AP1521

WHITE LED STEP-UP CONVERTER

Features

- Inherently Matched LED Current
- Drives Up to Four LED's from a 3.2V Supply
- Drives Up to Six LED's from a 5V Supply
- High Efficiency: 84% Typical
- Fast 1MHz Switching Frequency
- 36V Rugged Bipolar Switch
- Low Profile SOT25-5L Pb-Free Packaging
- Lead Free Finish/RoHS Compliant (Note 1)

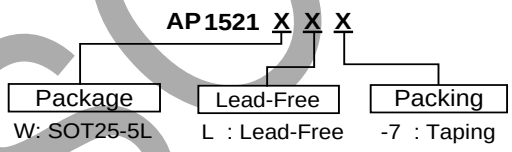
General Description

The AP1521 is a step-up DC/DC converter specifically designed to drive white LED's with a constant current. The device can drive two, three or four LED's in series from a Li-Ion cell. Series connection of the LED's provides identical LED currents resulting in uniform brightness and eliminates the need for ballast resistors. The AP1521 switches at 1MHz that allows the use of tiny external components. A low 300mV feedback voltage minimizes power loss in the current setting resistor for better efficiency.

Applications

- Cellular Phones
- PDA's, Hand-held Computers
- Digital Cameras
- MP3 Players
- GPS Receivers

Ordering Information

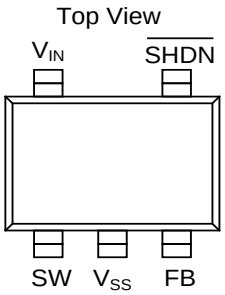


Note: 1. RoHS revision 13.2.2003. Glass and High Temperature Solder Exemptions Applied, see *EU Directive Annex Notes 5 and 7*.

Device (Note 2)	Package Code	Packaging	7" Tape and Reel	
			Quantity	Part Number Suffix
AP1521W	W	SOT25-5L	3000/Tape & Reel	-7

Note: 2. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at http://www.diodes.com/datasheets/ap02001.pdf.

