APW7581

0.6A, 5V Input, Low IQ Buck Converter

Features

- Input Voltage Range: 2.6V to 5.5V
- Low Switching Quiescent Current
- 0.6A Output Current
- Constant on Time Mode Operation
- 3MHz Switching Frequency
- Power-On-Reset Detection on VIN
- Integrated Soft Start Time
- Over-Temperature Protection
- Over-Current Protection
- Available in TDFN2x2-6 Package

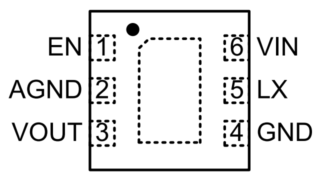
General Description

The APW7581 is a synchronous buck converter adopting constant on time control mode. Due to increasing the oscillation to high frequency, the mounting area including peripheral components can be reduced. APW7581 also has low switching quiescent current to improve efficiency and battery-powered equipment using time.
The APW7581 is equipped with Power-on-reset, internal soft start and over-current protection, over temperature into a single package. This device, available TDFN2x2-6 and, provides a very compact system solution external components and PCB area.

Applications

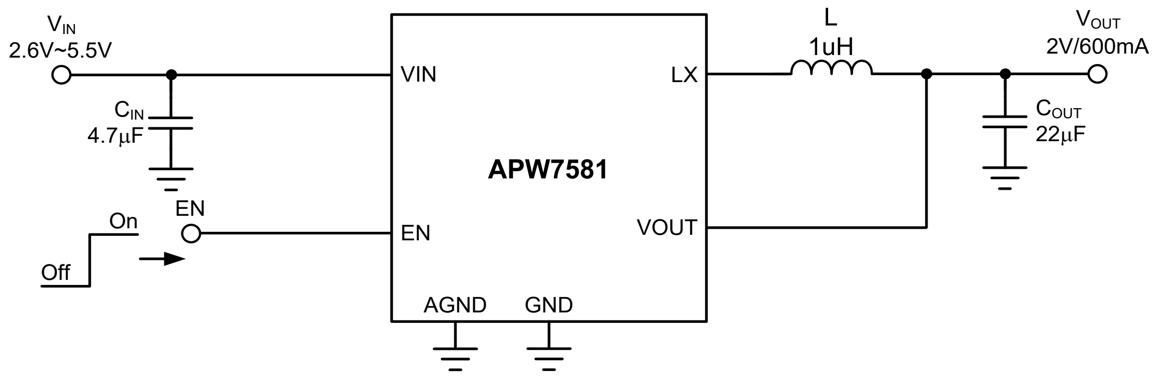
- NB-cam Module
- Wireless Mouse

Pin Configuration (Top View)



TDFN2x2-6
(Top View)

Typical Application Circuit



Ordering and Marking Information

APW7581 □□□-□□□ Assembly Material Handling Code Temperature Range Package Code	Package Code QB : TDFN2x2-6 Operating Ambient Temperature Range I : - 40 to 85°C Handling Code TR : Tape & Reel Assembly Material G : Green Part
APW7581QBI : W81 X	X - Date Code

Note: ANPEC's green product compliant RoHS and Halogen free.

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V_{VIN}	VIN Supply Voltage to GND	-0.3 ~ 6	V
V_{OUT}	Output Voltage to GND	-0.3 ~ 6	V
V_{LX}	LX Voltage to GND (< 20ns pulse width)	-3 ~ 7	V
	LX Voltage to GND (> 20ns pulse width)	-0.3 ~ 6	V
V_{EN}	EN Voltage to GND	-0.3 ~ 6	V
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C
T_{SDR}	Maximum Lead Soldering Temperature (10 Seconds)	260	°C

Note 1: 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
θ_{JA}	Junction-to-Ambient Resistance in free air (Note 2)	60	°C/W
θ_{JC}	Junction-to-Case Resistance in free air (Note 2)	26	°C/W

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

Recommended Operating Conditions (Note 3)

