

**Low-Power Off-line PSR LED Controller****AP1686****General Description**

The AP1686 is a high performance AC/DC power supply controller for LED lighting application. The device uses Pulse Frequency Modulation (PFM) method to build discontinuous conduction mode (DCM) flyback power supplies.

The AP1686 provides accurate constant voltage, constant current (CV/CC) regulation without requiring an opto-coupler and the secondary control circuitry. It also eliminates the need of loop compensation circuitry while maintaining good stability. The AP1686 can achieve excellent regulation and high average efficiency, yet meets no-load consumption less than 30mW.

It also has an adjustable built-in line compensation function to achieve tight CC.

The AP1686 is available in SOT-23-6 package.

**Features**

- Primary Side Control for Tight Constant Current and Constant Voltage
- 30mW No-load Input Power
- Bipolar Junction Transistor (BJT) Driving
- Open Circuit Protection
- Over Voltage Protection
- Short Circuit Protection
- SOT-23-6 Package

**Applications**

- LED Driver

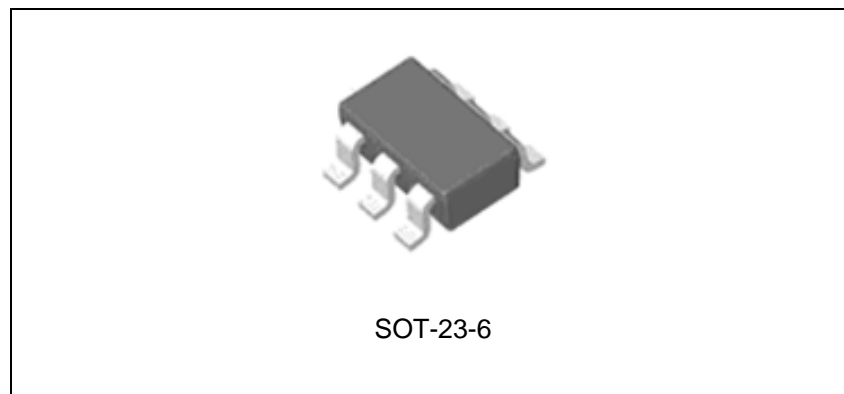


Figure 1. Package Type of AP1686

## Pin Configuration

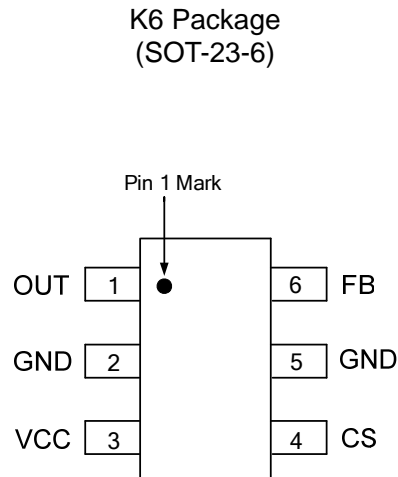


Figure 2. Pin Configuration of AP1686 (Top View)

## Pin Description

Pin Number	Pin Name	Function
1	OUT	The OUT pin is used to turn on and turn off the power switch. When turning on the power switch, the OUT pin will output 30mA source current to support the base current of the power BJT. When turning off the power switch, the resistance between the OUT and GND will become to 5Ω
2, 5	GND	The GND pin is the ground of the IC. When the power BJT is turned off, a fast reverse sinking current to the gate of BJT will flow out from this pin. Attention should be paid to in the PCB layout
3	VCC	The VCC pin supplies the power for the IC. In order to get the correct operation of the IC, a capacitor with low ESR should be placed as close as possible to the VCC pin
4	CS	The CS is the current sense pin of the IC. The IC will turn off the power BJT according to the voltage on the CS pin. When the power BJT is on, a current is output from the CS pin which is proportional to the line voltage to realize the function of line compensation
6	FB	The CV and CC regulation are realized based on the voltage sampling of this pin

