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Description

The AP2210 is a 300mA ULDO regulator which provides very low noise, ultra low dropout voltage (typically 250mV at 300mA), very low standby current (1µA maximum) and excellent power supply ripple rejection (PSRR 75dB at 100Hz) in battery powered applications, such as handsets, PDAs and in noise sensitive applications, such as RF electronics.

The AP2210 also 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 AP2210 has 2.5V, 2.8V, 3.0V, 3.3V, 3.6V, 4.0V, 5.0V and ADJ versions.

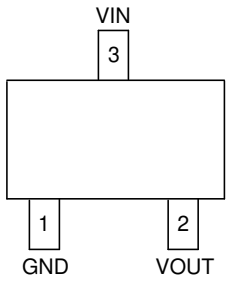
The AP2210 is available in space saving SOT-23-3 and SOT-23-5 packages.

Features

- Up to 300mA Output Current
- Excellent ESR Stability
- Low Standby Current
- Low Dropout Voltage: V_{DROP} = 250mV at 300mA
- 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
- Logic-controlled Enable
- Lead-Free Packages: SOT-23-3, SOT-23-5
  - **Totally Lead-Free; RoHS Compliant (Notes 1 & 2)**
- Lead-Free Packages, Available in "Green" Molding Compound: SOT-23-3, SOT-23-5
  - **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
  - **Halogen and Antimony Free. "Green" Device (Note 3)**

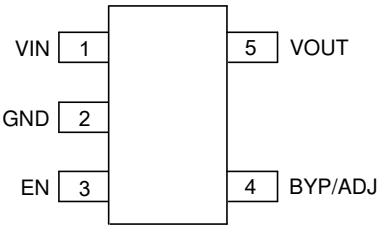
Pin Assignments

(Top View)



SOT-23-3

(Top View)



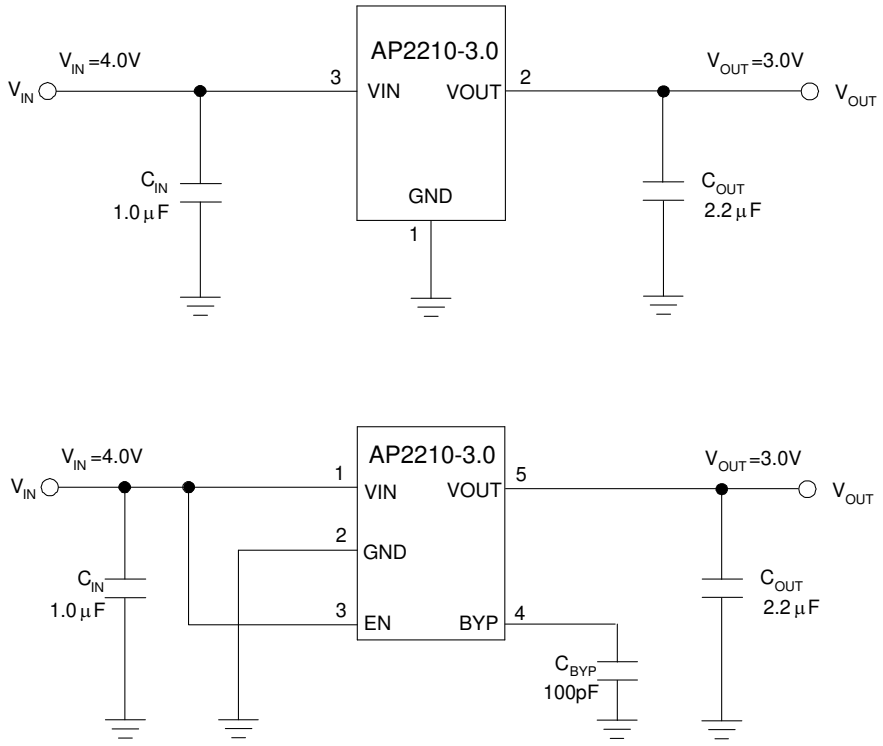
SOT-23-5

Applications

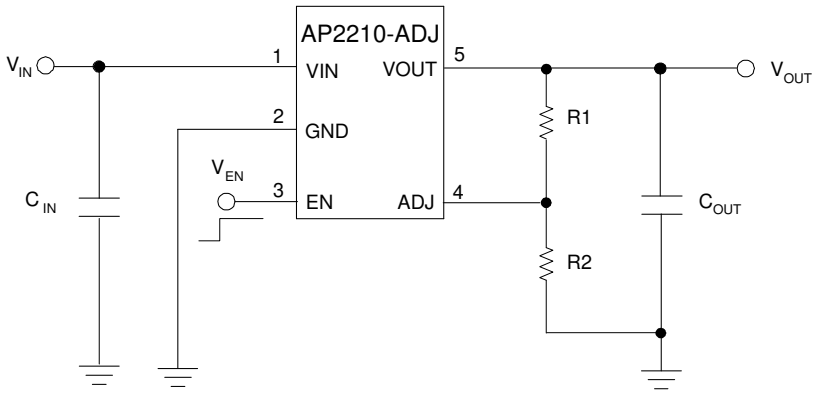
- Cellular Phones
- Cordless Phones
- Wireless Communicators
- PDAs/Palmtops
- PC Mother Board
- Consumer Electronics

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Applications Circuit (Note 4)



For Fixed Version



V_{OUT} = 1.25V*(1+R2/R1)

