LED Driver with Average-Mode Constant Current Control

Halogen Free

General Description

The FP7179 is an average current mode control LED driver IC operating in a constant off-time mode. FP7179 does not produce a peak-to-average error, and therefore greatly improves accuracy, line and load regulation of the LED current without any need for loop compensation or high-side current sensing. The output LED current accuracy is ±2%.

The FP7179 can be powered from an 8.0 - 450V supply. PWM & Linear dimming input is provided that accepts an external control TTL compatible signal. The output current can be programmed by an internal 277mV reference.

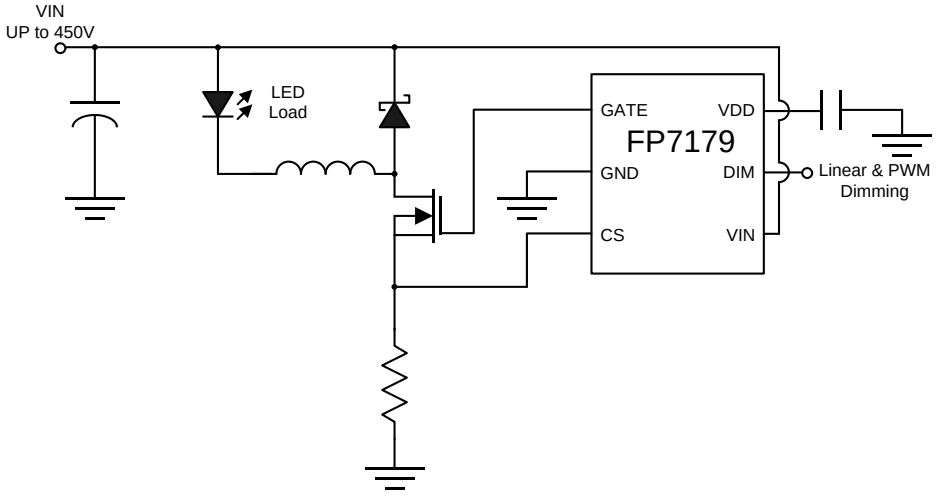
Features

- Fast Average Current Control
- Internal 8 to 450V Linear Regulator
- Linear and PWM Dimming Capability
- Output Short Circuit Protection with Skip Mode
- Requires Few External Components for Operation

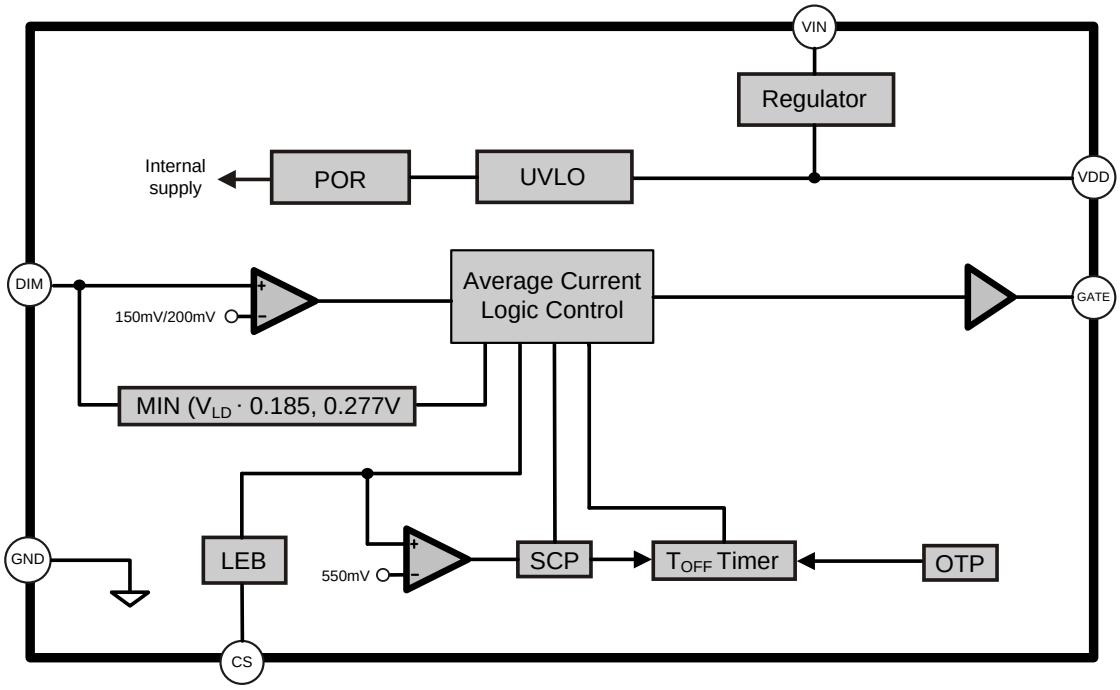
Applications

- DC/DC or AC/DC LED Driver Applications
- LED Street Lighting
- Back Lighting of Flat Panel Displays
- General Purpose Constant Current Source
- Signage and Decorative LED Lighting
- Chargers

