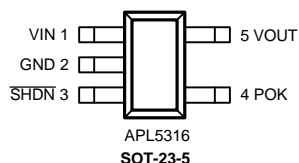


## Low Dropout 300mA Linear Regulator With Power-Ok Indicator

### Features

- **Wide Operating Voltage: 2.8-6V**
- **Fixed Output Voltage in the range of 0.8V-5.5V**
- **Low Dropout Voltage:**  
**170mV(typical) @ 300mA**
- **Guaranteed 300mA Output Current**
- **Power-Ok Indicator**
- **Current Limit Protection with Foldback Current**
- **Internal Soft-Start**
- **Over Temperature Protection**
- **Stable with Low ESR Ceramic Capacitors**
- **SOT-23-5 Package**
- **Lead Free and Green Devices Available**  
**(RoHS Compliant)**

### Pin Configuration



### General Description

The APL5316 is a low dropout linear regulator which needs only a single input voltage supply from 2.8 to 6V, and it can deliver output current up to 300mA. It can work with low ESR ceramic capacitors and ideally use in the battery-powered applications, such as notebook computers and cellular phones. Its typical dropout voltage is only 170mV at 300mA loading. A power-ok detection indicates the output status at POK pin. The current limit protection (with foldback current) and thermal shut-down functions protect the device against current overloads and over temperature. The APL5316 is available in a SOT-23-5 package.

### Applications

- **Cellular Phones**
- **Portable and Battery-powered Equipment**
- **Notebook and Personal Computers**

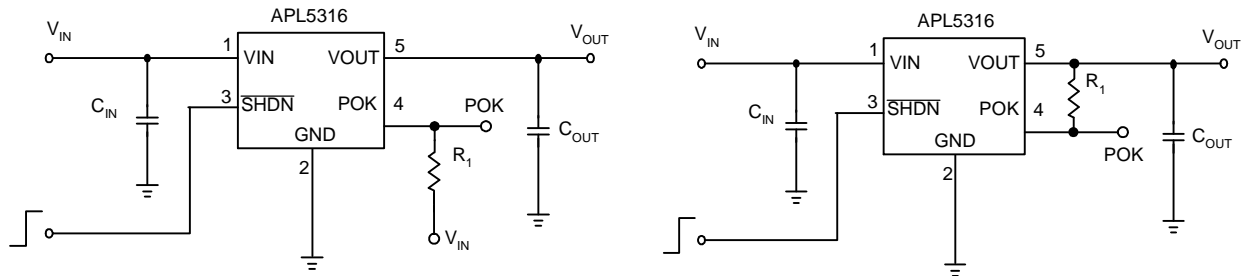
### Ordering and Marking Information

|  |   |
|--|---|
| <p>APL5316-□□□□ - □□□</p> <p style="margin-left: 40px;">             □□□□ — Assembly Material<br/>             □□□□ — Handling Code<br/>             □□□□ — Temperature Range<br/>             □□□□ — Package Code<br/>             □□□□ — Voltage Code         </p> | <p>Package Code<br/>B : SOT-23-5</p> <p>Operating Junction Temperature Range<br/>I : -40 to 85°C</p> <p>Handling Code<br/>TR : Tape &amp; Reel</p> <p>Voltage Code<br/>12 : 1.2V 15 : 1.5V 33 : 3.3V</p> <p>Assembly Material<br/>L : Lead Free Device G : Halogen and Lead Free Device</p> |
| <p>APL5316 -12 B: <span style="border: 1px solid black; padding: 2px 5px;">365X</span>      APL5316 -33 B: <span style="border: 1px solid black; padding: 2px 5px;">36RX</span>      X - Date code</p>   |   |
| <p>APL5316 -15 B: <span style="border: 1px solid black; padding: 2px 5px;">369X</span>      X - Date code</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-020D 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.

## Simplified Application Circuits



## Absolute Maximum Ratings

| Symbol                | Parameter                                      | Rating             | Unit |
|-----------------------|--|--------------------|------|
| $V_{IN}$              | VIN Supply Voltage (VIN to GND)                | -0.3 ~ 6.5         | V    |
| $V_{\overline{SHDN}}$ | SHDN Input Voltage ( $\overline{SHDN}$ to GND) | -0.3 ~ 6.5         | V    |
| $P_D$                 | Power Dissipation                              | Internally Limited | W    |
| $T_J$                 | Junction Temperature                           | -40 ~ 150          | °C   |
| $T_{STG}$             | Storage Temperature                            | -65 ~ 150          | °C   |
| $T_{SDR}$             | Maximum Lead Soldering Temperature, 10 Seconds | 260                | °C   |

Note1: Stresses beyond 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 rating conditions for extended periods may affect device reliability

## Thermal Characteristics

| Symbol        | Parameter  | Typical Value | Unit |
|---------------|--|---------------|------|
| $\theta_{JA}$ | Thermal Resistance-Junction to Ambient <sup>(Note 1)</sup> | 240           | °C/W |
| $\theta_{JC}$ | Thermal Resistance- Junction to Case                       | 130           | °C/W |

Note 2 :  $\theta_{JA}$  is measured with the component mounted on a high effective thermal conductivity test board in free air.

