300mA High Speed, Low Noise LDO with Fast Enable and Fast Discharge Function

Features

Operating Voltage Range：**+1.8V to +5.5V**
Output Voltages：**+0.9V to +5.0V (0.1V Step)**
Dropout Voltage：**90mV @ 100mA (Typ.)**
Fast Response in Power-on Transient
：**35 μS (Typ.)**
Low Current Consumption：**30μA (Typ.)**
Shutdown Current：**0.7μA (Typ.)**
±2% Output Voltage Accuracy (special ±1% highly accurate), V_{OUT}≧1.8V
Low ESR Capacitor Compatible
High Ripple Rejection：**70 dB (Typ.)**
Output Current Limit Protection：**500mA (Typ.)**
Short Circuit Protection：**70mA (Typ.)**
Thermal Overload Shutdown Protection
Control Output ON/OFF Function
SOT-25, UFN-6, SC-82, SC-70-5 Packages
RoHS Compliant and 100% Lead (Pb)-Free and Green (Halogen Free with Commercial Standard)

General Description

The AP6213A series is a low-dropout linear regulator with ON/OFF control that operates in the input voltage range from +1.8V to +5.5V and delivers 300mA output current.

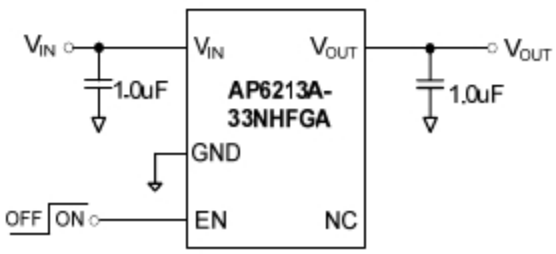
The fixed output voltage is preset at an internally trimmed voltage 1.8V, 2.5V, or 3.3V. Other options 1.0V, 1.2V, 1.5V, 2.2V, 3.0V and 3.6V are available by special order only.

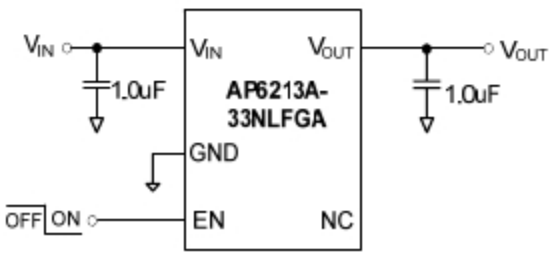
The AP6213A consists of a 0.87V bandgap reference, an error amplifier, and a P-channel pass transistor. Other features include short-circuit protection, thermal shutdown protection, fast respond and fast discharge functions. The AP6213A series devices are available in SOT-25, UFN-6, SC-82, and SC-70-5 packages.

Applications

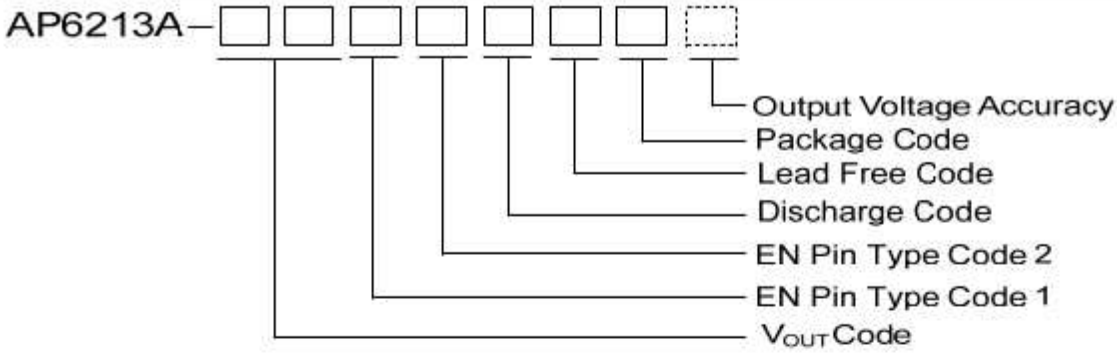
- Mobile Phone, Coreless Phone
- Radio Communication Equipment
- Portable Games
- Cameras
- Reference Voltage Sources
- Battery Powered Equipment

Simplified Application Circuit





Ordering Information



Vout Code :

VOUT Range : 1.0V~5.0V Exam. 10=1.0V, **33=**3.3V, **50**=5.0V **Please see Note 1 for detail description.**

EN Pin Type Code 1 :

N : None Function **U** : Pull High Function **D** : Pull Low Function

EN Pin Type Code 2 :

H : High Active Option Function **L** : Low Active Option Function

Discharge Code :

F : Fast Discharge

Lead Free Code :

P : Commercial Standard, Lead (Pb) Free and Phosphorous (P) Free Package

G : Green (Halogen Free with Commercial Standard)

Package Code :

A : SOT-25 **P** : SC-70-5 **U** : UFN-6 ***W** : SC-82 ***S** : SC-82

Output Voltage Accuracy :

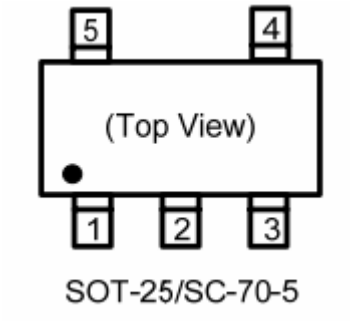
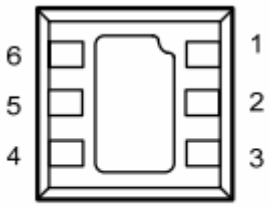
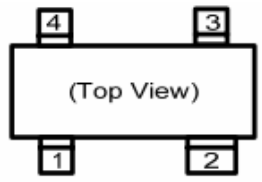
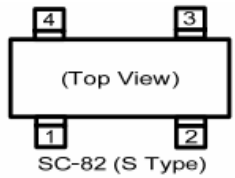
1 : ±1% **None Digit (Default)** : ±2%

Note 1 : W and S types are different between the footprints. Please refer “Pin Description”.
Note 2 : (“X” denotes the units digit of output voltage)

X0	X.0	XA	X.05
X1	X.1	XB	X.15
X2	X.2	XC	X.25
X3	X.3	XD	X.35
X4	X.4	XE	X.45
X5	X.5	XF	X.55
X6	X.6	XG	X.65
X7	X.7	XH	X.75
X8	X.8	XJ	X.85
X9	X.9	XK	X.95

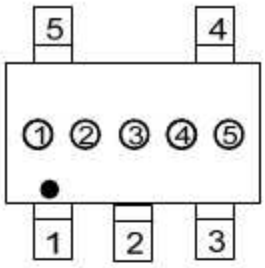
Examples	
Code	Voltage
12	1.2
22	2.2
36	3.6
42	4.2
1F	1.55
2C	2.25
3B	3.15
4H	4.75

Pin Description

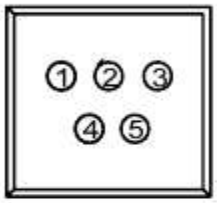
Part NO.	Pin	Symbol	Pin Description
 SOT-25/SC-70-5	1	V_{IN}	Regulator Input Pin
	2	GND	Ground Pin
	3	EN	Enable Pin
	4	NC	No Connect
	5	V_{OUT}	Regulator Output Pin
 UFN-6 (Bottom View)	1	V_{IN}	Regulator Input Pin
	2,4	NC	No Connection
	3	V_{OUT}	Regulator Output Pin
	5	GND	Ground Pin
	6	EN	Enable Pin
 SC-82 (W Type)	1	EN	Enable Pin
	2	GND	Ground Pin
	3	V_{OUT}	Regulator Output Pin
	4	V_{IN}	Regulator Input Pin
 SC-82 (S Type)	1	EN	Enable Pin
	2	GND	Ground Pin
	3	V_{OUT}	Regulator Output Pin
	4	V_{IN}	Regulator Input Pin

The AP6213A Series has two types of SC-82 packages, which are different in the footprint of 2nd pin.