Pin Assignments

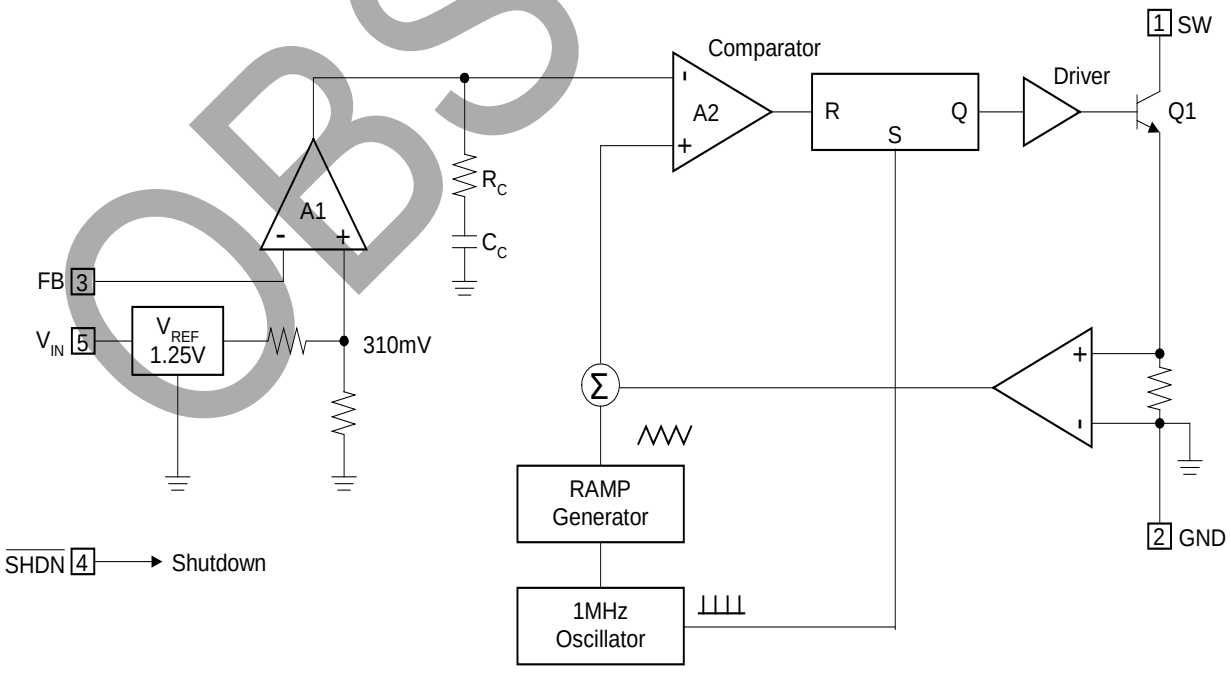


SOT25-5L

Pin Descriptions

Name	Description
SW	Switch Pin. Connect inductor/diode here. Minimize trace area at this pin to reduce EMI
V_{SS}	GND pin
FB	Feedback Pin. Reference voltage is 310mV. Connect cathode of lowest LED and resistor here. Calculate resistor value according to the formula： RFB = 310mV / ILED
$\overline{SHDN}$	Shutdown Pin. Tie to 1.5V or higher to enable the device；0.4V or less to disable the device
V_{IN}	Input Supply Pin. Must be locally bypassed

Block Diagram



Absolute Maximum Ratings

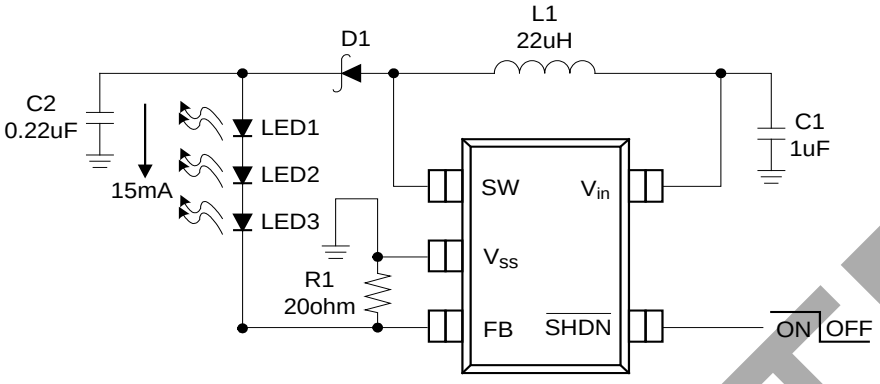
Symbol	Parameter	Rating	Unit
V_{IN}	VIN Pin Voltage	10	V
VSW	SW Voltage	36	V
V_{FB}	Feedback Pin Voltage	10	V
V_{SHDN}	SHDN Pin Voltage	10	V
T_J	Maximum Junction Temperature	125	°C
T_{LEAD}	Lead Temperature	300	°C
T_{OPR}	Operating Temperature Range	0 to +85	°C
T_{STG}	Storage Temperature Range	-40 to +125	°C

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any condition.

Electrical Characteristics (T_a = 25°C, V_{IN} = 3V, V_{SHDN} = 3V, unless otherwise noted)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
V_{IN}	Minimum Operation Voltage	-	2.5	--	--	V
V_{IN}	Maximum Operation Voltage	-	--	--	10	V
V_{FB}	Feedback Pin Voltage	-	280	310	340	mV
I_{FB}	Feedback Pin Bias Current	-	10	45	100	nA
	Supply Current		--	1.9	2.5	mA
		V_{SHDN} = 0V	--	0.1	1.0	μA
F_{SW}	Switching Frequency		0.75	1.0	1.25	MHz
Duty	PWM Maximum Duty Cycle		85	90	--	%
I_{SW}	Switch Current Limit		--	320	--	mA
V_{SAT}	Switch V_{SAT}	I_{SW} = 250mA	--	350	--	mV
	Switch Leakage Current	V_{SW} = 5V	--	0.01	5	μA
V_{SHDN}	SHDN Pin Voltage High	Enable	1.5	--	--	V
V_{SHDN}	SHDN Pin Voltage Low	Disable	--	--	0.4	V
I_{SHDN}	SHDN Pin Bias Current		--	65	--	μA

Typical Application Circuit



C1, C2: X5R or X7R Dielectric
D1: Central Semiconductor CMDSH-3
L1: MURATA LQH3C-220 or Equivalent

Figure 1.

