## Description

The AP5724 is a step-up DC/DC converter specifically designed to drive white LEDs with a constant current. The device can drive 2 ~ 6 LEDs in series from a Li-Ion cell. Series connection of the LEDs provides identical LED currents resulting in uniform brightness and eliminates the need for ballast resistors. For driving higher number of LEDs, AP5724 also supports a single feedback of parallel connected multiple strings of equal number of LEDs.

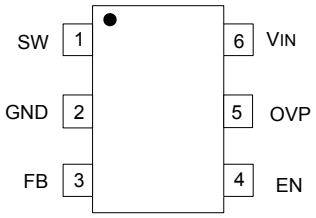
The AP5724 switches at 1.2MHz that allows the use of tiny external components. A low 0.1V feedback voltage minimizes power loss in the current setting resistor for better efficiency

## Features

- High Efficiency: 84% Typical
- Fast 1.2MHz Switching Frequency
- Current Limit and UVLO Protections
- Internal Thermal Shutdown
- Internal Over Voltage Protection
- Integrated Soft-Start Function
- SOT26, TSOT26 and U-DFN2020-6: Available in "Green" Molding Compound (No Br, Sb)
- **Lead-Free Finish; RoHS Compliant (Notes 1 & 2)**

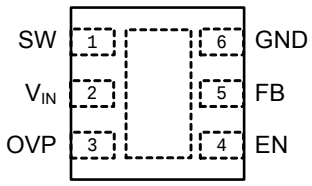
## Pin Assignments

**(Top View)**




**SOT26 / TSOT23-6**

**(Top View)**




**U-DFN2020-6**

## Applications

- Cellular Phones
- PDAs, Hand held Computers
- Digital Cameras
- MP3 Players
- GPS Receivers

Notes: 1. EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant. All applicable RoHS exemptions applied.
2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.

## Typical Applications Circuit

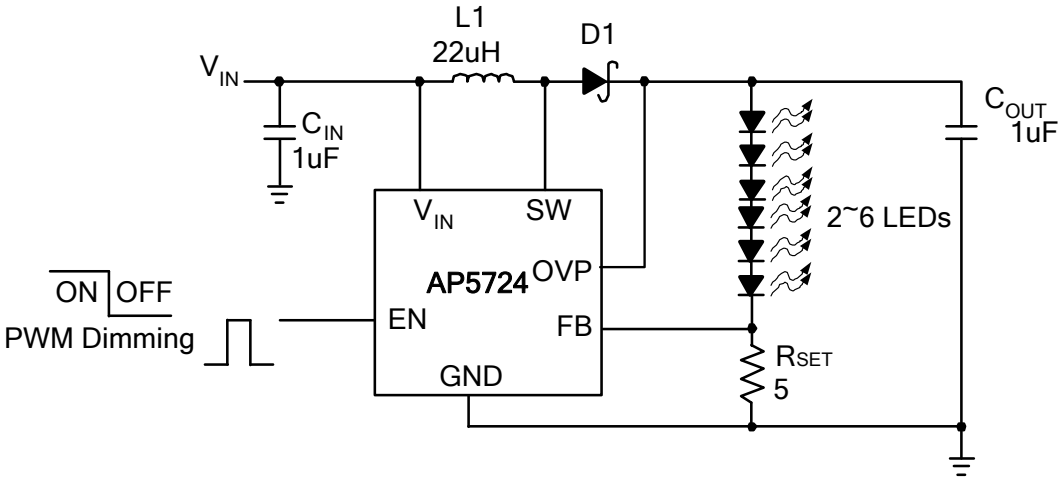


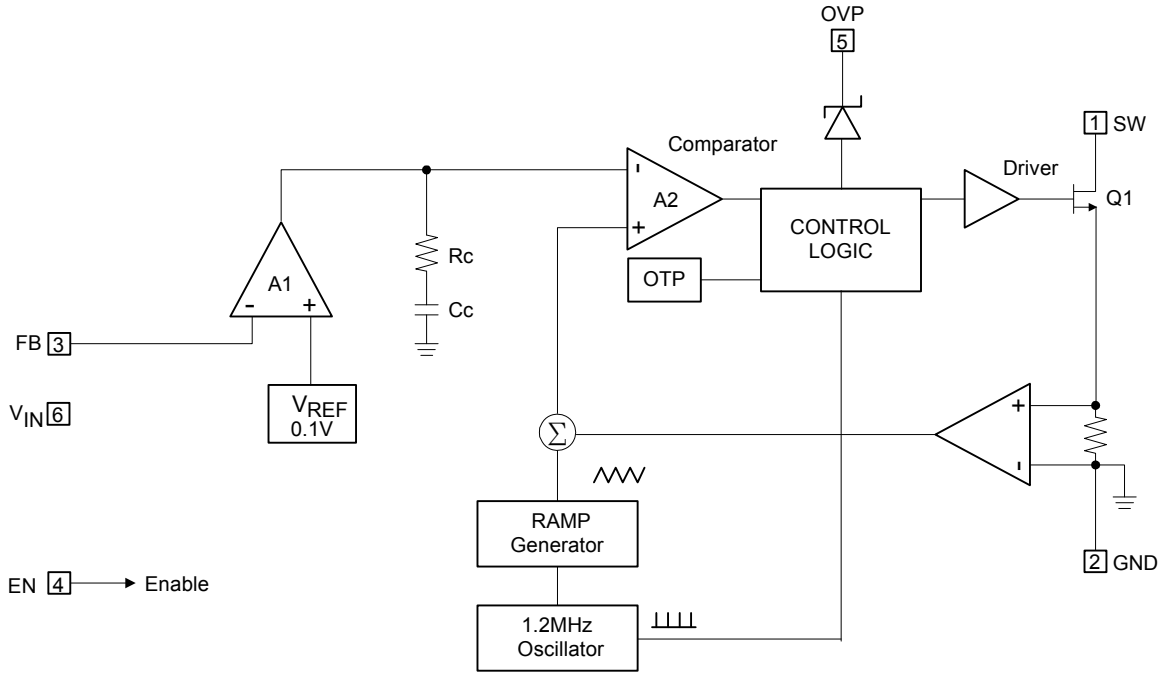

**Figure 1 Typical Application Circuit**


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## Pin Descriptions

| Pin Name | Functions |
|---|---|
| SW | Switch Pin. Connect inductor/diode here. Minimize trace area at this pin to reduce EMI. |
| GND | GND pin. |
| FB | Feedback Pin. Reference voltage is 0.1V. Connect cathode of lowest LED and a sense resister here. Calculate resistor value according to the formula: $R_{SET}$ = 0.1V / ILED |
| EN | Converter On/Off Control Input. A high input at EN turns the converter On, and a low input turns it off. If On/Off control is not needed, connect EN to the input source for automatic startup. The EN pin cannot be left floating. |
| OVP | Output Voltage detect pin for over voltage protection. |
| $V_{IN}$ | Input Supply Pin. Must be locally bypassed with 1μF or 2.2μF to reduce input noise. |

