33mΩ 3A High Side Load Switches

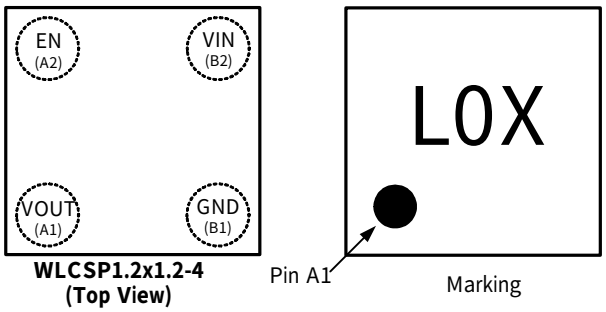
Features

- **33mW High Side MOSFET**
- **3A Continuous Current**
- **Wide Supply Voltage Range: 1.5V to 5.5V**
- **Internal Level Shift for CMOS/TTL Control Logic**
- **Ultra Low Quiescent Current**
- **Micro-power Shutdown Current**
- **Soft-Start and Auto Discharge Circuit**
- **Ultra Fast Turn Off Time**
- **Compact Package: 1.2mm x 1.2mm WLCSP-4**
- **Lead Free and Green Devices Available (RoHS Compliant)**

Applications

- **Mobile Phones**
- **Personal Media Players**
- **Portable Instrumentation**
- **PDAs**
- **Ultra Mobile PCs**
- **Other Portable Applications**

Pin Configuration



WLCSP1.2x1.2-4
(Top View)

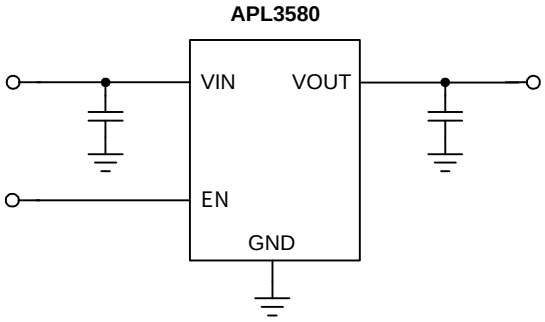
General Description

The APL3580 series are 33mΩ high-side load switches designed to be operated from 1.5V to 5.5V. The load switch that supports 1.5V logic level control and shut-down features can deliver load current up to 3A.

The APL3580 incorporates a soft-start control circuitry to limit inrush current during powering-up. When disabled, an internal discharge circuit automatically discharges a capacitive load. The enable input pin is actively pulled down to keep the device in off state until the enable pin is pulled above 1.2V. The level shift circuitry allows low voltage logic signals to switch higher supply voltage. The EN input voltage can be as high as 5.5V and is not limited by the input voltage.

With the virtues of low quiescent current and low shut down current, the APL3580 series are ideal for battery powered systems to maximum battery life, as well as non-battery powered applications. They are available in tiny 1.2mmx1.2mm WLCSP-4 packages.

Simplified Application Circuit



Ordering and Marking Information

APL3580 □□□-□□□ Assembly Material Handling Code Temperature Range Package Code	Package Code HA : WLCSP1.2x1.2-4 Operating Ambient Temperature Range I : -40 to 85 °C Handling Code TR : Tape & Reel Assembly Material G : Halogen and Lead Free Device
APL3580 HA : L0X ●	X - Date Code

Note : ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020D for MSL classification at lead-free peak reflow temperature. ANPEC defines "Green" to mean lead-free (RoHS compliant)and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V_{IN}	VIN to GND Voltage	-0.3 ~ 6	V
V_{OUT}	VOUT to GND Voltage	-0.3 ~ 6	V
V_{EN}	EN to GND Voltage	-0.3 ~ 6	V
I_{OUT}	Continue Output Current	±3.2	A
I_{OUTP}	Pulsed Output Current (Note 2)	±6	A
T_J	Maximum Junction Temperature	-40 ~ 150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C
T_{SDR}	Maximum Lead Soldering Temperature, 10 Seconds	260	°C

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
Note 2: Pulse width <300μs with <2% duty.

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JC}	Junction-to-Case Resistance in Free Air (Note 3) WLCSP1.2x1.2-4	90	°C/W

Note 3 : θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air.

