------------|
| $V_{IN}$       | Input Supply Voltage                    |                                                     | 5.5  |      | 28  | V          |
| $V_{UVLO}$     | Undervoltage Lockout Threshold          | IN rising                                           |      | 4.9  | 5.4 | V          |
| $V_{UVHYS}$    | Undervoltage Lockout Hysteresis         |                                                     |      | 400  |     | mV         |
| $I_{IN\_ON}$   | Input Quiescent Current                 | EN = IN, no load                                    |      | 220  | 400 | $\mu A$    |
| $I_{IN\_OFF}$  | Input Shutdown Current                  | EN = GND, no load                                   |      |      | 1   | $\mu A$    |
| $I_{LEAK}$     | Output Leakage Current                  | EN = GND, no load                                   |      |      | 1   | $\mu A$    |
| $R_{DS(ON)}$   | Switch On Resistance                    | AOZ1360AI $V_{IN} = 12V$                            |      | 22   | 35  | $m\Omega$  |
| $R_{DS(ON)}$   | Switch On Resistance                    | AOZ1360AI $V_{IN} = 5.5V$                           |      | 33   | 43  | $m\Omega$  |
| $I_{LIM}$      | Current Limit                           | $R_{SET} = 84.5k\Omega$                             | 2    | 2.7  | 3.4 | A          |
| $V_{EN\_L}$    | Enable Input Low Voltage                |                                                     |      |      | 0.8 | V          |
| $V_{EN\_H}$    | Enable Input High Voltage               |                                                     | 2.0  |      |     | V          |
| $V_{EN\_HYS}$  | Enable Input Hysteresis                 |                                                     |      | 100  |     | mV         |
| $I_{EN\_BIAS}$ | Enable Input Bias Current               |                                                     |      |      | 1   | $\mu A$    |
| $Td_{on}$      | Turn-On Delay Time<br>EN_50% to OUT_10% | $R_L = 120\Omega$ , $C_L = 1\mu F$ , SS = Floated   |      | 220  |     | $\mu s$    |
| $t_{ON}$       | Turn-On Rise Time<br>OUT_10% to 90%     | $R_L = 120\Omega$ , $C_L = 1\mu F$ , SS = Floated   |      | 280  |     | $\mu s$    |
|                |                                         | $R_L = 120\Omega$ , $C_L = 1\mu F$ , $C_{SS} = 1nF$ |      | 360  |     |            |
| $t_{OFF}$      | Turn-Off Fall Time                      | $R_L = 120\Omega$ , $C_L = 1\mu F$ , SS = Floated   |      | 280  |     | $\mu s$    |
| $T_{SD}$       | Thermal Shutdown Threshold              |                                                     |      | 130  |     | $^\circ C$ |
| $T_{SD\_HYS}$  | Thermal Shutdown Hysteresis             |                                                     |      | 30   |     | $^\circ C$ |

## Typical Performance Characteristics

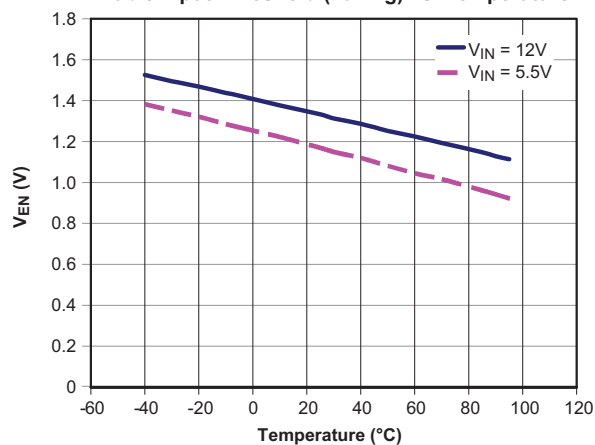


## Typical Performance Characteristics (Continued)

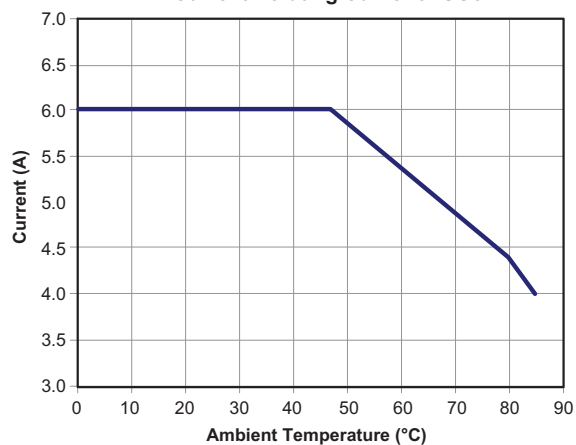
Enable Input Threshold (Rising) vs. Temperature



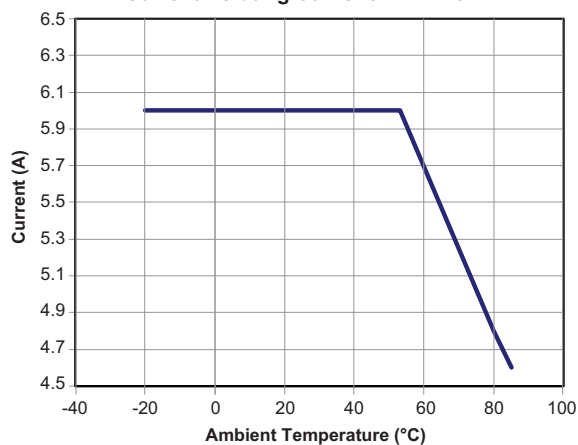
Enable Input Threshold (Falling) vs. Temperature



