500mA LOW NOISE LDO REGULATOR AP2213

General Description

The AP2213 is a 500mA output current fixed voltage regulator which provides low noise, very low dropout voltage (typically 350mV at 500mA), very low standby current (1μA maximum) and excellent power supply ripple rejection (PSRR 75dB at 100Hz) in battery powered applications, such as handsets and PDAs and in noise sensitive applications, such as RF electronics.

The AP2213 features individual logic compatible enable/shutdown control inputs, a low power shutdown mode for extended battery life, over current protection, over temperature protection, as well as reversed-battery protection.

The AP2213 has 2.5V, 3.0V and 3.3V versions.

The AP2213 is available in TO-252-2 (1), TO-252-2 (3), SOIC-8 and SOT-223 packages.

Features

- Up to 500mA Output Current
- Low Standby Current
- Low Dropout Voltage: V_{DROP}=350mV at 500mA
- High Output Accuracy: ±1%
- Good Ripple Rejection Ability: 75dB at 100Hz and I_{OUT}=100μA
- Tight Load and Line Regulation
- Low Temperature Coefficient
- Over Current Protection
- Thermal Protection
- Reversed-battery Protection
- Logic-controlled Enable

Applications

- Laptop, Notebook, and Palmtop Computer
- CD-ROM, CD-R/RW, DVD Driver
- Portable Electronic
- PC Peripheral

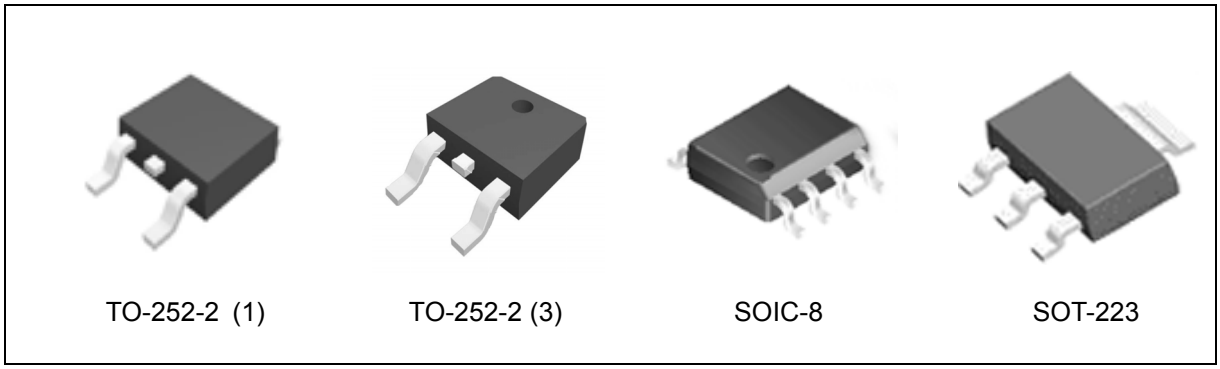


Figure 1. Package Types of AP2213

Pin Configuration

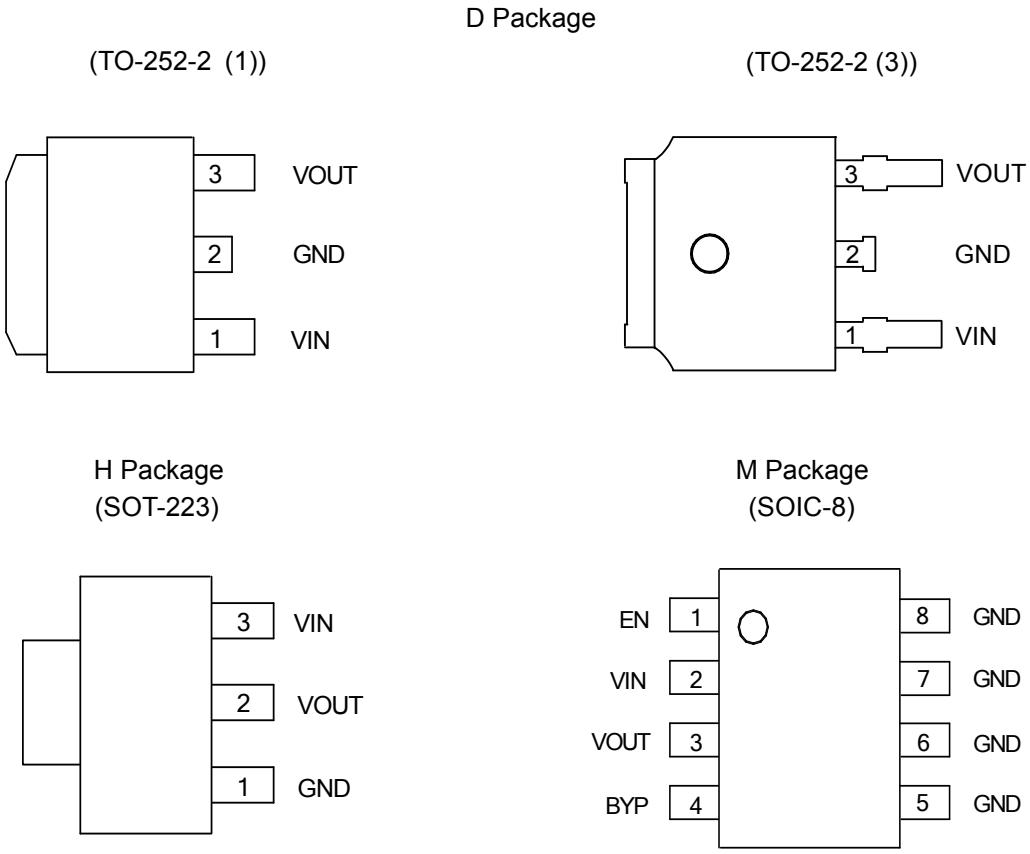


Figure 2. Pin Configuration of AP2213 (Top View)

Pin Description

Pin Number			Pin Name	Function
TO-252-2 (1)/ TO-252-2 (3)	SOIC-8	SOT-223		
3	3	2	VOUT	Regulated output voltage
2	5, 6, 7, 8	1	GND	Ground
1	2	3	VIN	Input Voltage
	1		EN	Enable input: CMOS or TTL compatible input. Logic high=enable, logic low=shutdown
	4		BYP	Bypass capacitor for low noise operation