Recommended Operating Conditions (Note 4)

Symbol	Parameter	Range	Unit
V_{IN}	VIN Input Voltage	1.5 ~ 5.5	V
I_{OUT}	OUT Output Current	0 ~3	A
T_A	Ambient Temperature	-40 ~ 85	°C
T_J	Junction Temperature	-40 ~ 125	°C

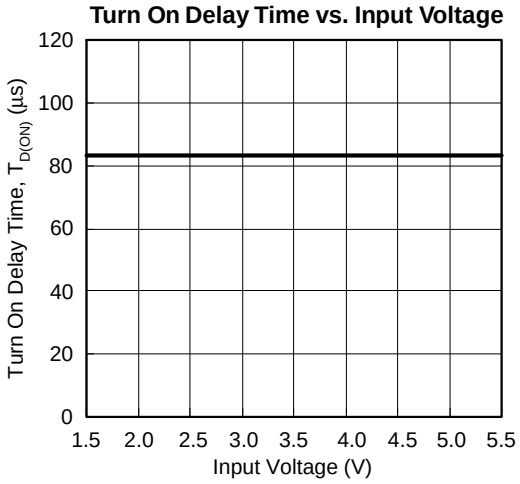
Note 4 : Refer to the typical application circuit

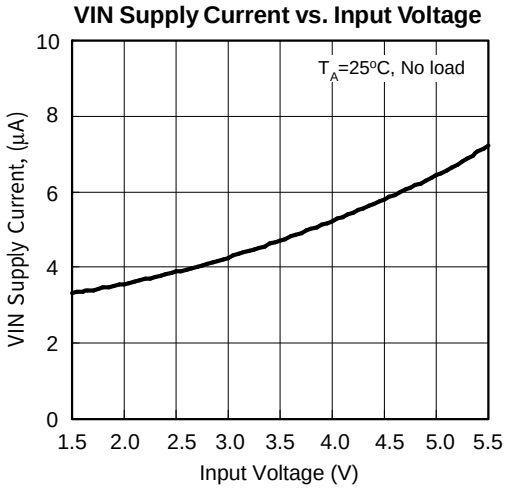
Electrical Characteristics

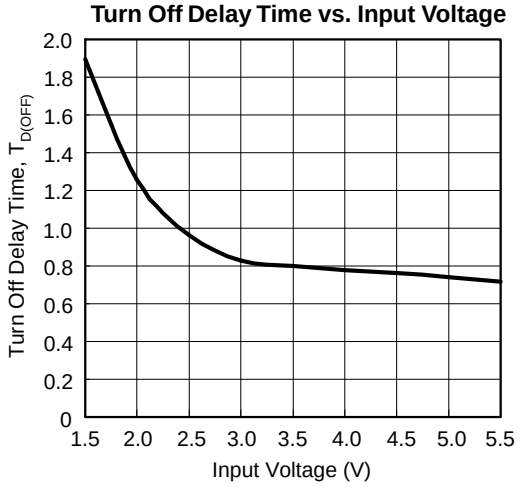
Unless otherwise specified, these specifications apply over V_{IN}=5V, and T_A=25 °C. Bold Values are at T_A= -40~85 °C.

