

300mA RF ULDO REGULATOR**AP2210****General 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 (1 μ A 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: $V_{DROPO} = 250\text{mV}$ at 300mA
- High Output Accuracy: $\pm 1\%$
- Good Ripple Rejection Ability: 75dB at 100Hz and $I_{OUT} = 100\mu\text{A}$
- Tight Load and Line Regulation
- Low Temperature Coefficient
- Over Current Protection
- Thermal Protection
- Reverse-battery Protection
- Logic-controlled Enable

Applications

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

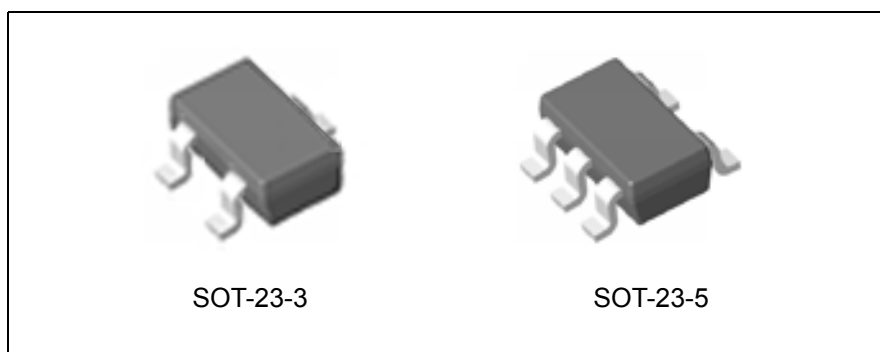


Figure 1. Package Types of AP2210

Pin Configuration

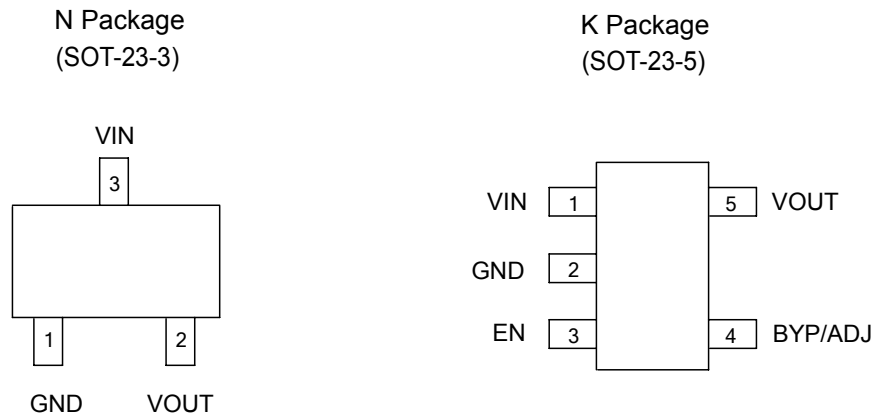
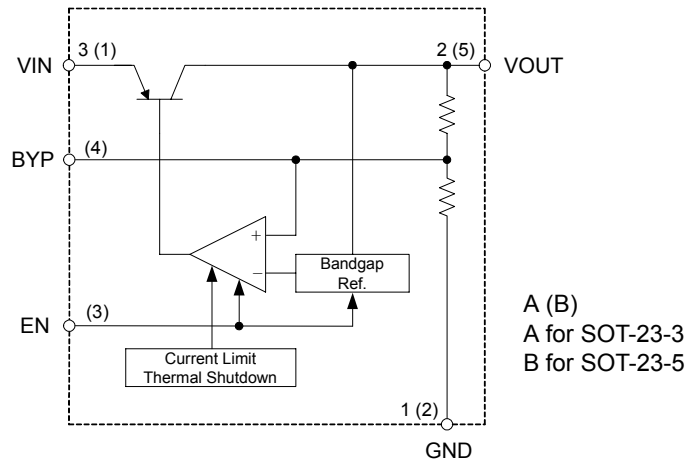


Figure 2. Pin Configuration of AP2210 (Top View)

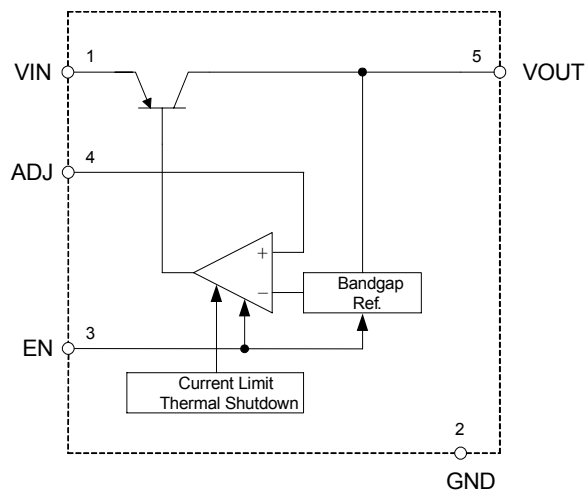
Pin Description

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)

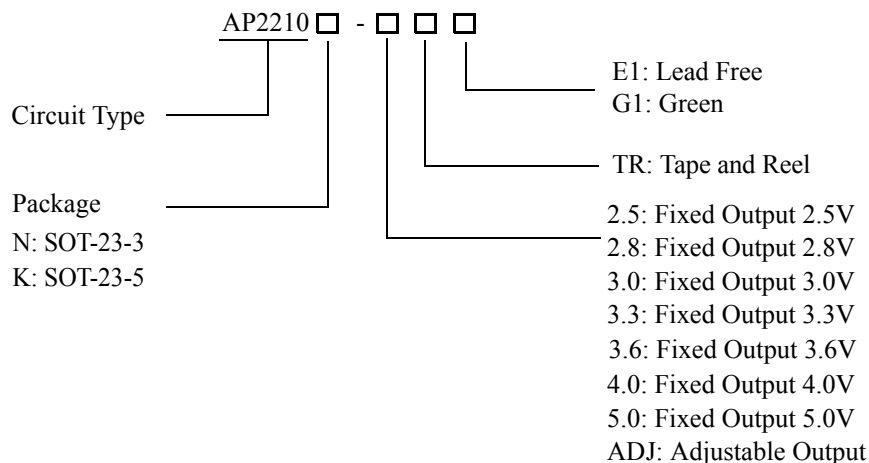
Figure 3. Functional Block Diagram of AP2210



