

**150mA RF ULDO REGULATOR****AP2202****General Description**

The AP2202 is a 150mA ULDO regulator which provides very low noise ( $45\mu\text{Vrms}$  at 80Hz-100KHz), ultra low dropout voltage (typically 165mV at 150mA), very low quiescent current (1 $\mu\text{A}$  maximum) and excellent power supply ripple rejection (PSRR 75dB at 100Hz) in battery powered applications, such as handsets and PDAs and in noise sensitive applications, such as RF electronics.

The AP2202 also features 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 output capacitor of 1.0 $\mu\text{F}$  minimum and 2.2 $\mu\text{F}$  minimum near its pin are recommended when  $C_{\text{BYP}}$  is unused and 470pF respectively. Tantalum or aluminium electrolytic capacitors are adequate. Bypass capacitor is connected to the internal voltage reference to quiet noise. Its recommended value is from 470pF to 1nF. If output noise is not a major concern and rapid turn-on is necessary, omit  $C_{\text{BYP}}$  and leave BYP open.

The AP2202 has adjustable, 2.5V, 2.6V, 2.7V, 2.8V, 2.9V, 3.0V, 3.3V and 4.0V versions.

The AP2202 is available in space saving SOT-23-5 package.

**Features**

- Up to 150mA Regulator Output
- Low Quiescent Current
- Low Dropout Voltage:  $V_{\text{D}}=165\text{mV}$  at 150mA
- High Precision Output Voltage:  $\pm 1\%$
- Output Noise:  $45\mu\text{Vrms}$  at 80Hz-100KHz
- Good Ripple Rejection Ability: 75dB at 100Hz and  $I_{\text{OUT}}=100\mu\text{A}$
- 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
- Digital Still Cameras
- Wireless Communicators
- PDAs / Palmtops
- PC Mother Board
- Consumer Electronics

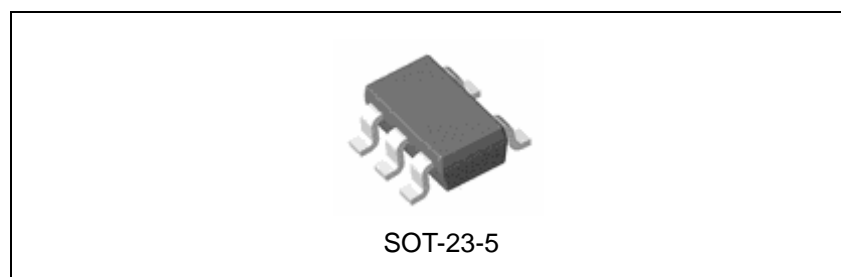


Figure 1. Package Type of AP2202

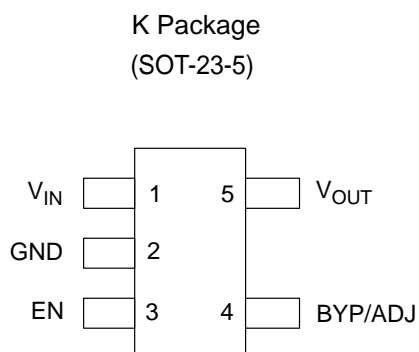
**150mA RF ULDO REGULATOR****AP2202****Pin Configuration**

Figure 2. Pin Configuration of AP2202 (Top View)

**Pin Description**

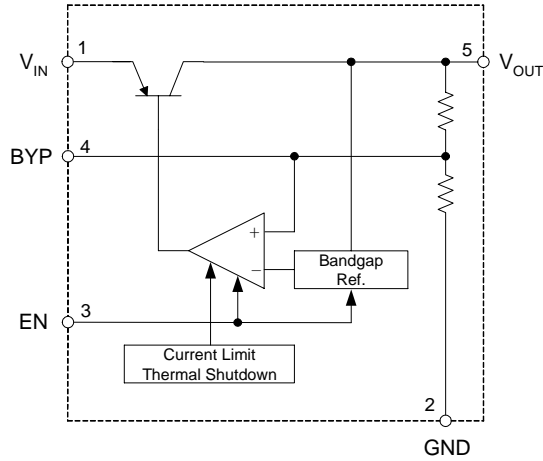
Pin Number	Pin Name	Function
1	$V_{IN}$	Input voltage.
2	GND	Ground.
3	EN	Logic high enable input.
4	BYP/ADJ	Bypass capacitor for low noise operation/Adjust output.
5	$V_{OUT}$	Regulated output voltage.