Symbol	Parameter	Range	Unit
V_{IN}	VIN Supply Voltage to GND	2.6 ~ 5.5	V
V_{EN}	EN Voltage to GND	-0.3 ~ 5.5	V
I_{OUT}	Output Current (continue)	0 ~ 0.6	A
T_A	Ambient Temperature	-40 ~ 85	°C
T_J	Junction Temperature	-40 ~ 125	°C

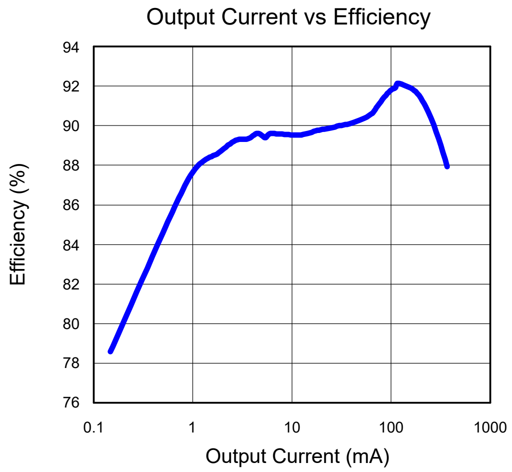
Note 3: Refer to the typical application circuit.

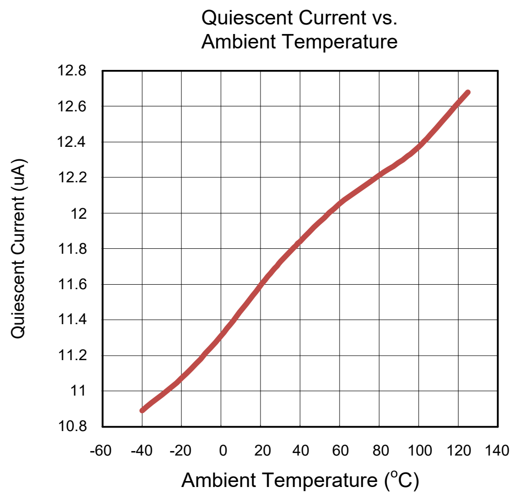
Electrical Characteristics

Unless otherwise specified, these specifications apply over V_{IN}=3.3V, T_A=25°C.

Symbol	Parameter	Test Condition	Specification			Unit
			Min.	Typ.	Max.	
SUPPLY POWER						
I_Q	Quiescent Current Into VIN	VIN=3.3V, no load, switching current	-	11	17	μA
I_{SD}	Shutdown Current Into VIN	VEN=0V	-	0.7	1	μA
V_{UVLO}	UVLO Threshold Voltage	VIN Rising	2.3	2.4	2.5	V
V_{UVLO_HYS}	UVLO Hysteresis	VIN Falling	-	200	-	mV
EN THRESHOLD						
V_{ENH}	Logic-High Threshold Voltage	EN Rising	1.5	-	-	V
V_{ENL}	Logic-Low Threshold Voltage	EN Falling	-	-	0.4	V
REFERENCE VOLTAGE						
Tss	Soft Start Time	VOUT From 10% to 90%	-	110	200	us
V_{OUT}	Output Voltage Accuracy	$T_{A=}$ -40°C ~ 85°C	-2	-	2	%
OSCILLATOR						
F_{SW}	Switching Frequency	FPWM Mode	-	3	-	MHz
POWER MOSFET						
R_{ON_H}	High Side MOSFET Resistance	VIN=3.3V, ILX=0.5A	-	320	-	mΩ
R_{ON_L}	Low Side MOSFET Resistance	VIN=3.3V, ILX=0.5A	-	91	-	mΩ
I_{LEAK_H}	High Side MOSFET Leakage Current	VIN=5.5V, VSW=GND	-	1	-	μA
I_{LEAK_L}	Low Side MOSFET Leakage Current	VIN=LX=5.5V, No Switching	-	1	-	μA
PROTECTIONS						
I_{CL_H}	High-side Current Limit		800	-	-	mA
OTP	Over Temperature Protection		-	160	-	°C
	Over Temperature Hysteresis		-	30	-	°C