Functional Block Diagram

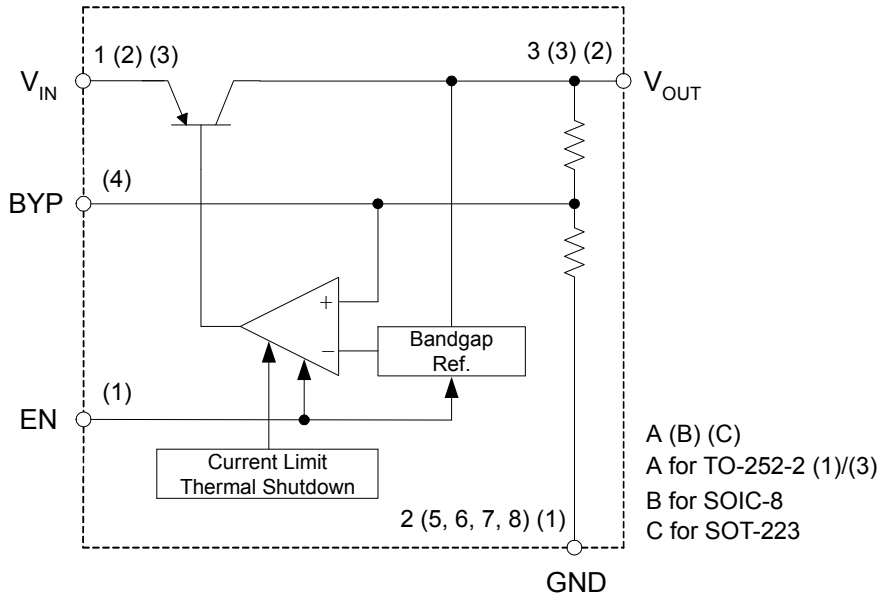
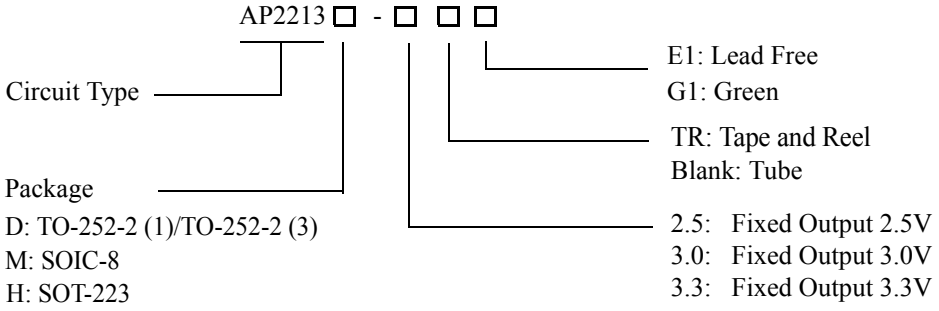


Figure 3. Functional Block Diagram of AP2213

Ordering Information



Package	Temperature Range	Part Number		Marking ID		Packing Type
		Lead Free	Green	Lead Free	Green	
TO-252-2 (1)/ TO-252-2 (3)	-40 to 125°C	AP2213D-2.5E1	AP2213D-2.5G1	AP2213D-2.5E1	AP2213D-2.5G1	Tube
		AP2213D-2.5TRE1	AP2213D-2.5TRG1	AP2213D-2.5E1	AP2213D-2.5G1	Tape & Reel
		AP2213D-3.0E1	AP2213D-3.0G1	AP2213D-3.0E1	AP2213D-3.0G1	Tube
		AP2213D-3.0TRE1	AP2213D-3.0TRG1	AP2213D-3.0E1	AP2213D-3.0G1	Tape & Reel
		AP2213D-3.3E1	AP2213D-3.3G1	AP2213D-3.3E1	AP2213D-3.3G1	Tube
		AP2213D-3.3TRE1	AP2213D-3.3TRG1	AP2213D-3.3E1	AP2213D-3.3G1	Tape & Reel
SOIC-8	-40 to 125°C	AP2213M-2.5E1	AP2213M-2.5G1	2213M-2.5E1	2213M-2.5G1	Tube
		AP2213M-2.5TRE1	AP2213M-2.5TRG1	2213M-2.5E1	2213M-2.5G1	Tape & Reel
		AP2213M-3.0E1	AP2213M-3.0G1	2213M-3.0E1	2213M-3.0G1	Tube
		AP2213M-3.0TRE1	AP2213M-3.0TRG1	2213M-3.0E1	2213M-3.0G1	Tape & Reel
		AP2213M-3.3E1	AP2213M-3.3G1	2213M-3.3E1	2213M-3.3G1	Tube
		AP2213M-3.3TRE1	AP2213M-3.3TRG1	2213M-3.3E1	2213M-3.3G1	Tape & Reel
SOT-223	-40 to 125°C	AP2213H-2.5TRE1	AP2213H-2.5TRG1	EH13C	GH13C	Tape & Reel
		AP2213H-3.0TRE1	AP2213H-3.0TRG1	EH13E	GH13E	Tape & Reel
		AP2213H-3.3TRE1	AP2213H-3.3TRG1	EH13F	GH13F	Tape & Reel

BCD Semiconductor's Pb-free products, as designated with "E1" suffix in the part number, are RoHS compliant. Products with "G1" suffix are available in green packages.

Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Value		Unit
Supply Input Voltage	V_{IN}	20		V
Enable Input Voltage	V_{EN}	20		V
Power Dissipation	P_D	Internally Limited (Thermal Protection)		W
Lead Temperature (Soldering, 10sec)	T_{LEAD}	260		°C
Junction Temperature	T_J	150		°C
Storage Temperature	T_{STG}	-65 to 150		°C
ESD (Machine Model)	ESD	300		V
Thermal Resistance (No Heatsink)	θ_{JA}	TO-252-2 (1)/TO-252-2 (3)	90	°C/W
		SOIC-8	160	
		SOT-223	108	

Note 1: Stresses greater than 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 Ratings" for extended periods may affect device reliability.

Recommended Operating Conditions

Parameter	Symbol	Min	Max	Unit
Supply Input Voltage	V_{IN}	2.5	18	V
Enable Input Voltage	V_{EN}	0	18	V
Operating Junction Temperature	T_J	-40	125	°C

Electrical Characteristics

AP2213-2.5 Electrical Characteristics

V_{IN}=3.5V, I_{OUT}=100μA, C_{IN}=1.0μF, C_{OUT}=2.2μF, V_{EN}≥2.0V, T_J=25°C, **Bold** typeface applies over -40°C≤T_J≤125°C (Note 2), unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage Accuracy	$\Delta V_{OUT}/V_{OUT}$	Variation from specified V_{OUT}	-1		1	%
			-2		**2**	
Output Voltage Temperature Coefficient (Note 3)	$\Delta V_{OUT}/\Delta T$			**120**		μV/°C
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			**48**		ppm/°C
Line Regulation	V_{RLINE}	V_{IN}=3.5V to 13.2V		1.5	4.5	mV
					12	
Load Regulation (Note 4)	V_{RLOAD}	I_{OUT}=0.1mA to 500mA		1	7	mV
					17	
Dropout Voltage (Note 5)	V_{DROP}	I_{OUT}=100μA		15	50	mV
					70	
		I_{OUT}=50mA		110	150	
					230	
		I_{OUT}=100mA		140	250	
					300	
		I_{OUT}=150mA		165	275	
					350	
		I_{OUT}=300mA		250	400	
					500	
		I_{OUT}=500mA		350	600	
					700	
Standby Current	I_{STD}	V_{EN}≤0.4V (shutdown)		0.01	1	μA
		V_{EN}≤0.18V (shutdown)			**5**	
Ground Pin Current (Note 6)	I_{GND}	V_{EN}≥2.0V, I_{OUT}=100μA		100	150	μA
					180	
		V_{EN}≥2.0V, I_{OUT}=50mA		350	600	
					800	
		V_{EN}≥2.0V, I_{OUT}=150mA		1.3	1.9	mA
					2.5	
		V_{EN}≥2.0V, I_{OUT}=300mA		4	10	
					15	
		V_{EN}≥2.0V, I_{OUT}=500mA		11	20	
					28	

