

Ultra-Low-Noise, High PSRR, Low-Dropout, 300mA Linear Regulator

Features

- **Wide Operating Voltage: 2.3V~6V**
- **Low Dropout Voltage: 290mV @ 3V/300mA**
- **Fixed Output Voltages: 1.5V~3.5V with step 100mV, 2.85V**
- **Guaranteed 300mA Output Current**
- **High PSRR: 74dB before 10kHz**
- **Low Output Noise: 36 μ V_{RMS} at 100Hz to 100kHz**
- **Current Limit Protection**
- **Controlled Short Circuit Current: 50mA**
- **Over Temperature Protection**
- **Stable with 1 μ F Capacitor for Any Load**
- **Excellent Load/Line Transient**
- **SOT-23-5 and SC70-5 Packages**
- **Lead Free and Green Devices Available (RoHS Compliant)**

Applications

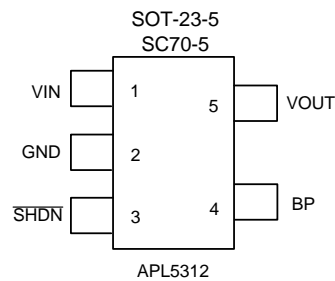
- **Cellular Phones**
- **Portable and Battery-Powered Equipment**
- **Wireless LANs**
- **GPS**

General Description

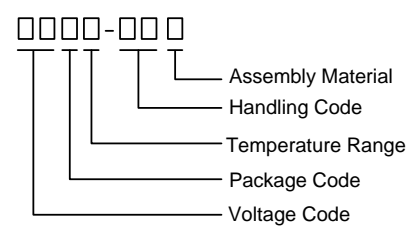
The APL5312 is a ultra low noise, low dropout linear regulator, which operate from 2.3V to 6V input voltage and deliver up to 300mA. Typical dropout voltage is only 290mV at 300mA loading. Designed for use in RF applications, the high PSRR 74dB and low noise 36 μ V_{RMS} makes it an ideal choice.

Design with an internal P-channel MOSET pass element, the APL5312 maintain a low supply current, independent of the load current and dropout voltage. Other features include thermal-shutdown protection and current limit protection to ensure specified output current and controlled short-circuit current. The APL5312 regulator come in a miniature SOT-23-5 and SC70-5 package.

Pin Configuration



Ordering and Marking Information

| | |
|--|---|
| <p>APL5312 □□□□-□□□</p>  <p>Assembly Material Handling Code Temperature Range Package Code Voltage Code</p> | <p>Package Code B : SOT23-5 S5 : SC70-5 Operating Ambient Temperature Range I : -40 to 85°C Handling Code TR : Tape & Reel Voltage Code 15 : 1.5V 30 : 3.0V Assembly Material L : Lead Free Device G : Halogen and Lead Free Device</p> |
|--|---|

Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020C for MSL classification at lead-free peak reflow temperature. ANPEC defines "Green" to mean lead-free (RoHS compliant) and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

Ordering and Marking Information (Cont.)

SOT23-5 packages

| Product Name | Marking | Product Name | Marking | Product Name | Marking | Product Name | Marking |
|--------------|---------|--------------|---------|--------------|---------|--------------|---------|
| APL5312-15B | 339X | APL5312-16B | 33AX | APL5312-17B | 33BX | APL5312-18B | 33CX |
| APL5312-19B | 33DX | APL5312-20B | 33EX | APL5312-21B | 33FX | APL5312-22B | 33GX |
| APL5312-23B | 33HX | APL5312-24B | 33IX | APL5312-25B | 33JX | APL5312-26B | 33KX |
| APL5312-27B | 33LX | APL5312-28B | 33MX | APL5312-29B | 33NX | APL5312-30B | 33OX |
| APL5312-31B | 33PX | APL5312-32B | 33QX | APL5312-33B | 33RX | APL5312-34B | 33SX |
| APL5312-35B | 33TX | APL5312-285B | 33αX | | | | |

SC70-5 packages

| Product Name | Marking | Product Name | Marking | Product Name | Marking | Product Name | Marking |
|--------------|---------|---------------|---------|--------------|---------|--------------|---------|
| APL5312-15S5 | 339 | APL5312-16S5 | 33A | APL5312-17S5 | 33B | APL5312-18S5 | 33C |
| APL5312-19S5 | 33D | APL5312-20S5 | 33E | APL5312-21S5 | 33F | APL5312-22S5 | 33G |
| APL5312-23S5 | 33H | APL5312-24S5 | 33I | APL5312-25S5 | 33J | APL5312-26S5 | 33K |
| APL5312-27S5 | 33L | APL5312-28S5 | 33M | APL5312-29S5 | 33N | APL5312-30S5 | 33O |
| APL5312-31S5 | 33P | APL5312-32S5 | 33Q | APL5312-33S5 | 33R | APL5312-34S5 | 33S |
| APL5312-35S5 | 33T | APL5312-285S5 | 33α | | | | |

Absolute Maximum Ratings

| Symbol | Parameter | Rating | Unit |
|----------------------|---|-------------|-------|
| V_{IN}, V_{OUT} | Input Voltage or Out Voltage | 6.5 | V |
| $\overline{SHDN/BP}$ | VOOUT Shutdown Control Pin/Bypass Signal Pin | 6.5 | V |
| $R_{TH,JA}$ | Thermal Resistance-Junction to Ambient (Note) SOT23-5 SC70-5 | 240 325 | °C /W |
| P_D | Power Dissipation, $T_A = 25^\circ\text{C}$ (Note) SOT23-5 SC70-5 | 410 310 | mW |
| T_J | Operating Junction Temperature | 0 to 125 | °C |
| T_{STG} | Storage Temperature Range | -65 to +150 | °C |
| T_{SDR} | Lead Temperature (Soldering, 10 second) | 260 | °C |

Note: When mounted on a (Copper foil area 50%, 45x45x1.6mm) glass epoxy board.