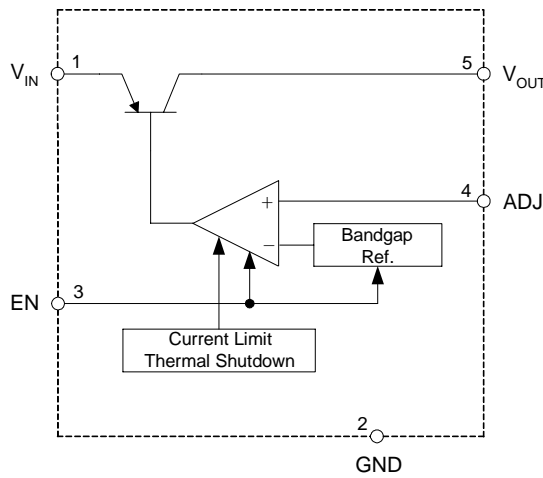
**150mA RF ULDO REGULATOR**

**AP2202**

**Functional Block Diagram**



Fixed Regulator



Adjustable Regulator

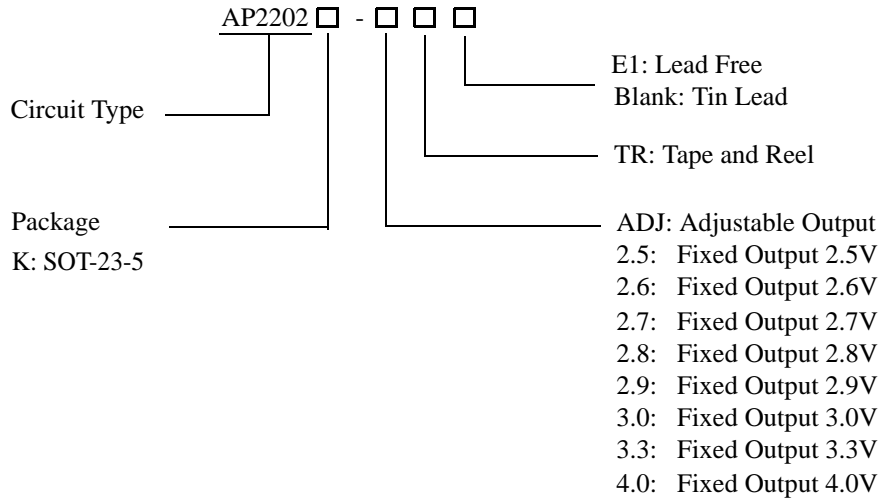
Figure 3. Functional Block Diagram of AP2202



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**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	AP2202K-ADJTR	AP2202K-ADJTRE1	K2C	E2C	Tape & Reel
		AP2202K-2.5TR	AP2202K-2.5TRE1	K2D	E2D	Tape & Reel
		AP2202K-2.6TR	AP2202K-2.6TRE1	K2E	E2E	Tape & Reel
		AP2202K-2.7TR	AP2202K-2.7TRE1	K2F	E2F	Tape & Reel
		AP2202K-2.8TR	AP2202K-2.8TRE1	K2G	E2G	Tape & Reel
		AP2202K-2.9TR	AP2202K-2.9TRE1	K2H	E2H	Tape & Reel
		AP2202K-3.0TR	AP2202K-3.0TRE1	K2I	E2I	Tape & Reel
		AP2202K-3.3TR	AP2202K-3.3TRE1	K2L	E2L	Tape & Reel
		AP2202K-4.0TR	AP2202K-4.0TRE1	K2S	E2S	Tape & Reel

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

**150mA RF ULDO REGULATOR****AP2202****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	W
Lead Temperature (Soldering, 5sec)	$T_{LEAD}$	260	°C
Storage Temperature	$T_{STG}$	-65 to 150	°C
ESD (Machine Model)		200	V
Thermal Resistance	$\theta_{JA}$	(Note 2)	

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.

