

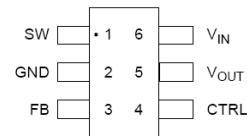


**SP6699**

## STEP UP WHITE LED CONVERTER

### FEATURES

- High Output Voltage: Up to 27V
  - Drives 2 to 5 LEDs @ 20mA
  - High Efficiency up to 84%
- Integrated Schottky Diode
- Fast 1.0MHz Switching Frequency
- 200mV Feedback Voltage
- PWM Dimming Capability up to 1KHz
- Over Output Voltage Protection
- Internal Soft Start Circuit
- Small SOT23-6 Package



### APPLICATIONS

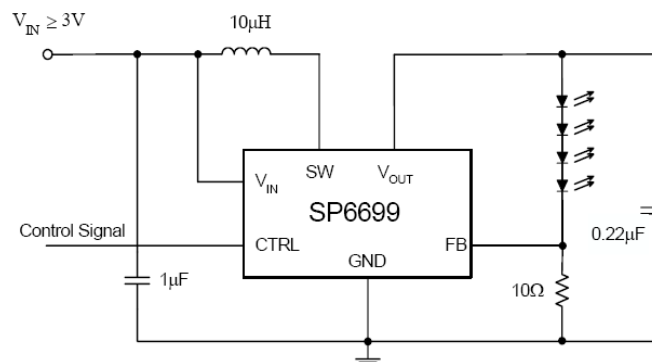
- Cellular Phones
- LCD Modules
- Keypad Backlighting
- Digital Cameras
- GPS Receivers
- Portable Media Players



### DESCRIPTION

The SP6699 is an inductor-based DC/DC converter designed to drive up to five white LEDs in series for LCD modules and keypad backlighting functions. Only one feedback resistor is needed to control the LED current and obtain the desired brightness. A 1.0MHz constant frequency PWM control scheme is used, enabling the usage of small external components. A typical application needs a 1mm tall inductor and a 0.22μF output capacitor. Additionally, the boost circuit Schottky diode is integrated, further reducing the overall foot print. A logic controlled enable pin allows this device to be placed in a low current consumption mode of a few microamps. Furthermore, the SP6699 is equipped with an over voltage output protection circuit which clamps the output voltage to 27 volts when any LED fails or in other abnormal conditions.

