

### Features

- **High Efficiency up to 95%**
- **- Automatic Skip/PWM Mode Operation**
- **Adjustable Output Voltage from 0.6V to VIN**
- **Integrated 110mW High side 80mW Low Side MOSFET**
- **Low Dropout Operation : 100% Duty cycle**
- **Stable with Low ESR Ceramic Capacitors**
- **Power-On-Reset Detection on VIN**
- **Integrate Soft Start and Soft-Stop**
- **Over-Temperature Protection**
- **Over Voltage Protection**
- **Under Voltage Protection**
- **High/ Low Side Current Limit**
- **Power Good Indication**
- **Enable/Shutdown Function**
- **Small SOT-23-6 and TDFN2x2-8 packages**
- **Lead Free and Green Devices Available (RoHS compliant)**

### General Description

APW8825A is a 3A synchronous buck converter with integrated 110mΩ high side and 80mΩ low side power MOSFETs. The APW8825A design with a current-mode control scheme, can convert wide input voltage of 2.6V to 5.5V to the output voltage adjustable from 0.6V to 5.5V to provide excellent output voltage regulation.

The APW8825A is equipped with an automatic Skip/PWM mode operation. At light load, the IC operates in the Skip mode to reduce the switching losses. At heavy load, the IC works in PWM mode. At PWM mode, the switching frequency is set by the external resistor.

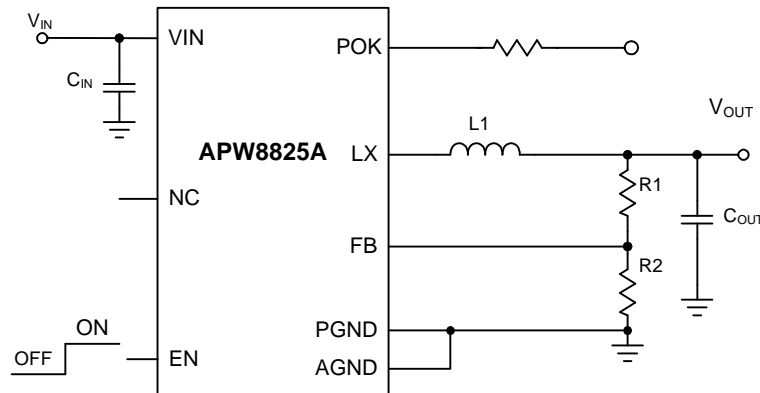
The APW8825A is also equipped with Power-on-reset, soft start, soft-stop, and whole protections (under-voltage, over-voltage, over-temperature and current-limit) into a single package.

This device, available TDFN2X2-8 and SOT-23-6 provide a very compact system solution external components and PCB area.

### Applications

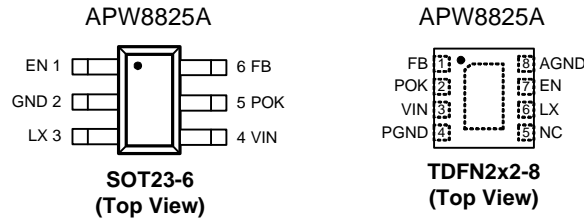
- **Notebook Computer & UMPC**
- **LCD Monitor/TV**
- **Set-Top Box**
- **DSL, Switch HUB**
- **Portable Instrument**

### Simplified Application Circuit






ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

## Pin Configurations



## Ordering and Marking Information

<p>APW8825A </p> <p>Assembly Material Handling Code Temperature Range Package Code</p>	<p>Package Code QB : TDFN-2x2-8      C: SOT23-6</p> <p>Operating Ambient Temperature Range I : -40 to 85°C</p> <p>Handling Code TR : Tape &amp; Reel</p> <p>Assembly Material G: Halogen and Lead Free Device</p>
<p>APW8825A QB :  X - Date Code</p>	<p>APW8825A C :  X - Date Code</p>

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
$V_{IN}$	Input Supply Voltage to PGND	-0.3 ~ 6.5	V
$V_{LX}$	LX to GND Voltage	< 30ns pulse width	-3 ~ 8
		> 30ns pulse width	-1 ~ $V_{IN}+0.3$
	POK, FB, EN to PGND Voltage	-0.3 ~ 6.5	V
	AGND to PGND Voltage	-0.3 ~ 0.3	V
$T_J$	Junction Temperature	150	°C
$T_{STG}$	Storage Temperature	-65 ~ 150	°C
$T_{SDR}$	Maximum Lead Soldering Temperature(10 Seconds)	260	°C

Note1: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
$\theta_{JA}$	Junction-to-Ambient Resistance in free air <sup>(Note 2)</sup>	TDFN2x2-8	75
		TSOT23-6	250

Note 2:  $\theta_{JA}$  is measured with the component mounted on a high effective thermal conductivity test board in free air.

