# 150mA RF ULDO REGULATOR AP2202

## General Description

The AP2202 is a 150mA ULDO regulator which provides very low noise, ultra low dropout voltage (typically 165mV at 150mA), very low standby current (1μA maximum) and excellent power supply ripple rejection (PSRR 75dB at 100Hz) in battery powered applications, such as handsets and PDAs and in noise sensitive applications, such as RF electronics.

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

The AP2202 is available in space saving SOT-23-5 and SOT-89 packages.

## Features

- Up to 150mA Output Current
- Low Standby Current
- Low Dropout Voltage: $V_{DROP}$=165mV at 150mA
- High Output Accuracy: ± 1%
- Good Ripple Rejection Ability: 75dB at 100Hz and $I_{OUT}$=100μA
- Tight Load and Line Regulation
- Low Temperature Coefficient
- Over Current Protection
- Thermal Protection
- Reverse-battery Protection
- Logic-controlled Enable

## Applications

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

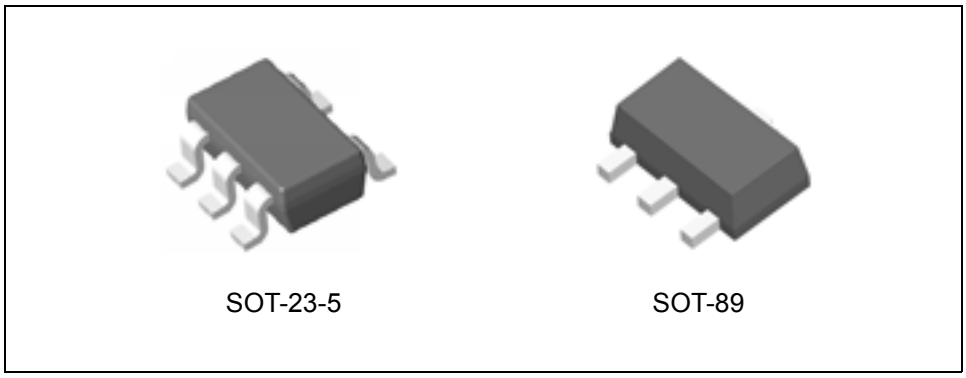



Figure 1. Package Types of AP2202

## Pin Configuration

K Package
(SOT-23-5)


R Package
(SOT-89)

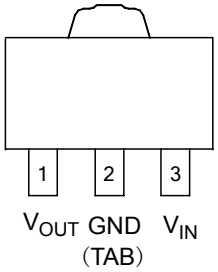
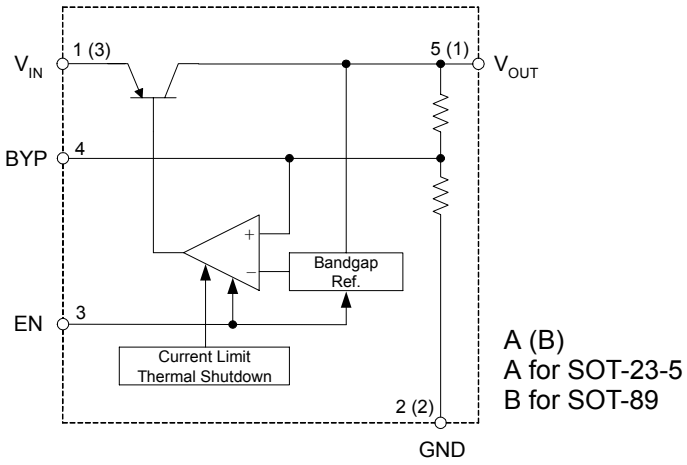



Figure 2. Pin Configuration of AP2202 (Top View)

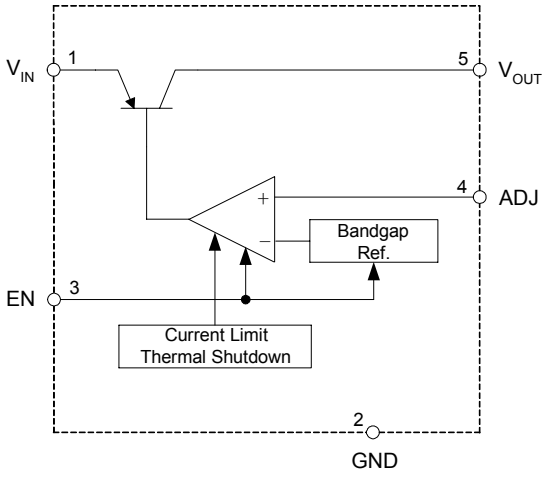
## Pin Description

| Pin Number | | Pin Name | Function |
|---|---|---|---|
| SOT-23-5 | SOT-89 | | |
| 1 | 3 | $V_{IN}$ | Input voltage |
| 2 | 2 | GND | Ground (TAB for SOT-89) |
| 3 | | EN | Enable input: CMOS or TTL compatible input. Logic high=enable, logic low=shutdown |
| 4 | | BYP/ADJ | Bypass capacitor for low noise operation/Adjust output |
| 5 | 1 | $V_{OUT}$ | Regulated output voltage |

## Functional Block Diagram



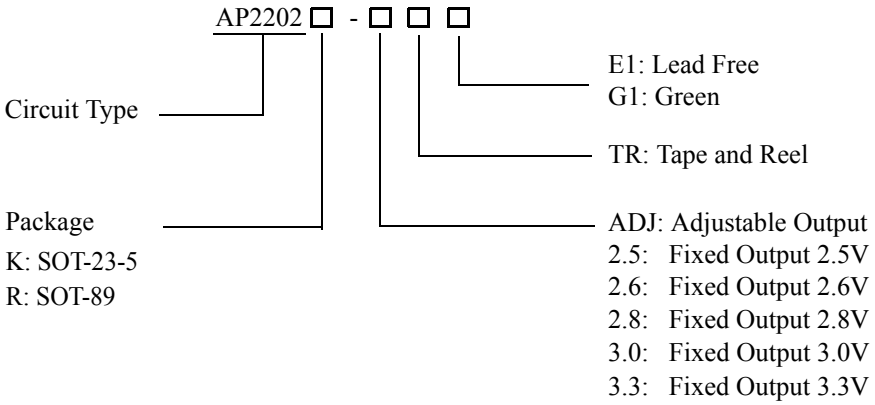

Fixed Regulator




Adjustable Regulator

Figure 3. Functional Block Diagram of AP2202

## Ordering Information




| Package | Temperature Range | Part Number | | Marking ID | | Packing Type |
|---|---|---|---|---|---|---|
| | | Lead Free | Green | Lead Free | Green | |
| SOT-23-5 | -40 to 125°C | AP2202K-ADJTRE1 | AP2202K-ADJTRG1 | E2C | G2C | Tape & Reel |
| | | AP2202K-2.5TRE1 | AP2202K-2.5TRG1 | E2D | G2D | Tape & Reel |
| | | AP2202K-2.6TRE1 | AP2202K-2.6TRG1 | E2E | G2E | Tape & Reel |
| | | AP2202K-2.8TRE1 | AP2202K-2.8TRG1 | E2G | G2G | Tape & Reel |
| | | AP2202K-3.0TRE1 | AP2202K-3.0TRG1 | E2I | G2I | Tape & Reel |
| | | AP2202K-3.3TRE1 | AP2202K-3.3TRG1 | E2L | G2L | Tape & Reel |
| SOT-89 | -40 to 125°C | AP2202R-3.3TRE1 | AP2202R-3.3TRG1 | E22B | G22B | Tape & Reel |

