150mA RF ULDO REGULATOR WITH ERROR FLAG AP2203

General Description

The AP2203 is a 150mA ULDO regulator, which provides ultra low dropout voltage (typically 165mV at 150mA), very low quiescent current (1μA maximum) in shutdown mode 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 AP2203 also features an undervoltage monitor with an error flag output, 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 AP2203 has 2.5V, 3.0V and 3.3V versions.

The AP2203 is available in space saving 5-pin SOT-23-5 package.

Features

- Error Flag to Indicate Undervoltage Fault
- Up to 150mA Regulator Output
- Low Quiescent Current
- Low Dropout Voltage: V_{DROP}=165mV at 150mA
- 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
- Reverse-battery Protection
- Zero Off-mode Current
- Logic-controlled Enable

Applications

- Cellular Phones
- Cordless Phones
- Wireless Communicators
- PDAs / Palmtops
- Consumer Electronics

SOT-23-5

Figure 1. Package Type of AP2203

Pin Configuration

K Package
(SOT-23-5)

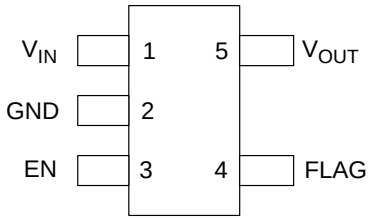


Figure 2. Pin Configuration of AP2203 (Top View)

Pin Description

Pin Number	Pin Name	Function
1	V_{IN}	Input voltage
2	GND	Ground
3	EN	Enable input: CMOS or TTL compatible input. Logic high=enable, logic low=shutdown
4	FLAG	Error flag (Output pin): Open-collector output. Active low indicates an output undervoltage condition
5	V_{OUT}	Regulated output voltage

Functional Block Diagram

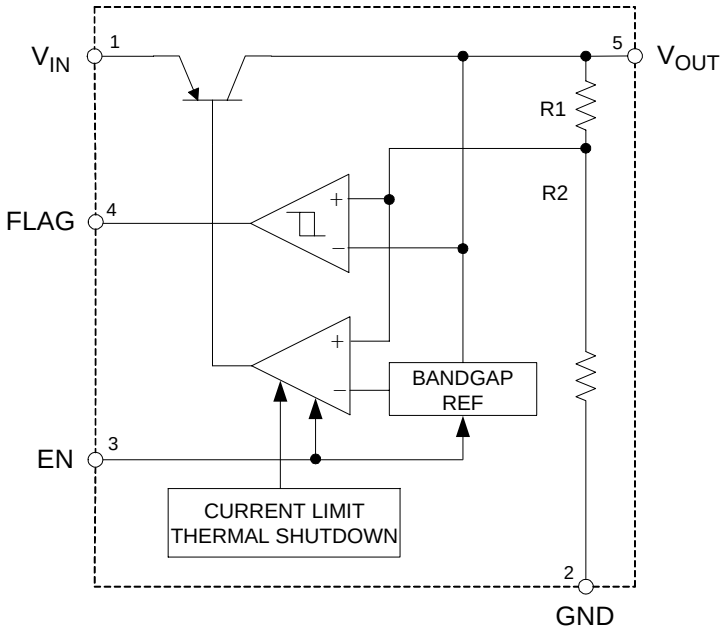
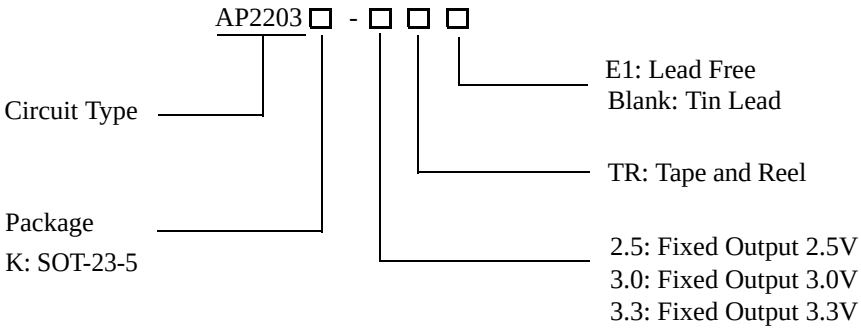