## Recommended Operating Conditions <sup>(Note 3)</sup>

Symbol	Parameter	Range	Unit
$V_{IN}$	Control and Driver Supply Voltage	2.6 ~ 5.5	V
L	Inductance	1 ~ 2.2	$\mu$ H
$I_{OUT}$	Converter Output Current	0 ~ 3	A
$T_A$	Ambient Temperature	-40 ~ 85	$^{\circ}$ C
$T_J$	Junction Temperature	-40 ~ 125	$^{\circ}$ C

Note 3 : Refer to the typical application circuit

## Electrical Characteristics

Unless otherwise specified, these specifications apply over  $V_{IN}=3.7V$  and  $T_A= -40$  to  $85^{\circ}C$ . Typical values are at  $T_A=25^{\circ}C$ .

Symbol	Parameter	Test Conditions	APW8825A			Unit
			Min	Typ	Max	
<b>Supply Current</b>						
$I_{DD}$	VIN Supply Current	$V_{FB}=0.66V$	-	65	-	$\mu$ A
$I_{SHDN}$	VIN Shutdown Supply Current	EN=GND	-	-	1	$\mu$ A
<b>Power-On-Reset (POR)</b>						
	VIN POR Voltage Threshold	$V_{IN}$ Rising	2.3	2.4	2.5	V
	VIN POR Hysteresis		0.1	0.2	0.3	V
<b>Reference Voltage</b>						
$V_{REF}$	Reference Voltage		-	0.6	-	V
		$T_A=25^{\circ}C$	-1	-	+1	%
	Output Accuracy	$I_{OUT}=10mA\sim 3A$ , $V_{IN}=2.6\sim 5.5V$	-1.5	-	+1.5	%
<b>Oscillator</b>						
$F_{OSC}$	Oscillator Frequency		0.85	1	1.15	MHz
	Minimum on Time		-	70	-	ns

## Electrical Characteristics

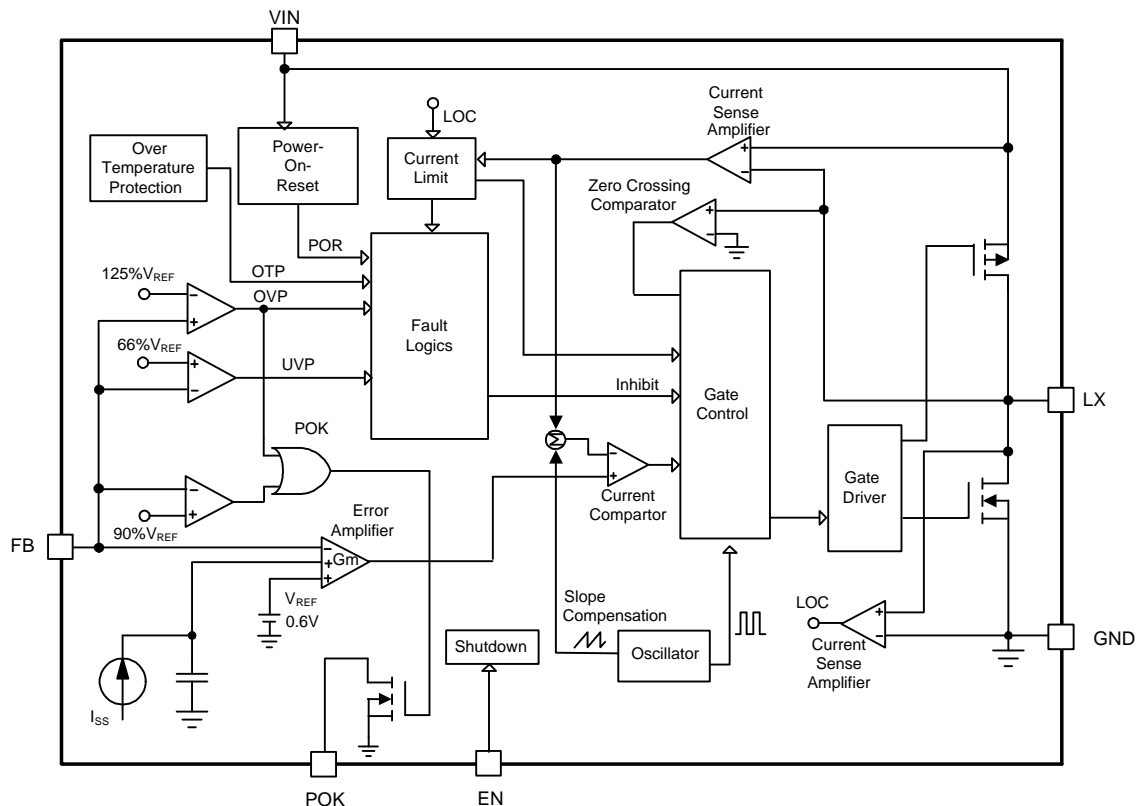
Unless otherwise specified, these specifications apply over  $V_{IN}=3.7V$  and  $T_A = -40$  to  $85^\circ C$ . Typical values are at  $T_A=25^\circ C$ .