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

## Absolute Maximum Ratings (Note 1)

| Parameter | Symbol | Value | | Unit |
|---|---|---|---|---|
| Supply Input Voltage | $V_{IN}$ | 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) | | 200 | | V |
| Thermal Resistance (No Heatsink) | $\theta_{JA}$ | SOT-23-5 | 200 | °C/W |
| | | SOT-89 | 165 | |

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 |

## Electrical Characteristics

### AP2202-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 2), unless otherwise specified.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output Voltage Accuracy | $\Delta V_{OUT}/V_{OUT}$ | Variation from specified $V_{OUT}$ | -1 | | 1 | % |
| | | | **-2** | | **2** | |
| Output Voltage Temperature Coefficient (Note 3) | $\Delta V_{OUT}/\Delta T$ | | | **120** | | μV/°C |
| Line Regulation | $V_{RLINE}$ | $V_{IN}$=$V_{OUT}$+1V to 13.2V | | 0.004 | 0.012 | %/V |
| | | | | | **0.05** | |
| Load Regulation (Note 4) | $V_{RLOAD}$ | $I_{OUT}$=0.1mA to 150mA | | 0.02 | 0.2 | % |
| | | | | | **0.5** | |
| Dropout Voltage (Note 5) | $V_{DROP}$ | $I_{OUT}$=100μA | | 15 | 50 | mV |
| | | | | | **70** | |
| | | $I_{OUT}$=50mA | | 110 | 150 | |
| | | | | | **230** | |
| | | $I_{OUT}$=100mA | | 140 | 250 | |
| | | | | | **300** | |
| | | $I_{OUT}$=150mA | | 165 | 275 | |
| | | | | | **350** | |
| Standby Current | $I_{STD}$ | $V_{EN}$≤0.4V (shutdown) | | 0.01 | 1 | μA |
| | | $V_{EN}$≤0.18V (shutdown) | | | **5** | |
| Ground Pin Current (Note 6) | $I_{GND}$ | $V_{EN}$≥2.0V, $I_{OUT}$=0μA | | 95 | 130 | μA |
| | | | | | **150** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100μA | | 98 | 140 | |
| | | | | | **160** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=50mA | | 350 | 600 | |
| | | | | | **800** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100mA | | 600 | 1000 | |
| | | | | | **1500** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=150mA | | 1300 | 1900 | |
| | | | | | **2500** | |
| Ripple Rejection | PSRR | frequency=100Hz, $I_{OUT}$=100μA | | 75 | | dB |
| Current Limit | $I_{LIMIT}$ | $V_{OUT}$=0V | | **320** | 550 | mA |
| Output Noise | $e_{no}$ | $I_{OUT}$=50mA, $C_{OUT}$=2.2μF, 100pF from BYP to GND | | 260 | | $nV/\sqrt{Hz}$ |
| Enable Input Logic-Low Voltage | $V_{IL}$ | Regulator shutdown | | | 0.4 | V |
| | | | | | **0.18** | |

## Electrical Characteristics (Continued)

### AP2202-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 2), unless otherwise specified.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Enable Input Logic-High Voltage | $V_{IH}$ | Regulator enabled | **2.0** | | | V |
| Enable Input Logic-Low Current | $I_{IL}$ | $V_{IL}$≤0.4V | | 0.01 | 1 | μA |
| | | $V_{IL}$≤0.18V | | | **2** | |
| Enable Input Logic-High Current | $I_{IH}$ | $V_{IH}$≥2.0V | | 5 | 20 | μA |
| | | $V_{IH}$≥2.0V | | | **25** | |
| Thermal Resistance | $\theta_{JC}$ | SOT-23-5 | | 63.4 | | °C/W |
| | | SOT-89 | | 50 | | |

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

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

Note 4: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1mA to 150mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

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

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

## Electrical Characteristics (Continued)

### AP2202-2.5 Electrical Characteristics

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

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output Voltage Accuracy | $\Delta V_{OUT}/V_{OUT}$ | Variation from specified $V_{OUT}$ | -1 | | 1 | % |
| | | | **-2** | | **2** | |
| Output Voltage Temperature Coefficient (Note 3) | $\Delta V_{OUT}/\Delta T$ | | | **120** | | μV/°C |
| | $(\Delta V_{OUT}/V_{OUT})/\Delta T$ | | | **48** | | ppm/°C |
| Line Regulation | $V_{RLINE}$ | $V_{IN}$=3.5V to 13.2V | | 1 | 3 | mV |
| | | | | | **13** | |
| Load Regulation (Note 4) | $V_{RLOAD}$ | $I_{OUT}$=0.1mA to 150mA | | 1 | 5 | mV |
| | | | | | **13** | |
| Dropout Voltage (Note 5) | $V_{DROP}$ | $I_{OUT}$=100μA | | 15 | 50 | mV |
| | | | | | **70** | |
| | | $I_{OUT}$=50mA | | 110 | 150 | |
| | | | | | **230** | |
| | | $I_{OUT}$=100mA | | 140 | 250 | |
| | | | | | **300** | |
| | | $I_{OUT}$=150mA | | 165 | 275 | |
| | | | | | **350** | |
| Standby Current | $I_{STD}$ | $V_{EN}$≤0.4V (shutdown) | | 0.01 | 1 | μA |
| | | $V_{EN}$≤0.18V (shutdown) | | | **5** | |
| Ground Pin Current (Note 6) | $I_{GND}$ | $V_{EN}$≥2.0V, $I_{OUT}$=0μA | | 95 | 130 | μA |
| | | | | | **150** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100μA | | 98 | 140 | |
| | | | | | **160** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=50mA | | 350 | 600 | |
| | | | | | **800** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100mA | | 600 | 1000 | |
| | | | | | **1500** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=150mA | | 1300 | 1900 | |
| | | | | | **2500** | |
| Ripple Rejection | PSRR | frequency=100Hz, $I_{OUT}$=100μA | | 75 | | dB |
| Current Limit | $I_{LIMIT}$ | $V_{OUT}$=0V | | **320** | 550 | mA |
| Output Noise | $e_{no}$ | $I_{OUT}$=50mA, $C_{OUT}$=2.2μF, 100pF from BYP to GND | | 260 | | $nV/\sqrt{Hz}$ |
| Enable Input Logic-Low Voltage | $V_{IL}$ | Regulator shutdown | | | 0.4 | V |
| | | | | | **0.18** | |

## Electrical Characteristics (Continued)

### AP2202-2.5 Electrical Characteristics

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

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Enable Input Logic-High Voltage | $V_{IH}$ | Regulator enabled | **2.0** | | | V |
| Enable Input Logic-Low Current | $I_{IL}$ | $V_{IL}$≤0.4V | | 0.01 | 1 | μA |
| | | $V_{IL}$≤0.18V | | | **2** | |
| Enable Input Logic-High Current | $I_{IH}$ | $V_{IH}$≥2.0V | | 5 | 20 | μA |
| | | $V_{IH}$≥2.0V | | | **25** | |
| Thermal Resistance | $\theta_{JC}$ | SOT-23-5 | | 63.4 | | °C/W |
| | | SOT-89 | | 50 | | |

