High Performance Low Cost Off-line PWM Power Switch

FEATURES

- **High Precision 5V Default Output**
- **Up to 50kHz Switching Frequency**
- **Integrated with 500V MOSFET and High Voltage Startup Circuit**
- **Integrated with Freewheeling Diode**
- **Integrated Sense Resistor, Low System Cost**
- **Support Ultra-low Input Voltage (>15V)**
- **Support Buck&Buck-Boost Topology**
- **On/OFF Peak Current Mode Control**
- **Lower Standby Power Dissipation(<50mW)**
- **Built-in Soft Start Circuit**
- **Ultra-low VDD Operation Current**
- **Built-in Protections:**
  - **Overload Protection (OLP)**
  - **On-Chip Thermal Shutdown (OTP)**
  - **Cycle-by-Cycle Current Limiting (OCP)**
  - **Abnormal Over Current Protection (AOCP)**
  - **Leading Edge Blanking (LEB)**
  - **VDD UVLO**
- **ASOP-7 Package Available**

APPLICATIONS

- **Small Home Appliance**
- **Linear Regulator / RCC Replacement**

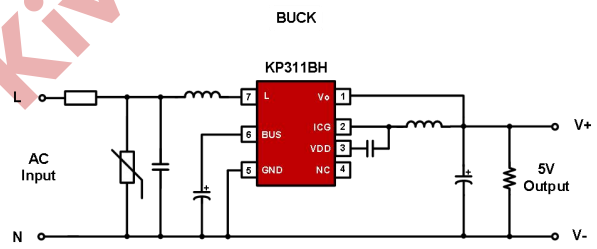
GENERAL DESCRIPTION

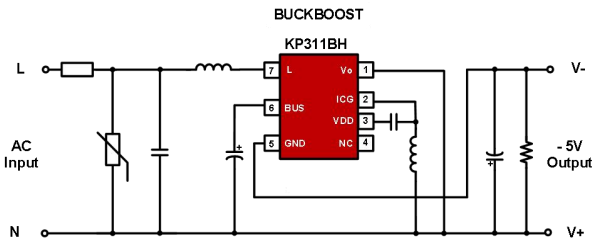
KP311BH is a low cost, highly integrated PWM power switch for non-isolated buck and buck-boost convertor applications.

KP311BH integrates a 500V power MOSFET with ON/OFF PWM controller in one chip. The IC can achieve high precision 5V default output at full range AC input. In KP311BH, Toff_min is set to 20μs with frequency jitter function to improve EMI performance. The IC has built-in green mode control for light and zero loadings, which can achieve lower than 50mW standby power dissipation.

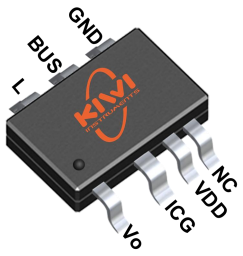
KP311BH integrates multiple protections: Under Voltage Lockout (UVLO), Cycle-by-cycle Current Limiting (OCP), On-chip Thermal Shutdown (OTP), Overload Protection (OLP), Short Load Protection (SLP), etc.

TYPICAL APPLICATION CIRCUIT





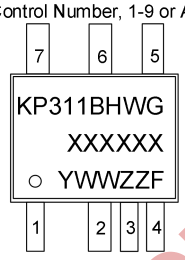
Pin Configuration



ASOP-7

Marking Information

XXXXXX: Wafer Lot Code
Y: Year Code
WW: Week Code, 01-52
ZZ: Serial Number, 01-99 or A0-ZZ
F: Control Number, 1-9 or A-Z, a-z



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Typical Output Power Table (1)

Product	Package	Maximum Load Current @ 85-265 Vac,5V
KP311BH	ASOP-7	150mA

(1) The maximum output power is limited by junction temperature. Default 5V Buck output.