Electrical Characteristics

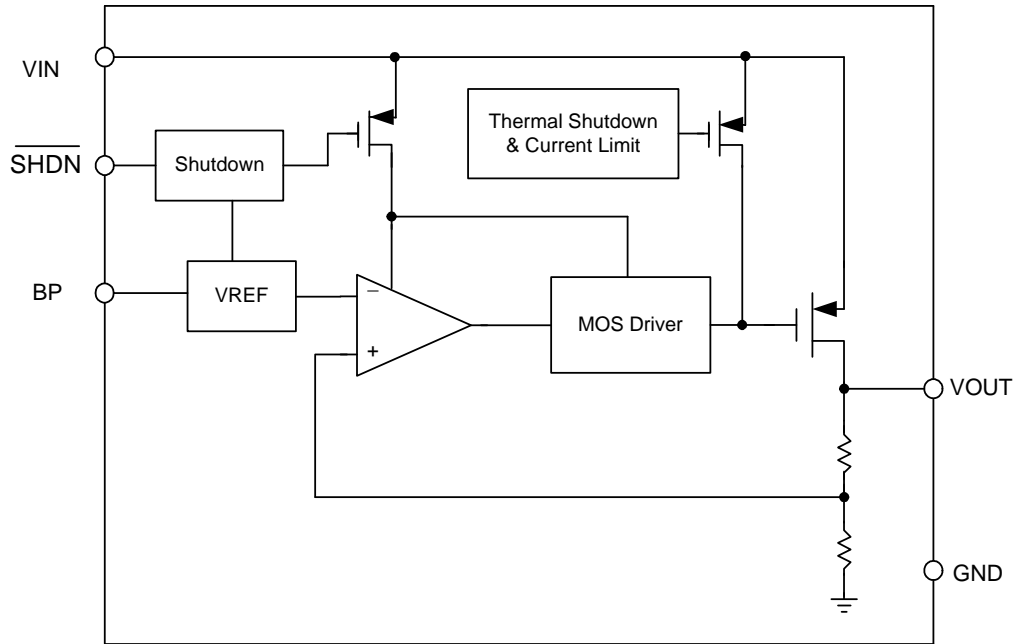
Unless otherwise noted these specifications apply over full temperature, $V_{IN} = V_{OUT} + 1V$, $C_{IN} = C_{OUT} = 1\mu F$,

$T_A = -40$ to $85^\circ C$. Typical values refer to $T_A = 25^\circ C$.

| Symbol | Parameter | Test Condition | APL5312 | | | Unit |
|--------------|--|---|---------|------|----------------|--------------------|
| | | | Min. | Typ. | Max. | |
| V_{IN} | Input Voltage | | 2.3 | | 6 | V |
| V_{OUT} | Output Voltage Accuracy | $V_{IN} = 5V$ | -2 | | 2 | % |
| | Output Voltage Range | | 1.5 | | 3.5 | V |
| I_{LIMIT} | Circuit Current Limit | | 450 | 500 | 550 | mA |
| I_Q | Quiescent Current | $I_{OUT} = 0mA$ | | 120 | 160 | μA |
| | | $I_{OUT} = 300mA$ | | 120 | 160 | |
| I_{OUT} | Load Current | | | 300 | | mA |
| REG_{LINE} | Line Regulation | $V_{OUT} + 0.5V < V_{IN} < 6V$, $I_{OUT} = 10mA$ | | 0.1 | 0.3 | % |
| REG_{LOAD} | Load Regulation | $V_{IN} = V_{OUT} + 1V$, $0mA < I_{OUT} < 300mA$ | | 0.8 | 1.5 | % |
| V_{DROP} | Dropout Voltage (Note) | $V_{OUT} = 1.5V$, $I_{OUT} = 300mA$ | | 520 | 680 | mV |
| | | $V_{OUT} = 2V$, $I_{OUT} = 300mA$ | | 430 | 560 | |
| | | $V_{OUT} = 3V$, $I_{OUT} = 300mA$ | | 290 | 380 | |
| PSRR | Ripple Rejection | $f = 1kHz$, $C_{BP} = 10nF$, $I_{OUT} = 10mA$ | | 73 | | dB |
| | | $f = 10kHz$, $C_{BP} = 10nF$, $I_{OUT} = 10mA$ | | 74 | | |
| | | $f = 100kHz$, $C_{BP} = 10nF$, $I_{OUT} = 10mA$ | | 55 | | |
| I_{SHORT} | Short Current | $V_{OUT} = 0V$ | | 50 | | mA |
| | Noise | $f = 100Hz$ to $100kHz$, $C_{BP} = 10nF$, $I_{OUT} = 10mA$ | | 36 | | μV_{RMS} |
| V_{SHDN} | High Threshold Voltage | | 1.6 | | $V_{IN} + 0.3$ | V |
| | Low Threshold Voltage | | -0.3 | | 0.4 | |
| I_{SHDN} | Shutdown Input Bias Current | $V_{SHDN} = V_{IN}$ | | 0.1 | 1 | μA |
| I_{OSHDN} | Shutdown Supply Current | $\overline{SHDN} = Low$, $V_{IN} = V_{OUT} + 1V$ | | 0.1 | 1 | μA |
| T_{EXIT} | Shutdown Exit Delay | $V_{OUT} = 90\%$, $R_{LOAD} = 50\Omega$ | | 100 | | μS |
| OTS | Over Temperature Shutdown | | | 160 | | $^\circ C$ |
| | Over Temperature Shutdown Hysteresis | | | 20 | | $^\circ C$ |
| TC | Output Voltage Temperature Coefficient | $T_J = -40 \sim 125^\circ C$ | | 100 | | ppm/ $^\circ C$ |
| C_{OUT} | Output Capacitor | | | 1 | | μF |
| | ESR | | 0.025 | | 1 | Ω |

Note: Dropout voltage definition: $V_{IN} - V_{OUT}$ when V_{OUT} is 2% below the value of V_{OUT} for $V_{IN} = V_{OUT} + 1V$.