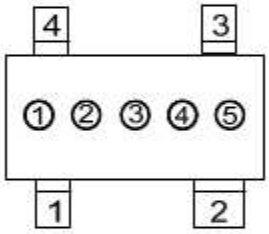
Package Marking Information



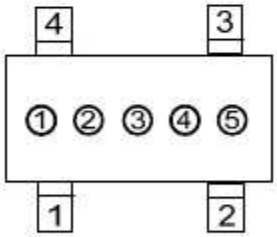
SOT-25
(Top View)



UFN-6
(Top View)



SC-82 (W Type)
(Top View)



SC-82 (S Type)
(Top View)

1 **Represents Products Series**

Mark	Products Series
2	Part No. : AP6213A

2 、 3 **Represents Products Series**

Mark		Description
○2	Voltage	Please See Note 3
○3	Function	Please See Note 4

4 、 5 **Represents Production Date Code**

* There is a under-line on 1st digit for A type package.
* There is a under-lines on 5th digit for Pb-Free package.
* There are two under-lines on 4th & 5th digit for Green package.
* There is a top-line on 1at digit for ±1% Output voltage accuracy.

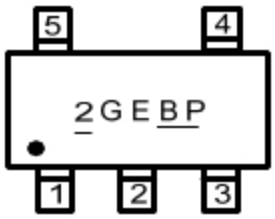
Note 3：

Mark	Voltage	Mark	Voltage
1	0.9V	G	2.5V
4	1.0V	L	2.85V
5	1.2V	M	3.0V
8	1.5V	N	3.1V
A	1.8V	Q	3.3V
2	2.1V	V	3.6V
E	2.2V	1	4.75V
J	2.7V	Z	5.0V

Note 4：

Mark	Code	EN Type		Discharge	Mark	Code	EN Type		Discharge
		Type Code 1	Type Code 2				Type Code 1	Type Code 2	
A	NHF	None	High	Fast	G	UHN	Pull High	High Active	Normal
B	NLF	None	Low	Fast	H	ULN	Pull High	Low Active	Normal
C	NHN	None	High	Normal	J	DHF	Pull Low	High Active	Fast
D	NLN	None	Low	Normal	K	DLF	Pull Low	Low Active	Fast
E	UHF	Pull	High	Fast	L	DHN	Pull Low	High Active	Normal
F	ULF	Pull	Low	Fast	M	DLN	Pull Low	Low Active	Normal

Example：



SOT-25
(Top View)

Part No.: AP6213A-25UHFGA
Type: High Active with Pull high
& Fast Discharge
Date Code: BP
2007/49th week
Green Package

Absolute Maximum Ratings

Parameter		Symbol	Ratings	Units
Input Voltage V_{IN} to GND		V_{IN}	6.0	V
Output Current Limit, $I_{(LIMIT)}$		I_{OUT}	0.5	A
Junction Temperature		T_J	+165	°C
Thermal Resistance	SOT-25	θ_{JA}	250	°C/W
	SC-70-5		333	
	UFN-6		165	
	SC-82		333	
Power Dissipation	SOT-25	P_D	400	mW
	SC-70-5		200	
	UFN-6		500	
	SC-82		200	
Operating Ambient Temperature		T_{OPR}	-40 ~ +125	°C
Storage Temperature		T_{STG}	-55 ~ +150	°C
Lead Temperature (soldering, 10sec)			+260	°C

Note：

* The power dissipation values are based on the condition that junction temperature T_J and ambient temperature T_A difference is 100°C.
* Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and function operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum -rated conditions for extended periods may affect device reliability.

