250mA Low- Quiescent Current Linear Regulator

Features

- **2.0μA Quiescent Current (Typ.)**
- **Operating Voltages Range：+1.8V to +6.0V**
- **Output Voltages Range：+1.2V to +5.0V with 100mV Increment**
- **Maximum Output Current：250 mA**
- **Low Dropout: 150 mV @ 100mA (V_{OUT}≧2.0 V)**
- **High Accuracy of Output Voltage**
  ±2.0% : V_{OUT}≧2.5 V
  ±50mV : V_{OUT}≦2.5 V
- **High Ripple Rejection：60 dB**
- **Output Current Limit Protection (350mA)**
- **Short Circuit Protection (200mA)**
- **Thermal Overload Shutdown Protection**
- **Low ESR Capacitor Compatible**
- **SOT-23, SOT-25, SOT-89, UFN-6 , SC-82 and TO92 Packages**
- **RoHS Compliant and 100% Lead (Pb)-Free and Green (Halogen Free with Commercial Standard)**

General Description

The AP6209 series is a positive voltage regulator with high accuracy output voltage and ultra-low quiescent current which is typically 2.0μA. The device is ideal for handheld communication equipments and battery powered applications which require low quiescent current.

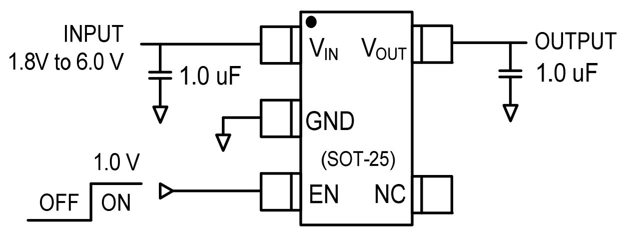
The AP6209 consists of a bandgap reference voltage source, an error amplifier, a P-channel pass transistor, a resistor-divider for setting output voltage, a current limiter, and temperature limit protection circuit. The high-accuracy output voltage is preset at an internally trimmed voltage 1.8V, 2.5V or 3.3V. Other output voltages can be mask- optioned from 1.2V to 5.0V with 100mV increment except the AP6209-1.3 which has 1.28V output voltage and AP6209-BB which has 1.85V output voltage.

The AP6209 has been designed to be used with low cost ceramic capacitors and requires a minimum output capacitor of 1.0μF. The devices are available in SOT-23, SOT-25, UFN-6, SOT-89, SC-82 and TO-92 packages.

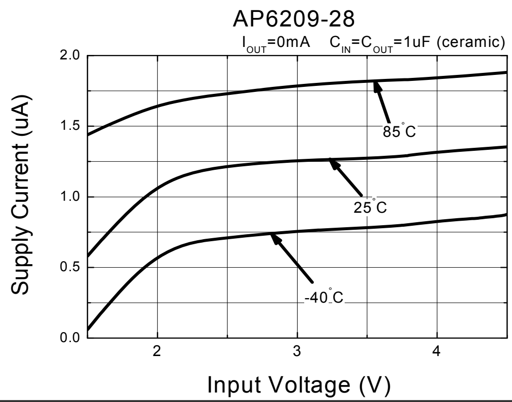
Applications

- DSC、PDA、MP3 Player
- Digital Video Recorder
- Battery Powered Instrument
- Portable Communication Device

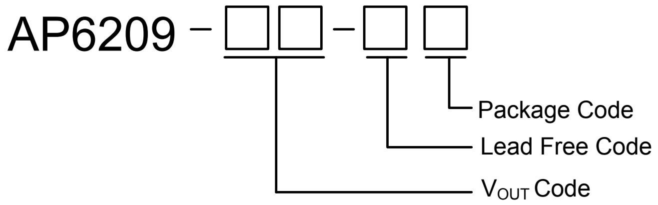
Simplified Application Circuit



Supply Current Diagram



Ordering Information



Vout Code：

Exam. 18=1.8V、**25=**2.5V、**33=**3.3V

Lead Free Code：

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

G：Green (Halogen Free with Commercial Standard)

Package Code：

A：SOT-25
B：SOT-23
E：TO-92
L：SOT-89
S：SC-82
U：UFN-6
V：SOT-25

Absolute Maximum Ratings

Parameter		Symbol	Ratings	Units
Input Voltage V_{IN} to GND		V_{IN}	7.0	V
EN to GND Voltage			7	V
EN to Input Voltage			0.3	V
Output Current Limit, $I_{(LIMIT)}$		I_{OUT}	350	mA
Junction Temperature		T_J	+155	°C
Power Dissipation	SOT-25	P_D	400	mW
	SOT-23		300	
	TO-92		550	
	SOT-89		550	
	SC-82		250	
	UFN-6		500	
Operating Ambient Temperature Range		T_{OPR}	-40 ~ +125	°C
Storage Temperature Range		T_{STG}	-55 ~ +150	°C
Lead Temperature (soldering, 10sec)			+260	°C

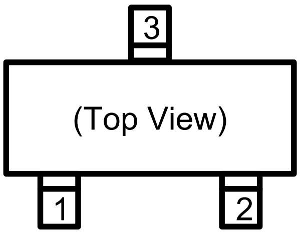
Note:
*Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and function operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum -rated conditions for extended periods may affect device reliability.

Electrical Characteristics

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

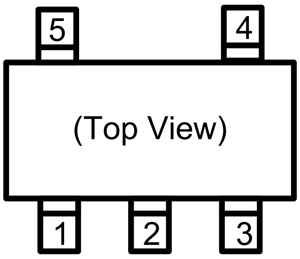
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
V_{IN}	Input Voltage		1.8		6.0	V
ΔV_{OUT}	Output Voltage	$V_{IN}=V_{OUT}+1.0V$, $V_{OUT} \leqq 2.5V$	-0.05	V_{OUT}	+0.05	V
		$V_{IN}=V_{OUT}+1.0V$, $V_{OUT} \geqq 2.5V$,	-2.0		+2.0	%
I_{MAX}	Output Current		250			mA
I_{SC}	Short Circuit Current	V_{OUT}=0V, $V_{IN} > V_{OUT}+0.48V$		200	300	mA
I_Q	Quiescent Current	I_{LOAD}=0mA, $V_{IN}=V_{OUT}+1.0V$		2.0	4.5	μA
V_{DROP}	Dropout Voltage	$V_{OUT} \geqq 2.0$ V, I_{OUT}=100mA		150	200	mV
ΔV_{LINE}	Line Regulation	$V_{OUT}+1.0V \leqq V_{IN} \leqq 6V$, I_{LOAD}=1mA		0.10	0.20	%/V
ΔV_{LOAD}	Load Regulation	I_{OUT}=1mA to 100mA		0.01	0.02	%/mA
V_{IH}	EN Pin Input Voltage "H"		1.0			V
V_{IL}	EN Pin Input Voltage "L"				0.3	V
I_{EN}	EN Pin Leakage Current			0.05	0.1	μA
PSRR	Ripple Rejection	F=100Hz, C_{OUT}=1uF		60		dB
e_N	Output Noise	F=10KHz, C_{OUT}=1uF		150		$\mu V_{(rms)}$
T_{SD}	Thermal Shutdown Temperature			155		°C
T_{HYS}	Thermal Shutdown Hysteresis			10		°C
T_C	Output Voltage Temperature Coefficient	I_{OUT}=1mA, -40°C $\leqq T_A \leqq$ 80°C		100		ppm/°C

Pin Assignment & Pin Description



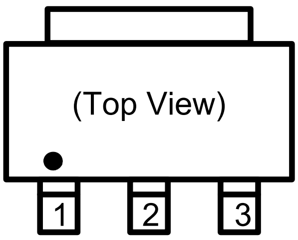
SOT-23-3

Pin Number	Pin Name	Functions
SOT-23		
1	GND	Ground
2	V_{OUT}	Output
3	V_{IN}	Power Input



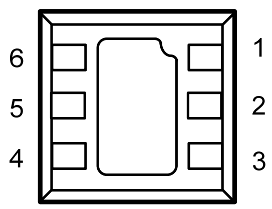
SOT-23-5

Pin Number		Pin Name	Functions
SOT-25(A)	SOT-25(V)		
1	5	V_{IN}	Power Input
2	2	GND	Ground
3	1	EN	Enable
4	3	NC	No Connection
5	4	V_{OUT}	Output



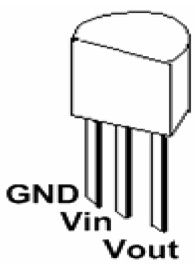
SOT-89

Pin Number	Pin Name	Functions
SOT-89		
1	GND	Ground
2	V_{IN}	Power Input
3	V_{OUT}	Output



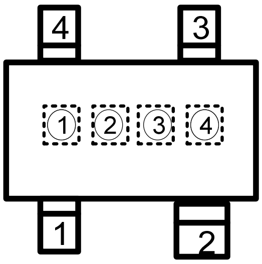
UFN-6
(Bottom View)

Pin Number	Pin Name	Functions
UFN-6		
2	GND	Ground
4	V_{IN}	Power Input
6	V_{OUT}	Output
1,3,5	NC	No Connection



Pin Number	Pin Name	Functions
TO-92		
1	GND	Ground
2	V_{IN}	Power Input
3	V_{OUT}	Output

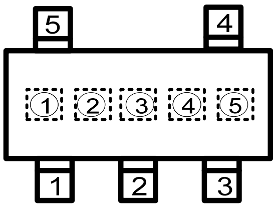
Pin Assignment & Pin Description (Continued)



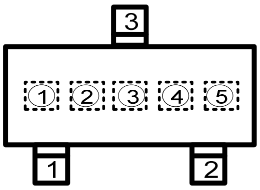
SC-82
(Top View)

Pin Number	Pin Name	Functions
SC-82		
1	EN	Enable
2	GND	Ground
3	V_{OUT}	Output
4	V_{IN}	Power Input

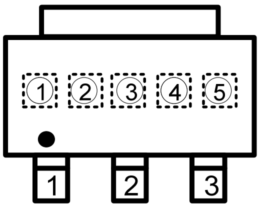
Package Marking Information



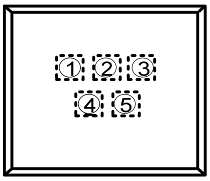
SOT-23-5
(Top View)



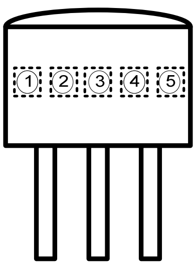
SOT-23-3
(Top View)



SOT-89
(Top View)



UFN-6
(Top View)



TO-92
(Top View)

① 、② Represents Products Series

Mark	Products Series
09	AP6209-XXXA/B/E/L/U/V

③ Represents Type of Regulator

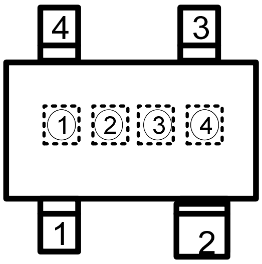
Mark	Products Series
5	AP6209-12XA/B/E/L/U/V
8	AP6209-15XA/B/E/L/U/V
A	AP6209-18XA/B/E/L/U/V
B	AP6209-BBXA/B/E/L/U/V (B：1.85V)
D	AP6209-20XA/B/E/L/U/V
E	AP6209-22XA/B/E/L/U/V
G	AP6209-25XA/B/E/L/U/V
J	AP6209-27XA/B/E/L/U/V
K	AP6209-28XA/B/E/L/U/V
M	AP6209-30XA/B/E/L/U/V
Q	AP6209-33XA/B/E/L/U/V
T	AP6209-35XA/B/E/L/U/V
V	AP6209-36XA/B/E/L/U/V
S	AP6209-42XA/B/E/L/U/V
Z	AP6209-50XA/B/E/L/U/V

④ 、⑤ Represents Production Date Code

Note：

* There are two under-lines on 4^{th} & 5^{th} digit for Green package.
* There are no under-lines on 4^{th} & 5^{th} digit for Pb-Free package.

Package Marking Information (Continued)



SC-82
(Top View)