## Recommended Operating Conditions

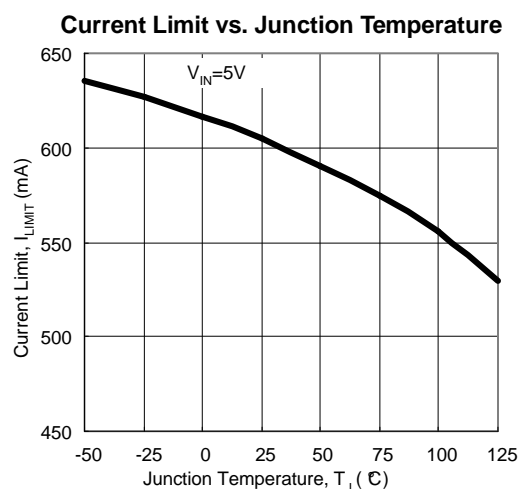
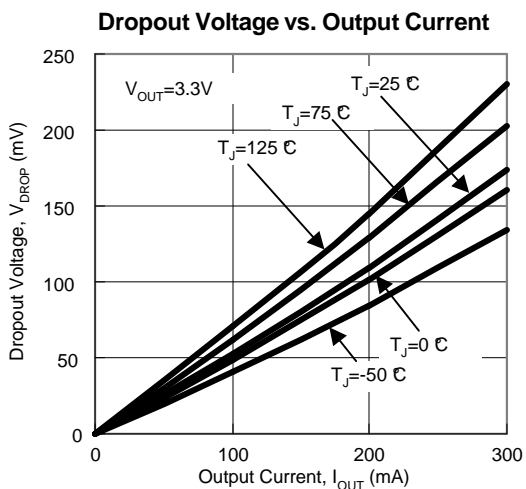
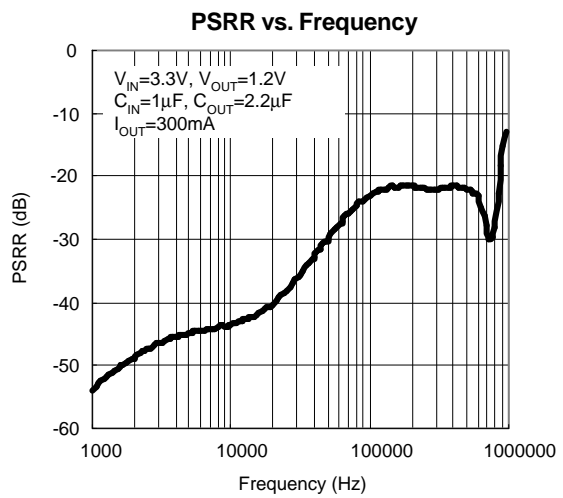
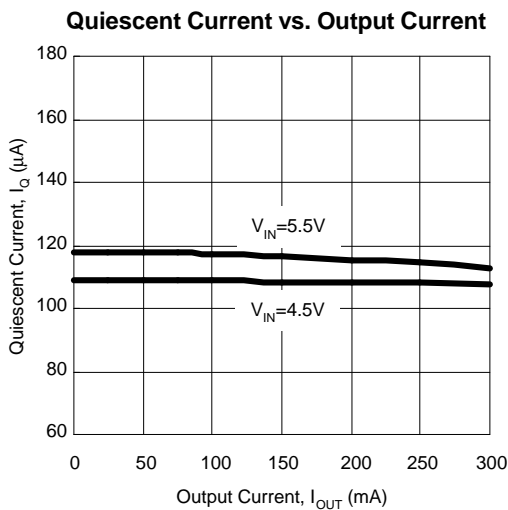
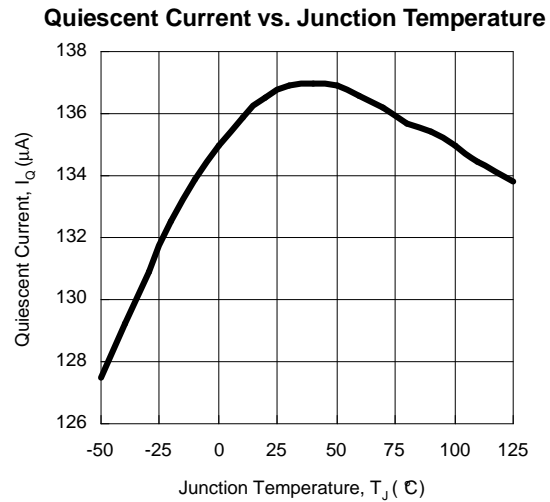
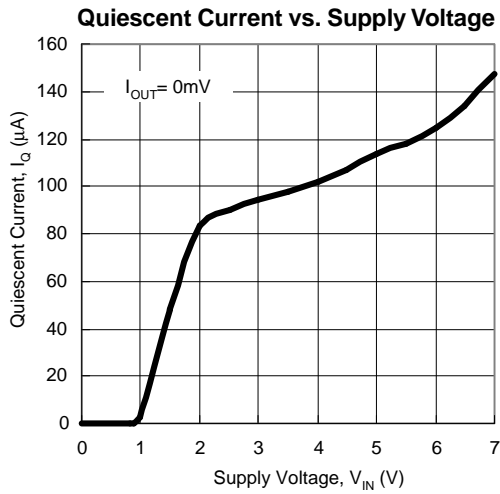
| Symbol    | Parameter            | Range         | Unit |
|-----------|----------------------|---------------|------|
| $V_{IN}$  | VIN Supply Voltage   | 2.8 ~ 6       | V    |
| $V_{OUT}$ | Output Voltage       | Fixed Voltage | V    |
| $I_{OUT}$ | VOUT Output Current  | 0 ~ 300       | mA   |
| $C_{OUT}$ | Output Capacitor     | 1.5 ~ 22      | μF   |
| $T_J$     | Junction Temperature | -40 ~ 125     | °C   |