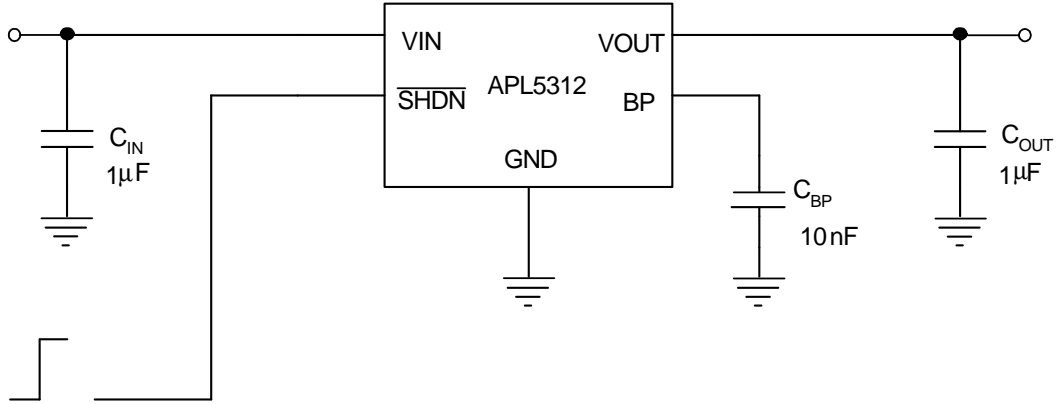
Block Diagram



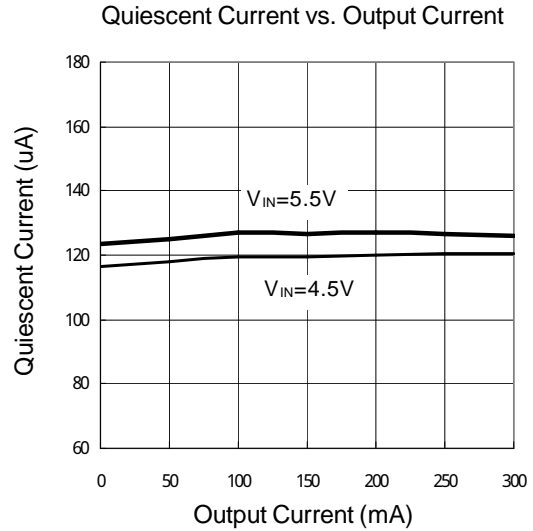
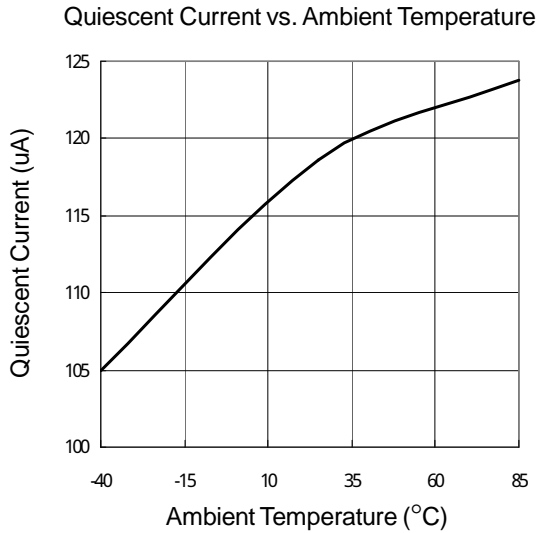
Pin Description

| PIN | | I/O | Description |
|-----|--------------------------|-----|--|
| No. | Name | | |
| 1 | VIN | I | Voltage supply input pin |
| 2 | GND | | GND pin |
| 3 | $\overline{\text{SHDN}}$ | I | Shutdown control pin, low = off, high = normal |
| 4 | BP | I | Bypass signal pin in fixed output type device |
| 5 | VOUT | O | Regulator output pin |

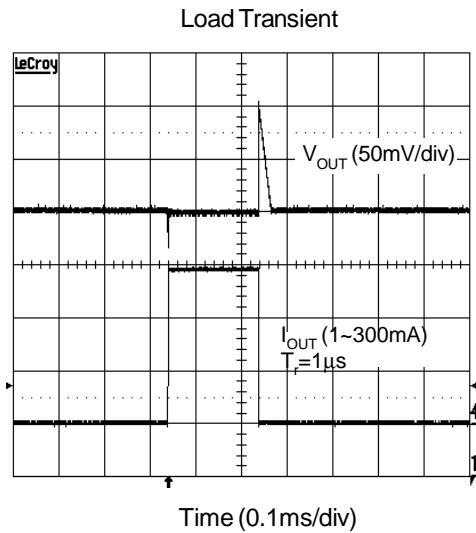
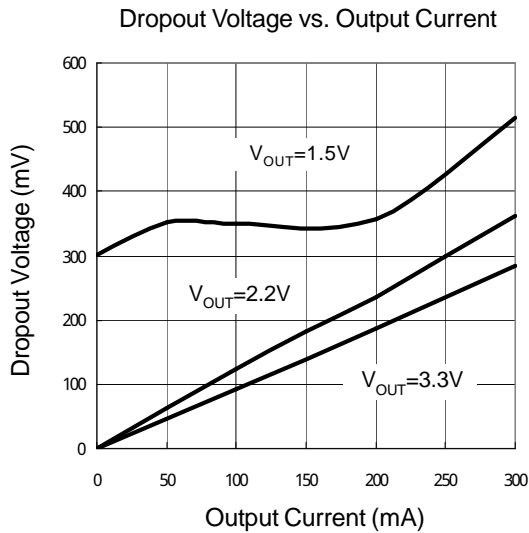
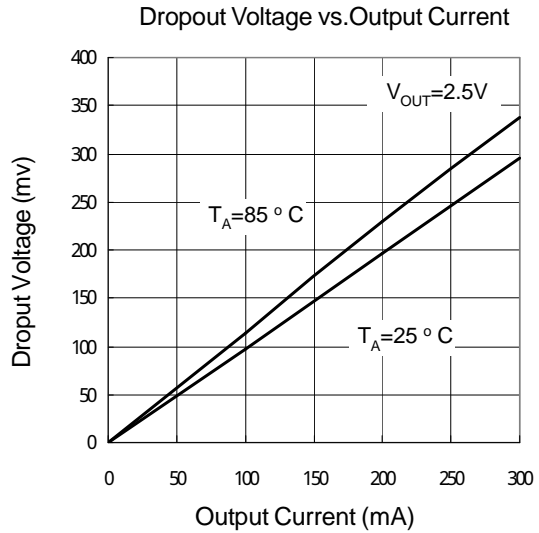
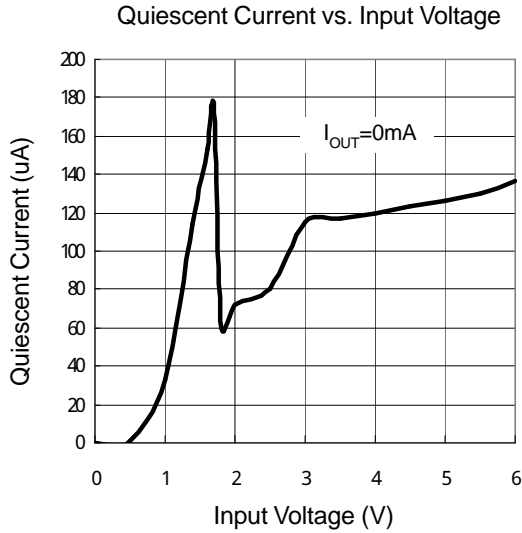
Typical Application Circuit