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Ordering Information



Package	Temperature Range	Part Number		Marking ID		Packing Type
		Lead Free	Green	Lead Free	Green	
SOT-23-3	-40 to 125°C	AP2210N-2.5TRE1	AP2210N-2.5TRG1	EH2	GH2	Tape & Reel
		AP2210N-2.8TRE1	AP2210N-2.8TRG1	EH3	GH3	Tape & Reel
		AP2210N-3.0TRE1	AP2210N-3.0TRG1	EH4	GH4	Tape & Reel
		AP2210N-3.3TRE1	AP2210N-3.3TRG1	EH5	GH5	Tape & Reel
			AP2210N-3.6TRG1		GB7	Tape & Reel
			AP2210N-4.0TRG1		GC7	Tape & Reel
			AP2210N-5.0TRG1		GH9	Tape & Reel
SOT-23-5	-40 to 125°C	AP2210K-2.5TRE1	AP2210K-2.5TRG1	E5C	G5C	Tape & Reel
		AP2210K-2.8TRE1	AP2210K-2.8TRG1	E5F	G5F	Tape & Reel
		AP2210K-3.0TRE1	AP2210K-3.0TRG1	E5H	G5H	Tape & Reel
		AP2210K-3.3TRE1	AP2210K-3.3TRG1	E5K	G5K	Tape & Reel
			AP2210K-3.6TRG1		G5I	Tape & Reel
			AP2210K-4.0TRG1		G5J	Tape & Reel
			AP2210K-5.0TRG1		G5L	Tape & Reel
	AP2210K-ADJTRG1		G5M	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.

**300mA RF ULDO REGULATOR****AP2210****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, 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}	SOT-23-3	200	°C/W
		SOT-23-5	200	

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	°C



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Electrical Characteristics (Continued)

AP2210-2.5 Electrical Characteristics

$V_{IN}=3.5V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C \leq T_J \leq 125^\circ C$ (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		$\mu V/^\circ C$		
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			48		ppm/ $^\circ C$		
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 300mA		1	6	mV		
					30			
Dropout Voltage (Note 5)	V_{DROP}	$I_{OUT}=100\mu A$		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			
Standby Current	I_{STD}	$V_{EN}\leq 0.4V$ (shutdown)		0.01	1	μA		
		$V_{EN}\leq 0.18V$ (shutdown)			5			
Ground Pin Current (Note 6)	I_{GND}	$V_{EN}\geq 2.0V$, $I_{OUT}=100\mu A$		100	150	μA		
					180			
		$V_{EN}\geq 2.0V$, $I_{OUT}=50mA$		350	600			
					800			
				$V_{EN}\geq 2.0V$, $I_{OUT}=150mA$		1.3	1.9	mA
							2.5	
		$V_{EN}\geq 2.0V$, $I_{OUT}=300mA$		4	10			
					15			
Ripple Rejection	PSRR	$f=100Hz$, $I_{OUT}=100\mu A$		75		dB		
Current Limit	I_{LIMIT}	$V_{OUT}=0V$		450	900	mA		
Output Noise	ϵ_{no}	$I_{OUT}=50mA$, $C_{OUT}=2.2\mu F$, 100pF from BYP to GND		260		nV/\sqrt{Hz}		

**300mA RF ULDO REGULATOR****AP2210****Electrical Characteristics (Continued)****AP2210-2.5 Electrical Characteristics**

$V_{IN}=3.5V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C\leq T_J\leq 125^\circ C$ (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}	$V_{IL}\leq 0.4V$		0.01	1	μA
		$V_{IL}\leq 0.18V$			2	
Enable Input Logic-high Current	I_{IH}	$V_{IL}\geq 2.0V$		5	20	μA
		$V_{IL}\geq 2.0V$			25	

Note 2: Specifications in bold type are limited to $-40^\circ C\leq T_J\leq 125^\circ C$. 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 300mA. 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% ($T_J=25^\circ C$) or 2% ($-40^\circ C\leq T_J\leq 125^\circ C$) 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.



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Electrical Characteristics (Continued)

AP2210-2.8 Electrical Characteristics

$V_{IN}=3.8V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C \leq T_J \leq 125^\circ C$ (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		$\mu V/^\circ C$
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			42.8		ppm/ $^\circ C$
Line Regulation	V_{RLINE}	$V_{IN}=3.8V$ to $13.2V$		1.5	4.5	mV
					12	
Load Regulation (Note 4)	V_{RLOAD}	$I_{OUT}=0.1mA$ to $300mA$		1	6	mV
					30	
Dropout Voltage (Note 5)	V_{DROP}	$I_{OUT}=100\mu A$		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	
Standby Current	I_{STD}	$V_{EN}\leq 0.4V$ (shutdown)		0.01	1	μA
		$V_{EN}\leq 0.18V$ (shutdown)			5	
Ground Pin Current (Note 6)	I_{GND}	$V_{EN}\geq 2.0V$, $I_{OUT}=100\mu A$		100	150	μA
					180	
		$V_{EN}\geq 2.0V$, $I_{OUT}=50mA$		350	600	mA
					800	
		$V_{EN}\geq 2.0V$, $I_{OUT}=150mA$		1.3	1.9	
					2.5	
		$V_{EN}\geq 2.0V$, $I_{OUT}=300mA$		4	10	
					15	
Ripple Rejection	PSRR	$f=100Hz$, $I_{OUT}=100\mu A$		75		dB
Current Limit	I_{LIMIT}	$V_{OUT}=0V$		450	900	mA
Output Noise	ϵ_{no}	$I_{OUT}=50mA$, $C_{OUT}=2.2\mu F$, 100pF from BYP to GND		260		nV/\sqrt{Hz}

**300mA RF ULDO REGULATOR****AP2210****Electrical Characteristics (Continued)****AP2210-2.8 Electrical Characteristics**

$V_{IN}=3.8V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C\leq T_J\leq 125^\circ C$ (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}	$V_{IL}\leq 0.4V$		0.01	1	μA
		$V_{IL}\leq 0.18V$			2	
Enable Input Logic-high Current	I_{IH}	$V_{IL}\geq 2.0V$		5	20	μA
		$V_{IL}\geq 2.0V$			25	

Note 2: Specifications in bold type are limited to $-40^\circ C\leq T_J\leq 125^\circ C$. 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 300mA. 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% ($T_J=25^\circ C$) or 2% ($-40^\circ C\leq T_J\leq 125^\circ C$) 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.