Pin Description

Pin Number	Pin Name	I / O (2)	Description
1	Vo	I	Sampling the Output Voltage as an Internal Feedback Signal
2	ICG	G	The Ground of the IC
3	VDD	P	Power Supply Pin of the Chip
4	NC	/	No Connection
5	GND	P	AC input. The Ground Reference for the IC.
6	BUS	P	Positive Output of Internal Half-bridge Rectifier Bridge. Internal Power MOSFET Drain
7	L	P	AC input, also used as Half-bridge rectifier bridge input

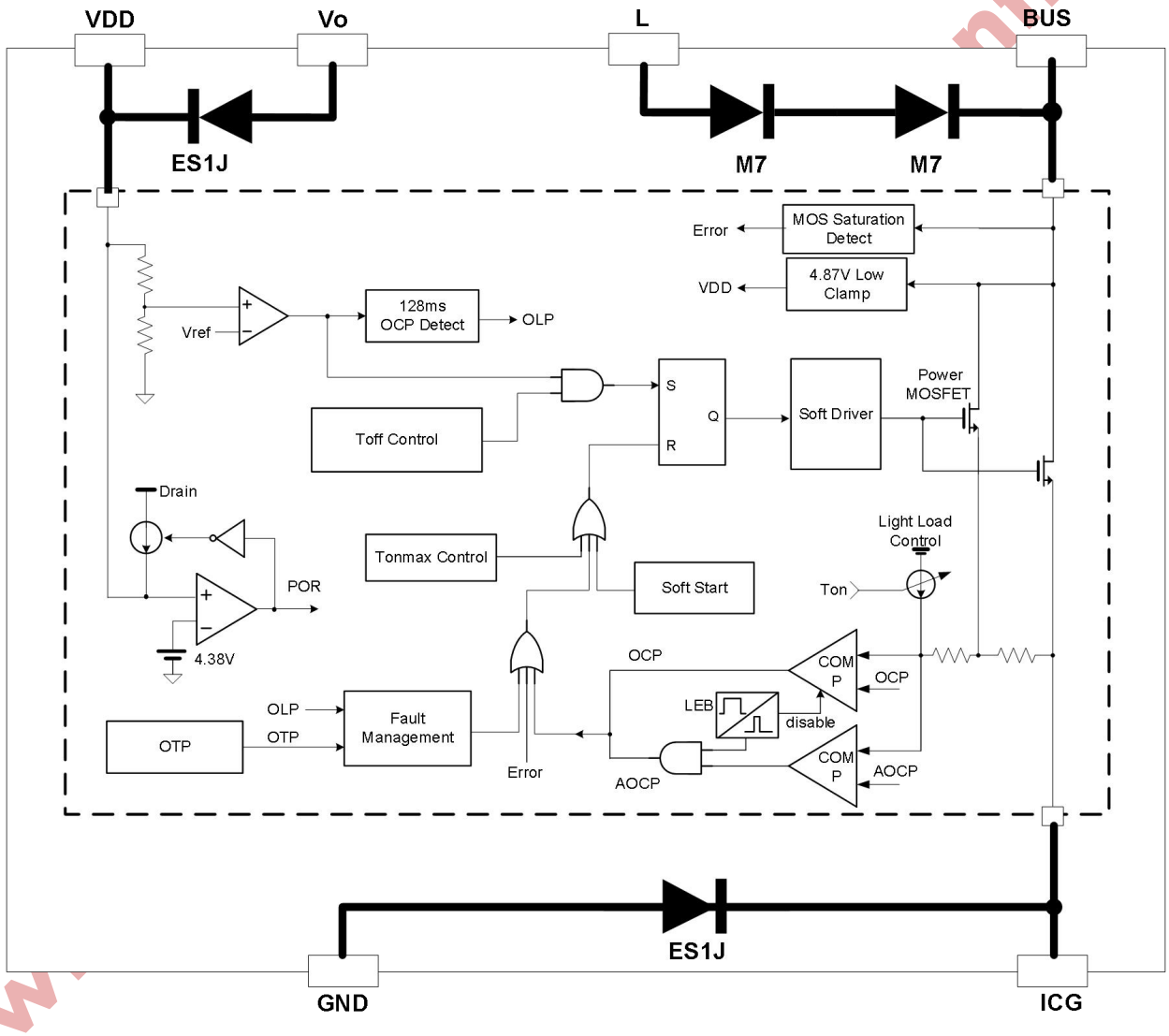
(2) I – Input; P – Power; G – GND.

Ordering Information

Part Number (3)	Description
KP311BHWGA	ASOP-7, Halogen free in T&R, 5000 Pcs / Reel

(3) Suffix "A" - Tape&Reel.