Symbol	Parameter	Test Conditions	APW8825A			Unit
			Min	Typ	Max	
<b>Power MOSFET</b>						
	High Side P-MOSFET Resistance	$V_{IN}=5V, I_{LX}=0.5A, T_A=25^\circ C$	-	110	-	m $\Omega$
	Low Side N-MOSFET Resistance	$V_{IN}=5V, I_{LX}=0.5A, T_A=25^\circ C$	-	80	-	m $\Omega$
	High/Low Side MOSFET Leakage Current		-	-	10	$\mu A$
<b>Protections</b>						
$I_{LIM}$	High Side MOSFET current-limit	Peak Current, $V_{IN}=2.6\sim 5.5V$ $T_A = -40 \sim 125^\circ C$	4	5	6	A
$T_{OTP}$	Over-temperature Trip Point (Resoft start after OTP)		-	160	-	$^\circ C$
	Over-temperature Hysteresis		-	50	-	$^\circ C$
	Over- Voltage Protection threshold	$V_{OUT}$ Rising	120	125	130	% $V_{REF}$
	Under-Voltage Protection threshold		57	66	75	% $V_{REF}$
	Over-Voltage Protection debounce time		20	25	30	$\mu s$
	Low Side Switch Current-Limit	From Drain to Source	-	-1	-	A
<b>Soft-Start, Enable and POK</b>						
	Soft Start time		-	0.8	-	ms
	EN Enable threshold		-	-	1.4	V
	EN shutdown threshold		0.5	-	-	V
	EN Leakage	EN=5V	-	-	1	$\mu A$
	POK threshold	POK in from Lower (POK Goes High)	87.5	90	92.5	% $V_{OUT}$
		POK Low Hysteresis (POK Goes Low)	-	5	-	% $V_{OUT}$
		POK in from Higher (POK Goes High)	120	125	130	% $V_{OUT}$
		POK High Hysteresis (POK Goes Low)	-	5	-	% $V_{OUT}$
	Power Good pull low resistance		-	100	-	$\Omega$
	Power Good Debounce	High to low	-	20	-	$\mu s$