## Functional Block Diagram




## Absolute Maximum Ratings (@$T_A$ = +25°C, unless otherwise specified.)

| Symbol | Parameter | Rating | Unit |
|---|---|---|---|
| $V_{IN}$ | VIN Pin Voltage | -0.3 to +7 | V |
| VSW | SW Voltage | -0.3 to +34 | V |
| $V_{OVP}$ | OVP Pin Voltage | -0.3 to +35 | V |
| $V_{FB}$ | Feedback Pin Voltage | -0.3 to +7 | V |
| EN | EN | -0.3 to +7 | V |
| $T_{J(MAX)}$ | Maximum Junction Temperature | 150 | °C |
| $T_{LEAD}$ | Lead Temperature | 300 | °C |
| $T_{ST}$ | Storage Temperature Range | -65 to +150 | °C |

Caution: Operation above the absolute maximum ratings can cause device failure. These values, therefore, must not be exceeded under any condition. Operation at the absolute maximum rating for extended periods, may reduce device reliability.


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## Recommended Operating Conditions (@$T_A$ = +25°C, unless otherwise specified.)

| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Input Voltage | 2.7 | 5.5 | V |
| $T_J$ | Operating Junction Temperature | -40 | 125 | °C |
| $T_A$ | Operating Ambient Temperature | -40 | 85 | °C |

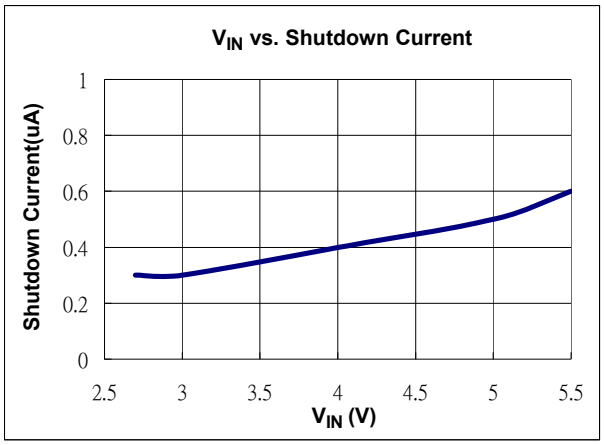
## Electrical Characteristics (@ $V_{IN}$ = 3.6V, $T_A$ = +25°C, unless otherwise specified.)

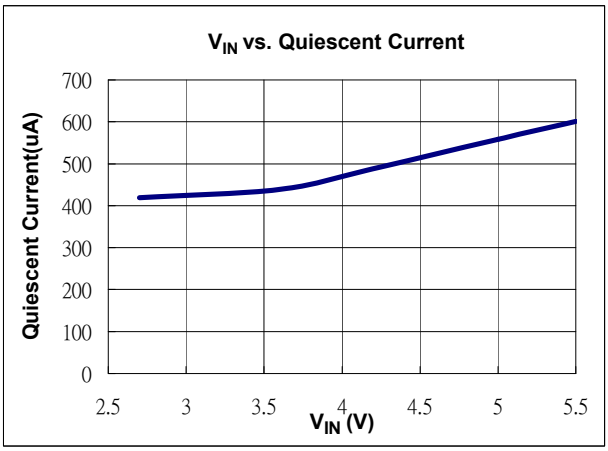
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **System Supply Input** | | | | | | |
| $V_{IN}$ | Operating Input Voltage | | 2.7 | — | 5.5 | V |
| UVLO | Under Voltage Lockout | | — | 2.2 | 2.4 | V |
| | Under Voltage Lockout Hysteretic | | — | 85 | — | mV |
| $I_Q$ | Quiescent Current | FB = 0.2V, No Switching | — | 500 | — | μA |
| $I_{SD}$ | Shutdown Current | $V_{EN}$ < 0.4V | — | 0.1 | 1 | μA |
| **Oscillator** | | | | | | |
| $F_{OSC}$ | Operation Frequency | | 1 | 1.2 | 1.4 | MHz |
| Dmax | Maximum Duty Cycle | | 86 | 90 | — | % |
| **Reference Voltage** | | | | | | |
| $V_{FB}$ | Feedback Voltage | | 0.09 | 0.1 | 0.11 | V |
| $I_{FB}$ | FB Pin Bias Current | | 10 | 45 | 100 | nA |
| **MOSFET** | | | | | | |
| Rds(on) | On Resistance of MOSFET | | — | 0.95 | 1.2 | Ω |
| $I_{OCP}$ | Switching Current Limit | Normal Operation | — | 750 | — | mA |
| **Control and Protection** | | | | | | |
| EN | Voltage High | ON | 1.5 | — | — | V |
| EN | Voltage Low | OFF | — | — | 0.4 | V |
| $I_{EN}$ | EN Pin Pull Low Current | | — | 4 | 6 | μA |
| OVP | OVP Threshold | | 26 | 30 | 34 | V |
| $\theta_{JA}$ | Thermal Resistance Junction-to-Ambient | SOT26 (Note 3) | — | 162 | — | °C/W |
| | | TSOT26 (Note 3) | — | 152 | — | |
| | | U-DFN2020-6 (Note 3) | — | 200 | — | |
| $\theta_{JC}$ | Thermal Resistance Junction-to-Case | SOT26 (Note 3) | — | 36 | — | °C/W |
| | | TSOT26 (Note 3) | — | 32 | — | |
| | | U-DFN2020-6 (Note 3) | — | 30 | — | |

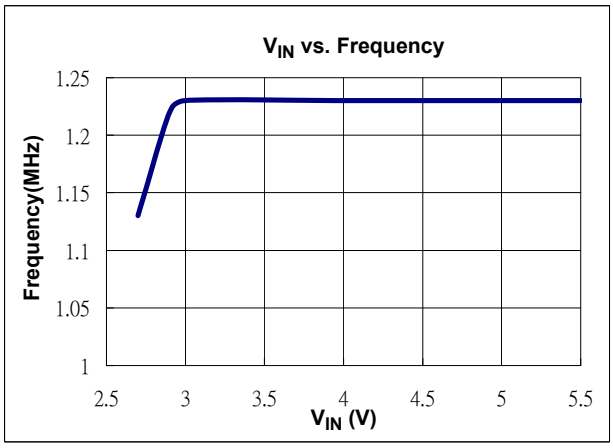
Note: 3. Test condition for SOT26, TSOT26 and U-DFN2020-6: Device mounted on FR-4 substrate, single-layer PC board, 2oz copper, with minimum recommended pad layout