Typical Characteristics

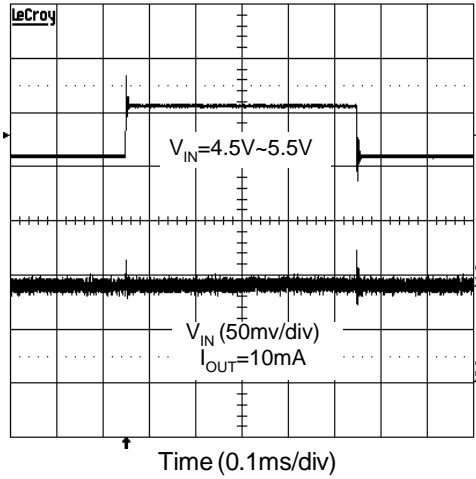


Typical Characteristics (Cont.)

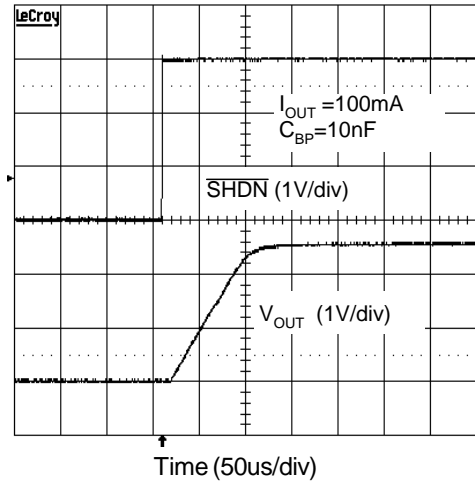


Typical Characteristics (Cont.)