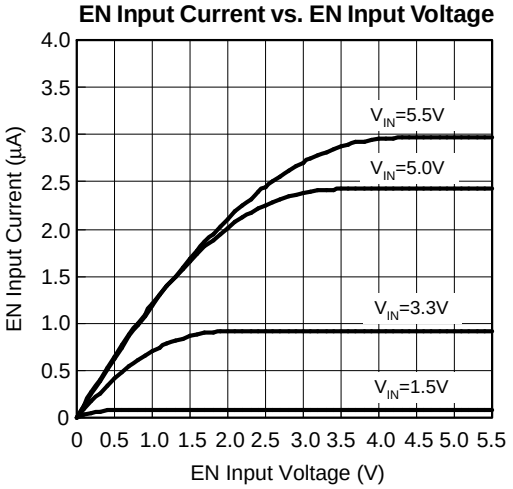
Symbol	Parameter	Test Conditions	APL3580			Unit
			Min.	Typ.	Max.	
SUPPLY CURRENT						
	VIN Supply Current	V_{IN}=V_{EN}=5V, VOUT open	-	7	10	μA
		V_{IN}=5V, V_{EN}=0V, VOUT open	-	0.1	1	μA
	Leakage Current	V_{IN}=5V, VOUT tied to GND, V_{EN}=0V, measured on VOUT	-	0.1	1	μA
POWER SWITCH						
$R_{DS(ON)}$	Power Switch On Resistance	V_N =5V, I_{OUT}=100mA, V_{EN}=1.5V	-	33	**55**	mΩ
		V_N =4.5V, I_{OUT}=100mA, V_{EN}=1.5V	-	35	**60**	
		V_N =3.6V, I_{OUT}=100mA, V_{EN}=1.5V	-	38	**65**	
		V_N =2.5V, I_{OUT}=100mA, V_{EN}=1.5V	-	45	**85**	
		V_N =1.8V, I_{OUT}=100mA, V_{EN}=1.5V	-	65	**120**	
		V_N =1.5V, I_{OUT}=100mA, V_{EN}=1.5V	-	77	**150**	
$t_{D(ON)}$	Turn-On Delay Time	V_{IN}=3.6V, R_{OUT}=36Ω, V_{EN}=1.5V	50	-	185	μs
$t_{D(OFF)}$	Turn-Off Delay Time	V_{IN}=3.6V, R_{OUT}=36Ω, V_{EN}=0V	-	0.8	1.2	μs
t_{ON_RISE}	Turn-On Rise Time	V_{IN}=3.6V, R_{OUT}=36Ω, V_{EN}=1.5V	50	-	200	μs
t_{OFF_FALL}	Turn-Off Fall Time	V_{IN}=3.6V, R_{OUT}=36Ω, no C_{OUT}, V_{EN}=0V	-	200	400	ns
EN INPUT PIN						
V_{IH}	EN Input Logic High	V_{IN}=1.5V to 5V	1.2	-	5.5	V
	EN Input Logic Low	V_{IN}=1.5V to 5V	0	-	0.4	V
	Input Current	V_{EN}=5.5V	-	2.5	4	μA
OUTPUT DISCHARGE RESISTANCE						
R_{SHD}	Output Discharge Resistance	I_{TEST} =1mA, V_{IN}=3.6V	-	250	400	Ω