Typical Operating Characteristics

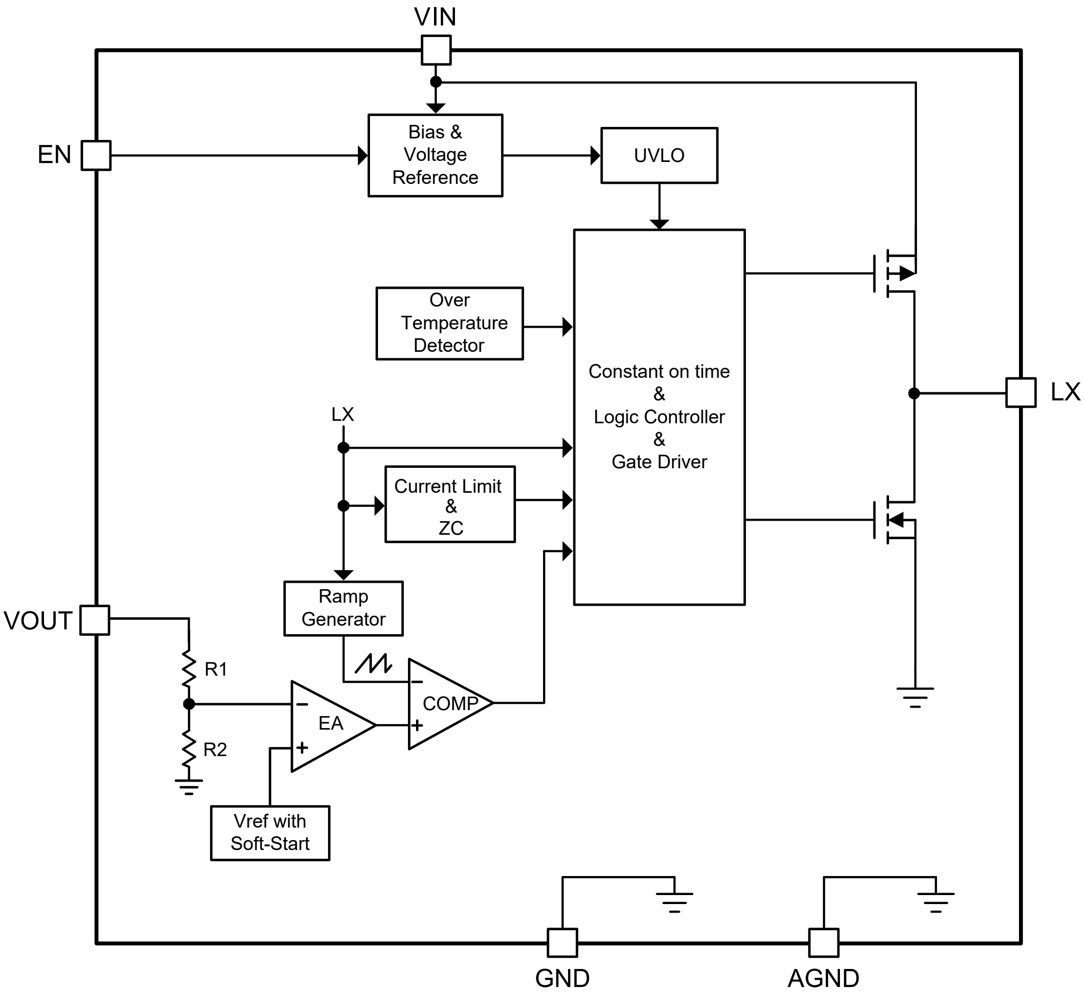




Pin Descriptions

PIN		FUNCTION
TDFN2x2-6	NAME	
1	EN	Enable Input Pin. Drive EN high to turn the converter on and pull low to turn it off. Do not leave this pin floating.
2	AGND	Signal Ground.
3	VOUT	Output Voltage Sense Pin. This pin is used to detect the output voltage.
4	GND	Ground Pin.
5	LX	Switching Output Pin. Connect this pin to the output inductor.
6	VIN	Power Input Pin. VIN supplies the power to the buck converter and the internal control circuitry.
-	Exposed Pad	Connect this pad to system ground plane for good thermal conductivity.