Electrical Characteristics (Continued)

AP2213-2.5 Electrical Characteristics

V_{IN}=3.5V, I_{OUT}=100μA, C_{IN}=1.0μF, C_{OUT}=2.2μF, V_{EN}≥2.0V, T_J=25°C, **Bold** typeface applies over -40°C≤T_J≤125°C (Note 2), unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Ripple Rejection	PSRR	f=100Hz, I_{OUT}=100μA		75		dB
Current Limit	I_{LIMIT}	V_{OUT}=0V		**700**	1000	mA
Output Noise	e_{no}	I_{OUT}=50mA, C_{OUT}=2.2μF, 100pF from BYP to GND		260		$nV/\sqrt{Hz}$
Enable Input Logic-low Voltage	V_{IL}	Regulator shutdown			0.4	V
					0.18	
Enable Input Logic-high Voltage	V_{IH}	Regulator enabled	**2.0**			V
Enable Input Logic-low Current	I_{IL}	V_{IL}≤0.4V		0.01	1	μA
		V_{IL}≤0.18V			**2**	
Enable Input Logic-high Current	I_{IH}	V_{IL}≥2.0V		5	20	μA
		V_{IL}≥2.0V			**25**	
Thermal Resistance	θ_{JC}	TO-252-2 (1)/TO-252-2 (3)		20		°C/W
		SOIC-8		45		
		SOT-223		31		

Note 2: Specifications in bold type are limited to -40°C≤T_J≤125°C. Limits over temperature are guaranteed by design, but not tested in production.

Note 3: Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

Note 4: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1mA to 500mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

Note 5: Dropout voltage is defined as the input to output differential at which the output voltage drops 1% (T_J=25°C) or 2% (-40°C≤T_J≤125°C) below its nominal value measured at 1V differential.

Note 6: Ground pin current is the regulator quiescent current plus pass transistor base current. The total current drawn from the

Electrical Characteristics (Continued)

AP2213-3.0 Electrical Characteristics

V_{IN}=4V, I_{OUT}=100μA, C_{IN}=1.0μF, C_{OUT}=2.2μF, V_{EN}≥2.0V, T_J=25°C, **Bold** typeface applies over -40°C≤T_J≤125°C (Note 2), unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage Accuracy	$\Delta V_{OUT}/V_{OUT}$	Variation from specified V_{OUT}	-1		1	%
			-2		**2**	
Output Voltage Temperature Coefficient (Note 3)	$\Delta V_{OUT}/\Delta T$			**120**		μV/°C
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			**40**		ppm/°C
Line Regulation	V_{RLINE}	V_{IN}=4V to 13.2V		1.5	4.5	mV
					12	
Load Regulation (Note 4)	V_{RLOAD}	I_{OUT}=0.1mA to 500mA		1	8	mV
					17	
Dropout Voltage (Note 5)	V_{DROP}	I_{OUT}=100μA		15	50	mV
					70	
		I_{OUT}=50mA		110	150	
					230	
		I_{OUT}=100mA		140	250	
					300	
		I_{OUT}=150mA		165	275	
					350	
		I_{OUT}=300mA		250	400	
					500	
		I_{OUT}=500mA		350	600	
					700	
Standby Current	I_{STD}	V_{EN}≤0.4V (shutdown)		0.01	1	μA
		V_{EN}≤0.18V (shutdown)			**5**	
Ground Pin Current (Note 6)	I_{GND}	V_{EN}≥2.0V, I_{OUT}=100μA		100	150	μA
					180	
		V_{EN}≥2.0V, I_{OUT}=50mA		350	600	
					800	
		V_{EN}≥2.0V, I_{OUT}=150mA		1.3	1.9	mA
					2.5	
		V_{EN}≥2.0V, I_{OUT}=300mA		4	10	
					15	
		V_{EN}≥2.0V, I_{OUT}=500mA		11	20	
					28	

Electrical Characteristics (Continued)

AP2213-3.0 Electrical Characteristics

V_{IN}=4V, I_{OUT}=100μA, C_{IN}=1.0μF, C_{OUT}=2.2μF, V_{EN}≥2.0V, T_J=25°C, **Bold** typeface applies over -40°C≤T_J≤125°C (Note 2), unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Ripple Rejection	PSRR	f=100Hz, I_{OUT}=100μA		75		dB
Current Limit	I_{LIMIT}	V_{OUT}=0V		**700**	1000	mA
Output Noise	e_{no}	I_{OUT}=50mA, C_{OUT}=2.2μF, 100pF from BYP to GND		260		$nV/\sqrt{Hz}$
Enable Input Logic-low Voltage	V_{IL}	Regulator shutdown			0.4	V
					0.18	
Enable Input Logic-high Voltage	V_{IH}	Regulator enabled	**2.0**			V
Enable Input Logic-low Current	I_{IL}	V_{IL}≤0.4V		0.01	1	μA
		V_{IL}≤0.18V			**2**	
Enable Input Logic-high Current	I_{IH}	V_{IL}≥2.0V		5	20	μA
		V_{IL}≥2.0V			**25**	
Thermal Resistance	θ_{JC}	TO-252-2 (1)/TO-252-2 (3)		20		°C/W
		SOIC-8		45		
		SOT-223		31		

Note 2: Specifications in bold type are limited to -40°C≤T_J≤125°C. Limits over temperature are guaranteed by design, but not tested in production.

Note 3: Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

Note 4: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1mA to 500mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

Note 5: Dropout voltage is defined as the input to output differential at which the output voltage drops 1% (T_J=25°C) or 2% (-40°C≤T_J≤125°C) below its nominal value measured at 1V differential.