### TYPICAL APPLICATION CIRCUIT



## BLOCK DIAGRAM

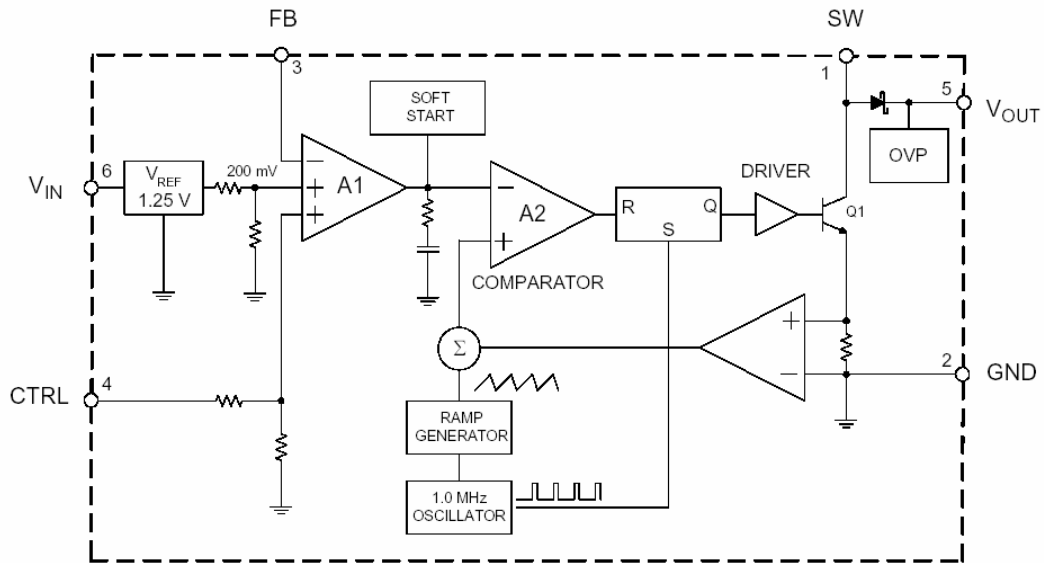


Figure 1: SP6699 Block Diagram

## PIN DESCRIPTION

### SOT23-6

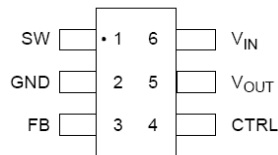


Figure 2: SP6699 Pin Out

Pin Number	Name	Description
1	SW	Switch pin. Connect external inductor
2	GND	Ground signal pin
3	FB	Voltage Feedback. Reference voltage is 200mV
4	CTRL	Shutdown and dimming pin. $V_{CTRL} > 1.8V$ : Device Enabled $50mV < V_{CTRL} < 1.8V$ : Linear dimming $V_{CTRL} < 50mV$ : Device Disabled
5	VOUT	Output Pin. Connected to the cathode of the internal Schottky diode
6	VIN	Input supply pin. Must be locally bypassed

## ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings

These are stress ratings only and functional operation is not implied. Exposure to absolute maximum ratings for prolonged time periods may affect device reliability. All voltages are with respect to ground.

Input Voltage $V_{IN}$ .....	20V	Operating Junction Temperature .....	150°C
SW Voltage .....	27V	Storage Temp. Range $T_{STG}$ .....	-65°C to 150°C
FB Voltage .....	20V	Lead Temperature (sold. 10s) $T_{LEAD}$ .....	260°C
CTRL Voltage .....	20V	ESD Ratings – Human Body Model .....	2000V
Thermal Resistance (junction to Atm.)		ESD Ratings – Machine Model .....	250V
$R_{\theta JA}$ .....	265°C/W		

### Recommended Operating Conditions

Operating Temperature $T_{OP}$ .....	-40°C to 85 °C	CTRL Voltage $V_{CTRL}$ .....	16V
Input voltage $V_{IN}$ .....	2.5V to 16V		

$V_{IN}=3V$ ,  $V_{CTRL}=3V$ ,  $T_A=25^\circ C$ , unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ.	Max	Unit
Minimum Operating Voltage	$V_{IN(min)}$		2.5			V
Maximum Operating Voltage	$V_{IN(max)}$				16	V
Feedback Voltage	$V_{FB}$	$I_{OUT}=20mA$ , 4 LEDs $T_A=-40^\circ C$ to $85^\circ C$	188	200	212	mV
FB Pin Bias Current	$I_{FB}$			35	100	nA
Supply Current	$I_{CC}$	$V_{FB}=V_{IN}$ , not switching	1.3	2.0	2.7	mA
Supply Current	$I_Q$	$V_{CTRL}=0V$	2.0	3.2	5.0	$\mu A$
Switching Frequency	f		0.7	1.0	1.3	MHz
Maximum Duty Cycle	$D_{MAX}$		90	93		%
Switch Current Limit (Note 1)	$I_{LIMIT}$	$T_A=25^\circ C$ , $D=40\%$		500		mA
		$T_A=25^\circ C$ , $D=80\%$		350		mA
Switch $V_{CE}$ Saturation Voltage	$V_{CESAT}$	$I_{SW}=250mA$		360		mV
Switch Leakage Current		$V_{SW}=5V$		0.01	5	$\mu A$
CTRL Pin Voltage	$V_{CTRL}$	High	1.8			V
		Low			0.05	V
CTRL Pin Bias Current	$I_{CTRL}$		40	55	72	$\mu A$
		$T_A=85^\circ C$		50		$\mu A$
		$T_A=-40^\circ C$		75		$\mu A$
Schottky Forward Drop	$V_{DROP}$	$I_D=150mA$		0.7		V
Schottky Leakage Current		$V_R=23V$		0.1	4	$\mu A$
		$V_R=27V$			150	$\mu A$
Soft Start Time	t			300		$\mu s$

Note 1: The Switch Current Limit is related to the Duty Cycle. Please refer to figure 15 for details.