Block Diagram



Function Description

Operation

The APW7581 integrates a synchronous buck PWM controller and high/low side power MOSFETs to generate VOUT. It offers the lower quiescent current that can provide up to 0.6A continuous output current over wide input supply range. Input voltage range of the PWM converter is 2.6V to 5.5V.

Constant-On-Time PWM Controller

This IC uses constant on-time control, has a simple control loop, and allows it to use ceramic-type output capacitors for excellent transient response. This architecture is pseudo-fixed frequency with input voltage feed forward. On-time is inversely proportional to input voltage and proportional to output voltage. When the voltage on FB is lower than the internal reference voltage, the high-side switch will be turned on for a calculated on-time. The on-time can be estimated as (V_{IN}=3.3V, V_{OUT}=2V):

$$T_{ON} \approx \frac{V_{OUT}}{V_{IN}} \times 0.4\mu s$$

In addition, the high side MOS driver transistor might keep on turning on and the 100% duty cycle mode might be set. The 100% duty cycle mode achieves high output voltage stability and highspeed response even under full load conditions and the condition where the input-output voltage difference is small.

VIN Power-On-Reset (POR)

The IC continuously monitors the voltage on the VIN pin. The soft start is activated when the VIN voltage and the EN voltage are above their respective POR thresholds. VIN POR is used to protect the IC from erroneous operation with insufficient VIN voltage. VIN POR also has hysteresis to resist ripple on the VIN voltage.

Enable and Shutdown

The IC provides the EN pin, which is a digital input that turns the converter on or off. Drive EN high to turn the converter on and pull low to turn it off.

Soft-Start

The IC has a built-in soft-start function that controls the rise time of the output voltage during start-up to reduce input current surges and prevent output overshoot.
The soft start function will be enabled when any condition that can initiate an output start-up, such as VIN power to the IC then setting the EN pin high, and when the converter is restarted from the OTP.

Over-Temperature Protection (OTP)

The IC features over-temperature protection to monitor junction temperature and prevent damage to the chip when operating at extremely high temperatures.
When the junction temperature exceeds the OTP threshold, the IC will be turned off to lower the junction temperature. The OTP circuit has hysteresis that allows the IC to restart when the junction temperature is below the OTP low threshold temperature.

Current-Limit Protection

The IC monitors the current through the power MOSFET to limits the inductor peak current to prevent IC from being damaged in the event of an overload or short circuit.
When the current limit protection is activated, the output current will be limited at peak current until output loading is down below to the valley current threshold.

Application Information

Input Capacitor Selection

The input capacitor is chosen based on the voltage rating and the RMS current rating. For reliable operation, select the capacitor voltage rating to be at least 1.3 times higher than the maximum input voltage.
Use low ESR capacitors for the best performance.
Ceramic capacitors with X5R or X7R dielectrics are recommended highly because of their low ESR and small temperature coefficients.
Since the input capacitor (CIN) absorbs the input-switching current, it requires an adequate ripple-current rating. The RMS current in the input capacitor can be estimated by:

$$I_{CIN} = I_{OUT} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)}$$

The worst-case condition occurs at VIN=2VOUT, where:

$$I_{CIN} = \frac{I_{OUT}}{2}$$

For simplification, choose an input capacitor with an RMS current rating greater than half of the maximum load current. The input capacitor can be electrolytic, tantalum or ceramic. When using electrolytic or tantalum capacitors, a small, high-quality ceramic capacitor (e.g. 0.1μF) should be placed as close to the IC as possible. When using ceramic capacitors, make sure that they have enough capacitance to provide sufficient charge to prevent excessive voltage ripple at the input. The input voltage ripple caused by the capacitance can be estimated by:

$$\Delta V_{IN} = \frac{I_{OUT}}{F_{OSC} \times C_{IN}} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Output Capacitor Selection