Note 6: Ground pin current is the regulator quiescent current plus pass transistor base current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

Electrical Characteristics (Continued)

AP2213-3.3 Electrical Characteristics

V_{IN}=4.3V, I_{OUT}=100μA, C_{IN}=1.0μF, C_{OUT}=2.2μF, V_{EN}≥2.0V, T_J=25°C, **Bold** typeface applies over -40°C≤T_J≤125°C (Note 2), unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage Accuracy	$\Delta V_{OUT}/V_{OUT}$	Variation from specified V_{OUT}	-1		1	%
			-2		**2**	
Output Voltage Temperature Coefficient (Note 3)	$\Delta V_{OUT}/\Delta T$			**120**		μV/°C
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			**36.3**		ppm/°C
Line Regulation	V_{RLINE}	V_{IN}=4.3V to 13.2V		1.5	4.5	mV
					12	
Load Regulation (Note 4)	V_{RLOAD}	I_{OUT}=0.1mA to 500mA		1	9	mV
					18	
Dropout Voltage (Note 5)	V_{DROP}	I_{OUT}=100μA		15	50	mV
					70	
		I_{OUT}=50mA		110	150	
					230	
		I_{OUT}=100mA		140	250	
					300	
		I_{OUT}=150mA		165	275	
					350	
		I_{OUT}=300mA		250	400	
					500	
		I_{OUT}=500mA		350	600	
					700	
Standby Current	I_{STD}	V_{EN}≤0.4V (shutdown)		0.01	1	μA
		V_{EN}≤0.18V (shutdown)			**5**	
Ground Pin Current (Note 6)	I_{GND}	V_{EN}≥2.0V, I_{OUT}=100μA		100	150	μA
					180	
		V_{EN}≥2.0V, I_{OUT}=50mA		350	600	
					800	
		V_{EN}≥2.0V, I_{OUT}=150mA		1.3	1.9	mA
					2.5	
		V_{EN}≥2.0V, I_{OUT}=300mA		4	10	
					15	
		V_{EN}≥2.0V, I_{OUT}=500mA		11	20	
					28	

Electrical Characteristics (Continued)

AP2213-3.3 Electrical Characteristics

V_{IN}=4.3V, I_{OUT}=100μA, C_{IN}=1.0μF, C_{OUT}=2.2μF, V_{EN}≥2.0V, T_J=25°C, **Bold** typeface applies over -40°C≤T_J≤125°C (Note 2), unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Ripple Rejection	PSRR	f=100Hz, I_{OUT}=100μA		75		dB
Current Limit	I_{LIMIT}	V_{OUT}=0V		**700**	1000	mA
Output Noise	e_{no}	I_{OUT}=50mA, C_{OUT}=2.2μF, 100pF from BYP to GND		260		$nV/\sqrt{Hz}$
Enable Input Logic-low Voltage	V_{IL}	Regulator shutdown			0.4	V
					0.18	
Enable Input Logic-high Voltage	V_{IH}	Regulator enabled	**2.0**			V
Enable Input Logic-low Current	I_{IL}	V_{IL}≤0.4V		0.01	1	μA
		V_{IL}≤0.18V			**2**	
Enable Input Logic-high Current	I_{IH}	V_{IL}≥2.0V		5	20	μA
		V_{IL}≥2.0V			**25**	
Thermal Resistance	θ_{JC}	TO-252-2 (1)/TO-252-2 (3)		20		°C/W
		SOIC-8		45		
		SOT-223		31		

Note 2: Specifications in bold type are limited to -40°C≤T_J≤125°C. Limits over temperature are guaranteed by design, but not tested in production.

Note 3: Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

Note 4: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1mA to 500mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

Note 5: Dropout voltage is defined as the input to output differential at which the output voltage drops 1% (T_J=25°C) or 2% (-40°C≤T_J≤125°C) below its nominal value measured at 1V differential.

Note 6: Ground pin current is the regulator quiescent current plus pass transistor base current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

Typical Performance Characteristics

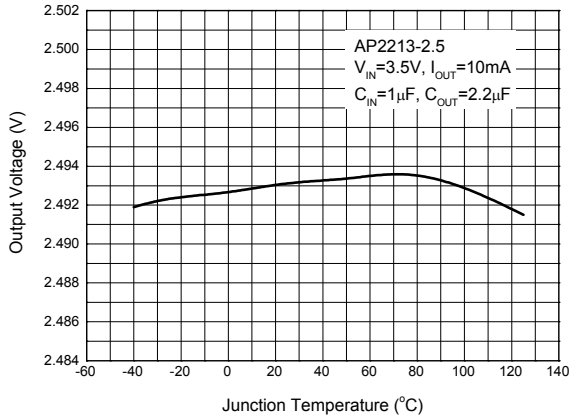


Figure 4. Output Voltage vs. Junction Temperature

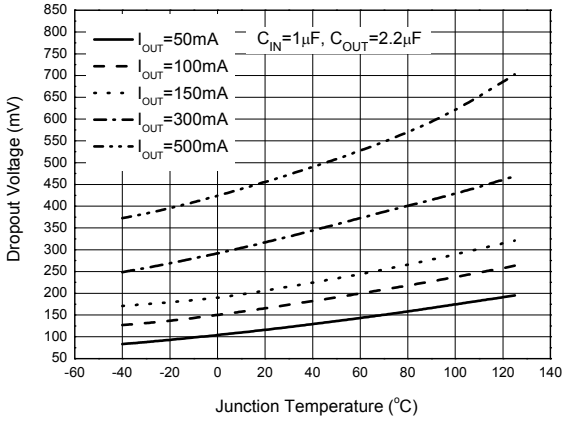


Figure 5. Dropout Voltage vs. Junction Temperature

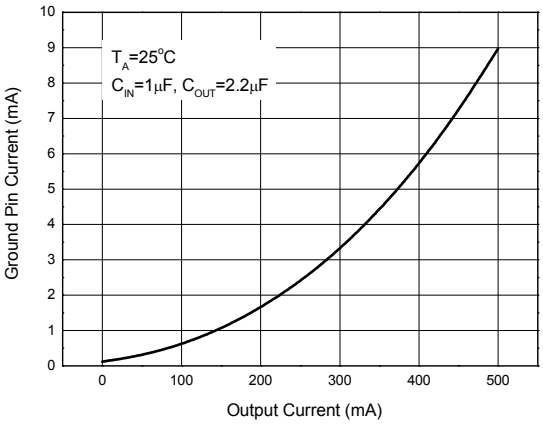


Figure 6. Ground Pin Current vs. Output Current

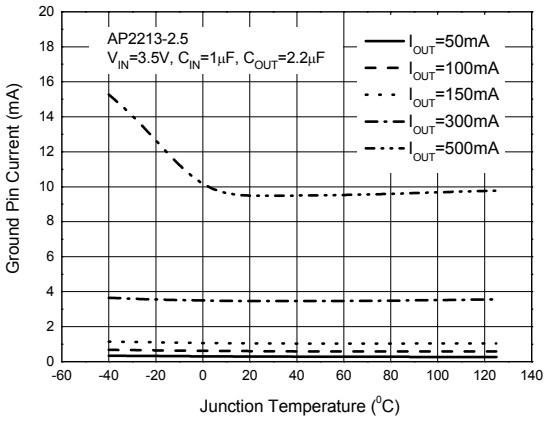


Figure 7. Ground Pin Current vs. Junction Temperature

Typical Performance Characteristics (Continued)