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

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

Note 4: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1mA to 150mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

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

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

## Electrical Characteristics (Continued)

### AP2202-2.6 Electrical Characteristics

$V_{IN}$=3.6V, $I_{OUT}$=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 2), unless otherwise specified.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output Voltage Accuracy | $\Delta V_{OUT}/V_{OUT}$ | Variation from specified $V_{OUT}$ | -1 | | 1 | % |
| | | | **-2** | | **2** | |
| Output Voltage Temperature Coefficient (Note 3) | $\Delta V_{OUT}/\Delta T$ | | | **120** | | μV/°C |
| | $(\Delta V_{OUT}/V_{OUT})/\Delta T$ | | | **46** | | ppm/°C |
| Line Regulation | $V_{RLINE}$ | $V_{IN}$=3.6V to 13.2V | | 1 | 3 | mV |
| | | | | | **13** | |
| Load Regulation (Note 4) | $V_{RLOAD}$ | $I_{OUT}$=0.1mA to 150mA | | 1 | 6 | mV |
| | | | | | **14** | |
| Dropout Voltage (Note 5) | $V_{DROP}$ | $I_{OUT}$=100μA | | 15 | 50 | mV |
| | | | | | **70** | |
| | | $I_{OUT}$=50mA | | 110 | 150 | |
| | | | | | **230** | |
| | | $I_{OUT}$=100mA | | 140 | 250 | |
| | | | | | **300** | |
| | | $I_{OUT}$=150mA | | 165 | 275 | |
| | | | | | **350** | |
| Standby Current | $I_{STD}$ | $V_{EN}$≤0.4V (shutdown) | | 0.01 | 1 | μA |
| | | $V_{EN}$≤0.18V (shutdown) | | | **5** | |
| Ground Pin Current (Note 6) | $I_{GND}$ | $V_{EN}$≥2.0V, $I_{OUT}$=0μA | | 95 | 130 | μA |
| | | | | | **150** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100μA | | 98 | 140 | |
| | | | | | **160** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=50mA | | 350 | 600 | |
| | | | | | **800** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100mA | | 600 | 1000 | |
| | | | | | **1500** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=150mA | | 1300 | 1900 | |
| | | | | | **2500** | |
| Ripple Rejection | PSRR | frequency=100Hz, $I_{OUT}$=100μA | | 75 | | dB |
| Current Limit | $I_{LIMIT}$ | $V_{OUT}$=0V | | **320** | 550 | mA |
| Output Noise | $e_{no}$ | $I_{OUT}$=50mA, $C_{OUT}$=2.2μF, 100pF from BYP to GND | | 260 | | $nV/\sqrt{Hz}$ |
| Enable Input Logic-Low Voltage | $V_{IL}$ | Regulator shutdown | | | 0.4 | V |
| | | | | | **0.18** | |

## Electrical Characteristics (Continued)

### AP2202-2.6 Electrical Characteristics

$V_{IN}$=3.6V, $I_{OUT}$=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 2), unless otherwise specified.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Enable Input Logic-High Voltage | $V_{IH}$ | Regulator enabled | **2.0** | | | V |
| Enable Input Logic-Low Current | $I_{IL}$ | $V_{IL}$≤0.4V | | 0.01 | 1 | μA |
| | | $V_{IL}$≤0.18V | | | **2** | |
| Enable Input Logic-High Current | $I_{IH}$ | $V_{IH}$≥2.0V | | 5 | 20 | μA |
| | | $V_{IH}$≥2.0V | | | **25** | |
| Thermal Resistance | $\theta_{JC}$ | SOT-23-5 | | 63.4 | | °C/W |
| | | SOT-89 | | 50 | | |

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

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

Note 4: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1mA to 150mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

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

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

## Electrical Characteristics (Continued)

### AP2202-2.8 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 2), unless otherwise specified.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output Voltage Accuracy | $\Delta V_{OUT}/V_{OUT}$ | Variation from specified $V_{OUT}$ | -1 | | 1 | % |
| | | | **-2** | | **2** | |
| Output Voltage Temperature Coefficient (Note 3) | $\Delta V_{OUT}/\Delta T$ | | | **120** | | μV/°C |
| | $(\Delta V_{OUT}/V_{OUT})/\Delta T$ | | | **42.8** | | ppm/°C |
| Line Regulation | $V_{RLINE}$ | $V_{IN}$=3.8V to 13.2V | | 1 | 4 | mV |
| | | | | | **14** | |
| Load Regulation (Note 4) | $V_{RLOAD}$ | $I_{OUT}$=0.1mA to 150mA | | 1 | 6 | mV |
| | | | | | **14** | |
| Dropout Voltage (Note 5) | $V_{DROP}$ | $I_{OUT}$=100μA | | 15 | 50 | mV |
| | | | | | **70** | |
| | | $I_{OUT}$=50mA | | 110 | 150 | |
| | | | | | **230** | |
| | | $I_{OUT}$=100mA | | 140 | 250 | |
| | | | | | **300** | |
| | | $I_{OUT}$=150mA | | 165 | 275 | |
| | | | | | **350** | |
| Standby Current | $I_{STD}$ | $V_{EN}$≤0.4V (shutdown) | | 0.01 | 1 | μA |
| | | $V_{EN}$≤0.18V (shutdown) | | | **5** | |
| Ground Pin Current (Note 6) | $I_{GND}$ | $V_{EN}$≥2.0V, $I_{OUT}$=0μA | | 95 | 130 | μA |
| | | | | | **150** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100μA | | 98 | 140 | |
| | | | | | **160** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=50mA | | 350 | 600 | |
| | | | | | **800** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100mA | | 600 | 1000 | |
| | | | | | **1500** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=150mA | | 1300 | 1900 | |
| | | | | | **2500** | |
| Ripple Rejection | PSRR | frequency=100Hz, $I_{OUT}$=100μA | | 75 | | dB |
| Current Limit | $I_{LIMIT}$ | $V_{OUT}$=0V | | **320** | 550 | mA |
| Output Noise | $e_{no}$ | $I_{OUT}$=50mA, $C_{OUT}$=2.2μF, 100pF from BYP to GND | | 260 | | $nV/\sqrt{Hz}$ |
| Enable Input Logic-Low Voltage | $V_{IL}$ | Regulator shutdown | | | 0.4 | V |
| | | | | | **0.18** | |

## Electrical Characteristics (Continued)

### AP2202-2.8 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 2), unless otherwise specified.

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Enable Input Logic-High Voltage | $V_{IH}$ | Regulator enabled | **2.0** | | | V |
| Enable Input Logic-Low Current | $I_{IL}$ | $V_{IL}$≤0.4V | | 0.01 | 1 | μA |
| | | $V_{IL}$≤0.18V | | | **2** | |
| Enable Input Logic-High Current | $I_{IH}$ | $V_{IH}$≥2.0V | | 5 | 20 | μA |
| | | $V_{IH}$≥2.0V | | | **25** | |
| Thermal Resistance | $\theta_{JC}$ | SOT-23-5 | | 63.4 | | °C/W |
| | | SOT-89 | | 50 | | |