Note 2: Electrical specifications do not apply when operating the device outside of its operating ratings. The maximum allowable power dissipation is a function of the maximum junction temperature,  $T_{J(max)}$ , the junction-to-ambient thermal resistance,  $\theta_{JA}$ , and the ambient temperature,  $T_A$ . The maximum allowable power dissipation at any ambient temperature is calculated using:  $P_{D(max)} = (T_{J(max)} - T_A) / \theta_{JA}$ . Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.

**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**

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

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Output Voltage Accuracy	$\Delta V_O/V_O$	Variation from specified $V_{OUT}$	-1		1	%
			-2		2	
Output Voltage Temperature Coefficient	$\Delta V_O/\Delta T$	(Note 3)		<b>120</b>		$\mu V/^\circ C$
Line Regulation	$V_{RLINE}$	AP2202-ADJ $V_{IN}=V_{OUT}+1V$ to 13.2V		0.004	0.012	%/ $V$
					<b>0.05</b>	
		AP2202-2.5V $V_{IN}=V_{OUT}+1V$ to 13.2V		1	3	mV
					<b>13</b>	
		AP2202-2.6V $V_{IN}=V_{OUT}+1V$ to 13.2V		1	3	
					<b>13</b>	
		AP2202-2.7V $V_{IN}=V_{OUT}+1V$ to 13.2V		1	4	
					<b>14</b>	
		AP2202-2.8V $V_{IN}=V_{OUT}+1V$ to 13.2V		1	4	
			<b>14</b>			
AP2202-2.9V $V_{IN}=V_{OUT}+1V$ to 13.2V		1	4			
			<b>14</b>			
AP2202-3.0V $V_{IN}=V_{OUT}+1V$ to 13.2V		1	4			
			<b>14</b>			
AP2202-3.3V $V_{IN}=V_{OUT}+1V$ to 13.2V		1	5			
			<b>15</b>			
AP2202-4.0V $V_{IN}=V_{OUT}+1V$ to 13.2V		1	6			
			<b>17</b>			
Load Regulation (Note 4)	$V_{RLOAD}$	AP2202-ADJ $I_{OUT}=0.1mA$ to 150mA		0.02	0.2	%
					<b>0.5</b>	
		AP2202-2.5V $I_{OUT}=0.1mA$ to 150mA		1	5	mV
					<b>13</b>	
		AP2202-2.6V $I_{OUT}=0.1mA$ to 150mA		1	6	
					<b>14</b>	
		AP2202-2.7V $I_{OUT}=0.1mA$ to 150mA		1	6	
			<b>14</b>			
AP2202-2.8V $I_{OUT}=0.1mA$ to 150mA		1	6			
			<b>14</b>			
AP2202-2.9V $I_{OUT}=0.1mA$ to 150mA		1	7			
			<b>15</b>			
AP2202-3.0V $I_{OUT}=0.1mA$ to 150mA		1	7			
			<b>15</b>			



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**Electrical Characteristics (Continued)**