**Functional Block Diagram**

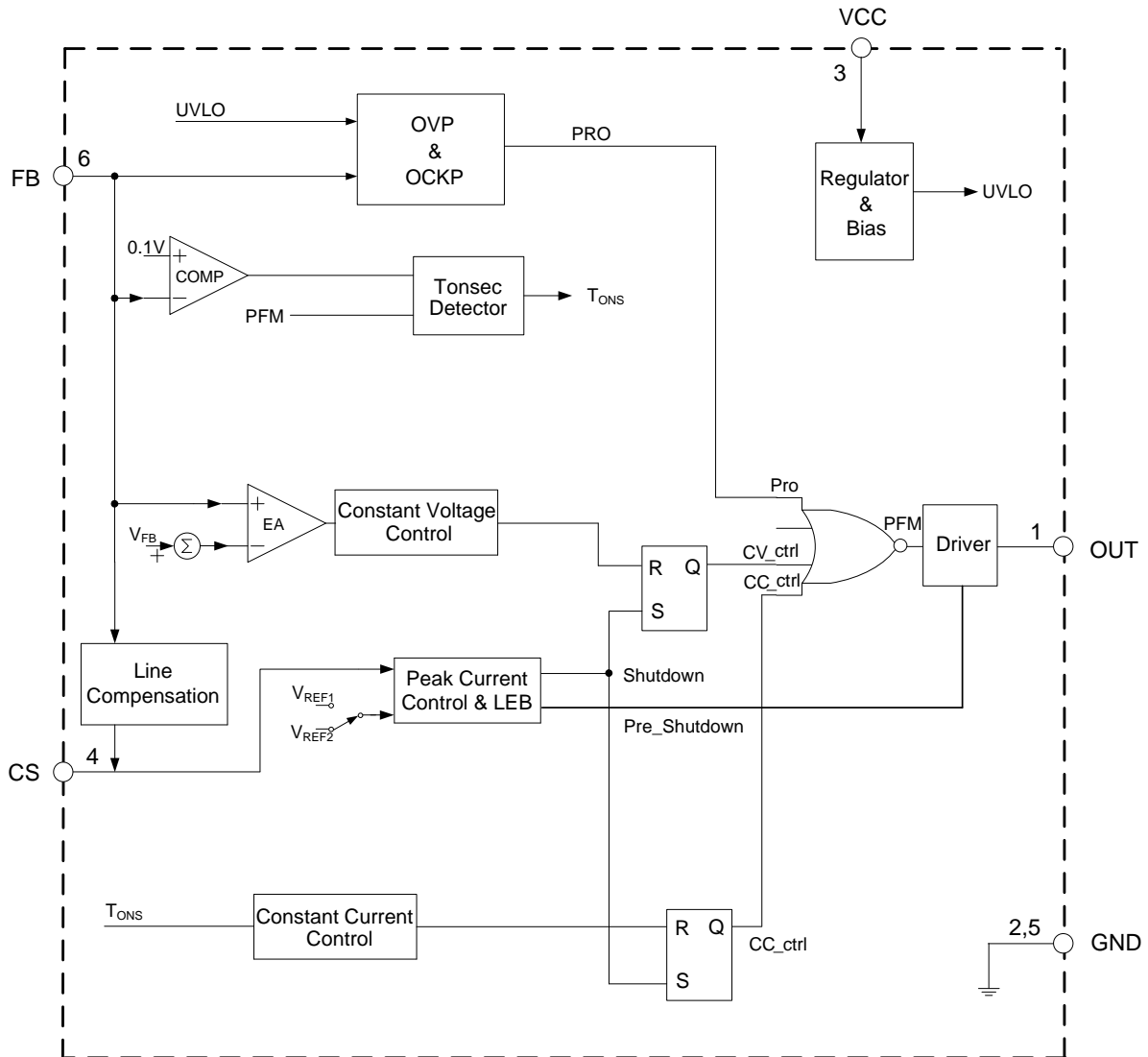
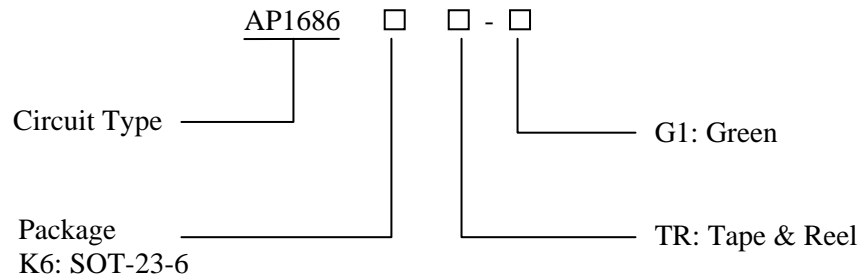