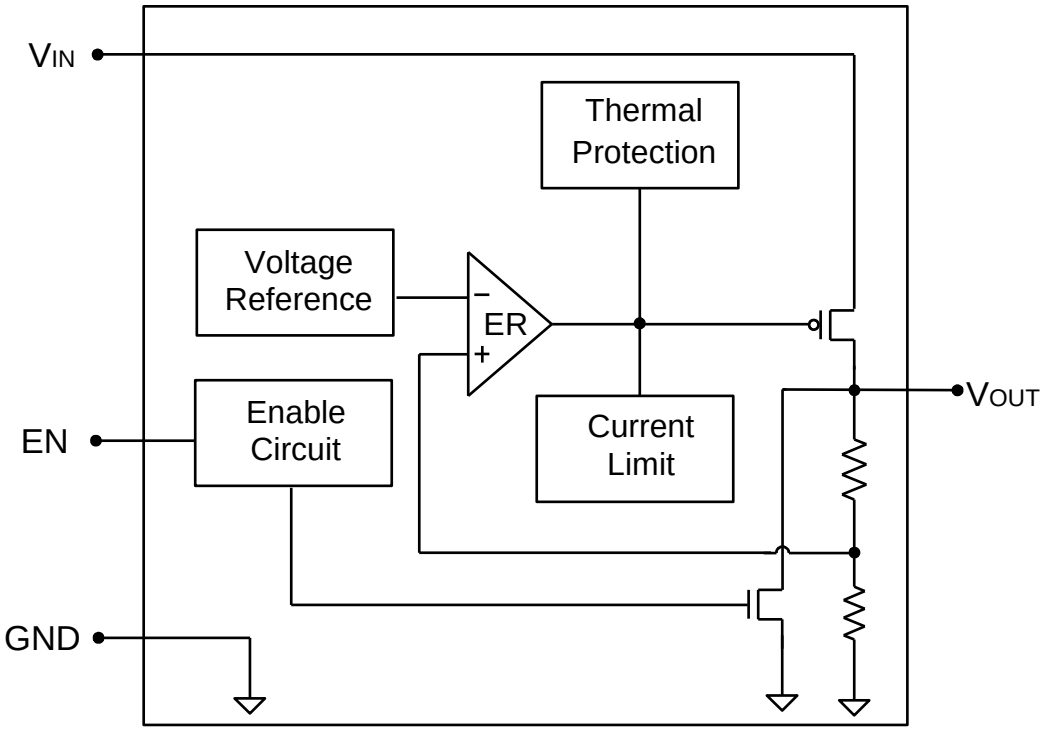
Electrical Characteristics

(V_{IN}=5V, T_A=25℃, unless otherwise noted.)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Input Voltage		1.8		5.5	V
V_{OUT}	Output Voltage	V_{IN} = V_{OUT}+1.0V, I_{OUT}=1mA, V_{OUT}≧1.8V	-1% -2%	V_{OUT}	+1% +2%	V
		V_{IN} = V_{OUT}+1.0V, I_{OUT}=1mA, V_{OUT}＜1.8V, V_{IN}＞2.4V	-35		+35	mV
I_{MAX}	Output Current (see note *1)	V_{OUT}+1.0V≦V_{IN}≦5.5V, V_{IN}≧2.4V	0.3			A
I_{LIMIT}	Current Limit			500		mA
V_{DROP}	Dropout Voltage	I_{OUT}=300mA, V_{OUT}＞2.0V		300	400	mV
ΔV_{LINE}	Line Regulation	V_{OUT}+1.0V≦V_{IN}≦5.5V, I_{OUT}=1mA		0.2	0.3	%/V
ΔV_{LOAD}	Load Regulation	V_{IN}=V_{OUT}+1V, 1mA≦I_{OUT}≦100mA		0.01	0.02	%/mA
I_Q	Ground Pin Current	I_{LOAD}=0mA to 300mA, V_{IN} = V_{OUT}+1V		30	50	μA
I_{SD}	Shutdown Current	V_{IN} = V_{OUT}+1V, EN=0V, No Load		0.7	1.0	μA
I_{SC}	Short Circuit Current			70	90	mA
PSRR	Ripple Rejection	I_{OUT}=30mA, F=1KHz, C_{OUT}=1uF		70		dB
e_N	Output Noise	I_{OUT}=100mA , F=1KHz, C_{OUT}=1uF		40		$\mu V_{(rms)}$
V_{IH}	EN Pin Input Voltage “H”	V_{IN}≦5.0V	1.6			V
V_{IL}	EN Pin Input Voltage “L”	V_{IN}≦5.0V			0.3	V
R_{DIS}	Discharge Resistor	V_{EN}=0V,		30	100	Ω
T_{DIS}	Discharge Time	V_{OUT}=3.3V to 0V, C_{OUT}=1uF		70	100	μs
T_C	Temperature Characteristics	I_{OUT}=1mA, -25°C≤T_{OPR}≤+85°C		±100		ppm/°C
T_{SD}	Thermal Shutdown Temperature			155		°C
T_{HYS}	Thermal Shutdown Hysteresis			30		°C

Note：*1) Measured using a double sided board with 1” x 2” square inches of copper area connected to the GND pins for “heat spreading”.

AP6213A Function Block Diagram



Detail Description

The AP6213A is a low-dropout linear regulator. The device provides preset 1.8V, 2.5V and 3.3V output voltages for output current up to 300mA. Other mask options for special output voltages are also available. As illustrated in function block diagram, it consists of a 0.87V bandgap reference, an error amplifier, a P-channel pass transistor and an internal feedback voltage divider.

The bandgap reference for is connected to the error amplifier, which compares this reference with the feedback voltage and amplifies the voltage difference. If the feedback voltage is lower than the reference voltage, the pass transistor's gate is pulled lower, which allows more current to pass to the output pin and increases the output voltage. If the feedback voltage is too high, the pass transistor's gate is pulled up to decrease the output voltage.

The output voltage is feed back through an internal resistor divider connected to V_{OUT} pin. Additional blocks include an output current limiter, thermal sensor, and shutdown logic.

Internal P-channel Pass Transistor

The AP6213A features a P-channel MOSFET pass transistor. Unlike similar designs using PNP pass transistors, P-channel MOSFETs require no base drive, which reduces quiescent current. PNP-based regulators also waste considerable current in dropout when the pass transistor saturates, and use high base-drive currents under large loads. The AP6213A does not suffer from these problems and consumes only 30μA (Typ.) of current consumption under heavy loads as well as in dropout conditions.

Enable Function

EN pin starts and stops the regulator. When the EN pin is switched to the power off level, the operation of all internal circuit stops, the build-in P-channel MOSFET output transistor between pins V_{IN} and V_{OUT} is switched off, allowing current consumption to be drastically reduced. The V_{OUT} pin enters the GND level through the internal discharge path between V_{OUT} and GND pins.

Fast Discharge Function

The AP6213A has fast discharge function on EN pin disable. When user turns off the device, its internal pull-low resistor will discharge output capacitor 's charge. It'll avoid the following device to arise malfunctions.

Output Voltage Selection

The output voltage is preset at an internally trimmed voltage. The first two digits of part number suffix identify the output voltage (see Ordering Information). For example, the AP6213A-33 has a preset 3.3V output voltage.

Current Limit

The AP6213A includes a foldback current limiter. It monitors and controls the pass transistor's gate voltage, estimates the output current, and limits the output current under 500mA.

Thermal Overload Protection

Thermal overload protection limits total power dissipation of the AP6213A. When the junction temperature exceeds T_J = +155°C, a thermal sensor turns off the pass transistor, allowing the IC to cool down. The thermal sensor turns the pass transistor on again after the junction temperature cools down by 30°C, resulting from a pulsed output during continuous thermal overload conditions.

Thermal overload protection is designed to protect AP6213A from the event of fault conditions. For continuous operation, the absolute maximum operating junction temperature rating of T_J = +125°C should not be exceeded.

Operating Region and Power Dissipation

Maximum power dissipation of the AP6213A depends on the thermal resistance of the case and circuit board, the temperature difference between the die junction and ambient air, and the rate of airflow. The power dissipation across the devices is P = I_{OUT} x (V_{IN}-V_{OUT}). The resulting maximum power dissipation is:

$$P_{MAX} = \frac{(T_J - T_A)}{\theta_{JC} + \theta_{CA}} = \frac{(T_J - T_A)}{\theta_{JA}}$$

Where (T_J-T_A) is the temperature difference between the AP6213A die junction and the surrounding air, θ_{JC} is the thermal resistance of the package chosen, and θ_{CA} is the thermal resistance through the printed circuit board, copper traces and other materials to the surrounding air. For better heatsinking, the copper area should be equally shared between the V_{IN}, V_{OUT}, and GND pins.

If the AP6213A uses a SOT-25 package and this package is mounted on a double sided printed circuit board with two square inches of copper allocated for heatsink, the resulting θ_{JA} is 250 °C/W.

Based on the maximum operating junction temperature 125 °C with an ambient of 25°C, the maximum power dissipation will be:

$$P_{MAX} = \frac{(T_J - T_A)}{\theta_{JC} + \theta_{CA}} = \frac{(125 - 25)}{250} = 0.40W$$

Thermal characteristics were measured using a double sided board with 1" x 2" square inches of copper area connected to the GND pin.

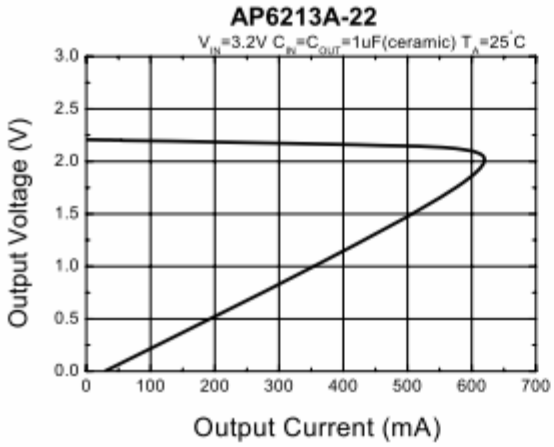
Dropout Voltage

A regulator's minimum input-output voltage differential, or dropout voltage, determines the lowest usable supply voltage. In battery-powered systems, this will determine the useful end-of-life battery voltage. The AP6213A use a P-channel MOSFET pass transistor, its dropout voltage is a function of drain-to-source on-resistance $R_{DS(ON)}$ multiplied by the load current.