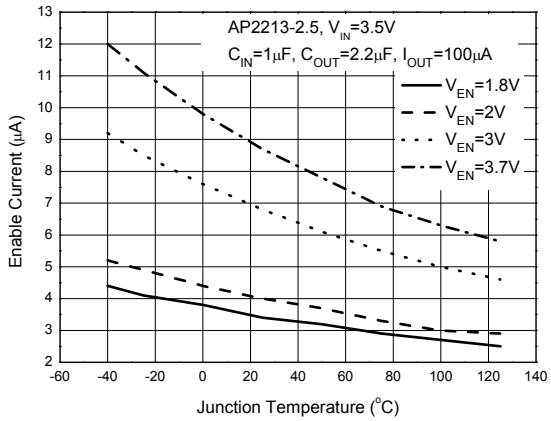


Figure 8. Enable Current vs. Junction Temperature

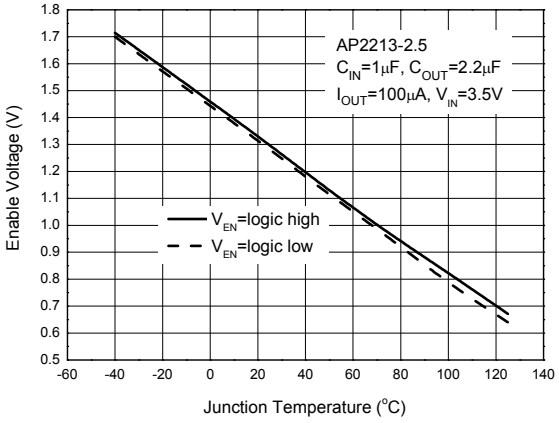


Figure 9. Enable Voltage vs. Junction Temperature

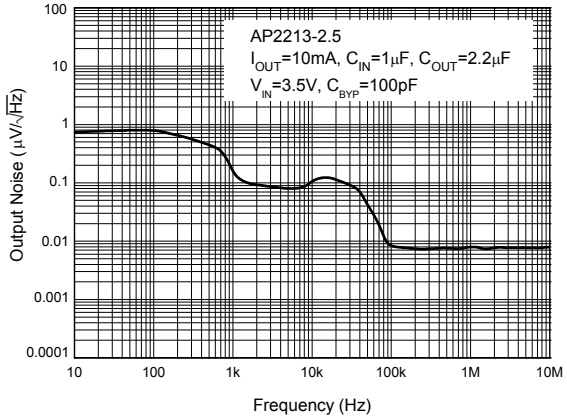


Figure 10. Output Noise vs. Frequency

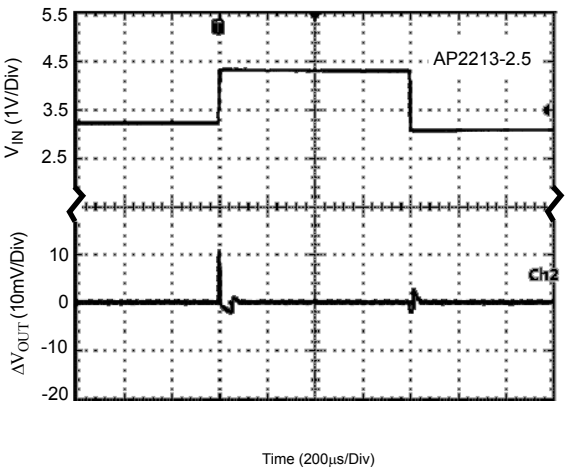


Figure 11. Line Transient
(Conditions: V_{IN}=3.4 to 4.4V, V_{EN}=2V, I_{OUT}=100μA, C_{BYP}=100pF, C_{OUT}=2.2μF)

Typical Performance Characteristics (Continued)

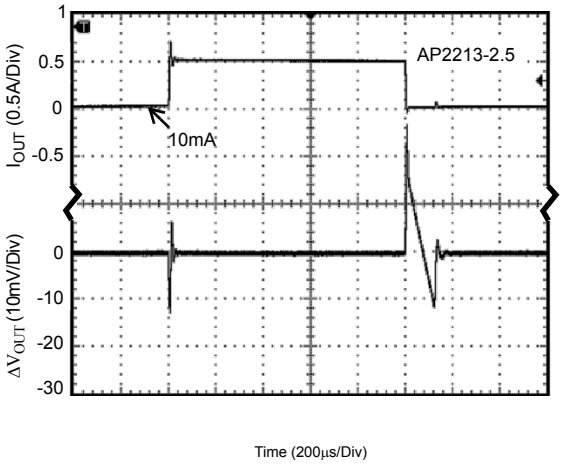


Figure 12. Load Transient
(Conditions: V_{IN}=3.5V, C_{BYP}=100pF, V_{EN}=2V, I_{OUT}=10 to 500mA, C_{IN}=1μF, C_{OUT}=2.2μF)

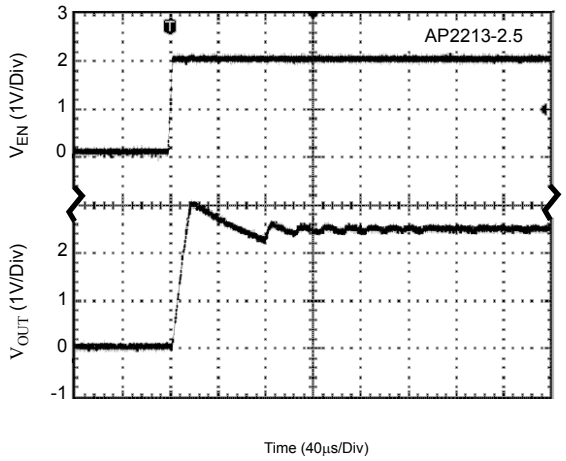


Figure 13. V_{EN} vs. V_{OUT}
(Conditions: V_{EN}=0 to 2V, V_{IN}=3.5V, I_{OUT}=30mA, C_{BYP}=open, C_{IN}=1μF, C_{OUT}=2.2μF)

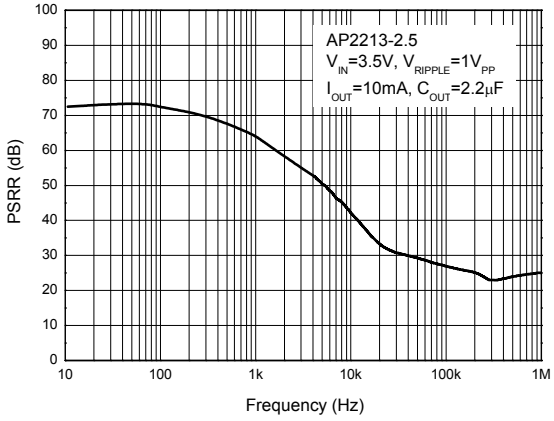


Figure 14. PSRR vs. Frequency

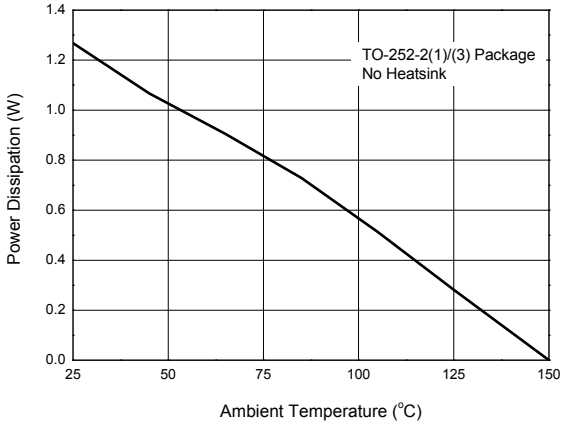


Figure 15. Power Dissipation vs. Ambient Temperature

Typical Performance Characteristics (Continued)