Typical Characteristics

$V_{IN}=3.6V$ ,  $EN=V_{IN}$ ,  $R_{SET}=24k\Omega$ ,  $C_{IN}=1\mu F$ ,  $T_A=25^\circ C$ , unless otherwise noted.

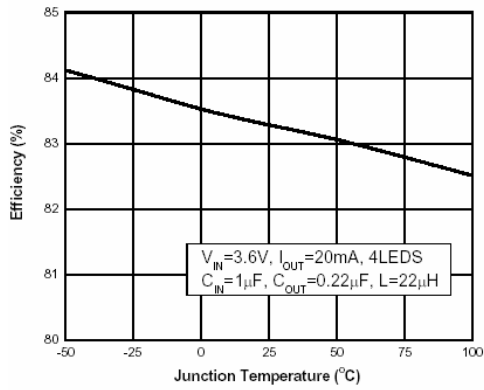


Fig. 3. Efficiency vs Junction Temperature

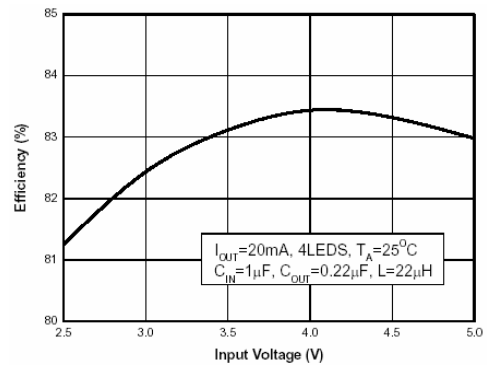


Fig. 4. Efficiency vs Input Voltage

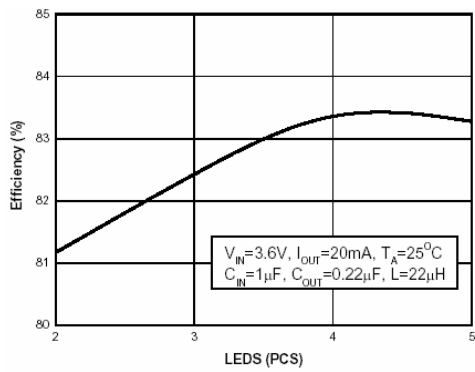


Fig. 5. Efficiency vs LED Number

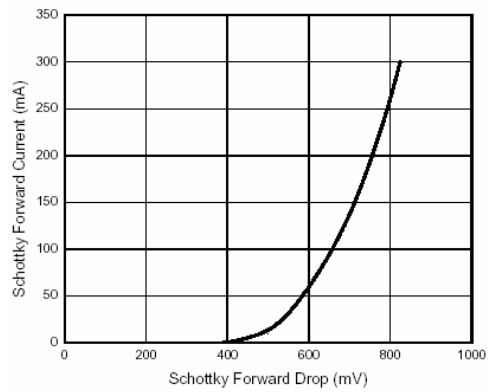


Fig. 6. Schottky Forward Current vs Schottky Forward Drop

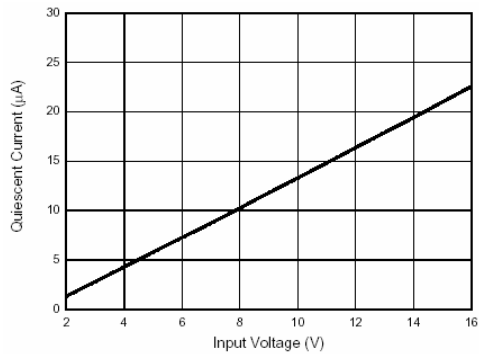


Fig. 7. Shutdown Quiescent Current vs Input Voltage

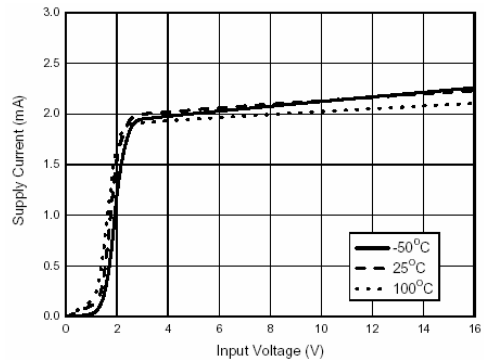


Fig. 8. Supply Current vs Input Voltage

## ELECTRICAL CHARACTERISTICS

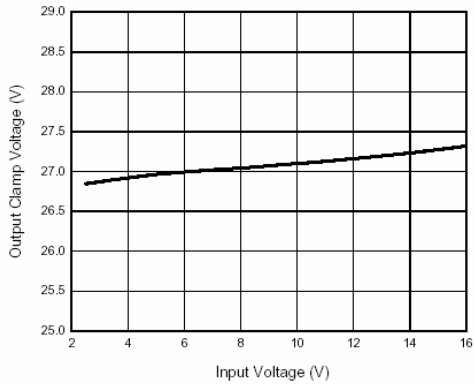


Fig. 9. Output Clamp Voltage vs Input Voltage

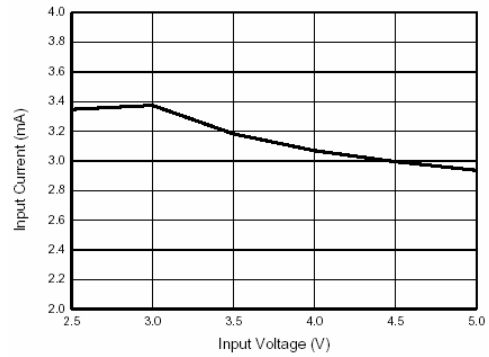


Fig. 10. Input Current in Output Open Circuit vs Input Voltage