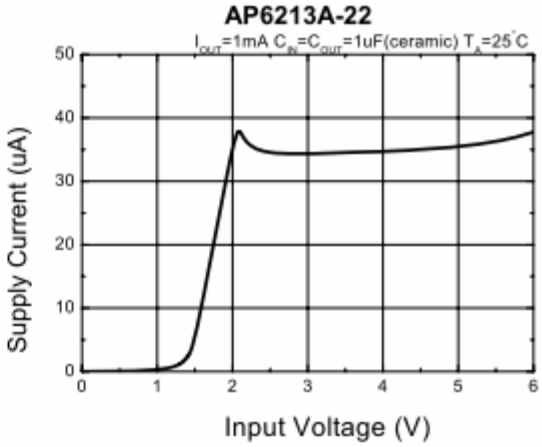
$$V_{DROPOUT} = V_{IN} \updownarrow V_{OUT} = R_{DS(ON)} \cdot I_{OUT}$$

Typical Operating Characteristics

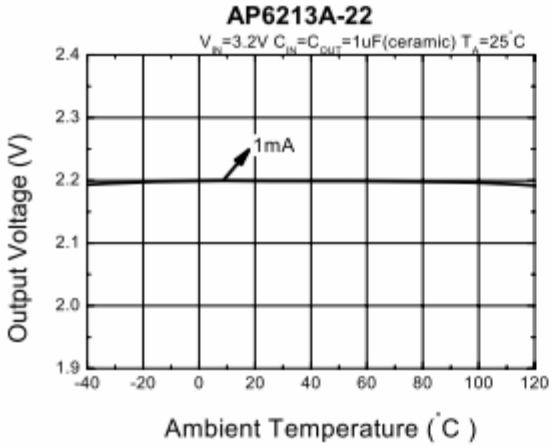
(1) Output Voltage vs. Output Current



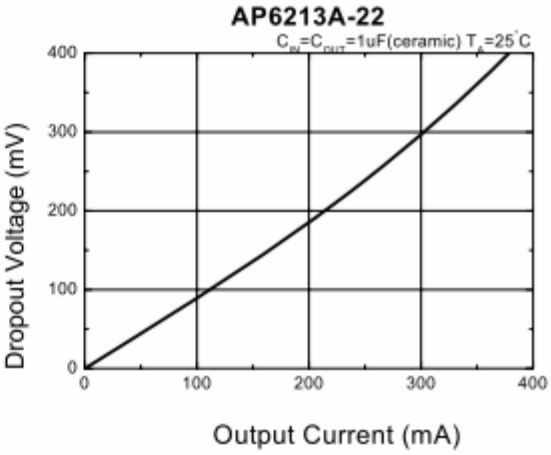
(2) Supply Current vs. Input Voltage



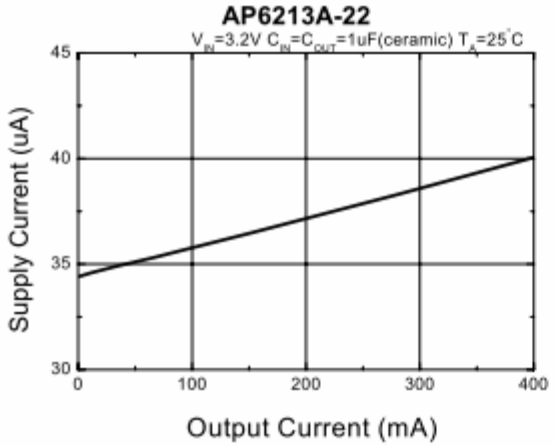
(3) Output Voltage vs. Ambient Temperature