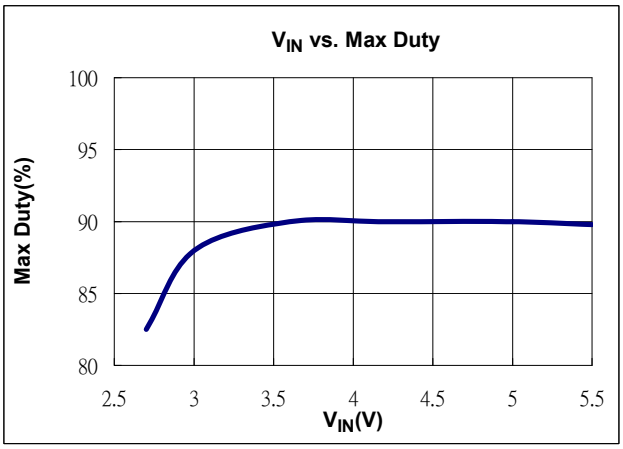

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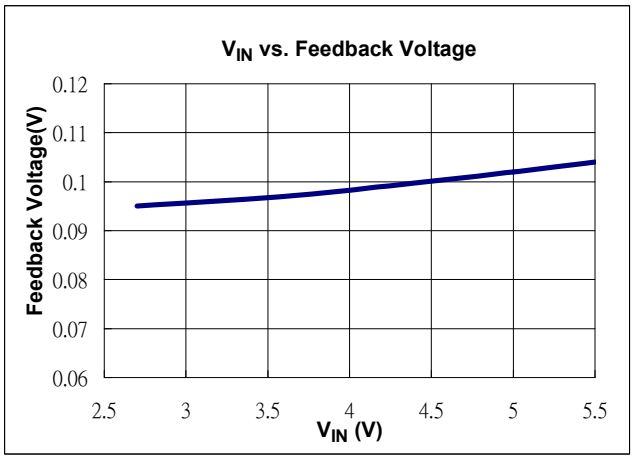
## Typical Performance Characteristics (6 LEDS, $V_{IN}$ = 3.6V, $I_{OUT}$ = 25mA)