① **Represents Products Series**

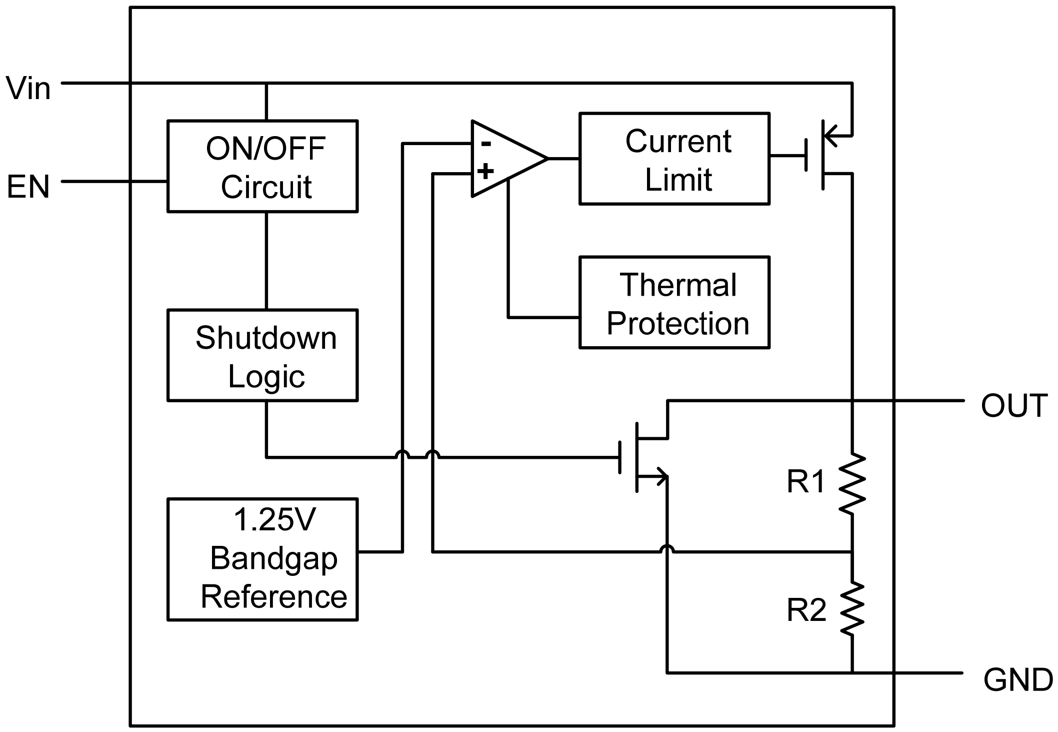
Mark	Products Series
9	AP6209-XXGS

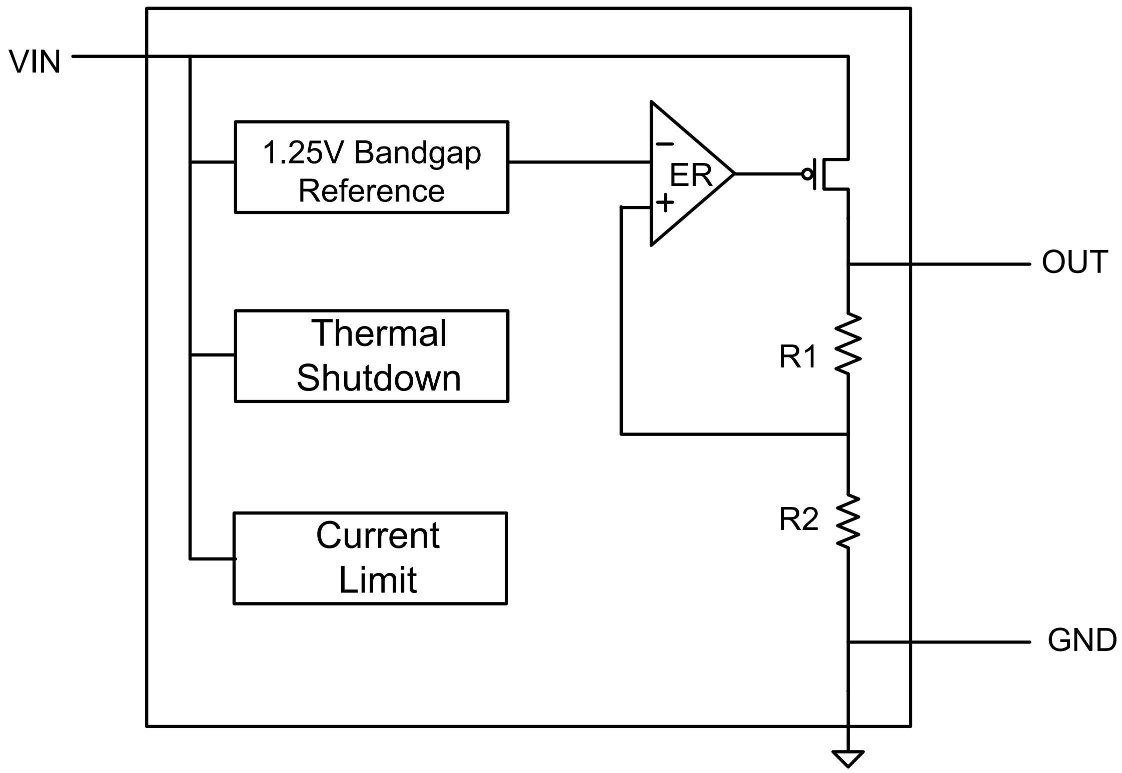
② **Represents Type of Regulator**

Mark	Products Series
5	AP6209-12GS
8	AP6209-15GS
A	AP6209-18GS
B	AP6209-BBGS (B：1.85V)
D	AP6209-20GS
E	AP6209-22GS
G	AP6209-25GS
J	AP6209-27GS
K	AP6209-28GS
M	AP6209-30GS
Q	AP6209-33GS
T	AP6209-35GS
V	AP6209-36GS
S	AP6209-42GS
Z	AP6209-50GS

③、④ **Represents Production Date Code**

Function Block Diagram





Detail Description

The AP6209 is a low quiescent current LDO linear regulator. The device provides preset 1.8V, 2.5V and 3.3V output voltages for output current up to 350mA. Other mask options for special output voltages from 1.2V to 5.0V with 100mV increment are also available (but only 1.28V in stead of 1.3V). As illustrated in function block diagram, it consists of a 1.23V reference, error amplifier, a P-channel pass transistor, an ON/OFF control logic, and an internal feedback voltage divider.

The 1.23V bandgap reference 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 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 gate is pulled up to decrease the output voltage.

The output voltage is feedback through an internal resistive divider connected to V_{OUT} pin. Additional blocks include with output current limiter and shutdown logic.

Internal P-channel Pass Transistor

The AP6209 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 conditions when the pass transistor saturates, and use high base-drive currents under large loads. The AP6209 does not suffer from these problems and consumes only 2.0μA (Typical) of current consumption under light loads.

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 VIN and VOUT is switched off, allowing current consumption to be drastically reduced. The V_{OUT} pin enters the GND level due to the several MΩ resistance of the feedback voltage divider between V_{OUT} and GND pins.

Output Voltage Selection

The AP6209 output voltage is preset at an internally trimmed voltage 1.8V, 2.5V or 3.3V. The output voltage also can be mask-optioned from 1.2V to 5.0V with 100mV increment by special order (but only 1.28V in stead of 1.3V). The first two digits of part number suffix identify the output voltage (see ***Ordering Information***). For example, AP6209-33 has a preset 3.3V output voltage.

Current Limit

The AP6209 also includes a fold back current limiter. It monitors and controls the pass-transistor's gate voltage, estimates the output current, and limits the output current within 350mA.

Thermal Overload Protection

Thermal overload protection limits total power dissipation in the AP6209. 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 active again after the junction temperature cools down by 10°C, resulting in a pulsed output during continuous thermal overload conditions.

Thermal overload protection is designed to protect the AP6209 in the event of fault conditions. For continuous operation, the maximum operating junction temperature rating of T_J=+125°C should not be exceeded.

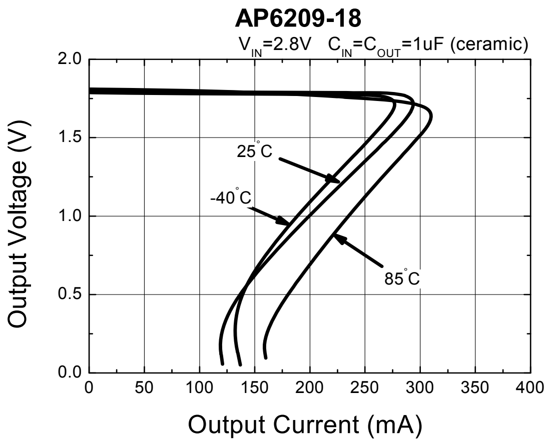
Dropout Voltage

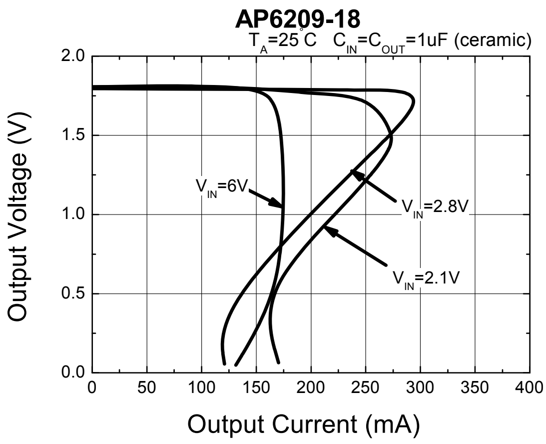
A regulator's minimum input-output voltage differential, or dropout voltage, determines the lowest us- able supply voltage. In battery-powered systems, this will determine the useful end-of-life battery voltage. The AP6209 uses a P-channel MOSFET pass transistor, its dropout voltage is a function of drain-to-source on-resistance ($R_{DS(ON)}$) multiplied by the load current.

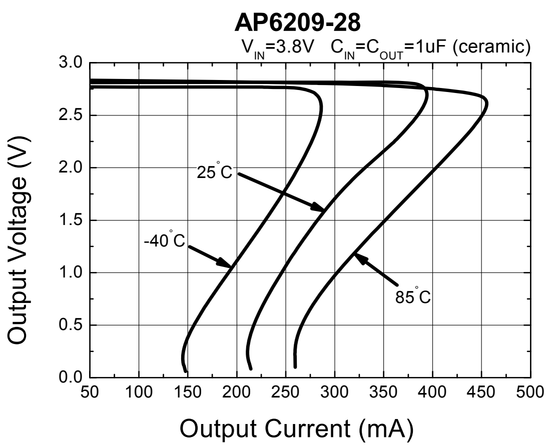
$$V_{DROPOUT} = V_{IN} - V_{OUT} = R_{DS(ON)} \times I_{OUT}$$