Applications Information

Capacitor Selection
The small size of ceramic capacitors makes them ideal for AP1521 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 0.22µF output capacitor are sufficient for most AP1521 applications.

Inductor Selection
A 22µH inductor is recommended for most AP1521 applications. Although small size and high efficiency are major concerns, the inductor should have low core losses at 1MHz and low DCR (copper wire resistance).

Diode Selection
Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for AP1521 applications. The forward voltage drop of 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 1MHz switching frequency of the AP1521. Schottky diode rated at 100mA to 200mA is sufficient for most AP1521 applications.

LED Current Control
The LED current is controlled by the feedback resistor (R1 in **Figure 1**). The feedback reference is 310mV. The LED current is 310mV/R1. In order to have accurate LED current, precision resistors are preferred (1% is recommended). The formula and table for R1 selection are shown below.

$R1 = 310mV/I_{LED}$ (See **Table 1**)

Table 1. R1 Resistor Value Selection

I_{LED} (mA)	R1 (Ω)
5	62
10	31
12	25.8
15	20.7
20	15.5

Open-Circuit Protection
In the cases of output open circuit, when the LED's are disconnected from the circuit or the LED's fail, the feedback voltage will be zero. The AP1521 will then switch at a high duty cycle resulting in a high output voltage, which may cause the SW pin voltage to exceed its maximum 36V rating. A Zener diode can be used at the output to limit the voltage on the SW pin (**Figure 2**). The Zener voltage should be larger than the maximum forward voltage of the LED string. The current rating of the Zener should be larger than 0.1mA.

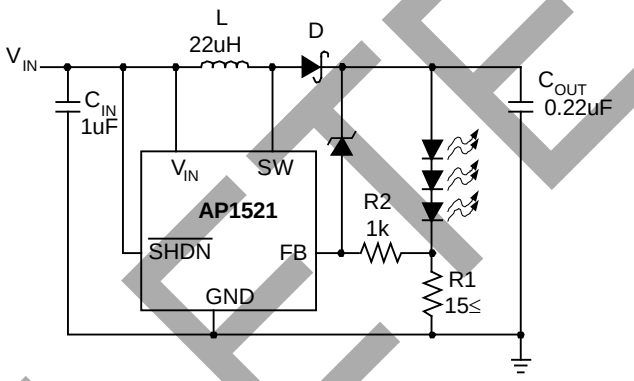
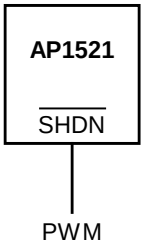


Figure 2. LED Driver with Open-Circuit Protection

Dimming Control
There are four different types of dimming control circuits:

1. Using a PWM Signal to $\overline{SHDN}$ Pin

With the PWM signal applied to the $\overline{SHDN}$ pin, the AP1521 is turned on or off by the PWM signal. The LED's 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 AP1521 and corresponds to zero LED current. A 100% duty cycle corresponds to full current. The typical frequency range of the PWM signal is 1kHz to 10kHz. The magnitude of the PWM signal should be higher than the minimum $\overline{SHDN}$ voltage.



Applications Information (Continued)

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 R1 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 15mA.

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. The circuit is shown in **Figure 4**.

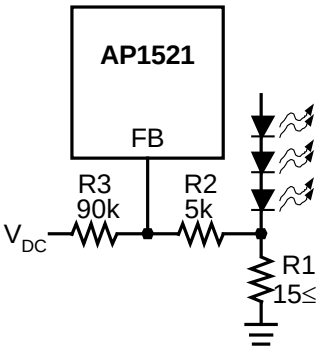


Figure 3. Dimming Control Using a DC Voltage

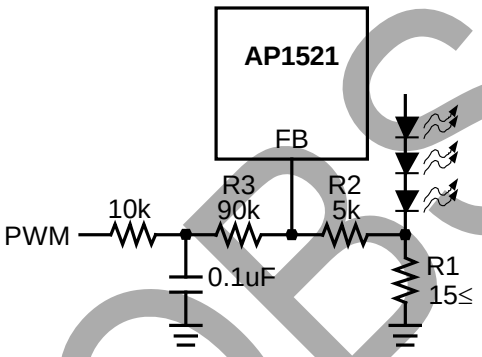


Figure 4. Dimming Control Using a Filtered PWM Signal

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 5**. R1 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.