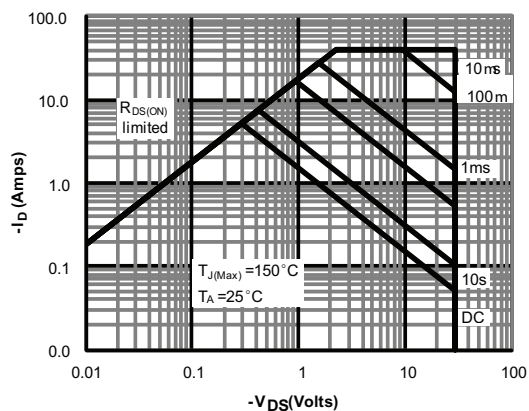
Current Derating Curve for SO8



Current Derating Curve for DFN-10 4x4

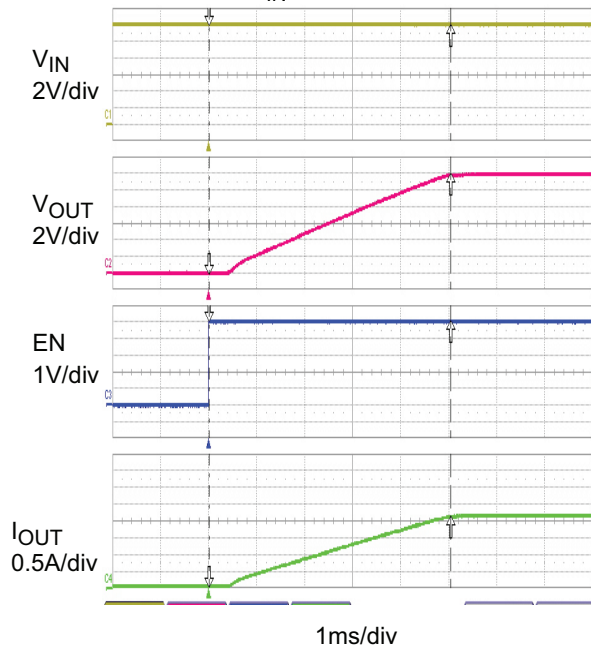


Internal Power MOSFET SOA

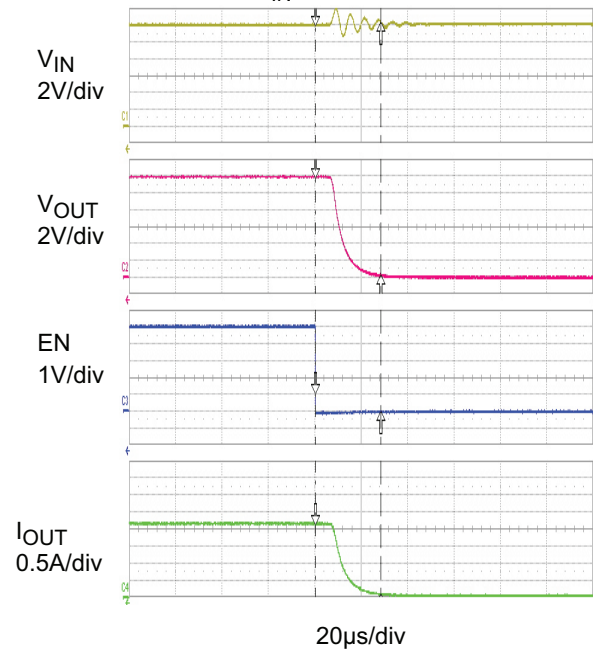


## Typical Performance Characteristics (Continued)

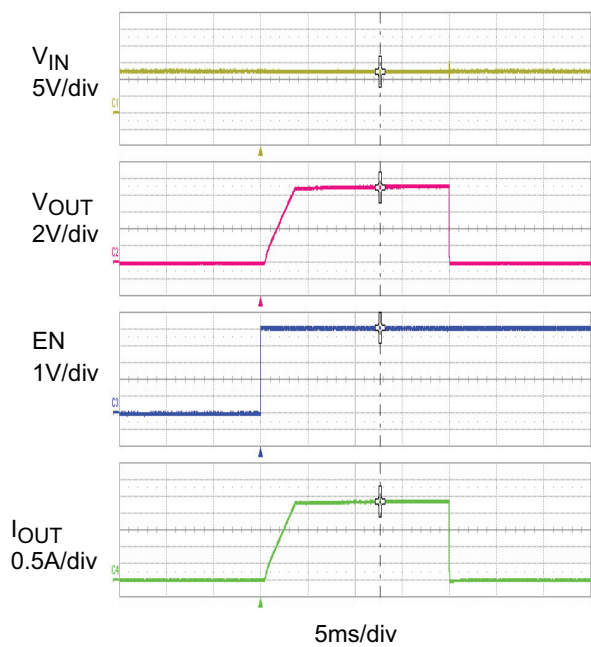
**Turn-On**  
( $V_{IN} = 12V$ ,  $R = 5.6\Omega$ )