Figure 3. Functional Block Diagram of AP2203

Ordering Information



Package	Temperature Range	Part Number		Marking ID		Packing Type
		Tin Lead	Lead Free	Tin Lead	Lead Free	
SOT-23-5	-40 to 125°C	AP2203K-2.5TR	AP2203K-2.5TRE1	K3C	E3C	Tape & Reel
		AP2203K-3.0TR	AP2203K-3.0TRE1	K3F	E3F	Tape & Reel
		AP2203K-3.3TR	AP2203K-3.3TRE1	K3G	E3G	Tape & Reel

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

Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Value	Unit
Supply Input Voltage	V_{IN}	15	V
Enable Input Voltage	V_{EN}	15	V
Power Dissipation	P_D	Internally Limited (Thermal Protection)	W
Lead Temperature (Soldering, 5sec)	T_{LEAD}	260	^oC
Storage Temperature	T_{STG}	-65 to 150	^oC
ESD (Machine Model)		300	V
Thermal Resistance (No Heatsink)	θ_{JA}	200	$^oC/W$

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	13.2	V
Enable Input Voltage	V_{EN}	0	13.2	V
Operating Junction Temperature	T_J	-40	125	^oC

Electrical Characteristics

AP2203-2.5V Electrical Characteristics

V_{IN}=3.5V, I_{OUT}=100μA, 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	V_{RLOAD}	I_{OUT}=0.1mA to 150mA (Note 4)		1	6	mV
					15	
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	
Quiescent Current	I_Q	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}=100mA		600	1000	
					1500	
		V_{EN} ≥ 2.0V, I_{OUT}=150mA		1300	1900	
					2500	
Ripple Rejection	PSRR	frequency=100Hz, I_{OUT}=100μA		75		dB
Current Limit	I_{LIMIT}	V_{OUT}=0V		**450**	650	mA

Electrical Characteristics (Continued)

AP2203-2.5V Electrical Characteristics

V_{IN}=3.5V, I_{OUT}=100μA, 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
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**	
Flag Threshold	V_{ERR}	Undervoltage condition (below nominal) (Note 7)	-10	-6	-2	%
Output Logic-low Voltage (Note 8)	V_{OL}	I_{FL}=1mA Undervoltage condition		0.2	**0.4**	V
Flag Leakage Current	I_{FL}	Flag off, V_{FLAG}=0V to 13.2V	-0.1	0.1	1	μA

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 150mA. 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 2% 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.
Note 7: The error flag comparator includes 2.5% hysteresis.
Note 8: The FLAG pin will be enabled if EN pin voltage is high, and disabled if EN pin voltage is low.

Electrical Characteristics (Continued)

AP2203-3.0V Electrical Characteristics

V_{IN}=4V, I_{OUT}=100μA, 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	V_{RLOAD}	I_{OUT}=0.1mA to 150mA (Note 4)		1	6	mV
					15	
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	
Quiescent Current	I_Q	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}=100mA		600	1000	
					1500	
		V_{EN} ≥ 2.0V, I_{OUT}=150mA		1300	1900	
					2500	
Ripple Rejection	PSRR	frequency=100Hz, I_{OUT}=100μA		75		dB
Current Limit	I_{LIMIT}	V_{OUT}=0V		**450**	650	mA

Electrical Characteristics (Continued)

AP2203-3.0V Electrical Characteristics

V_{IN}=4V, I_{OUT}=100μA, 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
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**	
Flag Threshold	V_{ERR}	Undervoltage condition (below nominal) (Note 7)	-10	-6	-2	%
Output Logic-low Voltage (Note 8)	V_{OL}	I_{FL}=1mA Undervoltage condition		0.2	**0.4**	V
Flag Leakage Current	I_{FL}	Flag off, V_{FLAG}=0V to 13.2V	-0.1	0.1	1	μA

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 150mA. 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 2% 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.
Note 7: The error flag comparator includes 2.5% hysteresis.
Note 8: The FLAG pin will be enabled if EN pin voltage is high, and disabled if EN pin voltage is low.