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Electrical Characteristics (Continued)

AP2210-3.0 Electrical Characteristics

$V_{IN}=4V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C\leq T_J\leq 125^\circ C$ (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		$\mu V/^\circ C$
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			40		ppm/ $^\circ C$
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 300mA		1	6	mV
					30	
Dropout Voltage (Note 5)	V_{DROP}	$I_{OUT}=100\mu A$		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		
Standby Current	I_{STD}	$V_{EN}\leq 0.4V$ (shutdown)		0.01	1	μA
		$V_{EN}\leq 0.18V$ (shutdown)			5	
Ground Pin Current (Note 6)	I_{GND}	$V_{EN}\geq 2.0V$, $I_{OUT}=100\mu A$		100	150	μA
				180		
		$V_{EN}\geq 2.0V$, $I_{OUT}=50mA$		350	600	mA
				800		
		$V_{EN}\geq 2.0V$, $I_{OUT}=150mA$		1.3	1.9	
				2.5		
		$V_{EN}\geq 2.0V$, $I_{OUT}=300mA$		4	10	
				15		
Ripple Rejection	PSRR	$f=100Hz$, $I_{OUT}=100\mu A$		75		dB
Current Limit	I_{LIMIT}	$V_{OUT}=0V$		450	900	mA
Output Noise	e_{no}	$I_{OUT}=50mA$, $C_{OUT}=2.2\mu F$, 100pF from BYP to GND		260		nV/\sqrt{Hz}

**300mA RF ULDO REGULATOR****AP2210****Electrical Characteristics (Continued)****AP2210-3.0 Electrical Characteristics**

$V_{IN}=4V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C\leq T_J\leq 125^\circ C$ (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}	$V_{IL}\leq 0.4V$		0.01	1	μA
		$V_{IL}\leq 0.18V$			2	
Enable Input Logic-high Current	I_{IH}	$V_{IL}\geq 2.0V$		5	20	μA
		$V_{IL}\geq 2.0V$			25	

Note 2: Specifications in bold type are limited to $-40^\circ C\leq T_J\leq 125^\circ C$. 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 300mA. 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% ($T_J=25^\circ C$) or 2% ($-40^\circ C\leq T_J\leq 125^\circ C$) 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.



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Electrical Characteristics (Continued)

AP2210-3.3 Electrical Characteristics

$V_{IN}=4.3V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C \leq T_J \leq 125^\circ C$ (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		$\mu V/^\circ C$
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			36.3		ppm/ $^\circ C$
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 $300mA$		1	6	mV
					30	
Dropout Voltage (Note 5)	V_{DROP}	$I_{OUT}=100\mu A$		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			
Standby Current	I_{STD}	$V_{EN}\leq 0.4V$ (shutdown)		0.01	1	μA
		$V_{EN}\leq 0.18V$ (shutdown)			5	
Ground Pin Current (Note 6)	I_{GND}	$V_{EN}\geq 2.0V$, $I_{OUT}=100\mu A$		100	150	μA
					180	
		$V_{EN}\geq 2.0V$, $I_{OUT}=50mA$		350	600	
					800	
$V_{EN}\geq 2.0V$, $I_{OUT}=150mA$		1.3	1.9	mA		
			2.5			
$V_{EN}\geq 2.0V$, $I_{OUT}=300mA$		4	10			
			15			
Ripple Rejection	PSRR	$f=100Hz$, $I_{OUT}=100\mu A$		75		dB
Current Limit	I_{LIMIT}	$V_{OUT}=0V$		450	900	mA
Output Noise	e_{no}	$I_{OUT}=50mA$, $C_{OUT}=2.2\mu F$, 100pF from BYP to GND		260		nV/\sqrt{Hz}

**300mA RF ULDO REGULATOR****AP2210****Electrical Characteristics (Continued)****AP2210-3.3 Electrical Characteristics**

$V_{IN}=4.3V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C\leq T_J\leq 125^\circ C$ (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}	$V_{IL}\leq 0.4V$		0.01	1	μA
		$V_{IL}\leq 0.18V$			2	
Enable Input Logic-high Current	I_{IH}	$V_{IL}\geq 2.0V$		5	20	μA
		$V_{IL}\geq 2.0V$			25	

Note 2: Specifications in bold type are limited to $-40^\circ C\leq T_J\leq 125^\circ C$. 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 300mA. 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% ($T_J=25^\circ C$) or 2% ($-40^\circ C\leq T_J\leq 125^\circ C$) 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.



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Electrical Characteristics (Continued)

AP2210-3.6 Electrical Characteristics

$V_{IN}=4.6V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C \leq T_J \leq 125^\circ C$ (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		$\mu V/^\circ C$
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			48		ppm/ $^\circ C$
Line Regulation	V_{RLINE}	$V_{IN}=4.6V$ to $13.2V$		1.5	4.5	mV
					12	
Load Regulation (Note 4)	V_{RLOAD}	$I_{OUT}=0.1mA$ to $300mA$		1	6	mV
					30	
Dropout Voltage (Note 5)	V_{DROP}	$I_{OUT}=100\mu A$		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		
Standby Current	I_{STD}	$V_{EN}\leq 0.4V$ (shutdown)		0.01	1	μA
		$V_{EN}\leq 0.18V$ (shutdown)			5	
Ground Pin Current (Note 6)	I_{GND}	$V_{EN}\geq 2.0V$, $I_{OUT}=100\mu A$		100	150	μA
				180		
		$V_{EN}\geq 2.0V$, $I_{OUT}=50mA$		350	600	
				800		
		$V_{EN}\geq 2.0V$, $I_{OUT}=150mA$		1.3	1.9	mA
				2.5		
$V_{EN}\geq 2.0V$, $I_{OUT}=300mA$		4	10			
		15				
Ripple Rejection	PSRR	$f=100Hz$, $I_{OUT}=100\mu A$		75		dB
Current Limit	I_{LIMIT}	$V_{OUT}=0V$		450	900	mA
Output Noise	ϵ_{no}	$I_{OUT}=50mA$, $C_{OUT}=2.2\mu F$, 100pF from BYP to GND		260		nV/\sqrt{Hz}

**300mA RF ULDO REGULATOR****AP2210****Electrical Characteristics (Continued)****AP2210-3.6 Electrical Characteristics**

$V_{IN}=4.6V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C\leq T_J\leq 125^\circ C$ (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}	$V_{IL}\leq 0.4V$		0.01	1	μA
		$V_{IL}\leq 0.18V$			2	
Enable Input Logic-high Current	I_{IH}	$V_{IL}\geq 2.0V$		5	20	μA
		$V_{IL}\geq 2.0V$			25	

Note 2: Specifications in bold type are limited to $-40^\circ C\leq T_J\leq 125^\circ C$. 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 300mA. 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% ($T_J=25^\circ C$) or 2% ($-40^\circ C\leq T_J\leq 125^\circ C$) 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.