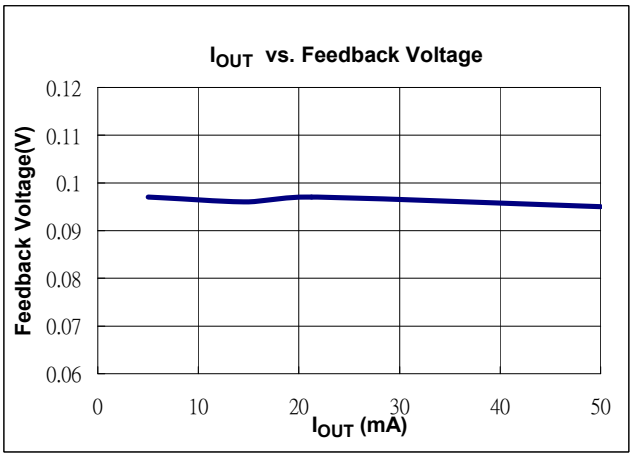


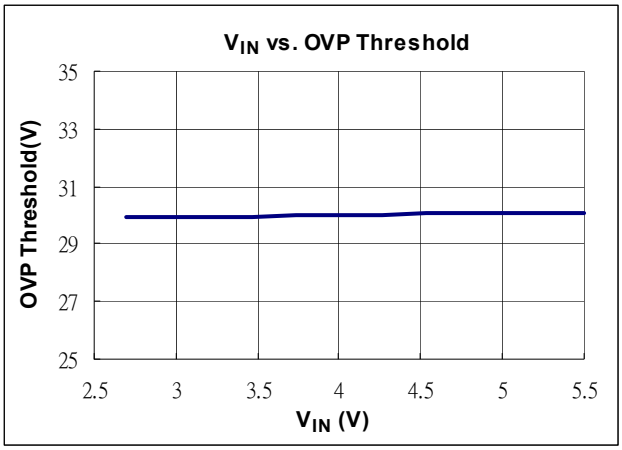



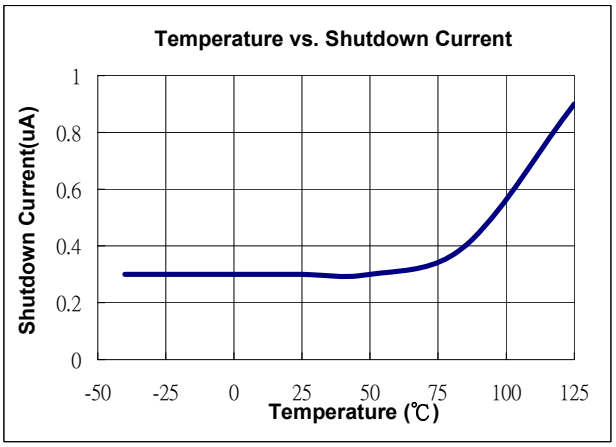



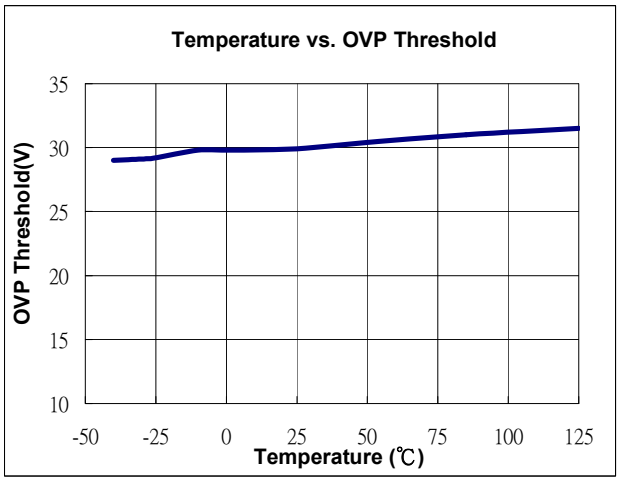


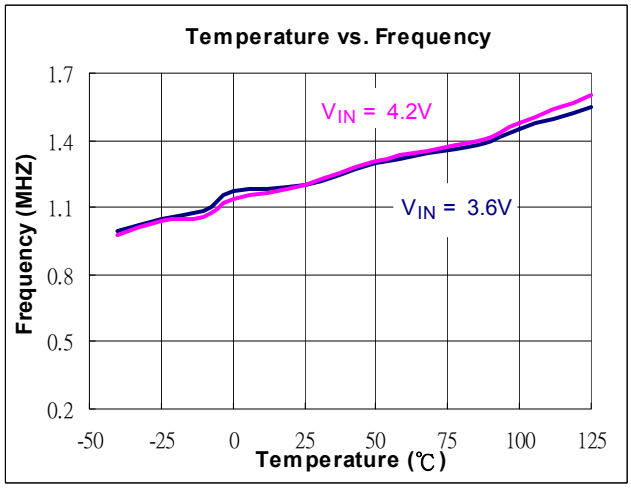
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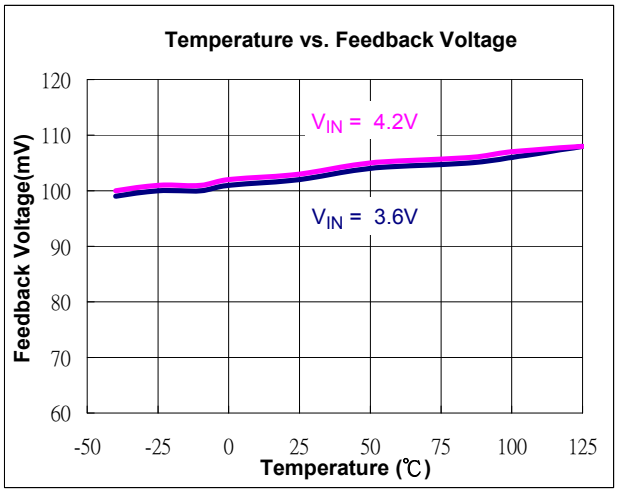
## Typical Performance Characteristics (cont.) (6 LEDS, $V_{IN}$ = 3.6V, $I_{OUT}$ = 25mA)



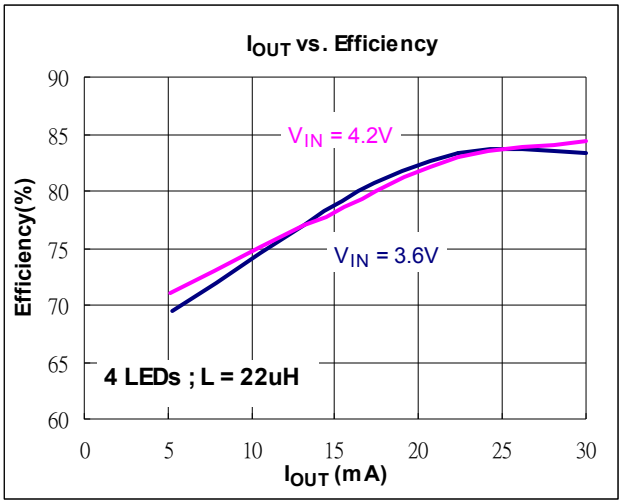



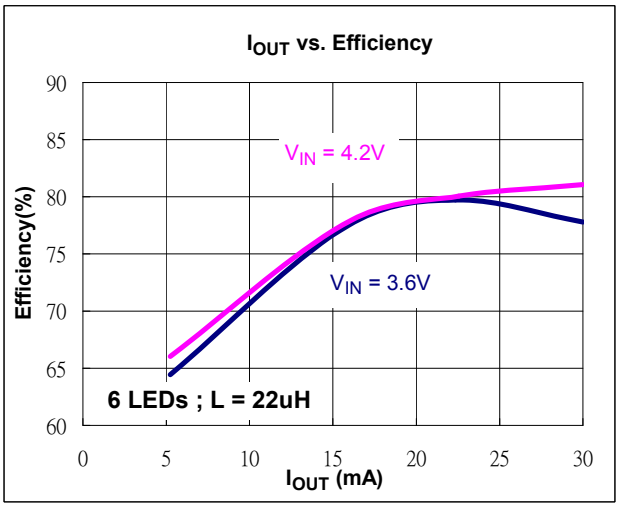



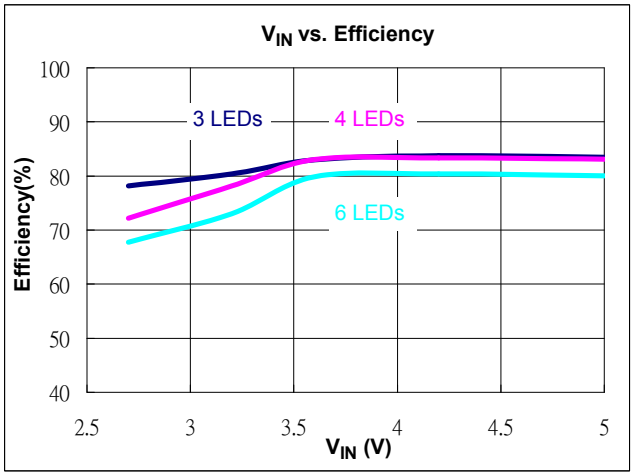


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## Typical Performance Characteristics (cont.) (6 LEDS, $V_{IN}$ = 3.6V, $I_{OUT}$ = 25mA)