Electrical Characteristics (Continued)

AP2203-3.3V Electrical Characteristics

V_{IN}=4.3V, I_{OUT}=100μA, 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**		ppm/°C
Line Regulation	V_{RLINE}	V_{IN}=4.3V to 13.2V		1.5	4.5	mV
					12	
Load Regulation	V_{RLOAD}	I_{OUT}=0.1mA to 150mA (Note 4)		1	6	mV
					15	
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	
Quiescent Current	I_Q	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}=100mA		600	1000	
					1500	
		V_{EN} ≥ 2.0V, I_{OUT}=150mA		1300	1900	
					2500	
Ripple Rejection	PSRR	frequency=100Hz, I_{OUT}=100μA		75		dB
Current Limit	I_{LIMIT}	V_{OUT}=0V		**450**	650	mA

Electrical Characteristics (Continued)

AP2203-3.3V Electrical Characteristics

V_{IN}=4.3V, I_{OUT}=100μA, 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
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**	
Flag Threshold	V_{ERR}	Undervoltage condition (below nominal) (Note 7)	-10	-6	-2	%
Output Logic-low Voltage (Note 8)	V_{OL}	I_{FL}=1mA Undervoltage condition		0.2	**0.4**	V
Flag Leakage Current	I_{FL}	Flag off, V_{FLAG}=0V to 13.2V	-0.1	0.1	1	μA

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 150mA. 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 2% 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.
Note 7: The error flag comparator includes 2.5% hysteresis.
Note 8: The FLAG pin will be enabled if EN pin voltage is high, and disabled if EN pin voltage is low.