Figure 3. Functional Block Diagram of AP1686

**Low-Power Off-line PSR LED Controller****AP1686****Ordering Information**

Package	Temperature Range	Part Number	Marking ID	Packing Type
SOT-23-6	-40 to 85°C	AP1686K6TR-G1	GBQ	Tape & Reel

BCD Semiconductor's Pb-free products, as designated with "G1" suffix in the part number, are RoHS compliant and green.

**Absolute Maximum Ratings (Note 1)**

Parameter	Symbol	Value	Unit
Supply Voltage	$V_{CC}$	-0.3 to 30	V
CS to GND Voltage		-0.3 to 7	V
FB Input Voltage	$V_{FB}$	-40 to 7.5	V
Source Current at OUT Pin	$I_{SOURCE}$	Internally Limited	A
Operating Junction Temperature	$T_J$	150	°C
Storage Temperature	$T_{STG}$	-65 to 150	°C
Lead Temperature (Soldering, 10 sec)	$T_{LEAD}$	300	°C
Thermal Resistance (Junction to Ambient)	$\theta_{JA}$	200	°C/W
ESD (Human Body Model)		2000	V

Note 1: Stresses greater than 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 Ratings" for extended periods may affect device reliability.



**Low-Power Off-line PSR LED Controller**

**AP1686**

**Electrical Characteristics**

V<sub>CC</sub>=15V, T<sub>A</sub>=25°C, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit		
<b>UVLO SECTION</b>								
Startup Threshold	V <sub>TH</sub> (ST)		13	15.5	18	V		
Minimal Operating Voltage	V <sub>OPR</sub> (MIN)		3	3.5	4.5	V		
<b>STANDBY CURRENT SECTION</b>								
Startup Current	I <sub>ST</sub>	V <sub>CC</sub> =V <sub>TH</sub> (ST)-1V, Before startup	0	0.2	0.6	μA		
Operating Current	I <sub>CC</sub> (OPR)	Static current	250	400	600			
<b>DRIVE OUTPUT SECTION</b>								
Output Current	Sink	I <sub>SINK</sub>	Apply 1V @OUT pin		200	300	500	mA
	Source	I <sub>SOURCE</sub>			24	30	45	mA
<b>CURRENT SENSE SECTION</b>								
Current Sense Threshold Voltage	V <sub>CS</sub>		440	500	550	mV		
Equivalent Current Sense Voltage Accuracy (Note 2)	$\frac{\Delta V_{cs,eq}}{V_{cs,eq}}$				4	%		
Leading Edge Blanking	t <sub>LEB</sub>	The minimum power switch turn on time	300	475	720	ns		
<b>FEEDBACK INPUT SECTION</b>								
Input Resistance of FB Pin	R <sub>FB</sub>	V <sub>FB</sub> =4V	1	1.6	2	MΩ		
Feedback Threshold	V <sub>FB</sub>		3.7	3.974	4.21	V		
<b>LINE COMPENSATION SECTION</b>								
Line Compensation Transconductance (Note 2)	g <sub>m</sub>		1.14	1.43	1.72	μS		
<b>PROTECTION SECTION</b>								
Over Voltage Protection	V <sub>FB</sub> (OVP)		6.5	7.5	8.5	V		
Maximum On Time of Primary Side	tonp (MAX)		11	18	50	μs		

Note 2: The output current is given by  $I_{OUT} = \frac{V_{cs,eq}}{R_{cs}} \times \frac{N_p}{N_s}$