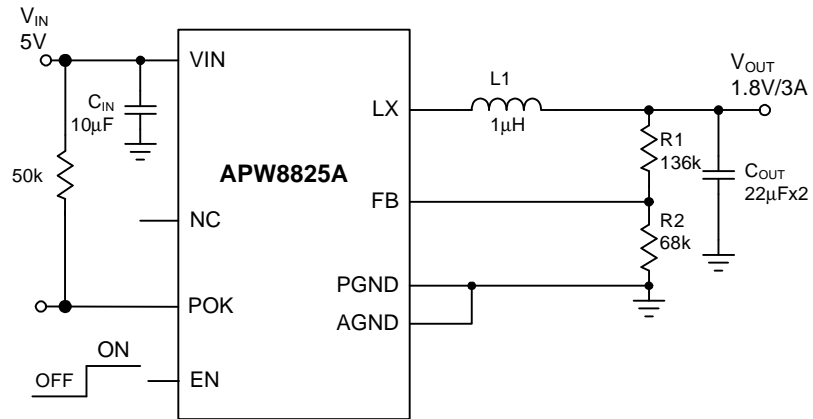
## Pin Description

PIN			Function
TDFN2x2-8	TSOP23-6	Name	
1	6	FB	Output Feedback Input. The APW8825A senses the feedback voltage via FB and regulates the voltage at 0.6V. Connecting FB with a resistor-divider from the converter's output sets the output voltage.
2	5	POK	Power Good Output. This pin is open-drain logic output that is pulled to ground when the output voltage is not within 10% of regulation point.
3	4	VIN	The control circuitry and converter supply input. Connecting a ceramic bypass capacitor from VIN to GND to eliminate switching noise and voltage ripple on the input to the IC.
4, Exposed pad	-	PGND	Power ground. Connect this pin to AGND.
5	-	NC	No internal connection.
6	3	LX	Power Switching Output. LX is the Junction of the high-side and low-side Power MOSFETs to supply power to the output LC filter.
7	1	EN	Enable Input. EN is a digital input that turns the regulator on or off. Drive EN high to turn on the regulator, drive it low to turn it off.
8	-	AGND	Analog ground. Connect this pin to PGND.
-	2	GND	Power and signal ground.

## Block Diagram



## Typical Application Circuit



## Function Description

### VIN Power-On-Reset (POR)

The APW8825A keeps monitoring the voltage on VIN pin to prevent wrong logic operations which may occur when VIN voltage is not high enough for internal control circuitry to operate. The VIN POR rising threshold is 2.4V with 0.2V hysteresis.

During startup, the VIN voltage must exceed the POR threshold. Then the IC starts a start-up process and ramps up the output voltage to the voltage target.

### Over-Voltage Protection (OVP)

The over-voltage function monitors the output voltage by FB pin. When the FB voltage increases over 125% of the reference voltage due to the high-side MOSFET failure or for other reasons, the over-voltage protection comparator will trigger soft-stop function and shutdown the converter output.

### Over-Temperature Protection (OTP)

The over-temperature circuit limits the junction temperature of the APW8825A. When the junction temperature exceeds  $T_j = 160^\circ\text{C}$ , a thermal sensor turns off the both power MOSFETs, allowing the devices to cool.

The thermal sensor allows the converters to start a start-up process and to regulate the output voltage again after the junction temperature cools by  $50^\circ\text{C}$ . The OTP is designed with a  $50^\circ\text{C}$  hysteresis to lower the average  $T_j$  during continuous thermal overload conditions, increasing lifetime of the APW8825A.

### Current-Limit Protection and Hiccup

The APW8825A has a cycle-by-cycle over-current limit when the inductor current peak value exceeds the set current limit threshold. Meanwhile, the output voltage drops until FB is below the Under-Voltage (UV) threshold. Once UV is triggered, the APW8825A enters hiccup mode to periodically restart the part. This protection mode is especially useful when the output is dead-shortened to ground. The average short circuit current is greatly reduced to alleviate thermal issues and to protect the regulator. The APW8825A exits the hiccup mode once the over-current condition is removed.

### Soft-Start

The APW8825A has a built-in soft-start to control the rise rate of the output voltage and limit the input current surge during start-up. During soft-start, an internal voltage ramp connected to one of the positive inputs of the error amplifier, rises up to replace the reference voltage until the voltage ramp reaches the reference voltage. During soft-start without output over-voltage, the APW8825A converter's sinking capability is disabled until the output voltage reaches the voltage target.

### Soft-Stop

At the moment of shutdown controlled by EN signal or over-voltage event, the APW8825A initiates a soft-stop process to discharge the output voltage in the output capacitors. Certainly, the load current also discharges the output voltage. During soft-stop, the low side MOSFET turns on each cycle to discharge the output voltage. Therefore, the output voltage falls down slowly at the light load. After the soft-stop interval elapses, the soft-stop process ends and the IC turns off.