## Electrical Characteristics

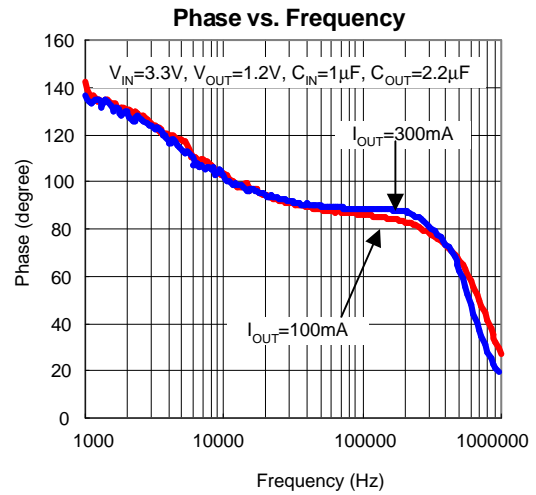
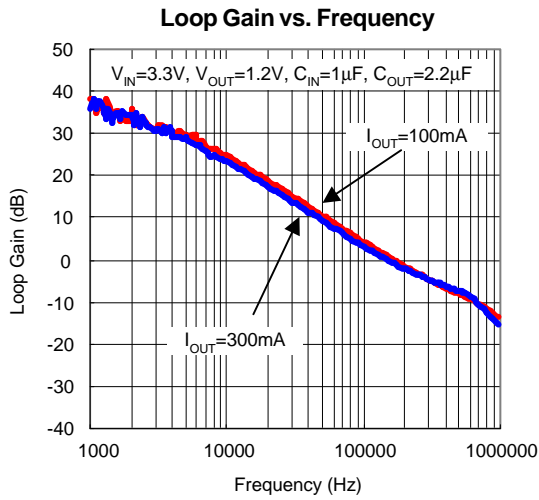
Unless otherwise specified, these specifications apply over  $V_{IN} = V_{OUT} + 1V$  (min  $V_{IN} = 2.8V$ ),  $I_{OUT} = 0 \sim 300mA$ ,  $C_{IN} = 1\mu F$ ,  $C_{OUT} = 2.2\mu F$ ,  $T_A = -40$  to  $85^\circ C$ . Typical values are at  $T_A = 25^\circ C$ .

| Symbol       | Parameter                               | Test Conditions                      | APL5316 |      |       | Unit        |
|--------------|---|--------------------------------------|---------|------|-------|-------------|
|              |   |                                      | Min.    | Typ. | Max.  |             |
| $V_{IN}$     | Input Voltage                           |                                      | 2.8     | -    | 6     | V           |
| $I_Q$        | Quiescent Current                       | $I_{OUT} = 10mA \sim 300mA$          | -       | 135  | 160   | $\mu A$     |
|              | Output Voltage Accuracy                 | $I_{OUT} = 10mA$                     | -2      | -    | +2    | %           |
| $REG_{LINE}$ | Line Regulation                         | $V_{OUT}\% / V_{IN}, I_{OUT} = 10mA$ | -0.06   | -    | +0.06 | %/V         |
| $REG_{LOAD}$ | Load Regulation                         | $V_{OUT}\% / I_{OUT}$                | -0.2    | -    | +0.2  | %/A         |
| $V_{DROP}$   | Dropout Voltage                         | $V_{OUT} = 3.3V, I_{OUT} = 300mA$    | -       | 170  | 300   | mV          |
| PSRR         | Power Supply Ripple Rejection Ratio     | $f = 10kHz, I_{OUT} = 300mA$         | -       | 45   | -     | dB          |
| $I_{LIMIT}$  | Current Limit                           |                                      | 450     | 600  | -     | mA          |
| $I_{SHORT}$  | Foldback Current                        | $V_{OUT} = 0V$                       | -       | 80   | -     | mA          |
|              | $\overline{SHDN}$ Input Voltage High    |                                      | 1.6     | -    | -     | V           |
|              | $\overline{SHDN}$ Input Voltage Low     |                                      | -       | -    | 0.4   |             |
|              | Shutdown VIN Supply Current             | $\overline{SHDN} = Low, V_{IN} = 6V$ | -       | 0.1  | 1     | $\mu A$     |
|              | $\overline{SHDN}$ Pull Low Resistance   |                                      | -       | 3    | -     | $M\Omega$   |
|              | $V_{OUT}$ Discharge MOSFET $R_{DS(ON)}$ | $\overline{SHDN} = Low$              | -       | 60   | -     | $\Omega$    |
|              | Over Temperature Threshold              |                                      | -       | 160  | -     | $^\circ C$  |
|              | Over Temperature Hysteresis             |                                      | -       | 40   | -     | $^\circ C$  |
| $T_{SS}$     | Soft-Start Interval                     |                                      | -       | 60   | -     | $\mu s$     |
| $V_{POK}$    | POK threshold Voltage for Power Ok      | $V_{OUT}$ Rising                     | 89      | 92   | 95    | $\%V_{OUT}$ |
| $V_{PNOK}$   | POK threshold Voltage for Power Not Ok  | $V_{OUT}$ falling                    | 78      | 81   | 84    | $\%V_{OUT}$ |
|              | POK Low Voltage                         | POK sinks 5mA                        | -       | 0.25 | 0.4   | V           |

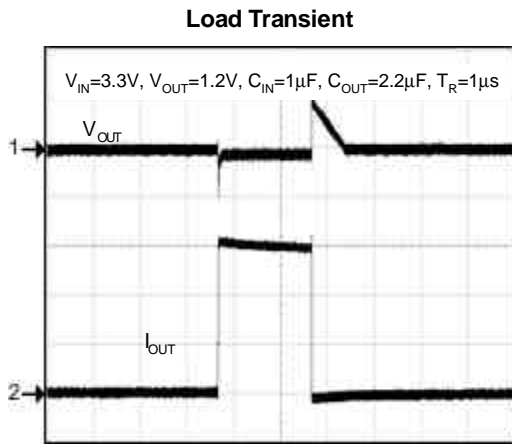
## Typical Operating Characteristics



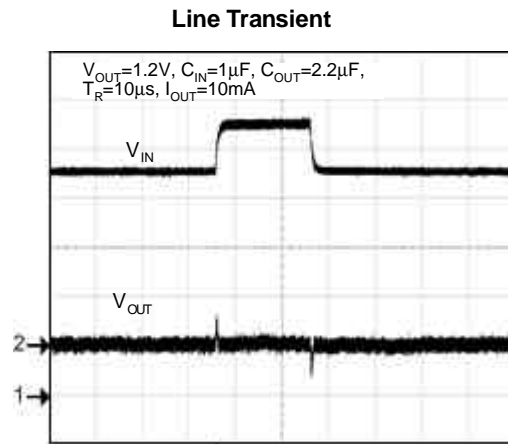
Typical Operating Characteristics (Cont.)