### Typical Performance Characteristics

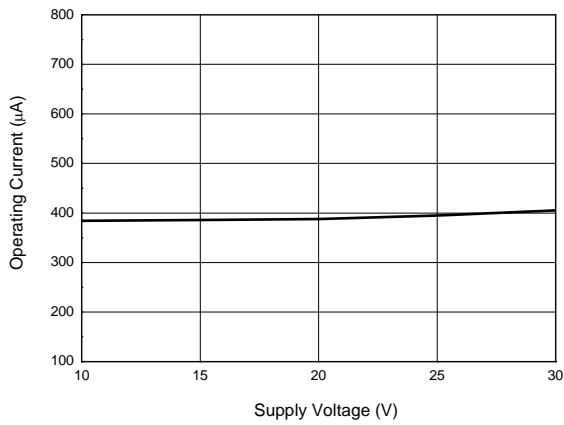


Figure 4. Operating Current vs. Supply Voltage

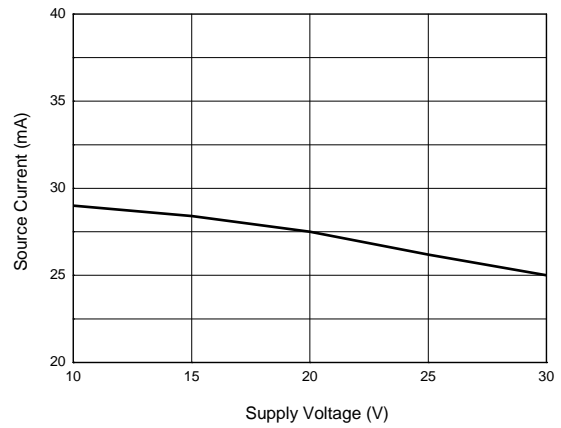


Figure 5. Source Current vs. Supply Voltage

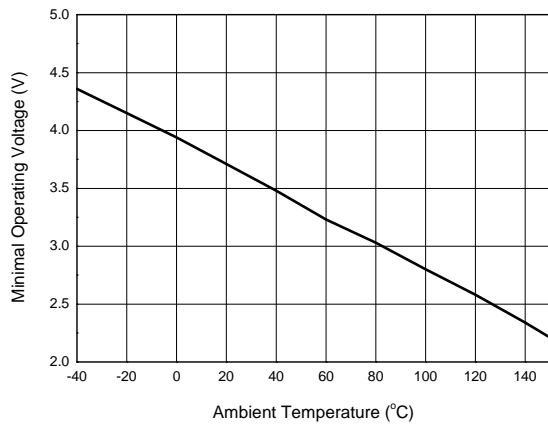


Figure 6. Minimal Operating Voltage vs. Ambient Temperature

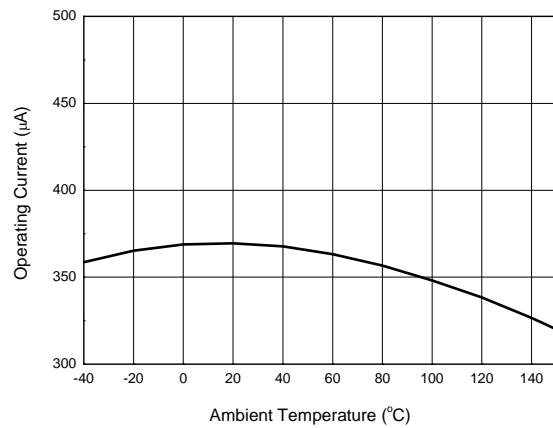


Figure 7. Operating Current vs. Ambient Temperature



Typical Performance Characteristics (Continued)