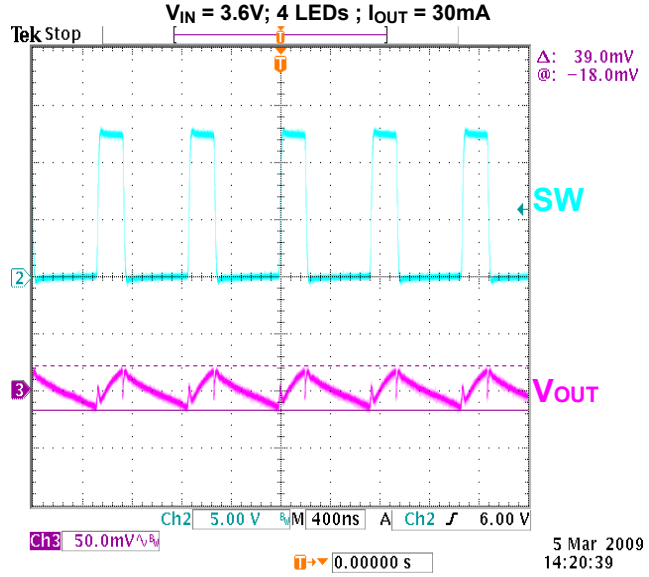





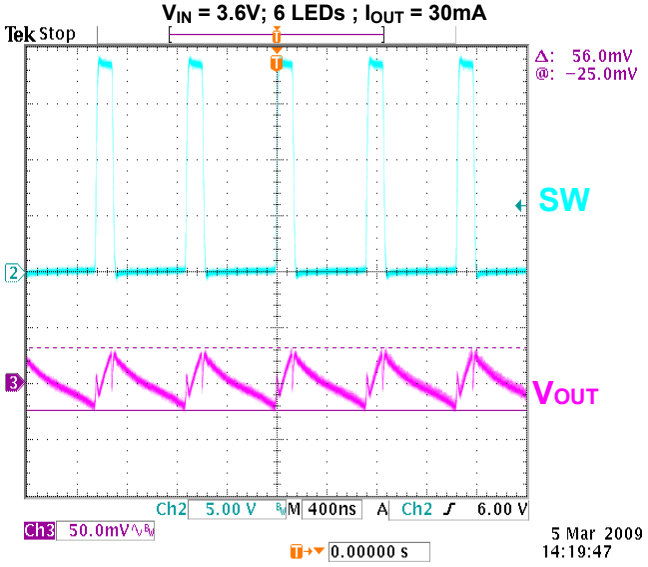
© Diodes Incorporated

## Typical Performance Characteristics (cont.) (6 LEDS, $V_{IN}$ = 3.6V, $I_{OUT}$ = 25mA)

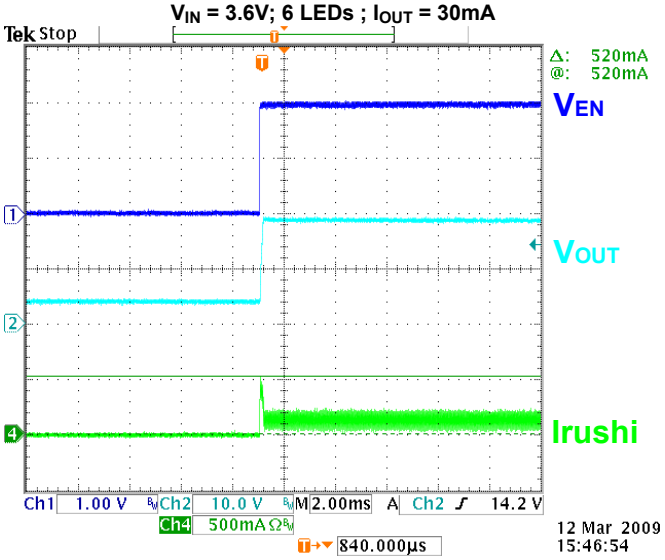
$V_{OUT}$ Ripple
$V_{IN}$ = 3.6V; 4 LEDs ; $I_{OUT}$ = 30mA



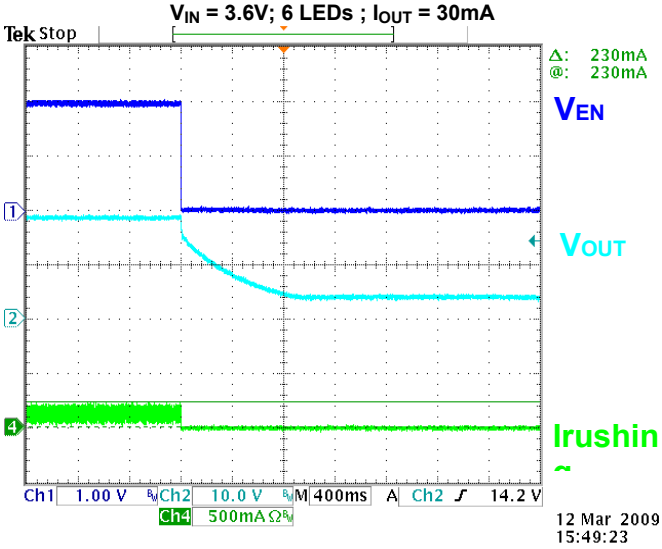

$V_{OUT}$ Ripple
$V_{IN}$ = 3.6V; 6 LEDs ; $I_{OUT}$ = 30mA




POWER ON
$V_{IN}$ = 3.6V; 6 LEDs ; $I_{OUT}$ = 30mA




POWER OFF
$V_{IN}$ = 3.6V; 6 LEDs ; $I_{OUT}$ = 30mA





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## Applications Information

### Inductor Selection

A 10μH to 22μH inductor is recommended for most AP5724 applications. For high efficiency the inductor should have low core losses at 1.2MHz and low DCR (copper wire resistance). The inductor saturation current rating should also exceed the peak input current, especially for high load current applications (like 3S8P).

### Capacitor Selection

The small size of the ceramic capacitors are ideal for AP5724 applications. X5R and X7R types are recommended because they retain their capacitance over wider voltage and temperature ranges than other types such as Y5V or Z5U. A 1μF input capacitor and a 1μF output capacitor are sufficient for most AP5724 applications. For high output current applications like 3S8P, larger output capacitor of 2.2μF to 4.7μF is recommended to minimize output ripple.

### Diode Selection

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for AP5724 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode, while the diode capacitance ($C_T$ or $C_D$) represents the switching losses. For diode selection, both forward voltage drop and diode capacitance need to be considered. Schottky diodes with higher current ratings usually have lower forward voltage drop and larger diode capacitance, which can cause significant switching losses at the 1.2MHz switching frequency of the AP5724. Schottky diodes with higher current ratings usually have lower forward voltage drop and larger diode capacitance. Larger Schottky diode capacitance can cause significant switching losses at the 1.2MHz switching frequency of the AP5724. A Schottky diode rated at 100mA to 200mA is sufficient for most AP5724 applications.