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

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Load Regulation (Note 4)	$V_{RLOAD}$	AP2202-3.3V $I_{OUT}=0.1mA$ to 150mA		1	8	mV
					<b>17</b>	
		AP2202-4.0V $I_{OUT}=0.1mA$ to 150mA		1	9	
					<b>20</b>	
Dropout Voltage (Note 5)	$V_{IN}-V_O$	$I_{OUT}=100\mu A$		15	50	mV
					<b>70</b>	
		$I_{OUT}=50mA$		110	150	
					<b>230</b>	
		$I_{OUT}=100mA$		140	250	
				<b>300</b>		
		$I_{OUT}=150mA$		165	275	
					<b>350</b>	
Quiescent Current	$I_Q$	$V_{EN}\leq 0.4V$ (shutdown)		0.01	1	$\mu A$
		$V_{EN}\leq 0.18V$ (shutdown)			<b>5</b>	
Ground Pin Current (Note 6)	$I_{GND}$	$V_{EN}\geq 2.0V$ , $I_{OUT}=0\mu A$		95	130	$\mu A$
					<b>150</b>	
		$V_{EN}\geq 2.0V$ , $I_{OUT}=100\mu A$		98	140	
					<b>160</b>	
		$V_{EN}\geq 2.0V$ , $I_{OUT}=50mA$		350	600	
					<b>800</b>	
		$V_{EN}\geq 2.0V$ , $I_{OUT}=100mA$		600	1000	
					<b>1500</b>	
		$V_{EN}\geq 2.0V$ , $I_{OUT}=150mA$		1300	1900	
					<b>2500</b>	
Ripple Rejection	PSRR	frequency=100Hz, $I_{OUT}=100\mu A$		75		dB
Current Limit	$I_{LIMIT}$	$V_{OUT}=0V$		<b>320</b>	550	mA
Output Noise (Regulator B only)	$e_{no}$	$I_{OUT}=50mA$ , $C_L=2.2\mu F$ , 470 pF from BYP to GND		260		$nV/\sqrt{Hz}$
Enable Input Logic-Low Voltage	$V_{IL}$	Regulator shutdown			0.4	V
					<b>0.18</b>	
Enable Input Logic-High Voltage	$V_{IH}$	Regulator enabled	<b>2.0</b>			V
Enable Input Logic-Low Current	$I_{IL}$	$V_{IL}\leq 0.4V$		0.01	-1	$\mu A$
		$V_{IL}\leq 0.18V$			<b>-2</b>	
Enable Input Logic-High Current	$I_{IH}$	$V_{IL}\geq 2.0V$		5	20	$\mu A$
		$V_{IL}\geq 2.0V$			<b>25</b>	



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**Electrical Characteristics (Continued)**

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.