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

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

Note 4: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1mA to 150mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

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

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

## Electrical Characteristics (Continued)

### AP2202-3.0 Electrical Characteristics

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

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output Voltage Accuracy | $\Delta V_{OUT}/V_{OUT}$ | Variation from specified $V_{OUT}$ | -1 | | 1 | % |
| | | | **-2** | | **2** | |
| Output Voltage Temperature Coefficient (Note 3) | $\Delta V_{OUT}/\Delta T$ | | | **120** | | μV/°C |
| | $(\Delta V_{OUT}/V_{OUT})/\Delta T$ | | | **40** | | ppm/°C |
| Line Regulation | $V_{RLINE}$ | $V_{IN}$=4V to 13.2V | | 1 | 4 | mV |
| | | | | | **14** | |
| Load Regulation (Note 4) | $V_{RLOAD}$ | $I_{OUT}$=0.1mA to 150mA | | 1 | 7 | mV |
| | | | | | **15** | |
| Dropout Voltage (Note 5) | $V_{DROP}$ | $I_{OUT}$=100μA | | 15 | 50 | mV |
| | | | | | **70** | |
| | | $I_{OUT}$=50mA | | 110 | 150 | |
| | | | | | **230** | |
| | | $I_{OUT}$=100mA | | 140 | 250 | |
| | | | | | **300** | |
| | | $I_{OUT}$=150mA | | 165 | 275 | |
| | | | | | **350** | |
| Standby Current | $I_{STD}$ | $V_{EN}$≤0.4V (shutdown) | | 0.01 | 1 | μA |
| | | $V_{EN}$≤0.18V (shutdown) | | | **5** | |
| Ground Pin Current (Note 6) | $I_{GND}$ | $V_{EN}$≥2.0V, $I_{OUT}$=0μA | | 95 | 130 | μA |
| | | | | | **150** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100μA | | 98 | 140 | |
| | | | | | **160** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=50mA | | 350 | 600 | |
| | | | | | **800** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100mA | | 600 | 1000 | |
| | | | | | **1500** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=150mA | | 1300 | 1900 | |
| | | | | | **2500** | |
| Ripple Rejection | PSRR | frequency=100Hz, $I_{OUT}$=100μA | | 75 | | dB |
| Current Limit | $I_{LIMIT}$ | $V_{OUT}$=0V | | **320** | 550 | mA |
| Output Noise | $e_{no}$ | $I_{OUT}$=50mA, $C_{OUT}$=2.2μF, 100pF from BYP to GND | | 260 | | $nV/\sqrt{Hz}$ |
| Enable Input Logic-Low Voltage | $V_{IL}$ | Regulator shutdown | | | 0.4 | V |
| | | | | | **0.18** | |

## Electrical Characteristics (Continued)

### AP2202-3.0 Electrical Characteristics

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

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Enable Input Logic-High Voltage | $V_{IH}$ | Regulator enabled | **2.0** | | | V |
| Enable Input Logic-Low Current | $I_{IL}$ | $V_{IL}$≤0.4V | | 0.01 | 1 | μA |
| | | $V_{IL}$≤0.18V | | | **2** | |
| Enable Input Logic-High Current | $I_{IH}$ | $V_{IH}$≥2.0V | | 5 | 20 | μA |
| | | $V_{IH}$≥2.0V | | | **25** | |
| Thermal Resistance | $\theta_{JC}$ | SOT-23-5 | | 63.4 | | °C/W |
| | | SOT-89 | | 50 | | |

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

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

Note 4: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1mA to 150mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

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

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

## Electrical Characteristics (Continued)

### AP2202-3.3 Electrical Characteristics

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

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Output Voltage Accuracy | $\Delta V_{OUT}/V_{OUT}$ | Variation from specified $V_{OUT}$ | -1 | | 1 | % |
| | | | **-2** | | **2** | |
| Output Voltage Temperature Coefficient (Note 3) | $\Delta V_{OUT}/\Delta T$ | | | **120** | | μV/°C |
| | $(\Delta V_{OUT}/V_{OUT})/\Delta T$ | | | **36.3** | | ppm/°C |
| Line Regulation | $V_{RLINE}$ | $V_{IN}$=4.3V to 13.2V | | 1 | 5 | mV |
| | | | | | **15** | |
| Load Regulation (Note 4) | $V_{RLOAD}$ | $I_{OUT}$=0.1mA to 150mA | | 1 | 8 | mV |
| | | | | | **17** | |
| Dropout Voltage (Note 5) | $V_{DROP}$ | $I_{OUT}$=100μA | | 15 | 50 | mV |
| | | | | | **70** | |
| | | $I_{OUT}$=50mA | | 110 | 150 | |
| | | | | | **230** | |
| | | $I_{OUT}$=100mA | | 140 | 250 | |
| | | | | | **300** | |
| | | $I_{OUT}$=150mA | | 165 | 275 | |
| | | | | | **350** | |
| Standby Current | $I_{STD}$ | $V_{EN}$≤0.4V (shutdown) | | 0.01 | 1 | μA |
| | | $V_{EN}$≤0.18V (shutdown) | | | **5** | |
| Ground Pin Current (Note 6) | $I_{GND}$ | $V_{EN}$≥2.0V, $I_{OUT}$=0μA | | 95 | 130 | μA |
| | | | | | **150** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100μA | | 98 | 140 | |
| | | | | | **160** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=50mA | | 350 | 600 | |
| | | | | | **800** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=100mA | | 600 | 1000 | |
| | | | | | **1500** | |
| | | $V_{EN}$≥2.0V, $I_{OUT}$=150mA | | 1300 | 1900 | |
| | | | | | **2500** | |
| Ripple Rejection | PSRR | frequency=100Hz, $I_{OUT}$=100μA | | 75 | | dB |
| Current Limit | $I_{LIMIT}$ | $V_{OUT}$=0V | | **320** | 550 | mA |
| Output Noise | $e_{no}$ | $I_{OUT}$=50mA, $C_{OUT}$=2.2μF, 100pF from BYP to GND | | 260 | | $nV/\sqrt{Hz}$ |
| Enable Input Logic-Low Voltage | $V_{IL}$ | Regulator shutdown | | | 0.4 | V |
| | | | | | **0.18** | |

## Electrical Characteristics (Continued)

### AP2202-3.3 Electrical Characteristics

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

| Parameter | Symbol | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Enable Input Logic-High Voltage | $V_{IH}$ | Regulator enabled | **2.0** | | | V |
| Enable Input Logic-Low Current | $I_{IL}$ | $V_{IL}$≤0.4V | | 0.01 | 1 | μA |
| | | $V_{IL}$≤0.18V | | | **2** | |
| Enable Input Logic-High Current | $I_{IH}$ | $V_{IH}$≥2.0V | | 5 | 20 | μA |
| | | $V_{IH}$≥2.0V | | | **25** | |
| Thermal Resistance | $\theta_{JC}$ | SOT-23-5 | | 63.4 | | °C/W |
| | | SOT-89 | | 50 | | |

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

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

Note 4: Regulation is measured at constant junction temperature using low duty cycle pulse testing. Parts are tested for load regulation in the load range from 0.1mA to 150mA. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