Typical Performance Characteristics

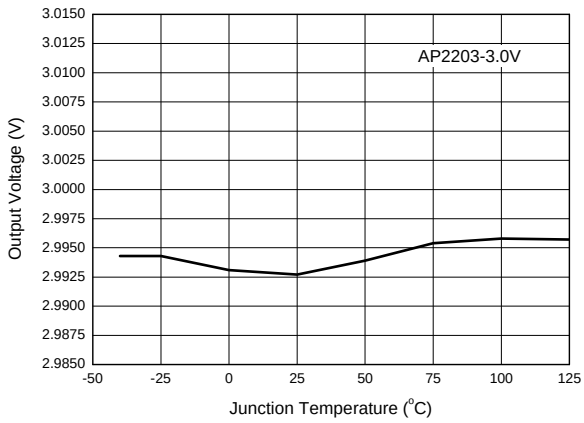


Figure 4. Output Voltage vs. Junction Temperature

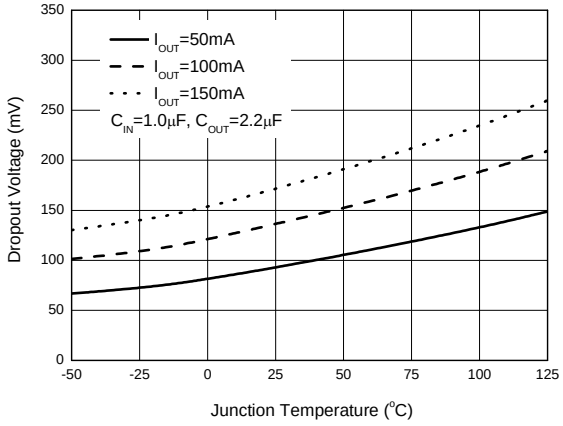


Figure 5. Dropout Voltage vs. Junction Temperature

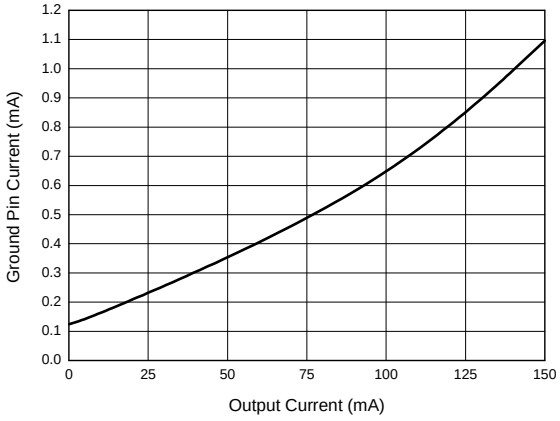


Figure 6. Ground Pin Current vs. Output Current

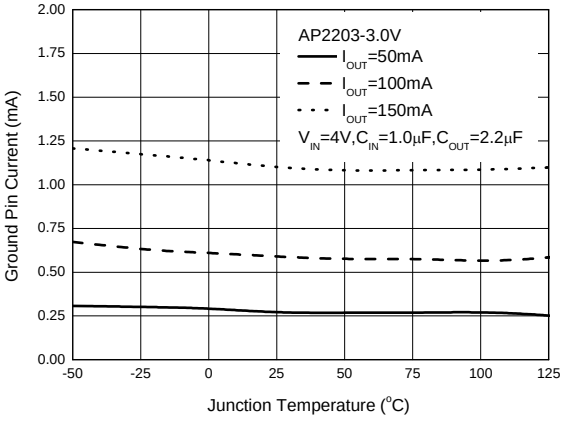


Figure 7. Ground Pin Current vs. Junction Temperature

Typical Performance Characteristics (Continued)

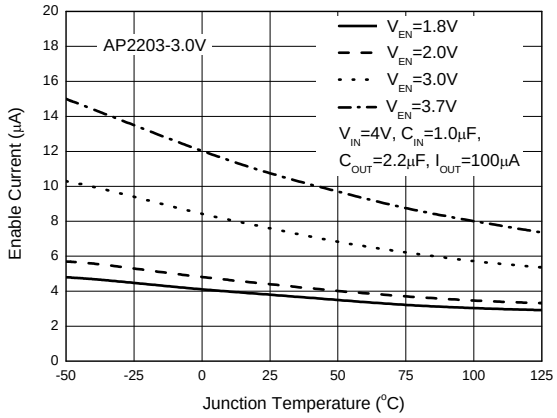


Figure 8. Enable Current vs. Junction Temperature

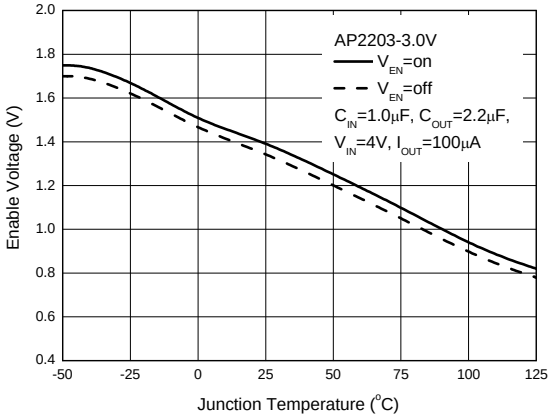


Figure 9. Enable Voltage vs. Junction Temperature

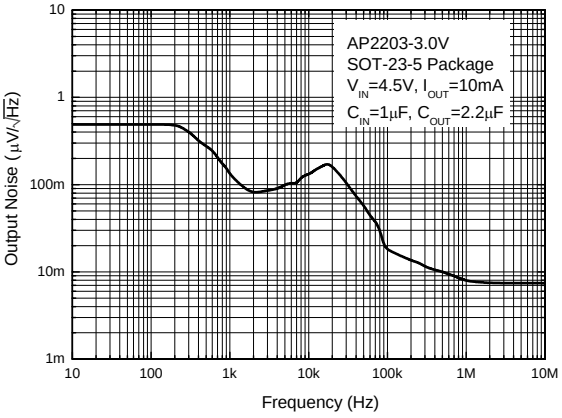


Figure 10. Output Noise vs. Frequency

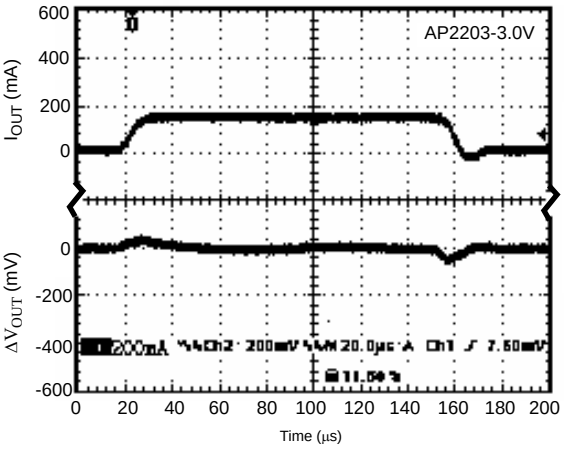


Figure 11. Load Transient
(Conditions: V_{IN}=4V, V_{EN}=2V, I_{OUT}=5mA to 200mA,
C_{IN}=1μF, C_{OUT}=2.2μF)