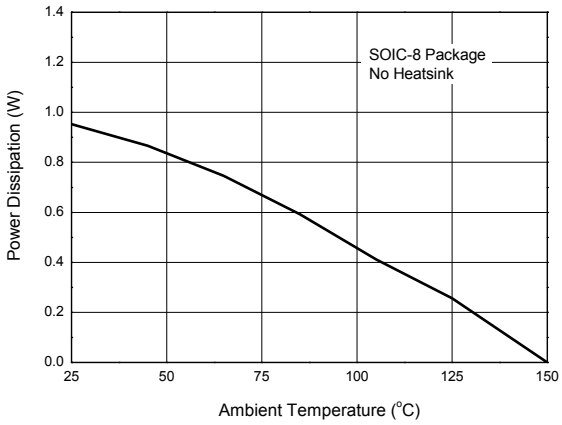


Figure 16. Power Dissipation vs. Ambient Temperature

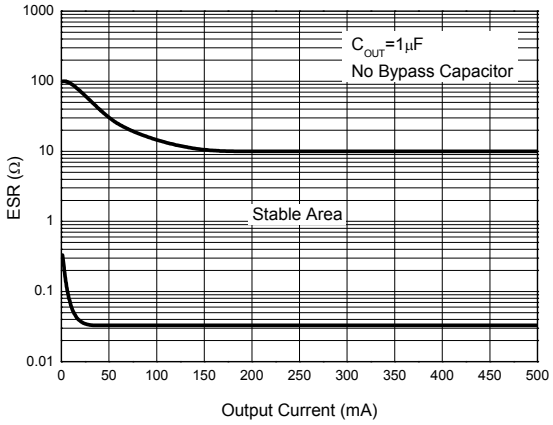


Figure 17. ESR vs. Output Current

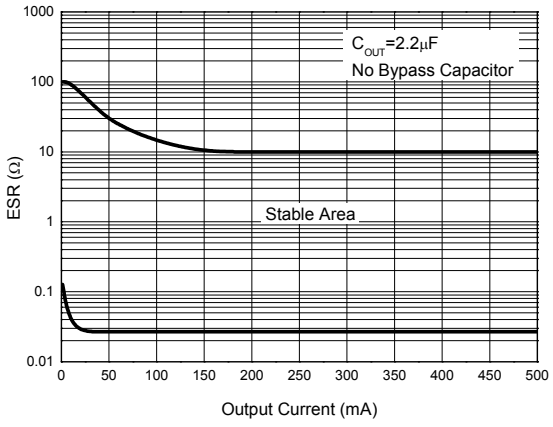


Figure 18. ESR vs. Output Current

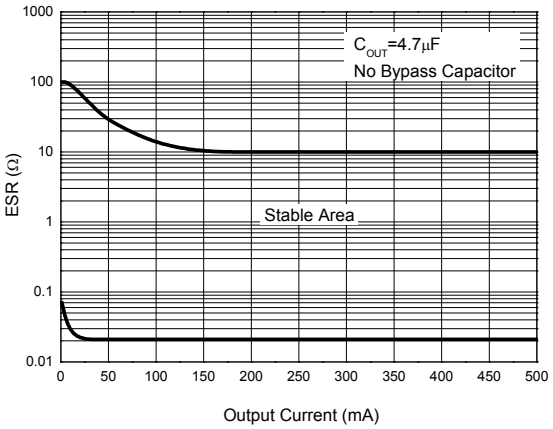


Figure 19. ESR vs. Output Current

Typical Application

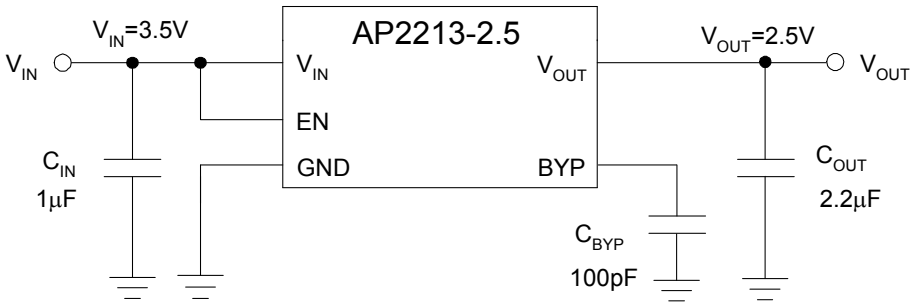


Figure 20. Typical Application of AP2213 (Note 7)

Note 7: Dropout voltage is 350mV when T_A=25°C. In order to obtain a normal output voltage, V_{OUT}+0.35V is the minimum input voltage which will results a low PSRR, imposing a bad influence on system. Therefore, the recommended input voltage is V_{OUT}+1V to 18V. For AP2213-2.5 version, its input voltage can be set from 3.5V(V_{OUT}+1V) to 18V.

Application Information

Input Capacitor
A 1μF minimum capacitor is recommended to be placed between V_{IN} and GND.

Output Capacitor
It is required to prevent oscillation. 1μF minimum is recommended when C_{BYP} is unused. 2.2μF minimum is recommended when C_{BYP} is 100pF. The output capacitor may be increased to improve transient response.

Noise Bypass Capacitor
Bypass capacitor is connected to the internal voltage reference. A small capacitor connected from BYP to GND make this reference quiet, resulting in a significant reduction in output noise, but the ESR stable area will be narrowed. In order to keep the output stability, it is recommended to use the bypass capacitor no more than 100pF.

The start-up speed of the AP2213 is inversely proportional to the value of reference bypass capacitor. In some cases, if output noise is not a major concern and rapid turn-on is necessary, omit C_{BYP} and leave BYP open.

Power Dissipation
Thermal shutdown may take place if exceeding the maximum power dissipation in application. Under all possible operating conditions, the junction temperature must be within the range specified under absolute maximum ratings to avoid thermal shutdown.
To determine if the power dissipated in the regulator reaches the maximum power dissipation (see figure 16, 17), using:
$T_J = P_D*\theta_{JA} + T_A$
$P_D=(V_{IN}-V_{OUT})*I_{OUT}+V_{IN}*I_{GND}$

Where: $T_J \le T_{J(max)}$, $T_{J(max)}$ is absolute maximum ratings for the junction temperature; $V_{IN}*I_{GND}$ can be ignored due to its small value.

