Low Dropout 600mA Fixed Voltage Linear Regulator

Features

- **Low Dropout Voltage: 220mV (Typical) @600mA**
- **Wide 2.9V~6V Input Voltage**
- **Low Quiescent Current: 140µA (Typical)**
- **Fixed Output Voltage with ±2% Accuracy**
- **Stable with Ceramic, 2.2µF Output Capacitor**
- **Short-Circuit Current-Limit**
- **Over-Temperature Protection**
- **Current-Limit Protection**
- **Internal Soft-Start**
- **SOT-23-5, TSOT-23-5, SOP-8, and DFN3x3-8 Packages**
- **Lead Free and Green Devices Available (RoHS Compliant)**

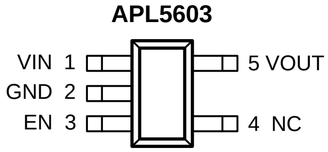
Applications

- **CD/DVD-ROM, CD-R/W**
- **Networking System, LAN Card, ADSL/Cable Modem**
- **Set-Top Box**
- **PC Peripherals**
- **Battery-Powered System**

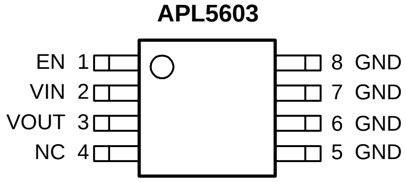
General Description

The APL5603 is a low-power and low dropout linear regulators which operates from 2.9V to 6V input voltage and delivers up to 600mA output current. Typical dropout voltage is only 220mV (typical) at 600mA output. The APL5603 regulators with low 140µA quiescent current are ideal for battery-powered system appliances. The APL5603 regulators are stable with a 2.2µF ceramic capacitor. The features of current-limit, short-circuit current-limit, and over-temperature protections can prevent the device against currnet overload and over-temperature. The APL5603 regulators are availabe in SOT-23-5, TSOT-23-5, SOP-8, and DFN3x3-8 packages.

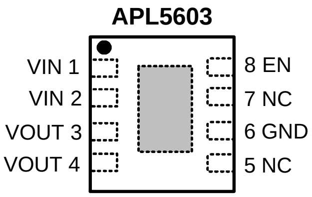
Pin Configurations



SOT-23-5/TSOT-23-5
(Top View)



SOP-8
(Top View)



DFN3x3-8
(Top View)

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.

Copyright © ANPEC Electronics Corp.

Ordering and Marking Information

APL5603 □□ □□□ - □□□ Assembly Material Handling Code Temperature Range Package Code Voltage Code		Voltage Code [(Note 1)] 12 : 1.2V 15 : 1.5V 18 : 1.8V 25 : 2.5V 28 : 2.8V 30 : 3.0V 33 : 3.3V Package Code B : SOT-23-5 BT : TSOT-23-5 K : SOP-8 QA : DFN3x3-8 Operating Ambient Temperature Range I : -40 to 85 °C Handling Code TR : Tape & Reel Assembly Material G : Halogen and Lead Free Device
APL5603-18 K :	APL5603 XXXXX 18	XXXXX - Date Code ; 18 - Voltage Code
APL5603-18 QA :	L5603 18 XXXXX	XXXXX - Date Code ; 18 - Voltage 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).

Note 1: For other voltage versions please contact ANPEC for details.

Marking for SOT-23-5 package

Product Name	Marking	Product Name	Marking	Product Name	Marking
APL5603-12B	635X	APL5603-15B	639X	APL5603-18B	63CX
APL5603-25B	63JX	APL5603-28B	63MX	APL5603-30B	63OX
APL5603-33B	63RX				

* "X" in the marking indicates data code.

Marking for TSOT-23-5 package

Product Name	Marking	Product Name	Marking	Product Name	Marking
APL5603-12BT	635X	APL5603-15BT	639X	APL5603-18BT	63CX
APL5603-25BT	63JX	APL5603-28BT	63MX	APL5603-30BT	63OX
APL5603-33BT	63RX				

* "X" in the marking indicates data code.

Absolute Maximum Ratings (Note 2)

Symbol	Parameter	Rating	Unit
V_{IN}	VIN Supply Voltage (VIN to GND)	-0.3 to 6.5	V
T_J	Maximum Junction Temperature	150	°C
V_{OUT}	Output Voltage (VOUT to GND)	-0.3 to V_{IN}+0.3	V
V_{EN}	EN Pin Voltage (VEN to GND)	-0.3 to 6.5	V
T_{STG}	Storage Temperature Range	-65 to 150	°C
T_{SDR}	Maximum Lead Soldering Temperature, 10 Seconds	260	°C
P_D	Power Dissipation	Internally Limited	

Note 2: 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.

Thermal Characteristics (Note 3, 4)

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Junction to Air Thermal Resistance SOT-23-5 TSOT-23-5 SOP-8 DFN3x3-8	 260 260 150 110	°C/W

Note 3: At elevated temperatures, device power dissipation must be derated based on package thermal resistance and heatsink values. The junction-to-ambient thermal resistance is measured on a PC board mounting with the device soldered down to minimum copper area. If power dissipation causes the junction temperature to exceed specified limits, the device will go into thermal shutdown.

Note 4: The maximum allowable power dissipation at any T_A (ambient temperature) is calculated using: $P_{D\,(max)} = (T_J - T_A) / \theta_{JA}$; T_J = 125°C. Exceeding the maximum allowable power dissipation will result in excessive die temperature.

Recommended Operating Conditions

Symbol	Parameter	Range	Unit
V_{IN}	VIN to GND	2.9 to 6	V
I_{OUT}	Output Current	0 to 0.6	A
C_{IN}	Input Capacitor	0.82 to 470	µF
C_{OUT}	Output Capacitor	1 to 330	µF
T_J	Junction Temperature	-40 to 125	°C
T_A	Ambient Temperature	-40 to 85	°C

Electrical Characteristics

Refer to the typical application circuit. $V_{IN} = V_{OUT}$+1V or 2.9V (minimum), whichever is great, $V_{EN} = V_{IN}$, I_{OUT} = 1mA, T_J = -40 to 125 °C, T_A = -40 to 85°C, unless otherwise specified. Typical values are at T_A = 25°C.