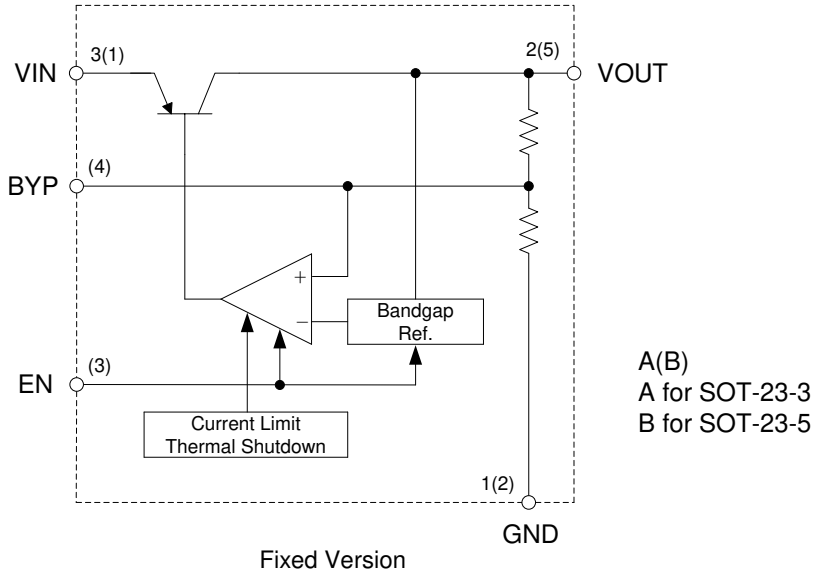
For Adjustable Version

Note 4: Dropout voltage is 250mV when T_A = +25°C. In order to obtain a normal output voltage, V_{OUT}+0.25V is the minimum input voltage which will result a low PSRR, imposing a bad influence on system. Therefore, the recommended input voltage is V_{OUT}+1V to 13.2V. For AP2210-3.0 version, its input voltage can be set from 4V (V_{OUT}+1V) to 13.2V.

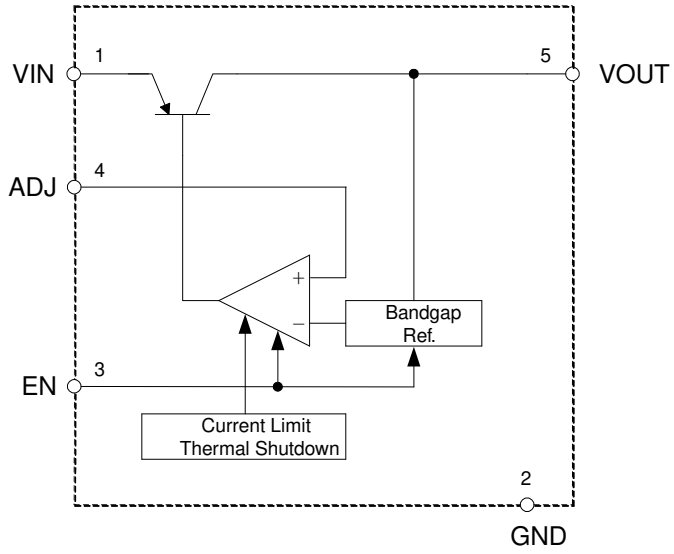
Pin Descriptions

Pin Number		Pin Name	Function
SOT-23-3	SOT-23-5		
1	2	GND	Ground
2	5	VOUT	Regulated output voltage
3	1	VIN	Input voltage
–	3	EN	Enable input: CMOS or TTL compatible input. Logic high=enable, logic low=shutdown
–	4	BYP/ADJ	Bypass capacitor for low noise operation/Adjustable Output

Functional Block Diagram



Fixed Version



ADJ Version (For SOT-23-5)

Absolute Maximum Ratings (Note 5)

Symbol	Parameter	Rating		Unit
V_{IN}	Supply Input Voltage	15		V
V_{EN}	Enable Input Voltage	15		V
P_D	Power Dissipation	Internally Limited (Thermal Protection)		W
T_{LEAD}	Lead Temperature (Soldering, 10sec)	+260		°C
T_J	Junction Temperature	+150		°C
T_{STG}	Storage Temperature	-65 to +150		°C
ESD	ESD (Machine Model)	300		V
θ_{JA}	Thermal Resistance (No Heatsink)	SOT-23-3	200	°C/W
		SOT-23-5	200	

Note 5: 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

Symbol	Parameter	Min	Max	Unit
V_{IN}	Supply Input Voltage	2.5	13.2	V
V_{EN}	Enable Input Voltage	0	13.2	V
T_J	Operating Junction Temperature	-40	+125	°C

Electrical Characteristics

AP2210-2.5 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\Delta V_{OUT}/V_{OUT}$	Output Voltage Accuracy	Variation from specified V_{OUT}	-1	–	1	%
			-2	–	**2**	
$\Delta V_{OUT}/\Delta T$	Output Voltage Temperature Coefficient (Note 7)	–	–	**120**	–	µV/°C
$(\Delta V_{OUT}/V_{OUT})/\Delta T$		–	–	**48**	–	ppm/°C
V_{RLINE}	Line Regulation	V_{IN} = 3.5V to 13.2V	–	1.5	4.5	mV
			–	–	**12**	
V_{RLOAD}	Load Regulation (Note 8)	I_{OUT} = 0.1mA to 300mA	–	1	6	mV
			–	–	**30**	
V_{DROP}	Dropout Voltage (Note 9)	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_{STD}	Standby Current	V_{EN} ≤ 0.4V (shutdown)	–	0.01	1	µA
		V_{EN} ≤ 0.18V (shutdown)	–	–	**5**	
I_{GND}	Ground Pin Current (Note 10)	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**	
PSRR	Ripple Rejection	f = 100Hz, I_{OUT} = 100µA	–	75	–	dB
I_{LIMIT}	Current Limit	V_{OUT} = 0V	–	**450**	900	mA

Electrical Characteristics (Cont.)

AP2210-2.5 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
e_{no}	Output Noise	I_{OUT} = 50mA, C_{OUT} = 2.2µF, 100pF from BYP to GND	–	260	–	$nV/\sqrt{Hz}$
V_{IL}	Enable Input Logic-low Voltage	Regulator shutdown	–	–	0.4	V
			–	–	**0.18**	
V_{IH}	Enable Input Logic-high Voltage	Regulator enabled	**2.0**	–	–	V
I_{IL}	Enable Input Logic-low Current	V_{IL} ≤ 0.4V	–	0.01	1	µA
		V_{IL} ≤ 0.18V	–	–	**2**	
I_{IH}	Enable Input Logic-high Current	V_{IL} ≥ 2.0V	–	5	20	µA
		V_{IL} ≥ 2.0V	–	–	**25**	

Notes:
6. 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.
7. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
9. 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 300mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
9. 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.
10. 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 (Cont.)