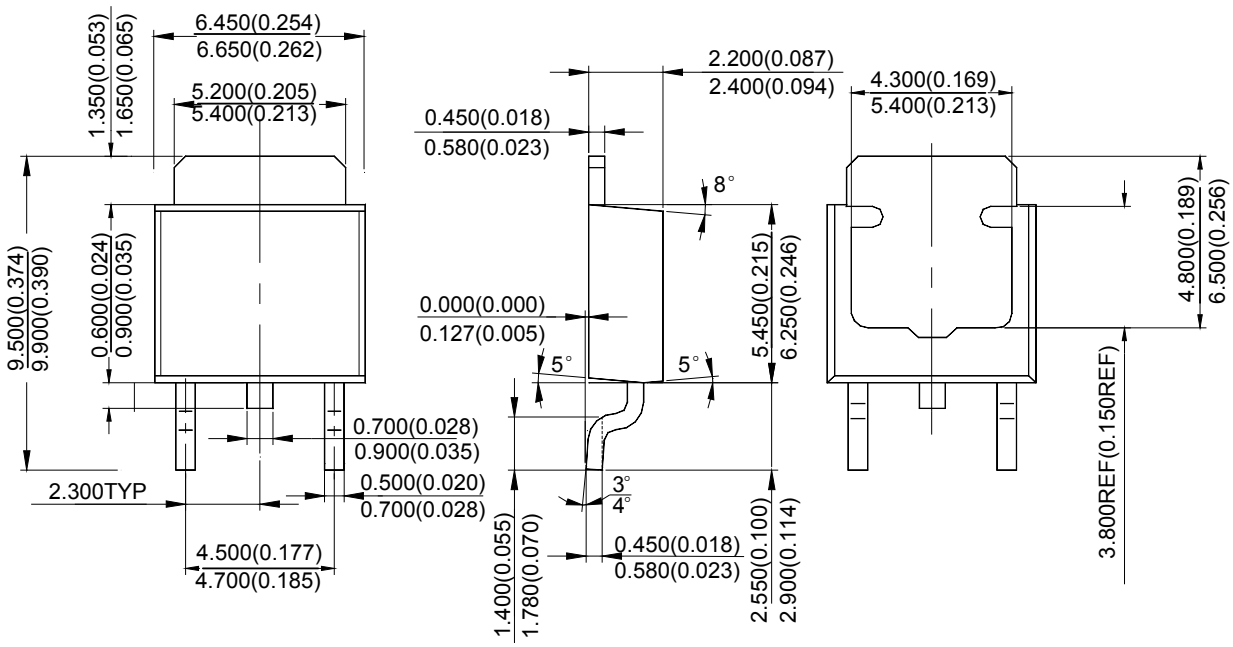
$T_{J(max)}$ is 150°C, θ_{JA} is 90°C/W for TO-252-2 (1)/ TO-252-2 (3) package and 160°C/W for SOIC-8 package.

Example: For 2.5V version packaged in SOIC-8, I_{OUT}=500mA, T_A=50°C, $V_{IN(Max)}$ is:
(150°C-50°C)/(0.5A*160°C/W)+2.5V=3.75V

Therefore, for good performance, please make sure that input voltage is less than 3.75V without heatsink when T_A=50°C.