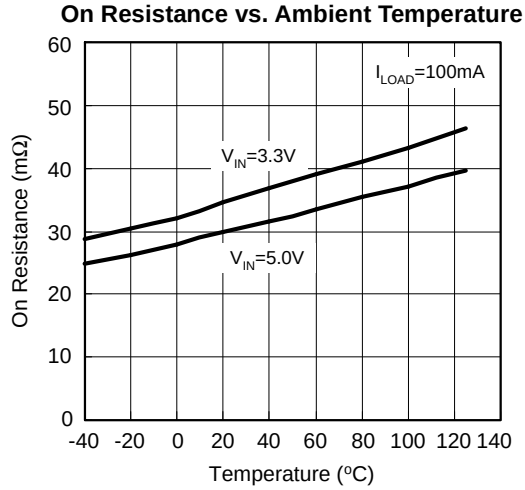
Typical Operating Characteristics

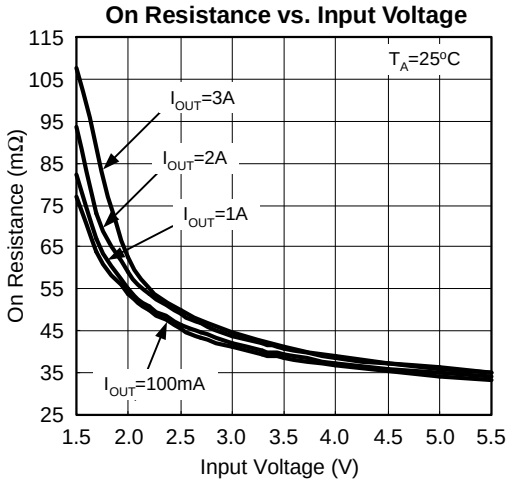




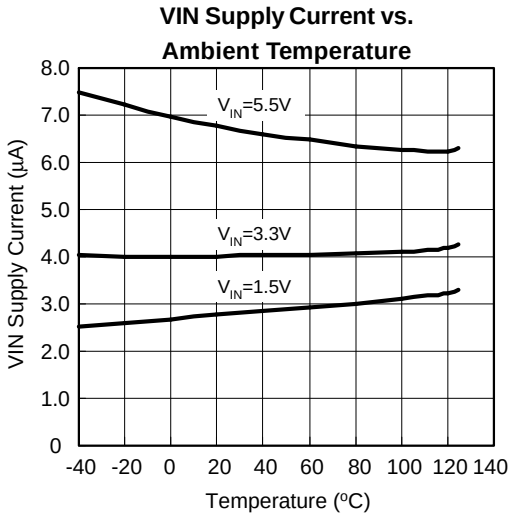


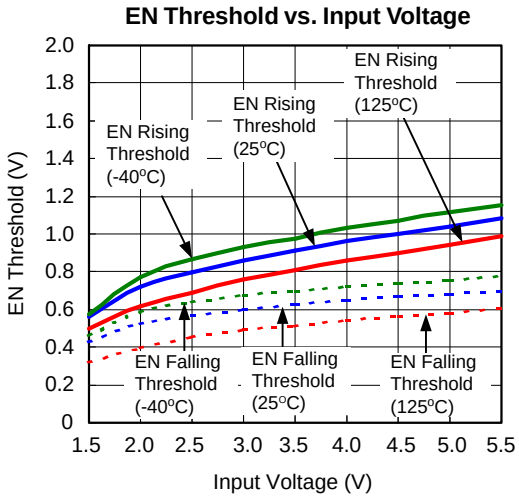






Typical Operating Characteristics (Cont.)

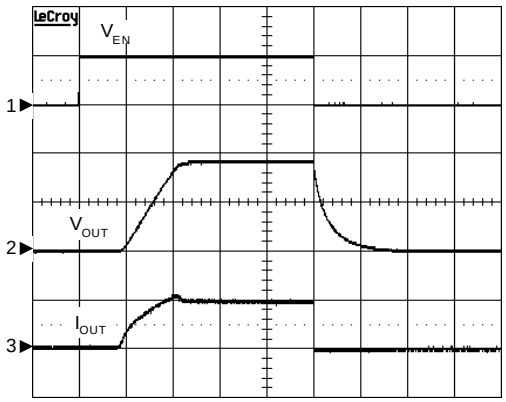




Operating Waveforms

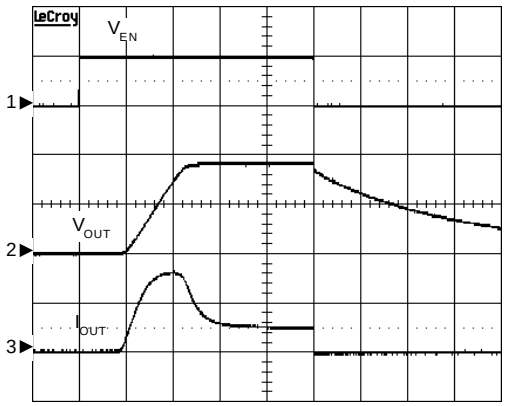
The test condition is T_A= 25°C unless otherwise specified.

Turn On /Turn Off Timing



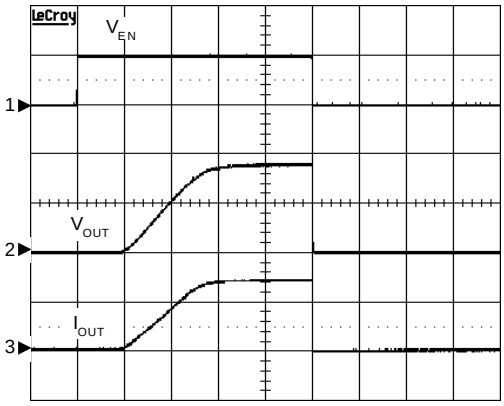
V_{IN} =3.6V, R_{LOAD} =36Ω, C_{OUT} =1μF
CH1: V_{EN}, 2V/Div, DC
CH2: V_{OUT}, 2V/Div, DC
CH3: I_{OUT}, 100mA/Div, DC
TIME: 100μs/Div

Turn On /Turn Off Timing



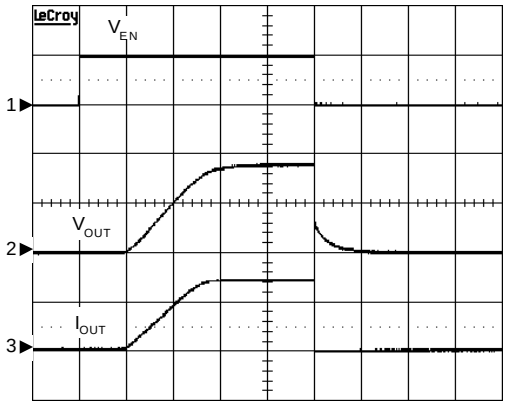
V_{IN} =3.6V, R_{LOAD} =36Ω, C_{OUT} =10μF
CH1: V_{EN}, 2V/Div, DC
CH2: V_{OUT}, 2V/Div, DC
CH3: I_{OUT}, 200mA/Div, DC
TIME: 100μs/Div