### Enable and Shutdown

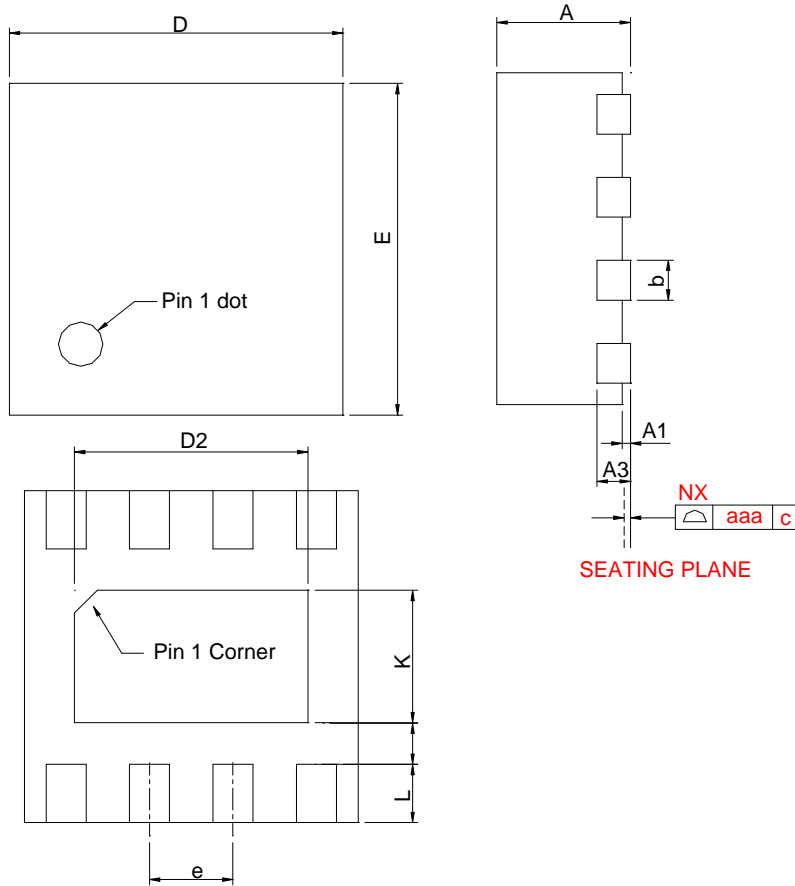
Driving EN to ground places the APW8825A in shutdown. In shutdown mode, the internal power MOSFETs turn off, all internal circuitry shuts down and the quiescent supply current reduces to less than  $1\mu\text{A}$ .

### Power Good Indicator

POK is actively held low in shutdown and soft-start status. In the soft-start process, the POK is an open-drain. When the soft-start is finished, the POK is high. In normal operation, the POK window is from 90% to 125% of the converter reference voltage. When the output voltage stays within this window, POK signal will become high. When the output voltage outruns 85% or 120% of the target voltage, POK signal will be pulled low immediately. In order to prevent false POK drop, capacitors need to parallel at the output to confine the voltage deviation with severe load step transient. The POK pin, if used, needs an external pull high resistor, the recommended resistor should be in the range of  $30\text{K}\Omega$  to  $100\text{K}\Omega$ .