Symbol	Parameter	Test Conditions	APL5603			Unit
			Min.	Typ.	Max.	
SUPPLY CURRENT						
I_Q	Quiescent Current	V_{EN} = 0V	-	-	1	µA
		$V_{IN}=V_{EN}$=5V, I_{OUT}=0mA	-	140	200	µA
UNDER-VOLTAGE-LOCKOUT						
	VIN UVLO Threshold	V_{IN} rising	2.1	2.5	2.9	V
	VIN UVLO Hysteresis		-	0.15	-	V
OUTPUT VOLTAGE						
V_{OUT}	Output Voltage	T_A = 25°C	-1	-	+1	%V_{OUT}
		T_A = -40 to 85°C (T_J = -40 to 125°C)	-2	-	+2	
	Line Regulation	$V_{IN} = V_{OUT}$ + 1V to 6V	-	0.03	0.19	%/V
	Load Regulation	I_{OUT} = 1mA to 600mA	-	0.6	1.5	%/A
V_{DROP}	Dropout Voltage	V_{OUT}=2.8V, I_{OUT}=600mA	-	240	500	mV
		V_{OUT}=3.3V, I_{OUT}=600mA	-	220	450	
		V_{OUT}=5V, I_{OUT}=600mA	-	200	420	
PSRR	Power Supply Ripple Rejection	$V_{IN} = V_{OUT}$ + 2V, f = 1kHz	-	55	-	dB

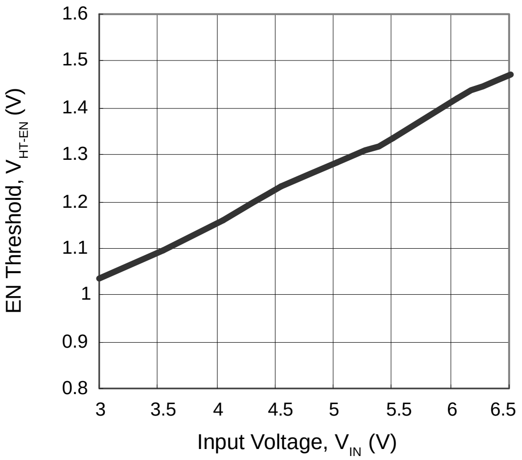
Electrical Characteristics (Cont.)

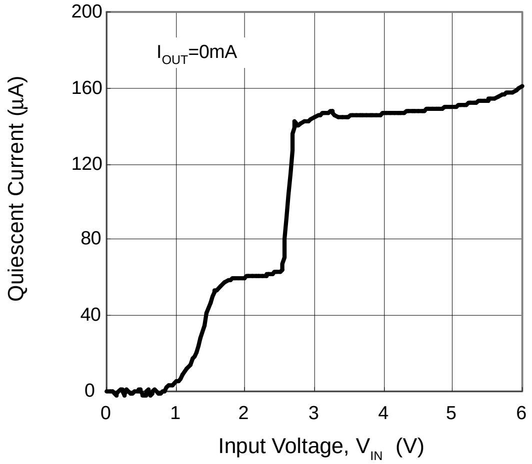
Refer to the typical application circuit. V_{IN} = V_{OUT}+1V or 2.9V (minimum), whichever is great, V_{EN} = V_{IN}, I_{OUT} = 1mA, T_J = -40 to 125 °C, T_A = -40 to 85°C, unless otherwise specified. Typical values are at T_A = 25°C.

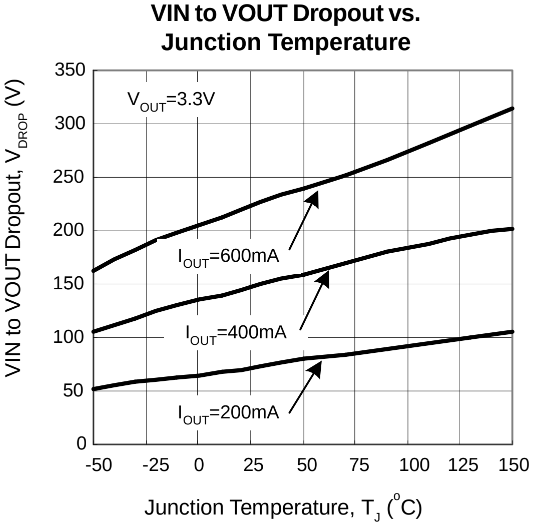
Symbol	Parameter	Test Conditions	APL5603			Unit
			Min.	Typ.	Max.	
SOFT-START AND PROTECTION						
I_{LIM}	Output Current-Limit		700	-	-	mA
	Thermal Shutdown Temperature		-	150	-	°C
	Thermal Shutdown Hysteresis		-	40	-	°C
	Short-Circuit Current-Limit	V_{OUT} < 0.6V	-	250	-	mA
T_{SS}	Soft-Start Time		-	130	300	µs
LOGIC INPUT						
	EN Logic Input-High Level		1.6	-	-	V
	EN Logic Input-Low Level		-	-	0.4	V
	EN Pull-Low Resistance	V_{EN}<3V	-	2	-	MΩ

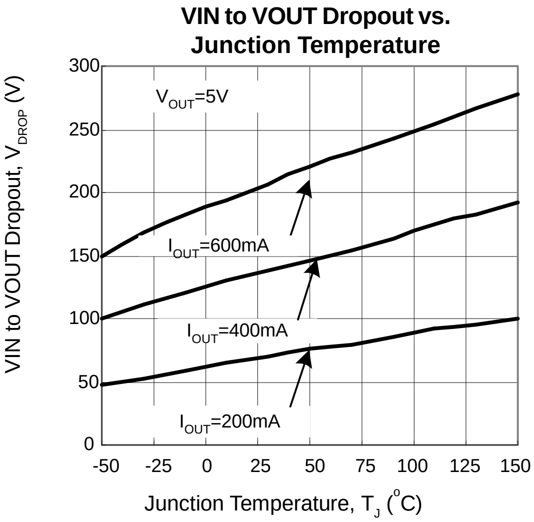
Typical Operating Characteristics

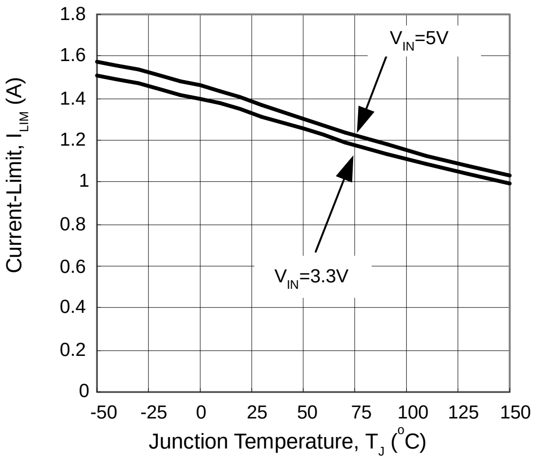
(Refer to the application circuit 1 in the section " Typical Application Circuits," V_{IN}=5V, V_{OUT}=3.3V, C_{OUT}=2.2μF, unless otherwise specified.)