Operating Waveforms



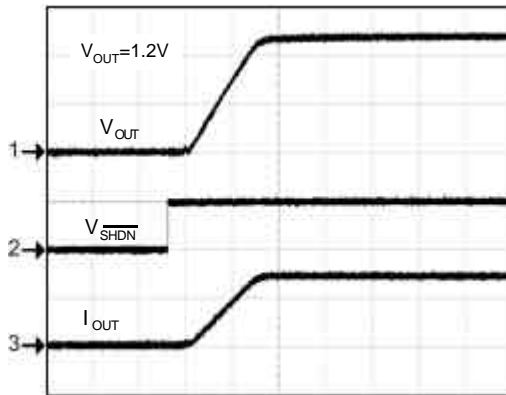
CH1 :  $V_{OUT}$ , 50mV/div, AC  
 CH2 :  $I_{OUT}$ , 100mA/div, DC  
 Time : 100μs/div



CH1 :  $V_{IN}$ , 1V/div, DC  
 CH2 :  $V_{OUT}$ , 20mV/div, AC  
 Time : 100μs/div

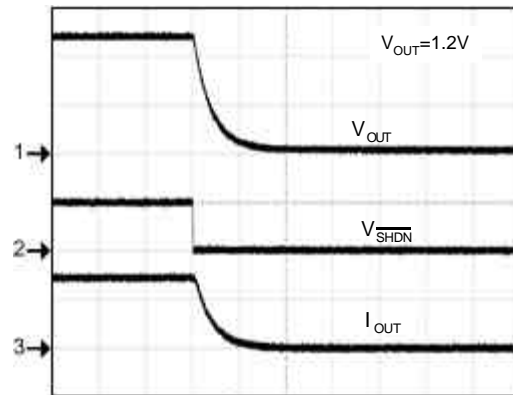
Operating Waveforms (Cont.)

Enable



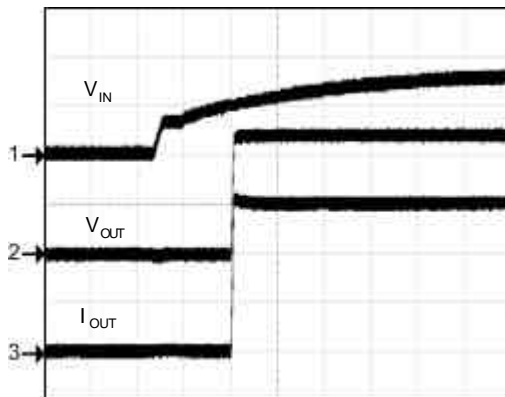
CH1 :  $V_{OUT}$ , 500mV/div  
 CH2 :  $V_{SHDN}$ , 5V/div  
 CH3 :  $I_{OUT}$ , 200mA/div  
 Time : 50 $\mu$ s/div

Shutdown



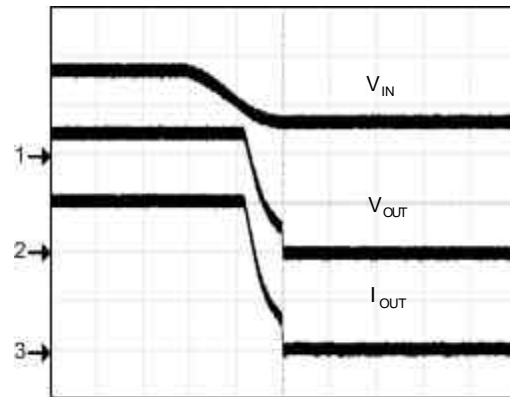
CH1 :  $V_{OUT}$ , 500mV/div  
 CH2 :  $V_{SHDN}$ , 5V/div  
 CH3 :  $I_{OUT}$ , 200mA/div DC  
 Time : 10 $\mu$ s/div

Power on



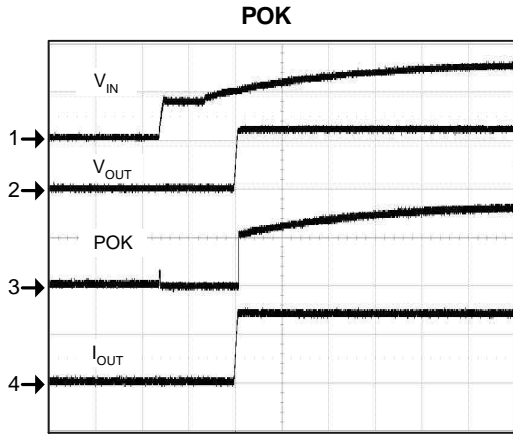
CH1 :  $V_{IN}$ , 2V/div  
 CH2 :  $V_{OUT}$ , 500mV/div  
 CH3 :  $I_{OUT}$ , 100mA/div  
 Time : 200 $\mu$ s/div

Power off



CH1 :  $V_{IN}$ , 2V/div  
 CH2 :  $V_{OUT}$ , 500mV/div,  
 CH3 :  $I_{OUT}$ , 100mA/div  
 Time : 50ms/div