The output capacitor is required to filter the output and provide load transient current. The higher capacitance value will provide the smaller output ripple and better load transient. Ceramic electrolytic capacitors with X5R or X7R dielectrics and low ESR are recommended to keep the output voltage ripple low. The output voltage ripple caused by the capacitance can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{F_{OSC} \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times F_{OSC} \times C_{OUT}}\right)$$

Where L is the inductor value and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor.

Output Inductor Selection

The inductance value will determine the inductor ripple current and affects the load transient response and output ripple voltage.
The larger inductance value will result in a smaller ripple current, which will result in a lower output ripple voltage but a slower transient response, while a smaller inductance value will have opposite result.
A good rule is to choose the inductor ripple current that is about 30% of the maximum output current. Use the following equation to derive the inductance value for most designs:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times F_{OSC}}$$

Where, ΔI_L is the inductor-ripple current.

To avoid inductor saturation, the inductor current rating should be at least the converter's maximum output current plus the inductor ripple current. The maximum inductor peak current can be estimated by:

$$I_{L(MAX)} = I_{OUT} + \frac{\Delta I_L}{2}$$

In addition, choosing an inductor with a smaller DCR will provide better efficiency.

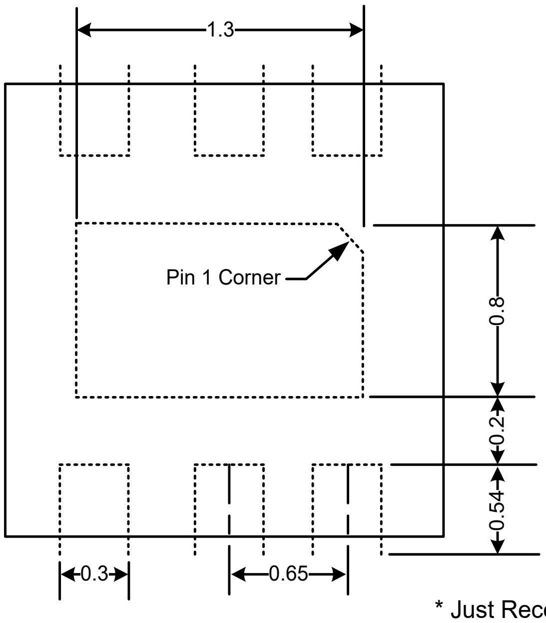
Application Information (Cont.)

Layout Consideration

For all switching power supplies, the layout is an important step in the design; especially at high peak currents and switching frequencies. If the layout is not carefully done, the regulator might show noise problems and duty cycle jitter.

1. The VIN input capacitor should be placed close to the VIN and GND pins. Connecting the capacitor and VIN/GND pins with short and wide trace without any via holes for good input voltage filtering.
2. Place the inductor as close as possible to the LX pin to minimize noise coupling into other circuits.
3. The ground of the output capacitor and input capacitor and the GND of the IC should be as close as possible.
4. It is recommended to place the input capacitor, output capacitor and inductor on top layer, and use a large power GND plane to connect the ground of the input capacitor, the ground of the output capacitor, and the GND of the IC.