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

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

## Typical Performance Characteristics

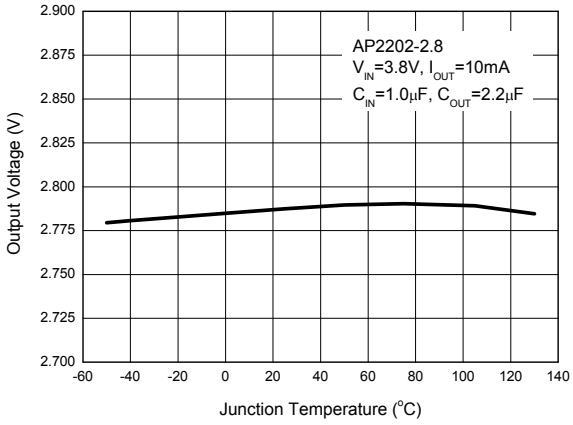



Figure 4. Output Voltage vs. Junction Temperature

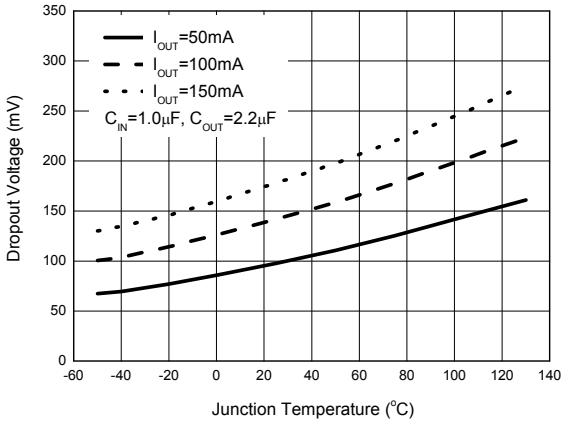



Figure 5. Dropout Voltage vs. Junction Temperature

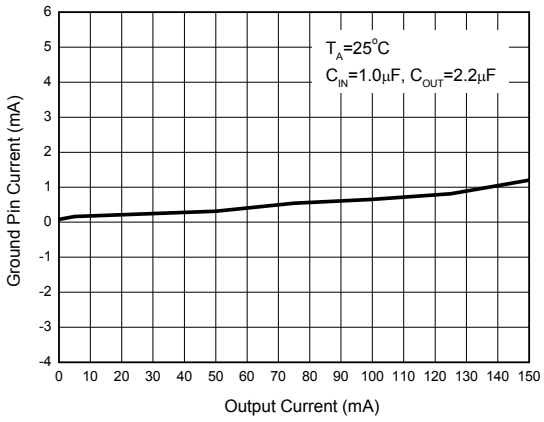



Figure 6. Ground Pin Current vs. Output Current

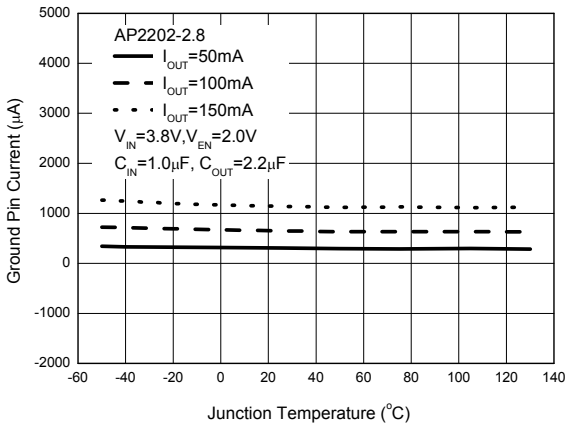



Figure 7. Ground Pin Current vs. Junction Temperature

## Typical Performance Characteristics (Continued)

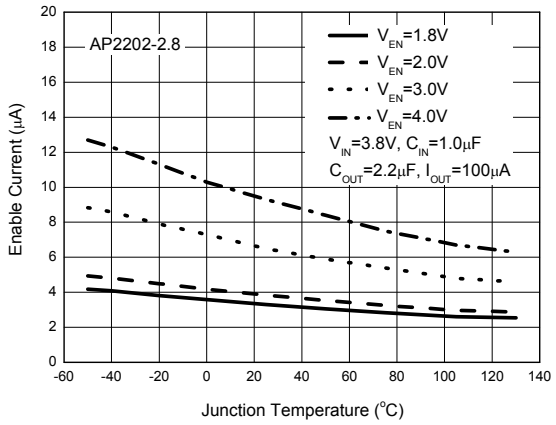



Figure 8. Enable Current vs. Junction Temperature

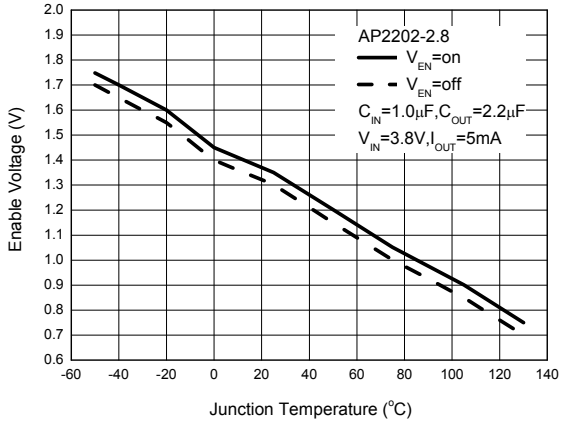



Figure 9. Enable Voltage vs. Junction Temperature

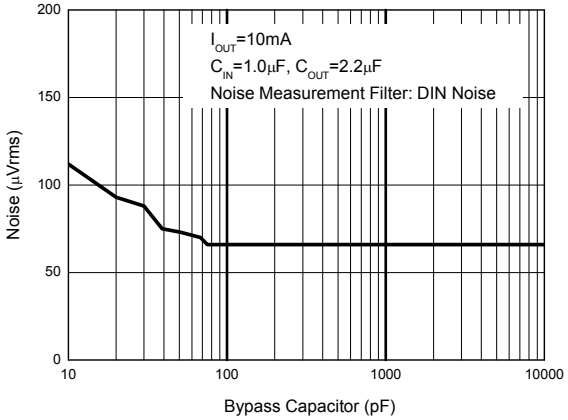



Figure 10. Noise vs. Bypass Capacitor

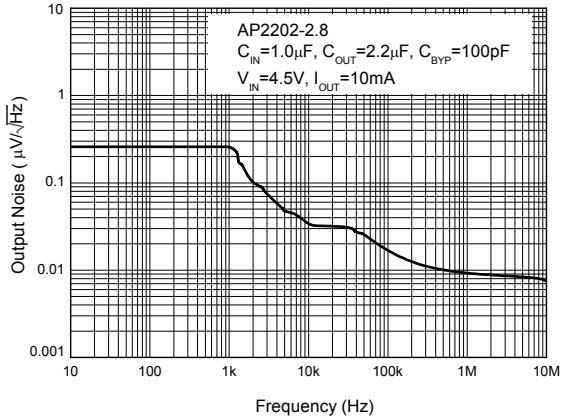



Figure 11. Output Noise vs. Frequency

## Typical Performance Characteristics (Continued)

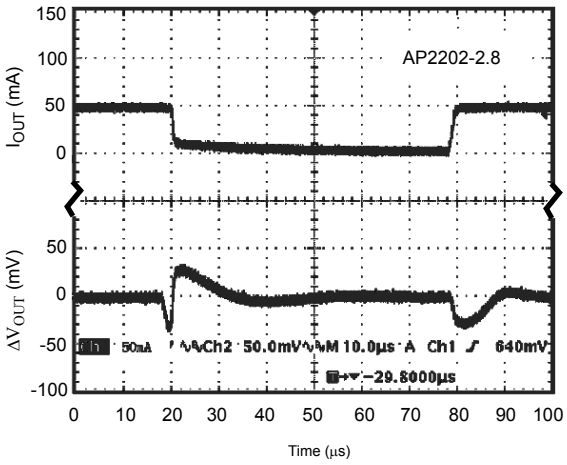



Figure 12. Load Transient
(Conditions: $V_{IN}$=3.8V, $C_{BYP}$=100pF, $V_{EN}$=2V, $I_{OUT}$=5mA to 50mA, $C_{IN}$=1.0µF, $C_{OUT}$=2.2µF)