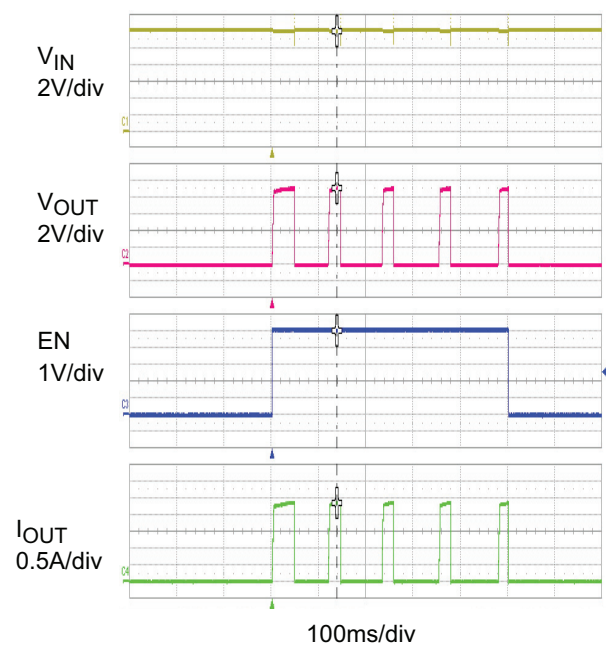
**Turn-Off**  
( $V_{IN} = 12V$ ,  $R = 5.6\Omega$ )



**Current Limit**  
( $V_{IN} = 12V$ ,  $R = 3.6\Omega$ )



**Over Temperature**  
( $V_{IN} = 12V$ ,  $R = 3.6\Omega$ )



## Detailed Description

### Introduction

The AOZ1360 is a 35 mΩ P-channel high-side load switch with adjustable soft-start slew-rate control, programmable current limit and thermal shutdown. It operates with an input voltage range from 5.5 V to 28 V.

### Enable

The EN pin is the On/Off control for the output switch. It is an active-high input. The EN pin is active after  $V_{IN}$  is above the UVLO threshold of 4.9 V. Conversely, the EN pin will be deactivated if the  $V_{IN}$  falls below the UVLO of 2.0V. The EN pin must be driven to a logic high or logic low state to guarantee operation. While disabled, the AOZ1360 only draws approximately 1 μA supply current. The EN is a high impedance input with an ESD protection diode to ground and should not be forced below ground. This input level is compatible with most microcontroller outputs and other logic families.

### Under-Voltage Lockout (UVLO)

The under-voltage lockout (UVLO) circuit of the AOZ1360 monitors the input voltage and prevents the output MOSFET from turning on until  $V_{IN}$  exceeds 4.9 V.

### Adjustable Soft-Start Slew-Rate Control

When the EN pin is high, the slew rate control circuitry applies voltage on the gate of the PMOS switch in a manner such that the output voltage and current is ramped up linearly until it reaches the steady-state load current level. The slew rate can be adjusted by an external capacitor connected between the SS pin and ground.

The slew rate rise time,  $T_{on}$ , can be set using the following equation:

$$T_{on} = \frac{C_{ss} \times V_{IN}}{30\mu A}$$

### Programmable Current Limit

The current limit is programmed by an external resistor connected between the SET pin and ground. This sets a reference voltage to the current limit error amplifier that compares it to a sensed voltage that is generated by passing a small portion of the load current through an internal amplifier. When the sensed load current exceeds the set current limit, the load current is then clamped at the set limit and the  $V_{out}$  drops to whatever voltage is necessary to clamp the load current. The AOZ1360 will stay in this condition until the load current no longer exceeds the current limit or if the thermal shutdown protection is engaged.

### Thermal-Shutdown Protection

During current limit or short circuit conditions, the PMOS resistance is increased to clamp the load current. This increases the power dissipation in the chip causing the die temperature to rise. When the die temperature reaches 130 °C the thermal shutdown circuitry will shutdown the device. There is a 30 °C hysteresis after which the device will turn back on and go through soft start. The thermal shutdown will cycle repeatedly until the short circuit condition is resolved or the enable pin is pulled LOW externally.



## Application Information

### 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. The input capacitor also limits input voltage drop and prevents high-frequency noise on the power line from passing through the output of the power side. The choice of input capacitor is based on its ripple current and voltage ratings rather than the actual capacitance value. The input capacitor should be located as close to VIN as possible. A 1  $\mu\text{F}$  ceramic cap is recommended. However, higher capacitor values will further reduce the voltage drop at the input.

### Output Capacitor Selection

The output capacitor acts in a similar way. A small 0.1  $\mu\text{F}$  capacitor prevents high-frequency noise from going into the system. Also, the output capacitor has to supply enough current for any large load that may occur during system transients. This bulk capacitor must be large enough to supply fast transient load in order to prevent the output from dropping.

### Current Limit Setting

The current limit is set by an external resistor connected to the SET pin. Refer to Figure 3 for current limit settings.

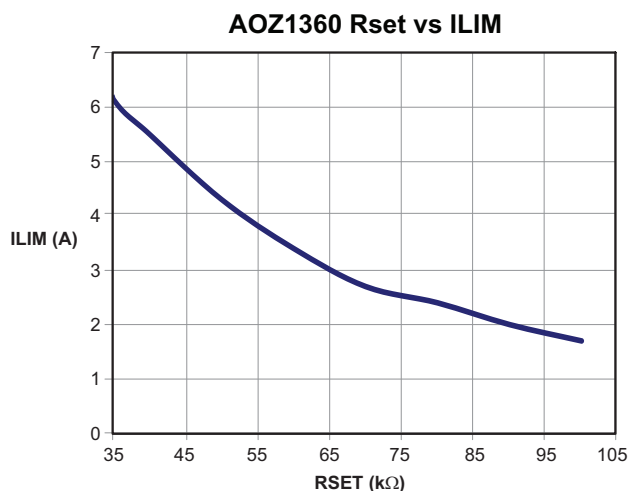


Figure 3

### Slew Rate Setting

Slew rate is set by changing the capacitor value on the SS pin of the device. A capacitor connected between the SS pin and ground will reduce the output slew-rate. The capacitive range is 0.001  $\mu\text{F}$  to 0.1  $\mu\text{F}$ . Refer to Figure 4.