Typical Performance Characteristics (Continued)

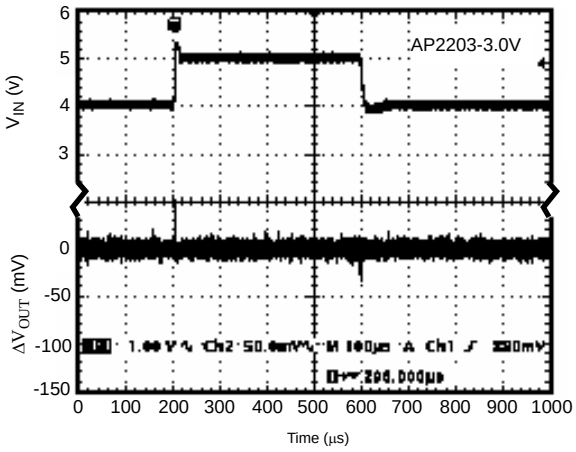


Figure 12. Line Transient
(Conditions: V_{IN}=4 to 5V, V_{EN}=2V, I_{OUT}=100μA
C_{IN}=1μF, C_{OUT}=10μF)

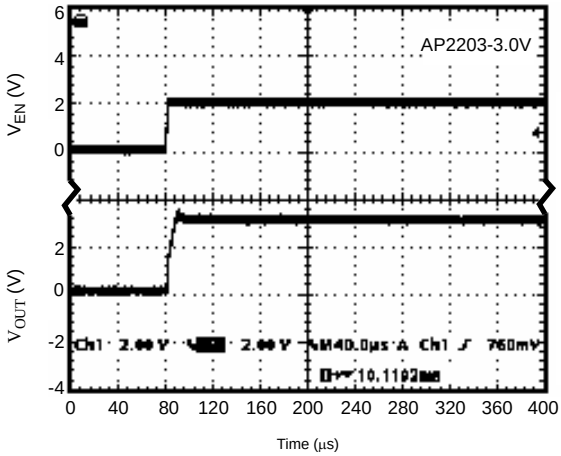


Figure 13. V_{EN}(on) vs. V_{OUT}
(Conditions: V_{EN}=0 to 2V, V_{IN}=4V, I_{OUT}=30mA,
C_{IN}=1.0μF, C_{OUT}=2.2μF)

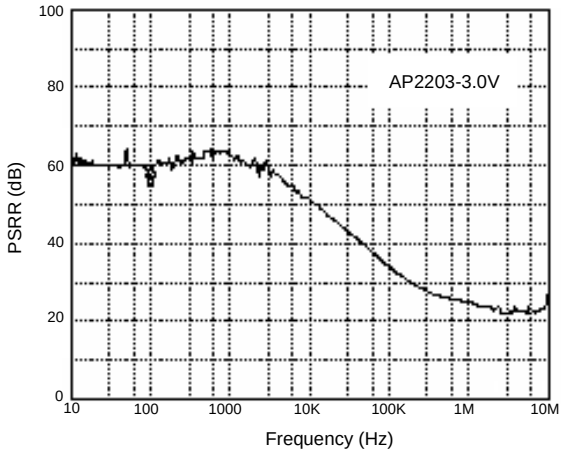


Figure 14. PSRR vs. Frequency
(Conditions: C_{IN}=1.0μF, C_{OUT}=2.2μF, V_{IN}=4V,
I_{OUT}=100mA, V_{EN}=2V)

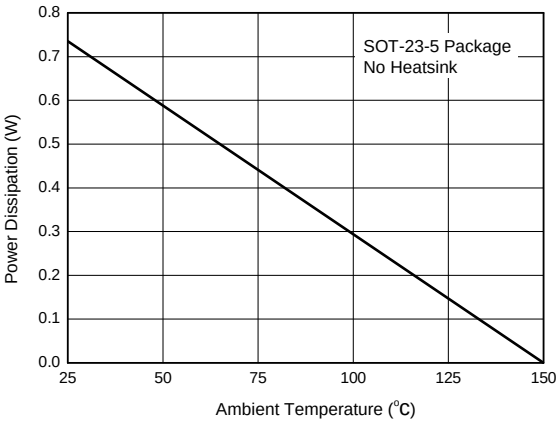


Figure 15. Power Dissipation vs. Ambient Temperature

Typical Performance Characteristics (Continued)