300mA RF ULDO REGULATOR

AP2210

Electrical Characteristics (Continued)

AP2210-4.0 Electrical Characteristics

$V_{IN}=5.0V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C \leq T_J \leq 125^\circ C$ (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		$\mu V/^\circ C$		
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			48		ppm/ $^\circ C$		
Line Regulation	V_{RLINE}	$V_{IN}=5.0V$ to $13.2V$		1.5	4.5	mV		
					12			
Load Regulation (Note 4)	V_{RLOAD}	$I_{OUT}=0.1mA$ to $300mA$		1	6	mV		
					30			
Dropout Voltage (Note 5)	V_{DROP}	$I_{OUT}=100\mu A$		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			
Standby Current	I_{STD}	$V_{EN}\leq 0.4V$ (shutdown)		0.01	1	μA		
		$V_{EN}\leq 0.18V$ (shutdown)			5			
Ground Pin Current (Note 6)	I_{GND}	$V_{EN}\geq 2.0V$, $I_{OUT}=100\mu A$		100	150	μA		
					180			
		$V_{EN}\geq 2.0V$, $I_{OUT}=50mA$		350	600			
					800			
				$V_{EN}\geq 2.0V$, $I_{OUT}=150mA$		1.3	1.9	mA
							2.5	
		$V_{EN}\geq 2.0V$, $I_{OUT}=300mA$		4	10			
					15			
Ripple Rejection	PSRR	$f=100Hz$, $I_{OUT}=100\mu A$		75		dB		
Current Limit	I_{LIMIT}	$V_{OUT}=0V$		450	900	mA		
Output Noise	ϵ_{no}	$I_{OUT}=50mA$, $C_{OUT}=2.2\mu F$, 100pF from BYP to GND		260		nV/\sqrt{Hz}		

**300mA RF ULDO REGULATOR****AP2210****Electrical Characteristics (Continued)****AP2210-4.0 Electrical Characteristics**

$V_{IN}=5.0V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C\leq T_J\leq 125^\circ C$ (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}	$V_{IL}\leq 0.4V$		0.01	1	μA
		$V_{IL}\leq 0.18V$			2	
Enable Input Logic-high Current	I_{IH}	$V_{IL}\geq 2.0V$		5	20	μA
		$V_{IL}\geq 2.0V$			25	

Note 2: Specifications in bold type are limited to $-40^\circ C\leq T_J\leq 125^\circ C$. 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 300mA. 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% ($T_J=25^\circ C$) or 2% ($-40^\circ C\leq T_J\leq 125^\circ C$) 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.



300mA RF ULDO REGULATOR

AP2210

Electrical Characteristics (Continued)

AP2210-5.0 Electrical Characteristics

$V_{IN}=6.0V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C \leq T_J \leq 125^\circ C$ (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		$\mu V/^\circ C$		
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			48		ppm/ $^\circ C$		
Line Regulation	V_{RLINE}	$V_{IN}=6.0V$ to $13.2V$		1.5	4.5	mV		
					12			
Load Regulation (Note 4)	V_{RLOAD}	$I_{OUT}=0.1mA$ to $300mA$		1	6	mV		
					30			
Dropout Voltage (Note 5)	V_{DROP}	$I_{OUT}=100\mu A$		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			
Standby Current	I_{STD}	$V_{EN}\leq 0.4V$ (shutdown)		0.01	1	μA		
		$V_{EN}\leq 0.18V$ (shutdown)			5			
Ground Pin Current (Note 6)	I_{GND}	$V_{EN}\geq 2.0V$, $I_{OUT}=100\mu A$		100	150	μA		
					180			
		$V_{EN}\geq 2.0V$, $I_{OUT}=50mA$		350	600			
					800			
				$V_{EN}\geq 2.0V$, $I_{OUT}=150mA$		1.3	1.9	mA
							2.5	
		$V_{EN}\geq 2.0V$, $I_{OUT}=300mA$		4	10			
					15			
Ripple Rejection	PSRR	$f=100Hz$, $I_{OUT}=100\mu A$		75		dB		
Current Limit	I_{LIMIT}	$V_{OUT}=0V$		450	900	mA		
Output Noise	ϵ_{no}	$I_{OUT}=50mA$, $C_{OUT}=2.2\mu F$, 100pF from BYP to GND		260		nV/\sqrt{Hz}		

**300mA RF ULDO REGULATOR****AP2210****Electrical Characteristics (Continued)****AP2210-5.0 Electrical Characteristics**

$V_{IN}=6.0V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C\leq T_J\leq 125^\circ C$ (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}	$V_{IL}\leq 0.4V$		0.01	1	μA
		$V_{IL}\leq 0.18V$			2	
Enable Input Logic-high Current	I_{IH}	$V_{IL}\geq 2.0V$		5	20	μA
		$V_{IL}\geq 2.0V$			25	

Note 2: Specifications in bold type are limited to $-40^\circ C\leq T_J\leq 125^\circ C$. 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 300mA. 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% ($T_J=25^\circ C$) or 2% ($-40^\circ C\leq T_J\leq 125^\circ C$) 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.



300mA RF ULDO REGULATOR

AP2210

Electrical Characteristics (Continued)

AP2210-ADJ Electrical Characteristics

$V_{IN}=V_{OUT}+1V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C\leq T_J\leq 125^\circ C$ (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		$\mu V/^\circ C$
	$(\Delta V_{OUT}/V_{OUT})/\Delta T$			48		ppm/ $^\circ C$
Line Regulation	V_{RLINE}	$V_{IN}=V_{OUT}+1V$ to 13.2V		1.5	4.5	mV
					12	
Load Regulation (Note 4)	V_{RLOAD}	$I_{OUT}=0.1mA$ to 300mA		1	6	mV
					30	
Standby Current	I_{STD}	$V_{EN}\leq 0.4V$ (shutdown)		0.01	1	μA
		$V_{EN}\leq 0.18V$ (shutdown)			5	
Ground Pin Current (Note 6)	I_{GND}	$V_{EN}\geq 2.0V$, $I_{OUT}=100\mu A$		100	150	μA
					180	
		$V_{EN}\geq 2.0V$, $I_{OUT}=50mA$		350	600	mA
					800	
		$V_{EN}\geq 2.0V$, $I_{OUT}=150mA$		1.3	1.9	mA
					2.5	
		$V_{EN}\geq 2.0V$, $I_{OUT}=300mA$		4	10	mA
					15	
Ripple Rejection	PSRR	$f=100Hz$, $I_{OUT}=100\mu A$		75		dB
Current Limit	I_{LIMIT}	$V_{OUT}=0V$		450	900	mA
Output Noise	e_{no}	$I_{OUT}=50mA$, $C_{OUT}=2.2\mu F$, 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}	$V_{IL}\leq 0.4V$		0.01	1	μA
		$V_{IL}\leq 0.18V$			2	
Enable Input Logic-high Current	I_{IH}	$V_{IL}\geq 2.0V$		5	20	μA
		$V_{IL}\geq 2.0V$			25	

**Electrical Characteristics (Continued)****AP2210-ADJ Electrical Characteristics**

$V_{IN}=V_{OUT}+1V$, $I_{OUT}=100\mu A$, $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$, $V_{EN}\geq 2.0V$, $T_J=25^\circ C$, **Bold** typeface applies over $-40^\circ C\leq T_J\leq 125^\circ C$ (Note 2), unless otherwise specified.