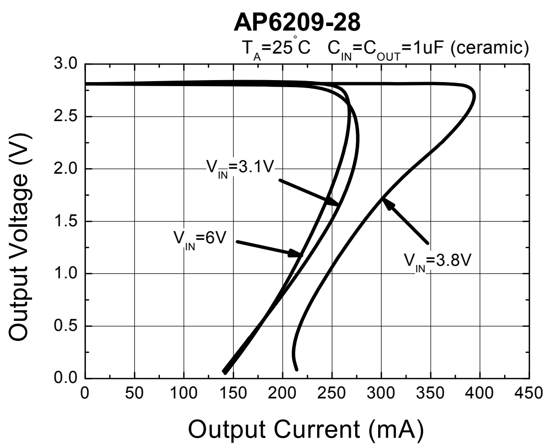
Typical Operating Characteristics

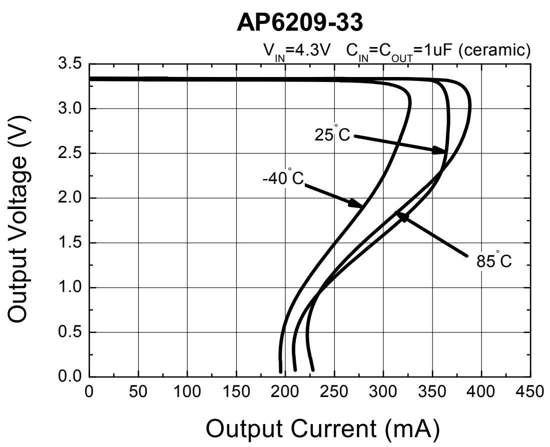
(1) Output Voltage vs. Output Current

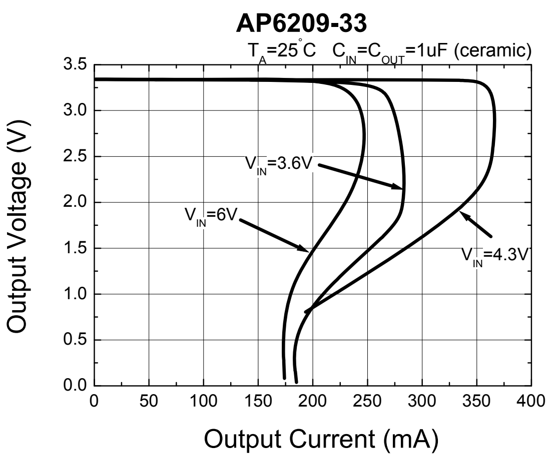




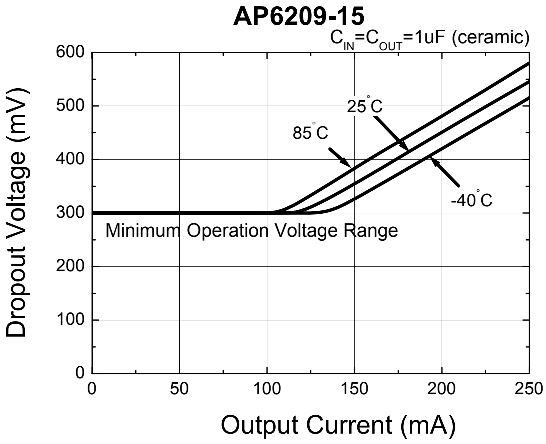


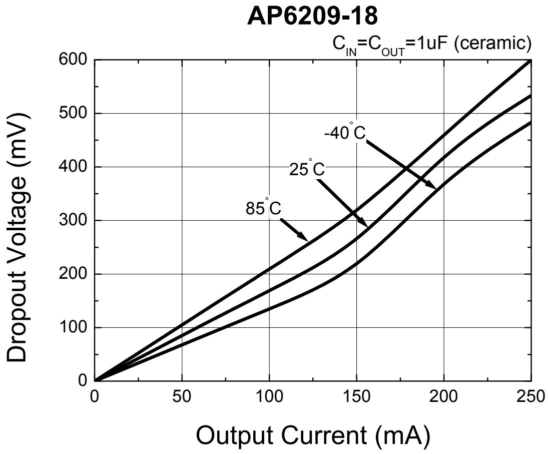


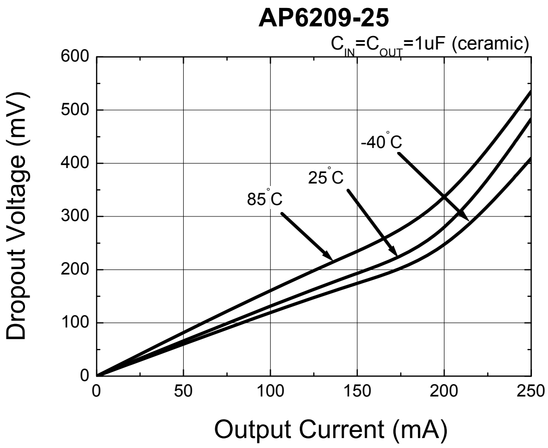


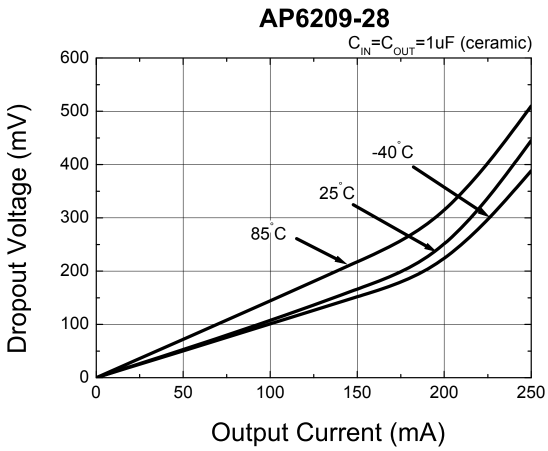


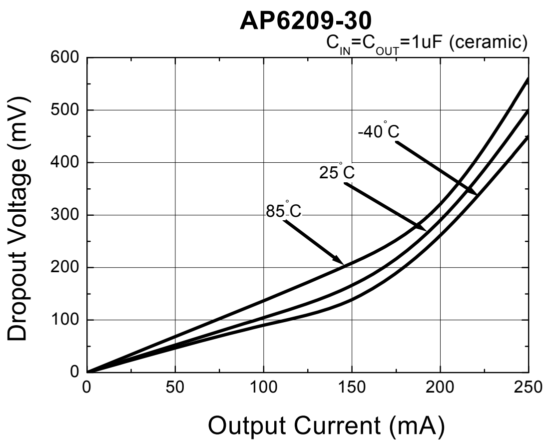
(2) Dropout Voltage vs. Output Current

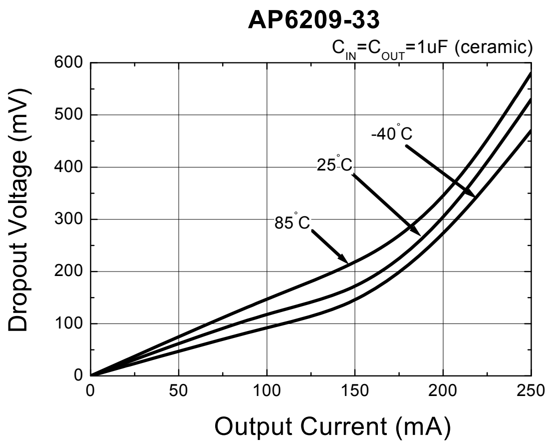




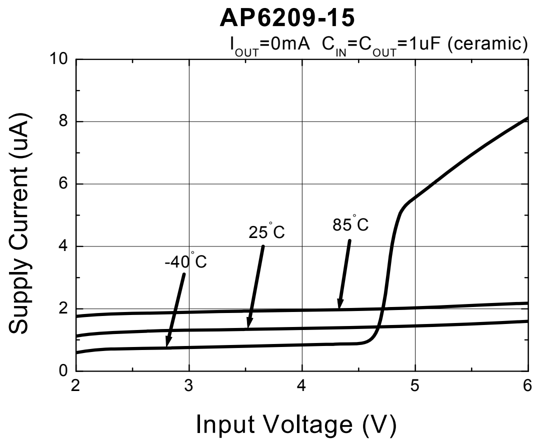


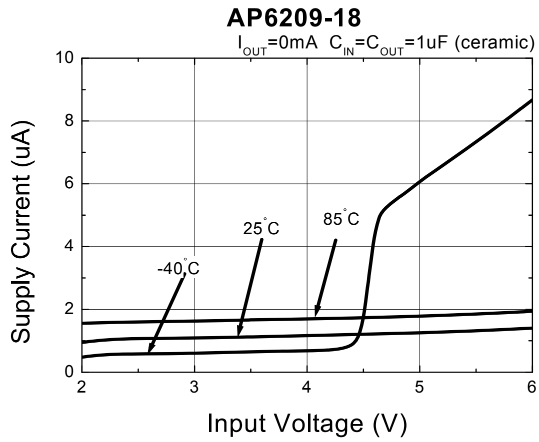


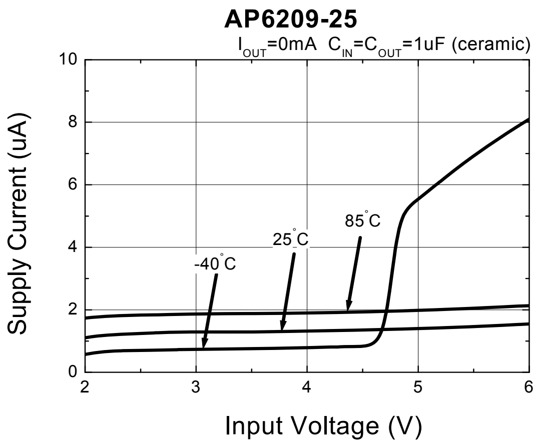


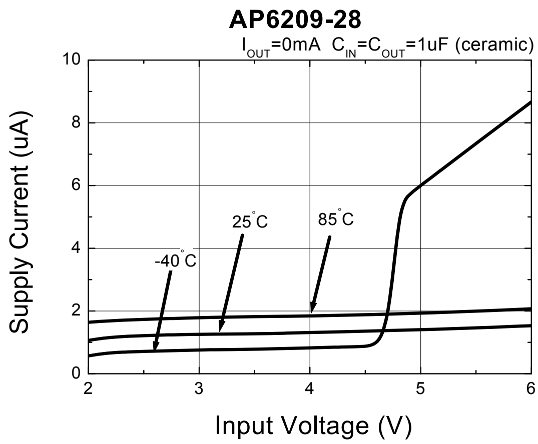


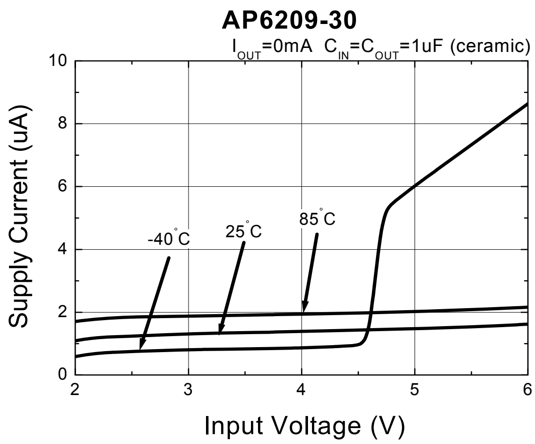
(3) Supply Current vs. Input Voltage

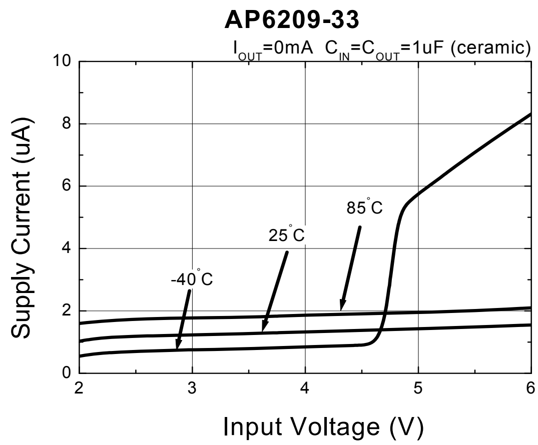




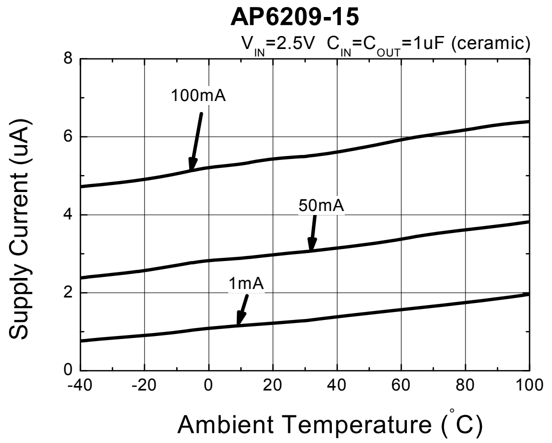


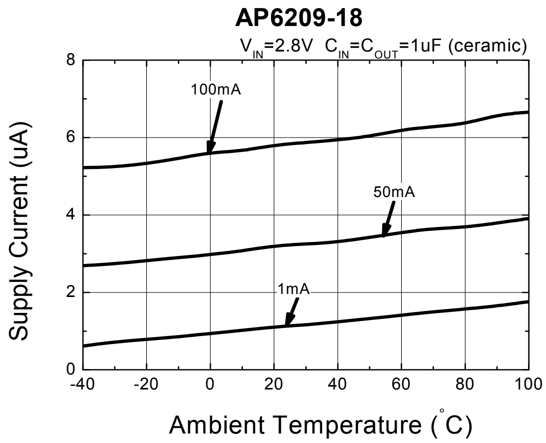


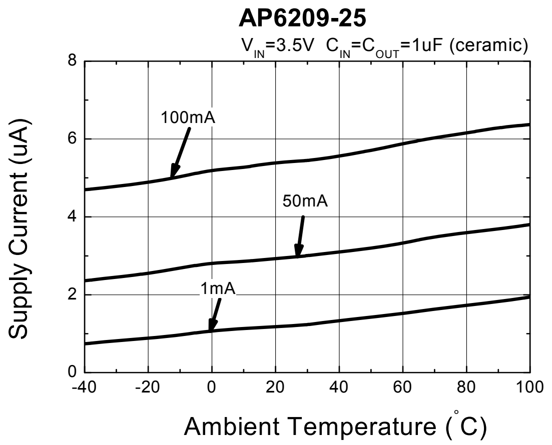


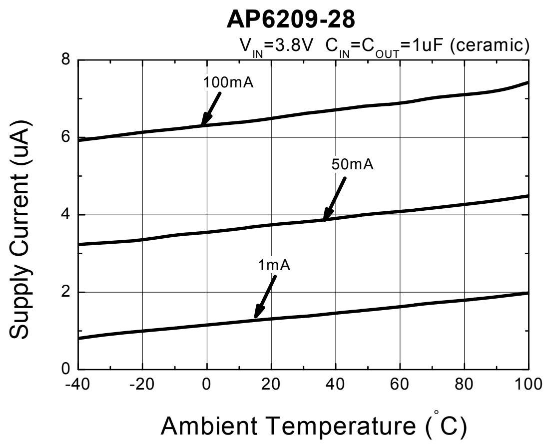


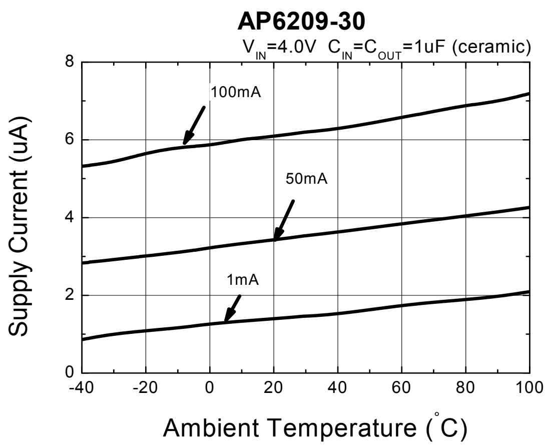
(4) Supply Current vs. Ambient Temperature

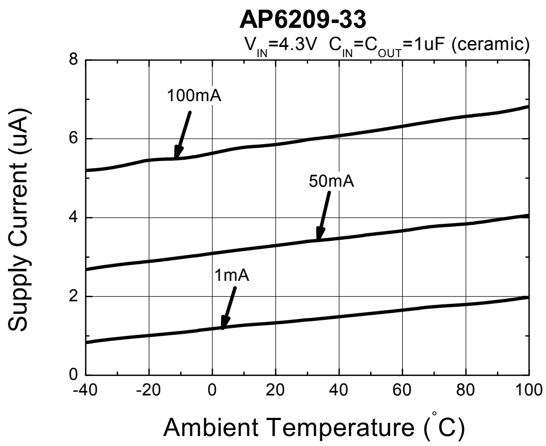




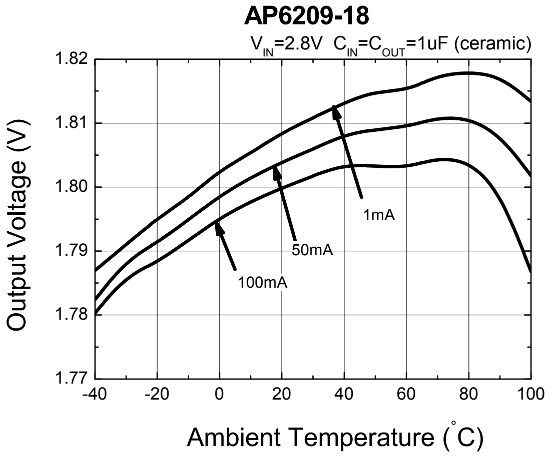


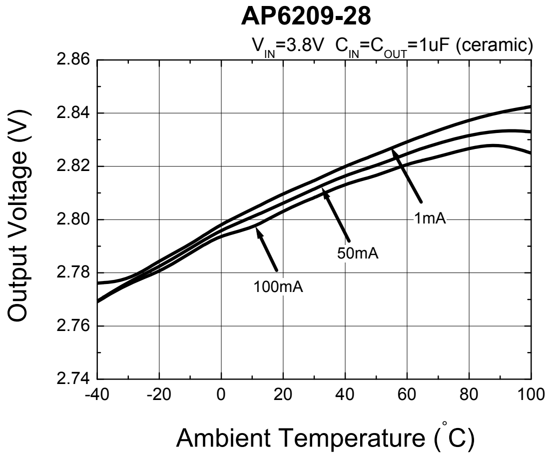


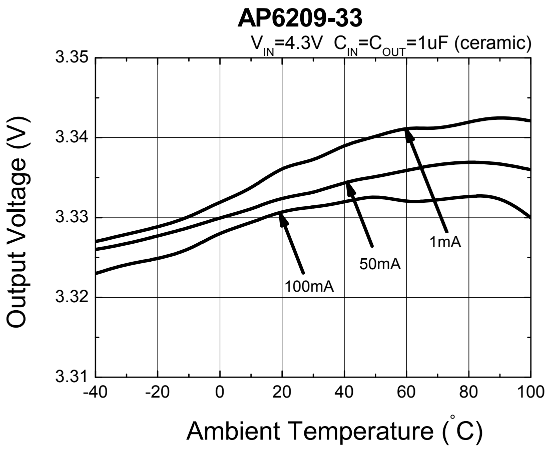




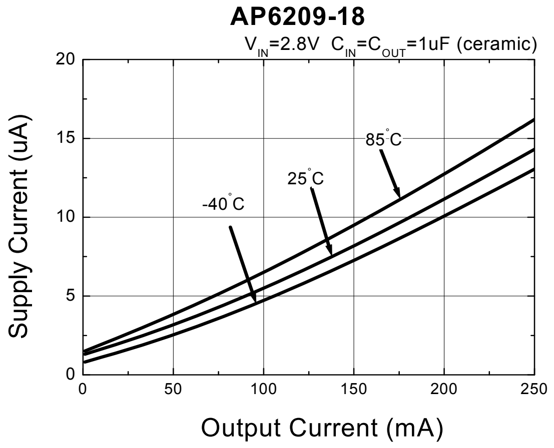
(5) Output Voltage vs. Ambient Temperature