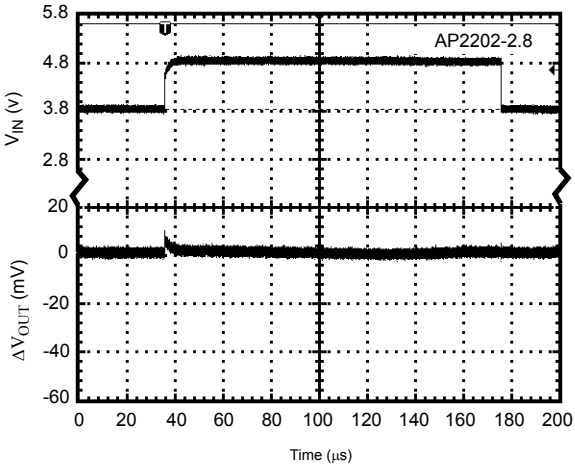



Figure 13. Line Transient
(Conditions: $V_{IN}$=3.8V to 4.8V, $V_{EN}$=2V, $I_{OUT}$=100µA $C_{BYP}$=100pF, $C_{OUT}$=10µF)

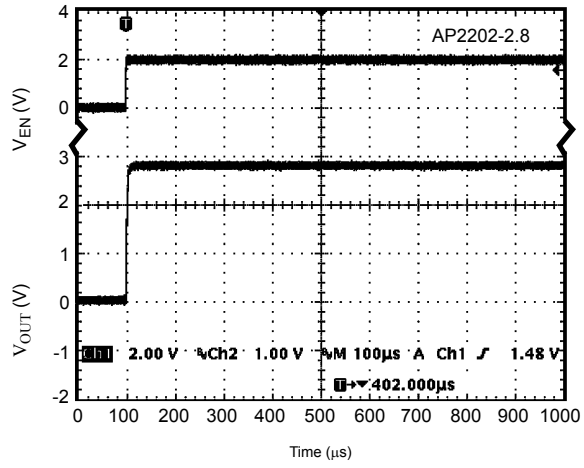



Figure 14. $V_{EN}$(on) vs. $V_{OUT}$
(Conditions: $V_{EN}$=0V to 2V, $V_{IN}$=3.8V, $I_{OUT}$=30mA, $C_{BYP}$=open, $C_{IN}$=1.0µF, $C_{OUT}$=2.2µF)