**Typical Performance Characteristics**

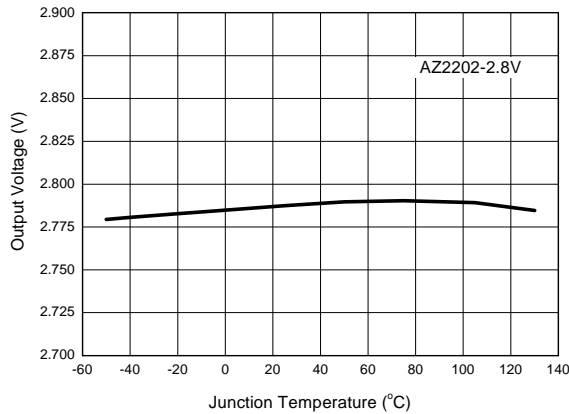


Figure 4. Output Voltage vs. Junction Temperature

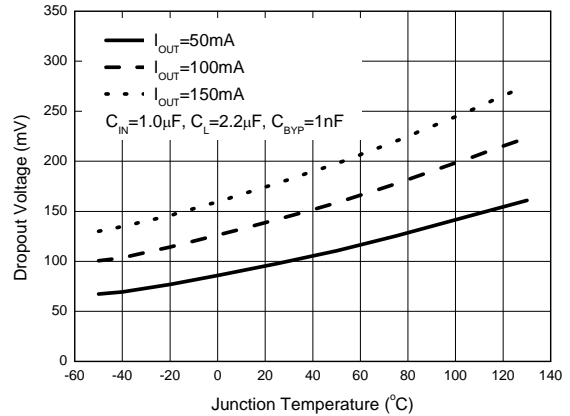


Figure 5. Dropout Voltage vs. Junction Temperature

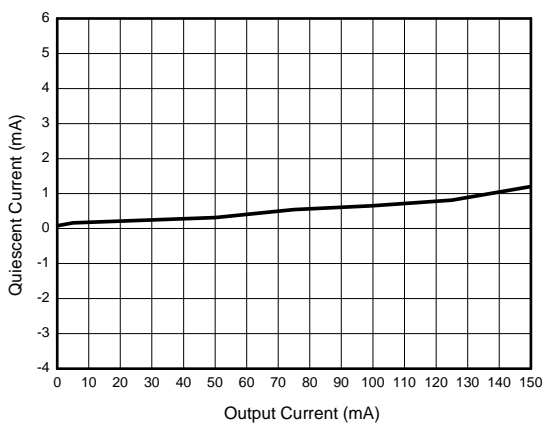


Figure 6. Quiescent Current vs. Output Current

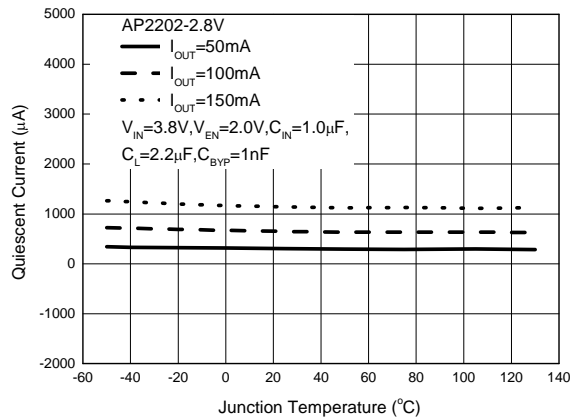


Figure 7. Quiescent Current vs. Junction Temperature





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**Typical Performance Characteristics (Continued)**