Turn On /Turn Off Timing



V_{IN} =3.6V, R_{LOAD} =1.2Ω, C_{OUT} =1μF
CH1: V_{EN}, 2V/Div, DC
CH2: V_{OUT}, 2V/Div, DC
CH3: I_{OUT}, 2A/Div, DC
TIME: 100μs/Div

Turn On /Turn Off Timing

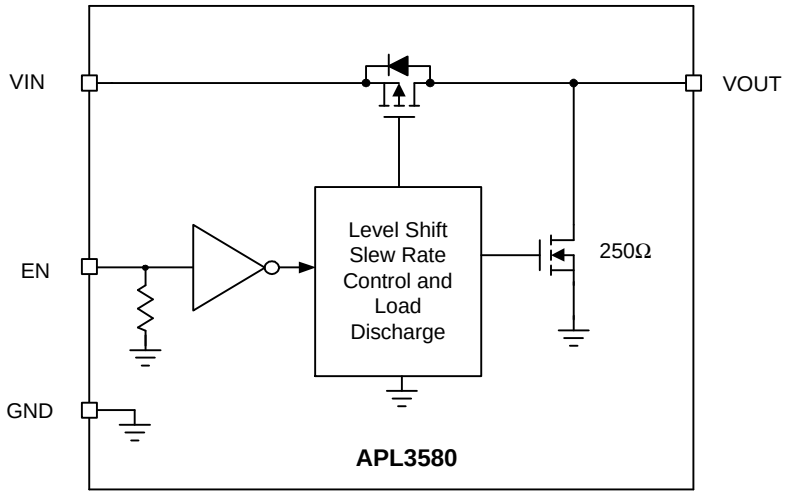


V_{IN} =3.6V, R_{LOAD} =1.2Ω, C_{OUT} =10μF
CH1: V_{EN}, 2V/Div, DC
CH2: V_{OUT}, 2V/Div, DC
CH3: I_{OUT}, 2A/Div, DC
TIME: 100μs/Div

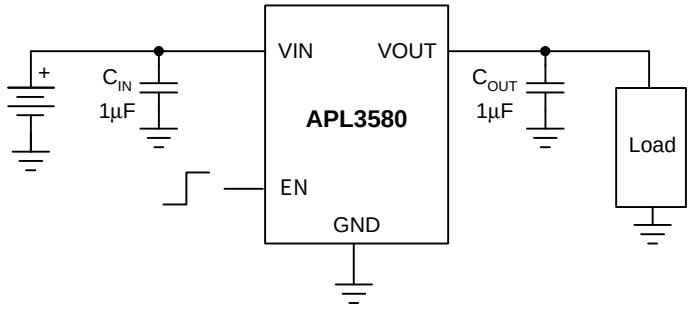
Pin Description

PIN		FUNCTION
NO.	NAME	
A1	VOUT	Output Voltage Pin. The output voltage follows the input voltage when the EN is high. The output voltage is discharged by an internal resistor if the EN is low or left open.
A2	EN	Enable Input. Pulling this pin high enables the device and low disables. The EN pin is internally pulled down. Leaving this pin floating shuts down output.
B1	GND	Ground
B2	VIN	Power Supply Input. Connect this pin to an external DC supply.

Block Diagram



Typical Application Circuit



Function Description

Enable/Disable

Pulling EN below 0.4V or leaving EN open disables the device and pulling EN above 1.2V enables the device. When the IC is disabled, the supply current is reduced to less than 1μA. The enable input has an internal level shift circuitry. The EN can accept a control signal whose voltage can be either higher or lower than VIN, not limited by the VIN's supply voltage.

Soft-Start

The device has a built-in soft-start control to prevent inrush current from pulling VIN's supply voltage down during power-up.

Output Discharge

The device incorporates an automatically discharging circuitry to discharge output's capacitive load when switch is disabled.