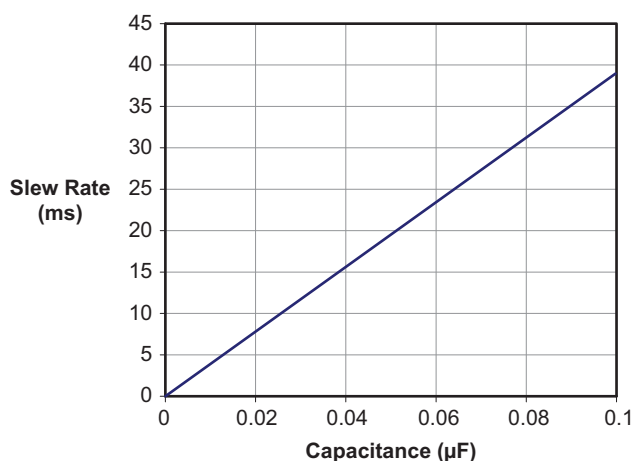


Figure 4. Output Slew Rate Adjustment vs. Capacitance

### Power Dissipation Calculation

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

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

The worst case power dissipation occurs when the load current hits the current limit due to over-current or short circuit faults. The power dissipation under these conditions can be calculated using the following equation:

$$P_D = (V_{IN} - V_{OUT}) \times I_{LIMIT}$$

## Layout Guidelines

Proper PCB layout is important for improving the thermal and overall performance of the AOZ1360. To optimize the switch response time for outputting short-circuit conditions, keep all traces as short as possible. This will also reduce the effect of unwanted parasitic inductance.

Place the input and output bypass capacitors as close as possible 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.

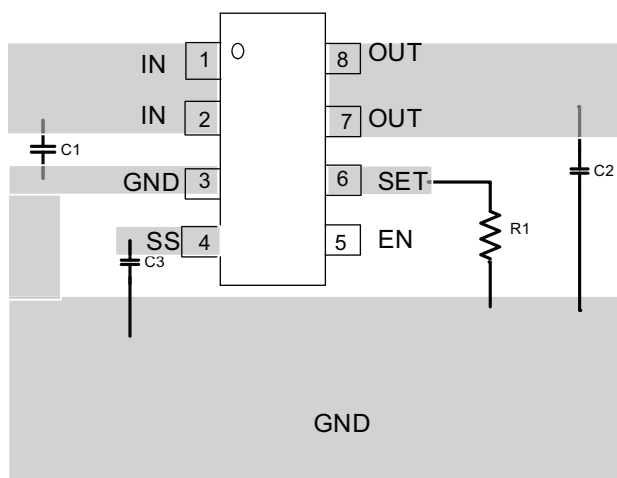


Figure 5. AOZ1360AI (SO-8) Layout

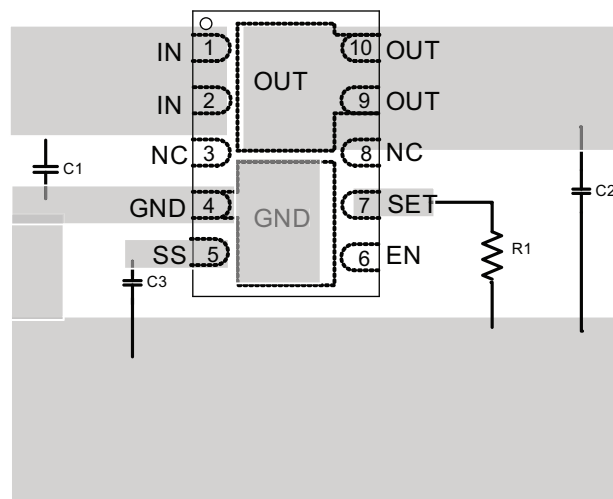
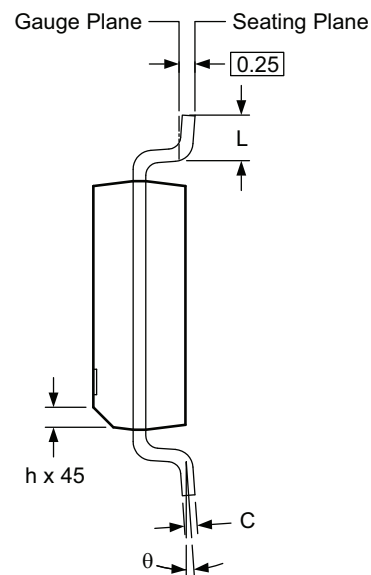
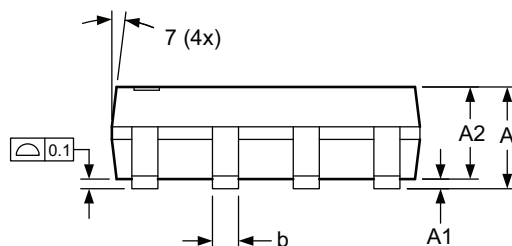
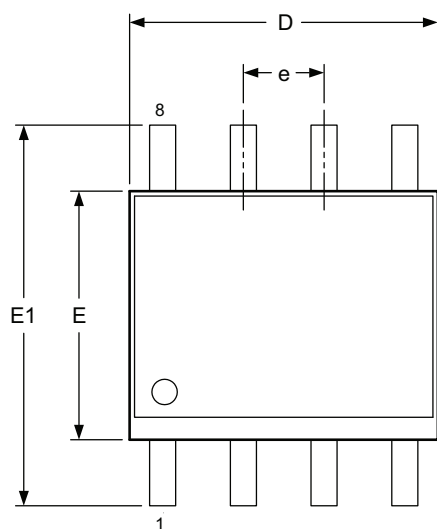
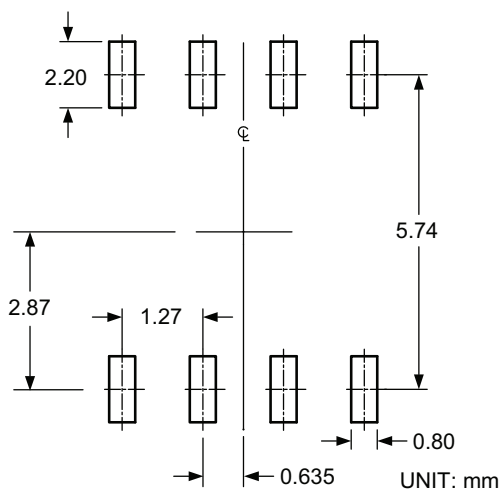