Start-up and Inrush Current

To achieve minimum start-up delay, no internal soft-start circuit is included in AP1521. When first turned on without an external soft-start circuit, inrush current is about 200mA. If soft-start is desired, the recommended circuit and the waveforms are shown in **Figure 6**. If both soft-start and dimming are used, a 10kHz PWM signal on SHDN is not recommended. Use a lower frequency or implement dimming through the FB pin as shown in **Figures 3, 4 or 5**.

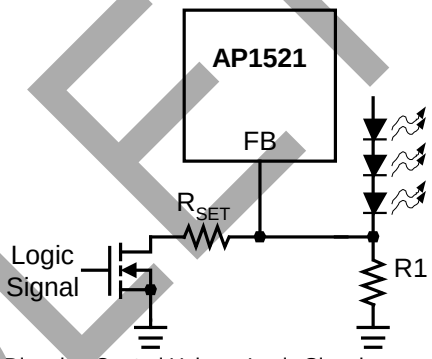


Figure 5. Dimming Control Using a Logic Signal

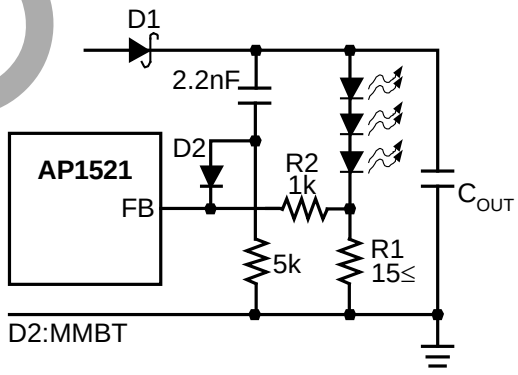
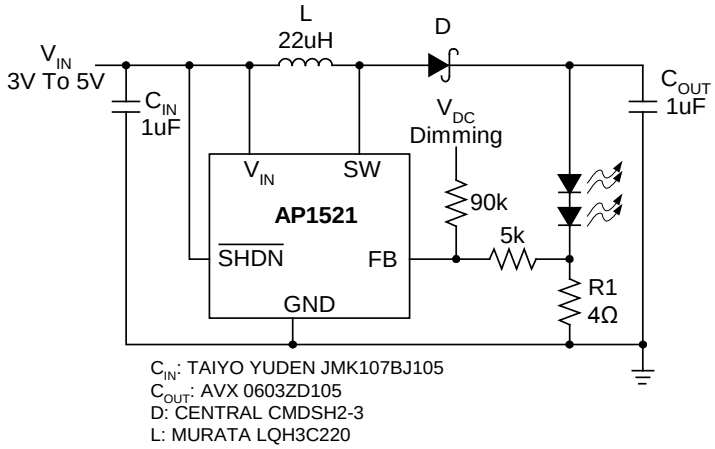


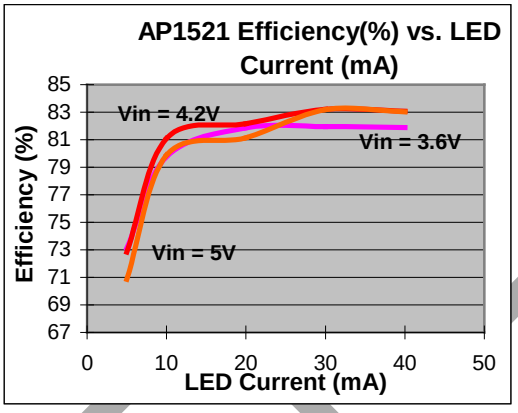
Figure 6. Recommended Soft-Startup Circuit