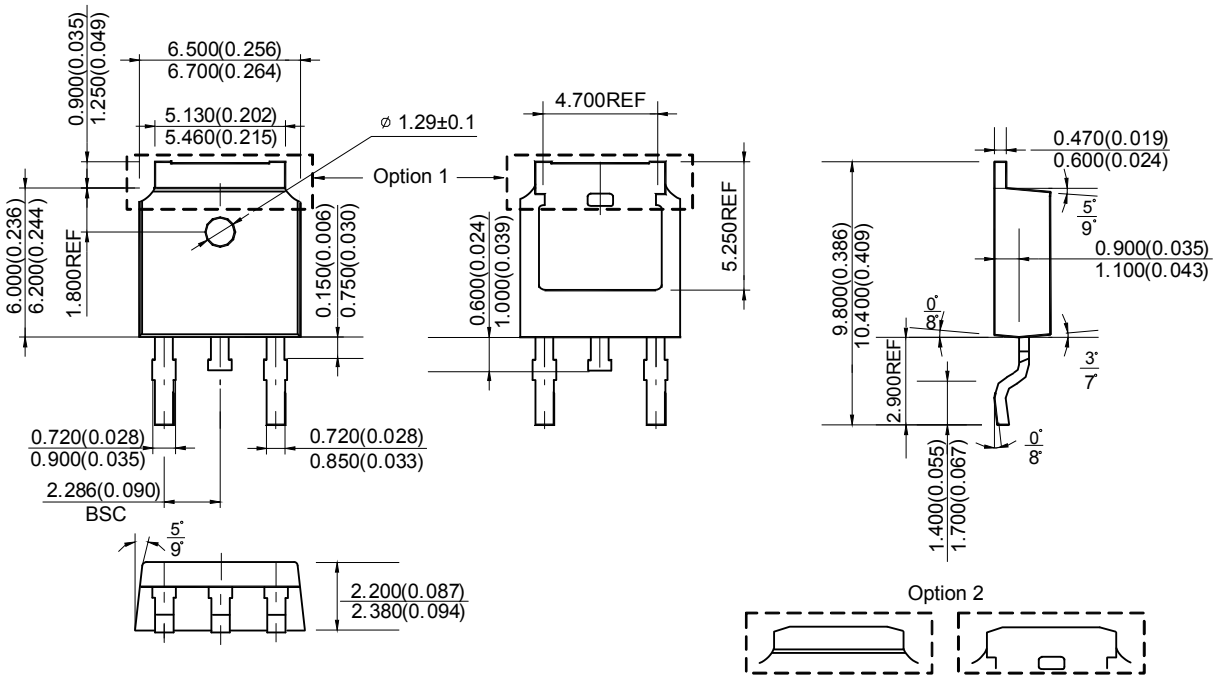
Mechanical Dimensions

TO-252-2 (1) **Unit: mm(inch)**



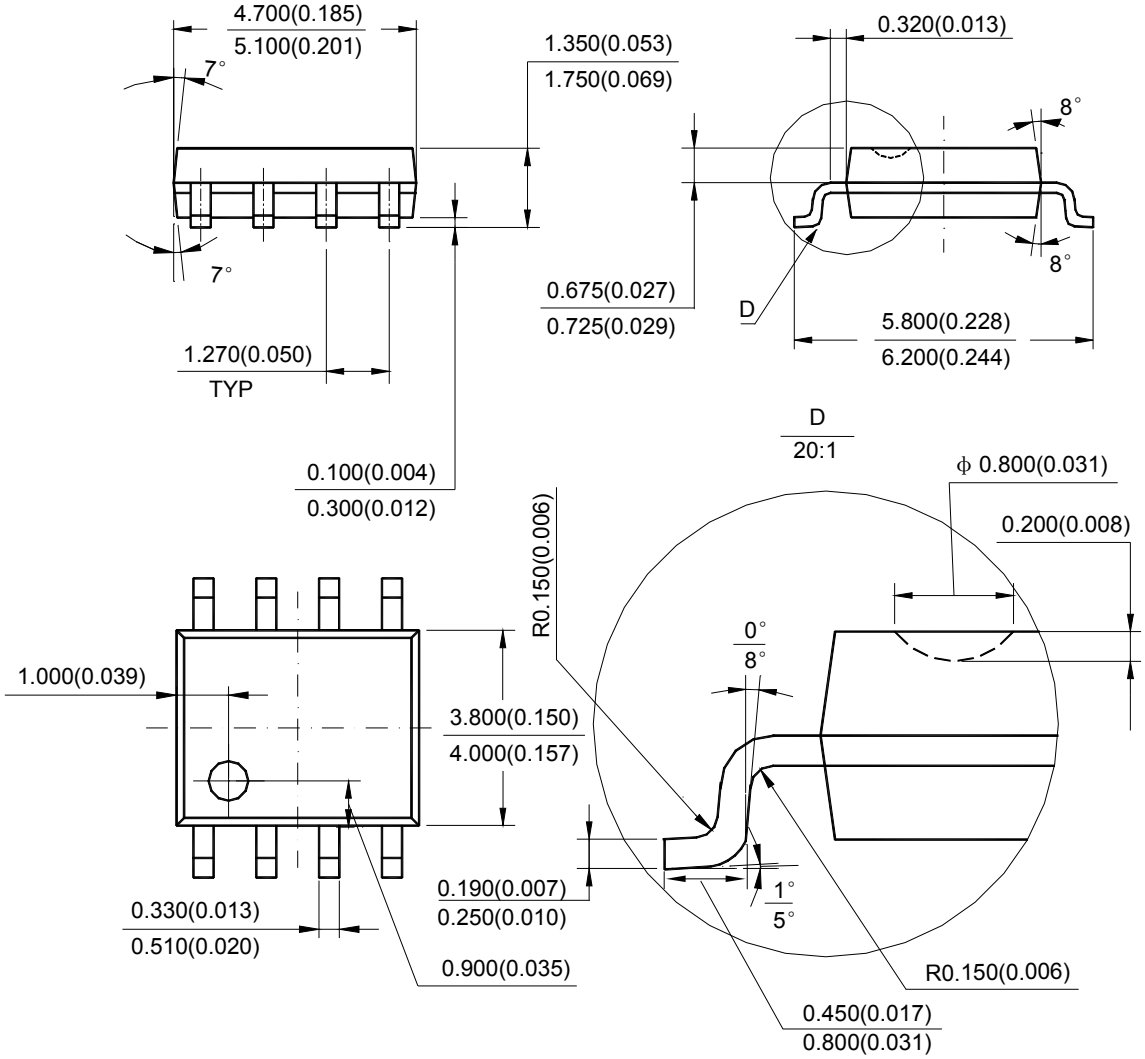
Mechanical Dimensions (Continued)

TO-252-2 (3) **Unit: mm(inch)**



Mechanical Dimensions (Continued)

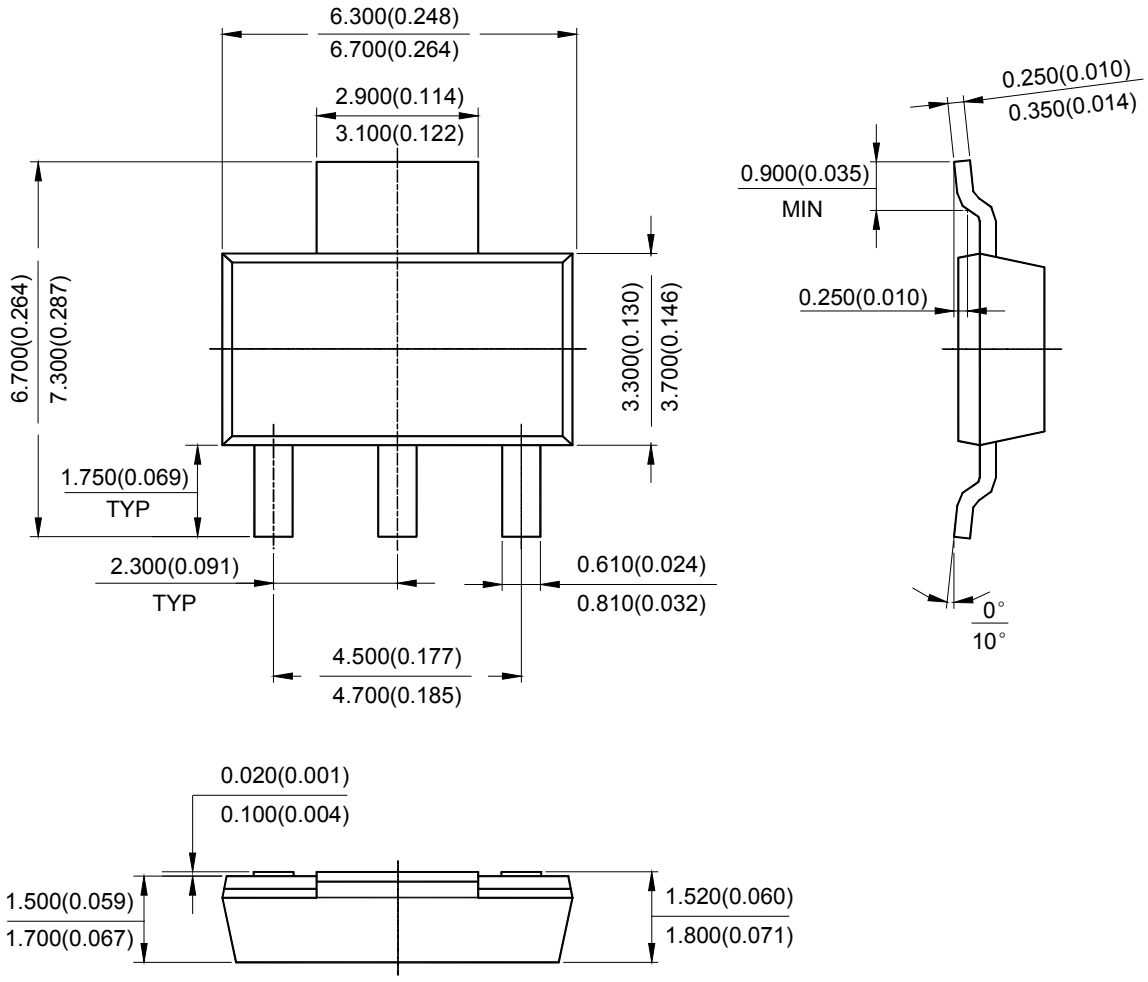
SOIC-8 **Unit: mm(inch)**



Note: Eject hole, oriented hole and mold mark is optional.

Mechanical Dimensions (Continued)

SOT-223 **Unit: mm(inch)**



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