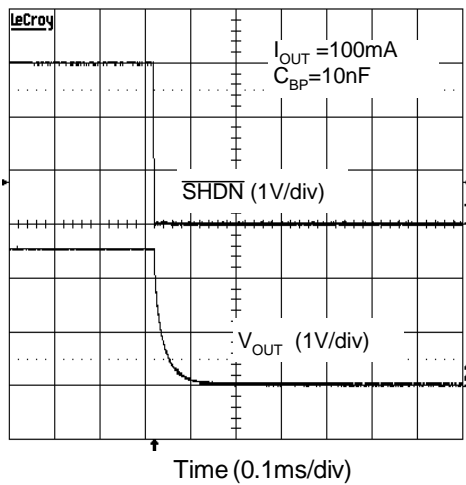
Line Transient



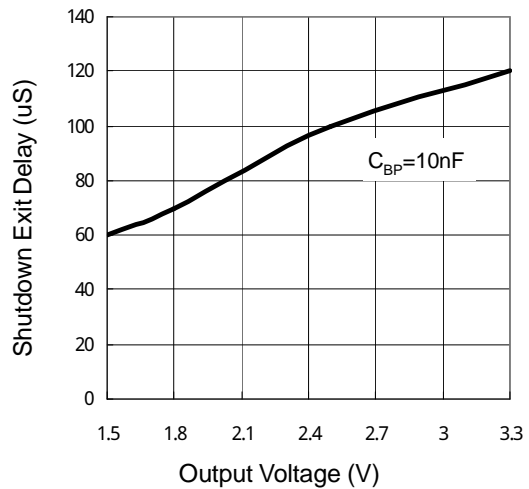
Exiting Shutdown Waveform



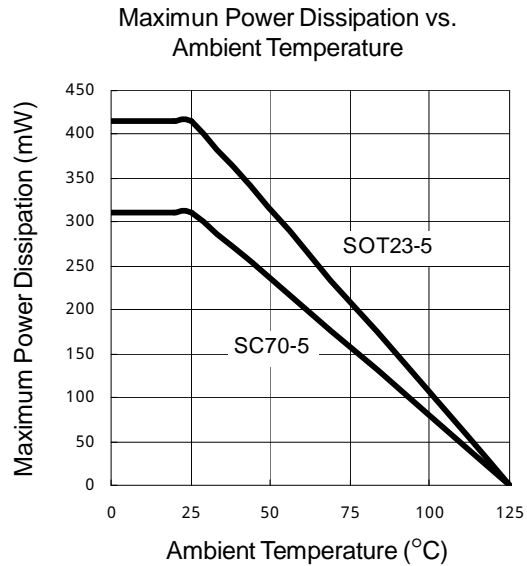
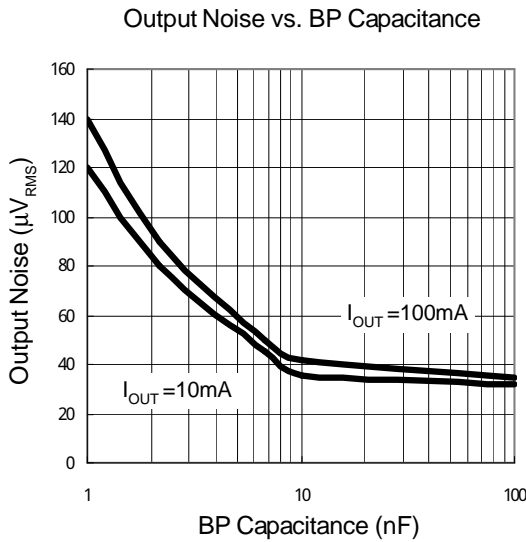
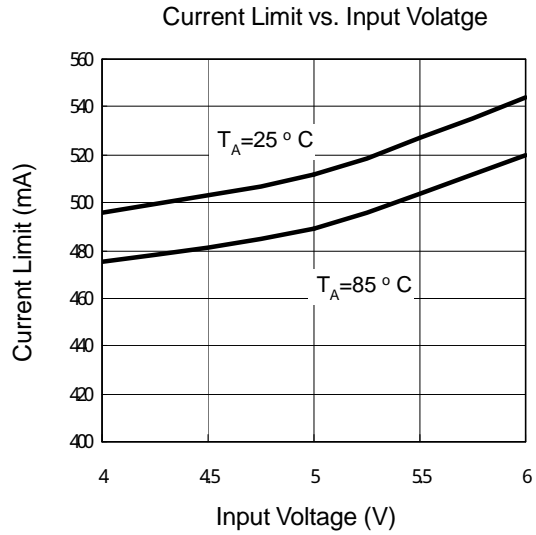
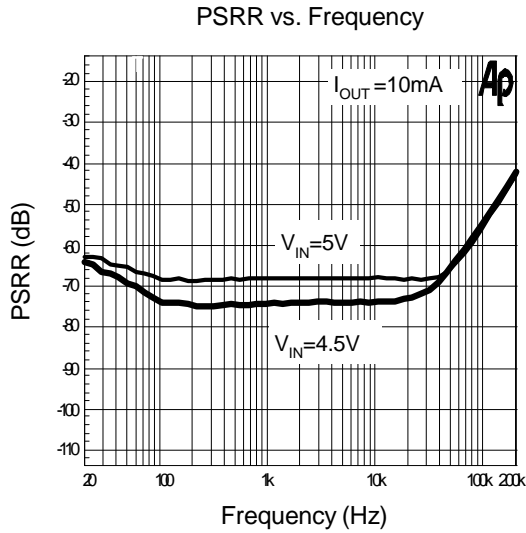
Entering Shutdown Delay



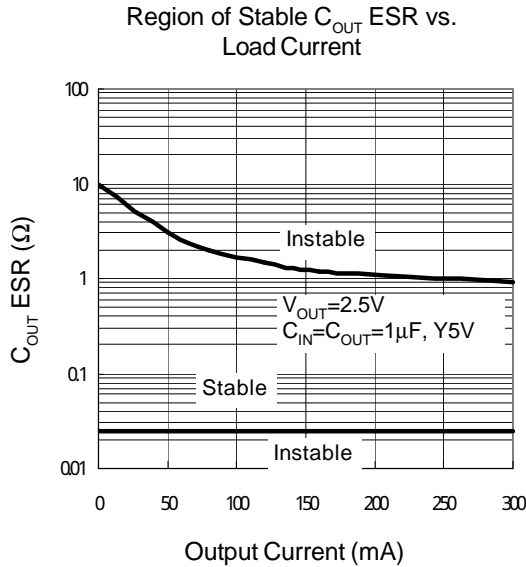
Shutdown Exit Delay



Typical Characteristics (Cont.)



Typical Characteristics (Cont.)



Application Information

Output Voltage Selection

The APL5312 are supplied with factory-set output voltages from 1.5V to 3.5V.

Capacitor Selection and Regulation Stability

The APL5312 uses at least a 1μF capacitor on the input. This capacitor can use Aluminum, Tantalum or Ceramic capacitors. Input capacitor with large value and low ESR provides better PSRR and line-transient response. The output capacitor also can use Aluminum, Tantalum or Ceramic capacitor, and its proper values is at least 1μF, ESR must be above 25mΩ. Large output capacitor values can reduce noise and improve load-transient response, stability, and PSRR. With X5R and Y5V dielectrics, 1μF is sufficient at all operating temperatures. The selection of output capacitor's is important because it with C_{OUT} form a zero to provide the sufficient phase margin (see the Figure C_{OUT} ESR vs. Load Current).

Bypass Capacitor

Use a 10nF bypass capacitor at BP for low-output voltage noise. The leakage current going into the BP pin should be less than 10nA. Increasing the capacitance slightly de-

creases the output noise. Value above 0.1μF and below 1nF are not recommended (see the Figure Output Noise vs. BP Capacitance).

Noise, PSRR, and Load-Transient Response

The APL5312 is designed to deliver ultra-low noise and high PSRR, as well as low dropout and low quiescent currents in battery-powered systems. When operating from sources other than batteries, improve PSRR and transient response can be achieved by increasing input and output capacitors, and bypass capacitor to form the passive filtering techniques (see Output Noise vs. BP Capacitance).

Shutdown

The APL5312 has an active high enable function. Force SHDN high (>1.6V) enables the V_{OUT}, SHDN low (<0.4V) disables the V_{OUT}. Enter the shutdown mode, it also causes the output voltage to discharge through a 500Ω resistance to ground. In shutdown mode, the quiescent current can reduce to 0.1μA. The SHDN pin cannot be floating, a floating SHDN pin may cause an indeterminate state on the output. If it is no use, connect to V_{IN} for normal operation.

Application Information (Cont.)

Input-Output (Dropout) Voltage

The minimum input-output voltage differential (dropout) determines the lowest usable supply voltage. The dropout voltage is a function of drain-to-source on resistance multiplied by the load current.