Application Information

Thermal Consideration

The APL3580 maximum power dissipation depends on the differences of the thermal resistance and temperature between junction and ambient air. The power dissipation P_D across the device is:

$$P_D = (T_J - T_A) / \theta_{JA}$$

where (T_J-T_A) is the temperature difference between the junction and ambient air. θ_{JA} is the thermal resistance between junction and ambient air. Assuming the T_A=25°C and maximum T_J=150°C (typical thermal limit threshold), the maximum power dissipation is calculated as:

$$P_{D(max)} = (150-25)/90$$
$$=1.38(W)$$

For normal operation, do not exceed the maximum operating junction temperature of T_J=125°C. The calculated power dissipation should be less than:

$$P_D=(125-25)/90$$
$$= 1.11(W)$$

Layout Consideration

Figure 1 illustrates the layout. Below is a checklist for your layout:

1. Please place the input capacitors close to the VIN.
2. Please place the output capacitors near to the Load as close as possible.
3. Keep VIN and VOUT traces as wide and short as possible.

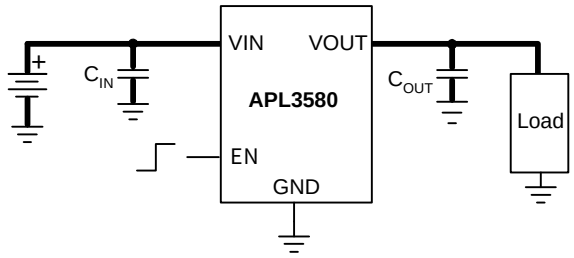
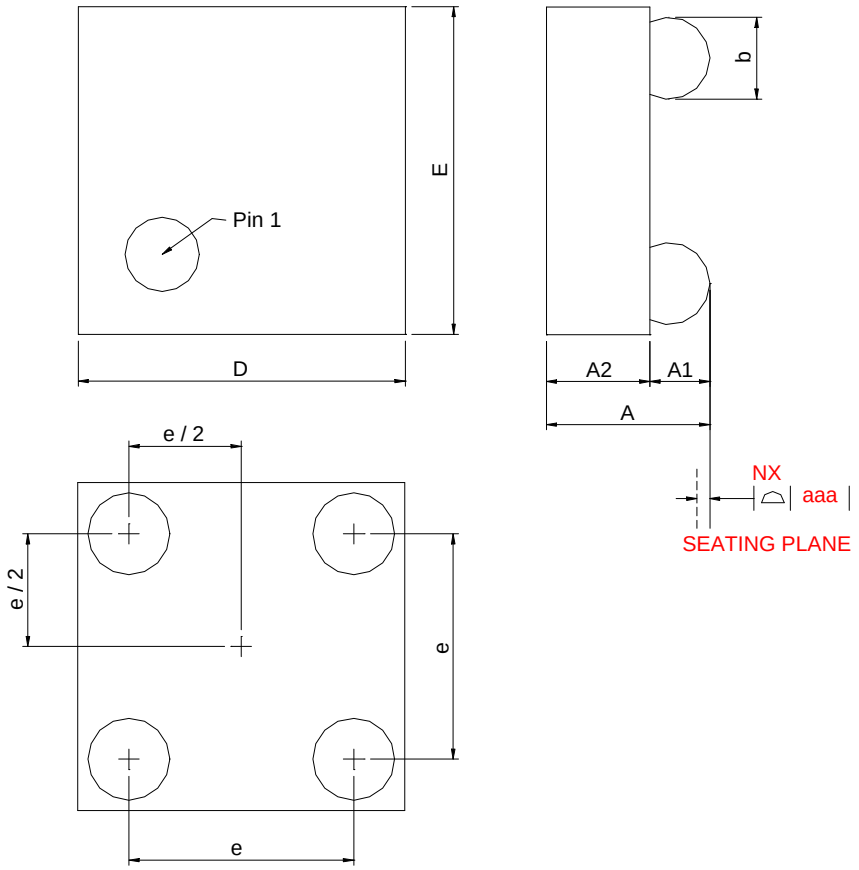


Figure 1.