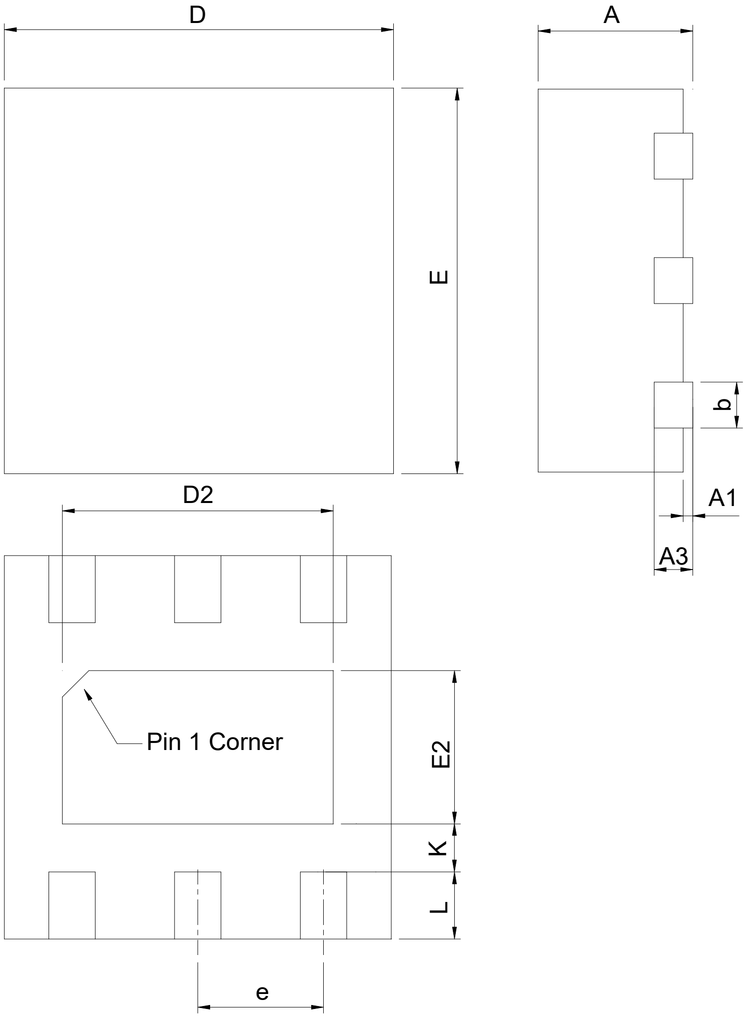
Recommended Minimum Footprint



* Just Recommend

Package Information

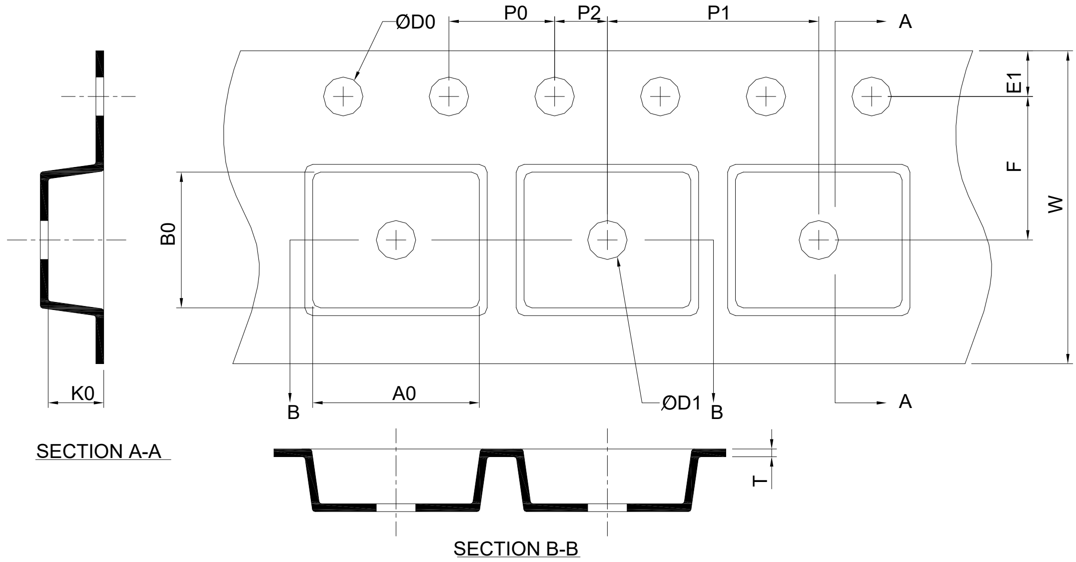
TDFN2x2-6

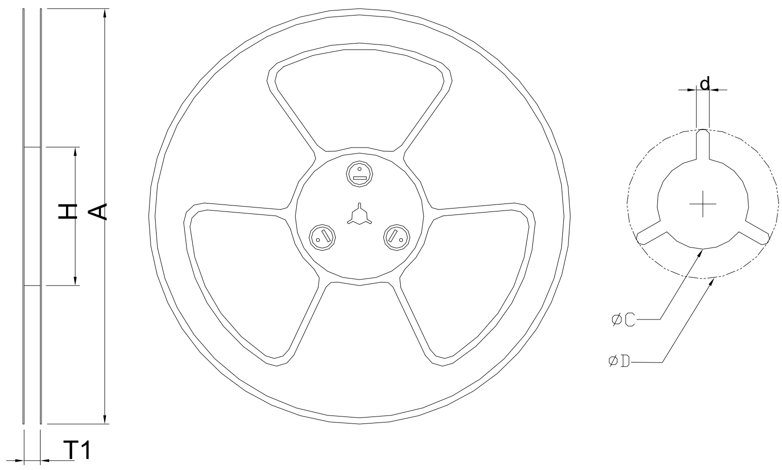


SYMBOL	TDFN2x2-6			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.18	0.30	0.007	0.012
D	1.90	2.10	0.075	0.083
D2	1.00	1.60	0.039	0.063
E	1.90	2.10	0.075	0.083
E2	0.60	1.00	0.024	0.039