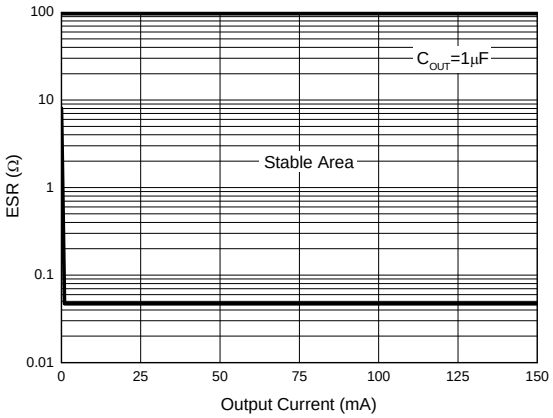


Figure 16. ESR vs. Output Current

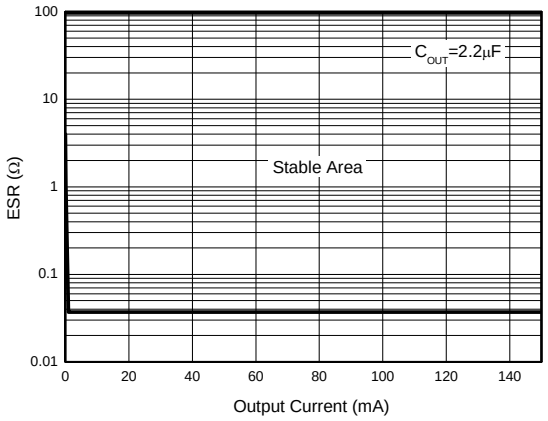


Figure 17. ESR vs. Output Current

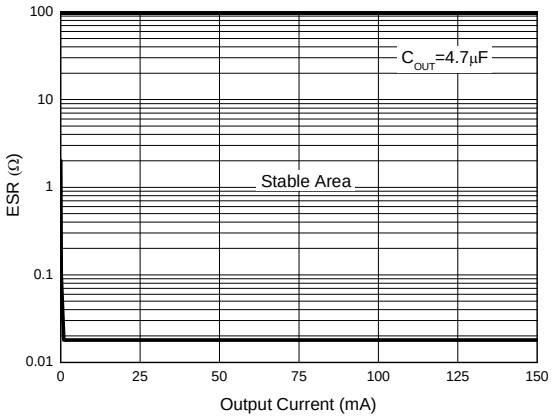


Figure 18. ESR vs. Output Current

Typical Application

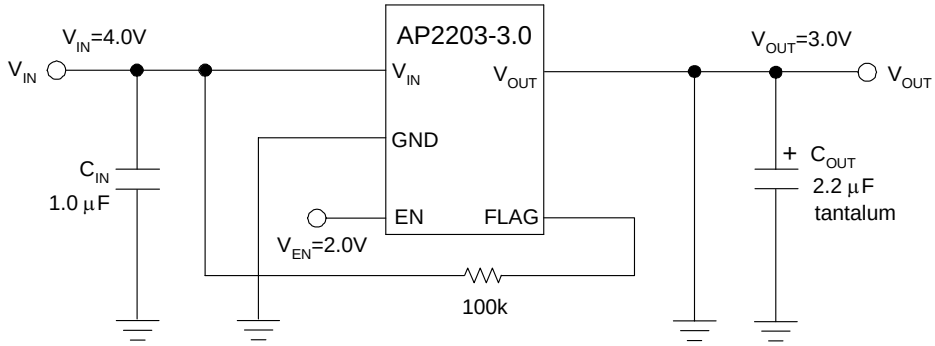


Figure 19. Typical Application of AP2203

Note 9: Dropout voltage is 165mV when T_A=25°C. In order to obtain a normal output voltage, V_{OUT}+0.165V 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}+0.5V to 13.2V. For AP2203-3.0V version, its input voltage can be set from 3.5V(V_{OUT}+0.5V) to 13.2V.

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. 1.0μF minimum is recommended The output capacitor may be increased to improve transient response.