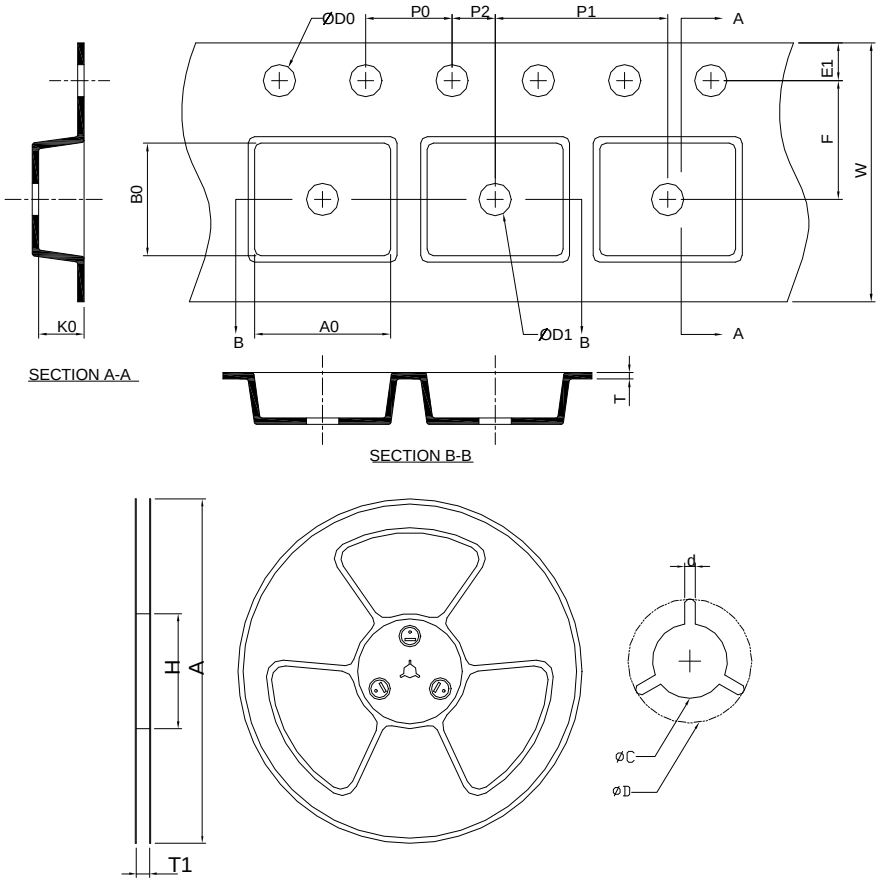
Package Information

WLCSP1.2x1.2-4



SYMBOL	WLCSP1.2x1.2-4			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.60	0.75	0.024	0.030
A1	0.20	0.25	0.008	0.010
A2	0.40	0.50	0.016	0.020
b	0.25	0.35	0.010	0.014
D	1.15	1.25	0.045	0.049
E	1.15	1.25	0.045	0.049
e	0.825 BSC		0.032 BSC	
aaa	0.08		0.003	

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
WLCSP1.2x1.2-4	330.0±2.00	50 MIN.	12.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	12.0±0.30	1.75±0.10	3.5±0.05
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	4.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	1.30±0.10	1.30±0.10	0.95±0.20

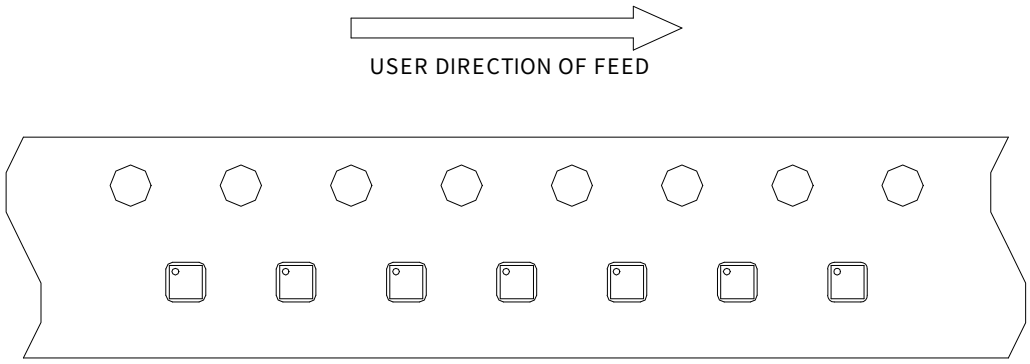
(mm)