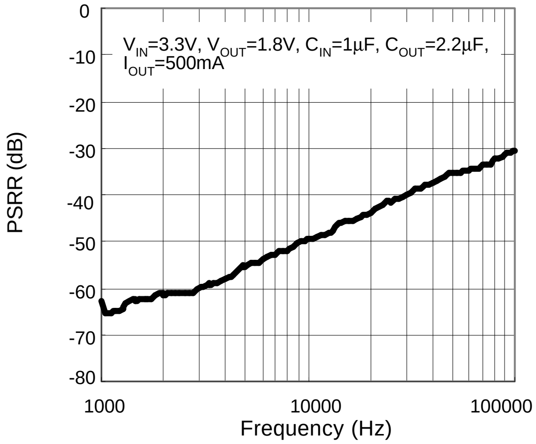

EN Threshold vs. Input Voltage


Quiescent Current vs. Input Voltage


VIN to VOUT Dropout vs. Junction Temperature


VIN to VOUT Dropout vs. Junction Temperature

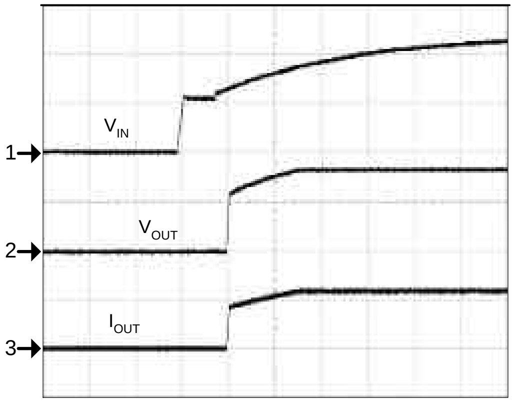

Current-Limit vs. Junction Temperature


Power Supply Ripple Rejection

Operating Waveforms

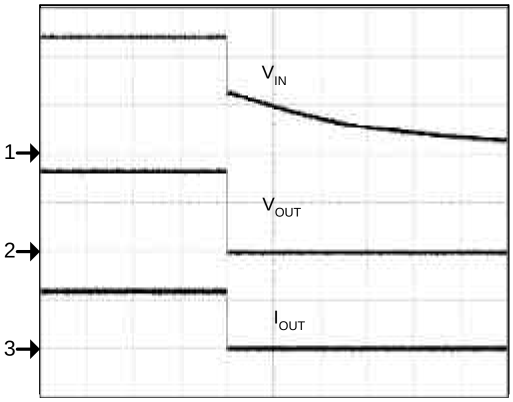
(Refer to the application circuit 1 in the section "Typical Application Circuits," V_{IN}=5V, V_{OUT}=3.3V, C_{OUT}=2.2µF, unless otherwise specified.)

Power On



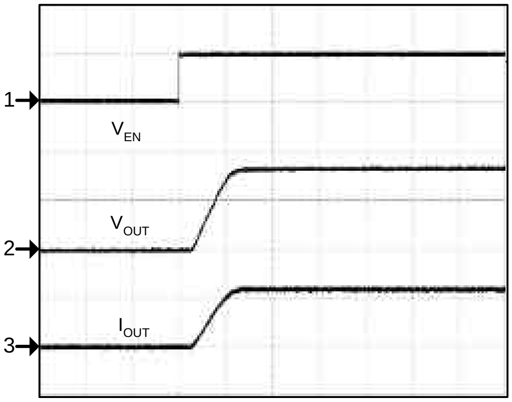
CH1 : V_{IN} , 2V/div
CH3 : V_{OUT} , 2V/div
CH4 : I_{OUT} , 500mA/div
Time : 1ms/div

Power Off



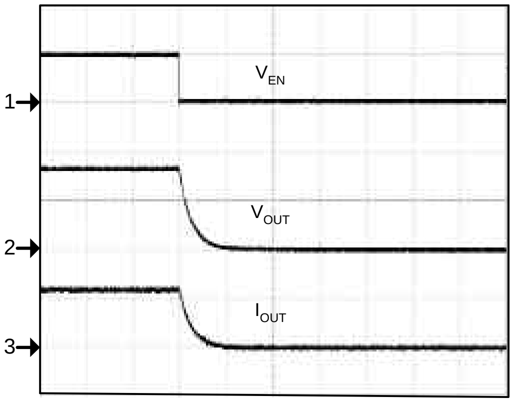
CH1 : V_{IN} , 2V/div
CH2 : V_{OUT} , 2V/div
CH3 : I_{OUT} , 500mA/div
Time : 200ms/div

Enable



CH1 : V_{EN} , 5V/div
CH2 : V_{OUT} , 2V/div
CH3 : I_{OUT} , 500mA/div
Time : 100µs/div

Shutdown

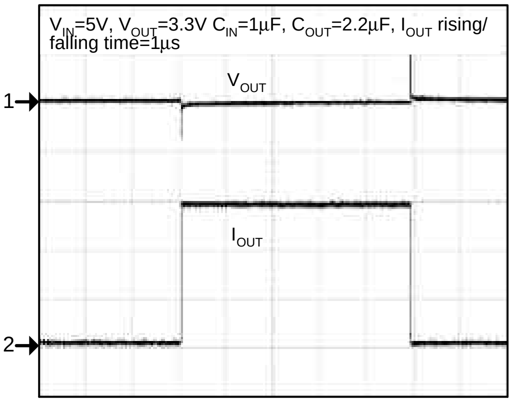


CH1 : V_{EN} , 5V/div
CH2 : V_{OUT} , 2V/div
CH3 : I_{OUT} , 500mA/div
Time : 20µs/div

Operating Waveforms (Cont.)

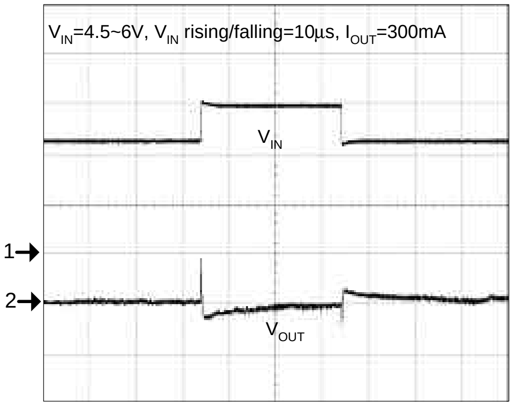
(Refer to the application circuit 1 in the section "Typical Application Circuits," V_{IN}=5V, V_{OUT}=3.3V, C_{OUT}=2.2µF, unless otherwise specified.)