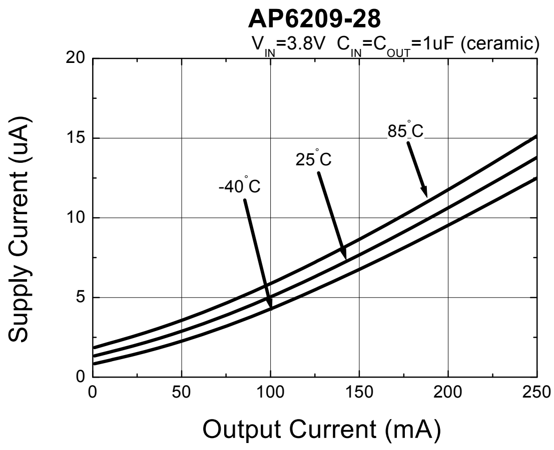


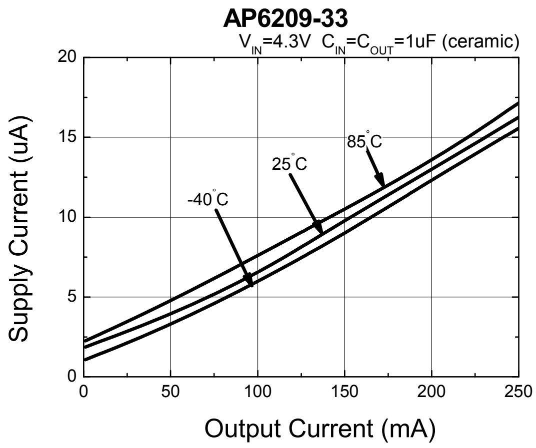




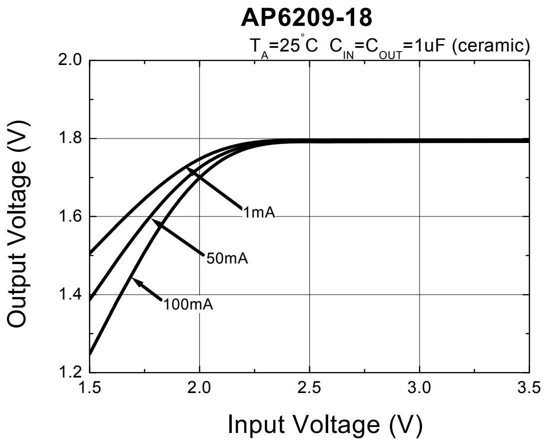
(6) Supply Current vs. Output Current

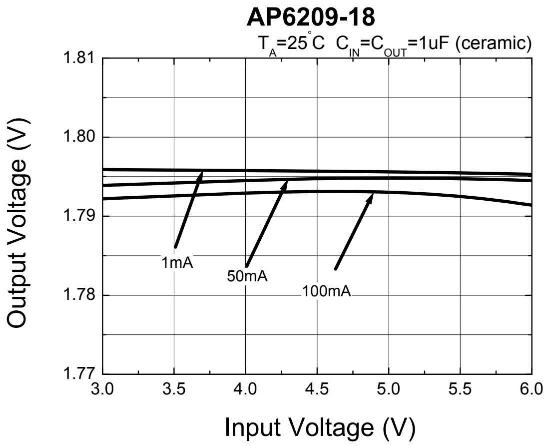


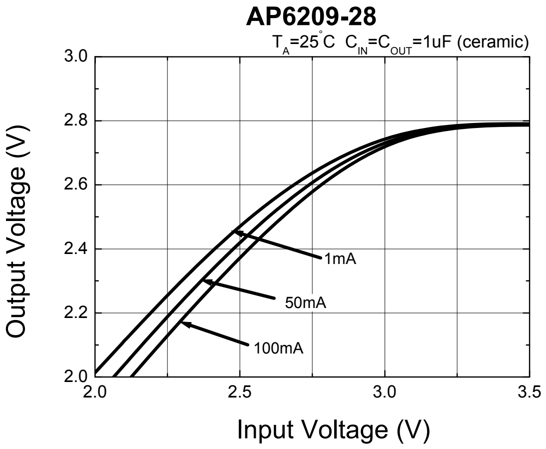


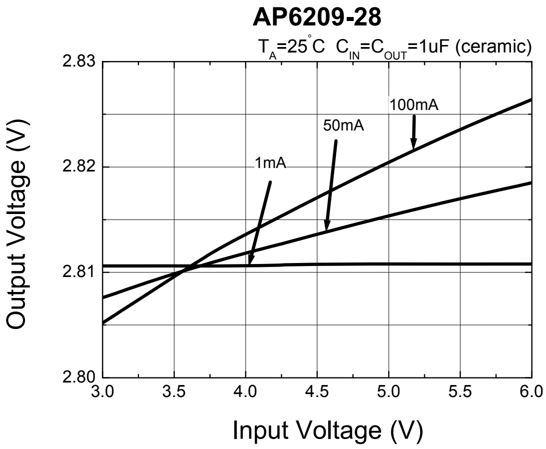


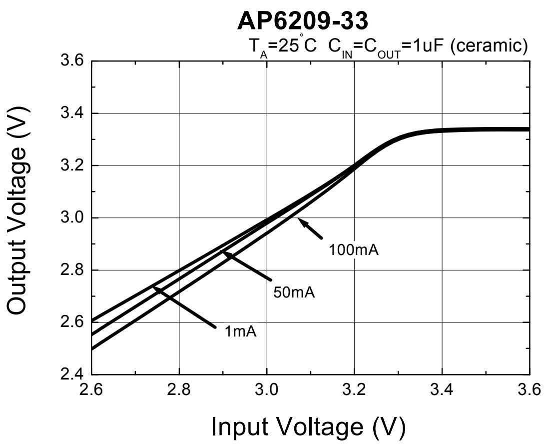
(7) Output Voltage vs. Input Voltage

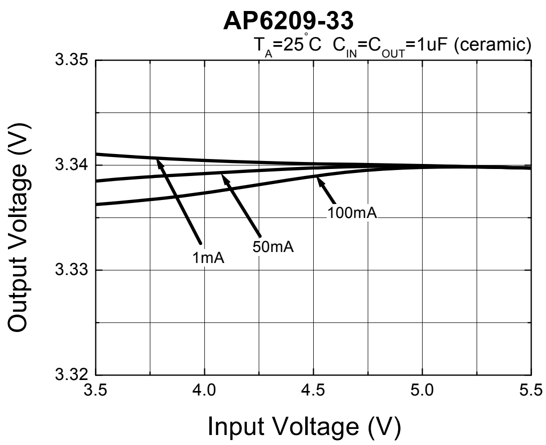




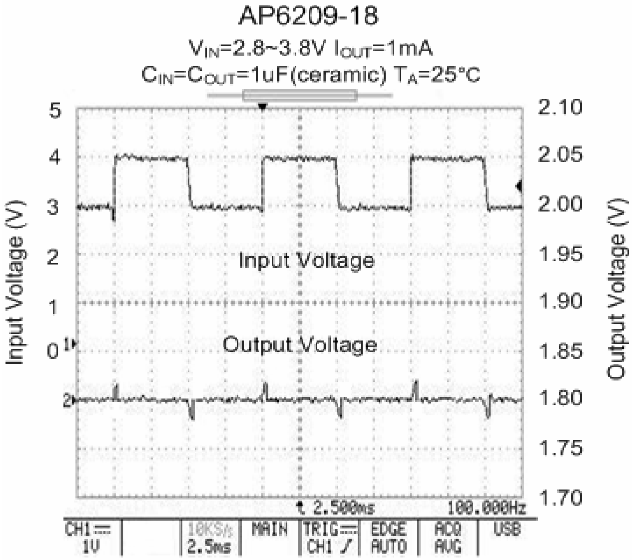


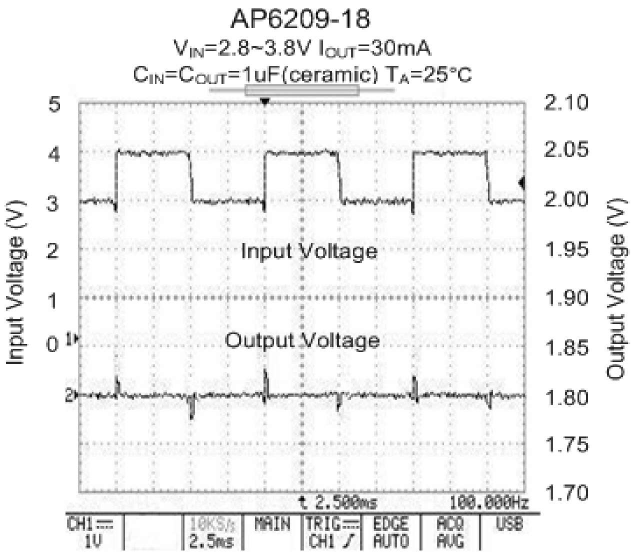


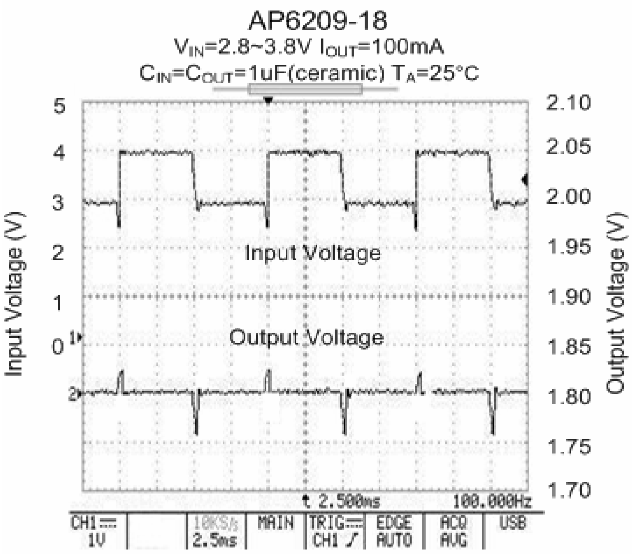


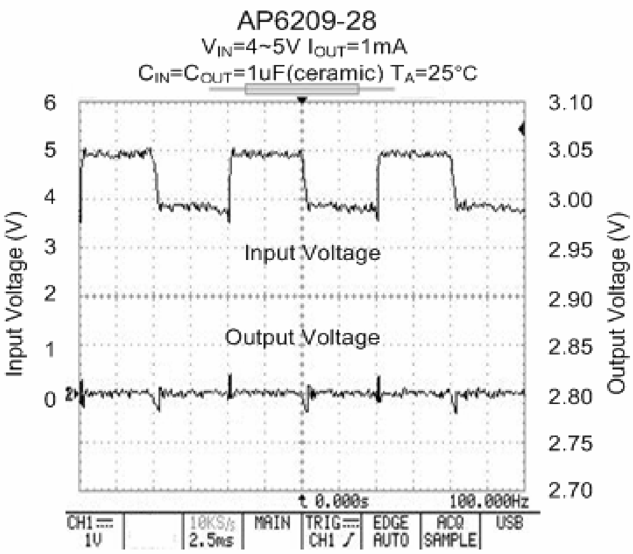


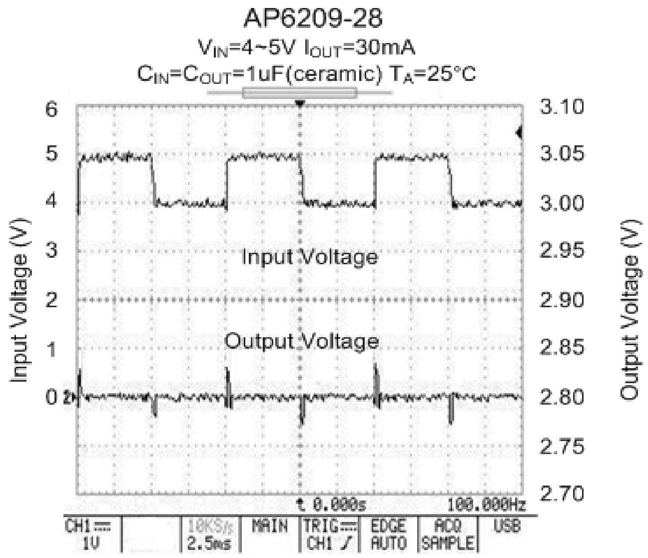
(8) Input Transient Response