Figure 6. AOZ1360DI (DFN4x4 10L) Layout

## Package Dimensions, SO-8L



### RECOMMENDED LAND PATTERN



### Dimensions in millimeters

| Symbols | Min.     | Nom. | Max. |
|---------|----------|------|------|
| A       | 1.35     | 1.65 | 1.75 |
| A1      | 0.10     | —    | 0.25 |
| A2      | 1.25     | 1.50 | 1.65 |
| b       | 0.31     | —    | 0.51 |
| c       | 0.17     | —    | 0.25 |
| D       | 4.80     | 4.90 | 5.00 |
| E       | 3.80     | 3.90 | 4.00 |
| e       | 1.27 BSC |      |      |
| E1      | 5.80     | 6.00 | 6.20 |
| h       | 0.25     | —    | 0.50 |
| L       | 0.40     | —    | 1.27 |
| θ       | 0°       | —    | 8°   |

### Dimensions in inches

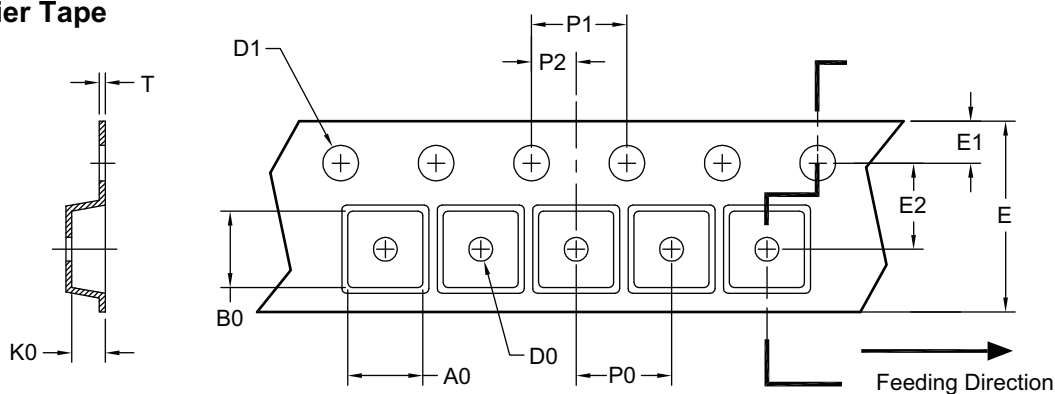
| Symbols | Min.      | Nom.  | Max.  |
|---------|-----------|-------|-------|
| A       | 0.053     | 0.065 | 0.069 |
| A1      | 0.004     | —     | 0.010 |
| A2      | 0.049     | 0.059 | 0.065 |
| b       | 0.012     | —     | 0.020 |
| c       | 0.007     | —     | 0.010 |
| D       | 0.189     | 0.193 | 0.197 |
| E       | 0.150     | 0.154 | 0.157 |
| e       | 0.050 BSC |       |       |
| E1      | 0.228     | 0.236 | 0.244 |
| h       | 0.010     | —     | 0.020 |
| L       | 0.016     | —     | 0.050 |
| θ       | 0°        | —     | 8°    |

### Notes:

1. All dimensions are in millimeters.
2. Dimensions are inclusive of plating
3. Package body sizes exclude mold flash and gate burrs. Mold flash at the non-lead sides should be less than 6 mils.
4. Dimension L is measured in gauge plane.
5. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