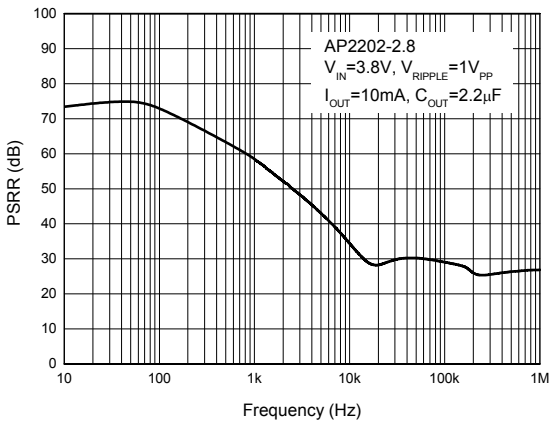



Figure 15. PSRR vs. Frequency

## Typical Performance Characteristics (Continued)

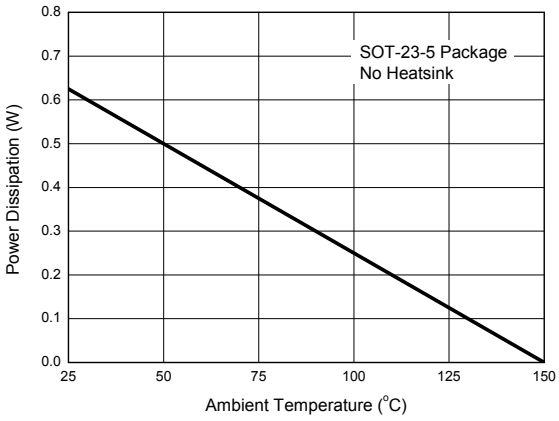



Figure 16. Power Dissipation vs. Ambient Temperature

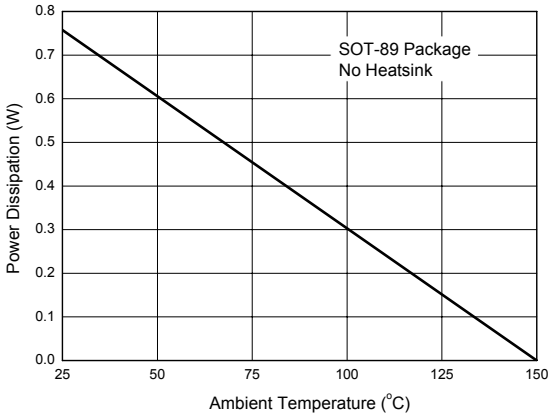



Figure 17. Power Dissipation vs. Ambient Temperature

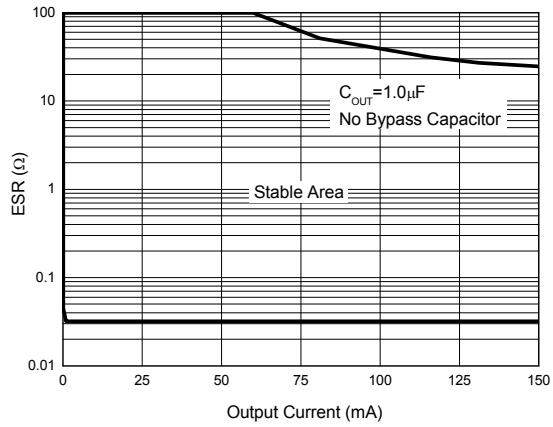



Figure 18. ESR vs. Output Current

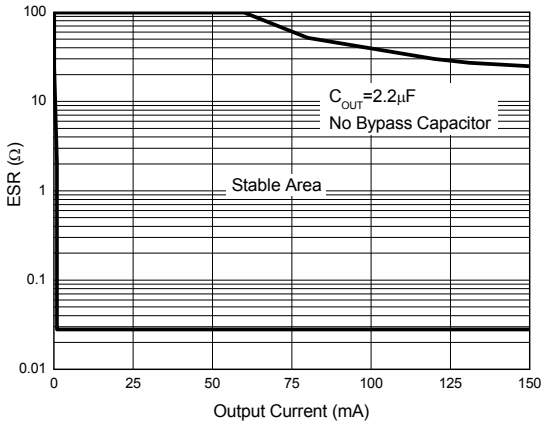



Figure 19. ESR vs. Output Current

## Typical Performance Characteristics (Continued)

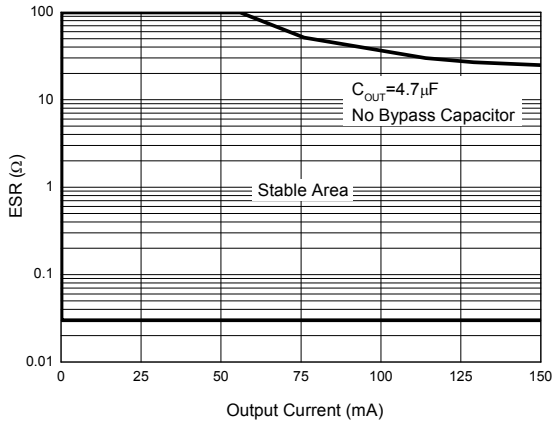



Figure 20. ESR vs. Output Current

## Typical Application

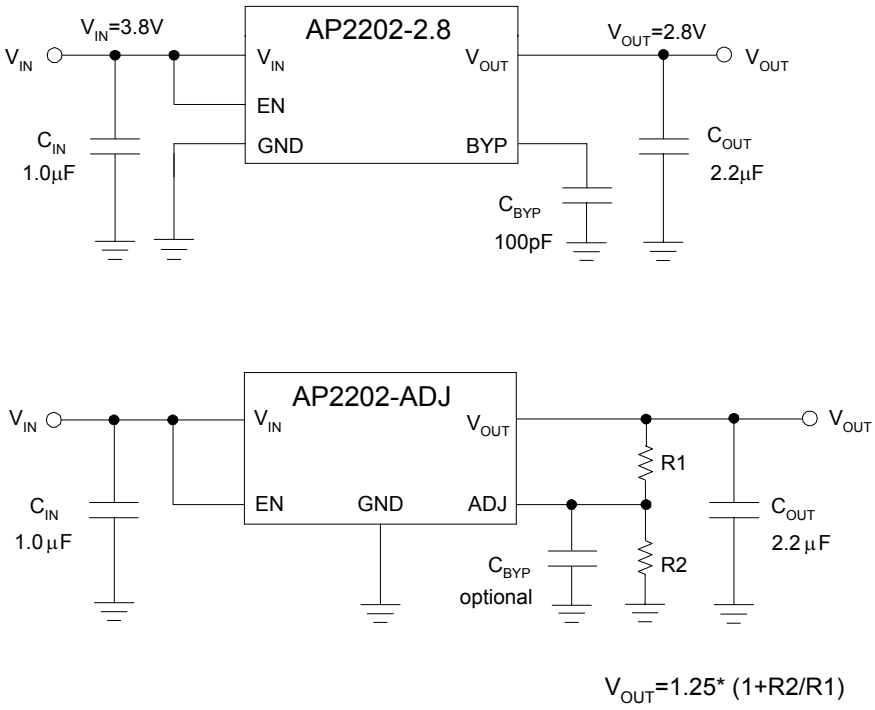



Figure 21. Typical Application of AP2202 (Note 7)

Note 7: Dropout voltage is 165mV when $T_A$=25°C. In order to obtain a normal output voltage, $V_{OUT}$+0.165V is the minimum input voltage which will result a low PSRR, imposing a bad influence on system. Therefore, the recommended input voltage is $V_{OUT}$+0.5V to 13.2V. For AP2202-2.8 version, its input voltage can be set from 3.3V($V_{OUT}$+0.5V) to 13.2V. For that of Adj version, any value from $V_{OUT}$+0.5V to 13.2V is available. R1 and R2 must be correctly selected when setting the output voltage. For example, if 3.0V output voltage is required, R1 and R2 can be set to 10kΩ and 14kΩ respectively. For Adj version, we recommend 2.3V as minimum output voltage.

## 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 100pF 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.

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 $C_{BYP}$ and leave BYP open.

**Power Dissipation**
Thermal shutdown may take place if exceeding the maximum power dissipation in application. Under all possible operating conditions, the junction temperature must be within the range specified under absolute maximum ratings to avoid thermal shutdown.

To determine if the power dissipated in the regulator reaches the maximum power dissipation (see figure 16,17), using:
$T_J = P_D*\theta_{JA} + T_A$
$P_D=(V_{IN}-V_{OUT})*I_{OUT}+V_{IN}*I_{GND}$

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

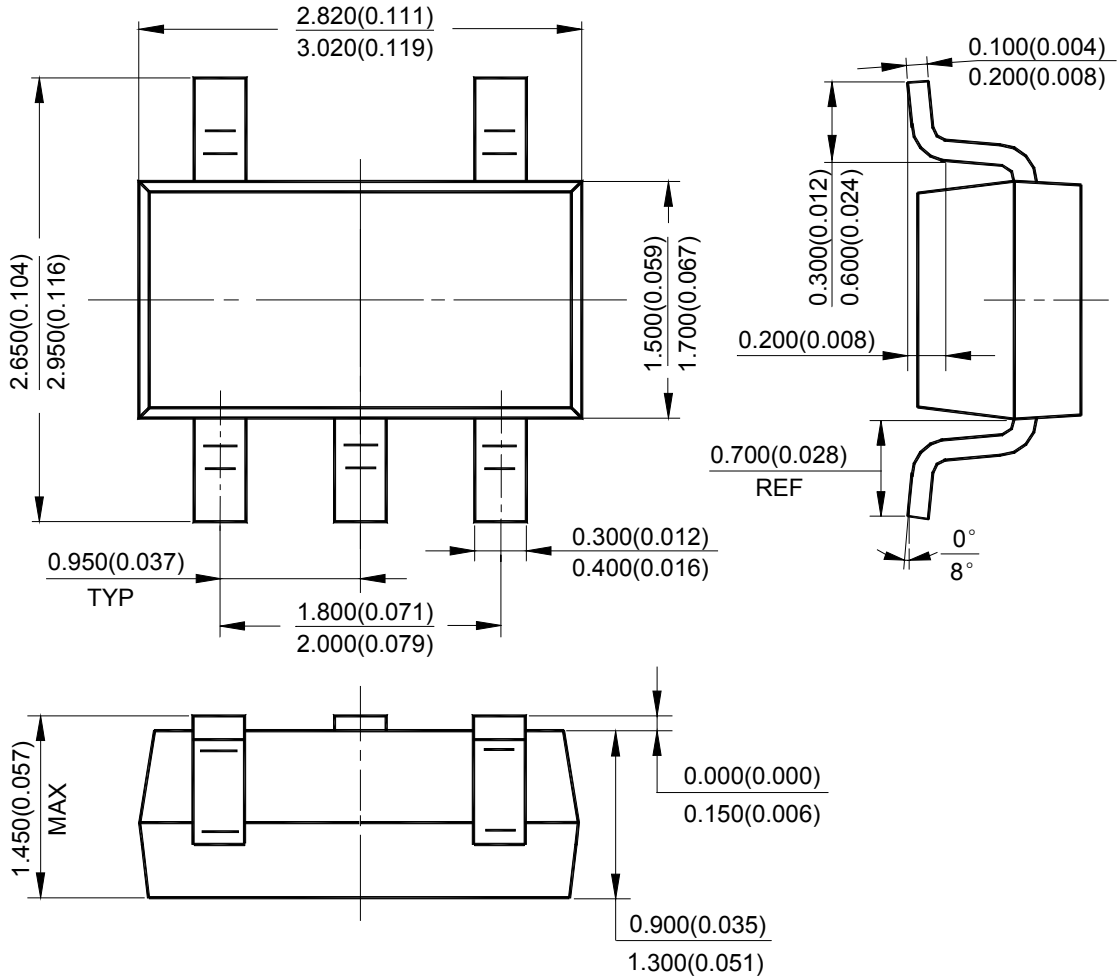
$T_{J(max)}$ is 150°C, $\theta_{JA}$ is 200°C/W for SOT-23-5 package and 165°C/W for SOT-89 package, no heatsink is required since the package alone will dissipate enough heat to satisfy these requirements unless the calculated value for power dissipation exceeds the limit.