Load Transient



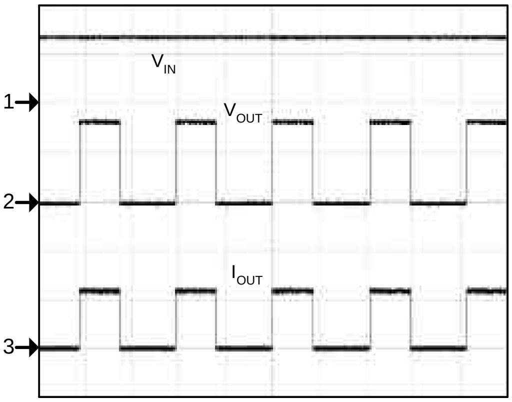
CH1 : V_{OUT} , 100mV/div (offset=3.3V)
CH2 : I_{OUT} , 200mV/div
Time : 200µs/div

Line Transient



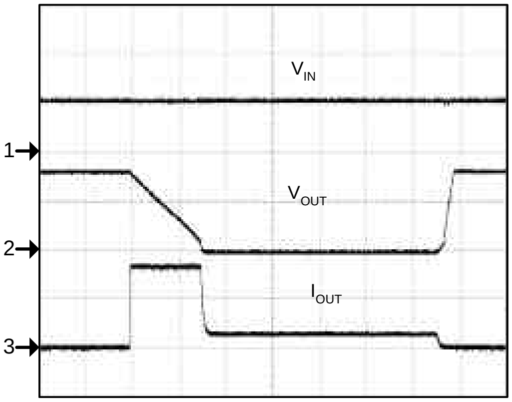
CH1 : V_{IN} , 2V/div
CH2 : V_{OUT} , 20mV/div (offset=3.3V)
Time : 200µs/div

Thermal Shutdown



CH1 : V_{IN} , 5V/div
CH2 : V_{OUT} , 2V/div
CH3 : I_{OUT} , 500mA/div
Time : 500ms/div

Current-Limit and Short-Circuit Current-Limit

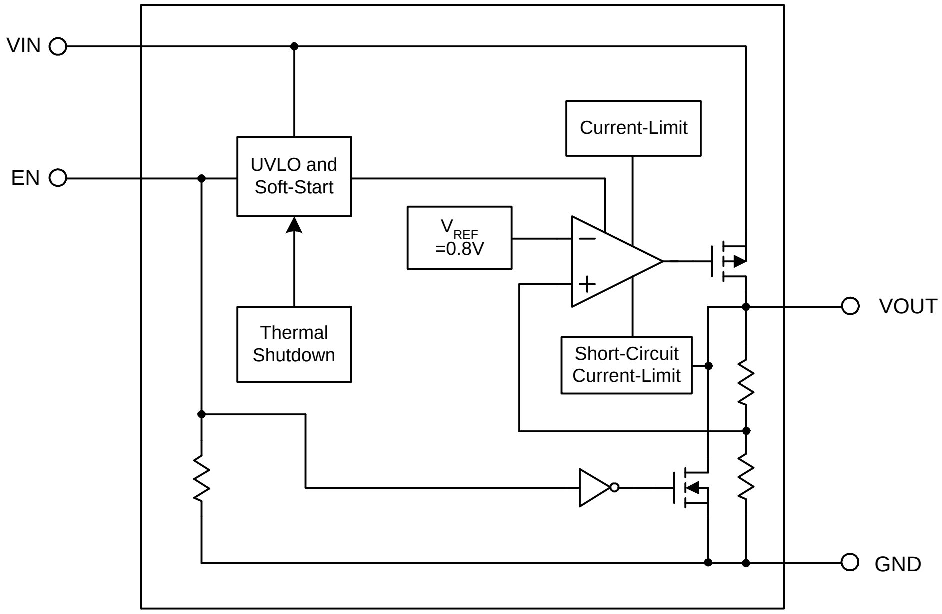


CH1 : V_{IN} , 5V/div
CH2 : V_{OUT} , 2V/div
CH3 : I_{OUT} , 1A/div
Time : 2ms/div

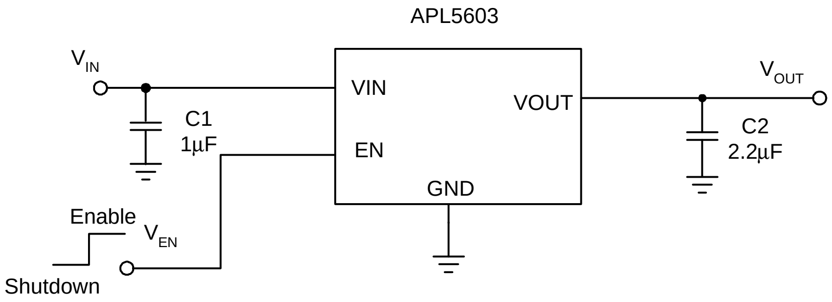
Pin Description

PIN NAME	FUNCTION
VIN	Input Supply Pin. Supply voltage can range from 2.9V to 6V. Bypass with a 1µF capacitor to GND.
VOUT	Regulator Output. Sources up to 600mA. A small capacitor (2.2µF, typical) is needed from this pin to ground to assure stability.
EN	Shutdown Control Input. Driving the EN high turns on the regulator. Driving the EN pin low puts the regulator into shutdown mode. The EN pin is pulled low by an internal resistor.
GND	Ground.

Block Diagram



Typical Application Circuit



Function Description

Under-Voltage Lockout (UVLO)

The APL5603 regulator has a built-in under-voltage lockout circuit to keep the output shut off until internal circuitry is operating properly. The UVLO function initiates a soft-start process after input voltage exceeds its rising UVLO threshold during power on. Typical UVLO threshold is 2.4V with 0.15V hysteresis.

Soft-Start

The APL5603 provides an internal soft-start circuitry to control rise rate of the output voltage and limit the current surge during start-up. Approximate 20μs delay time after the V_{IN} is over the UVLO threshold, the output voltage starts the soft-start. The typical soft-start interval is about 130μs.