### LED Current Control

The LED current is controlled by the feedback resistor ($R_{SET}$ in **Figure 1**). The feedback reference is 0.1V. The LED current is 0.1V/ $R_{SET}$. In order to have accurate LED current, precision resistors are preferred (1% is recommended). The formula and table for $R_{SET}$ selection are shown below.
$R_{SET}$ = 0.1V/$I_{LED}$ (See **Table 1**)

**Table 1. $R_{SET}$ Resistor Value Selection**

| $I_{LED}$ (mA) | $R_{SET}$ (Ω) |
|---|---|
| 5 | 20 |
| 10 | 10 |
| 15 | 6.6 |
| 20 | 5 |
| 30 | 3.3 |
| 40 | 2.5 |

### Open-Circuit Protection

In the cases of output open circuit, when the LEDs are disconnected from the circuit or the LEDs fail, the feedback voltage will be zero. The AP5724 will then switch at a high duty cycle resulting in a high output voltage, which may cause the SW and OVP pin voltage to exceed the voltage rating of these pins. The OVP pin monitors the output voltage. If the output voltage reaches the over voltage protection threshold at the OVP pin (**Figure 2**), the over voltage protection is activated and SW pin stops switching.

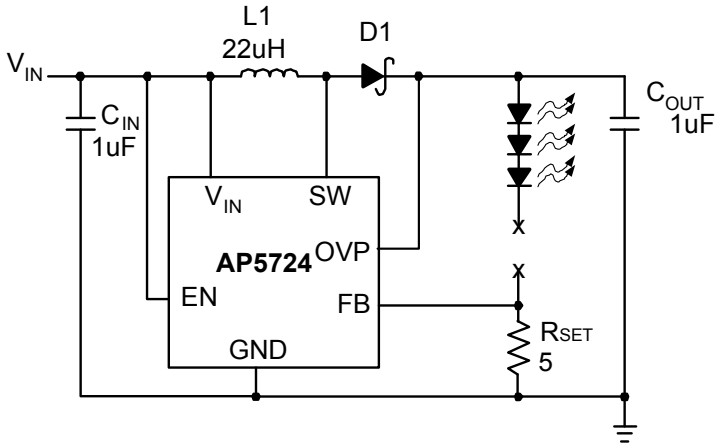



**Figure 2 LED Driver with Open-Circuit Protection**


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## Applications Information (cont.)

### Dimming Control

There are four different types of dimming control circuits:

#### 1. Using a PWM Signal to EN Pin

With the PWM signal applied to the EN pin, the AP5724 is turned on or off by the PWM signal. The LEDs operate at either zero or full current. The average LED current increases proportionally with the duty cycle of the PWM signal. A 0% duty cycle will turn off the AP5724 and corresponds to zero LED current. A 100% duty cycle corresponds to full current. The typical frequency range of the PWM signal is below 2 kHz.

#### 2. Using a DC Voltage

For some applications, the preferred method of brightness control is a variable DC voltage to adjust the LED current. The dimming control using a DC voltage is shown in **Figure 3**. As the DC voltage increases, the voltage drop on R2 increases and the voltage drop on $R_{SET}$ decreases. Thus, the LED current decreases. The selection of R2 and R3 will make the current from the variable DC source much smaller than the LED current and much larger than the FB pin bias current. For $V_{DC}$ range from 0V to 2V, the selection of resistors in **Figure 3** gives dimming control of LED current from 0mA to 20mA.

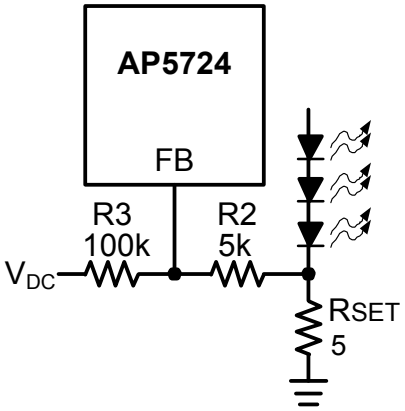



**Figure 3 Dimming Control Using a DC Voltage**

#### 3. Using a Filtered PWM Signal

The filtered PWM signal can be considered as an adjustable DC voltage. It can be used to replace the variable DC voltage source in dimming control.

#### 4. Using a Logic Signal

For applications that need to adjust the LED current in discrete steps, a logic signal can be used as shown in **Figure 4**. $R_{SET}$ sets the minimum LED current (when the NMOS is off). $R_{SET}$ sets how much the LED current increases when the NMOS is turned on.

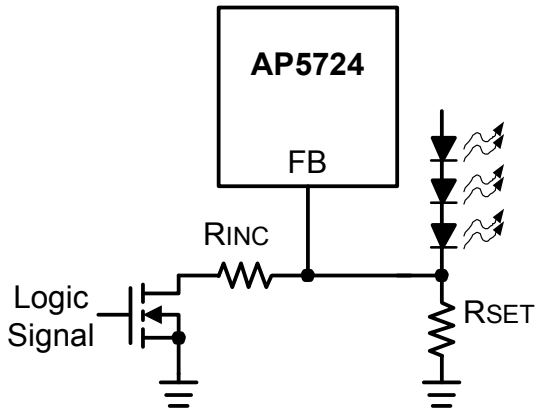



**Figure 4 Dimming Control Using a Logic Signal**


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## Applications Information (cont.)

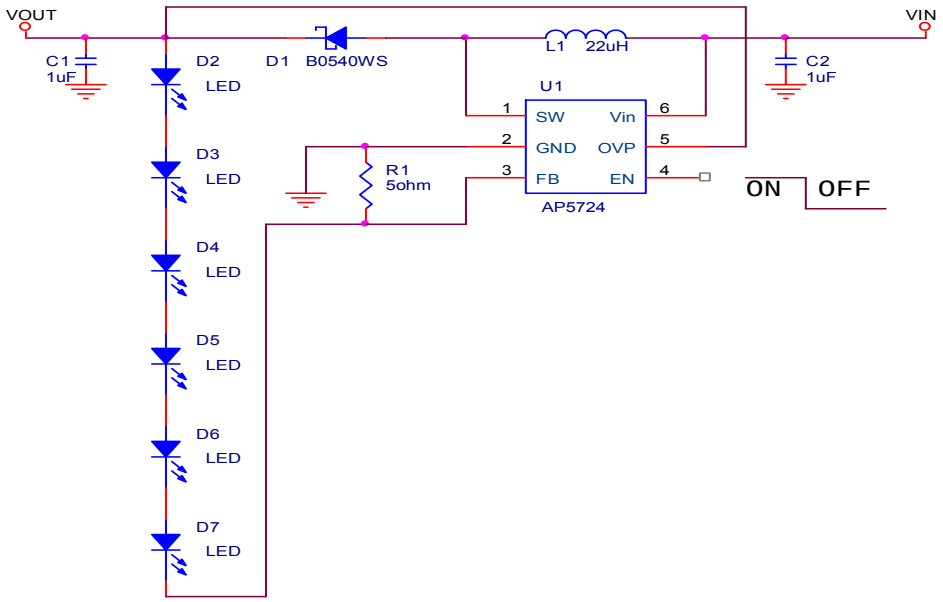



**Table 2. Suggested Inductors**

| Vendor | Inductors (μH) | Current Rating (A) | Type | Dimensions (mm) | Series |
|---|---|---|---|---|---|
| Wurth Electronics | 22 | 0.51A | SMD | 3.8X 3.8 X 1.6 | 744031220 |
| GOTREND | 22 | 0.56A | SMD | 3.8 X 3.8 X 1.05 | GLP3810PH220N |
| TAIYO YUDRN | 22 | 0.51A | SMD | 4.0 X 4.0 X 1.25 | NR4012 |