e	0.65 BSC		0.026 BSC	
L	0.30	0.45	0.012	0.018
K	0.20		0.008	

Note: Followed from JEDEC MO-229 WCCC.

Carrier Tape & Reel Dimensions





Application	A	H	T1	C	d	D	W	E1	F
TDFN 2x2	178.0±2.00	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
	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	2.35±0.20	2.35±0.20	1.00±0.20

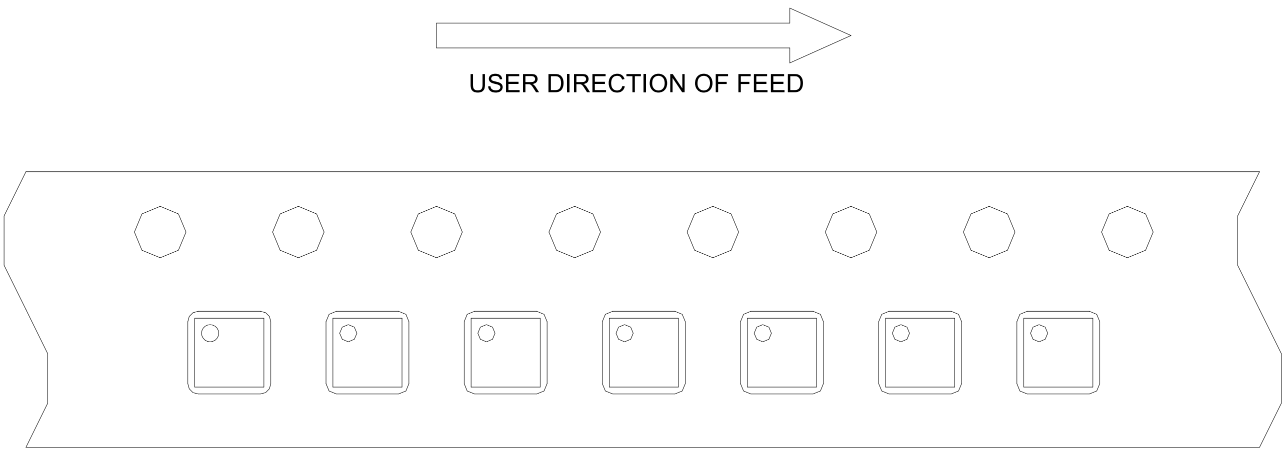
(mm)