Current Limit

APL5312 includes a current-limit circuitry for linear regulator. The current limit protection, which senses the current flowing to the P-channel MOSFET, and controls the output voltage. The point where limiting occurs is $I_{OUT} = 500mA$. The output can be shorted to ground for an indefinite amount of time without damaging to the part.

Thermal Protection

Thermal protection limits total power dissipation in the APL5312. When the junction temperature exceeds $+160^{\circ}C$, the thermal sensor generate a logic signal to turn off the pass element and let IC to cool. When the IC's junction temperature cools down by $20^{\circ}C$, the thermal sensor will turn the pass element on again, resulting in a pulsed output during continuous thermal protection. Thermal protection is designed to protect the IC in the event of fault conditions.

Operating Region and Power Dissipation

The thermal resistance of the case and circuit board, ambient and junction air temperature, and the rate of air flow all control the APL5312's maximum power dissipation. The power dissipation across the device is $P = I_{OUT} (V_{IN} - V_{OUT})$. The maximum power dissipation is:

$$P_{MAX} = (T_J - T_A) / (\theta_{JC} + \theta_{CA})$$

$$\theta_{JA} = \theta_{JC} + \theta_{CA}$$

where $T_J - T_A$ is the temperature difference between the junction and ambient air.

θ_{JC} is the thermal resistance of the package, θ_{CA} is the thermal resistance through the printed circuit board, copper traces, and other materials to the surrounding air, θ_{JA} is the thermal resistance between Junction and ambient air. For continual operation, do not exceed the absolute maximum junction Temperature rating of $T_J = 125^{\circ}C$.

For example:

The SOT23-5 package has maximum power dissipation 300mW at $T_A = 55^{\circ}C$, relatively 225m W at SC70-5 package (see Maximum Power Dissipation vs. Ambient Temperature).

$$V_{IN} = 5V, I_{OUT} = 250mA, V_{OUT} = 3.3V,$$

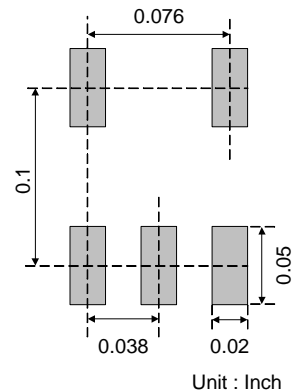
$$P_D = (5-3.3)V \times 150mA = 255mW$$

According the power dissipation issue, we should adapt the SOT23-5 package. It could reduce the thermal resistance to maintain the IC longer life.

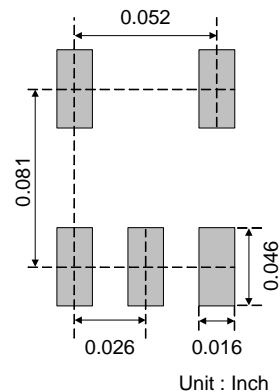
The GND pin provides an electrical connection to ground and channeling heat away. The printed circuit board (PCB) forms a heat sink and dissipates most of the heat into ambient air.