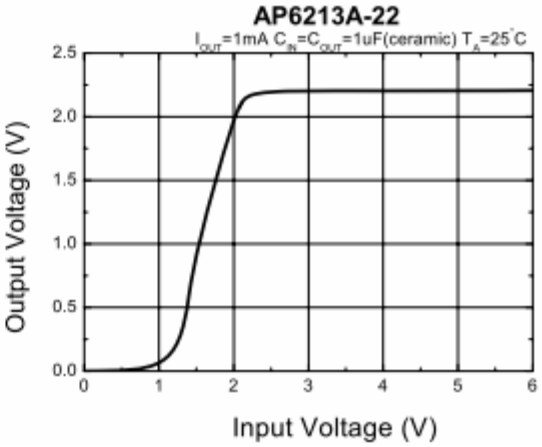
(4) Dropout Voltage vs. Output Current



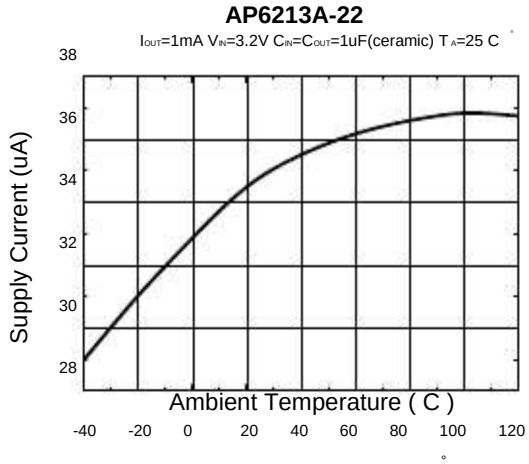
(5) Supply Current vs. Output Current



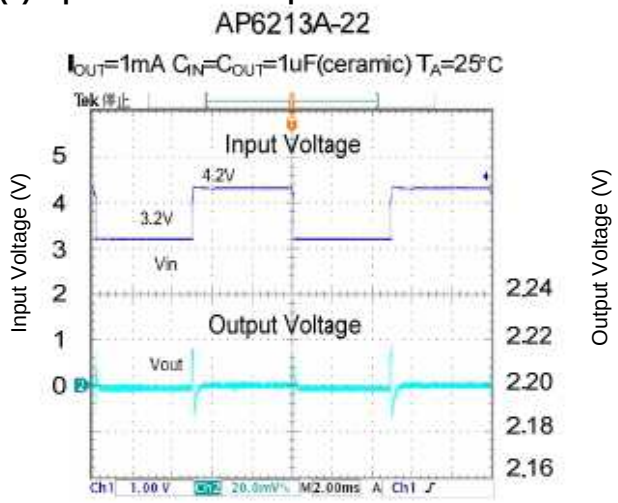
(6) Output Voltage vs. Input Voltage

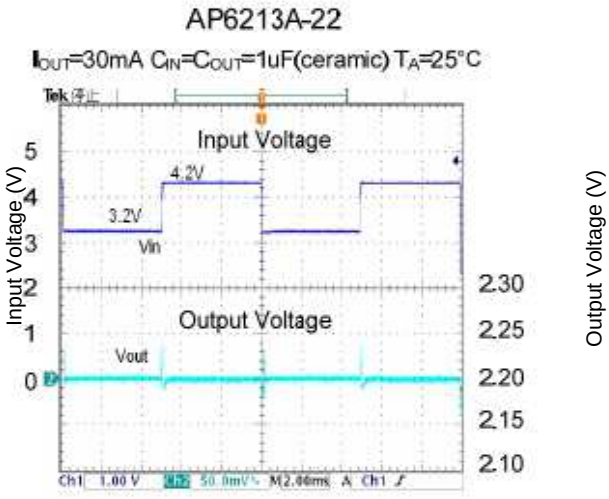


(7) Supply Current vs. Ambient Temperature

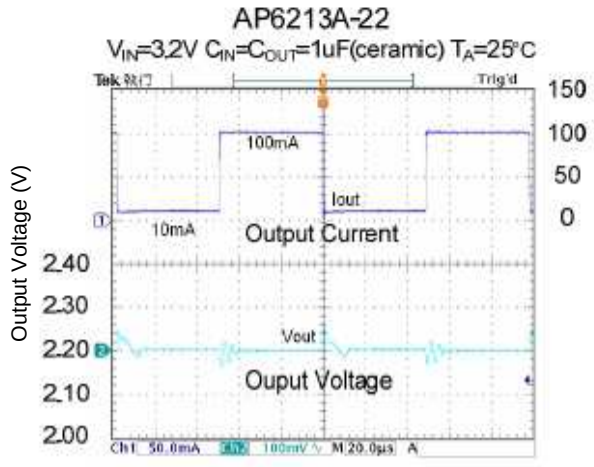


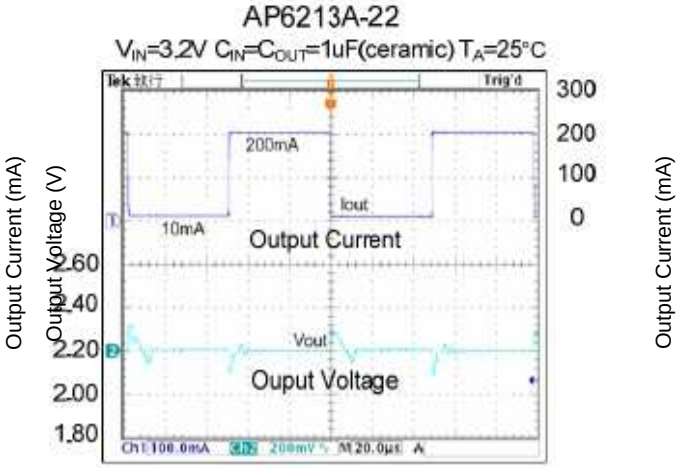
(8) Input Transient Response



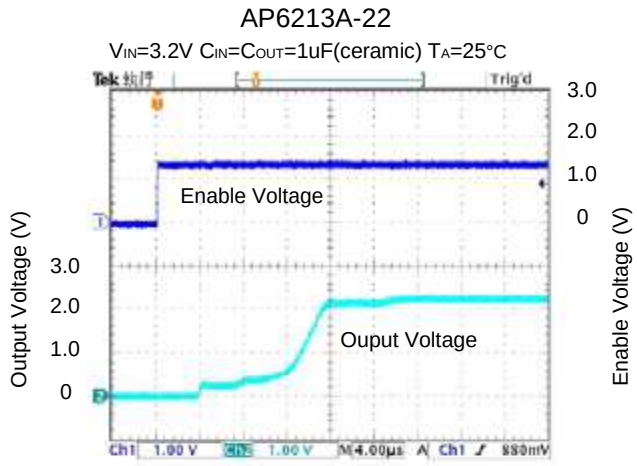


(9) Load Transient Response

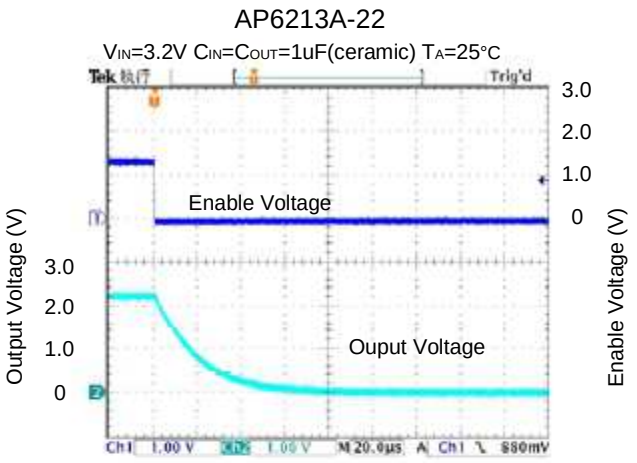




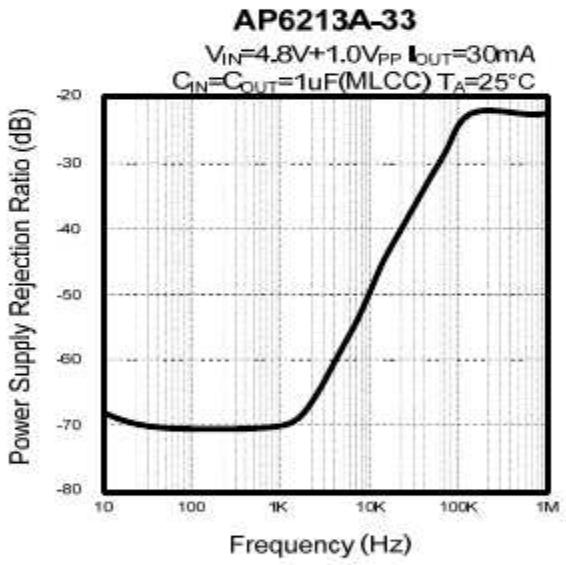