Current-Limit

The APL5603 provides a current-limit circuitry, which monitors and controls P-MOS's gate voltage, limiting the output current to 700mA. For reliable operation, the device should not be operated in current-limit for extended period.

Short-Circuit Current-Limit

When the output voltage drops below 0.6V due to overload or short-circuit, the internal short-circuit current-limit circuitry limits the output current down to 250mA. The short-circuit current-limit is used to reduce the power dissipation during short-circuit condition. In some high V_{IN}-V_{OUT} conditions, if the junction temperature is over the thermal shutdown temperature, the device will enter the thermal shutdown. Please refer to the section on thermal considerations for power dissipation calculations. The short-circuit current-limit has featured with blanking time after the UVLO threshold is reached, so that it will avoid the output causing short-circuit current-limit protection during start-up; the blanking time is about 600μs.

Enable and Shutdown

Driving the EN high turns on the regulator, driving the EN low puts the regulator into shutdown mode. A logic low also causes the output voltage to discharge to the GND. The EN is pulled low by an internal resistor.

Thermal Shutdown

A thermal shutdown circuit limits the junction temperature of APL5603. When the junction temperature exceeds $+150^{o}C$, the thermal shutdown circuitry disables the output, which allows the device to cool down. The output circuitry is enabled again after the junction temperature cools down by $40^{o}C$, resulting in a pulsed output during continuous thermal overload conditions. Thermal protection is designed to protect the IC in the event of over-temperature conditions. For reliable operation, the junction temperature cannot exceed $T_J=+125\,^{o}C$.

Copyright © ANPEC Electronics Corp.

Application Information

Input Capacitor

The APL5603 requires proper input capacitors to supply surge current during stepping load transients to prevent the input rail from dropping. Because the parasitic inductor from the voltage sources or other bulk capacitors to the VIN limits the slew rate of the surge current, it is necessary to place the input capacitors near VIN as close as possible. Input capacitors should be larger than 0.82µF.

Output Capacitor

The APL5603 needs a proper output capacitor to maintain circuit stability and to improve transient response over-temperature and current. In order to insure the circuit stability, the proper output capacitor value should be larger than 1µF. With X5R and X7R dielectrics, 2.2µF is sufficient at all operating temperatures. Maximum output capacitor should be less than 330µF to insure the system can be powered on effectively.

Operation Region and Power Dissipation

The APL5603 maximum power dissipation depends on the thermal resistance and temperature difference between the die 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 $T_A = 25^oC$ and maximum $T_J = 150^oC$ (typical thermal limit threshold), the maximum power dissipation is calculated as:

$$P_{D(max)} = (150-25)/260$$
$$= 0.48(W)$$

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

$$P_D = (125-25)/260$$
$$= 0.38(W)$$

The GND provides an electrical connection to ground and channels heat away. Connect the GND to the ground by using a large pad or ground plane.

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. Ceramic capacitors for load must be placed near the load as close as possible.
3. To place APL5603 and output capacitors near the load is good for performance.
4. Large current paths, the bold lines in figure 1, must have wide tracks.

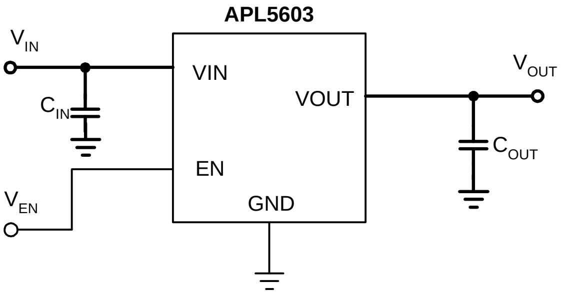


Figure 1.

Large ground plane is good for heating. Optimum performance can only be achieved when the device is mounted on a PC board according to the Board layout diagrams which are shown as Figure2, 3, and 4.

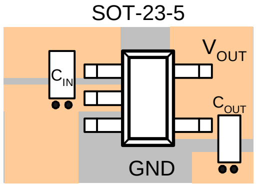


Figure 2.

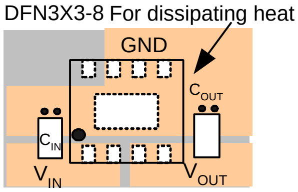


Figure 3.

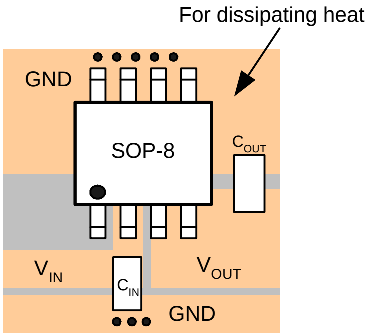
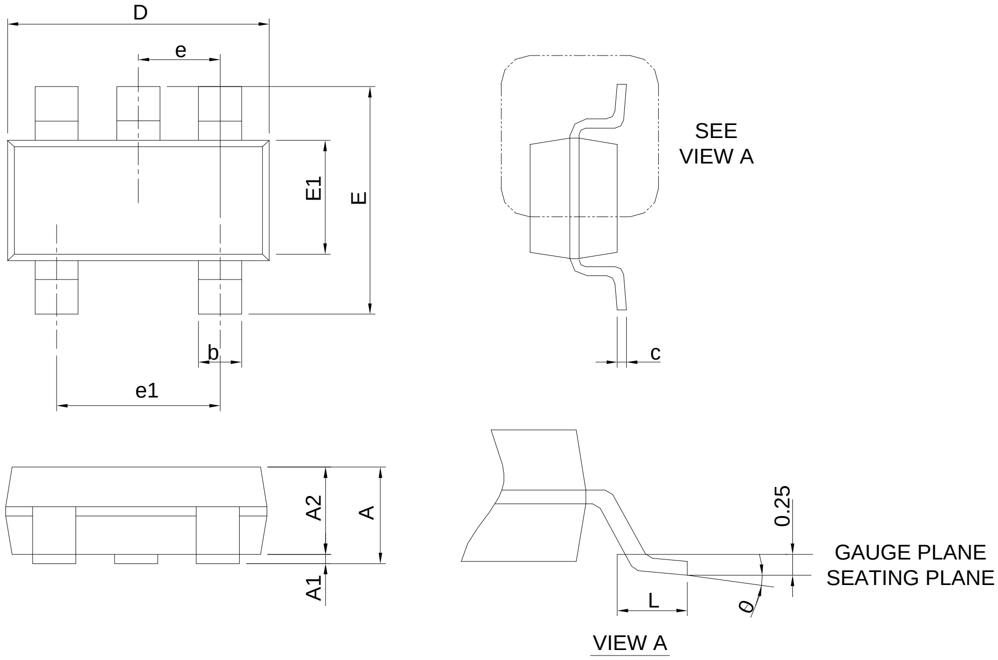


Figure 4.