AP2210-2.8 Electrical Characteristics (V_{IN} = 3.8V, 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\Delta V_{OUT}/V_{OUT}$	Output Voltage Accuracy	Variation from specified V_{OUT}	-1	–	1	%
			-2	–	**2**	
$\Delta V_{OUT}/\Delta T$	Output Voltage Temperature Coefficient (Note 7)	–	–	**120**	–	µV/°C
$(\Delta V_{OUT}/V_{OUT})/\Delta T$		–	–	**42.8**	–	ppm/°C
V_{RLINE}	Line Regulation	V_{IN} = 3.8V to 13.2V	–	1.5	4.5	mV
			–	–	**12**	
V_{RLOAD}	Load Regulation (Note 8)	I_{OUT} = 0.1mA to 300mA	–	1	6	mV
			–	–	**30**	
V_{DROP}	Dropout Voltage (Note 9)	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_{STD}	Standby Current	V_{EN} ≤ 0.4V (shutdown)	–	0.01	1	µA
		V_{EN} ≤ 0.18V (shutdown)	–	–	**5**	
I_{GND}	Ground Pin Current (Note 10)	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**	
PSRR	Ripple Rejection	f = 100Hz, I_{OUT} = 100µA	–	75	–	dB
I_{LIMIT}	Current Limit	V_{OUT} = 0V	–	**450**	900	mA

Electrical Characteristics (Cont.)

AP2210-2.8 Electrical Characteristics (V_{IN} = 3.8V, 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
e_{no}	Output Noise	I_{OUT} = 50mA, C_{OUT} = 2.2µF, 100pF from BYP to GND	–	260	–	$nV/\sqrt{Hz}$
V_{IL}	Enable Input Logic-low Voltage	Regulator shutdown	–	–	0.4	V
			–	–	**0.18**	
V_{IH}	Enable Input Logic-high Voltage	Regulator enabled	**2.0**	–	–	V
I_{IL}	Enable Input Logic-low Current	V_{IL} ≤ 0.4V	–	0.01	1	µA
		V_{IL} ≤ 0.18V	–	–	**2**	
I_{IH}	Enable Input Logic-high Current	V_{IL} ≥ 2.0V	–	5	20	µA
		V_{IL} ≥ 2.0V	–	–	**25**	

Notes:
6. 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.
7. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
8. 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 300mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
9. 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.
10. 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 (Cont.)

AP2210-3.0 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\Delta V_{OUT}/V_{OUT}$	Output Voltage Accuracy	Variation from specified V_{OUT}	-1	–	1	%
			-2	–	**2**	
$\Delta V_{OUT}/\Delta T$	Output Voltage Temperature Coefficient (Note 7)	–	–	**120**	–	µV/°C
$(\Delta V_{OUT}/V_{OUT})/\Delta T$		–	–	**40**	–	ppm/°C
V_{RLINE}	Line Regulation	V_{IN} = 4V to 13.2V	–	1.5	4.5	mV
			–	–	**12**	
V_{RLOAD}	Load Regulation (Note 8)	I_{OUT} = 0.1mA to 300mA	–	1	6	mV
			–	–	**30**	
V_{DROP}	Dropout Voltage (Note 9)	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_{STD}	Standby Current	V_{EN} ≤ 0.4V (shutdown)	–	0.01	1	µA
		V_{EN} ≤ 0.18V (shutdown)	–	–	**5**	
I_{GND}	Ground Pin Current (Note 10)	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**	
PSRR	Ripple Rejection	f = 100Hz, I_{OUT} = 100µA	–	75	–	dB
I_{LIMIT}	Current Limit	V_{OUT} = 0V	–	**450**	900	mA

Electrical Characteristics (Cont.)

AP2210-3.0 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
e_{no}	Output Noise	I_{OUT} = 50mA, C_{OUT} = 2.2µF, 100pF from BYP to GND	–	260	–	$nV/\sqrt{Hz}$
V_{IL}	Enable Input Logic-low Voltage	Regulator shutdown	–	–	0.4	V
			–	–	**0.18**	
V_{IH}	Enable Input Logic-high Voltage	Regulator enabled	**2.0**	–	–	V
I_{IL}	Enable Input Logic-low Current	V_{IL} ≤ 0.4V	–	0.01	1	µA
		V_{IL} ≤ 0.18V	–	–	**2**	
I_{IH}	Enable Input Logic-high Current	V_{IL} ≥ 2.0V	–	5	20	µA
		V_{IL} ≥ 2.0V	–	–	**25**	

Notes:
6. 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.
7. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
8. 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 300mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
9. 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.
10. 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 (Cont.)

AP2210-3.3 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\Delta V_{OUT}/V_{OUT}$	Output Voltage Accuracy	Variation from specified V_{OUT}	-1	–	1	%
			-2	–	**2**	
$\Delta V_{OUT}/\Delta T$	Output Voltage Temperature Coefficient (Note 7)	–	–	**120**	–	µV/°C
$(\Delta V_{OUT}/V_{OUT})/\Delta T$		–	–	**36.3**	–	ppm/°C
V_{RLINE}	Line Regulation	V_{IN} = 4.3V to 13.2V	–	1.5	4.5	mV
			–	–	**12**	
V_{RLOAD}	Load Regulation (Note 8)	I_{OUT} = 0.1mA to 300mA	–	1	6	mV
			–	–	**30**	
V_{DROP}	Dropout Voltage (Note 9)	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_{STD}	Standby Current	V_{EN} ≤ 0.4V (shutdown)	–	0.01	1	µA
		V_{EN} ≤ 0.18V (shutdown)	–	–	**5**	
I_{GND}	Ground Pin Current (Note 10)	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**	
PSRR	Ripple Rejection	f = 100Hz, I_{OUT} = 100µA	–	75	–	dB
I_{LIMIT}	Current Limit	V_{OUT} = 0V	–	**450**	900	mA

Electrical Characteristics (Cont.)