Typical Performance Characteristics

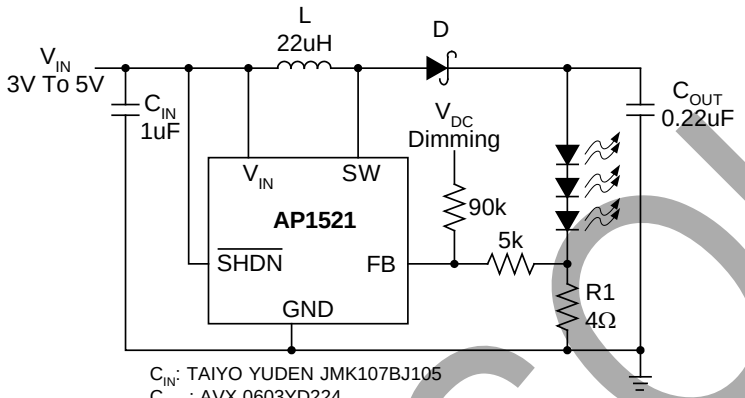
Li-Ion to Two White LEDs



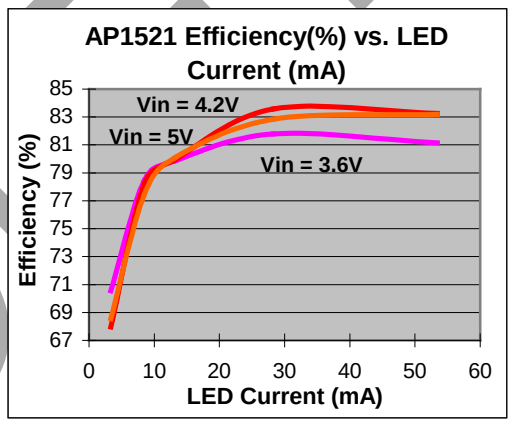
C_{IN}: TAIYO YUDEN JMK107BJ105
C_{OUT}: AVX 0603ZD105
D: CENTRAL CMDSH2-3
L: MURATA LQH3C220



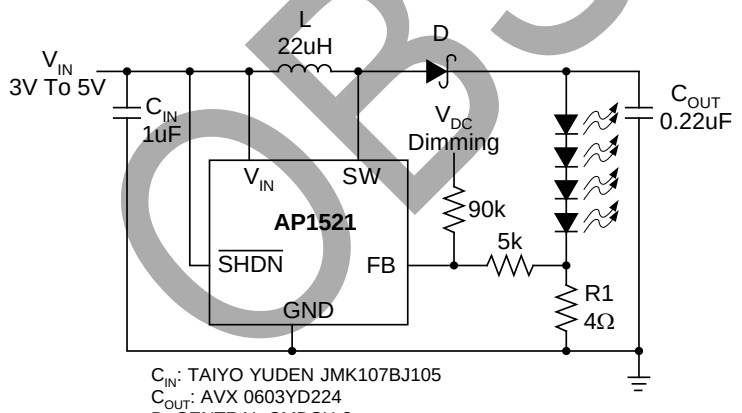
Li-Ion to Three White LEDs



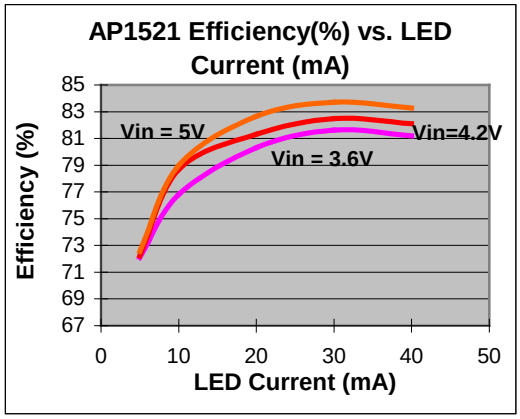
C_{IN}: TAIYO YUDEN JMK107BJ105
C_{OUT}: AVX 0603YD224
D: CENTRAL CMDSH-3
L: MURATA LQH3C220