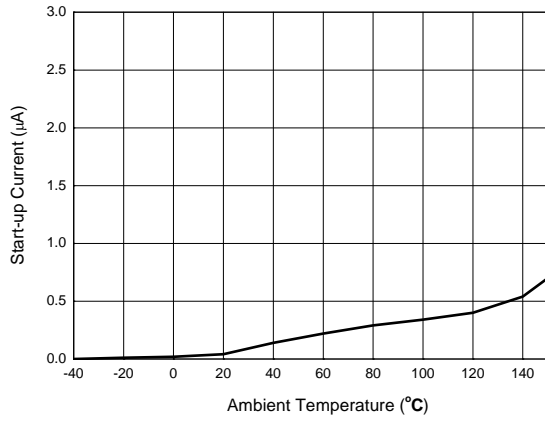


Figure 8. Start-up Current vs. Ambient Temperature

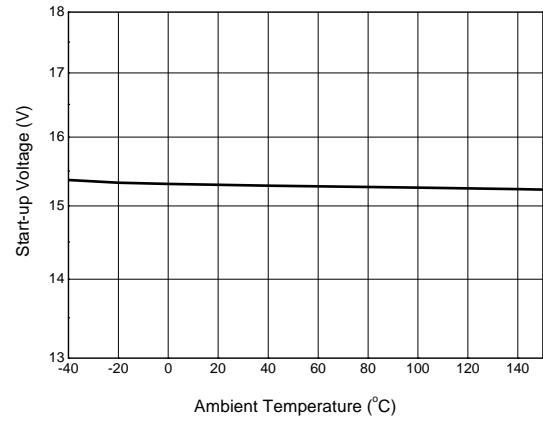


Figure 9. Start-up Voltage vs. Ambient Temperature

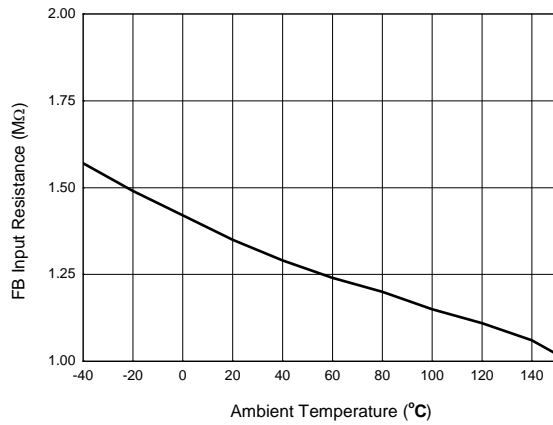


Figure 10. FB Input Resistance vs. Ambient Temperature

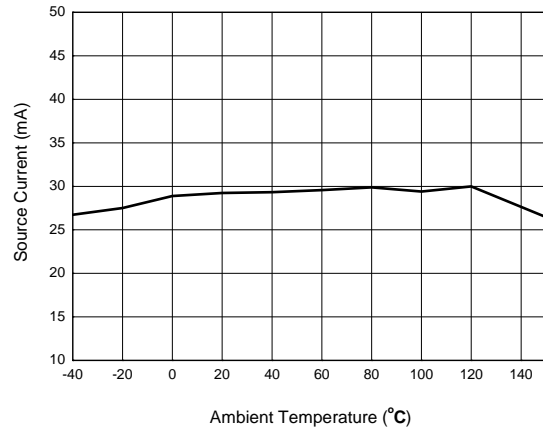