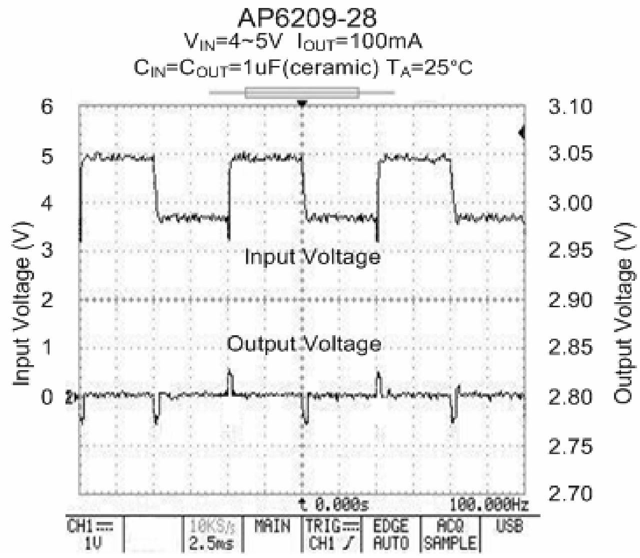




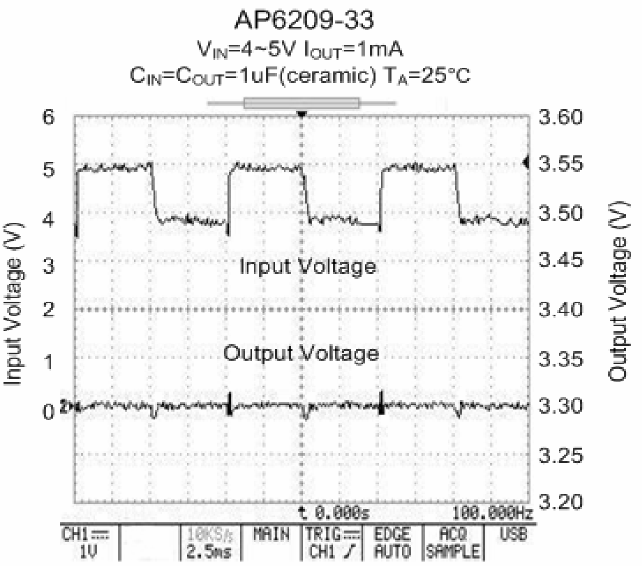


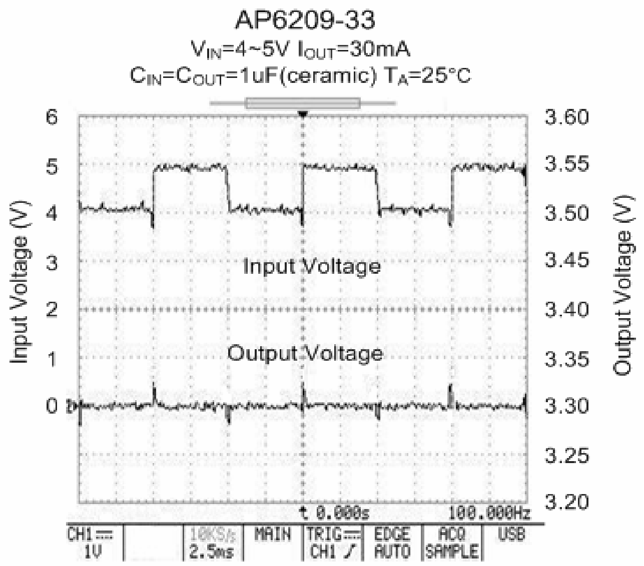


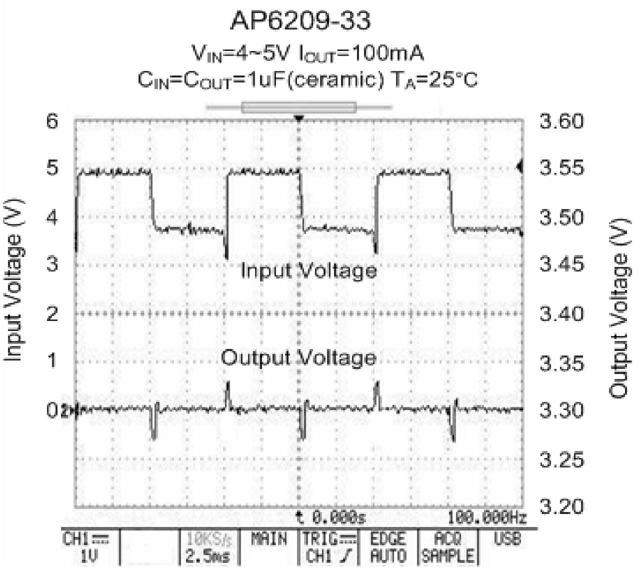




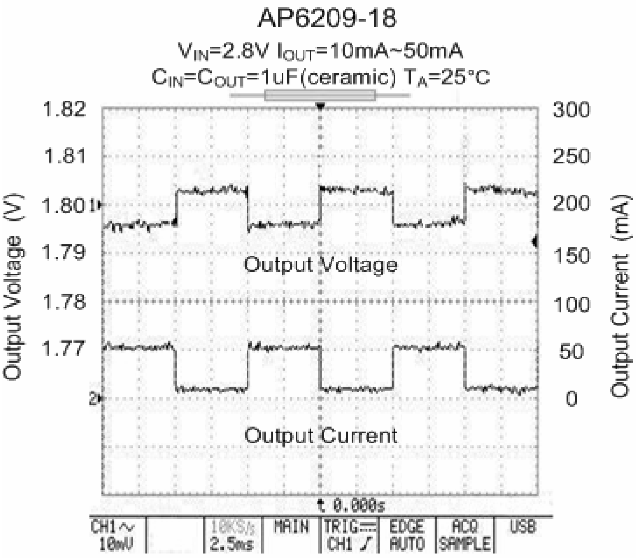
(8) Input Transient Response (Continued)

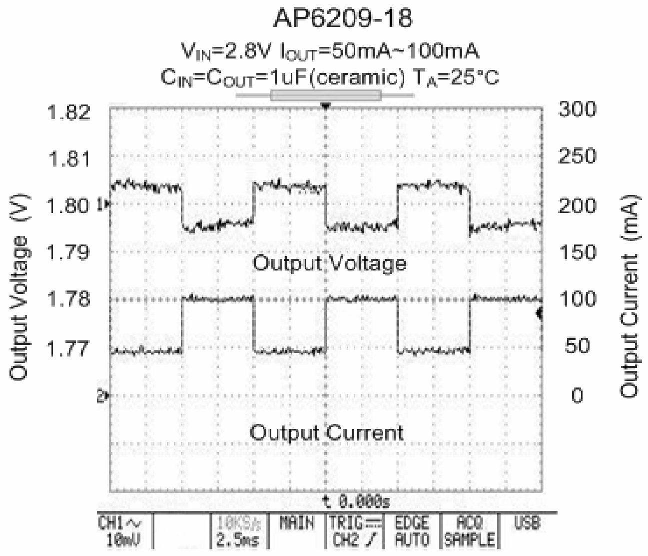


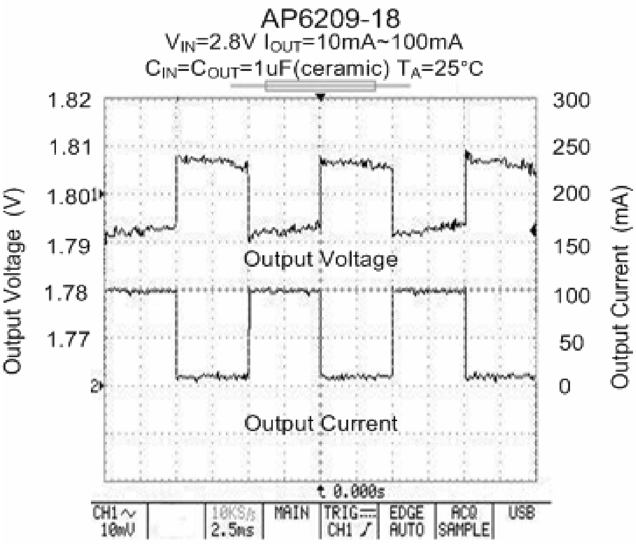


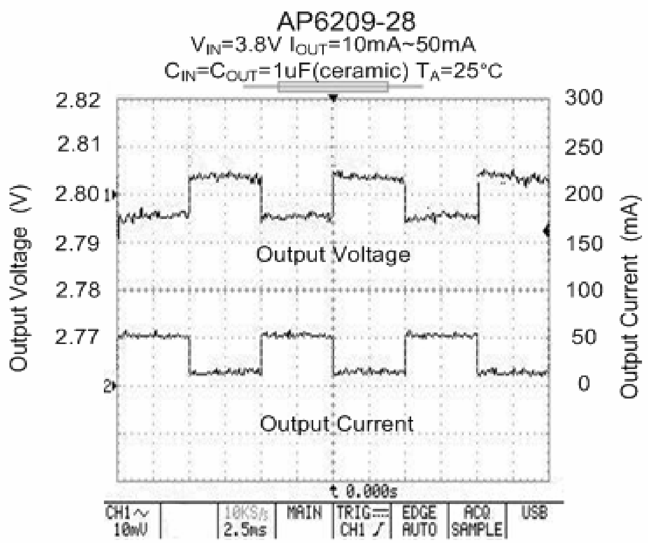


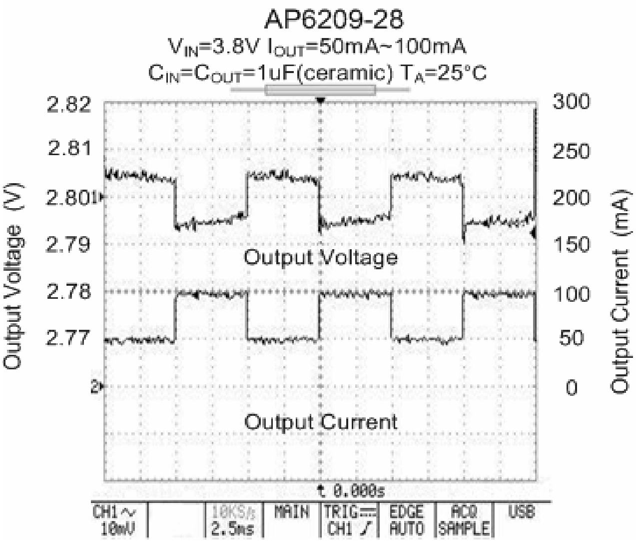
(9) Load Transient Response

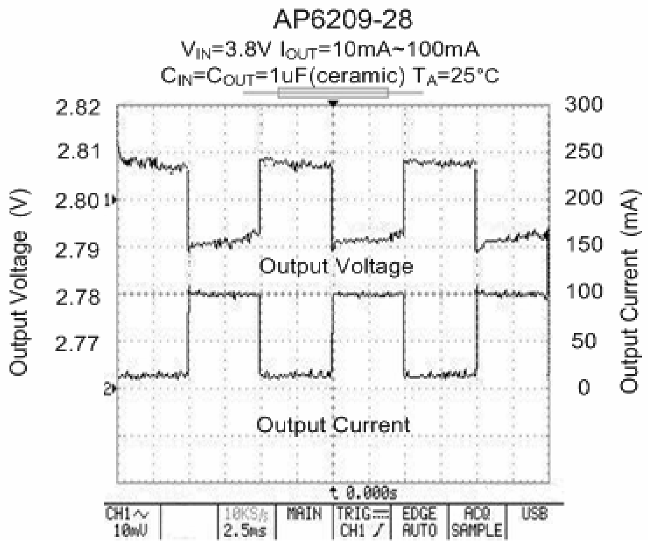




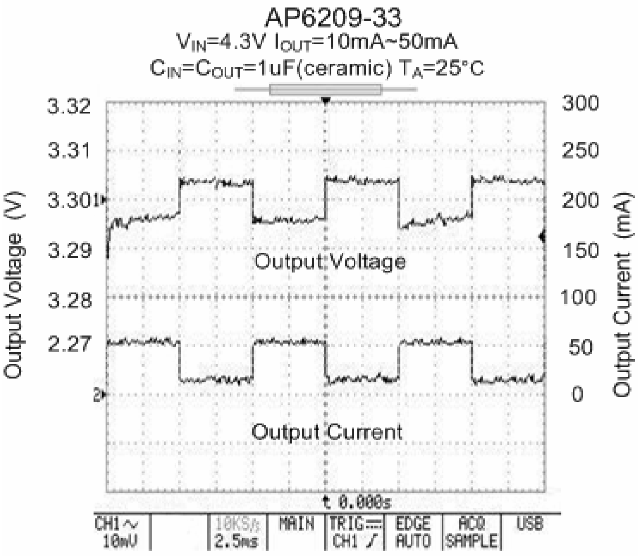


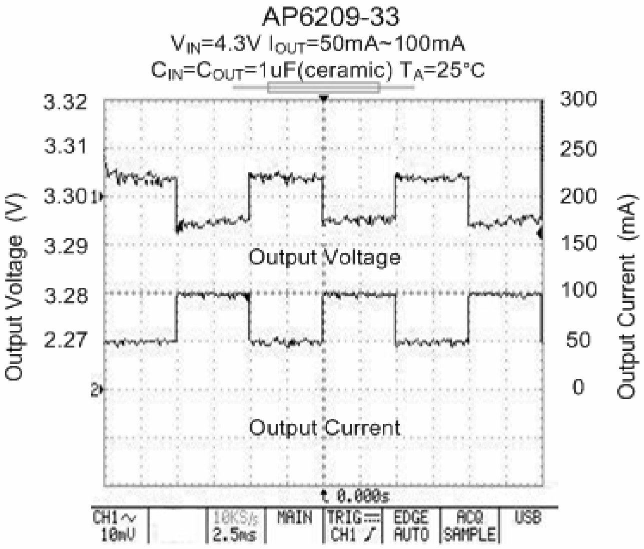


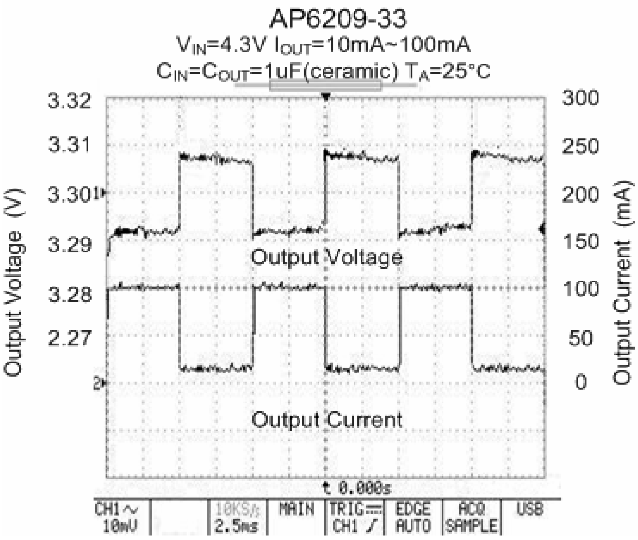




(9) Load Transient Response (Continued)