Devices Per Unit

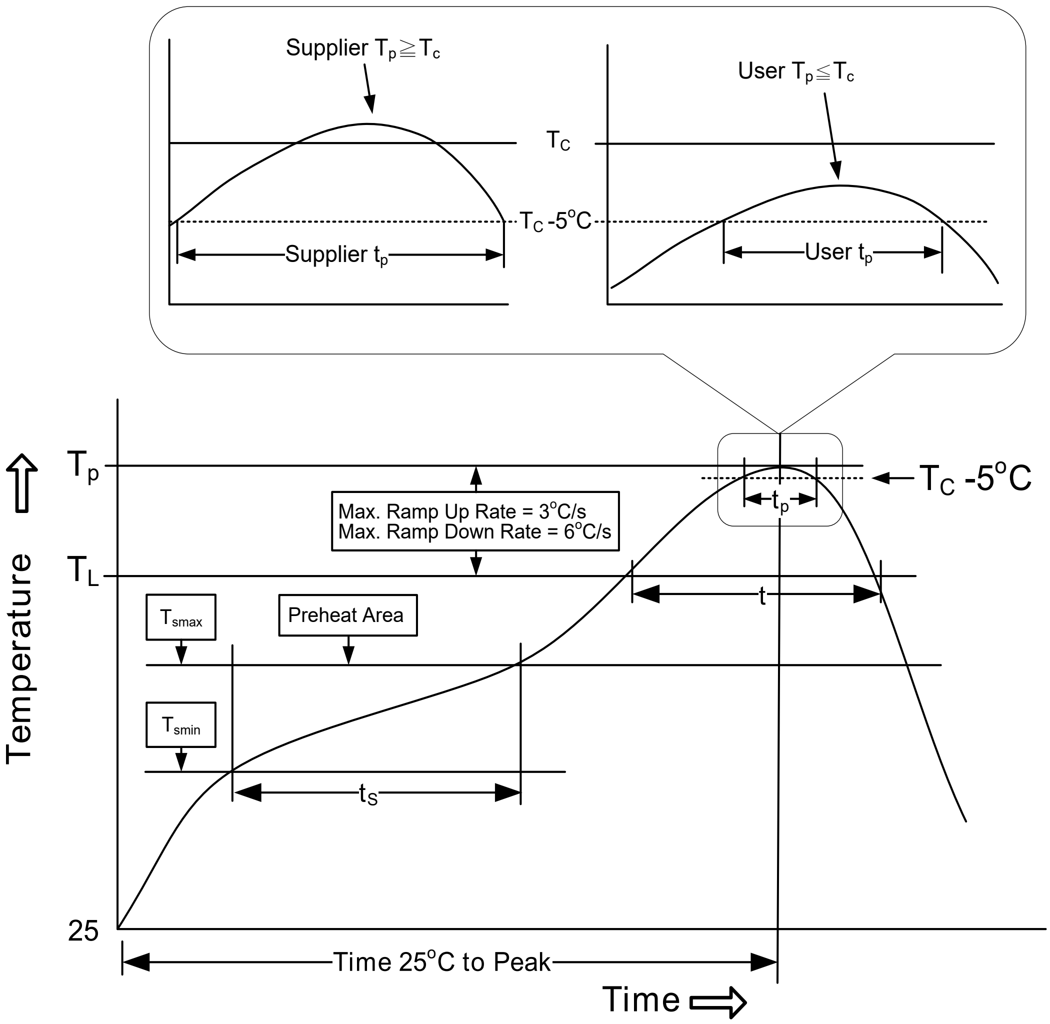
Package Type	Packing	Quantity
TDFN 2x2	Tape & Reel	3000

Taping Direction Information

TDFN2x2-6



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.		

Note: ANPEC's green products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020D for MSL classification at lead-free peak reflow temperature.

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

Package Thickness	Volume mm^3 <350	Volume mm^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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