Figure 11. Source Current vs. Ambient Temperature

**Typical Performance Characteristics (Continued)**

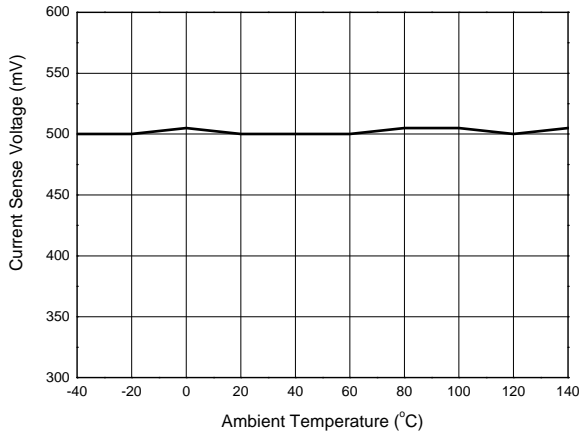


Figure 12. Current Sense Voltage vs. Ambient Temperature

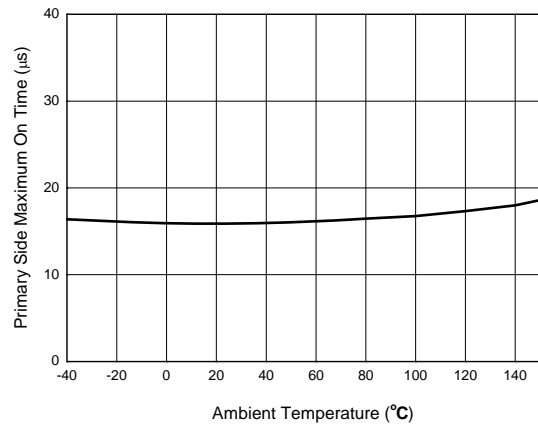


Figure 13. Primary Side Maximum On Time vs. Ambient Temperature