Recommended Minimum Footprint

SOT-23-5

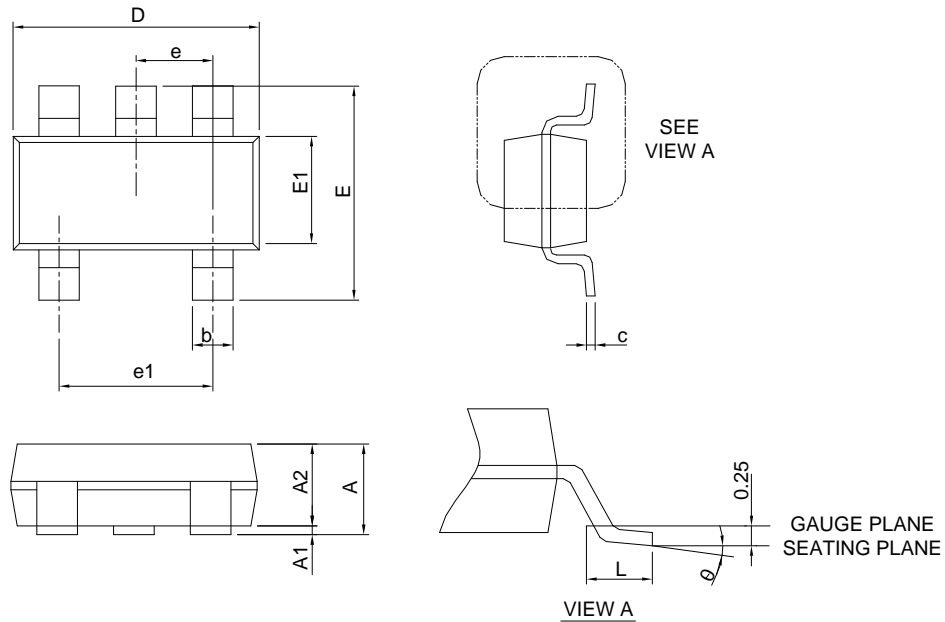


SC70-5



Package Information

SOT-23-5

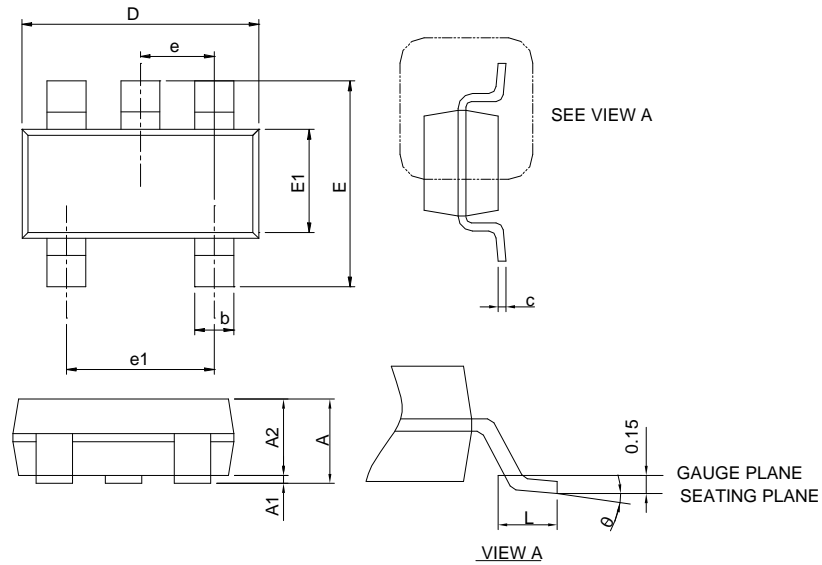


| SYMBOL | SOT-23-5 | | | |
|--------|-------------|------|-----------|-------|
| | MILLIMETERS | | INCHES | |
| | MIN. | MAX. | MIN. | MAX. |
| A | | 1.45 | | 0.057 |
| A1 | 0.00 | 0.15 | 0.000 | 0.006 |
| A2 | 0.90 | 1.30 | 0.035 | 0.051 |
| b | 0.30 | 0.50 | 0.012 | 0.020 |
| c | 0.08 | 0.22 | 0.003 | 0.009 |
| D | 2.70 | 3.10 | 0.016 | 0.122 |
| E | 2.60 | 3.00 | 0.102 | 0.118 |
| E1 | 1.40 | 1.80 | 0.055 | 0.071 |
| e | 0.95 BSC | | 0.037 BSC | |
| e1 | 1.90 BSC | | 0.075 BSC | |
| L | 0.30 | 0.60 | 0.012 | 0.024 |
| θ | 0° | 8° | 0° | 8° |

Note : 1. Follow JEDEC TO-178 AA.
 2. Dimension D and E1 do not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.

Package Information

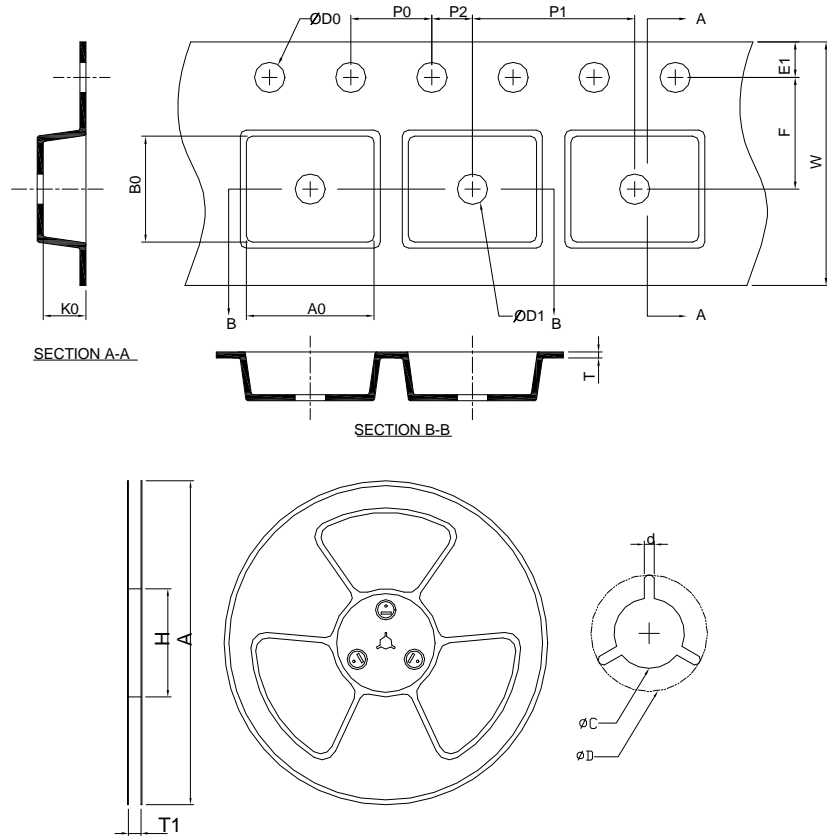
SC70-5



| SYMBOL | SC-70-5 | | | |
|--------|-------------|------|-----------|-------|
| | MILLIMETERS | | INCHES | |
| | MIN. | MAX. | MIN. | MAX. |
| A | | 1.10 | | 0.043 |
| A1 | 0.00 | 0.10 | 0.000 | 0.004 |
| A2 | 0.80 | 1.00 | 0.031 | 0.040 |
| b | 0.15 | 0.30 | 0.006 | 0.012 |
| c | 0.08 | 0.25 | 0.003 | 0.010 |
| D | 1.90 | 2.20 | 0.075 | 0.087 |
| E | 2.00 | 2.20 | 0.079 | 0.087 |
| E1 | 1.15 | 1.35 | 0.045 | 0.053 |
| e | 0.65 BSC | | 0.026 BSC | |
| e1 | 1.30 BSC | | 0.051 BSC | |
| L | 0.15 | 0.45 | 0.006 | 0.018 |
| θ | 0° | 8° | 0° | 8° |

- Note : 1. Follow JEDEC MO-223 AB.
 2. Dimension D and E1 do not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side.