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 15), 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.

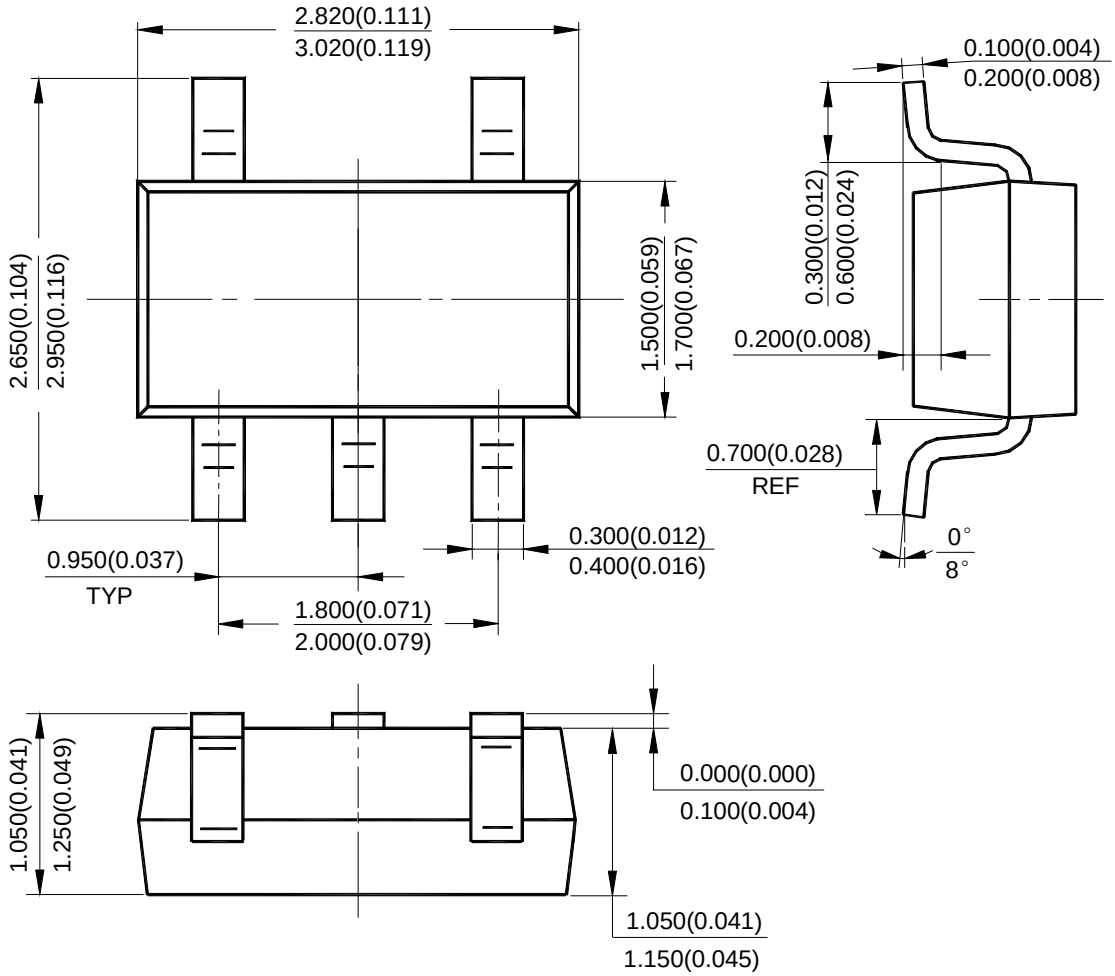
$T_{J(max)}$ is 150°C while θ_{JA} is 200°C/W, no heatsink is required since the package alone will dissipate enough heat to satisfy these requirements unless the calculated value for power dissipation exceeds the limit.

Take 3.0V version as an example:
I_{OUT}=150mA, T_A=50°C, $V_{IN(Max)}$ is:
(150°C-50°C)/(0.15A*200°C/W)+3.0V=6.333V

Therefore, for good performance, please make sure that input voltage is less than 6.333V without heatsink when T_A=50°C.

Mechanical Dimensions

SOT-23-5 **Unit: mm(inch)**



BCD Semiconductor Manufacturing Limited

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