## Package Information

TDFN2x2-8



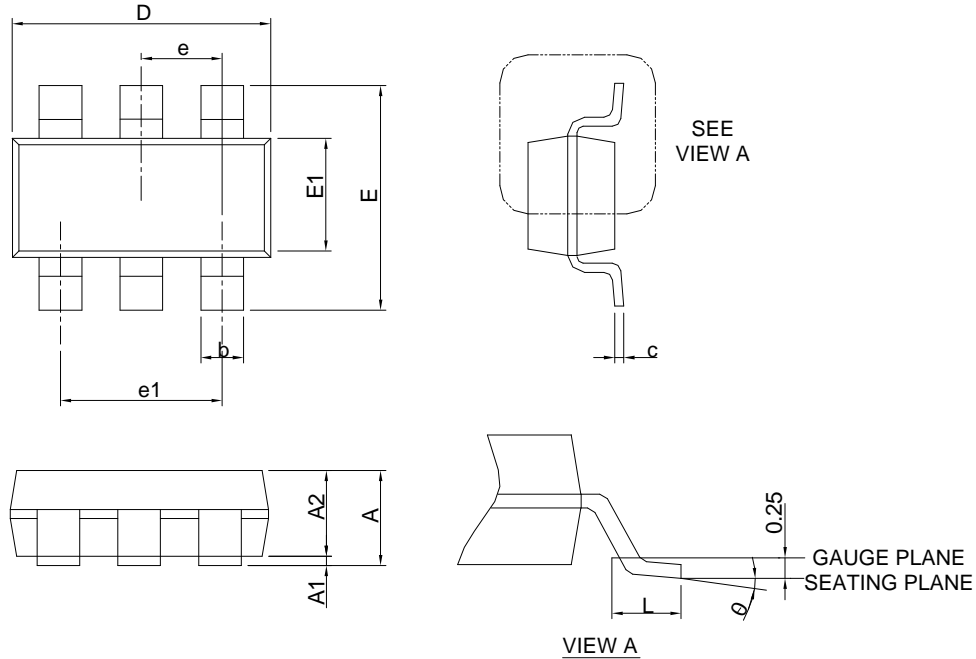
SYMBOL	TDFN2*2-8			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.18	0.30	0.007	0.012
D	1.90	2.10	0.075	0.083
D2	1.00	1.60	0.039	0.063
E	1.90	2.10	0.075	0.083
E2	0.60	1.00	0.024	0.039
e	0.50 BSC		0.020 BSC	
L	0.30	0.45	0.012	0.018
K	0.20		0.008	
aaa	0.08		0.003	

Note : 1. Followed from JEDEC MO-229 WCCD-3.