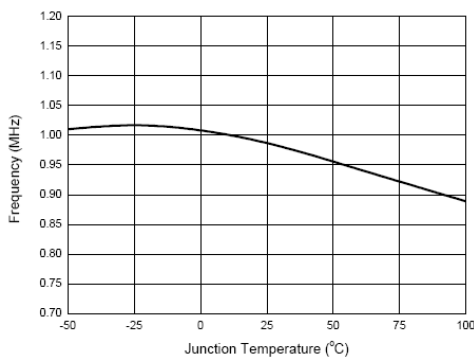


Fig. 11. Switching Frequency vs Junction Temperature

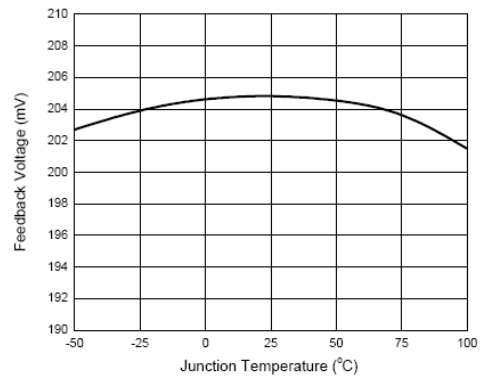


Fig. 12. Feedback Voltage vs Junction Temperature

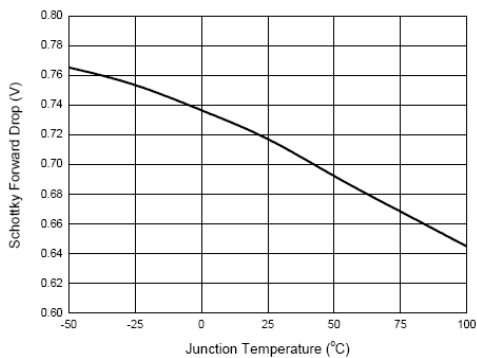


Fig. 13. Schottky Forward Drop vs Junction Temperature

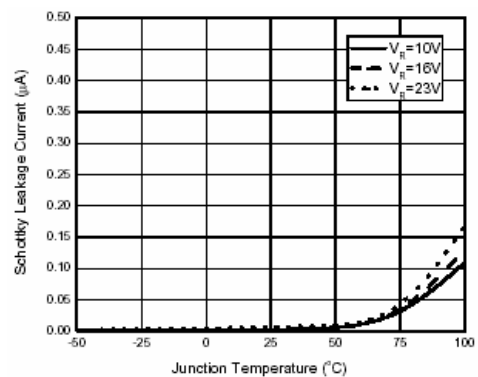


Fig. 14. Schottky Leakage Current vs Junction Temperature

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## ELECTRICAL CHARACTERISTICS

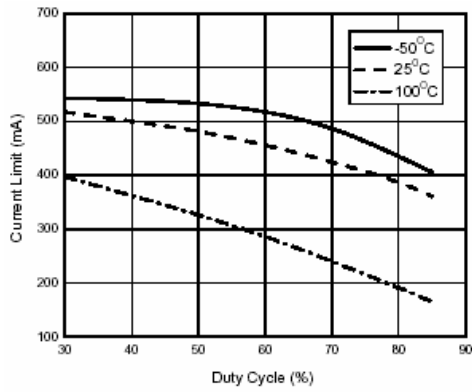


Fig. 15. Switch Current Limit vs Duty Cycle

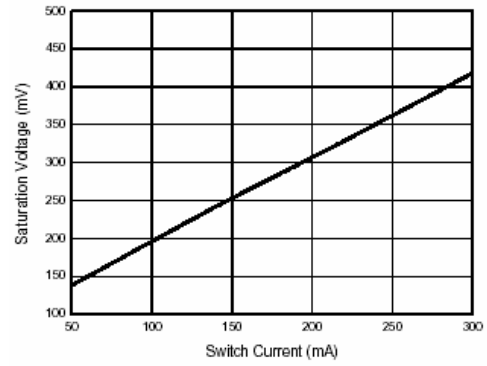


Fig. 16. Switch Saturation Current vs Switch Current

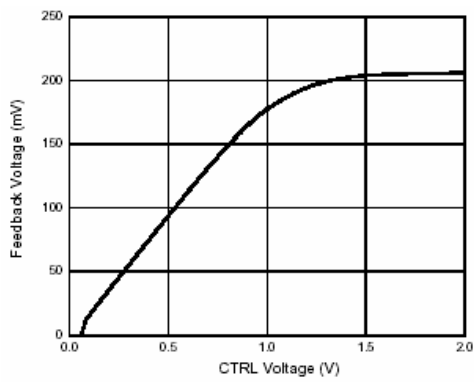


Fig. 17. Feedback Voltage vs CTRL Pin Voltage

**Detailed Description**

The SP6699 is a boost DC-DC converter which uses a constant frequency, current mode control scheme to provide excellent line and load regulation. Operation can be best understood by referring to the Figure 1. At the start of each oscillator cycle, the SR latch is set and the switch Q1 turns on. The switch current will increase linearly. The voltage on sense resistor is proportional to the switch current. The output of the current sense amplifier is added to a stabilizing ramp and the result is fed into the non-inversion input of the PWM comparator A2. When this voltage exceeds the output voltage level of the error amplifier A1, the SR latch is reset and the switch is turned off. It is clear that the voltage level at non-inversion input of A2 sets the peak current level to keep the output in regulation. This voltage level is the output signal of error amplifier A1, and is the amplified signal of the voltage difference between feedback voltage and reference voltage of 200mV. So, a constant output current can be provided by this operation mode.