Block Diagram



Absolute Maximum Ratings (4)

Parameter	Value	Unit
BUS – ICG Voltage Range	-0.3 to 500	V
BUS – L Voltage Range	-1.2 to 1600	V
ICG – GND Voltage Range	-0.6 to 600	V
VDD – ICG Voltage Range	-0.3 to 7	V
VDD – Vo Voltage Range	-0.6 to 600	V
Package Thermal Resistance (ASOP-7)	150	°C / W
Maximum Junction Temperature	160	°C
Storage Temperature Range	-65 to 150	°C
Lead Temperature (Soldering, 10sec.)	260	°C
ESD Capability, HBM (Human Body Model) (5)	7.5	kV
Maximum Internal MOSFET DC Drain Current	0.4	A
Maximum Internal MOSFET Pulse Drain Current (Duration below 100μs)	1.2	A

(4) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(5) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

Recommended Operation Conditions

Parameter	Value	Unit
Operating Junction Temperature	-40 to 125	°C
Operation Switching Frequency	40 to 50	kHz

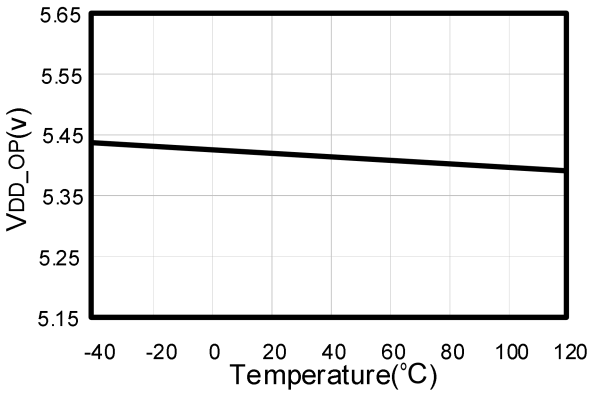
Electrical Characteristics (Ta = 25℃, unless otherwise specified)

Symbol	Parameter	Test Conditions	Min	Typ.	Max	Unit
Power MOSFET Section (Drain Pin, same as BUS Pin)						
$I_{Drain\_to\_VDD}$	High Voltage VDD Charging Current Source	Drain=40V, VDD=0V	1.1	2	3.6	mA
$I_{Drain\_leakage}$	Drain Leakage Current	HV=500V, VDD=6V			80	μA
V_{Drain_on}	HV-Startup Voltage			14		V
V_{BR}	Power MOSFET Drain Source Breakdown Voltage		500			V

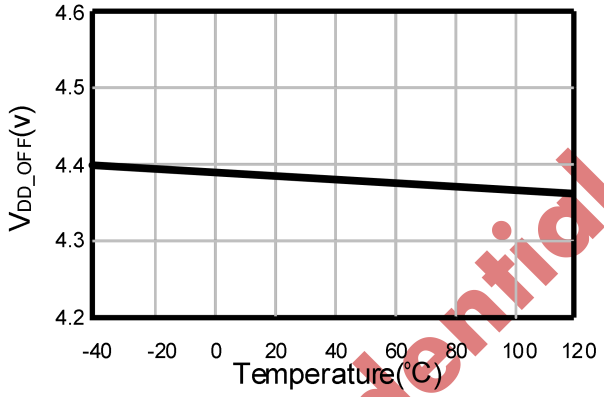
R_{dson}	Static Drain-Source On Resistance	I (Drain)=50mA		25		Ω
Supply Voltage Section (VDD Pin)						
I_{VDD_OP}	VDD Operation Current			640		μA
V_{DD_ON}	VDD Startup Voltage			4.87		V
V_{DD_OP}	VDD Regulation Voltage	Full Load	5.43	5.44	5.56	V
V_{DD_OFF}	VDD Under Voltage Lockout Enter			4.38		V
Oscillator Section						
T_{OFF_MIN}	Minimum Turn Off Time	VDD=5.46V	17.5	20	22.5	μs
T_{ON_MAX}	Maximum Turn On Time			60		μs
T_{D_OLP}	Over Loading Debounce Time	VDD=4.9V		128		ms
Internal Current Sense Section						
T_{LEB}	Leading Edge Blanking Time			400		ns
I_{peak_limit}	Peak Current Limit		200	210	220	mA
I_{peak_AOCP}	AOCP Current Limit			250		mA
T_{D_OCP}	Over Current Detection and Control Delay			200		ns
Over Temperature Protection						
T_{SD}	Thermal Shutdown (6)			155		°C

(6) Guaranteed by design.