(9) Output Fast Respond function



(10) Output Fast Discharge Function

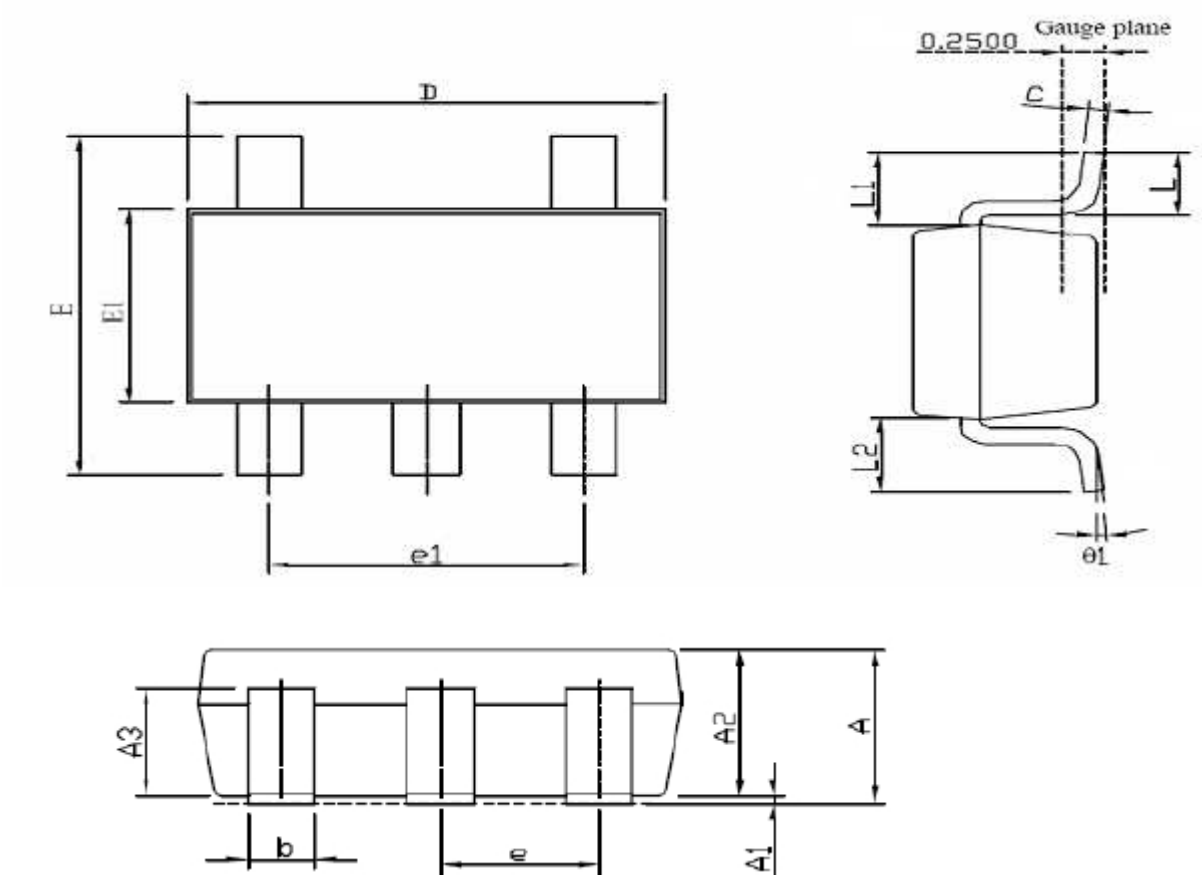


(11) Power Supply Rejection Ratio



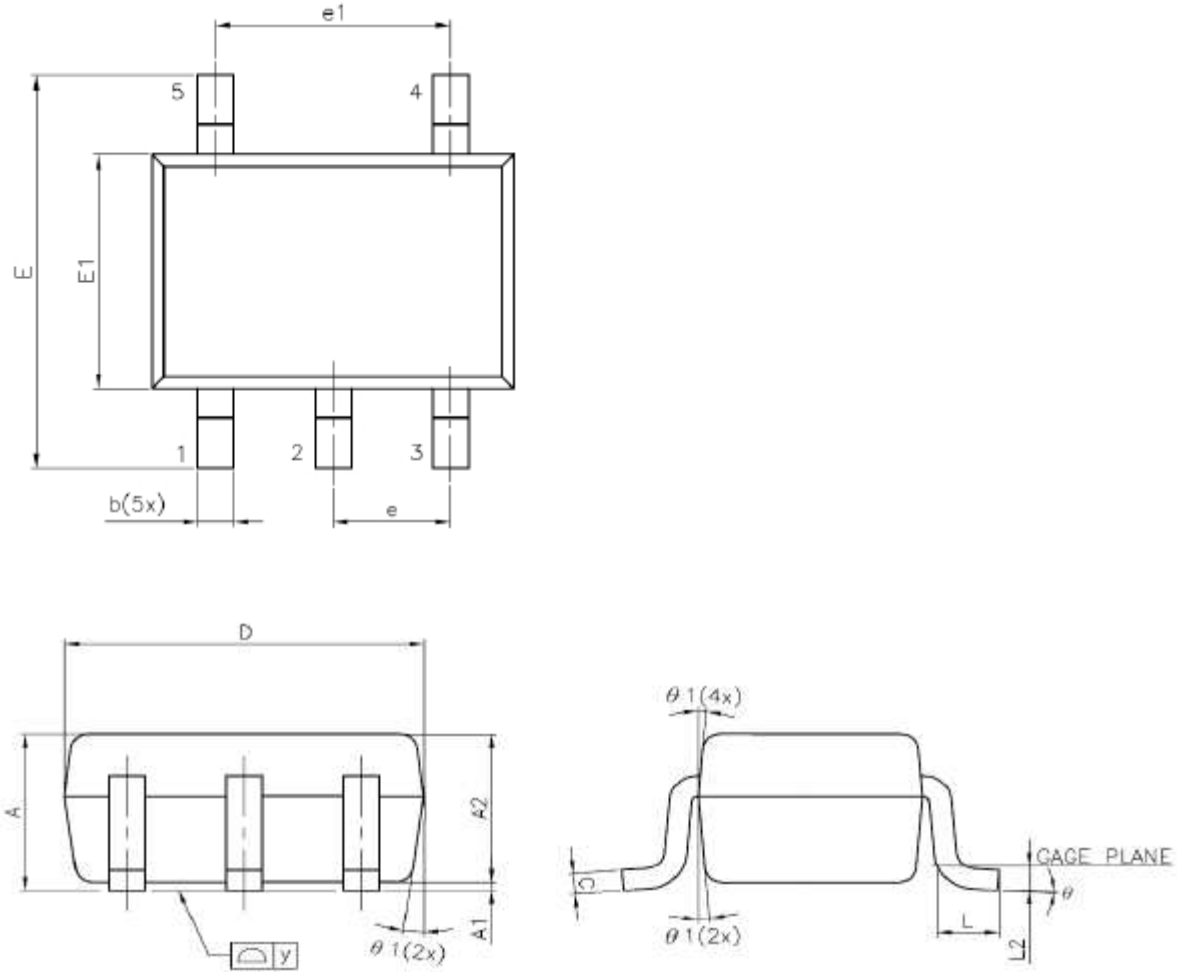
Package Outline

A) SOT-25



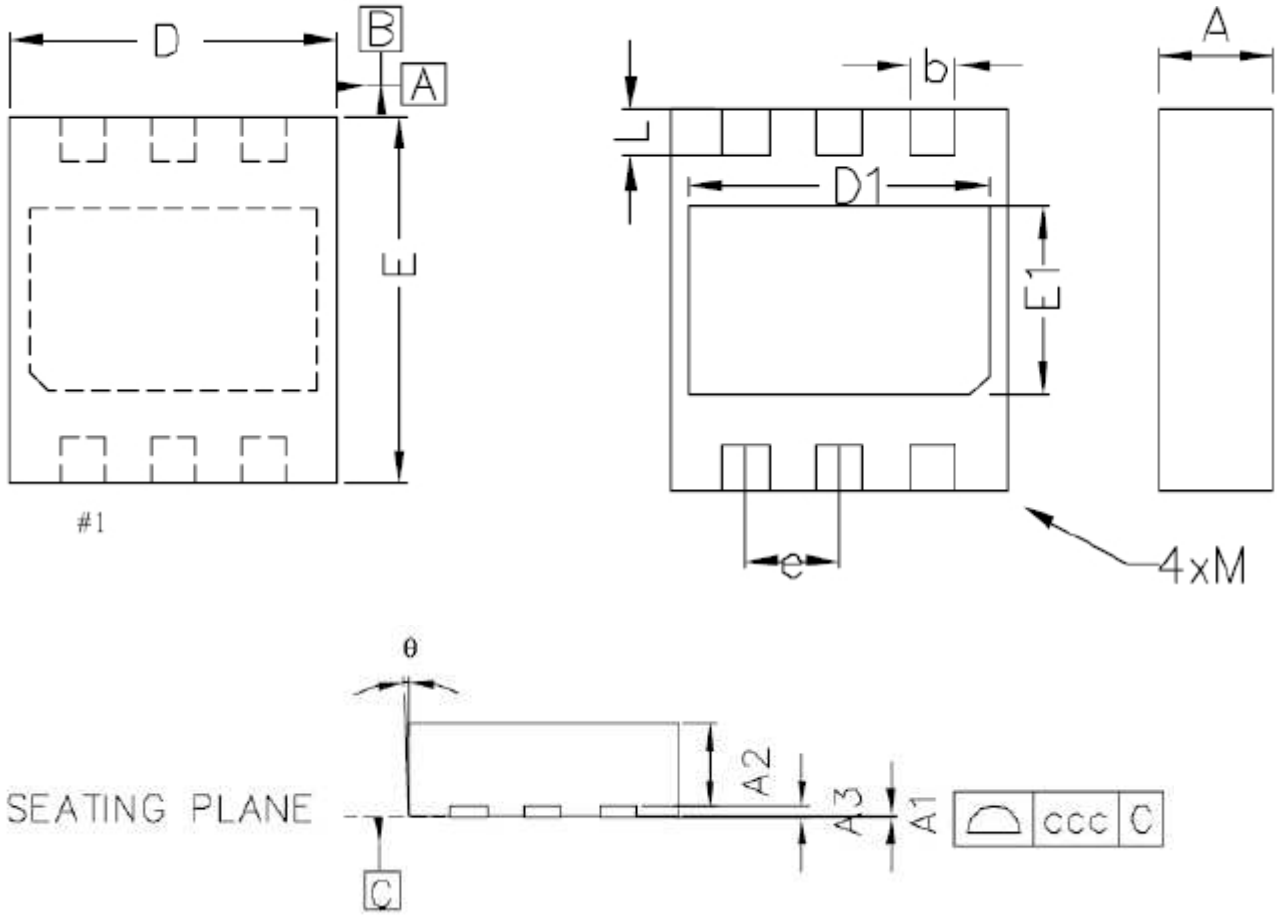
Symbols	Dimensions in Millimeters		
	Min	Nom	Max
A	1.00	1.10	1.40
A1	0.00	---	0.10
A2	1.00	1.10	1.30
A3	0.70	0.80	0.90
b	0.35	0.40	0.50
C	0.12	0.125	0.225
D	2.70	2.90	3.10
E1	1.40	1.60	1.80
e1	---	1.90(TYP)	---
E	2.60	2.80	3.00
L	0.37	---	---
θ1	1°	5°	9°
e	---	0.95(TYP)	---
L1	---	0.6(REF)	---
LI-L2	---	---	0.12