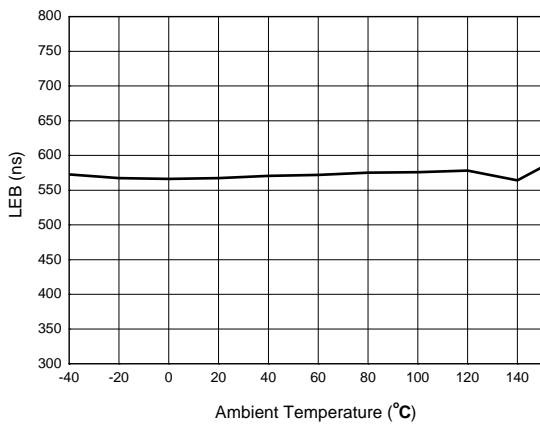


Figure 14. LEB vs. Ambient Temperature



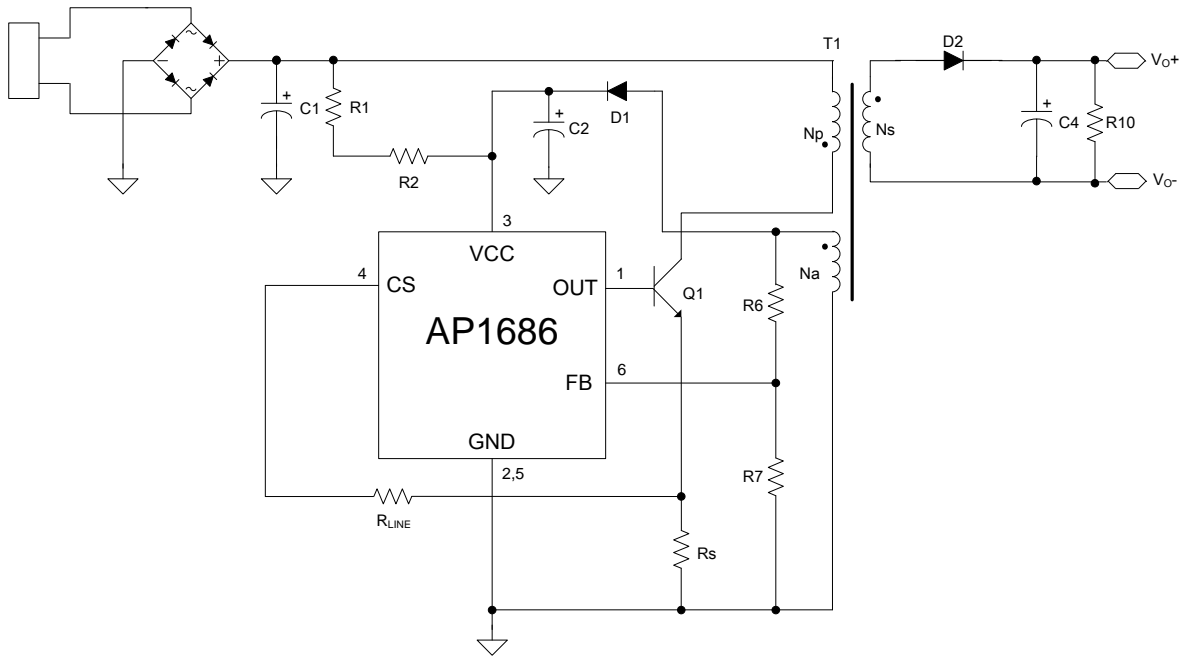
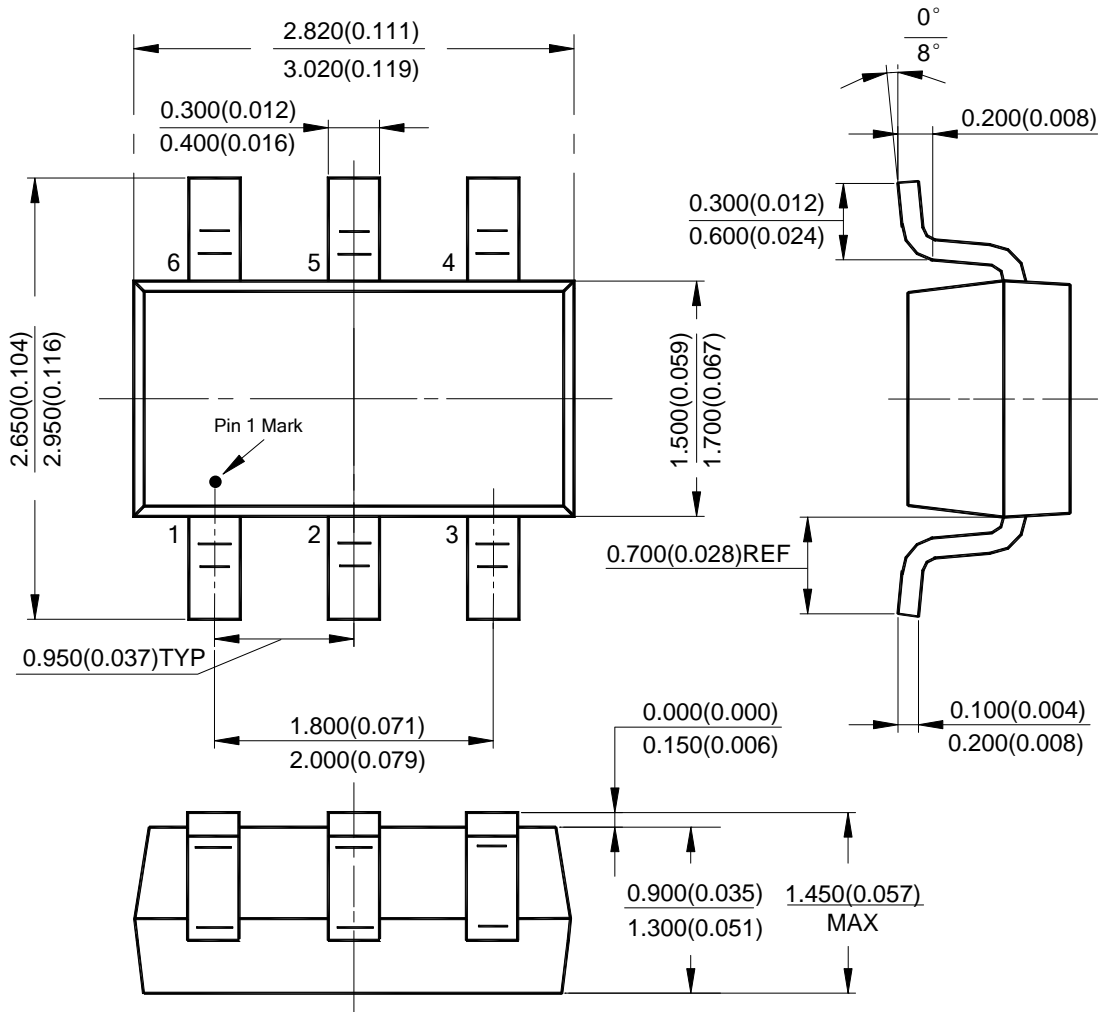
**Typical Application**


Figure 15. Typical LED Driver Application

**Mechanical Dimensions**

**SOT-23-6**

**Unit: mm(inch)**





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