Example: For 2.8V version packaged in SOT-23-5, $I_{OUT}$=150mA, $T_A$=50°C, $V_{IN(Max)}$ is:
(150°C-50°C)/(0.15A*200°C/W)+2.8V=6.133V

Therefore, for good performance, please make sure that input voltage is less than 6.133V without heatsink when $T_A$=50°C.

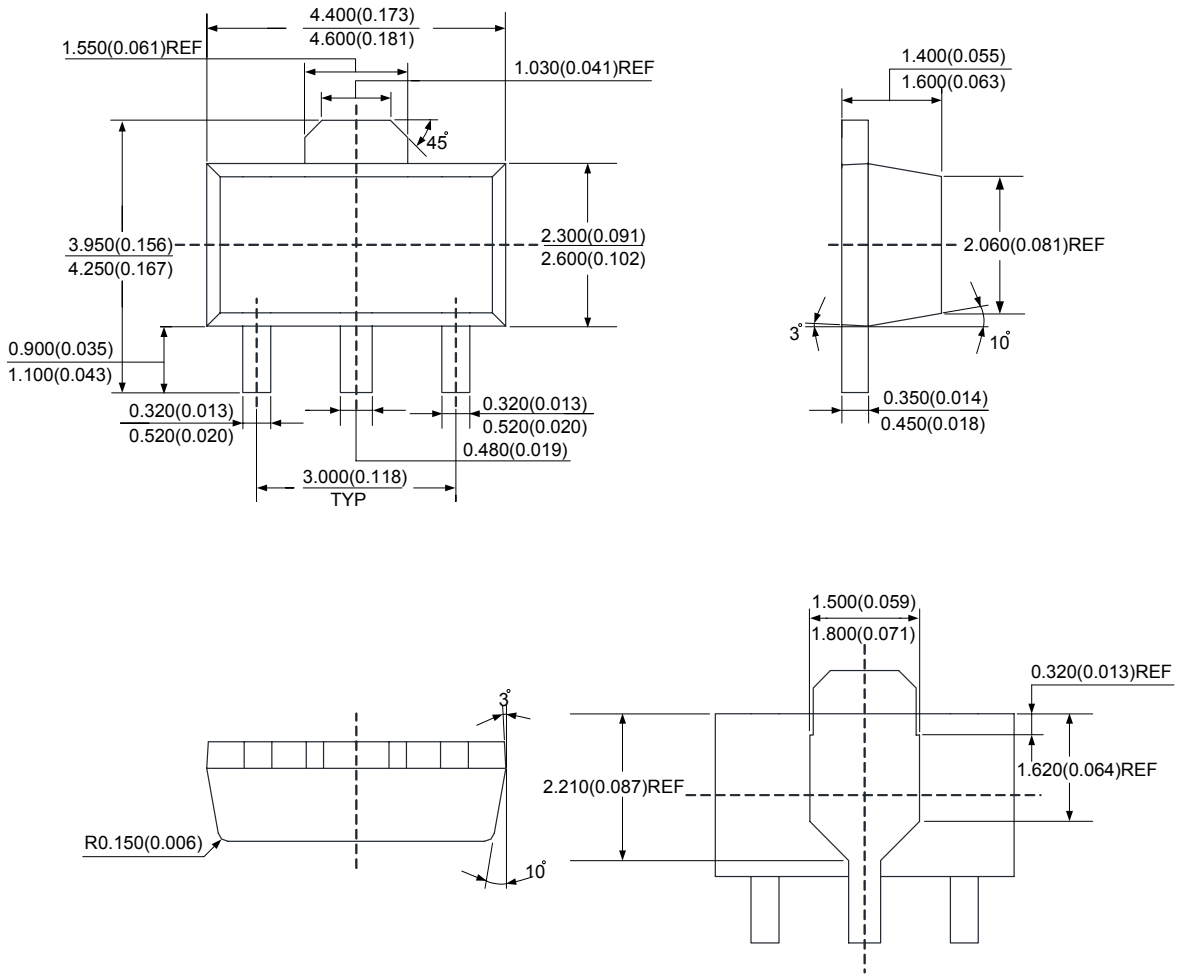
## Mechanical Dimensions

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



## Mechanical Dimensions (Continued)

**SOT-89** **Unit: mm(inch)**



**BCD Semiconductor Manufacturing Limited**

http://www.bcdsemi.com

**IMPORTANT NOTICE**

BCD Semiconductor Manufacturing Limited reserves the right to make changes without further notice to any products or specifications herein. BCD Semiconductor Manufacturing Limited does not assume any responsibility for use of any its products for any particular purpose, nor does BCD Semiconductor Manufacturing Limited assume any liability arising out of the application or use of any its products or circuits. BCD Semiconductor Manufacturing Limited does not convey any license under its patent rights or other rights nor the rights of others.


**MAIN SITE**

**- Headquarters**
**BCD Semiconductor Manufacturing Limited**
No. 1600, Zi Xing Road, Shanghai ZiZhu Science-based Industrial Park, 200241, China
Tel: +86-21-24162266, Fax: +86-21-24162277

**- Wafer Fab**
**Shanghai SIM-BCD Semiconductor Manufacturing Co., Ltd.**
800 Yi Shan Road, Shanghai 200233, China
Tel: +86-21-6485 1491, Fax: +86-21-5450 0008

**REGIONAL SALES OFFICE**

**Shenzhen Office**
**Shanghai SIM-BCD Semiconductor Manufacturing Co., Ltd., Shenzhen Office**
Unit A Room 1203, Skyworth Bldg., Gaoxin Ave.1.S., Nanshan District, Shenzhen, China
Tel: +86-755-8826 7951
Fax: +86-755-8826 7865

**Taiwan Office**
**BCD Semiconductor (Taiwan) Company Limited**
4F, 298-1, Rui Guang Road, Nei-Hu District, Taipei, Taiwan
Tel: +886-2-2656 2808
Fax: +886-2-2656 2806

**USA Office**
**BCD Semiconductor Corp.**
30920 Huntwood Ave. Hayward, CA 94544, USA
Tel : +1-510-324-2988
Fax: +1-510-324-2788