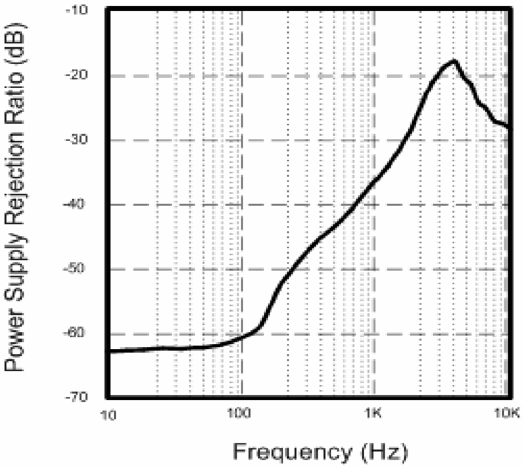


(10) Power Supply Rejection Ratio

AP6209-18

V_{IN}=2.8V+0.5$V_{PP\text{-}AC}$ I_{OUT}=1mA

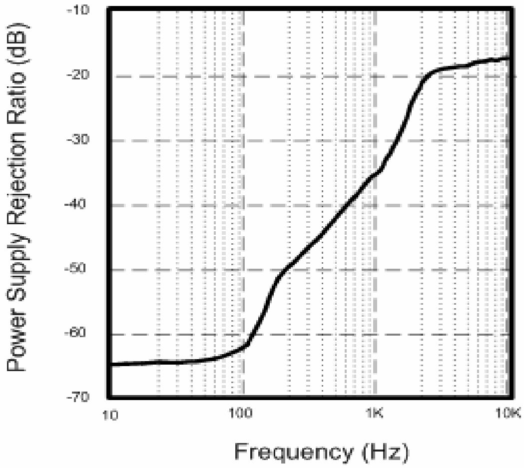
T_A=25℃ C_{IN}=1.0uF Cout=1.0uF



AP6209-18

V_{IN}=2.8V+0.5$V_{PP\text{-}AC}$ I_{OUT}=30mA

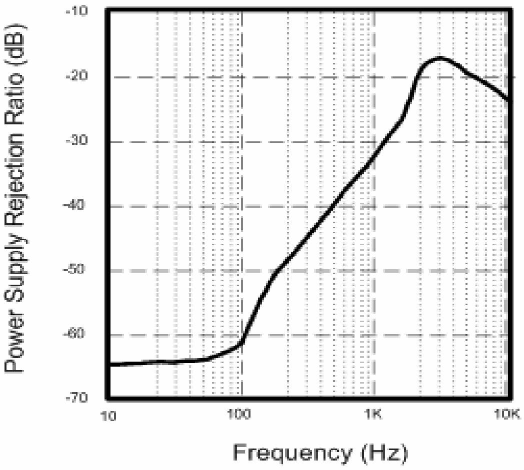
T_A=25℃ C_{IN}=1.0uF Cout=1.0uF



AP6209-28

V_{IN}=3.8V+0.5$V_{PP\text{-}AC}$ I_{OUT}=1mA

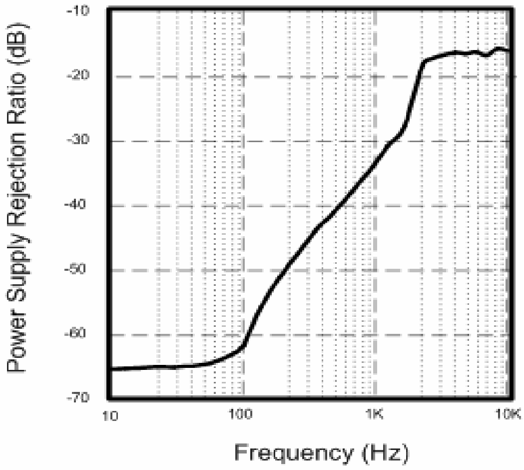
T_A=25℃ C_{IN}=1.0uF Cout=1.0uF



AP6209-28

V_{IN}=3.8V+0.5$V_{PP\text{-}AC}$ I_{OUT}=30mA

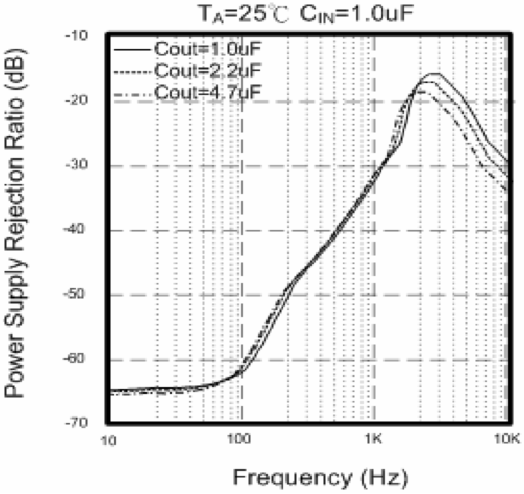
T_A=25℃ C_{IN}=1.0uF Cout=1.0uF



AP6209-33

V_{IN}=4.3V+0.5$V_{PP\text{-}AC}$ I_{OUT}=1mA

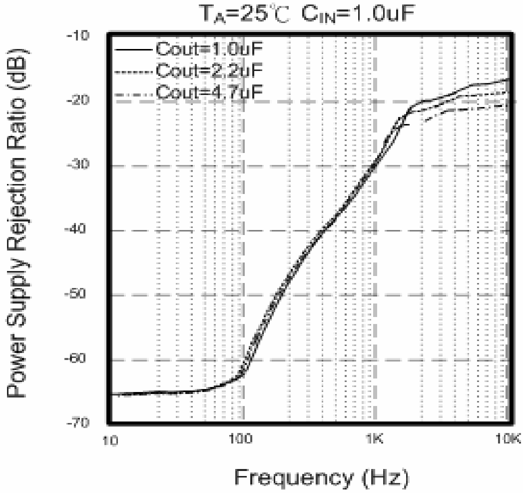
T_A=25℃ C_{IN}=1.0uF



AP6209-33

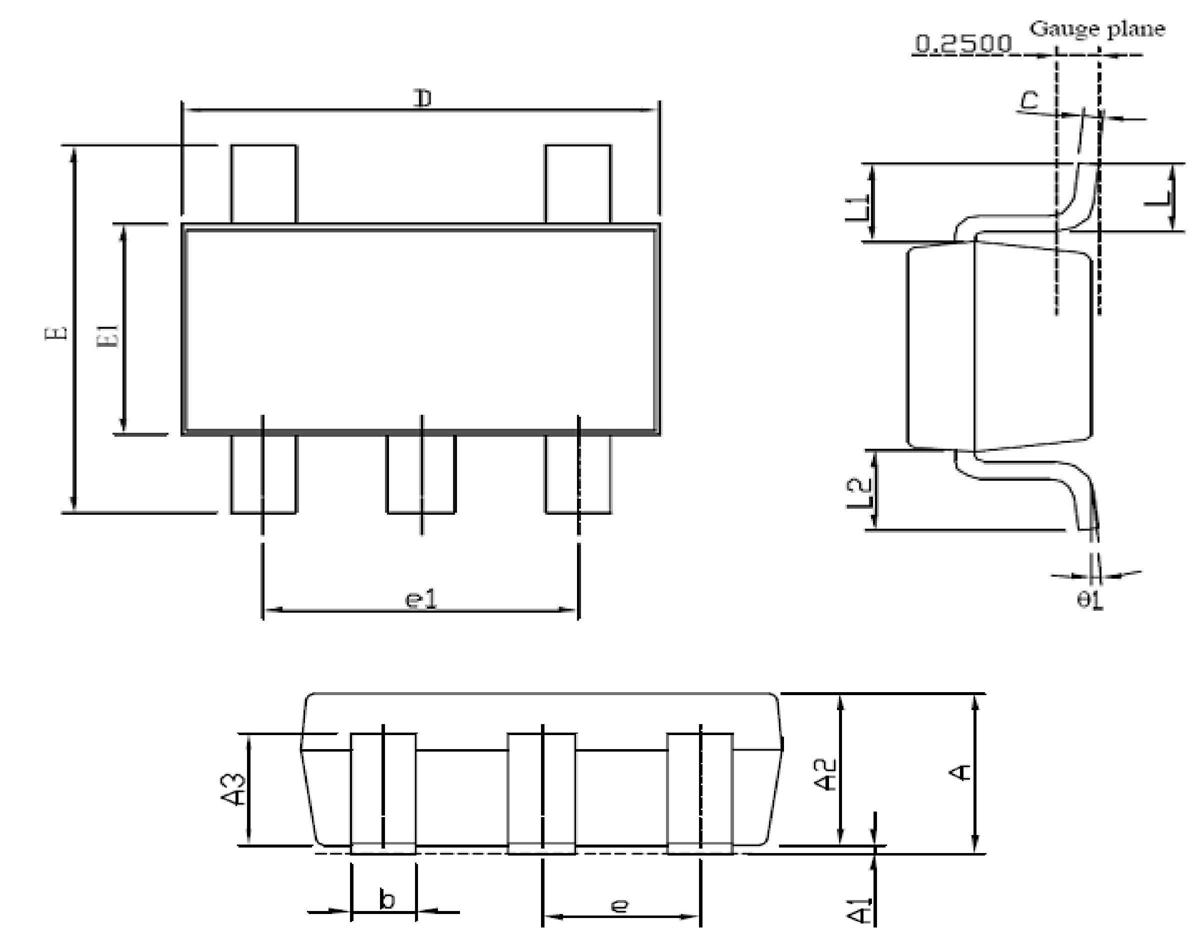
V_{IN}=4.3V+0.5$V_{PP\text{-}AC}$ I_{OUT}=30mA

T_A=25℃ C_{IN}=1.0uF



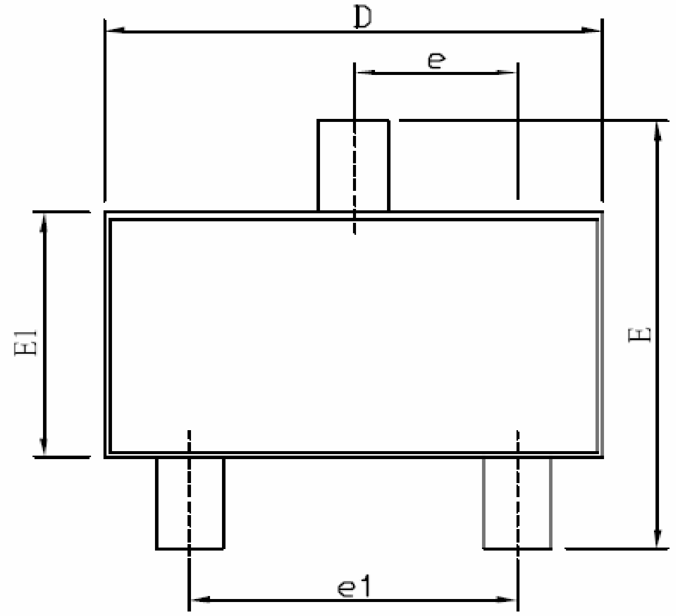
Package Outline

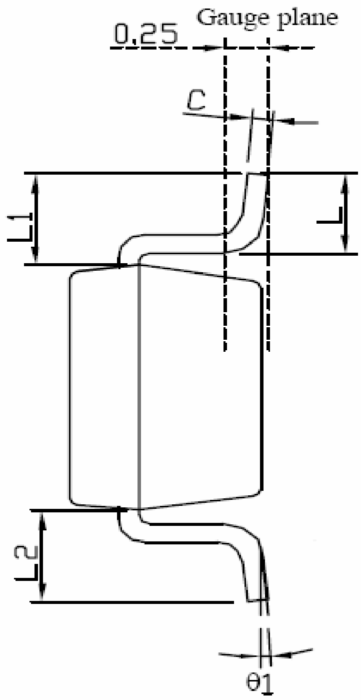
A) SOT-25

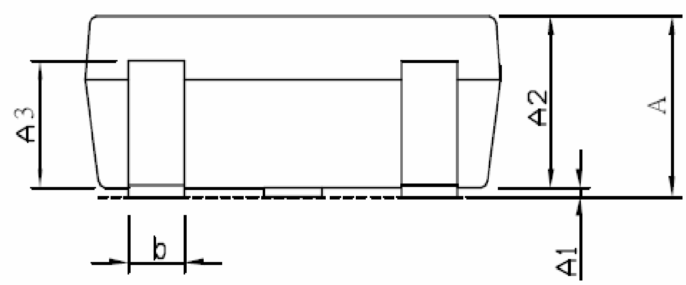


Symbols	Dimensions in Millimeters		
	Min	Nom	Max
A	1.00	1.10	1.40
A1	0.00	---	0.10
A2	1.00	1.10	1.30
A3	0.70	0.80	0.90
b	0.35	0.40	0.50
C	0.12	0.125	0.225
D	2.70	2.90	3.10
E1	1.40	1.60	1.80
e1	---	1.90(TYP)	---
E	2.60	2.80	3.00
L	0.37	---	---
θ1	1°	5°	9°
e	---	0.95(TYP)	---
L1	---	0.6(REF)	---
LI-L2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

B) SOT-23

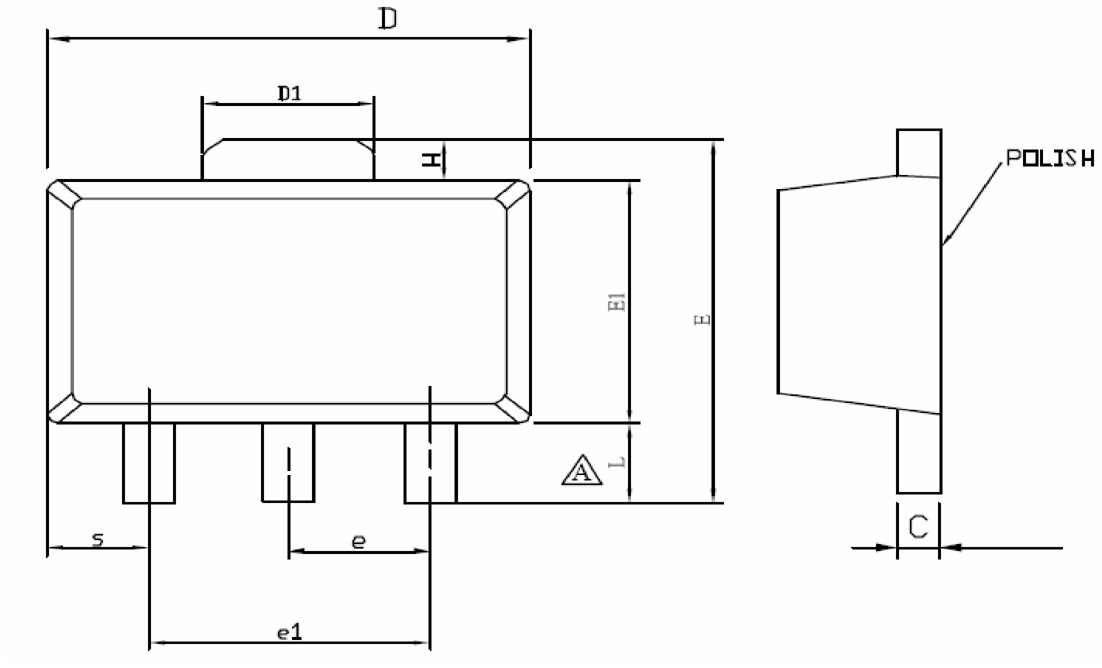


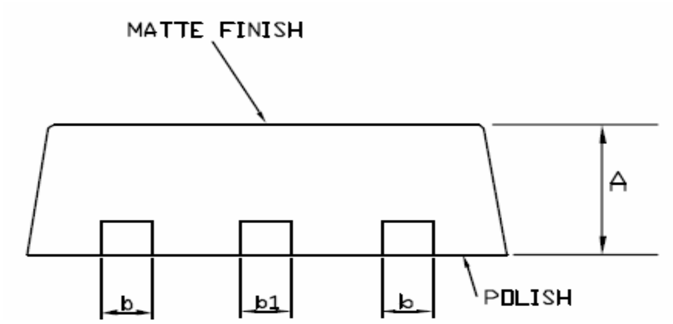




Symbols	Dimensions in Millmeters		
	Min	Nom	Max
A	1.00	1.10	1.40
A1	0.00	0.05	0.10
A2	1.00	1.10	1.30
A3	0.70	0.80	0.90
b	0.35	0.40	0.50
C	0.12	0.125	0.225
D	2.70	2.90	3.10
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	---	0.95(Typ)	---
e1	---	1.90(Typ)	---
θ1	1°	5°	9°
L	0.37	---	---
L1	---	0.6REF	---
L1-L2	---	---	0.12