### Operating Waveforms (Cont.)

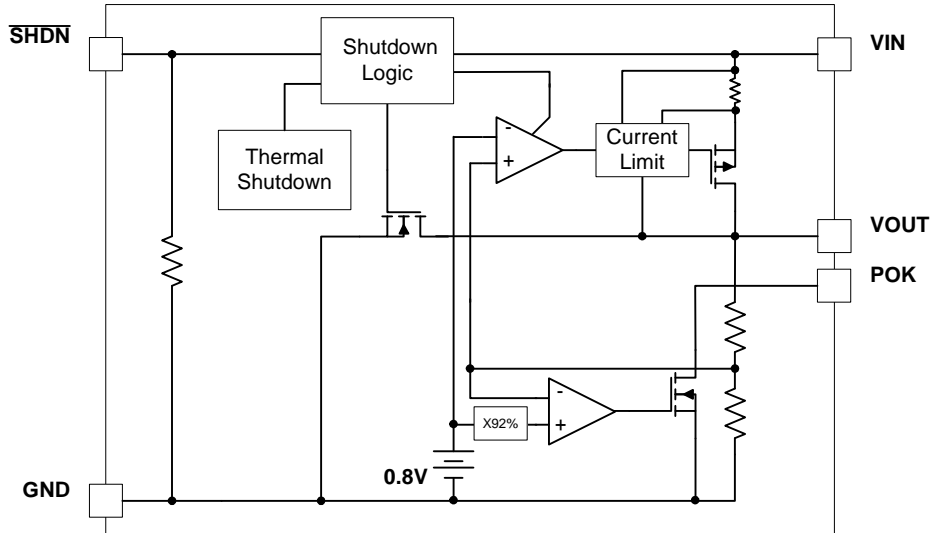


CH1 :  $V_{IN}$ , 2V/div  
 CH2 :  $V_{OUT}$ , 1V/div,  
 CH3 :  $P_{OK}$ , 2V/div  
 CH4 :  $I_{OUT}$ , 200mA/div  
 Time : 1ms/div

### Pin Description

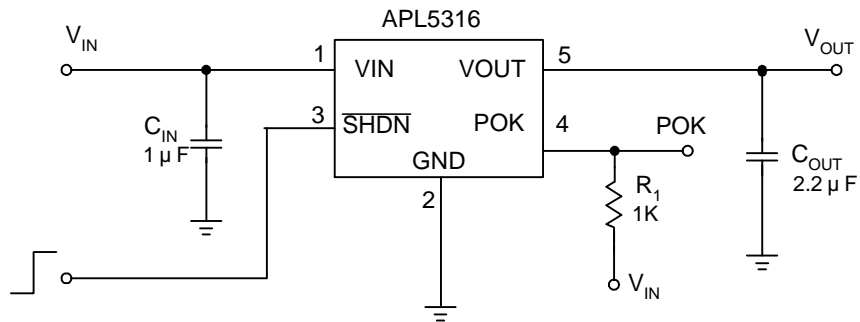
| PIN |      | FUNCTION  |
|-----|------|---|
| No  | NAME |   |
| 1   | VIN  | Voltage supply input pin                                      |
| 2   | GND  | Ground pin  |
| 3   | SHDN | Shutdown control pin, logic high: enable; logic low: shutdown |
| 4   | POK  | Power-ok signal output pin                                    |
| 5   | VOUT | Regulator output pin  |

Block Diagram



Typical Application Circuit

1

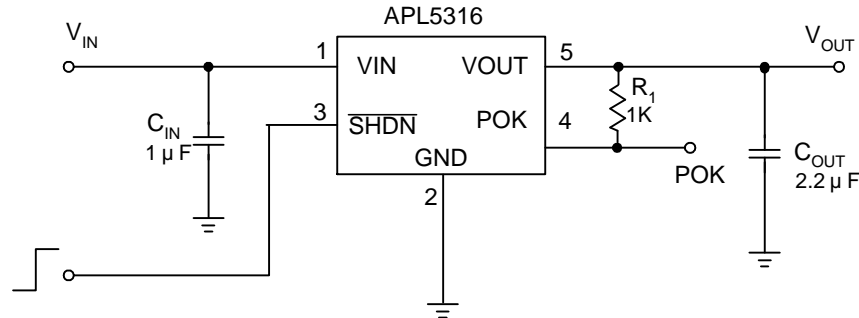


2.2μF/GRM155R60J225M Murata



## Typical Application Circuit (Cont.)

2.



## Function Description

### Internal Soft-Start

An internal soft-start function controls rising rate of the output voltage to limit the surge current at start-up. The typical soft-start interval is about 60μs.

### Power-ok (POK)

The APL5316 indicates the status of the output voltage. As the  $V_{OUT}$  rises and reaches the Power-ok threshold ( $V_{POK}$ ), the IC turns off the internal NMOS of the POK to indicate the output is ok. As the  $V_{OUT}$  falls and reaches the falling Power-ok threshold ( $V_{PNOK}$ ), the IC immediately turns on the NMOS of the POK to indicate the output is not ok. The resistance of the resistor R1 connected from  $V_{OUT}$  to POK or  $V_{IN}$  to POK should be in the range from 1K to 50K.

### Thermal Shutdown

A thermal shutdown circuit limits the junction temperature of the APL5316. When the junction temperature exceeds +160°C, a thermal sensor turns off the output PMOS, allowing the device to cool down. The regulator regulates the output again through initiation of a new soft-start cycle after the junction temperature cools by 40°C. The thermal shutdown is designed with a 40°C hysteresis to lower the average junction temperature during continuous thermal overload conditions, extending life time of the device.

For normal operation, the device power dissipation should be externally limited by the design to keep the junction temperature below 125°C.

### Shutdown Control

The APL5316 has an active-low shutdown function. Forcing  $\overline{SHDN}$  high (>1.6V) enables the  $V_{OUT}$ ; forcing  $\overline{SHDN}$  low (<0.4V) disables the  $V_{OUT}$ .  $\overline{SHDN}$  is internally pulled low by a resistor (3MΩ typical). If shutdown control is not necessary, please connect  $\overline{SHDN}$  pin to VIN for normal operation.