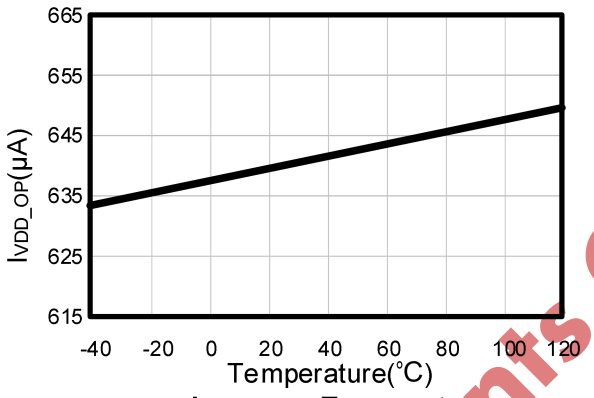
Characterization Curves



V_{DD_OP} vs Temperature



V_{DD_OFF} vs Temperature



I_{VDD_OP} vs Temperature

Operation Description

KP311BH is an un-isolated PWM switch controller integrated with a high voltage(500V) power MOSFET. It can be applied for Buck, Buck-Boost convertor in small home appliances and linear regulator replacement. The IC utilizes the ON/OFF current mode PWM control to regulate a 5V default output with high precision and low cost. At the same time, KP311BH supports ultra-low input voltage (>15V) under normal load.

● Ultra-low Operation Current

KP311BH standby operating current is very small, which reduces the VDD hold-up capacitance requirement and is helpful for the system cost. Normally 0.1-1μF ceramic capacitor is recommended.

● Oscillator with Frequency Jitter

In KP311BH, the minimum turn-off time is fixed to T_{OFF_MIN} (typically 20μs). To improve system EMI performance, KP311BH operates the system with ±5% frequency jitter around setting frequency. In actual applications, the system switching frequency is determined by the load conditions and the comparison between VDD voltage and output voltage reference, so it works in the frequency-regulation mode.

● Current Limit and Leading Edge Blanking (LEB)

The current limit circuit detects the differential voltage on the power MOSFET as the input of the OCP comparator. When the sampled differential voltage exceeds the threshold value, the power MOSFET is turned off until next time cycle. To avoid unexpected turn-off of power MOSFET, an internal leading edge blanking circuit is built in. During the T_{LEB} (typically 400ns), the cycle-by-cycle current limiting comparator is disabled and high voltage MOSFET cannot be turned off.

● Green Mode Operation

In light/zero load condition, the system usually works in DCM mode, so the main power dissipation is proportional to the inductor peak current. In KP311BH, the IC can automatically reduce the peak current limit under light/zero load conditions, which can achieve lower than 50mW standby power dissipation.

● Soft Start

KP311BH incorporates soft start function, which slowly increases the threshold of OCP current cycle-by-cycle. The longest soft start time is T_{ss} (typically 4ms). Every restart attempt is followed by the soft start activation.

● Overload Protection (OLP) / Short Load Protection (SLP)

If overload or short circuit occurs, output voltage and VDD will decrease. If this fault exists for more than T_{D_OLP} (typically 128ms), the protection will be triggered, the IC will stop switching and enter auto-recovery mode as mentioned below.

● Abnormal Over Current Protection (AOCP)

Under heavy load or output short conditions, the inductor current will increase sharply. To avoid this high current causing system components damage, KP311BH integrates an abnormal over current limit function AOCP (typically 250mA). When the detect current is higher than this threshold value, the internal power MOSFET is turned off immediately and keeps for 2 cycles.

● On Chip Thermal Shutdown (OTP)

When the IC temperature is over T_{SD} (typically 155°C), the IC will shut down and enters auto-recovery mode as mentioned below.

● Auto Recovery Mode Protection

When OTP or OLP fault occurs, the IC enters auto-recovery mode and VDD oscillation mode. In this mode, the power MOSFET is disabled and the VDD hold-up capacitor voltage will oscillate between V_{DD_ON} (typically 4.87V) and V_{DD_OFF} (typically 4.38V). After the oscillation is timing for 511 cycles, the IC will reset and start up the system again. If the fault still exists, the system will repeat the above actions; If the fault is removed, the system will resume normal operations.

Application Information

● Inductor Calculation

In order to ensure stable system operation, KP311BH is recommended to work under light CCM condition, which means inductor current ripple ΔI is close to Max CS-PK (210mA). Detail calculation shows below:

$$L=(Vo+Vf)*Toff\_min/\Delta I$$

Vo：Output Voltage;

Vf：Forward voltage on freewheeling diode；

Toff_min：Internal Toff-min, ~20μs；

ΔI：inductor current ripple,2* (Iocp-Io_max) under CCM condition.