Note 2: Specifications in bold type are limited to $-40^\circ C\leq T_J\leq 125^\circ C$. 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 300mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

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

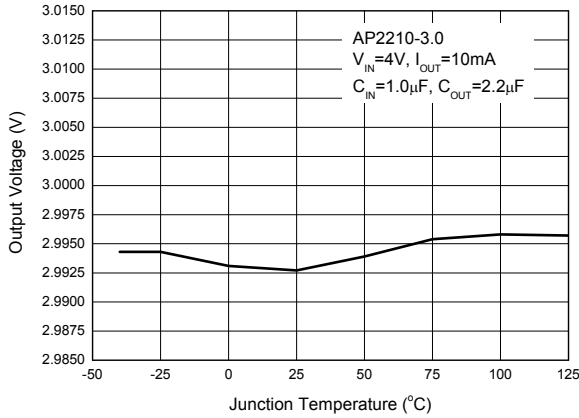


Figure 4. Output Voltage vs. Junction Temperature

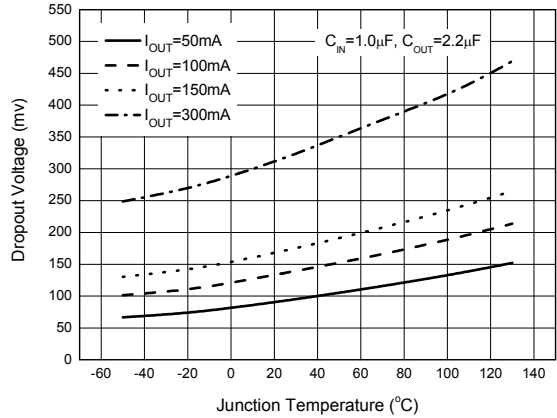


Figure 5. Dropout Voltage vs. Junction Temperature

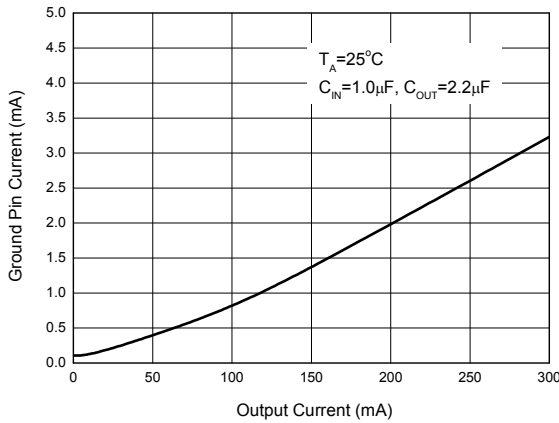


Figure 6. Ground Pin Current vs. Output Current

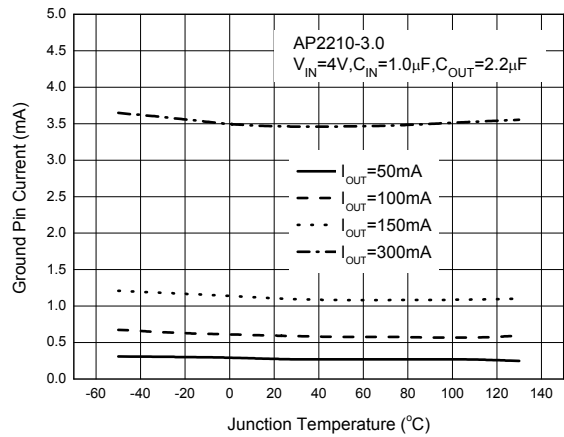


Figure 7. Ground Pin Current vs. Junction Temperature



300mA RF ULDO REGULATOR

AP2210

Typical Performance Characteristics (Continued)

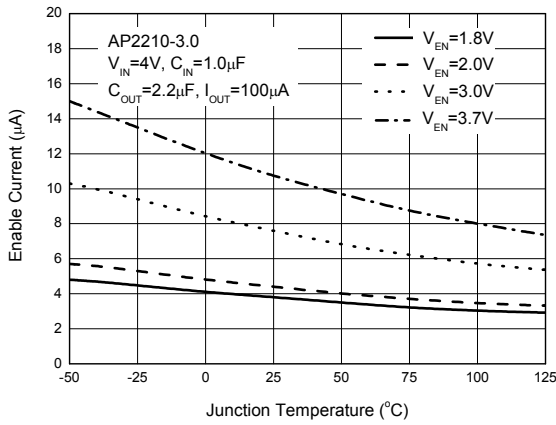


Figure 8. Enable Current vs. Junction Temperature

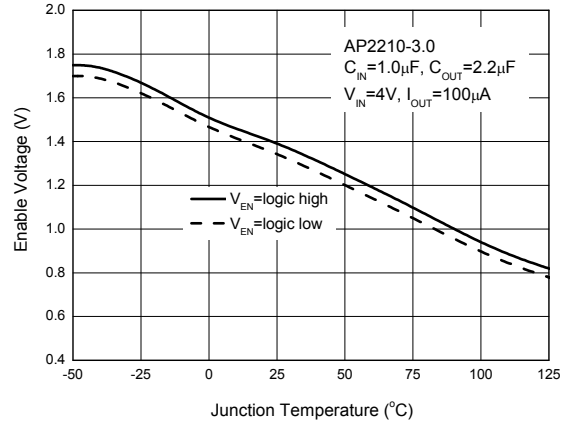


Figure 9. Enable Voltage vs. Junction Temperature

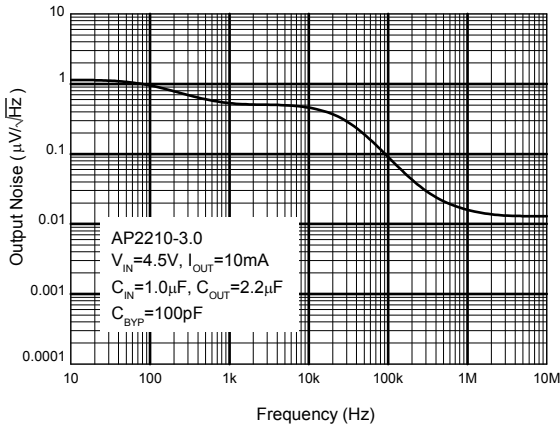


Figure 10. Output Noise vs. Frequency

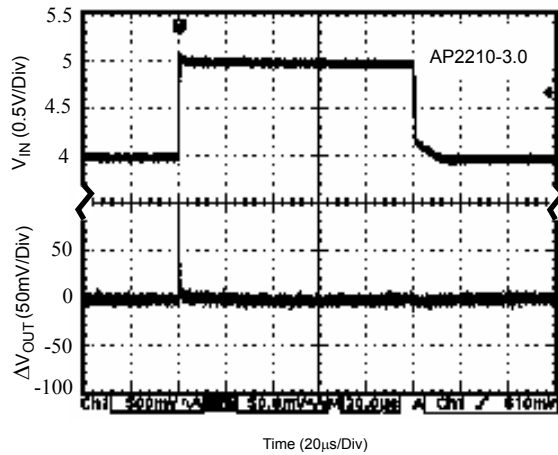


Figure 11. Line Transient
(Conditions: $V_{IN}=4$ to $5V$, $V_{EN}=2V$, $I_{OUT}=1mA$, $C_{OUT}=2.2\mu F$)