**Table 3. Suggested Capacitors for $C_{IN}$ and $C_{OUT}$**

| Vendor | Capacitance | Type | Series |
|---|---|---|---|
| TAIYO YUDEN | 1μF | SMD | TMK212 B7105MG-T |

**Table 4. Suggested Diodes**

| Vendor | Rating | Type | Series |
|---|---|---|---|
| ZETEX | 40V/0.5A | SOD323 | ZLLS400 |
| DIODES | 40V/0.5A | SOD323 | B0540WS |
| DIODES | 40V/0.25A | SOD523 | SDM20U40 |

**Table 5. Suggested Resistor**

| Vendor | Type | Series |
|---|---|---|
| YAGEO | SMD | FR-SK |

**Table 6. Suggested W-LED**

| Vendor | Type | Series |
|---|---|---|
| LITEON | SMD | LTW-C1911UC5 |


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## Ordering Information

**AP 5724 XXX G - 7**

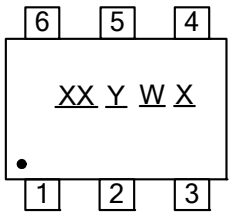
| Package | Green | Packing |
|---|---|---|
| W : SOT26<br>WU : TSOT26<br>FDC : U-DFN2020-6 | G : Green | 7 : Tape & Reel |

| Part Number | Package Code | Packaging | 7" Tape and Reel | |
|---|---|---|---|---|
| | | | Quantity | Part Number Suffix |
| AP5724WG-7 | W | SOT26 | 3000/Tape & Reel | -7 |
| AP5724WUG-7 | WU | TSOT26 | 3000/Tape & Reel | -7 |
| AP5724FDCG-7 | FDC | U-DFN2020-6 | 3000/Tape & Reel | -7 |

## Marking Information

**(1) SOT26 and TSOT26**

( Top View )

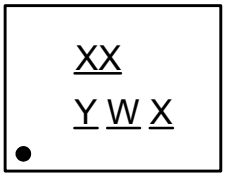



XX : Identification Code
Y : Year 0~9
W : Week : A~Z : 1~26 week; a~z : 27~52 week; z represents 52 and 53 week
X : A~Z : Green

| Part Number | Package | Identification Code |
|---|---|---|
| AP5724WG-7 | SOT26 | FB |
| AP5724WUG-7 | TSOT26 | GB |

**(2) U-DFN2020-6**

( Top View )




XX : Identification Code
Y : Year : 0~9
W : Week : A~Z : 1~26 week; a~z : 27~52 week; z represents 52 and 53 week
X : A~Z : Green

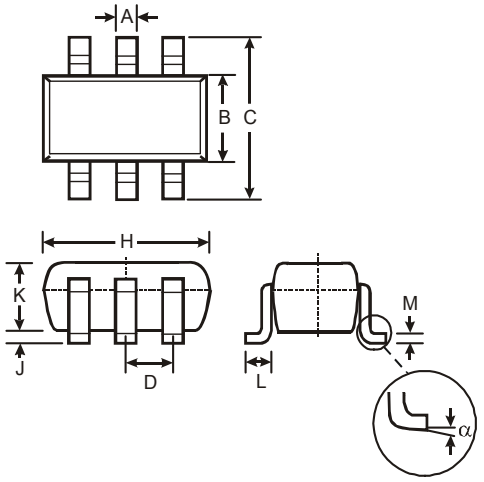
| Part Number | Package | Identification Code |
|---|---|---|
| AP5724FDCG-7 | U-DFN2020-6 | GB |


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## Package Outline Dimensions (All dimensions in mm.)

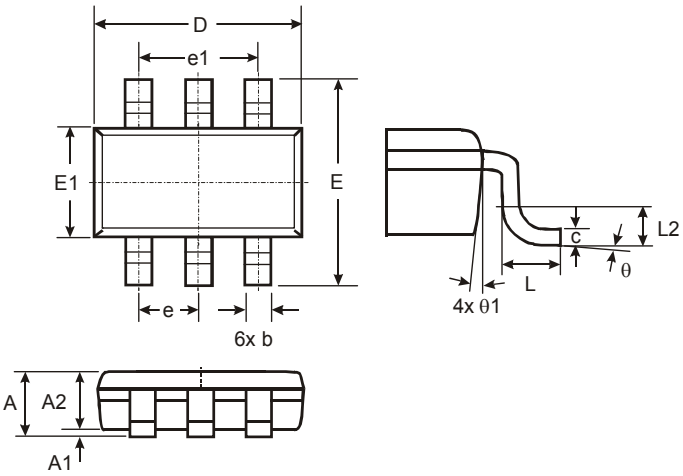
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for latest version.

### (1) SOT26



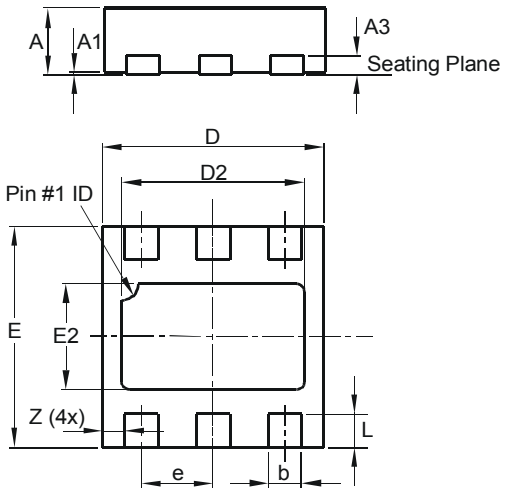

| SOT26 | | | |
|---|---|---|---|
| Dim | Min | Max | Typ |
| A | 0.35 | 0.50 | 0.38 |
| B | 1.50 | 1.70 | 1.60 |
| C | 2.70 | 3.00 | 2.80 |
| D | — | — | 0.95 |
| H | 2.90 | 3.10 | 3.00 |
| J | 0.013 | 0.10 | 0.05 |
| K | 1.00 | 1.30 | 1.10 |
| L | 0.35 | 0.55 | 0.40 |
| M | 0.10 | 0.20 | 0.15 |
| α | 0° | 8° | — |
| All Dimensions in mm | | | |