## Application Information

### Input Capacitor

The APL5316 requires proper input capacitors to supply surge current during stepping load transients to prevent the input rail from dropping. Because the parasitic inductor from the voltage sources or other bulk capacitors to the VIN limits the slew rate of the surge current, it is recommended to place the Input capacitors near VIN as close as possible. Input capacitors should be larger than 1μF and a minimum ceramic capacitor of 1μF is necessary.

### Output Capacitor

The APL5316 needs a proper output capacitor to maintain circuit stability and improve transient response over temperature and current. In order to insure the circuit stability, the proper output capacitor value should be larger than 2.2μF. With X5R and X7R dielectrics, 2.2μF is sufficient at all operating temperatures. Large output capacitor value can reduce noise and improve load-transient response and PSRR, however, it also affects power on issue. Equation (1) shows the relationship between the maximum C<sub>OUT</sub> value and V<sub>OUT</sub>.

$$C_{OUT(max)} = 31 - \frac{6}{V_{OUT}} \dots\dots\dots(1)$$

Where the unit of C<sub>OUT</sub> is μF and V<sub>OUT</sub> is V. Figure 1 shows the curve of maximum output capacitor over the output voltage. The output voltage range is from 0.8 to 5.5V and the output capacitor value should be under the line. Output capacitors must be placed at the load and ground pin as close as possible and the impedance of the layout must be minimized.

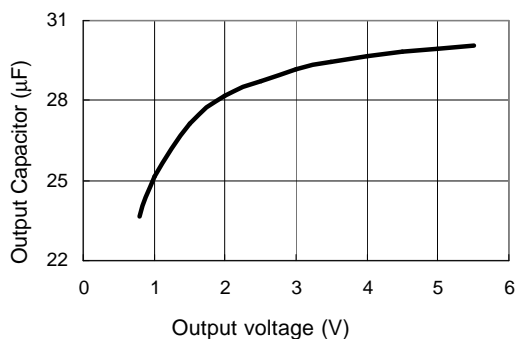


Figure 1

### Operation Region and Power dissipation

The APL5316 maximum power dissipation depends on the thermal resistance and temperature difference between the die junction and ambient air. The power dissipation P<sub>D</sub> across the device is:

$$P_D = (T_J - T_A) / \theta_{JA}$$

where (T<sub>J</sub>-T<sub>A</sub>) is the temperature difference between the junction and ambient air. θ<sub>JA</sub> is the thermal resistance between Junction and ambient air. Assuming the T<sub>A</sub>=25°C and maximum T<sub>J</sub>=160°C (typical thermal limit threshold), the maximum power dissipation is calculated as:

$$P_{D(max)} = (160-25)/240 = 0.56(W)$$

For normal operation, do not exceed the maximum junction temperature rating of T<sub>J</sub> = 125 °C. The calculated power dissipation should be less than:

$$P_D = (125-25)/240 = 0.41(W)$$

The GND provides an electrical connection to ground and channels heat away. Connect the GND to ground by using a large pad or ground plane.

### Layout Consideration

Figure 2 illustrates the layout. Below is a checklist for your layout:

1. Please place the input capacitors close to the VIN.
2. Ceramic capacitors for load must be placed near the load as close as possible.
3. To place APL5316 and output capacitors near the load is good for performance.
4. Large current paths, the bold lines in figure 2, must have wide tracks.

## Application Information (Cont.)

### PCB Layout Consideration ( Cont.)

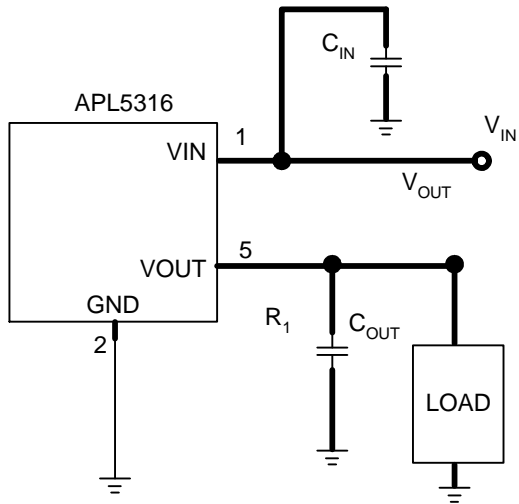
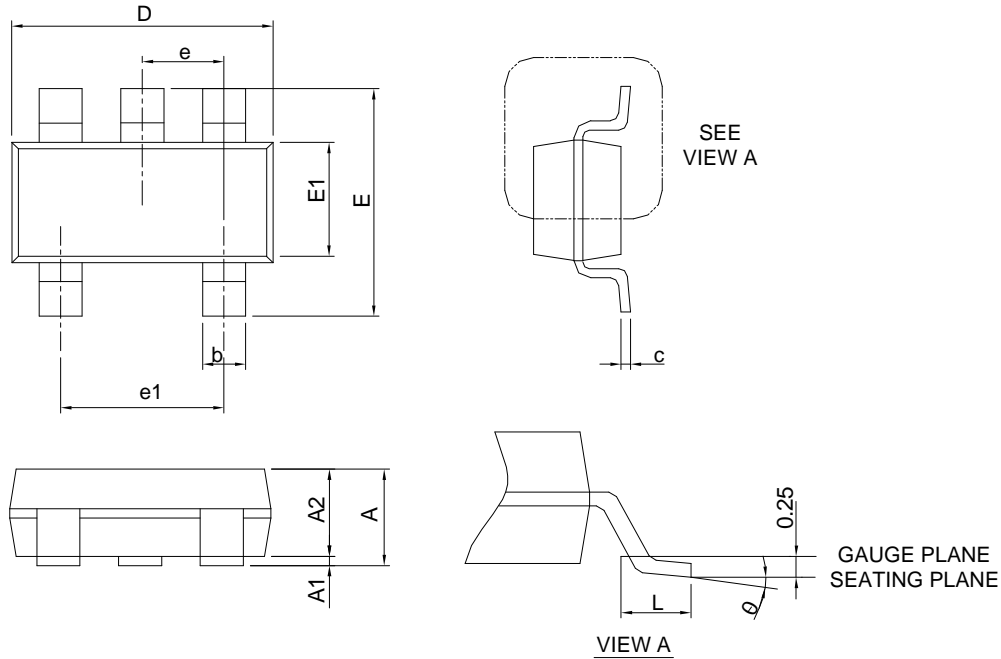