Typical Performance Characteristics (Continued)

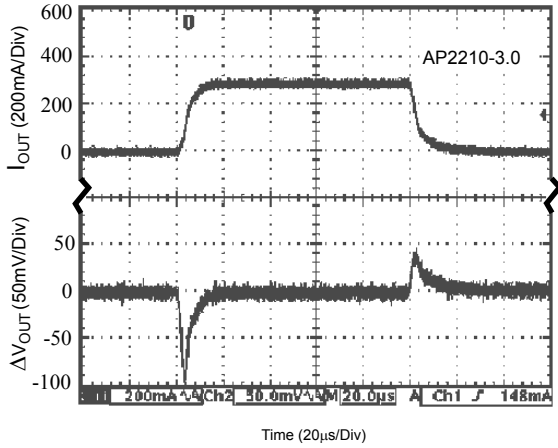


Figure 12. Load Transient
 (Conditions: $V_{IN}=4V$, $V_{EN}=2V$, $I_{OUT}=10mA$ to $300mA$,
 $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$)

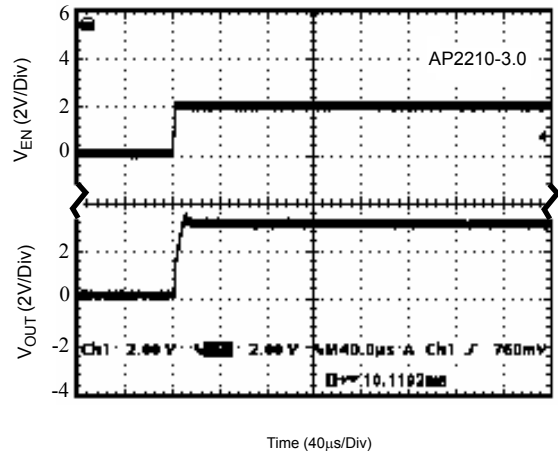


Figure 13. V_{EN} vs. V_{OUT}
 (Conditions: $V_{EN}=0$ to $2V$, $V_{IN}=4V$, $I_{OUT}=30mA$,
 $C_{IN}=1.0\mu F$, $C_{OUT}=2.2\mu F$)

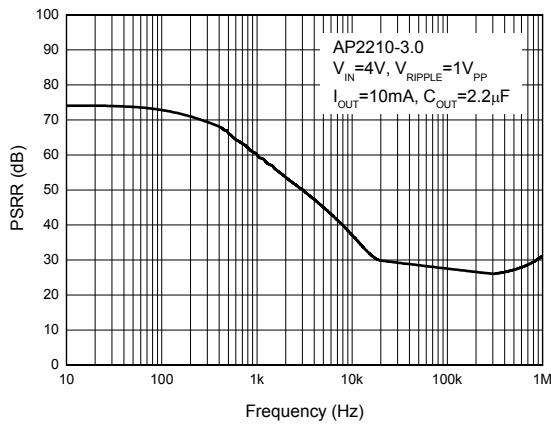


Figure 14. PSRR vs. Frequency

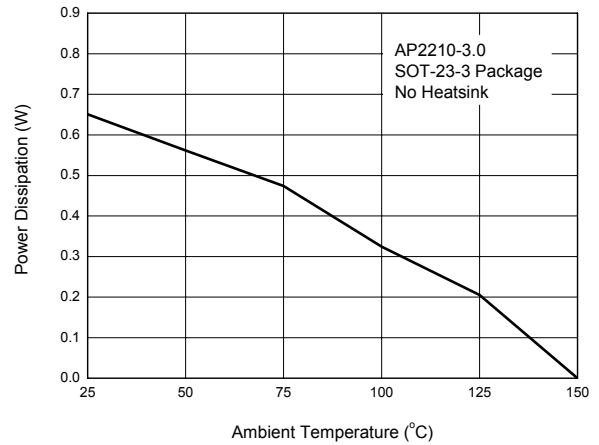


Figure 15. Power Dissipation vs. Ambient Temperature



Typical Performance Characteristics (Continued)