Package Information

SOT-23-5

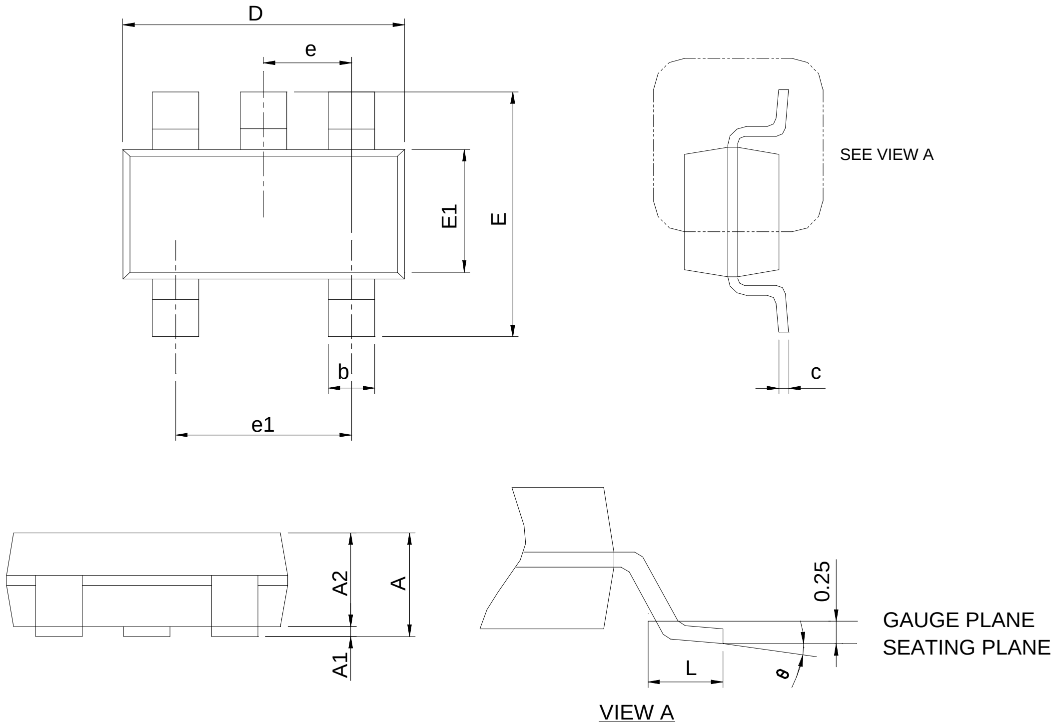


S Y M B O L	SOT-23-5			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.45		0.057
A1	0.00	0.15	0.000	0.006
A2	0.90	1.30	0.035	0.051
b	0.30	0.50	0.012	0.020
c	0.08	0.22	0.003	0.009
D	2.70	3.10	0.106	0.122
E	2.60	3.00	0.102	0.118
E1	1.40	1.80	0.055	0.071
e	0.95 BSC		0.037 BSC	
e1	1.90 BSC		0.075 BSC	
L	0.30	0.60	0.012	0.024
θ	0°	8°	0°	8°

Note : 1. Follow JEDEC TO-178 AA.
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.

Package Information

TSOT-23-5

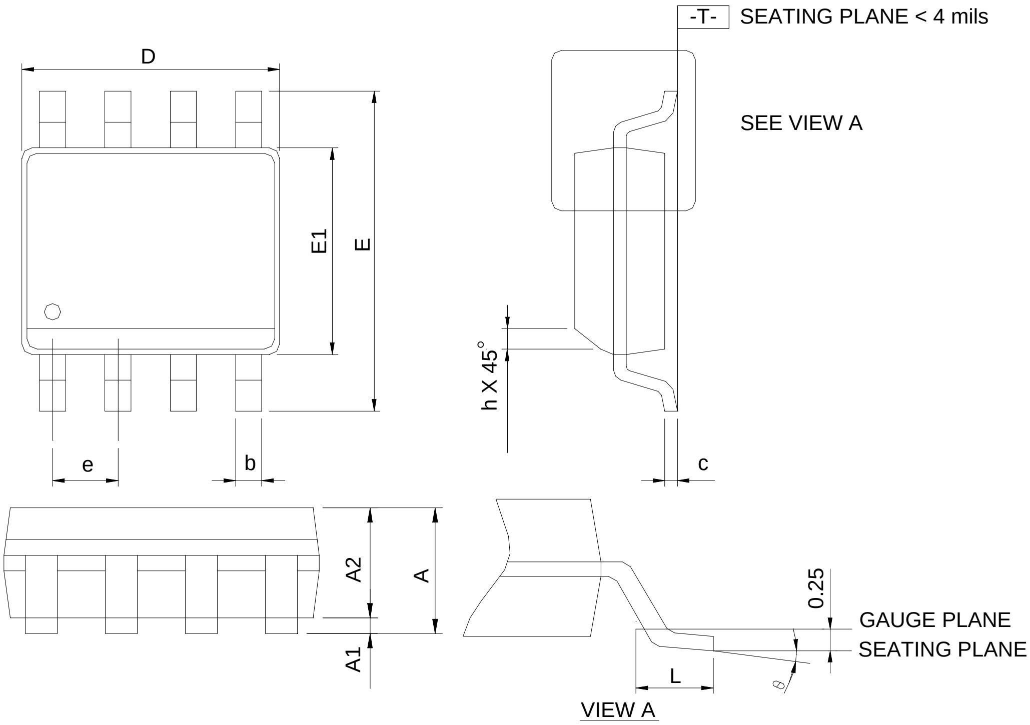


SYMBOL	TSOT-23-5			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	1.00	0.028	0.039
A1	0.01	0.10	0.000	0.004
A2	0.70	0.90	0.028	0.035
b	0.30	0.50	0.012	0.020
c	0.08	0.22	0.003	0.009
D	2.70	3.10	0.106	0.122
E	2.60	3.00	0.102	0.118
E1	1.40	1.80	0.055	0.071
e	0.95 BSC		0.037 BSC	
e1	1.90BSC		0.075 BSC	
L	0.30	0.60	0.012	0.024
θ	0°	8°	0°	8°

Note : 1. Followed from JEDEC TO-178 AA.
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.