For example, take 5V-130mA as the output spec, Io_max is set to 1.2 times of the normal output current (160mA):

L=(5V+0.7V)*20μs / (210-160)mA/2=1.1mH.

Choose L=1mH & Isat>210mA as the specific inductor parameter demand.

● Output Capacitor and Dummy Load Selection

Output Capacitor Selection: For 5V-150mA application, Output capacitor is chosen between 100μF-220μF according to actual output voltage ripple.

Dummy Load Selection: Heavy dummy load could suppress the output voltage from floating up, but too heavy dummy load would increase the standby power loss. So, need to take balance among load regulation and standby power loss.

Usually, 1k-2k dummy load is recommended in KP311BH system for good output regulation and low dummy load power loss (10-15mW).

● PCB Guideline

PCB layout design has significant impact on the power supply operation, system reliability, EMC and thermal performance. Figure 1 shows some recommended suggestions, these should be considered for actual application:

1. The main power loop (Loop1&Loop2) should be as small as possible, and the trace should be wide for better efficiency performance.
2. Feedback Routing (Loop3): a) Put the feedback loop out of the main power loop，and minimize this loop area as small as possible; b) Do not route chip Vo line too long and beneath the IC, otherwise system may not operation normally; c) Put the components of this loop close to IC as much as possible, and far away from the power inductor; d) Place the output feedback point at the positive of the output capacitor, and do not route this line beneath the power inductor, in case coupled high-frequency noise interrupts system normal operation.
3. Place VDD capacitor close to the IC to ensure the VDD loop is small.
4. Others: a) If adding the filter inductor, need to make sure power inductor is far away from filter inductor, to avoid the coupling has bad

impact on EMC; b) Increase copper area at IC BUS side for better thermal dissipation if PCB area is enough.