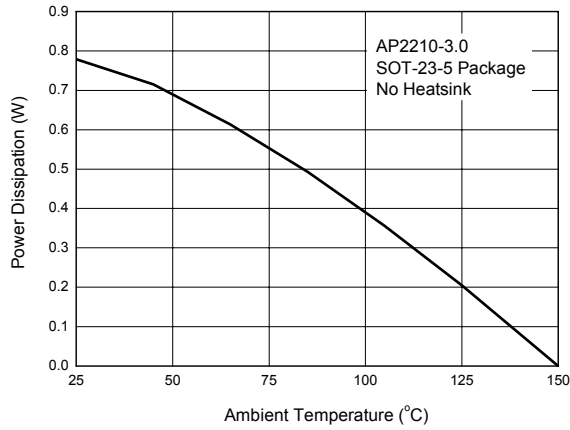


Figure 16. Power Dissipation vs. Ambient Temperature

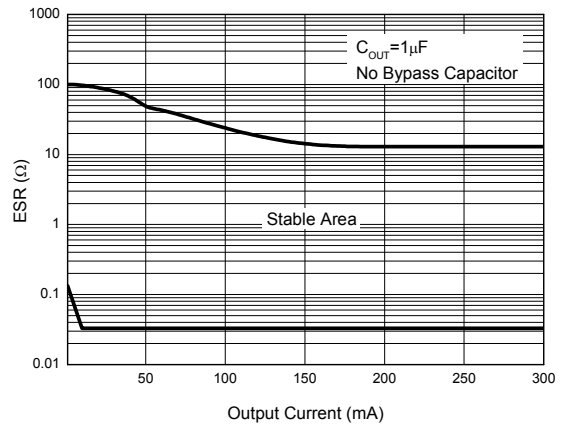


Figure 17. ESR vs. Output Current

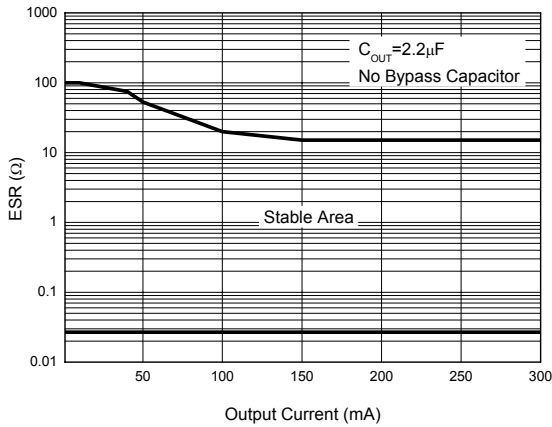


Figure 18. ESR vs. Output Current

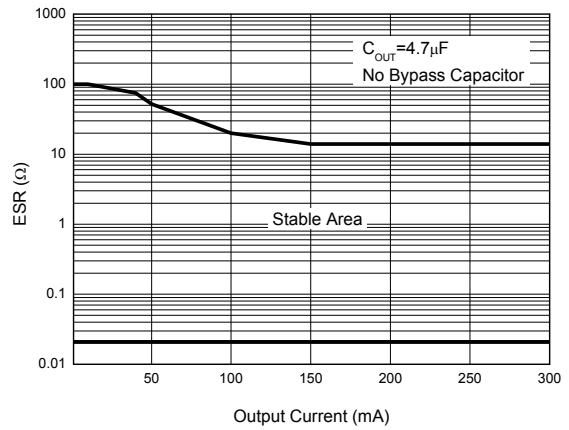
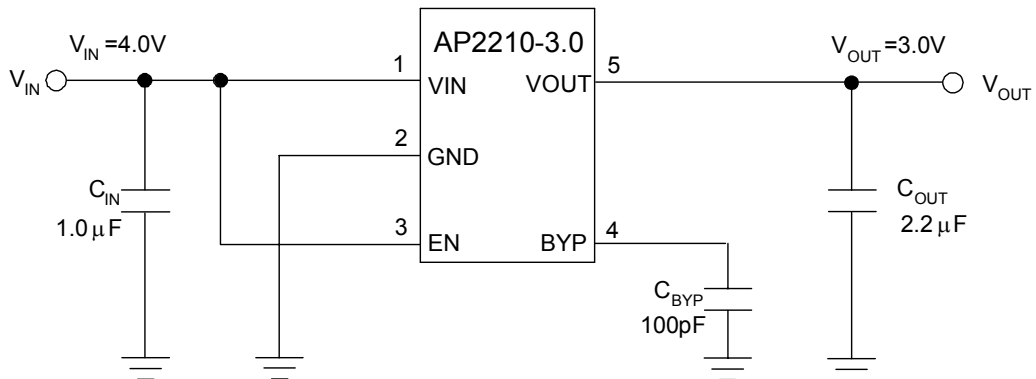
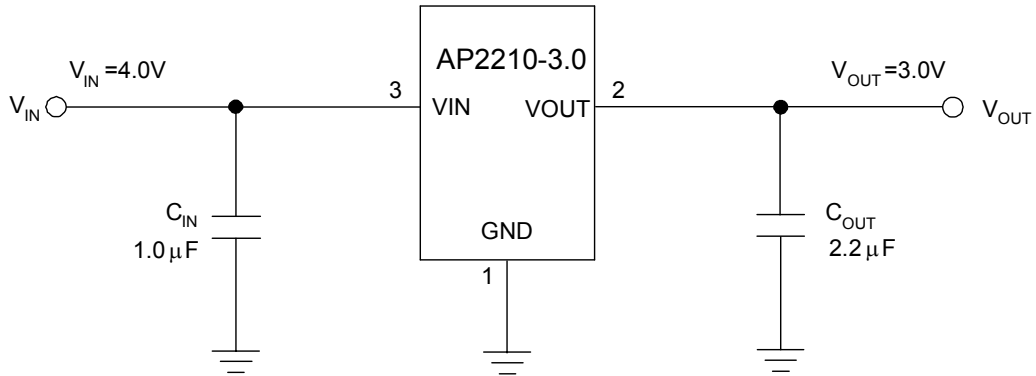
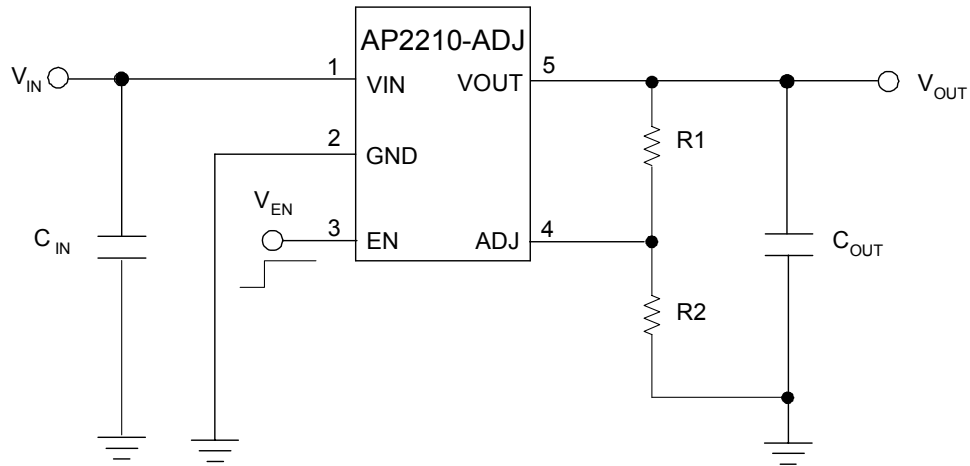


Figure 19. ESR vs. Output Current

Typical Application



For Fixed Version

Typical Application (Continued)


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

For Adjustable Version

Figure 20. Typical Application of AP2210 (Note 7)

Note 7: Dropout voltage is 250mV when $T_A = 25^\circ\text{C}$. In order to obtain a normal output voltage, $V_{OUT} + 0.25\text{V}$ is the minimum input voltage which will result in a low PSRR, imposing a bad influence on the system. Therefore, the recommended input voltage is $V_{OUT} + 1\text{V}$ to 13.2V. For AP2210-3.0 version, its input voltage can be set from $4V(V_{OUT} + 1V)$ to 13.2V.

**300mA RF ULDO REGULATOR****AP2210****Application Information****Input Capacitor**

A 1 μ F minimum capacitor is recommended to be placed between V_{IN} and GND.

Output Capacitor

It is required to prevent oscillation. 1.0 μ F minimum is recommended when C_{BYP} is unused. 2.2 μ F 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 tempera-

ture 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: $T_J \leq T_{J(max)}$. $T_{J(max)}$ 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):

$$I_{OUT} = 300\text{mA}, T_A = 50^\circ\text{C}, V_{IN(Max)} \text{ is:}$$

$$(150^\circ\text{C} - 50^\circ\text{C}) / (0.3\text{A} * 200^\circ\text{C/W}) + 3.0\text{V} = 4.67\text{V}$$

Therefore, for good performance, please make sure that input voltage is less than 4.67V without heatsink when $T_A = 50^\circ\text{C}$.