B) SC-70-5



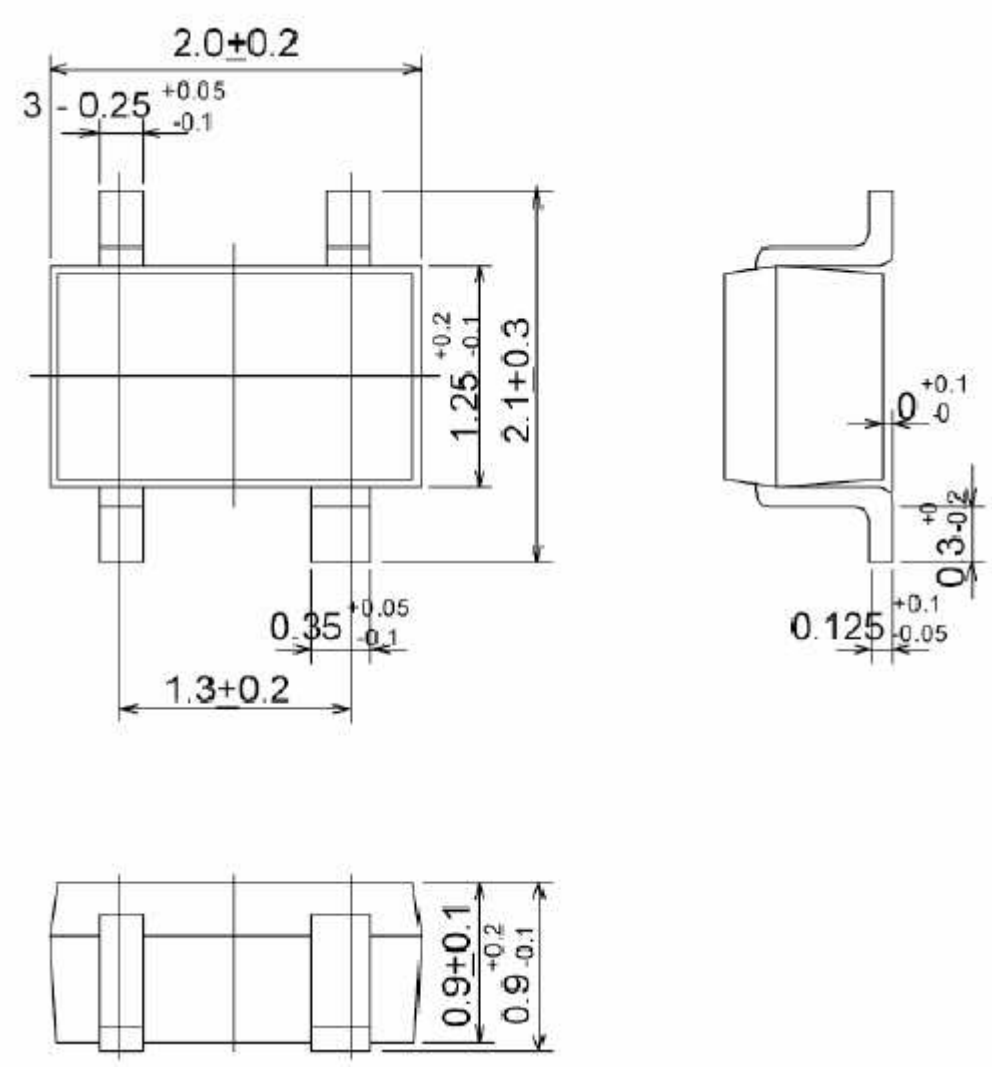
Symbols	Millimeters			Inches		
	Min	Nom	Max	Min	Nom	Max
A	0.80	---	1.10	0.031	---	0.043
A1	0.00	---	0.10	0.000	---	0.004
A2	0.70	0.90	1.00	0.028	0.035	0.039
b	0.15	---	0.30	0.006	---	0.012
C	0.08	---	0.22	0.003	---	0.009
D	1.80	2.00	2.20	0.071	0.079	0.087
E	1.80	2.10	2.40	0.071	0.083	0.094
E1	1.15	1.25	1.35	0.045	0.049	0.053
e	---	0.65	---	---	0.026	---
e1	---	1.30	---	---	0.051	---
L	0.26	0.36	0.46	0.010	0.014	0.018
L2	---	0.15	---	---	0.006	---
y	---	---	0.10	---	---	0.004
θ	0°	4°	8°	0°	4°	8°
θ1	4°	---	12°	4°	---	12°