AP2210-3.3 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
e_{no}	Output Noise	I_{OUT} = 50mA, C_{OUT} = 2.2µF, 100pF from BYP to GND	–	260	–	$nV/\sqrt{Hz}$
V_{IL}	Enable Input Logic-low Voltage	Regulator shutdown	–	–	0.4	V
			–	–	**0.18**	
V_{IH}	Enable Input Logic-high Voltage	Regulator enabled	**2.0**	–	–	V
I_{IL}	Enable Input Logic-low Current	V_{IL} ≤ 0.4V	–	0.01	1	µA
		V_{IL} ≤ 0.18V	–	–	**2**	
I_{IH}	Enable Input Logic-high Current	V_{IL} ≥ 2.0V	–	5	20	µA
		V_{IL} ≥ 2.0V	–	–	**25**	

Notes:
6. 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.
7. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
8. 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 300mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
9. 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.
10. 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 (Cont.)

AP2210-3.6 Electrical Characteristics (V_{IN} = 4.6V, 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\Delta V_{OUT}/V_{OUT}$	Output Voltage Accuracy	Variation from specified V_{OUT}	-1	–	1	%
			-2	–	**2**	
$\Delta V_{OUT}/\Delta T$	Output Voltage Temperature Coefficient (Note 7)	–	–	**120**	–	µV/°C
$(\Delta V_{OUT}/V_{OUT})/\Delta T$		–	–	**48**	–	ppm/°C
V_{RLINE}	Line Regulation	V_{IN} = 4.6V to 13.2V	–	1.5	4.5	mV
			–	–	**12**	
V_{RLOAD}	Load Regulation (Note 8)	I_{OUT} = 0.1mA to 300mA	–	1	6	mV
			–	–	**30**	
V_{DROP}	Dropout Voltage (Note 9)	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_{STD}	Standby Current	V_{EN} ≤ 0.4V (shutdown)	–	0.01	1	µA
		V_{EN} ≤ 0.18V (shutdown)	–	–	**5**	
I_{GND}	Ground Pin Current (Note 10)	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**	
PSRR	Ripple Rejection	f = 100Hz, I_{OUT} = 100µA	–	75	–	dB
I_{LIMIT}	Current Limit	V_{OUT} = 0V	–	**450**	900	mA

Electrical Characteristics (Cont.)

AP2210-3.6 Electrical Characteristics (V_{IN} = 4.6V, 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
e_{no}	Output Noise	I_{OUT} = 50mA, C_{OUT} = 2.2µF, 100pF from BYP to GND	–	260	–	$nV/\sqrt{Hz}$
V_{IL}	Enable Input Logic-low Voltage	Regulator shutdown	–	–	0.4	V
			–	–	**0.18**	
V_{IH}	Enable Input Logic-high Voltage	Regulator enabled	**2.0**	–	–	V
I_{IL}	Enable Input Logic-low Current	V_{IL} ≤ 0.4V	–	0.01	1	µA
		V_{IL} ≤ 0.18V	–	–	**2**	
I_{IH}	Enable Input Logic-high Current	V_{IL} ≥ 2.0V	–	5	20	µA
		V_{IL} ≥ 2.0V	–	–	**25**	

Notes:
6. 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.
7. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
8. 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 300mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
9. 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.
10. 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 (Cont.)

AP2210-4.0 Electrical Characteristics (V_{IN} = 5.0V, 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\Delta V_{OUT}/V_{OUT}$	Output Voltage Accuracy	Variation from specified V_{OUT}	-1	–	1	%
			-2	–	**2**	
$\Delta V_{OUT}/\Delta T$	Output Voltage Temperature Coefficient (Note 7)	–	–	**120**	–	µV/°C
$(\Delta V_{OUT}/V_{OUT})/\Delta T$		–	–	**48**	–	ppm/°C
V_{RLINE}	Line Regulation	V_{IN} = 5.0V to 13.2V	–	1.5	4.5	mV
			–	–	**12**	
V_{RLOAD}	Load Regulation (Note 8)	I_{OUT} = 0.1mA to 300mA	–	1	6	mV
			–	–	**30**	
V_{DROP}	Dropout Voltage (Note 9)	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_{STD}	Standby Current	V_{EN} ≤ 0.4V (shutdown)	–	0.01	1	µA
		V_{EN} ≤ 0.18V (shutdown)	–	–	**5**	
I_{GND}	Ground Pin Current (Note 10)	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**	
PSRR	Ripple Rejection	f = 100Hz, I_{OUT} = 100µA	–	75	–	dB
I_{LIMIT}	Current Limit	V_{OUT} = 0V	–	**450**	900	mA

Electrical Characteristics (Cont.)

AP2210-4.0 Electrical Characteristics (V_{IN} = 5.0V, 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
e_{no}	Output Noise	I_{OUT} = 50mA, C_{OUT} = 2.2µF, 100pF from BYP to GND	–	260	–	$nV/\sqrt{Hz}$
V_{IL}	Enable Input Logic-low Voltage	Regulator shutdown	–	–	0.4	V
			–	–	**0.18**	
V_{IH}	Enable Input Logic-high Voltage	Regulator enabled	**2.0**	–	–	V
I_{IL}	Enable Input Logic-low Current	V_{IL} ≤ 0.4V	–	0.01	1	µA
		V_{IL} ≤ 0.18V	–	–	**2**	
I_{IH}	Enable Input Logic-high Current	V_{IL} ≥ 2.0V	–	5	20	µA
		V_{IL} ≥ 2.0V	–	–	**25**	

Notes:
6. 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.
7. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
8. 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 300mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
9. 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.
10. 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 (Cont.)