Figure 2

Package Information

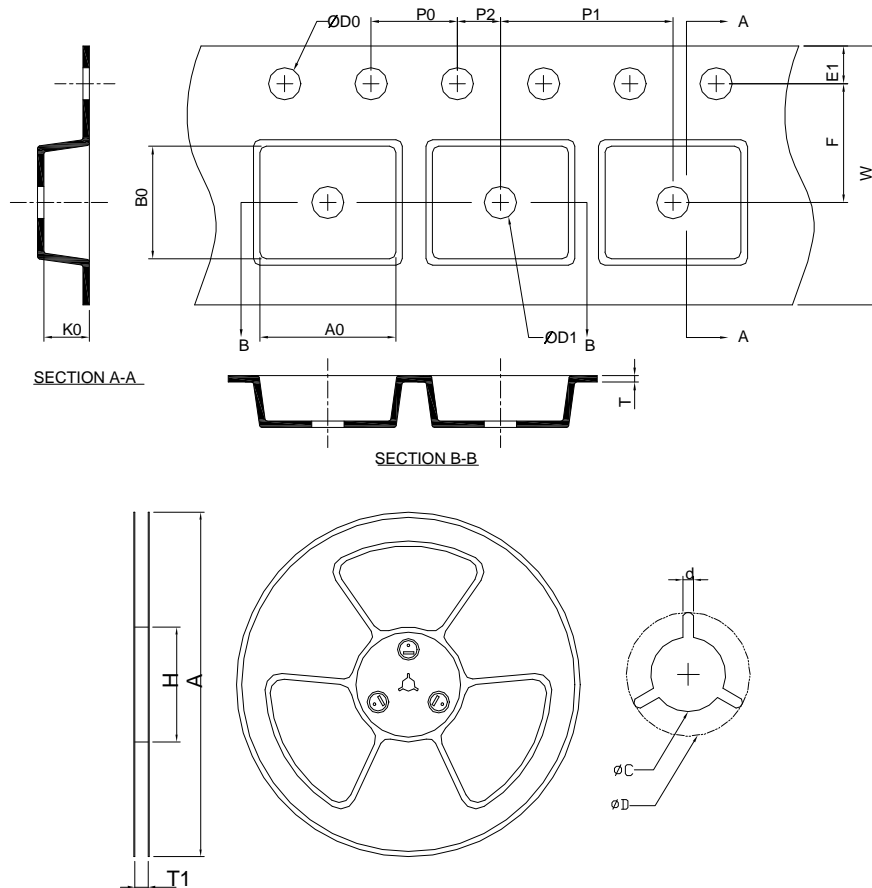
SOT-23-5



| 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 | 0.106     | 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 |
| $\theta$ | 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.

### 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<br>-0.00 | 13.0+0.50<br>-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 ±0.05         | 1.5+0.10<br>-0.00  | 1.0 MIN. | 0.6+0.00<br>-0.40 | 3.20 ±0.20 | 3.10 ±0.20 | 1.50 ±0.20 |

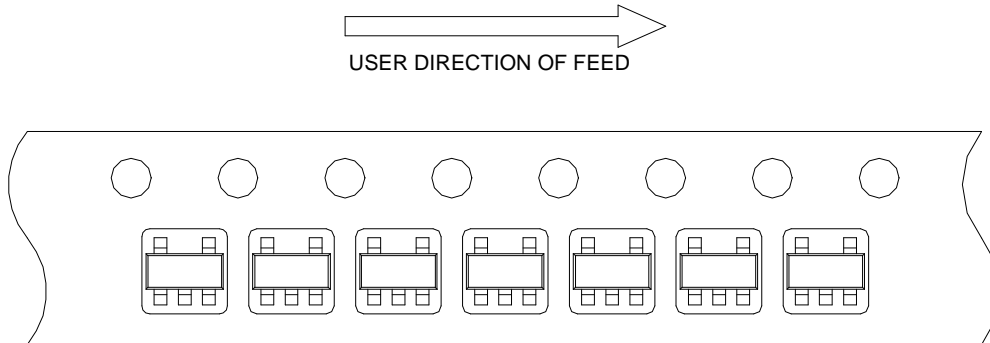
(mm)