Carrier Tape & Reel Dimensions



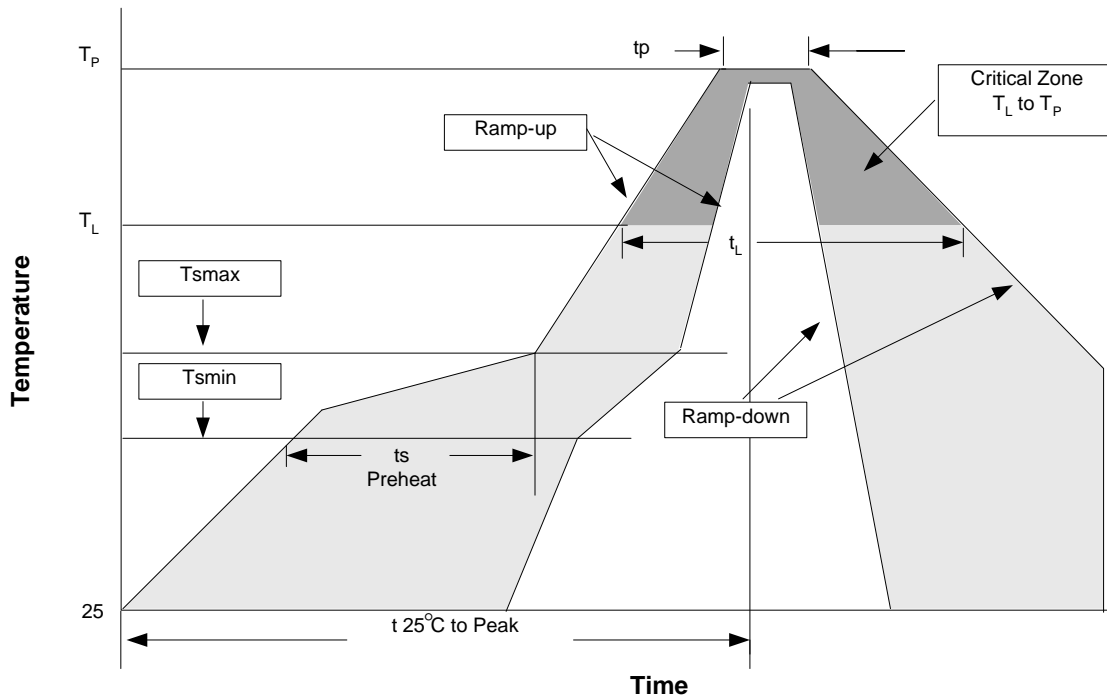
| Application | A | H | T1 | C | d | D | W | E1 | F |
|-------------|------------|----------|-------------------|--------------------|-----------|-------------------|-----------|-----------|-----------|
| SOT-23-5 | 178.0±2.00 | 50 MIN. | 8.4+2.00 -0.00 | 13.0+0.50 -0.20 | 1.5 MIN. | 20.2 MIN. | 8.0±0.30 | 1.75±0.10 | 3.5±0.05 |
| | P0 | P1 | P2 | D0 | D1 | T | A0 | B0 | K0 |
| | 4.0±0.10 | 4.0±0.10 | 2.0±0.10 | 1.5+0.10 -0.00 | 1.5 MIN. | 0.6+0.00 -0.40 | 3.20±0.20 | 3.10±0.20 | 1.50±0.20 |
| Application | A | H | T1 | C | d | D | W | E1 | F |
| SC70-5 | 178.0±2.00 | 50 MIN. | 8.4+2.00 -0.00 | 13.0+0.50 -0.20 | 1.5 MIN. | 20.2 MIN. | 8.0±0.30 | 1.75±0.10 | 3.50±0.05 |
| | P0 | P1 | P2 | D0 | D1 | T | A0 | B0 | K0 |
| | 4.0±0.10 | 4.0±0.10 | 2.0±0.05 | 1.5+0.10 -0.00 | 1.00 MIN. | 0.6+0.00 -0.40 | 2.40±0.20 | 2.40±0.20 | 1.20±0.20 |

(mm)

Devices Per Unit

| Package Type | Unit | Quantity |
|--------------|-------------|----------|
| SOT-23-5 | Tape & Reel | 3000 |
| SC70-5 | Tape & Reel | 3000 |

Reflow Condition (IR/Convection or VPR Reflow)



Reliability Test Program

| Test item | Method | Description |
|---------------|---------------------|-------------------------------|
| SOLDERABILITY | MIL-STD-883D-2003 | 245°C, 5 sec |
| HOLT | MIL-STD-883D-1005.7 | 1000 Hrs Bias @ 125°C |
| PCT | JESD-22-B,A102 | 168 Hrs, 100%RH, 121°C |
| TST | MIL-STD-883D-1011.9 | -65°C~150°C, 200 Cycles |
| ESD | MIL-STD-883D-3015.7 | VHBM > 2KV, VMM > 200V |
| Latch-Up | JESD 78 | 10ms, $I_{tr} > 100\text{mA}$ |

Classification Reflow Profiles

| Profile Feature | Sn-Pb Eutectic Assembly | Pb-Free Assembly |
|--|----------------------------------|----------------------------------|
| Average ramp-up rate (T _L to T _P) | 3°C/second max. | 3°C/second max. |
| Preheat - Temperature Min (T _{sm}) - Temperature Max (T _{sm}) - Time (min to max) (t _s) | 100°C 150°C 60-120 seconds | 150°C 200°C 60-180 seconds |
| Time maintained above: - Temperature (T _L) - Time (t _L) | 183°C 60-150 seconds | 217°C 60-150 seconds |
| Peak/Classification Temperature (T _p) | See table 1 | See table 2 |
| Time within 5°C of actual Peak Temperature (t _p) | 10-30 seconds | 20-40 seconds |
| Ramp-down Rate | 6°C/second max. | 6°C/second max. |
| Time 25°C to Peak Temperature | 6 minutes max. | 8 minutes max. |

Note: All temperatures refer to topside of the package. Measured on the body surface.

Table 1. SnPb Eutectic Process – Package Peak Reflow Temperatures

| Package Thickness | Volume mm ³ <350 | Volume mm ³ ≥350 |
|-------------------|--------------------------------|--------------------------------|
| <2.5 mm | 240 +0/-5°C | 225 +0/-5°C |
| ≥2.5 mm | 225 +0/-5°C | 225 +0/-5°C |

Table 2. Pb-free Process – Package Classification Reflow Temperatures

| Package Thickness | Volume mm ³ <350 | Volume mm ³ 350-2000 | Volume mm ³ >2000 |
|-------------------|--------------------------------|------------------------------------|---------------------------------|
| <1.6 mm | 260 +0°C* | 260 +0°C* | 260 +0°C* |
| 1.6 mm – 2.5 mm | 260 +0°C* | 250 +0°C* | 245 +0°C* |
| ≥2.5 mm | 250 +0°C* | 245 +0°C* | 245 +0°C* |

* Tolerance: The device manufacturer/supplier shall assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.

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