AP2210-5.0 Electrical Characteristics (V_{IN} = 6.0V, 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\Delta V_{OUT}/V_{OUT}$	Output Voltage Accuracy	Variation from specified V_{OUT}	-1	–	1	%
			-2	–	**2**	
$\Delta V_{OUT}/\Delta T$	Output Voltage Temperature Coefficient (Note 7)	–	–	**120**	–	µV/°C
$(\Delta V_{OUT}/V_{OUT})/\Delta T$		–	–	**48**	–	ppm/°C
V_{RLINE}	Line Regulation	V_{IN} = 6.0V to 13.2V	–	1.5	4.5	mV
			–	–	**12**	
V_{RLOAD}	Load Regulation (Note 8)	I_{OUT} = 0.1mA to 300mA	–	1	6	mV
			–	–	**30**	
V_{DROP}	Dropout Voltage (Note 9)	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_{STD}	Standby Current	V_{EN} ≤ 0.4V (shutdown)	–	0.01	1	µA
		V_{EN} ≤ 0.18V (shutdown)	–	–	**5**	
I_{GND}	Ground Pin Current (Note 10)	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**	
PSRR	Ripple Rejection	f = 100Hz, I_{OUT} = 100µA	–	75	–	dB
I_{LIMIT}	Current Limit	V_{OUT} = 0V	–	**450**	900	mA

Electrical Characteristics (Cont.)

AP2210-5.0 Electrical Characteristics (V_{IN} = 6.0V, 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
e_{no}	Output Noise	I_{OUT} = 50mA, C_{OUT} = 2.2µF, 100pF from BYP to GND	–	260	–	$nV/\sqrt{Hz}$
V_{IL}	Enable Input Logic-low Voltage	Regulator shutdown	–	–	0.4	V
			–	–	**0.18**	
V_{IH}	Enable Input Logic-high Voltage	Regulator enabled	**2.0**	–	–	V
I_{IL}	Enable Input Logic-low Current	V_{IL} ≤ 0.4V	–	0.01	1	µA
		V_{IL} ≤ 0.18V	–	–	**2**	
I_{IH}	Enable Input Logic-high Current	V_{IL} ≥ 2.0V	–	5	20	µA
		V_{IL} ≥ 2.0V	–	–	**25**	

Notes:
6. 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.
7. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
8. 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 300mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.
9. 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.
10. 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 (Cont.)

AP2210-ADJ Electrical Characteristics (V_{IN} = V_{OUT}+1V, 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 6), unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
$\Delta V_{OUT}/V_{OUT}$	Output Voltage Accuracy	Variation from specified V_{OUT}	-1	–	1	%
			-2	–	**2**	
$\Delta V_{OUT}/\Delta T$	Output Voltage Temperature Coefficient (Note 7)	–	–	**120**	–	µV/°C
$(\Delta V_{OUT}/V_{OUT})/\Delta T$		–	–	**48**	–	ppm/°C
V_{RLINE}	Line Regulation	V_{IN} = V_{OUT}+1V to 13.2V	–	1.5	4.5	mV
			–	–	**12**	
V_{RLOAD}	Load Regulation (Note 8)	I_{OUT} = 0.1mA to 300mA	–	1	6	mV
			–	–	**30**	
I_{STD}	Standby Current	V_{EN} ≤ 0.4V (shutdown)	–	0.01	1	µA
		V_{EN} ≤ 0.18V (shutdown)	–	–	**5**	
I_{GND}	Ground Pin Current (Note 10)	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**	
PSRR	Ripple Rejection	f = 100Hz, I_{OUT} = 100µA	–	75		dB
I_{LIMIT}	Current Limit	V_{OUT} = 0V	–	**450**	900	mA
e_{no}	Output Noise	I_{OUT} = 50mA, C_{OUT} = 2.2µF, 100pF from BYP to GND	–	260	–	$nV/\sqrt{Hz}$
V_{IL}	Enable Input Logic-low Voltage	Regulator shutdown	–	–	0.4	V
			–	–	**0.18**	
V_{IH}	Enable Input Logic-high Voltage	Regulator enabled	**2.0**	–	–	V
I_{IL}	Enable Input Logic-low Current	V_{IL} ≤ 0.4V	–	0.01	1	µA
		V_{IL} ≤ 0.18V	–	–	**2**	
I_{IH}	Enable Input Logic-high Current	V_{IL} ≥ 2.0V	–	5	20	µA
		V_{IL} ≥ 2.0V	–	–	**25**	

Notes: 6. 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.

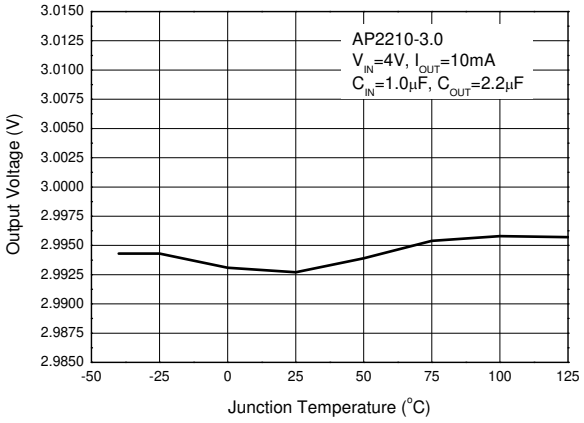
7. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

8. 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 300mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

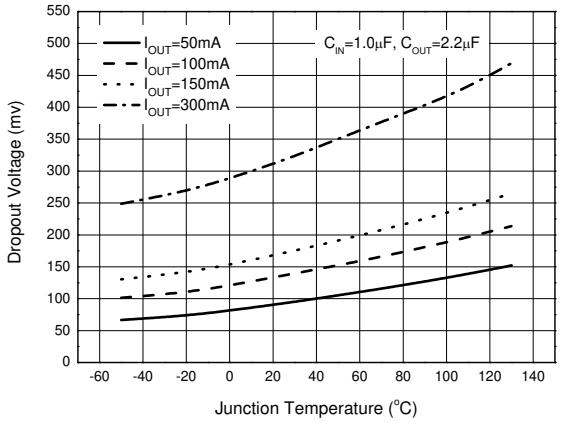
10. Ground pin current is the regulator quiescent current plus pass transistor base current. The total current drawn from the supply is the sum of the load current plus the ground pin current.