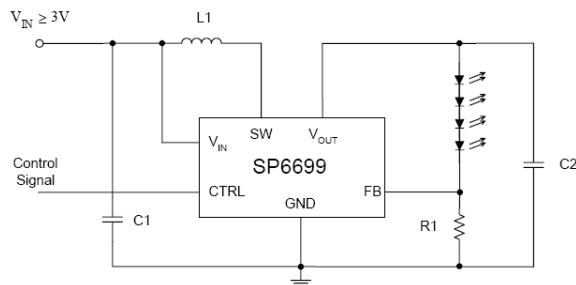


Fig. 18: R1 Selection Typical Application Circuit

**LED Current Control**

Refer to Figure 18, the LED current is controlled by the feedback resistor R1. LEDs' current accuracy is determined by the regulator's feedback threshold accuracy and is independent of the LED's forward voltage variation. So the precise resistors are preferred. The resistance of R1 is in inverse proportion to the LED current since the feedback reference is fixed at 200mV.

The relation for R<sub>1</sub> and LED current can be expressed as below:

$$R_1 = 200\text{mV}/I_{LED}$$

**Over Voltage Protection**

The SP6699 has an internal open-circuit protection circuit. When the LEDs are disconnected from the circuit or fail open, the output voltage is clamped at 27V. The SP6699 will switch at a low frequency, and minimize input current.

**Soft Start**

The SP6699 has an internal soft start circuit to limit the inrush current during startup. The startup delay is controlled by internal soft start capacitor. Please refer to Figure 19.

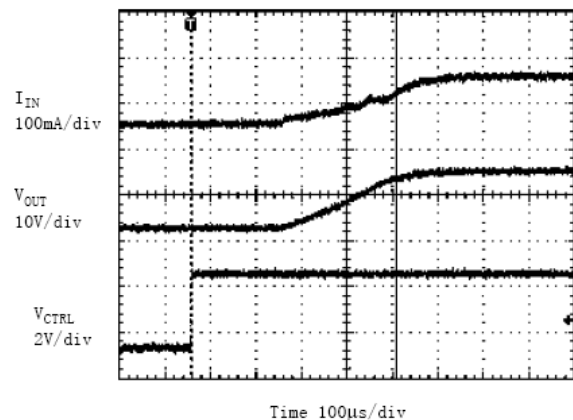


Fig. 19: Soft Start Waveform  
V<sub>IN</sub>=3.6V, 4 LEDs, I<sub>LED</sub>=20mA

**Dimming Control**

Two typical types of dimming control circuit are present. First, controlling the CTRL Pin voltage to change operation state is a good choice. Second, changing the feedback voltage to get appropriate duty and luminous intensity is also useful.

**1. Adding a Control Signal to CTRL Pin**

There are three methods to control CTRL pin signal.

First, adding a PWM Signal to the CTRL pin directly. The SP6699 is turned on or off by the PWM signal when it is applied on the CTRL pin. The typical frequency of this

## THEORY OF OPERATION

PWM signal is 200Hz to 1KHz. Please refer to figure 20.

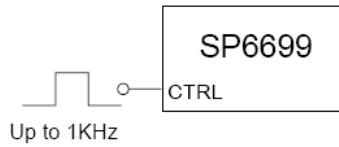


Fig. 20: Dimming Control Using a PWM Signal on CTRL Pin

Secondly, adding a constant DC voltage through a resistor divider to CTRL pin can control the dimming. The FB voltage is indirectly adjusted when the CTRL pin voltage is between 50mV to 1.8V, which can be used as dimming control. Please refer Figure 21.

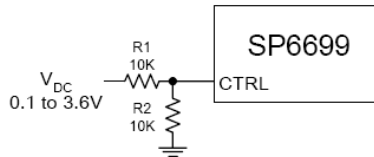


Fig. 21: Dimming Control Using a DC Voltage on CTRL Pin

Thirdly, using a filtered PWM signal added to the CTRL pin can achieve dimming control. The filtered PWM signal can be considered as an adjustable DC voltage. It will change the FB voltage indirectly and achieve dimming control. The circuit is shown in Figure 22.

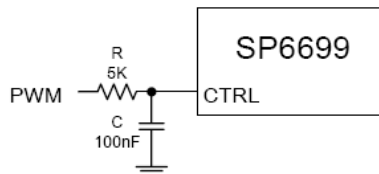


Fig. 22: Dimming Control Using a Filtered PWM Signal Voltage on CTRL Pin

### 2. Changing the Effective Feedback Voltage

There are three methods to change the effective feedback voltage.