## Tape and Reel Dimensions, SO-8

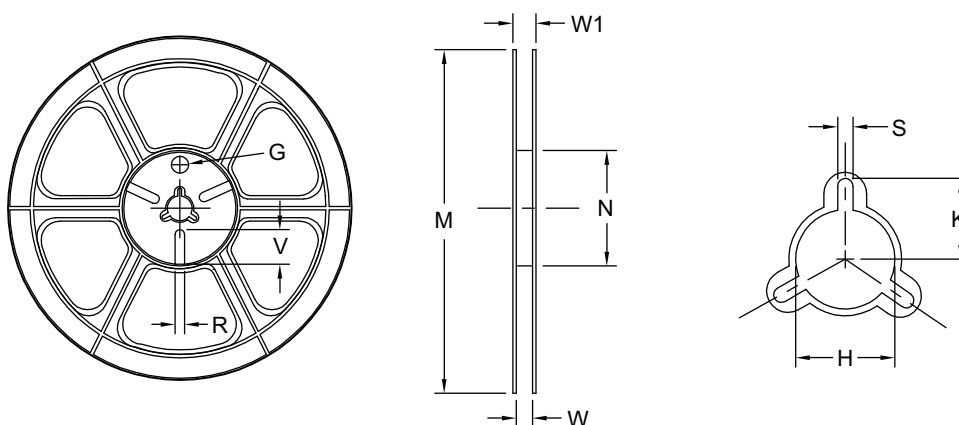
### Carrier Tape



UNIT: mm

| Package        | A0            | B0            | K0            | D0            | D1            | E              | E1            | E2            | P0            | P1            | P2            | T             |
|----------------|---------------|---------------|---------------|---------------|---------------|----------------|---------------|---------------|---------------|---------------|---------------|---------------|
| SO-8<br>(12mm) | 6.40<br>±0.10 | 5.20<br>±0.10 | 2.10<br>±0.10 | 1.60<br>±0.10 | 1.50<br>±0.10 | 12.00<br>±0.10 | 1.75<br>±0.10 | 5.50<br>±0.10 | 8.00<br>±0.10 | 4.00<br>±0.10 | 2.00<br>±0.10 | 0.25<br>±0.10 |

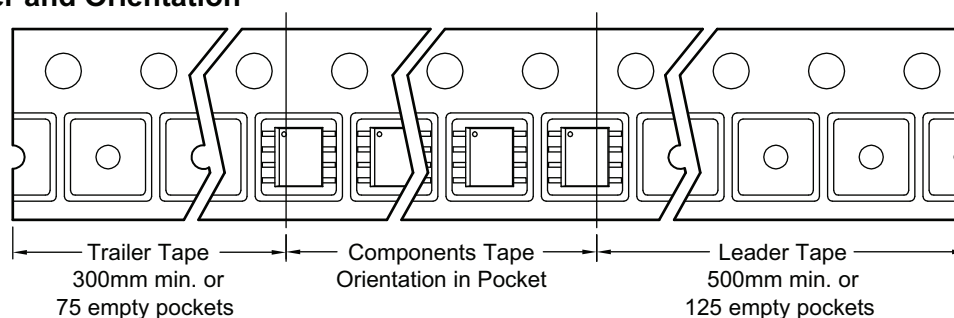
### Reel



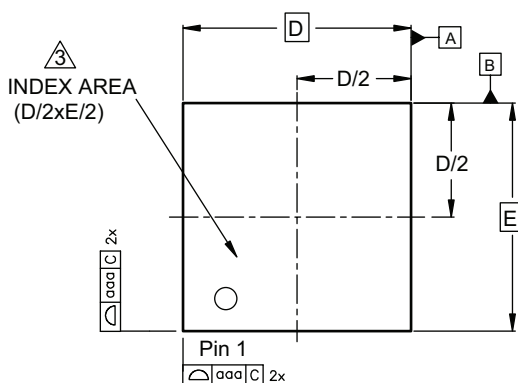
UNIT: mm

| Tape Size | Reel Size | M                | N               | W              | W1             | H                     | K     | S             | G | R | V |
|-----------|-----------|------------------|-----------------|----------------|----------------|-----------------------|-------|---------------|---|---|---|
| 12mm      | ø330      | ø330.00<br>±0.50 | ø97.00<br>±0.10 | 13.00<br>±0.30 | 17.40<br>±1.00 | ø13.00<br>+0.50/-0.20 | 10.60 | 2.00<br>±0.50 | — | — | — |

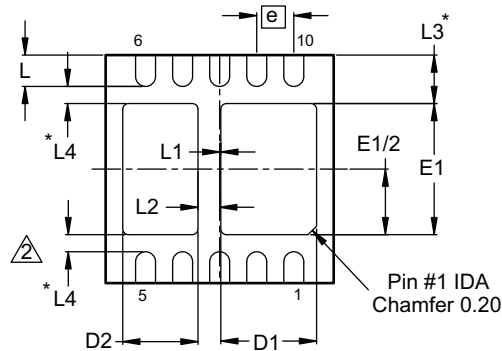
### Leader/Trailer and Orientation



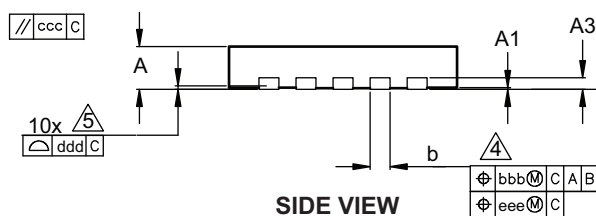
## Package Dimensions, DFN-10L, 4x4



**TOP VIEW**

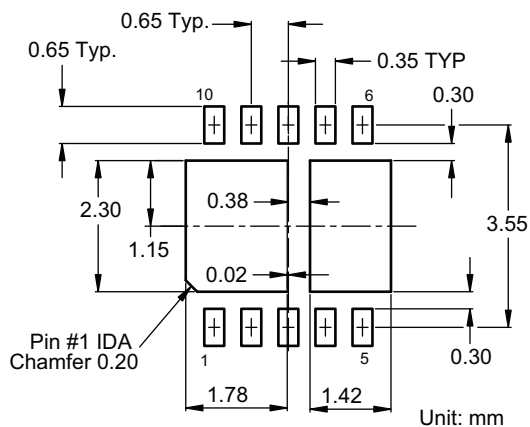


**BOTTOM VIEW**



**SIDE VIEW**

### RECOMMENDED LAND PATTERN



#### Notes:

1. All dimensions are in millimeters.

2. The dimensions with \* are just for reference.

3. The location of the terminal #1 identifier and terminal numbering convention conforms to JEDEC publication 95 SPP-002.