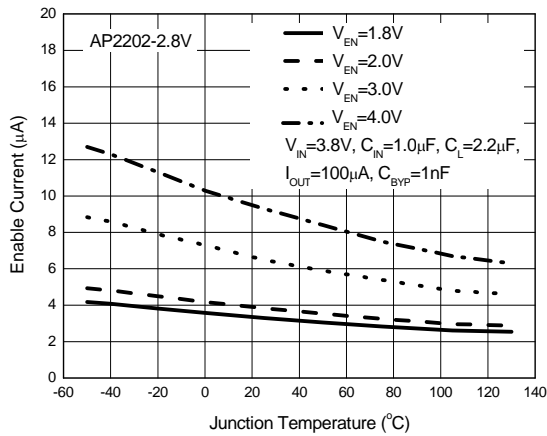


Figure 8. Enable Current vs. Junction Temperature

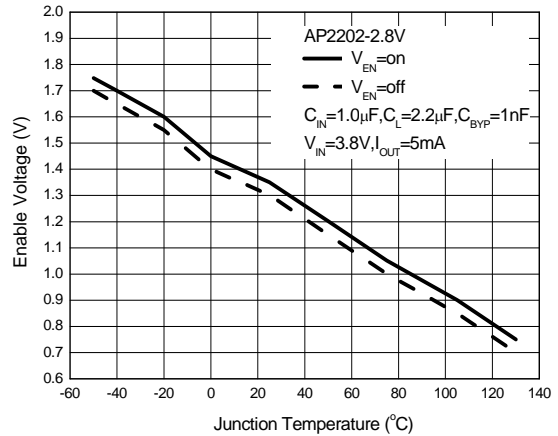


Figure 9. Enable Voltage vs. Junction Temperature

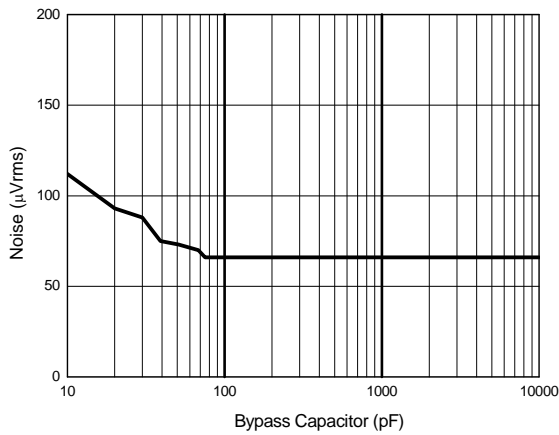


Figure 10. Noise vs. Bypass Capacitor

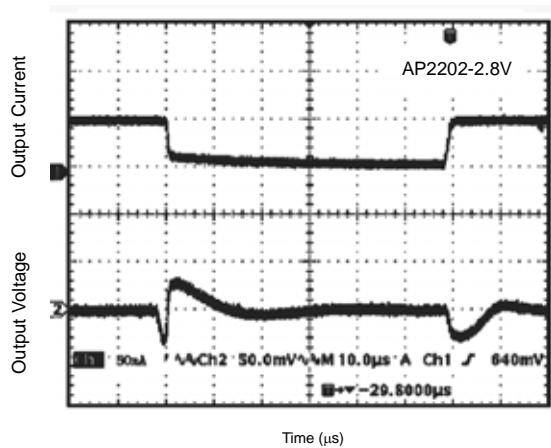


Figure 11. Load Transient  
(Conditions:  $V_{IN}=3.8V$ ,  $C_{BYF}=680pF$ ,  $V_{EN}=2V$ ,  $I_{OUT}=5mA$  to  $50mA$ ,  $C_L=2.2µF$ )



150mA RF ULDO REGULATOR

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Typical Performance Characteristics (Continued)

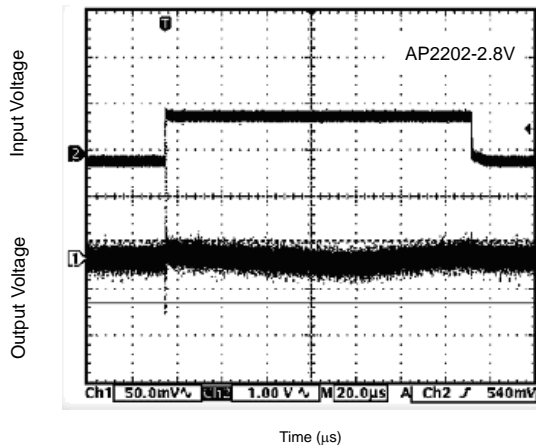


Figure 12. Line Transient  
 (Conditions:  $V_{IN}=3.8V$  to  $4.8V$ ,  $V_{EN}=2V$ ,  $I_{OUT}=100\mu A$ ,  $C_{BYP}=680pF$ ,  $C_L=10\mu F$ )

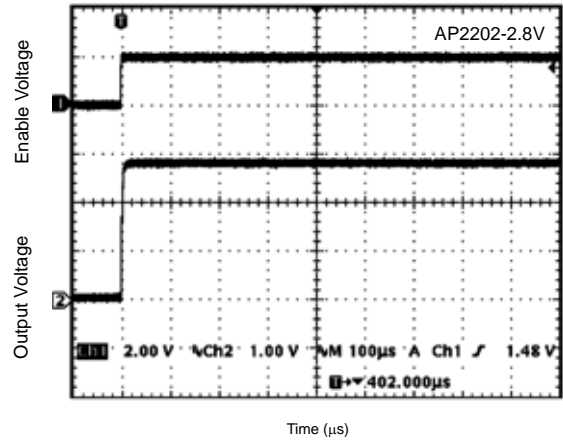


Figure 13.  $V_{EN(on)}$  vs.  $V_O$   
 (Conditions:  $V_{EN}=0V$  to  $2V$ ,  $V_{IN}=3.8V$ ,  $I_{OUT}=30mA$ ,  $C_{BYP}=open$ ,  $C_L=2.2\mu F$ )