First, adding a constant DC voltage through a resistor divider to FB pin can control the dimming. Changing the DC voltage or resistor between the FB Pin and

the DC voltage can get appropriate luminous intensity. Comparing with all kinds of PWM signal control, this method features a stable output voltage and LEDs current. Please refer Figure 23.

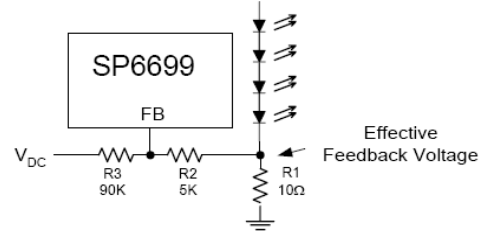


Fig. 23: Dimming Control Using a DC Voltage

Second, using a filtered PWM signal can do it. The filtered PWM signal can be considered as a varying and adjustable DC voltage.

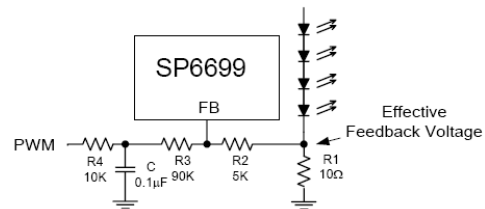


Fig. 24: Dimming Control Using a Filtered PWM Voltage

Third, using a logic signal to change the feedback voltage. For example, the FB pin is connected to the GND through a MOSFET and a resistor. And this MOSFET is controlled by a logic signal. The luminous intensity of LEDs will be changed when the MOSFET turns on or off.

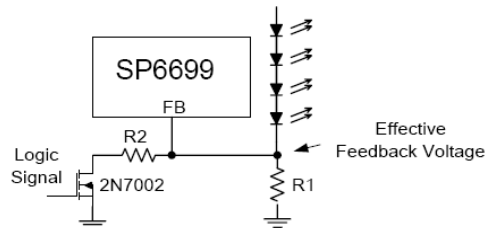
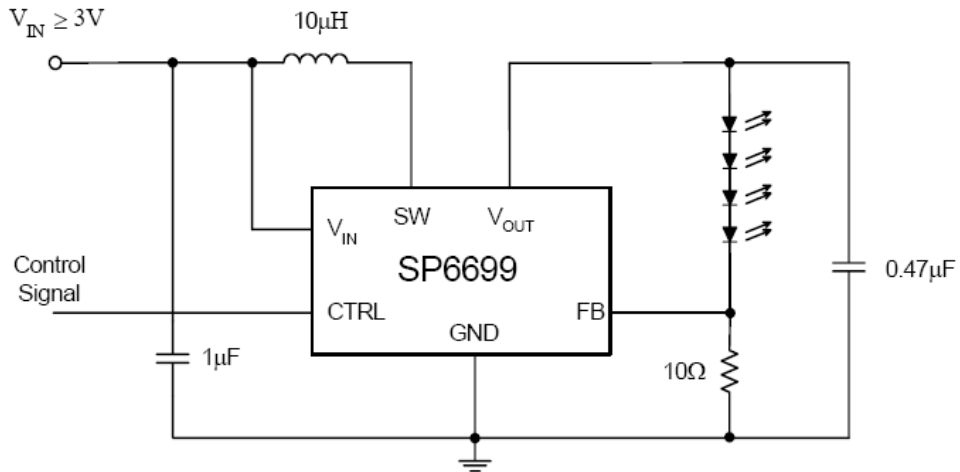