4. Dimension b applies to metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip. If the terminal has the optional radius on the other end of the terminal, then dimension b should not be measured in that radius area.

5. Coplanarity applies to the terminals and all other bottom surface metallization.

6. Drawings shown are for illustration only.

#### Dimensions in millimeters

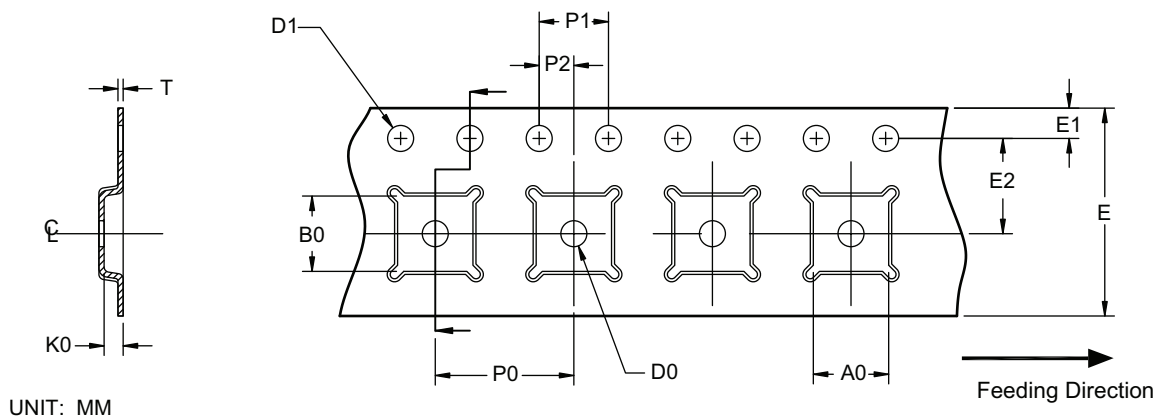
| Symbols | Min.      | Nom. | Max. |
|---------|-----------|------|------|
| A       | 0.70      | 0.75 | 0.80 |
| A1      | 0.00      | 0.02 | 0.05 |
| A3      | 0.203 REF |      |      |
| b       | 0.30      | 0.35 | 0.40 |
| D       | 3.95      | 4.00 | 4.05 |
| D1      | 1.58      | 1.68 | 1.78 |
| D2      | 1.22      | 1.32 | 1.42 |
| E       | 3.95      | 4.00 | 4.05 |
| E1      | 2.20      | 2.30 | 2.40 |
| e       | 0.65 BSC  |      |      |
| L       | 0.50      | 0.55 | 0.60 |
| L1      | —         | 0.02 | 0.12 |
| L2      | 0.28      | 0.38 | 0.48 |
| L3      | 0.85 REF  |      |      |
| L4      | 0.30 REF  |      |      |
| aaa     | 0.15      |      |      |
| bbb     | 0.10      |      |      |
| ccc     | 0.10      |      |      |
| ddd     | 0.08      |      |      |
| eee     | 0.05      |      |      |

#### Dimensions in inches

| Symbols | Min.       | Nom.  | Max.  |
|---------|------------|-------|-------|
| A       | 0.028      | 0.030 | 0.031 |
| A1      | 0.000      | 0.001 | 0.002 |
| A3      | 0.008 REF  |       |       |
| b       | 0.012      | 0.014 | 0.016 |
| D       | 0.156      | 0.157 | 0.159 |
| D1      | 0.062      | 0.066 | 0.070 |
| D2      | 0.048      | 0.052 | 0.056 |
| E       | 0.156      | 0.157 | 0.159 |
| E1      | 0.087      | 0.091 | 0.094 |
| e       | 0.026 BSC  |       |       |
| L       | 0.020      | 0.022 | 0.024 |
| L1      | —          | 0.001 | 0.005 |
| L2      | 0.011      | 0.015 | 0.019 |
| L3      | 0.033 REF. |       |       |
| L4      | 0.012 REF  |       |       |
| aaa     | 0.006      |       |       |
| bbb     | 0.004      |       |       |
| ccc     | 0.004      |       |       |
| ddd     | 0.003      |       |       |
| eee     | 0.002      |       |       |