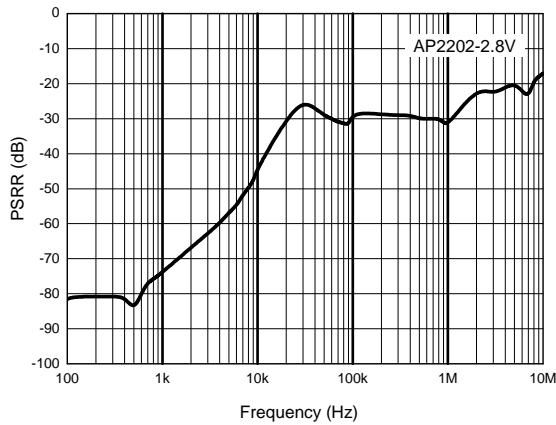


Figure 14. PSRR vs. Frequency  
 ( Conditions:  $C_{IN}=1.0\mu F$ ,  $C_L=2.2\mu F$ ,  $C_{BYP}=open$ ,  $V_{IN}=3.8V$ ,  $I_{OUT}=10mA$ ,  $V_{EN}=2V$ )



**150mA RF ULDO REGULATOR**

**AP2202**

**Typical Application**

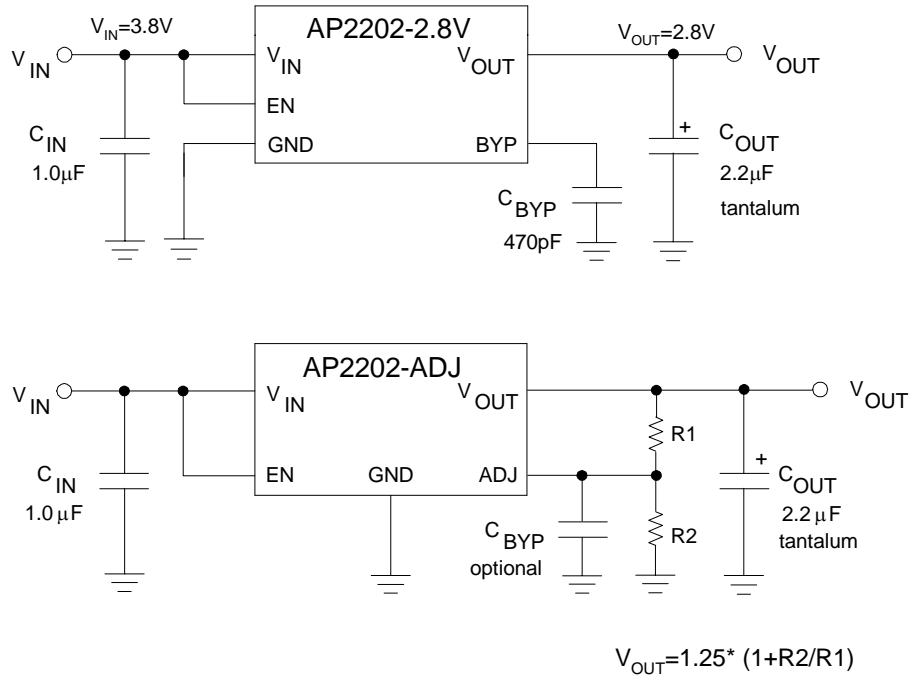


Figure 15. Typical Application of AP2202

**Application Information**

**External Capacitors**

Regarding good performance of regulator stability, external capacitors required by the AP2202 should be prudently selected.

**Input Capacitor**

If there is more than 10 inches of wire between the input and the AC filter, or if a battery is used as the input, a 1µF capacitor should be placed from IN to GND.

**Output Capacitor**

It is required to prevent oscillation. 1.0µF minimum is recommended when CBYP is unused. 2.2µF minimum is recommended when CBYP is 470pF. The output capacitor may be increased without limit for large values to improve transient response.

In most cases, tantalum or aluminium electrolytic capacitors are adequate.