Performance Characteristics

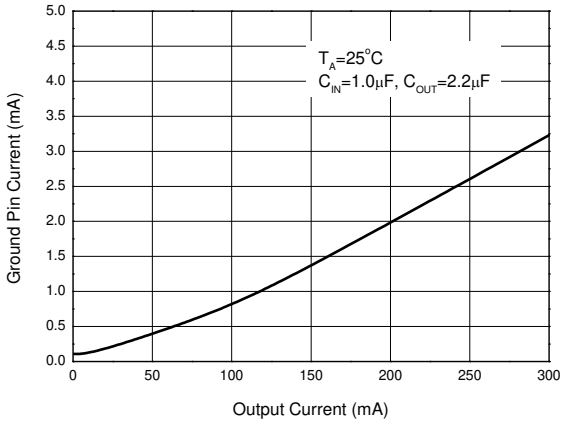
Output Voltage vs. Junction Temperature



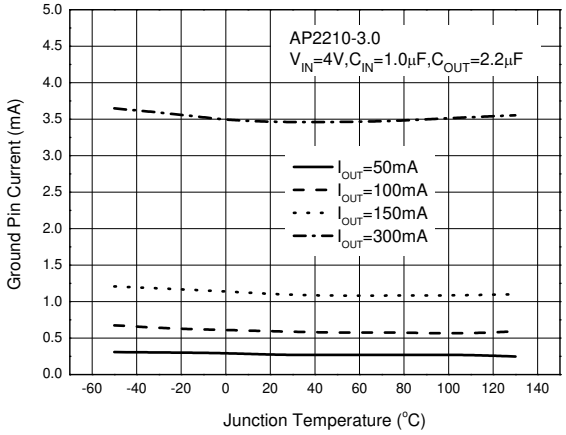
Dropout Voltage vs. Junction Temperature



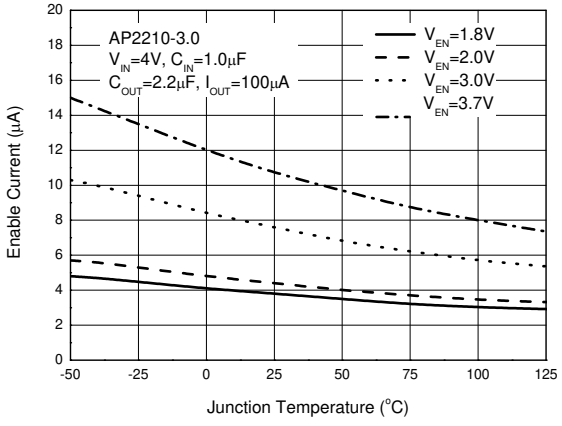
Ground Pin Current vs. Output Current



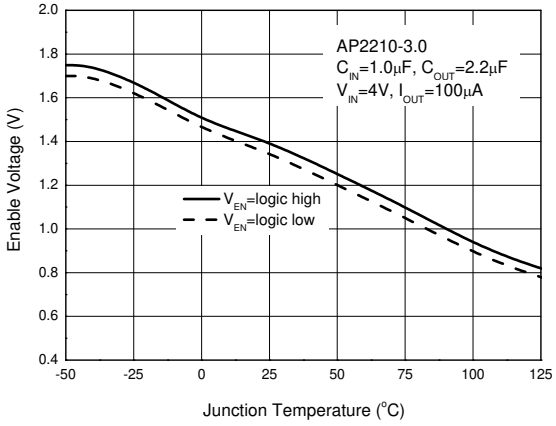
Ground Pin Current vs. Junction Temperature



Enable Current vs. Junction Temperature

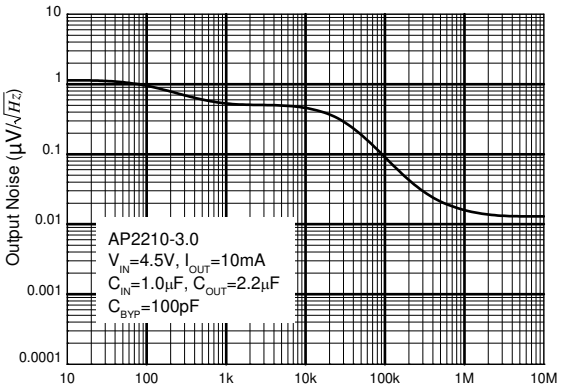


Enable Voltage vs. Junction Temperature

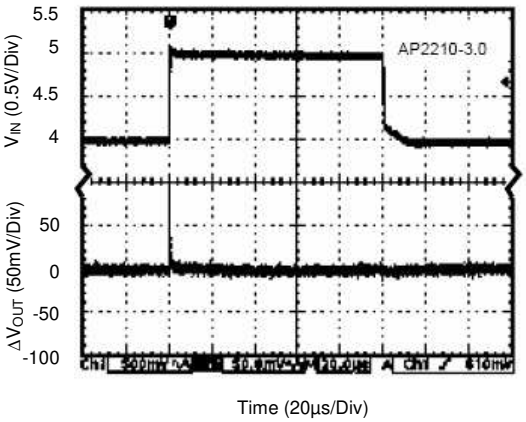


Performance Characteristics (Cont.)