## Tape and Reel Dimensions, DFN-10L, 4x4

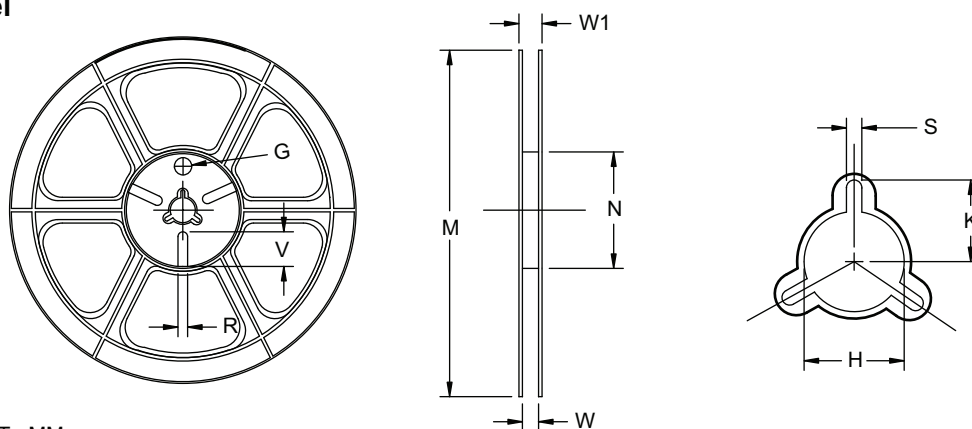
### Carrier Tape



UNIT: MM

| Package           | A0            | B0            | K0            | D0           | D1                | E            | E1            | E2            | P0            | P1            | P2            | T             |
|-------------------|---------------|---------------|---------------|--------------|-------------------|--------------|---------------|---------------|---------------|---------------|---------------|---------------|
| DFN 4x4<br>(12mm) | 4.35<br>±0.10 | 4.35<br>±0.10 | 1.10<br>±0.10 | 1.50<br>Min. | 1.50<br>+0.1/-0.0 | 12.0<br>±0.3 | 1.75<br>±0.10 | 5.50<br>±0.05 | 8.00<br>±0.10 | 4.00<br>±0.10 | 2.00<br>±0.05 | 0.30<br>±0.05 |

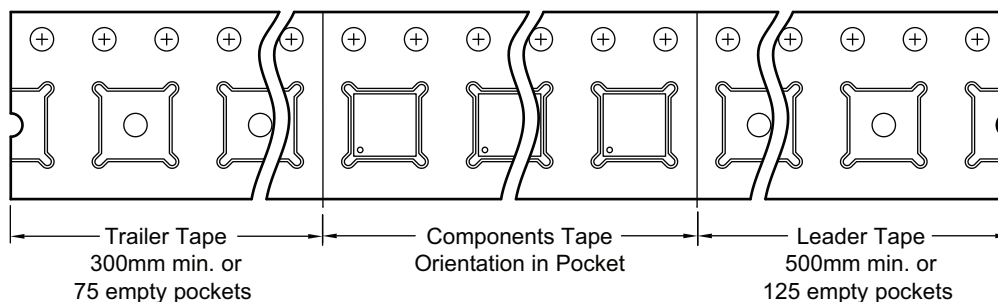
### Reel



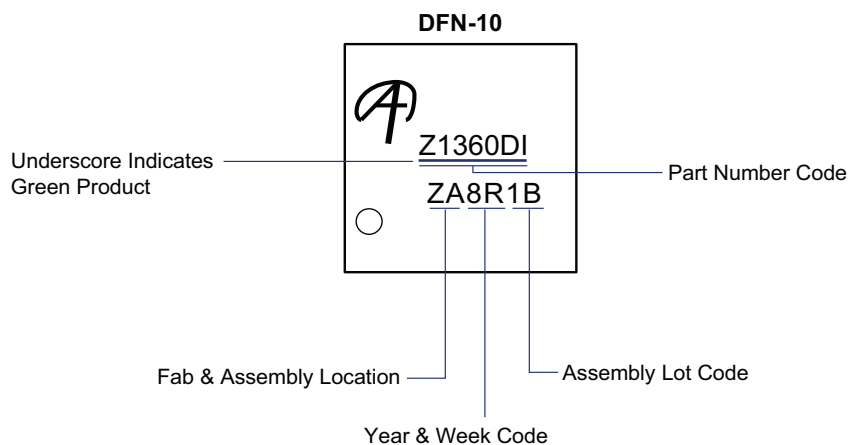
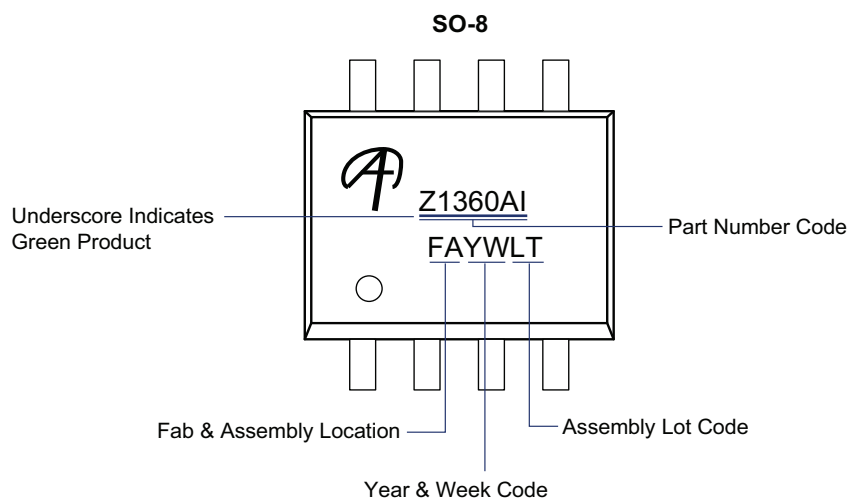
UNIT: MM

| Tape Size | Reel Size | M              | N             | W                 | W1                | H             | K            | S           | G | R | V |
|-----------|-----------|----------------|---------------|-------------------|-------------------|---------------|--------------|-------------|---|---|---|
| 12 mm     | ø330      | ø330.0<br>±2.0 | ø79.0<br>±1.0 | 12.4<br>+2.0/-0.0 | 17.0<br>+2.6/-0.0 | ø13.0<br>±0.5 | 10.5<br>±0.2 | 2.0<br>±0.5 | — | — | — |

### Leader/Trailer and Orientation



## Part Marking



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