Devices Per Unit

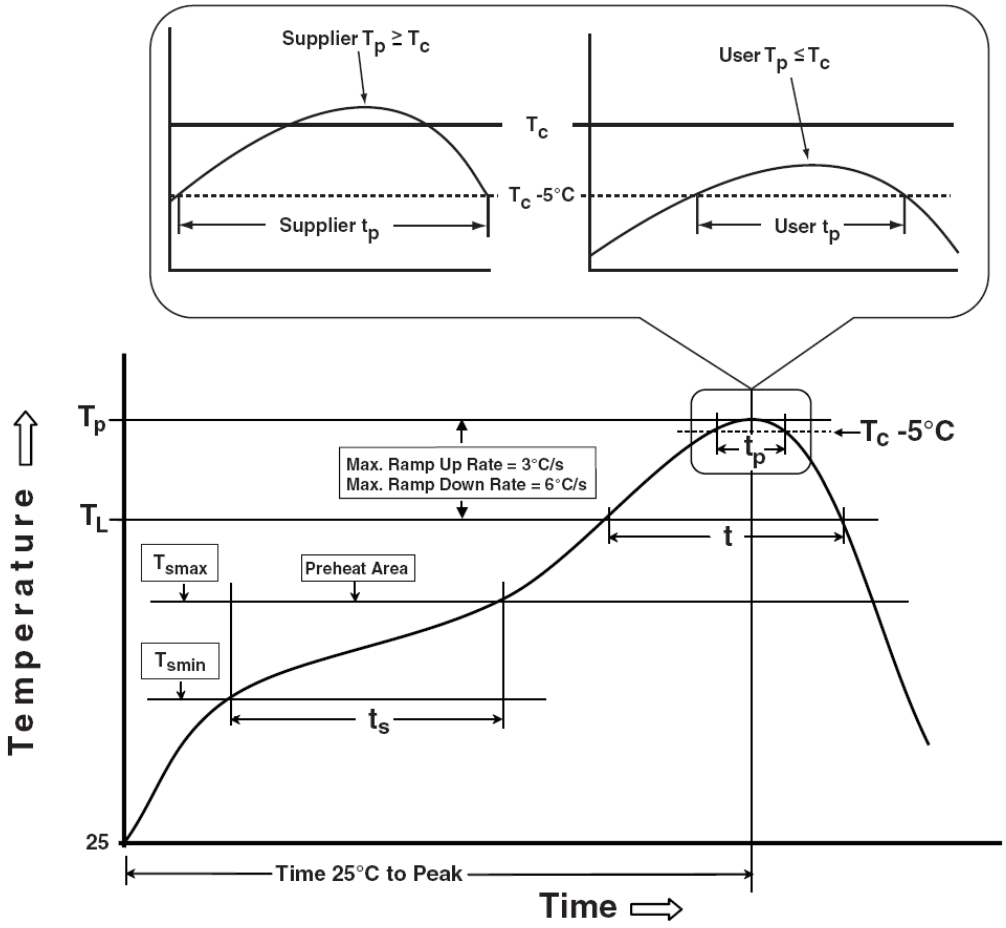
Package Type	Unit	Quantity
WLCSP1.2x1.2-4	Tape & Reel	5000

Taping Direction Information

WLCSP1.2x1.2-4



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak Temperature min (T_{smin}) Temperature max (T_{smax}) Time (T_{smin} to T_{smax}) (t_s)	 100 °C 150 °C 60-120 seconds	 150 °C 200 °C 60-120 seconds
Average ramp-up rate (T_{smax} to T_P)	3 °C/second max.	3 °C/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	183 °C 60-150 seconds	217 °C 60-150 seconds
Peak package body Temperature (T_p)*	See Classification Temp in table 1	See Classification Temp in table 2
Time (t_P)** within 5°C of the specified classification temperature (T_c)	20** seconds	30** seconds
Average ramp-down rate (T_p to T_{smax})	6 °C/second max.	6 °C/second max.
Time 25°C to peak temperature	6 minutes max.	8 minutes max.
* Tolerance for peak profile Temperature (T_p) is defined as a supplier minimum and a user maximum. ** Tolerance for time at peak profile temperature (t_p) is defined as a supplier minimum and a user maximum.		

Table 1. SnPb Eutectic Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 ^{3}350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2. Pb-free Process – Classification Temperatures (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm – 2.5 mm	260 °C	250 °C	245 °C
≥2.5 mm	250 °C	245 °C	245 °C

Reliability Test Program

Test item	Method	Description
SOLDERABILITY	JESD-22, B102	5 Sec, 245°C
HOLT	JESD-22, A108	1000 Hrs, Bias @ T_j=125°C
PCT	JESD-22, A102	168 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	500 Cycles, -65°C~150°C
HBM	MIL-STD-883-3015.7	VHBM≧2KV
MM	JESD-22, A115	VMM≧200V
Latch-Up	JESD 78	10ms, 1_{tr}≧100mA

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