Package Information

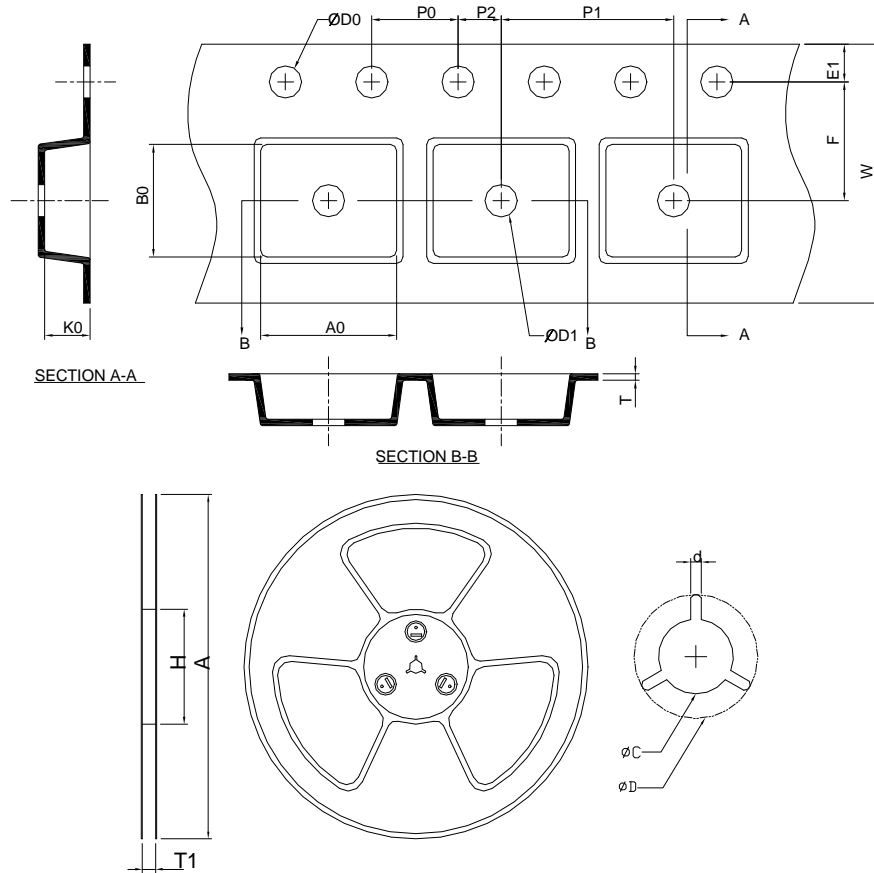
SOT-23-6



SYMBOL	SOT-23-6			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.45		0.057
A1	0.00	0.15	0.000	0.006
A2	0.90	1.30	0.035	0.051
b	0.30	0.50	0.012	0.020
c	0.08	0.22	0.003	0.009
D	2.70	3.10	0.106	0.122
E	2.60	3.00	0.102	0.118
E1	1.40	1.80	0.055	0.071
e	0.95 BSC		0.037 BSC	
e1	1.90 BSC		0.075 BSC	
L	0.30	0.60	0.012	0.024
θ	0°	8°	0°	8°

Note : 1. Follow JEDEC TO-178 AB.  
 2. Dimension D and E1 do not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
TDFN2x2-8	178.0 ±0.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0 ±0.20	1.75 ±0.10	3.5 ±0.05
	<b>P0</b>	<b>P1</b>	<b>P2</b>	<b>D0</b>	<b>D1</b>	<b>T</b>	<b>A0</b>	<b>B0</b>	<b>K0</b>
	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	2.35 ±0.20	2.35 ±0.20	1.00 ±0.20
Application	A	H	T1	C	d	D	W	E1	F
SOT-23-6	178.0 ±0.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0 ±0.30	1.75 ±0.10	3.5 ±0.05
	<b>P0</b>	<b>P1</b>	<b>P2</b>	<b>D0</b>	<b>D1</b>	<b>T</b>	<b>A0</b>	<b>B0</b>	<b>K0</b>
	4.0 ±0.10	4.0 ±0.10	2.0 ±0.05	1.5+0.10 -0.00	1.0 MIN.	0.6+0.00 -0.40	3.20 ±0.20	3.10 ±0.20	1.50 ±0.20

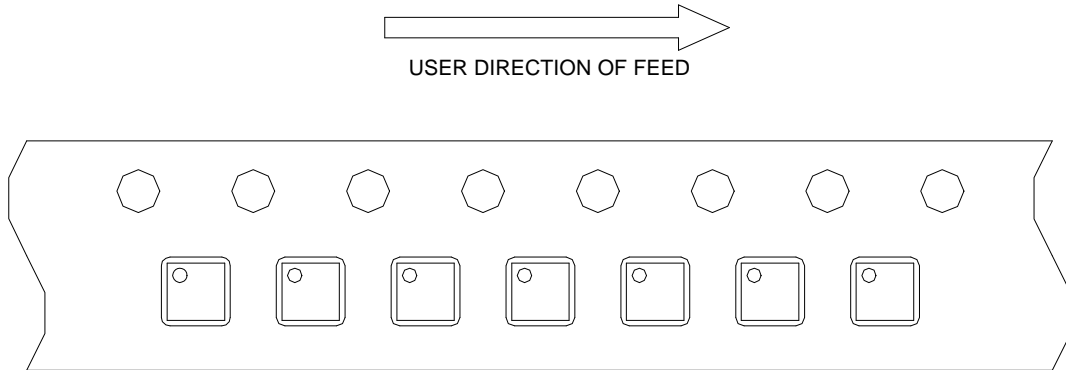
(mm)

Devices Per Unit

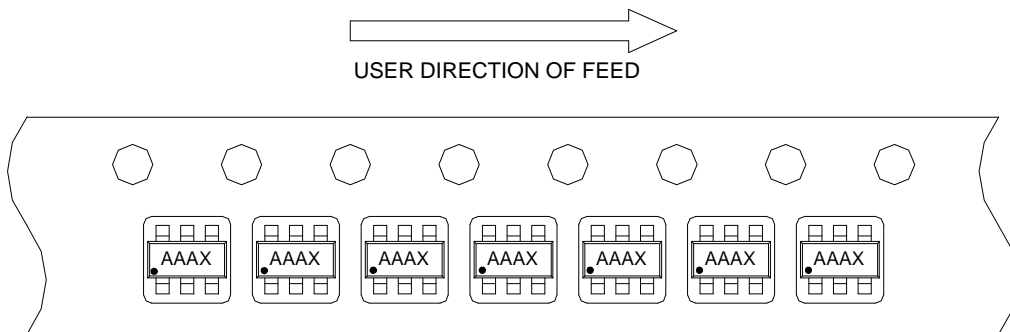
Package Type	Unit	Quantity
SOT-23-6	Tape & Reel	3000
TDFN2x2-8	Tape & Reel	3000