Package Information

SOP-8

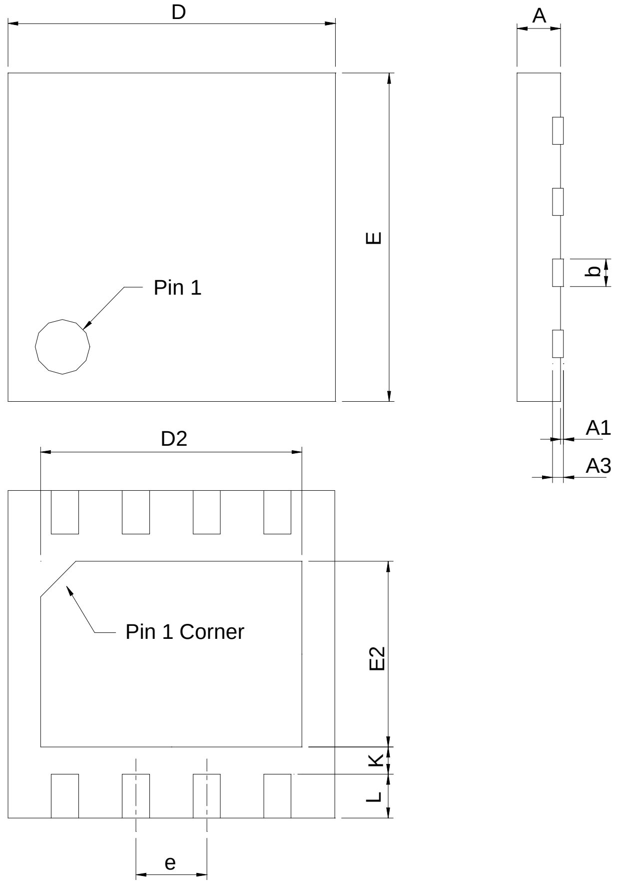


SYMBOL	SOP-8			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.75		0.069
A1	0.10	0.25	0.004	0.010
A2	1.25		0.049	
b	0.31	0.51	0.012	0.020
c	0.17	0.25	0.007	0.010
D	4.80	5.00	0.189	0.197
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
h	0.25	0.50	0.010	0.020
L	0.40	1.27	0.016	0.050
θ	0°	8°	0°	8°

Note: 1. Follow JEDEC MS-012 AA.
2. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side.
3. Dimension “E” does not include inter-lead flash or protrusions. Inter-lead flash and protrusions shall not exceed 10 mil per side.

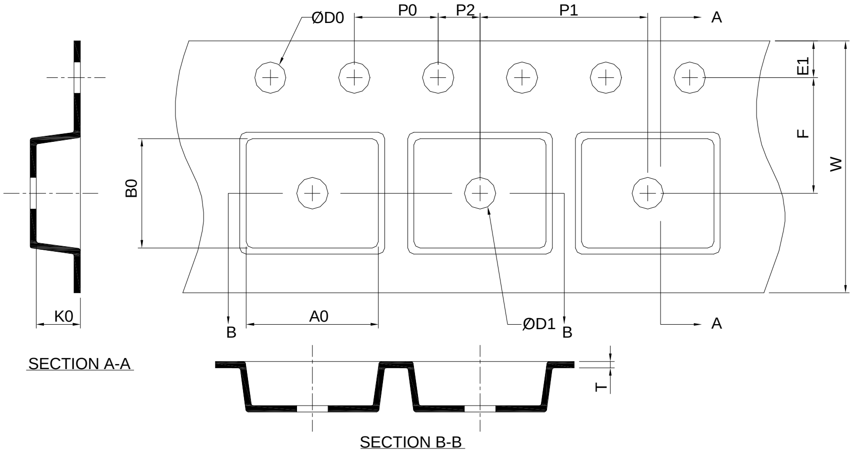
Package Information

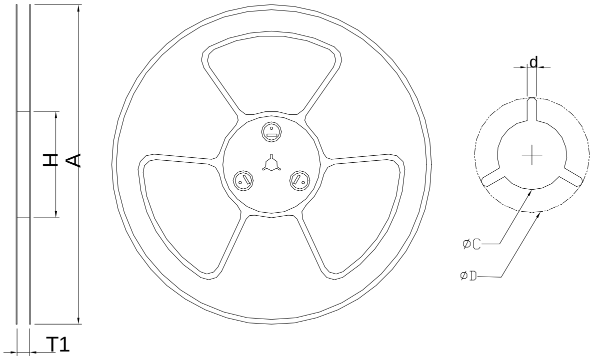
DFN3x3-8



SYMBOL	DFN3x3-8			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.80	1.00	0.031	0.039
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.25	0.35	0.010	0.014
D	2.90	3.10	0.114	0.122
D2	1.90	2.40	0.075	0.094
E	2.90	3.10	0.114	0.122
E2	1.40	1.75	0.055	0.069
e	0.65 BSC		0.026 BSC	
L	0.30	0.50	0.012	0.020
K	0.20		0.008	

Carrier Tape & Reel Dimensions





Application	A	H	T1	C	d	D	W	E1	F
SOT-23-5	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±0.30	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	1.0 MIN.	0.6+0.00 -0.40	3.20±0.20	3.10±0.20	1.50±0.20
Application	**A**	**H**	**T1**	**C**	**d**	**D**	**W**	**E1**	**F**
TSOT-23-5	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±0.30	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	1.0 MIN.	0.6+0.00 -0.40	3.20±0.20	3.10±0.20	1.50±0.20
Application	**A**	**H**	**T1**	**C**	**d**	**D**	**W**	**E1**	**F**
SOP- 8	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	5.5±0.05
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	8.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.40±0.20	5.20±0.20	2.10±0.20

(mm)

Carrier Tape & Reel Dimensions (Cont.)