### Devices Per Reel

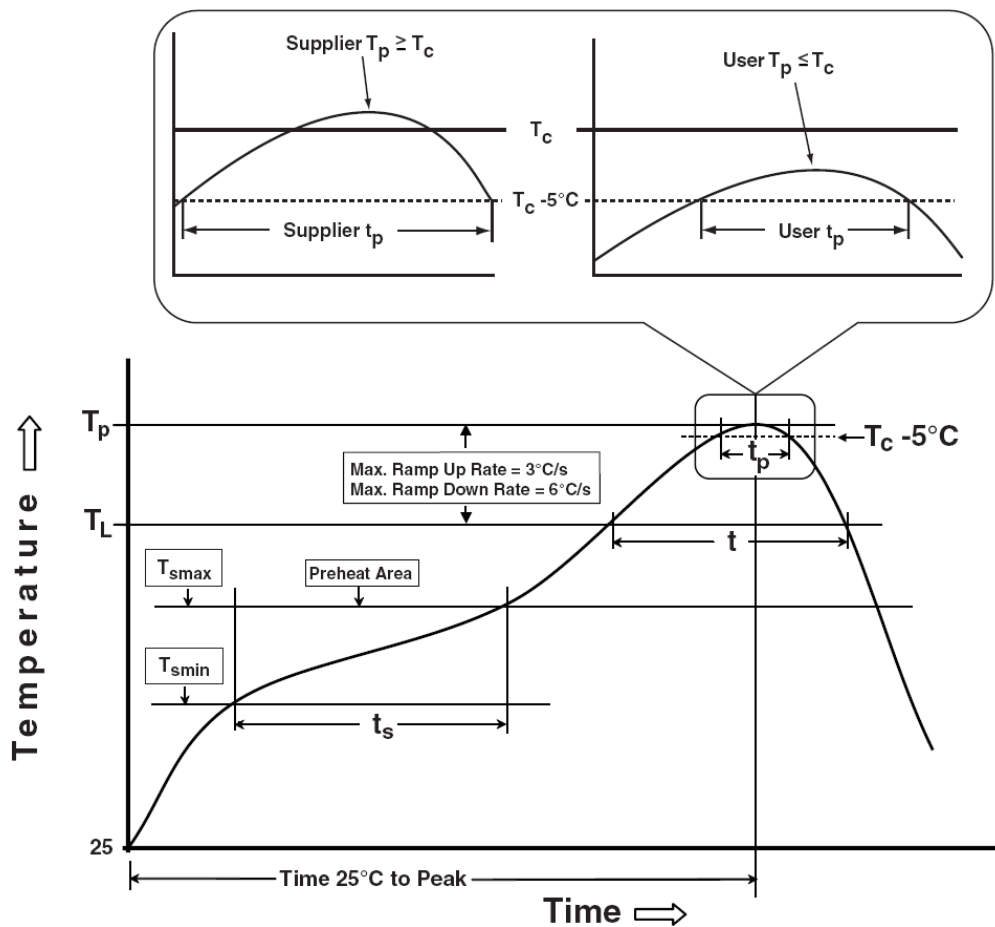
| Package Type | Unit        | Quantity |
|--------------|-------------|----------|
| SOT-23-5     | Tape & Reel | 3000     |

## Taping Direction Information

SOT-23-5



## Classification Profile



## Classification Reflow Profiles

| Profile Feature  | Sn-Pb Eutectic Assembly            | Pb-Free Assembly                   |
|--|------------------------------------|------------------------------------|
| <b>Preheat &amp; Soak</b>  |                                    |                                    |
| Temperature min ( $T_{smin}$ )   | 100 °C                             | 150 °C                             |
| Temperature max ( $T_{smax}$ )   | 150 °C                             | 200 °C                             |
| Time ( $T_{smin}$ to $T_{smax}$ ) ( $t_s$ )  | 60-120 seconds                     | 60-120 seconds                     |
| Average ramp-up rate ( $T_{smax}$ to $T_p$ )   | 3 °C/second max.                   | 3°C/second max.                    |
| Liquidous temperature ( $T_L$ )  | 183 °C                             | 217 °C                             |
| Time at liquidous ( $t_L$ )  | 60-150 seconds                     | 60-150 seconds                     |
| Peak package body Temperature ( $T_p$ )*   | See Classification Temp in table 1 | See Classification Temp in table 2 |
| Time ( $t_p$ )** within 5°C of the specified classification temperature ( $T_c$ )                                | 20** seconds                       | 30** seconds                       |
| Average ramp-down rate ( $T_p$ to $T_{smax}$ )   | 6 °C/second max.                   | 6 °C/second max.                   |
| Time 25°C to peak temperature  | 6 minutes max.                     | 8 minutes max.                     |
| * Tolerance for peak profile Temperature ( $T_p$ ) is defined as a supplier minimum and a user maximum.          |                                    |                                    |
| ** Tolerance for time at peak profile temperature ( $t_p$ ) is defined as a supplier minimum and a user maximum. |                                    |                                    |

Table 1. SnPb Eutectic Process – Classification Temperatures ( $T_c$ )

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>≥350 |
|-------------------|--------------------------------|--------------------------------|
| <2.5 mm           | 235 °C                         | 220 °C                         |
| ≥2.5 mm           | 220 °C                         | 220 °C                         |

Table 2. Pb-free Process – Classification Temperatures ( $T_c$ )

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>350-2000 | Volume mm <sup>3</sup><br>>2000 |
|-------------------|--------------------------------|------------------------------------|---------------------------------|
| <1.6 mm           | 260 °C                         | 260 °C                             | 260 °C                          |
| 1.6 mm – 2.5 mm   | 260 °C                         | 250 °C                             | 245 °C                          |
| ≥2.5 mm           | 250 °C                         | 245 °C                             | 245 °C                          |

## Reliability Test Program

| Test item     | Method             | Description                              |
|---------------|--------------------|--|
| SOLDERABILITY | JESD-22, B102      | 5 Sec, 245°C                             |
| HOLT          | JESD-22, A108      | 1000 Hrs, Bias @ $T_j=125^\circ\text{C}$ |
| PCT           | JESD-22, A102      | 168 Hrs, 100%RH, 2atm, 121°C             |
| TCT           | JESD-22, A104      | 500 Cycles, -65°C~150°C                  |
| HBM           | MIL-STD-883-3015.7 | VHBM 2KV                                 |
| MM            | JESD-22, A115      | VMM 200V                                 |
| Latch-Up      | JESD 78            | 10ms, 1 <sub>tr</sub> 100mA              |

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