### Taping Direction Information

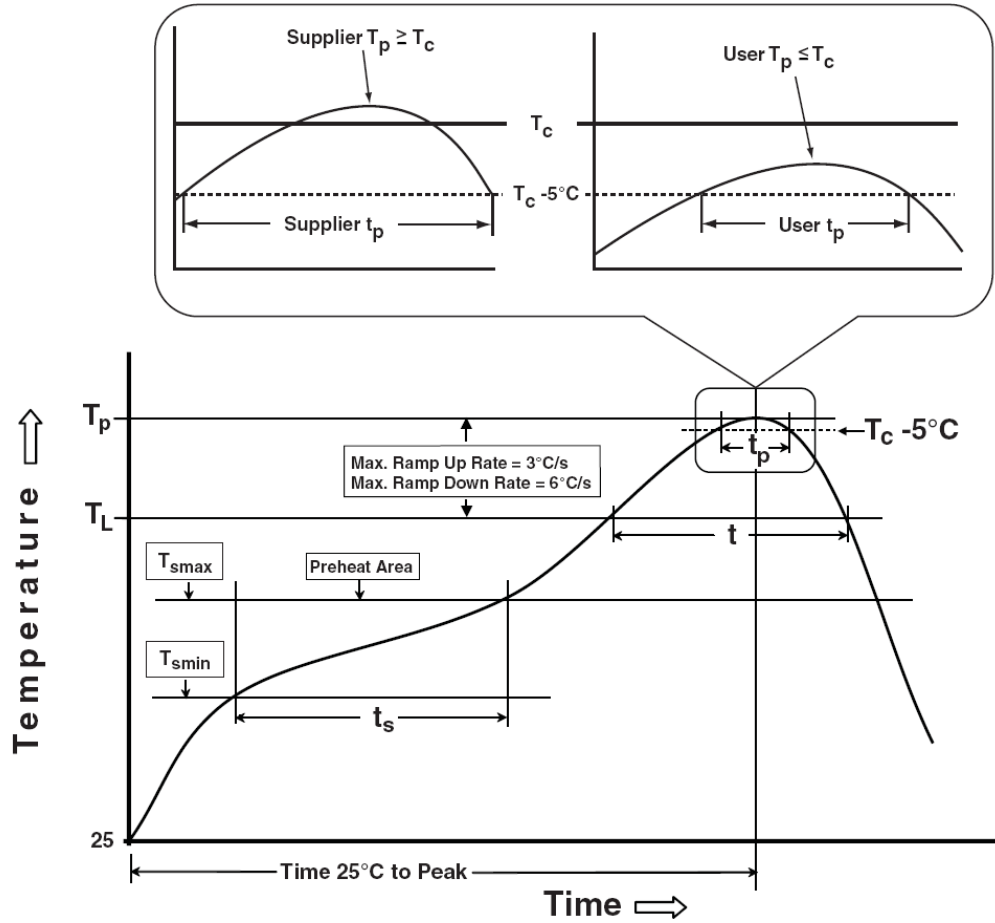
TDFN2x2-8



SOT-23-6



Classification Profile



## Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
<b>Preheat &amp; Soak</b> 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 ( $T_c$ )

Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> ≥350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

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

Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> 350-2000	Volume mm <sup>3</sup> >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 @ $T_j=125^{\circ}\text{C}$
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 <sub>tr</sub> 100mA

## Customer Service

### **Anpec Electronics Corp.**

#### Head Office :

No.6, Dusing 1st Road, SBIP,  
Hsin-Chu, Taiwan, R.O.C.  
Tel : 886-3-5642000  
Fax : 886-3-5642050

#### Taipei Branch :

2F, No. 11, Lane 218, Sec 2 Jhongsing Rd.,  
Sindian City, Taipei County 23146, Taiwan  
Tel : 886-2-2910-3838  
Fax : 886-2-2917-3838