C) UFN-6

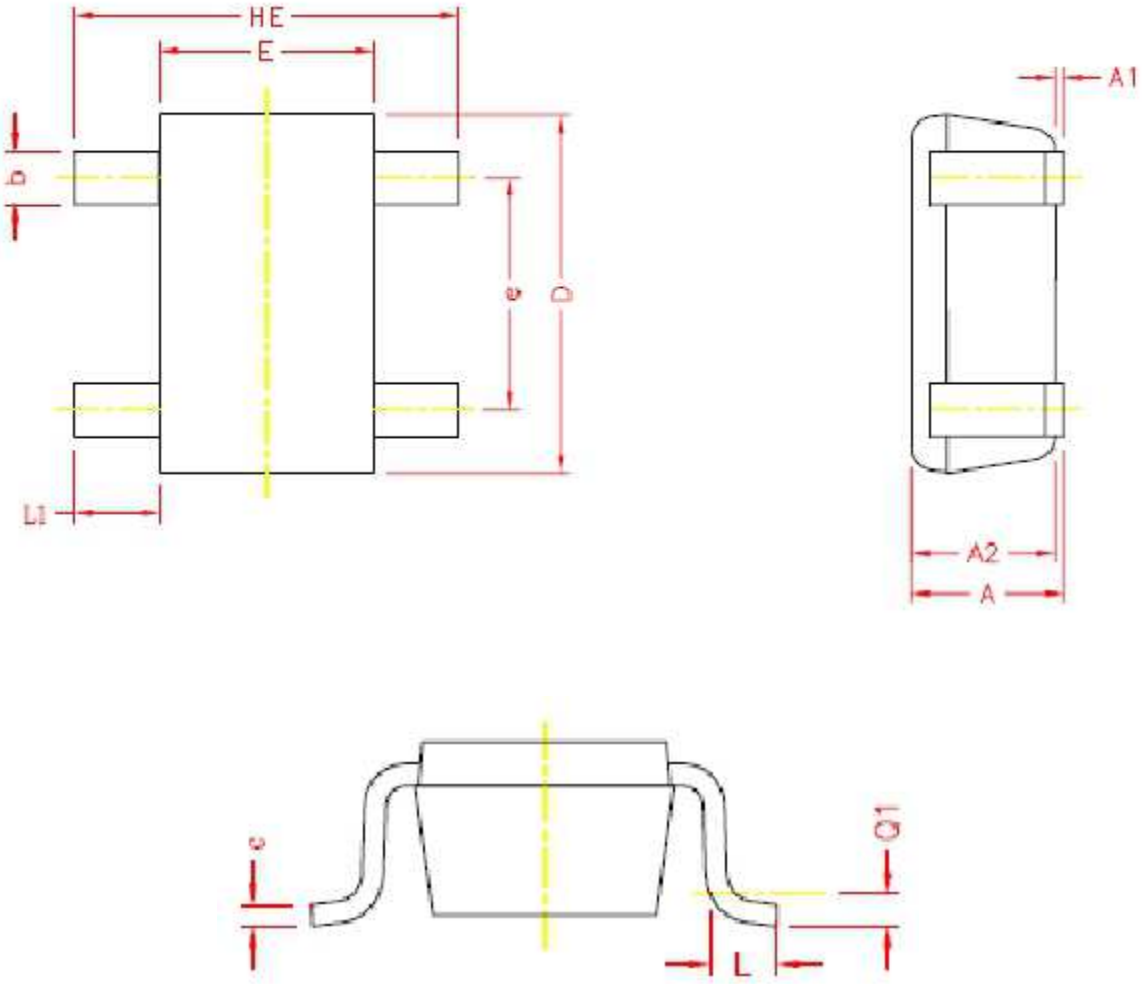


Dimension	mm		
	Min.	Nom.	Max.
A	0.55	0.60	0.65
A1	0.000	0.002	0.004
A2	0.51	0.54	0.59
A3	---	0.06REF	---
b	0.20	0.25	0.30
D	1.95	2.00	2.03
D1	---	1.60BSC	---
E	1.95	2.00	2.03
E1	---	1.0BSC	---
e	---	0.50BSC	---
L	0.20	0.25	0.30
θ	-12	---	0
ccc	---	0.08	---
M	---	---	0.05
Burr	0.00	0.03	0.06

D) SC-82 (W Type)

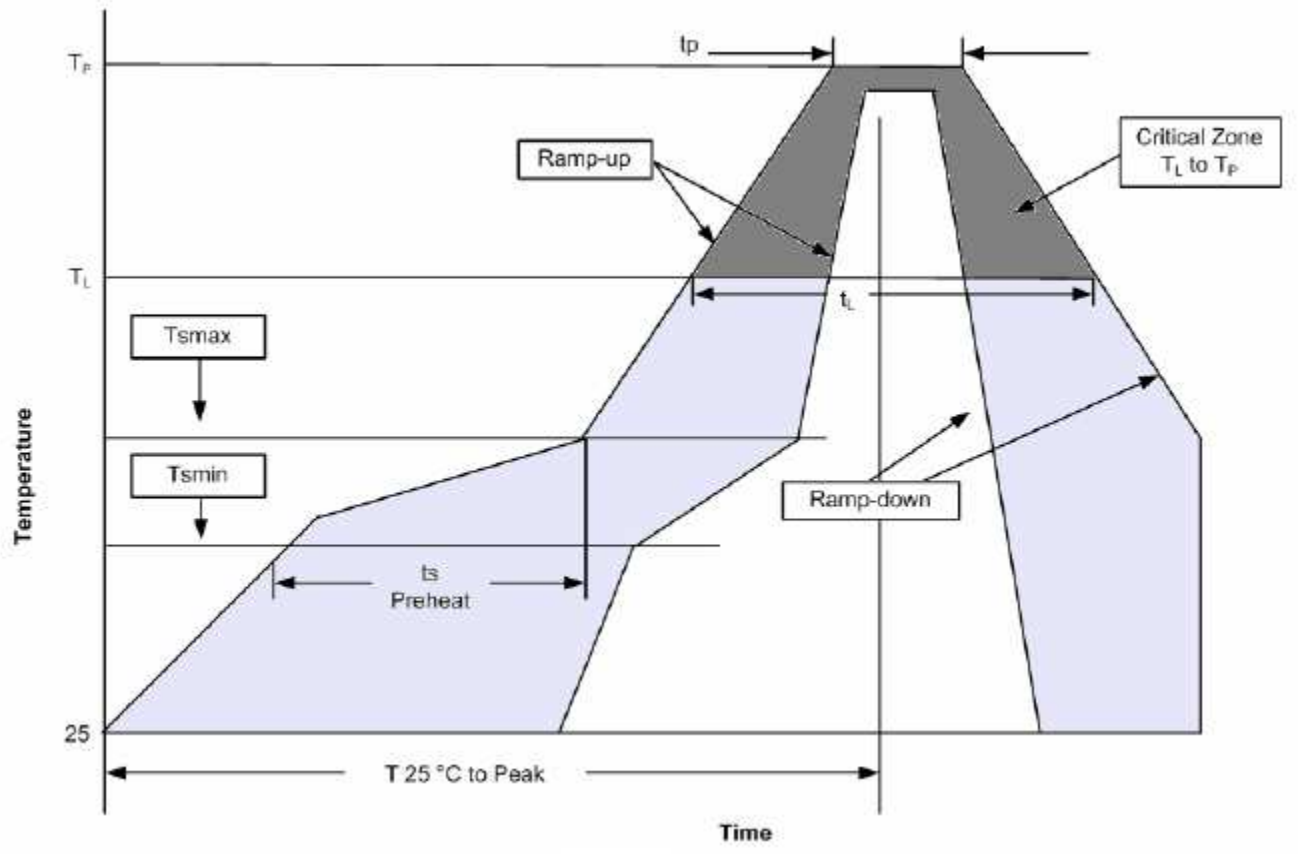

2.0±0.2
3 - 0.25 +0.05 -0.1
1.25 +0.2 -0.1
2.1±0.3
0 +0.1 -0
0.3 +0 -0.2
0.35 +0.05 -0.1
0.125 +0.1 -0.05
1.3±0.2
0.9±0.1
0.9 +0.2 -0.1

E) SC-82 (S Type)



DIMENSIONS					
REF.	Millimeter		REF.	Millimeter	
	Min.	Max.		Min.	Max.
A	0.80	1.00	L1	0.48 REF.	
A1	0	0.10	L	0.15	0.45
A2	0.70	0.90	b	0.25	0.40
D	1.80	2.20	c	0.10	0.25
E	1.15	1.35	e	1.30 REF.	
HE	2.00	2.30	Q1	0.15 REF.	

Reflow Condition (IR/Convection or VPR Reflow)



Classification Reflow Profiles

Profile Feature	Pb-Free / Green Assembly
Average ramp-up rate (T_L to T_P)	3°C/second max
Preheat - Temperature Min (Tsmin) - Temperature Max (Tsmax) - Time (min to max) (ts)	150°C 200°C 60-180 seconds
Time maintained above: - Temperature (T_L) - Time (t_L)	217°C 60-150 seconds
Peak/Classification Temperature (Tp)	See table 1
Time within 5°C of actual Peak Temperature (tp)	20-40 seconds
Ramp-down Rate	6°C/second max
Time 25°C to Peak Temperature	8 minutes max

Notes：
1) All temperatures refer to topside of the package.
2) Measured on the body surface.

Classification Reflow Profiles (Continued)

Table 1. Pb-free / Green Process – Package Classification Reflow Temperatures

Package Thickness	Volume mm³ <350	Volume mm³ 350~2000	Volume mm³ ≧2000
<2.5 mm	260 +0°C*	260 +0°C*	260 +0°C*
1.6-2.5 mm	260 +0°C*	250 +0°C*	245 +0°C*
≧2.5 mm	250 +0°C*	245 +0°C*	245 +0°C*

Notes：

* Tolerance: The device manufacturer/supplier shall assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.