Li-Ion to Four White LEDs

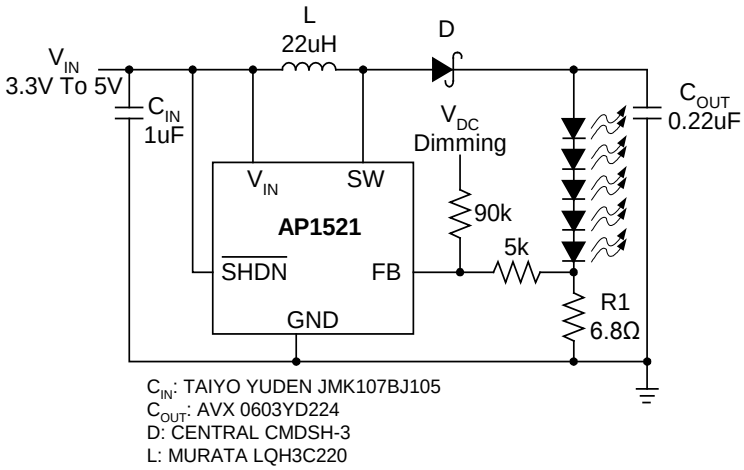


C_{IN}: TAIYO YUDEN JMK107BJ105
C_{OUT}: AVX 0603YD224
D: CENTRAL CMDSH-3
L: MURATA LQH3C220

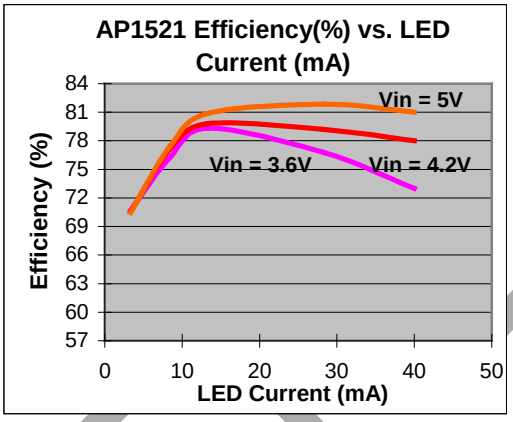


Typical Performance Characteristics (Continued)

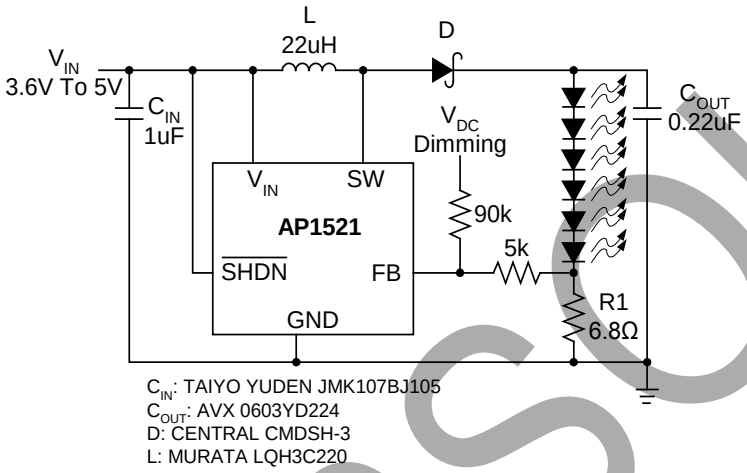
Li-Ion to Five White LEDs



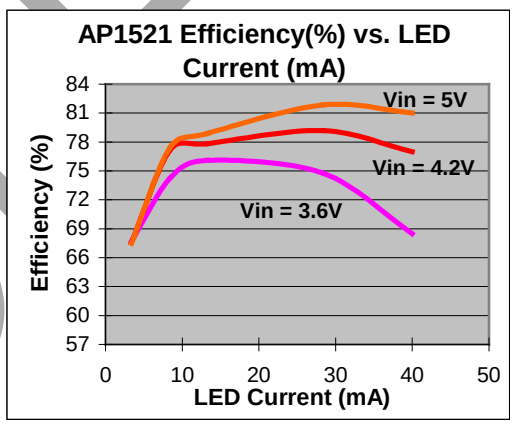
C_{IN}: TAIYO YUDEN JMK107BJ105
C_{OUT}: AVX 0603YD224
D: CENTRAL CMDSH-3
L: MURATA LQH3C220