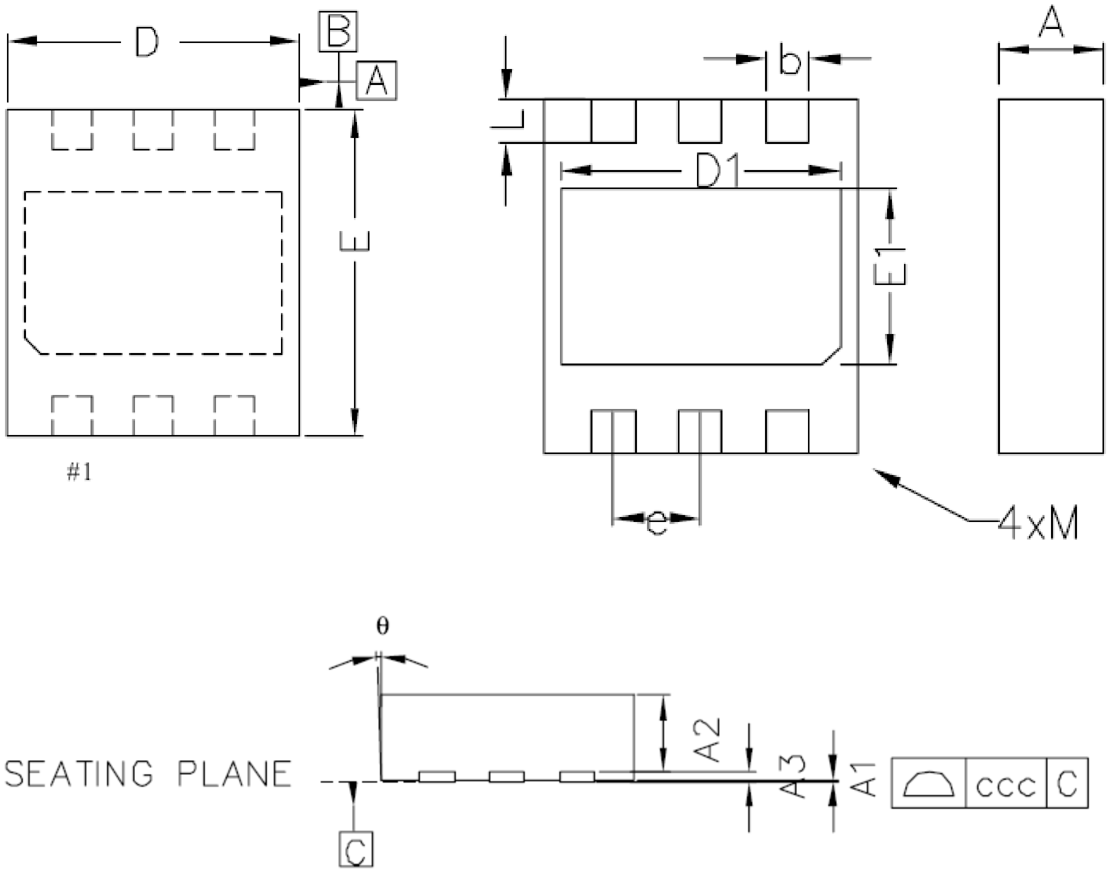
C) SOT-89-3





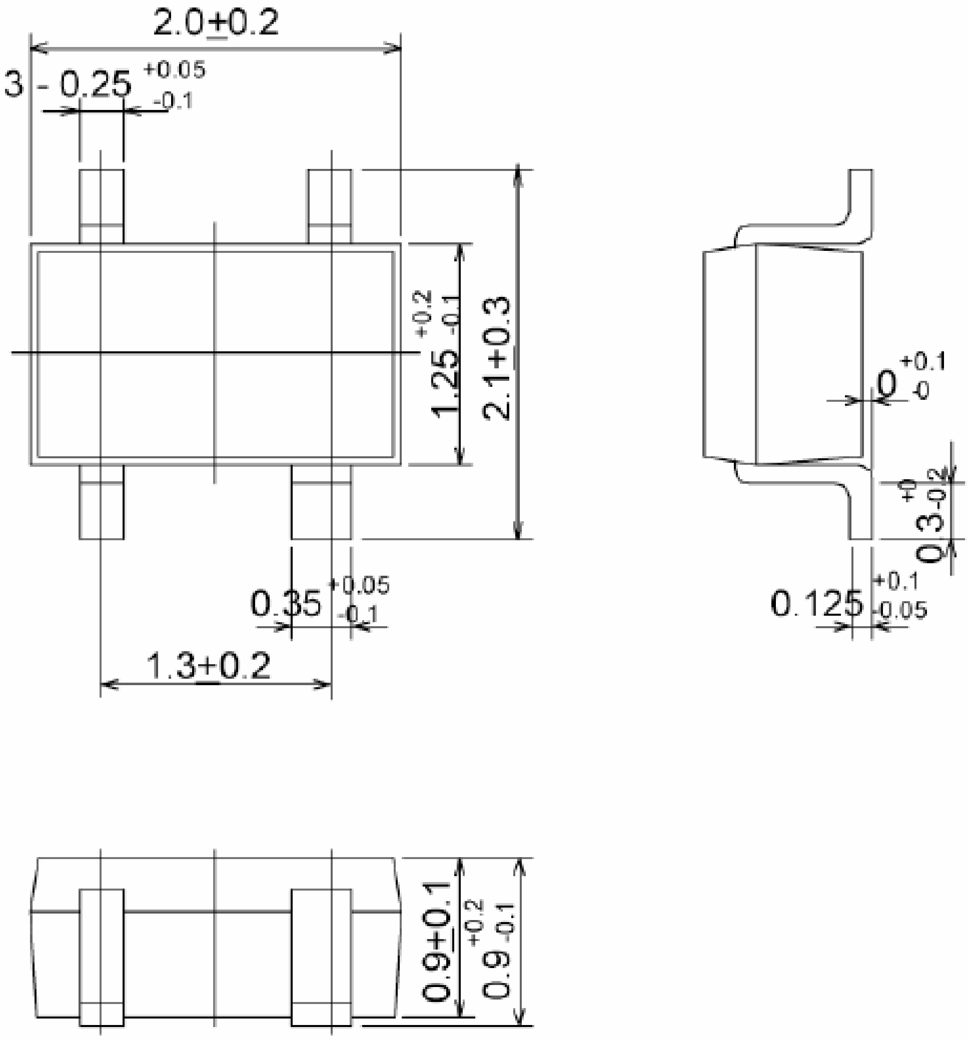
Symbol	Dimensions in millimeters			Dimensions in inches		
	Min	Nom	Max	Min	Nom	Max
A	1.40	1.50	1.60	0.055	0.059	0.063
L	0.89	1.04	1.20	0.0350	0.041	0.047
b	0.36	0.42	0.48	0.014	0.016	0.018
b1	0.41	0.47	0.53	0.016	0.018	0.020
C	0.38	0.40	0.43	0.014	0.015	0.017
D	4.40	4.50	4.60	0.173	0.177	0.181
D1	1.40	1.60	1.75	0.055	0.062	0.069
E	3.64	---	4.25	0.143	---	0.167
E1	2.40	2.50	2.60	0.094	0.098	0.102
e1	2.90	3.00	3.10	0.114	0.118	0.122
H	0.35	0.40	0.45	0.014	0.0169	0.018
S	0.65	0.75	0.85	0.026	0.030	0.034
e	1.40	1.50	1.60	0.054	0.059	0.063

D) UFN-6



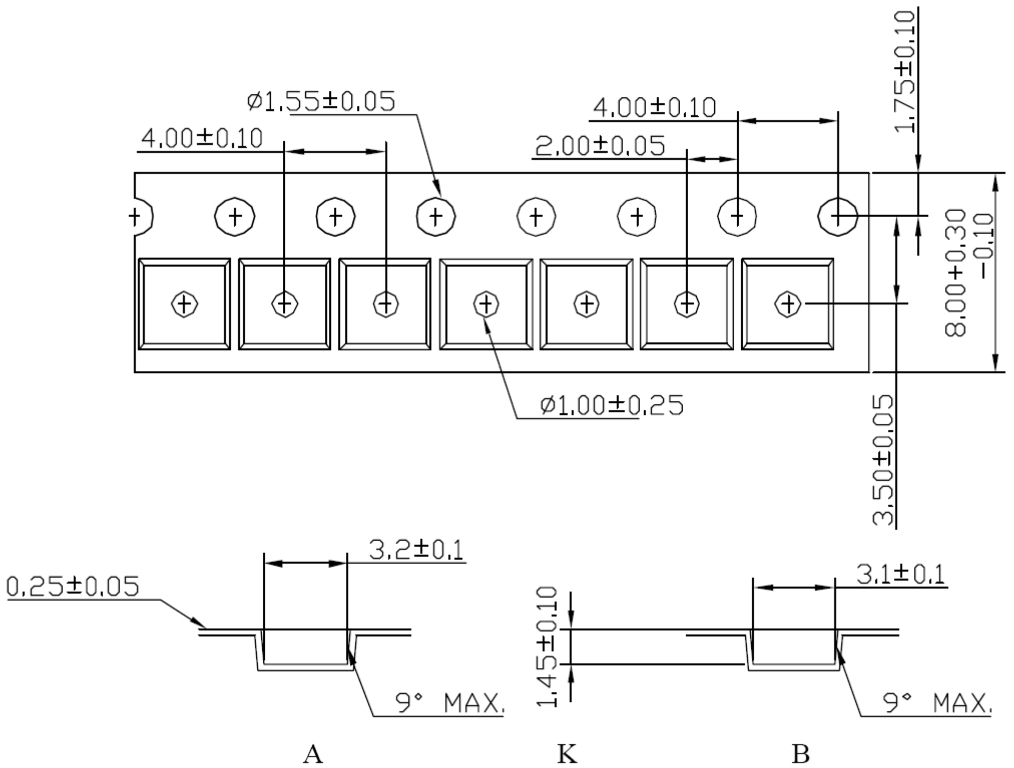
Dimension	mm		
	Min.	Nom.	Max.
A	0.55	0.60	0.65
A1	0.000	0.002	0.004
A2	0.51	0.54	0.59
A3	---	0.06REF	---
b	0.20	0.25	0.30
D	1.95	2.00	2.03
D1	---	1.60BSC	---
E	1.95	2.00	2.03
E1	---	1.0BSC	---
e	---	0.50BSC	---
L	0.20	0.25	0.30
θ	-12	---	0
ccc	---	0.08	---
M	---	---	0.05
Burr	0.00	0.03	0.06

E) SC-82

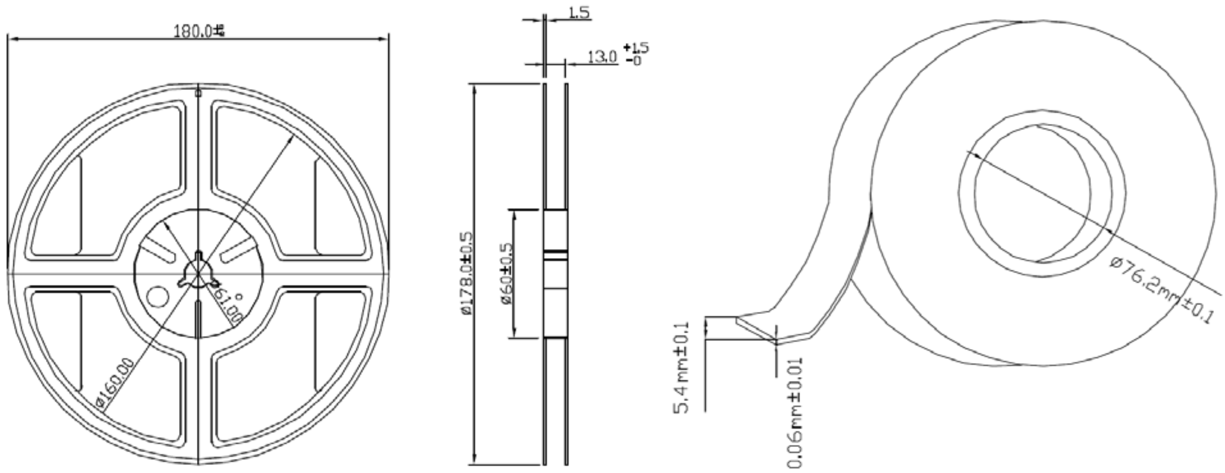

2.0±0.2
3 - 0.25 +0.05 -0.1
1.25 +0.2 -0.1
2.1±0.3
0 +0.1 -0
0.3 +0 -0.2
0.35 +0.05 -0.1
0.125 +0.1 -0.05
1.3±0.2
0.9±0.1
0.9 +0.2 -0.1

Carrier Tape & Reel Dimensions

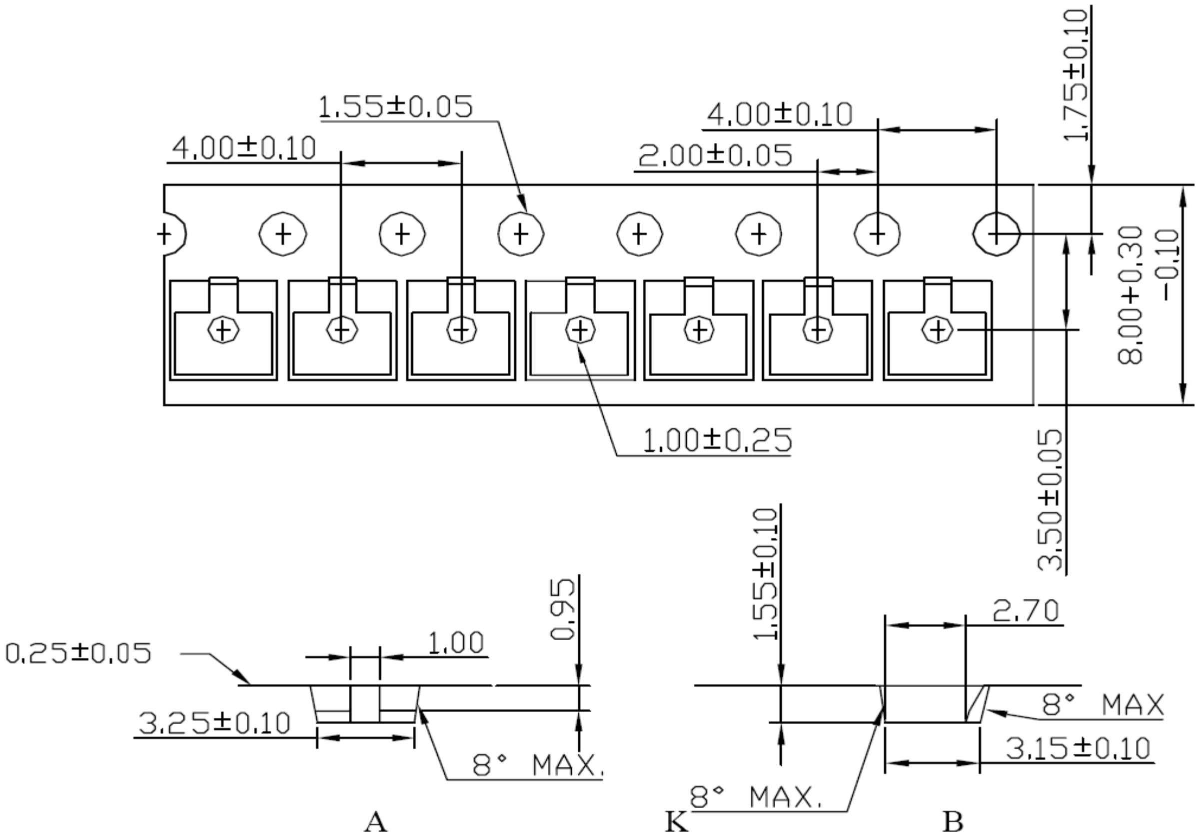
A) SOT-25



Notes:
1. Material: black advantek polystyrene.
2. Dim in mm.
3. 10 sprocket hole pitch cumulative tolerance ±0.2.
4. Camber not to exceed 1 mm in 100mm.
5. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.
6. Surface resistance less than or equal to 1.0x10e3~10 ohms/sq.
7. A and B measured on a plane 0.3mm above the bottom of the pocket.
8. K measured from a plane on the inside bottom of the pocket to the to surface of the carrier.