**Noise Bypass Capacitor**

Bypass capacitor is connected to the internal voltage reference. A 680pF capacitor connected from BYP to GND leads reference to be quiet which results in a significant reduction in output noise. When using CBYP, output capacitors of 2.2µF or greater are required for better stability.

The start-up speed of the AP2202 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 CBYP and leave BYP open.



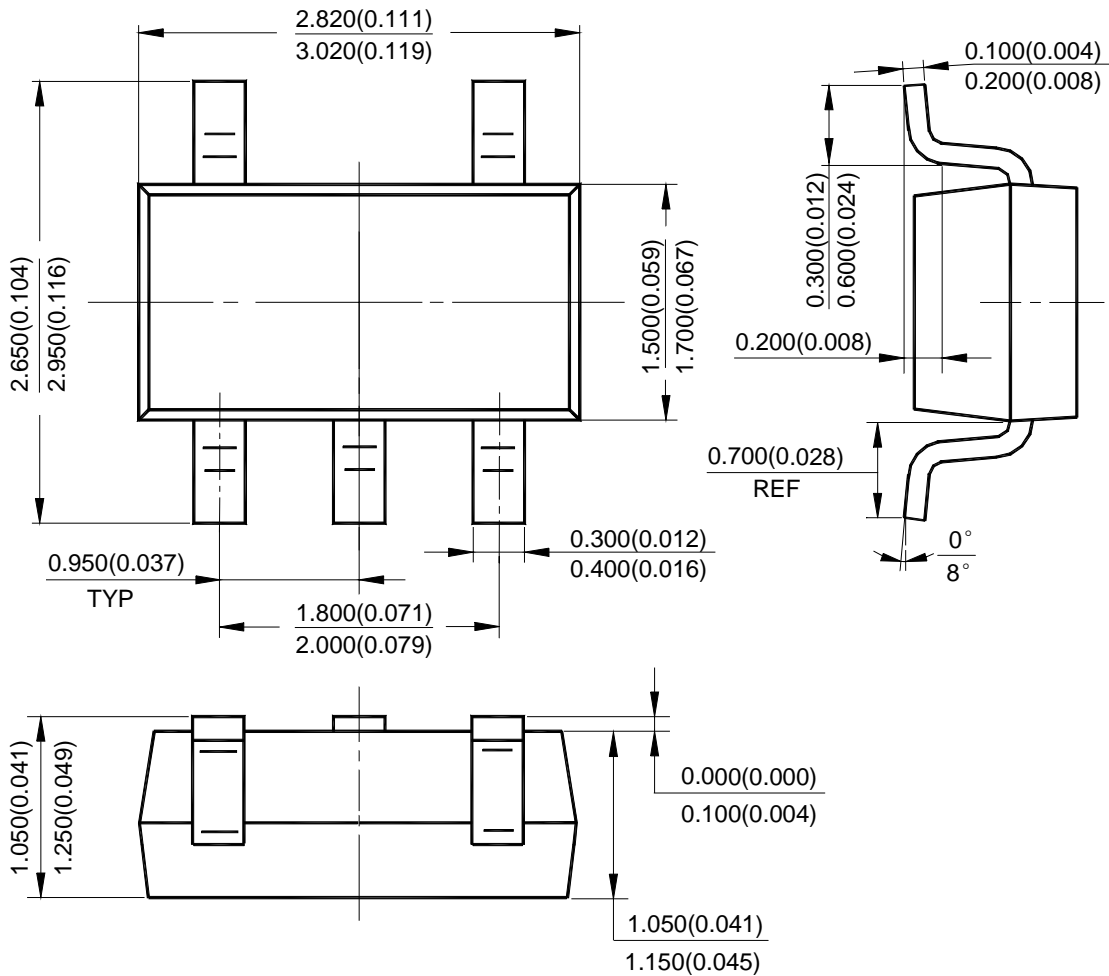
**150mA RF ULDO REGULATOR**

**AP2202**

**Mechanical Dimensions**

**SOT-23-5**

**Unit: mm(inch)**





BCD Semiconductor Manufacturing Limited

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