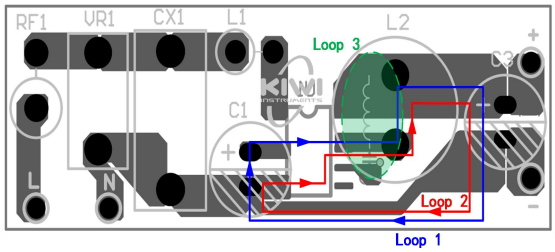


Fig. 1

Typical Application Diagram

- **BuckBoost Convertor (-5V/150mA)**

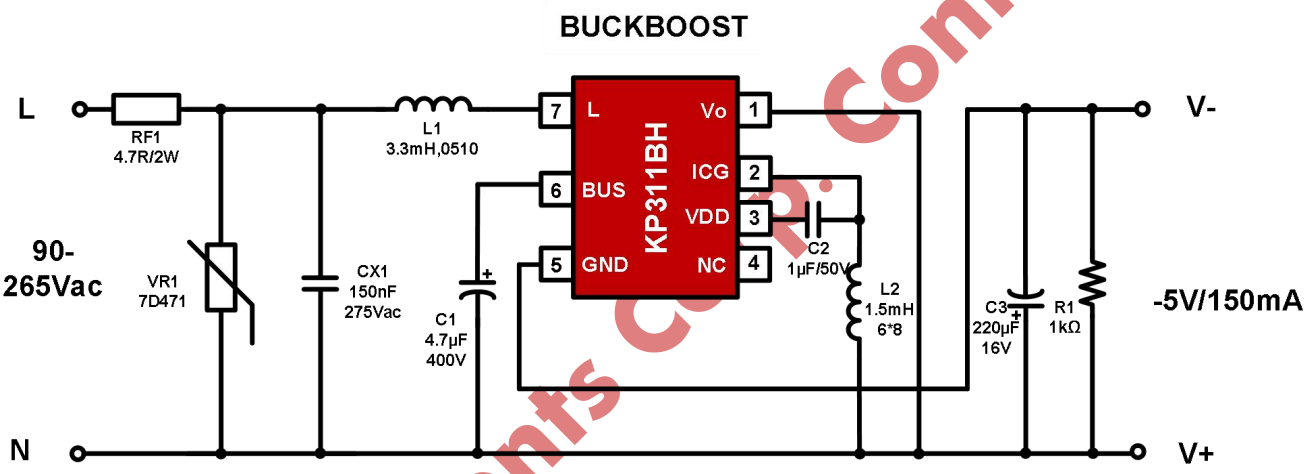


Fig. 2

Package Dimension

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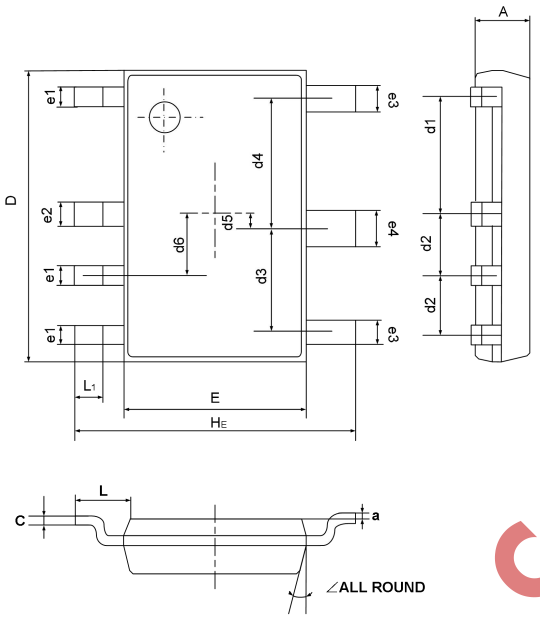
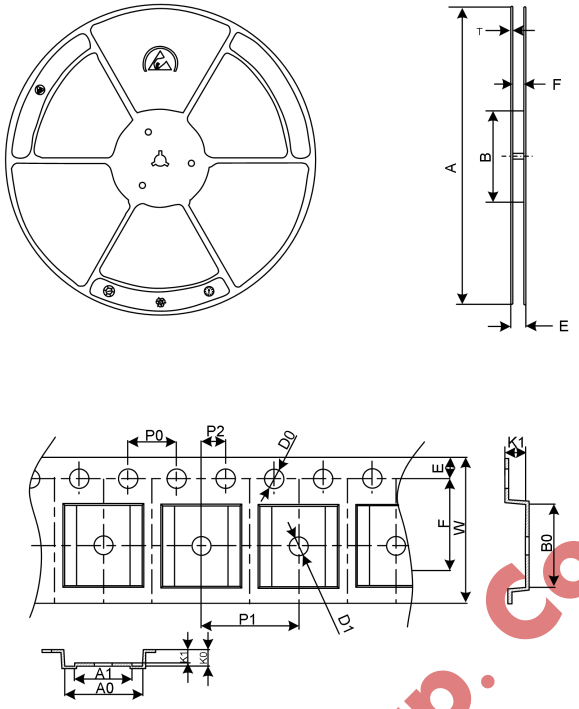


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.050	1.250	0.041	0.049
C	0.150	0.220	0.006	0.009
D	6.100	6.300	0.240	0.248
E	3.800	4.000	0.149	0.157
H_E	5.900	6.100	0.232	0.240
d1	2.410	2.610	0.094	0.103
d2	1.230	1.430	0.048	0.056
d3	2.080	2.280	0.081	0.090
d4	2.580	2.780	0.101	0.109
d5	0.25		0.010	
d6	1.28		0.050	
e1	0.300	0.500	0.012	0.020
e2	0.410	0.610	0.016	0.024
e3	0.450	0.650	0.017	0.025
e4	0.700	0.900	0.027	0.035
L	0.950	1.150	0.037	0.045
L1	0.500	1.000	0.019	0.039
a	0.2(ref.)		0.008(ref.)	
∠	12°			

Tape and Reel Information



Reel Dimensions (mm)				
A	**B (Inner Diameter)**	**E**	**F**	**T**
330±2	100±1	16.9±0.5	$12.7^{+2}_{-0.5}$	2.1±0.2

Tape Dimensions			
Symbol	**Dimensions (mm)**	**Symbol**	**Dimensions (mm)**
A0	6.40±0.10	K1	1.50±0.10
B0	6.60±0.10	E	1.75±0.10
K0	1.70±0.10	F	5.50±0.05
P0	4.00±0.10	D0	1.55±0.05
P1	8.00±0.10	D1	1.55±0.05
P2	2.00±0.05	W	12.0±0.30
A1	3.80±0.10		

Packing Quantity				
Package	**Pcs/Reel**	**Reels/Box**	**Boxes/Carton**	**Pcs/Carton**
ASOP-7	5000	2	5	50000

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