Fig. 25: Dimming Control Using Logic Signal

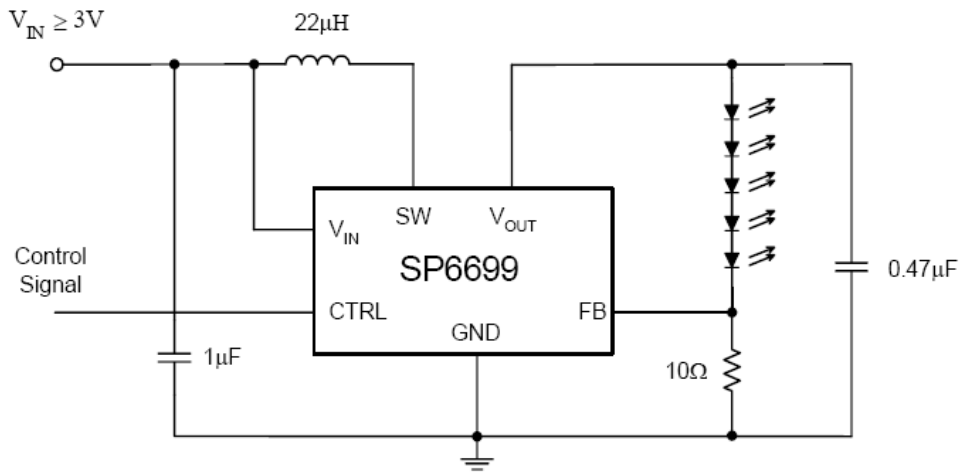


**Four White LED Driver**



C: X5R or X7R Dielectric  
 L: SUMIDA CDRH5D28R-100NC or Equivalent  
 For use over the full operating temperature range

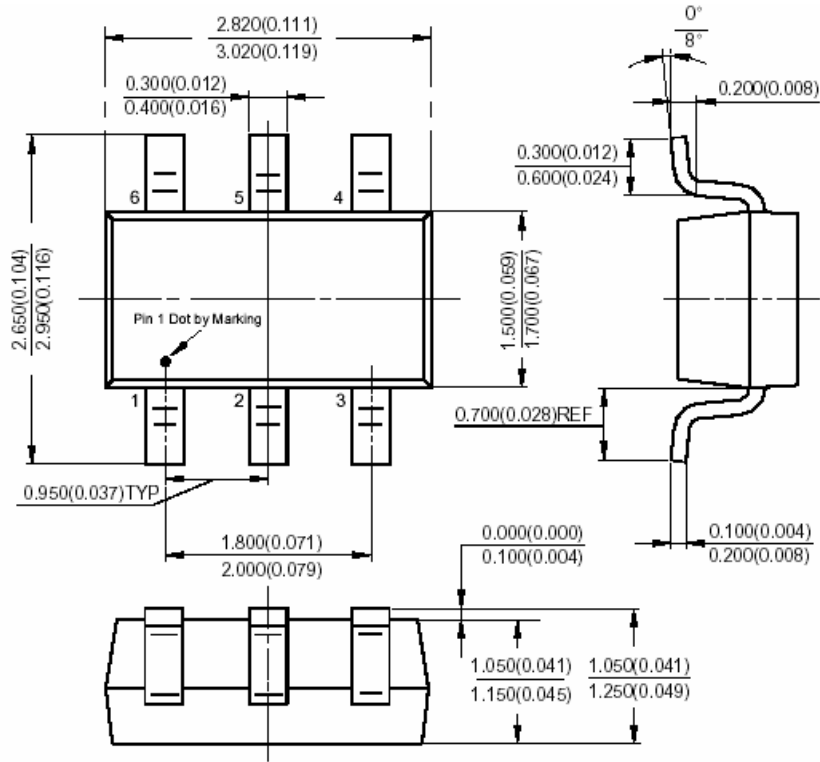
**Five White LED Driver**



C: X5R or X7R Dielectric  
 L: SUMIDA CDRH5D28R-220NC or Equivalent  
 For use over the full operating temperature range

**SOT23-6L**

Unit: mm (inch)



**ORDERING INFORMATION**

Part Number	Operating Temperature Range	Package	Marking	Packing Quantity
SP6699EK-L/TR	-40°C to +85°C	SOT23-6	PBWW	3,000/T&R

"WW" = Work Week



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