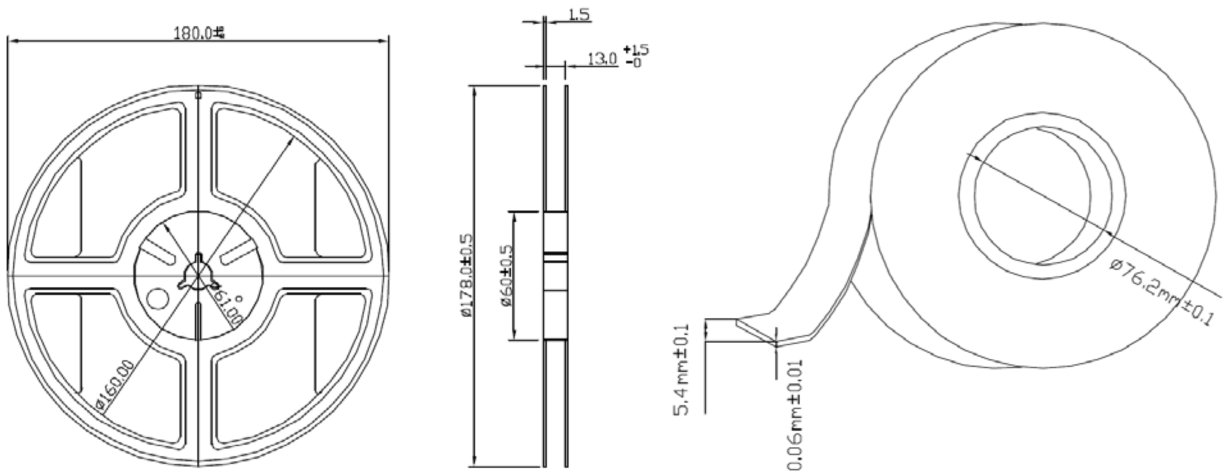


B) SOT-23

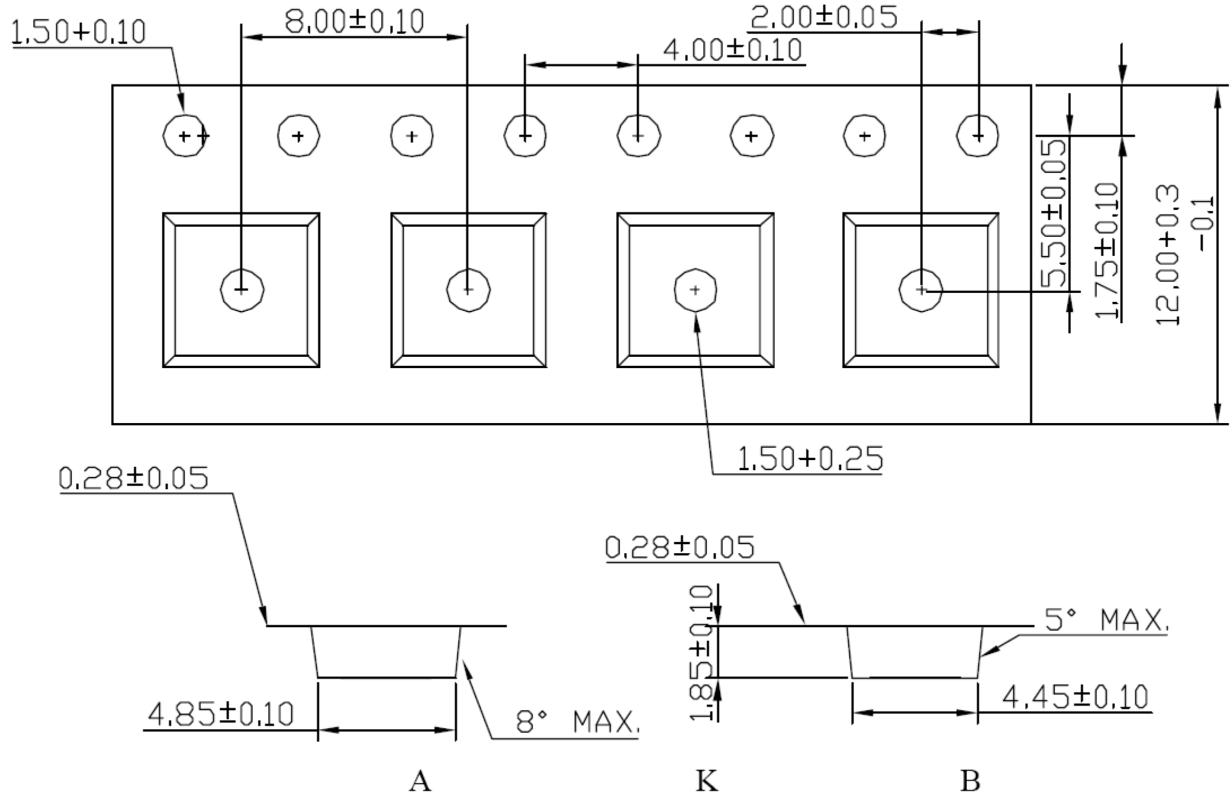


Notes:

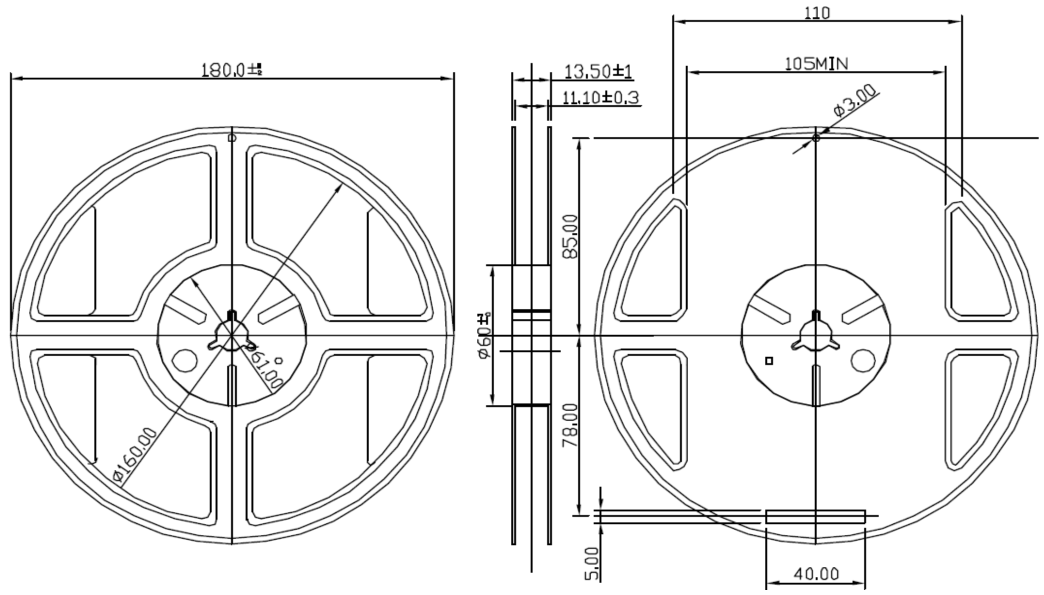
1. Material: black advantek polystyrene.
2. Dim in mm.
3. 10 sprocket hole pitch cumulative tolerance ±0.2.
4. Camber not to exceed 1 mm in 100mm.
5. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.
6. Surface resistance less than or equal to 1.0x10E3~10 ohms/sq.
7. A and B measured on a plane 0.3mm above the bottom of the pocket.
8. K measured from a plane on the inside bottom of the pocket to the top surface of the carrier.

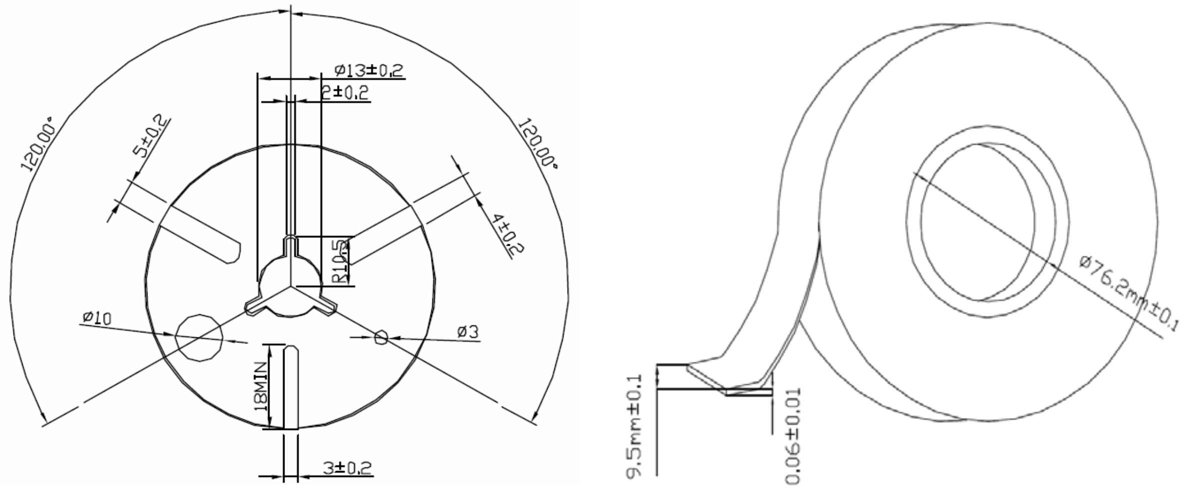


C) SOT-89-3

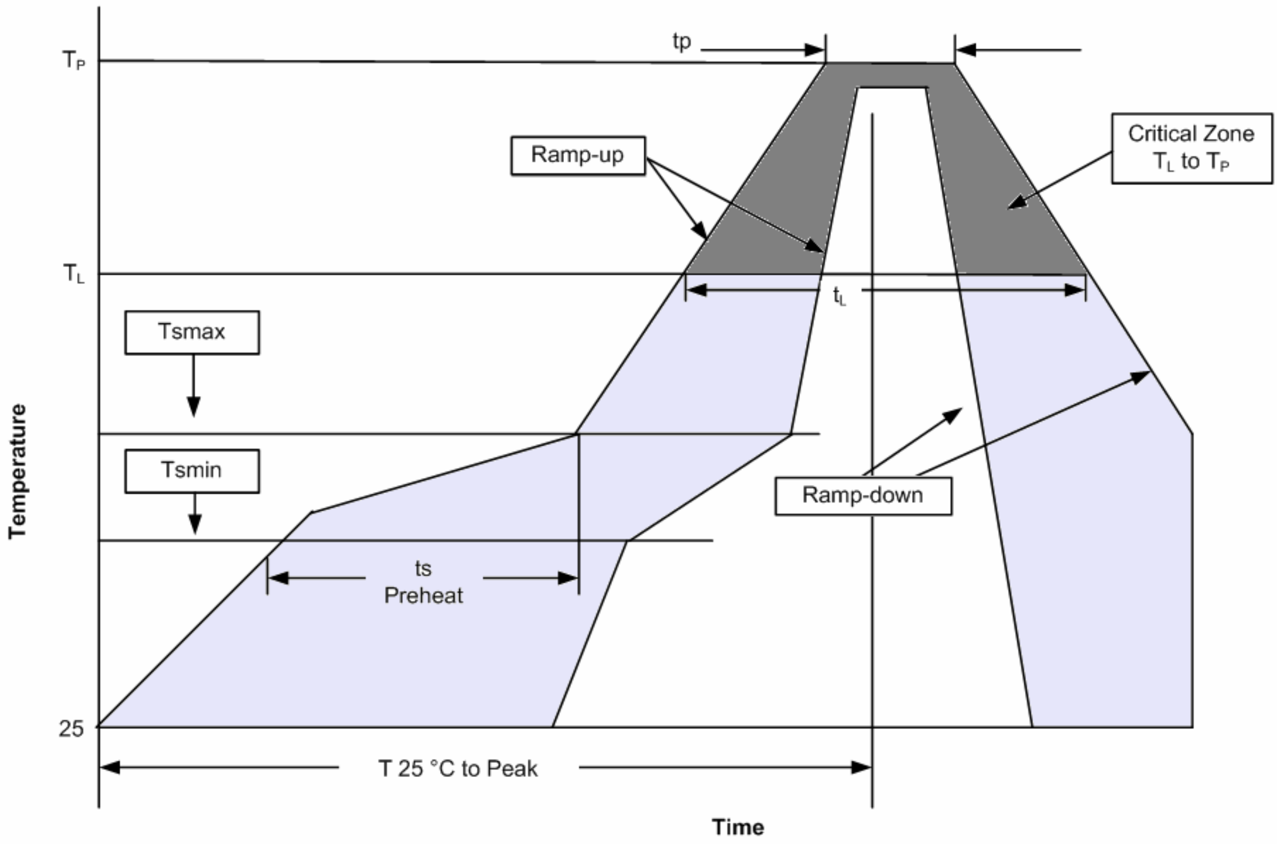


Notes:
1. Material: black advantek polystyrene.
2. Dim in mm.
3. 10 sprocket hole pitch cumulative tolerance ±0.2.
4. Camber not to exceed 1 mm in 100mm.
5. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.
6. Surface resistance less than or equal to 1.0x10E3~10 ohms/sq.
7. A and B measured on a plane 0.3mm above the bottom of the pocket.
8. K measured from a plane on the inside bottom of the pocket to the top surface of the carrier.





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

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.