### (2) TSOT26




| TSOT26 | | | |
|---|---|---|---|
| Dim | Min | Max | Typ |
| A | – | 1.00 | – |
| A1 | 0.01 | 0.10 | – |
| A2 | 0.84 | 0.90 | – |
| D | – | – | 2.90 |
| E | – | – | 2.80 |
| E1 | – | – | 1.60 |
| b | 0.30 | 0.45 | – |
| c | 0.12 | 0.20 | – |
| e | – | – | 0.95 |
| e1 | – | – | 1.90 |
| L | 0.30 | 0.50 | |
| L2 | – | – | 0.25 |
| θ | 0° | 8° | 4° |
| θ1 | 4° | 12° | – |
| All Dimensions in mm | | | |

### (3) U-DFN2020-6 Type C



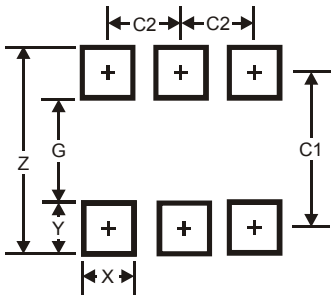

| U-DFN2020-6 Type C | | | |
|---|---|---|---|
| Dim | Min | Max | Typ |
| A | 0.57 | 0.63 | 0.60 |
| A1 | 0.00 | 0.05 | 0.02 |
| A3 | — | — | 0.15 |
| b | 0.25 | 0.35 | 0.30 |
| D | 1.95 | 2.075 | 2.00 |
| D2 | 1.55 | 1.75 | 1.65 |
| E | 1.95 | 2.075 | 2.00 |
| E2 | 0.86 | 1.06 | 0.96 |
| e | — | — | 0.65 |
| L | 0.25 | 0.35 | 0.30 |
| Z | — | — | 0.20 |
| All Dimensions in mm | | | |


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## Suggested Pad Layout

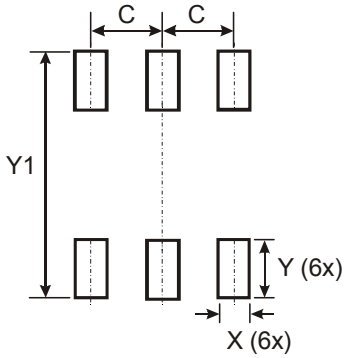
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

### (1) SOT26



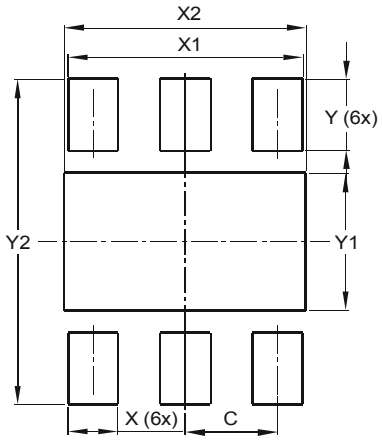

| Dimensions | Value (in mm) |
|---|---|
| Z | 3.20 |
| G | 1.60 |
| X | 0.55 |
| Y | 0.80 |
| C1 | 2.40 |
| C2 | 0.95 |

### (2) TSOT26




| Dimensions | Value (in mm) |
|---|---|
| C | 0.950 |
| X | 0.700 |
| Y | 1.000 |
| Y1 | 3.199 |

### (3) U-DFN2020-6 Type C

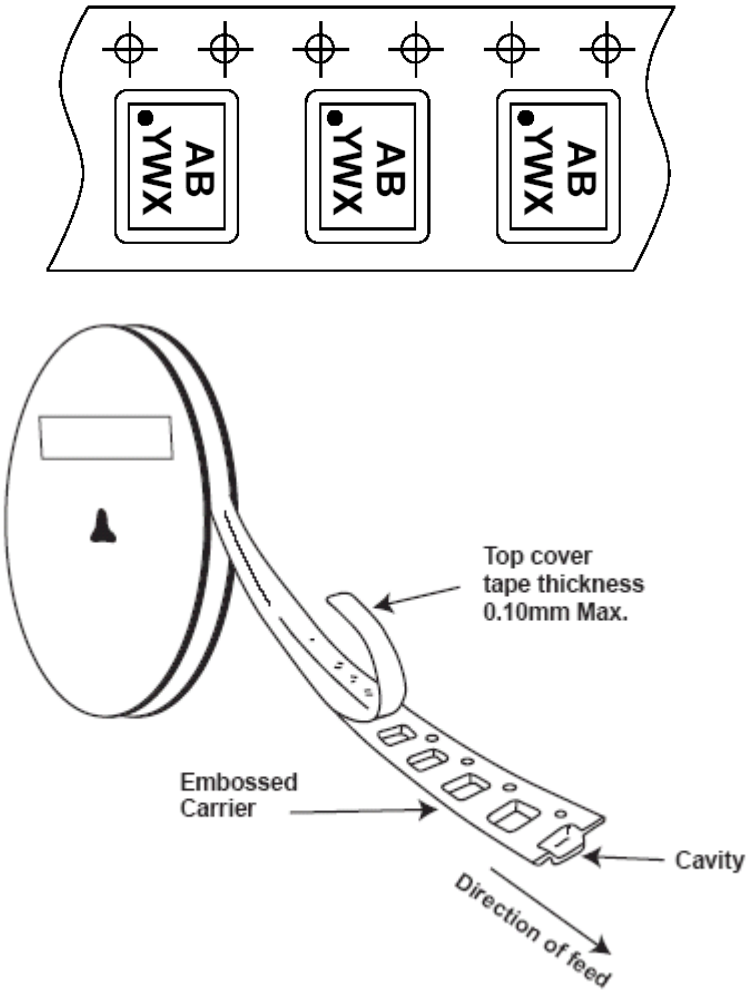



| Dimensions | Value (in mm) |
|---|---|
| C | 0.650 |
| X | 0.350 |
| X1 | 1.650 |
| X2 | 1.700 |
| Y | 0.525 |
| Y1 | 1.010 |
| Y2 | 2.400 |


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## Tape Orientation

**For U-DFN2020-6**




Note: 4. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf.


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