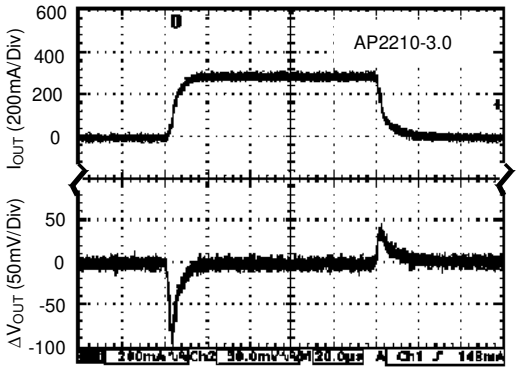
Output Noise vs. Frequency



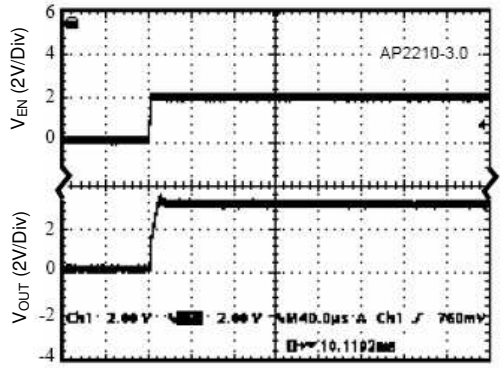
Line Transient
(Conditions: V_{IN} =4 to 5V, V_{EN} =2V, I_{OUT} = 1mA, C_{OUT} = 2.2μF)



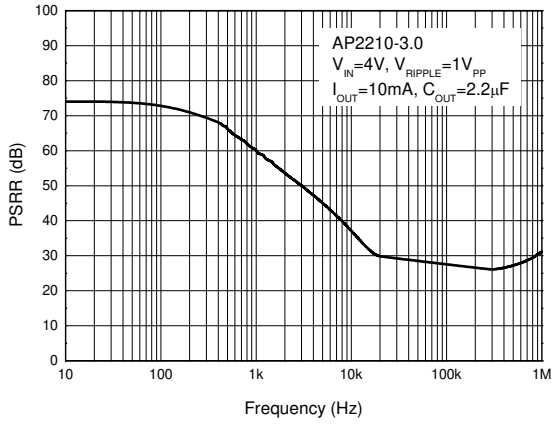
Load Transient
(Conditions: V_{IN} = 4V, V_{EN} = 2V, I_{OUT} = 10mA to 300mA, C_{IN} = 1.0μF, C_{OUT} = 2.2μF)



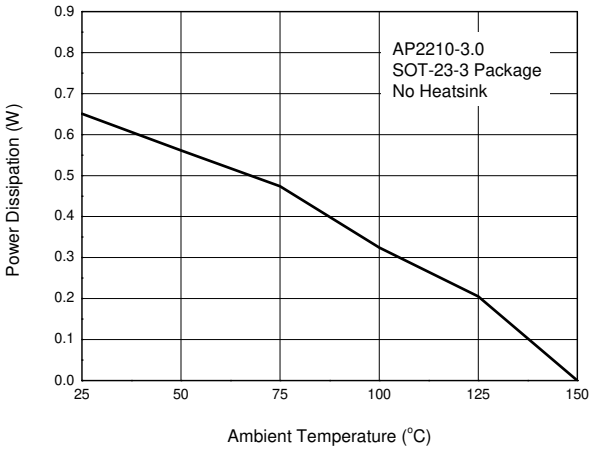
V_{EN} vs. V_{OUT}
(Conditions: V_{EN} = 0 to 2V, V_{IN} = 4V, I_{OUT} = 30mA, C_{IN} = 1.0μF, C_{OUT} = 2.2μF)



PSRR vs. Frequency

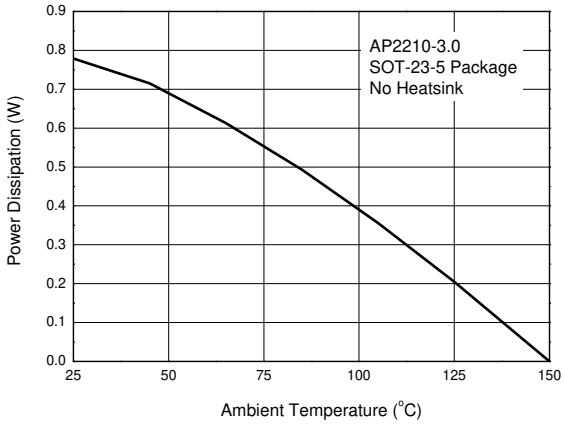


Power Dissipation vs. Ambient Temperature

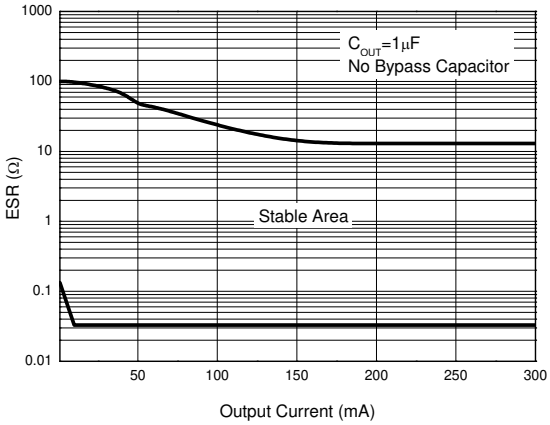


Performance Characteristics (Cont.)