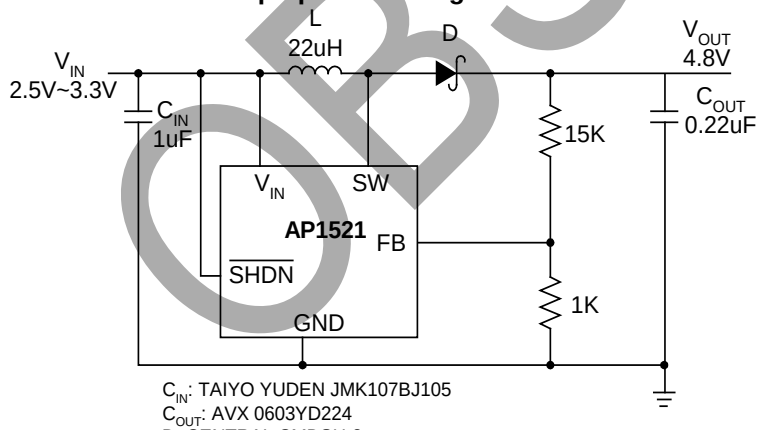
Li-Ion to Six White LEDs



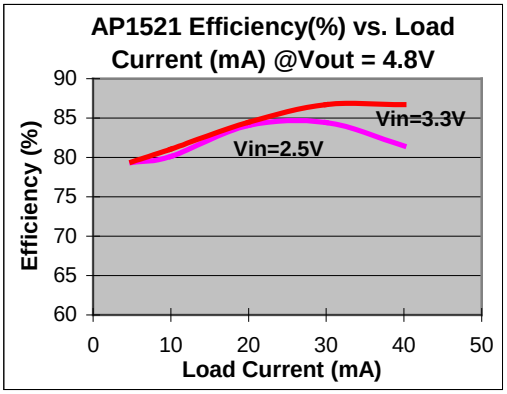
C_{IN}: TAIYO YUDEN JMK107BJ105
C_{OUT}: AVX 0603YD224
D: CENTRAL CMDSH-3
L: MURATA LQH3C220



Step up DC-DC Regulator

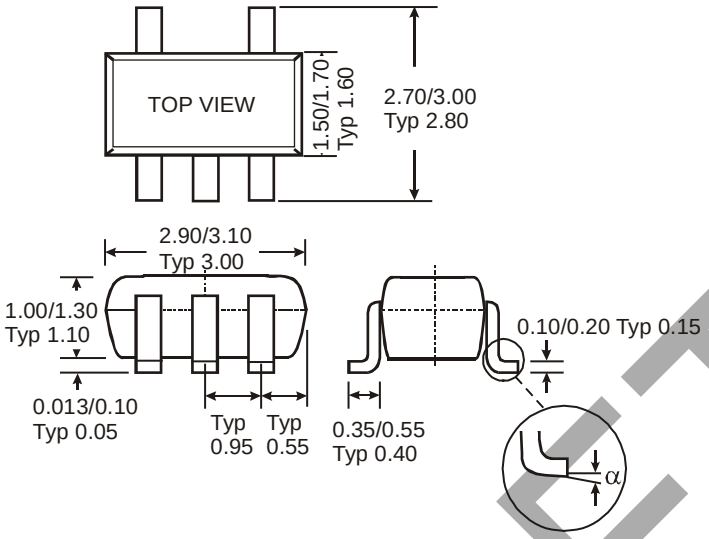


C_{IN}: TAIYO YUDEN JMK107BJ105
C_{OUT}: AVX 0603YD224
D: CENTRAL CMDSH-3
L: MURATA LQH3C220



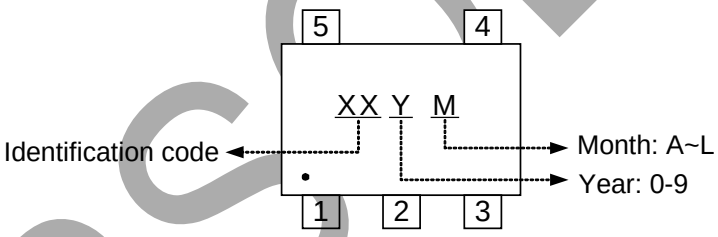
Package Diagrams (All Dimensions in mm)

(1) SOT25-5L



Marking Information

(1) SOT25-5L



Device	Package (Note 3)	Identification Code
AP1521W	SOT25-5L	FZ

Note: 3. For Packaging Details, go to our website at http://www.diodes.com/datasheets/ap02007.pdf.

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