Application	A	H	T1	C	d	D	W	E1	F
DFN3x3-8	178.0±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	5.5±0.05
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	8.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	3.30±0.20	3.30±0.20	1.30±0.20

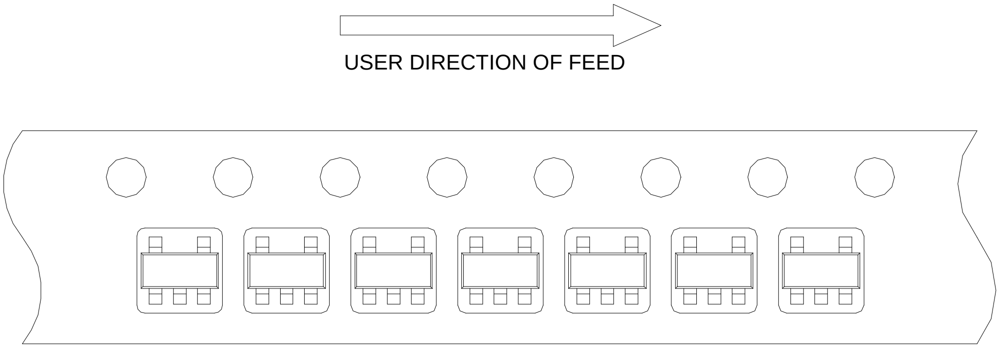
(mm)

Devices Per Unit

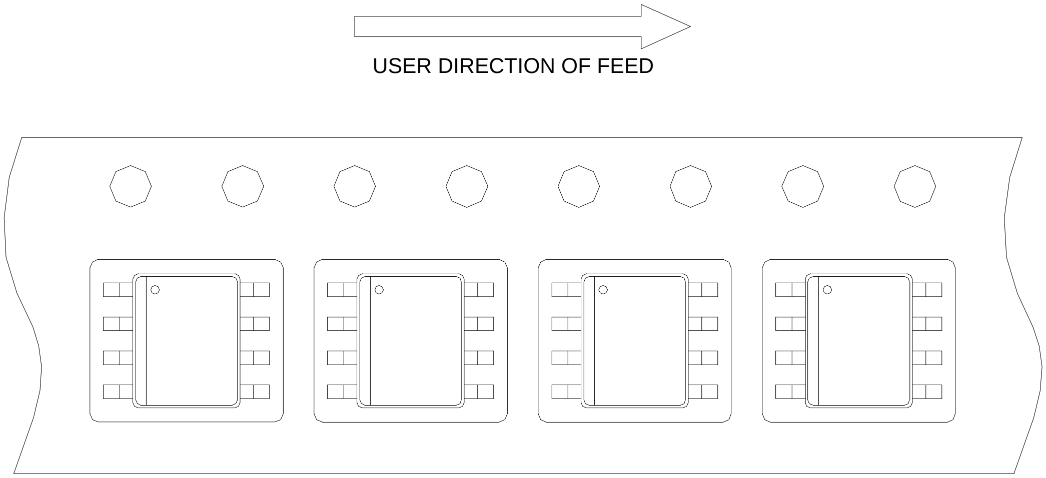
Package Type	Unit	Quantity
SOT-23-5	Tape & Reel	3000
TSOT-23-5	Tape & Reel	3000
SOP-8	Tape & Reel	2500
DFN3x3-8	Tape & Reel	3000

Taping Direction Information

(T)SOT-23-5

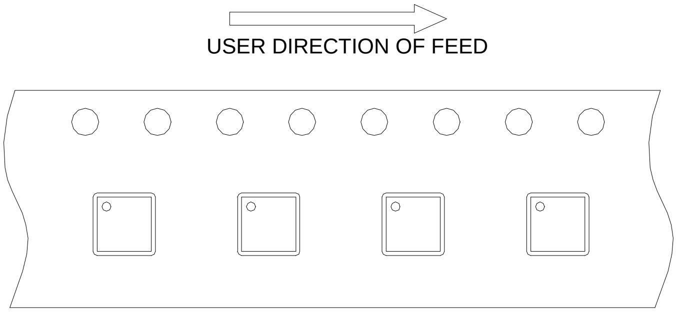


SOP-8

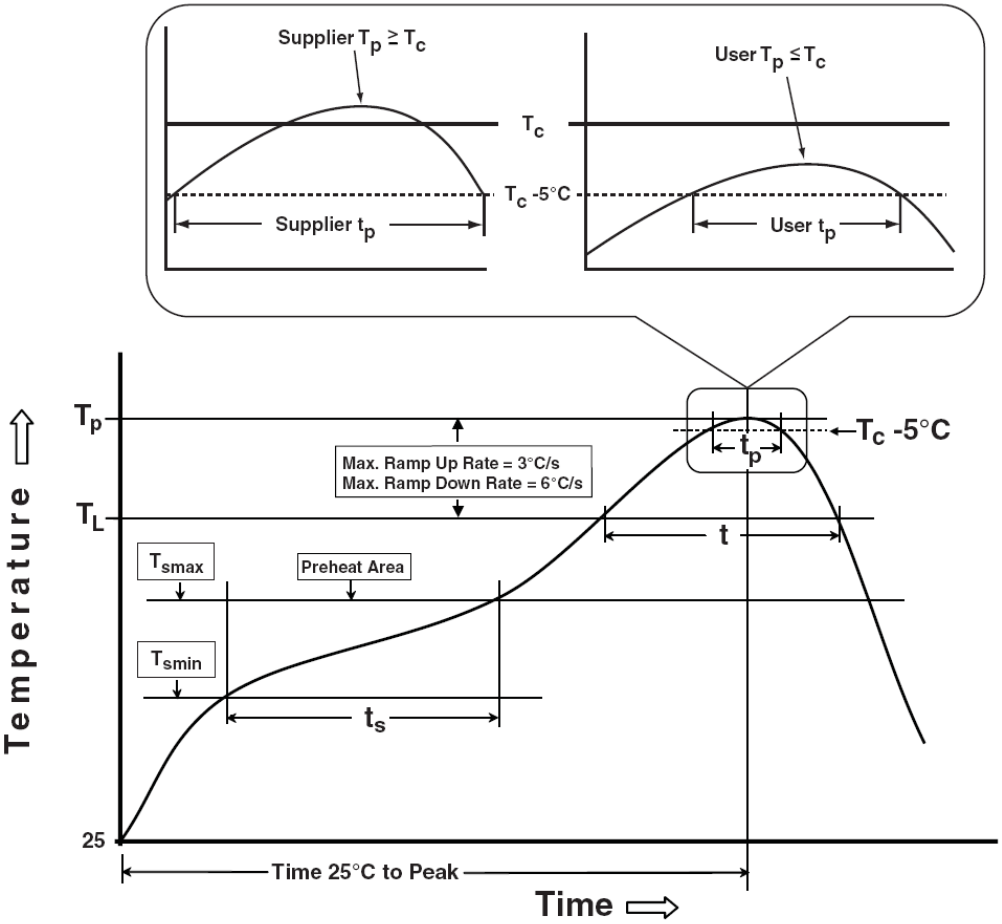


Taping Direction Information (Cont.)

DFN3x3-8



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

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