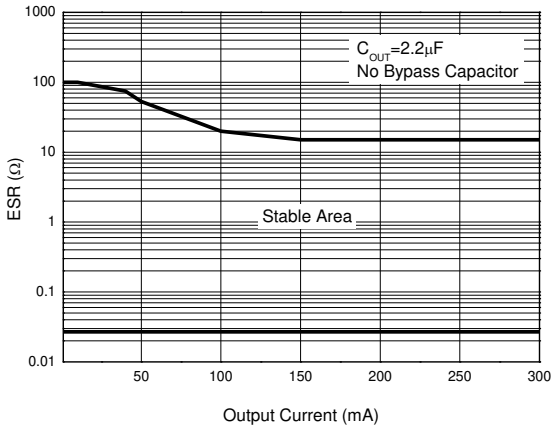
Power Dissipation vs. Ambient Temperature



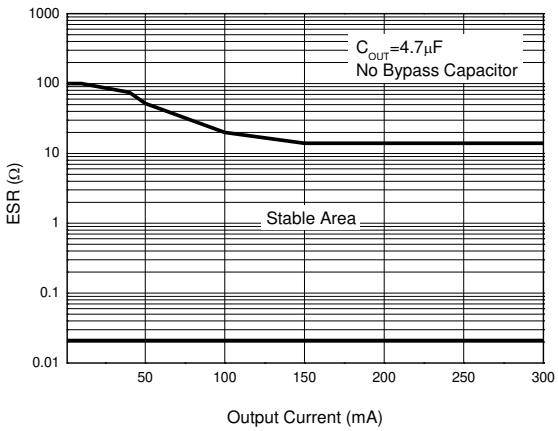
ESR vs. Output Current



ESR vs. Output Current



ESR vs. Output Current



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 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 AP2210 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 Power Dissipation vs. Ambient Temperature and Figure ESR vs. Output Current in Page 22), 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 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.

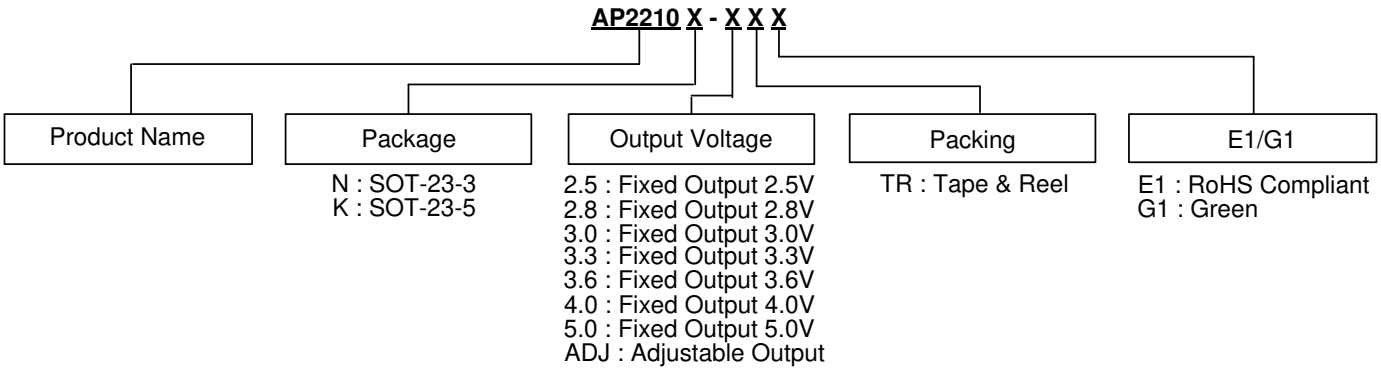
Example (3.0V version):

I_{OUT} = 300mA, T_A = +50°C, $V_{IN(Max)}$ is:

(150°C-50°C)/(0.3A*200°C/W)+3.0V=4.67V

Therefore, for good performance, please make sure that input voltage is less than 4.67V without heatsink when T_A = +50°C.

Ordering Information



Package	Temperature Range	Part Number		Marking ID		Packing
		RoHS Complicant	Green	RoHS Complicant	Green	
SOT-23-3	-40°C to +85°C	AP2210N-2.8TRE1 (Note 11)	AP2210N-2.8TRG1	EH3	GH3	3000/Tape & Reel
		AP2210N-3.0TRE1 (Note 11)	AP2210N-3.0TRG1	EH4	GH4	3000/Tape & Reel
		AP2210N-3.3TRE1 (Note 11)	AP2210N-3.3TRG1	EH5	GH5	3000/Tape & Reel
		–	AP2210N-3.6TRG1	–	GB7	3000/Tape & Reel
		–	AP2210N-4.0TRG1	–	GC7	3000/Tape & Reel
		–	AP2210N-5.0TRG1	–	GH9	3000/Tape & Reel
SOT-23-5	-40°C to +85°C	AP2210K-2.5TRE1 (Note 11)	–	E5C	–	3000/Tape & Reel
		AP2210K-2.8TRE1 (Note 11)	AP2210K-2.8TRG1	E5F	G5F	3000/Tape & Reel
		AP2210K-3.0TRE1 (Note 11)	AP2210K-3.0TRG1	E5H	G5H	3000/Tape & Reel
		AP2210K-3.3TRE1 (Note 11)	AP2210K-3.3TRG1	E5K	G5K	3000/Tape & Reel
		–	AP2210K-3.6TRG1	–	G5I	3000/Tape & Reel
		–	AP2210K-4.0TRG1	–	G5J	3000/Tape & Reel
		–	AP2210K-5.0TRG1	–	G5L	3000/Tape & Reel
		–	AP2210K-ADJTRG1	–	G5M	3000/Tape & Reel

Lead-Free

Lead-free Green

Lead-Free

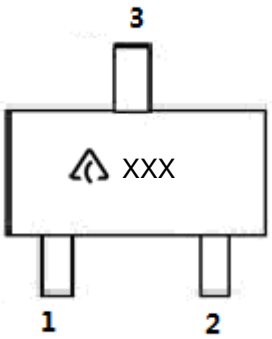
Lead-free Green

Note 11: Not recommended for new design.

Marking Information

(1) SOT-23-3

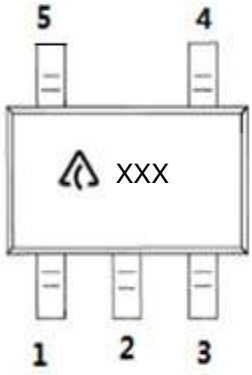
(Top View)



: Logo
XXX: Marking ID
(See Ordering Information)

(2) SOT-23-5

(Top View)



: Logo
XXX: Marking ID
(See Ordering Information)