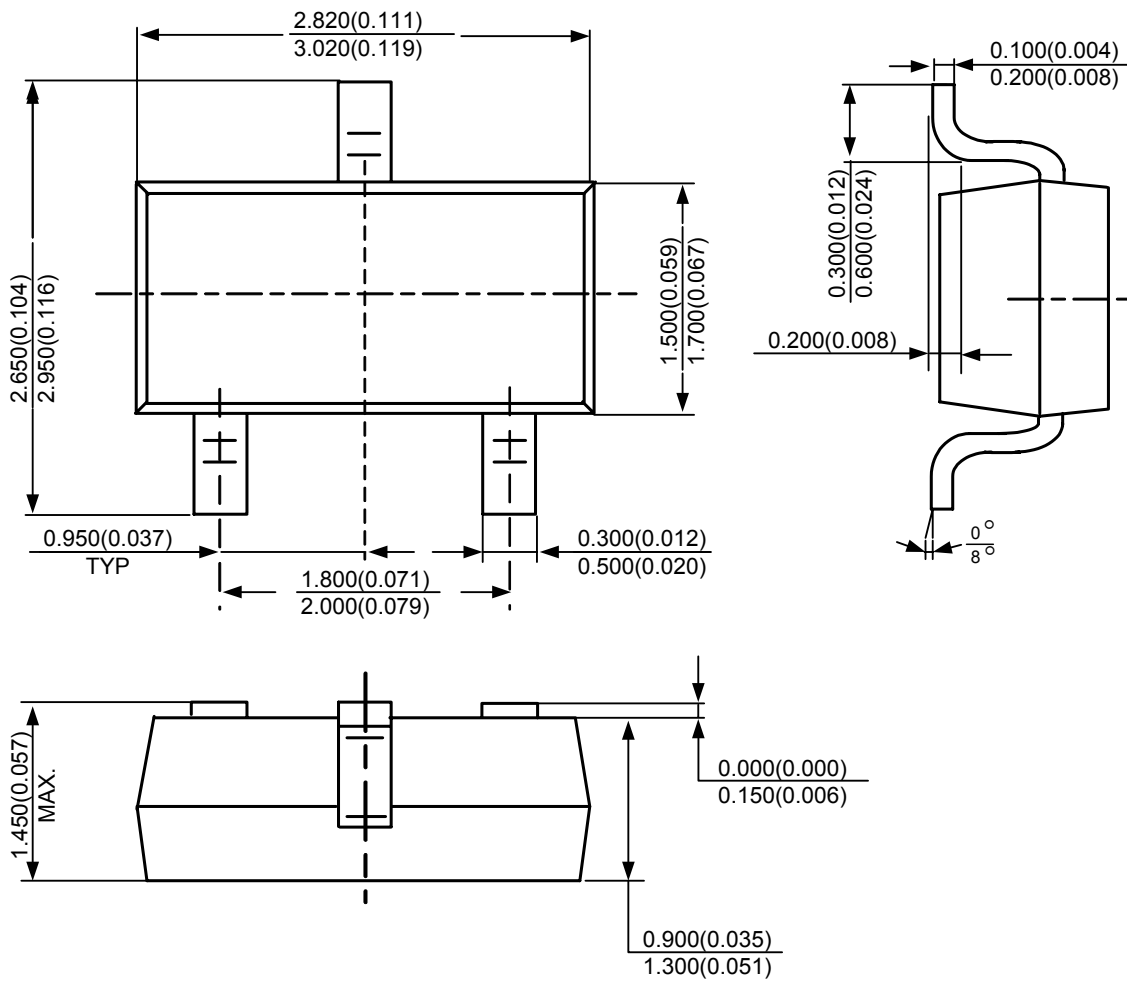
300mA RF ULDO REGULATOR

AP2210

Mechanical Dimensions

SOT-23-3

Unit: mm(inch)





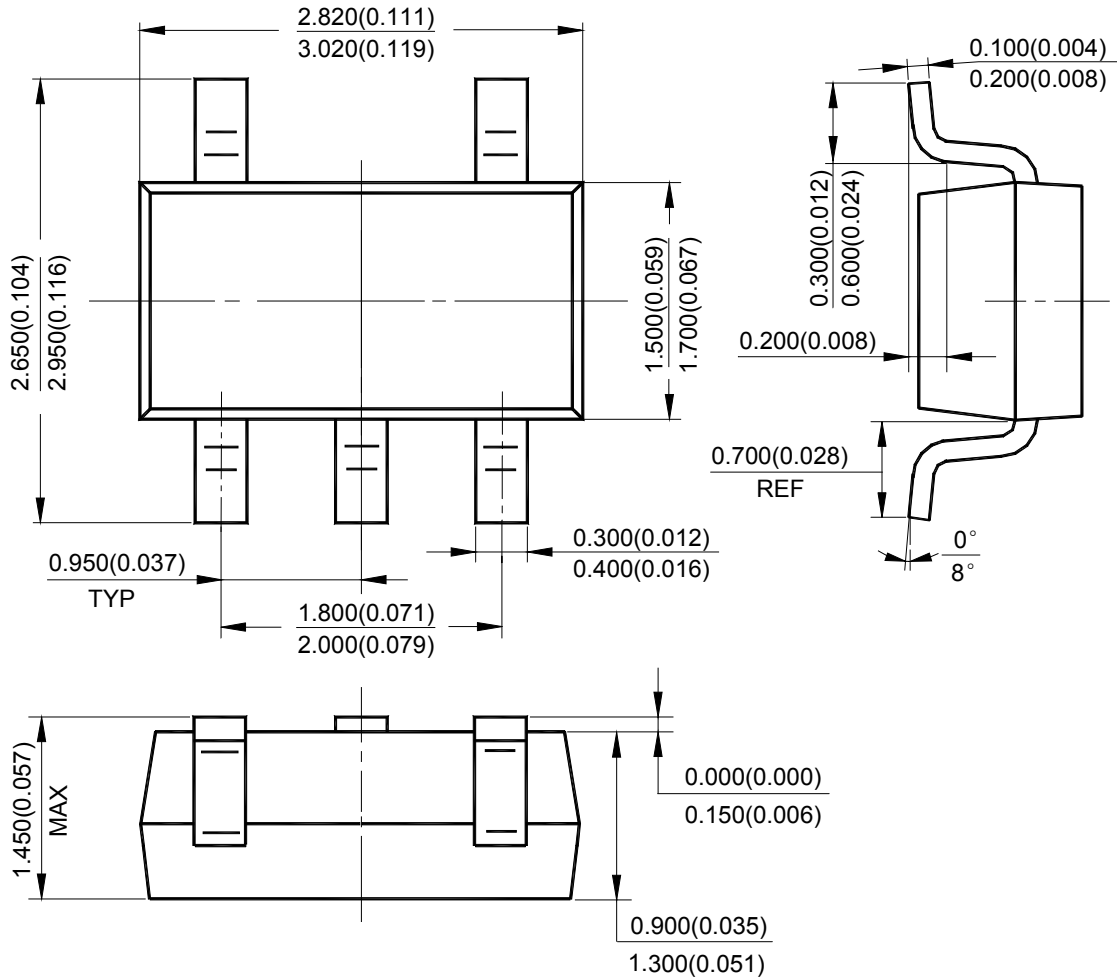
300mA RF ULDO REGULATOR

AP2210

Mechanical Dimensions (Continued)

SOT-23-5

Unit: mm(inch)





BCD Semiconductor Manufacturing Limited

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