Typical Application Circuit

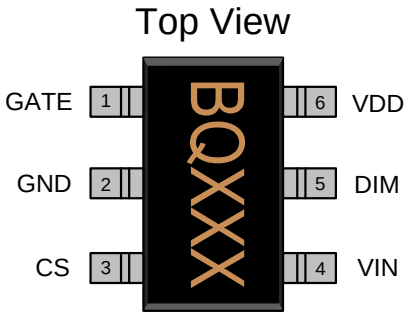


Function Block Diagram



Pin Descriptions

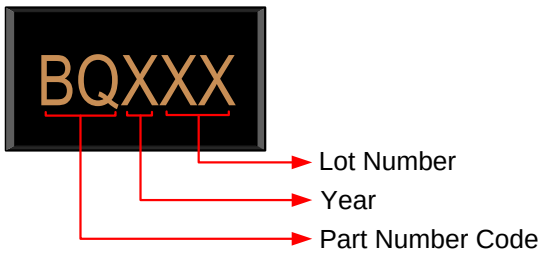
SOT23-6L



Name	No.	I / O	Description
GATE	1	O	This pin is the output GATE driver for an external N-channel power MOSFET.
GND	2	P	Ground return for all internal circuitry.
CS	3	I	This pin is the current sense pin used to sense the FET current by means of an external sense resistor.
VIN	4	P	This pin is the input of an 8 - 450V linear regulator.
DIM	5	I	This pin is the linear & PWM dimming input of the IC.
VDD	6	I	This is the power supply pin for all internal circuits.

Marking Information

SOT23-6L



Lot Number: Wafer lot number's last two digits

For Example: XX486 → 86

Year: Production year's last digit

Part Number Code: Part number identification code for this product. It should be always "BQ".

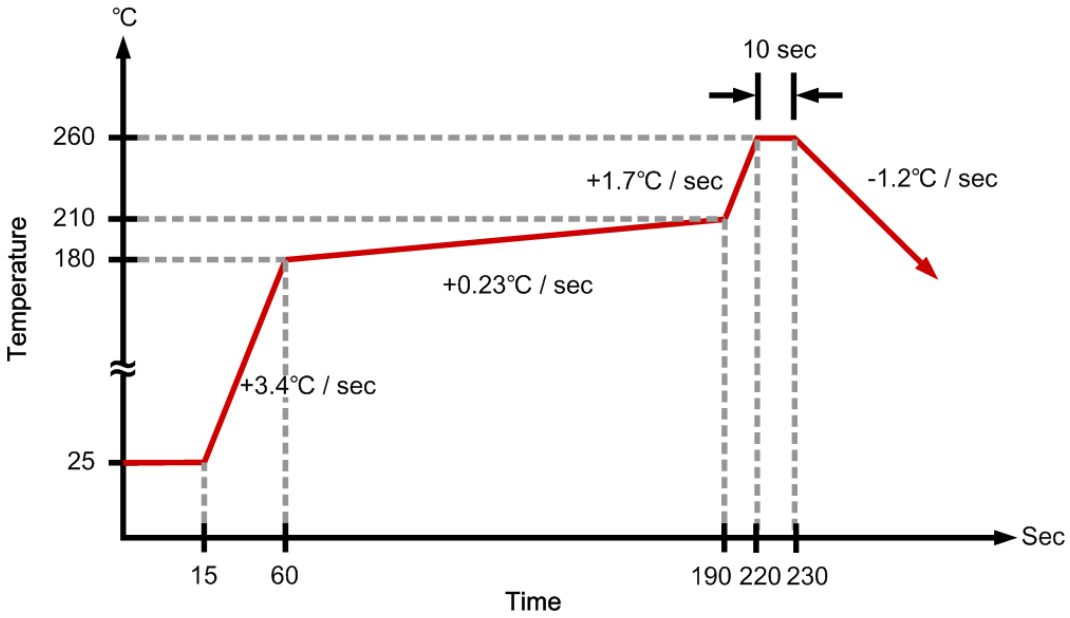
Ordering Information

Part Number	Code	Operating Temperature	Package	MOQ	Description
FP7179LR-G1	BQ	-25°C ~ +85°C	SOT23-6L	3000 EA	Tape & Reel

Absolute Maximum Ratings

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Power Supply Voltage	V_{IN}	V_{IN} to GND			470	V
	V_{DD}	V_{DD} to GND			8	V
CS, DIM, GATE			-0.3		V_{DD}-0.3V	V
Allowable Power Dissipation	P_D	SOT23-6L $T_A \leqq +25°C$			455	mW
Junction to Ambient Thermal Resistance	θ_{JA}				220	°C / W
Operating Temperature			-25		+125	°C
Storage Temperature	T_S	SOT23-6L	-40		+150	°C
SOT23-6L Lead Temperature		(soldering, 10 sec)			+260	°C

IR Re-flow Soldering Curve



Recommended Operating Conditions

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply Voltage	V_{IN}		8		450	V
Operating Temperature			-25		125	°C

DC Electrical Characteristics (V_{IN}=12V,T_A = 25°C, unless otherwise noted)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Internal Regulator						
Internally regulated voltage	V_{DD}	VIN = 8V, $I_{DD(ext)}$= 0, 500pF at GATE;DIM = VDD	7.25	7.5	7.75	V
Line regulation of VDD	$\Delta V_{DD,line}$	VIN = 8 – 450V, $I_{DD(ext)}$=0, 500pF at GATE; DIM = VDD	0	-	1.0	V
Load regulation of V_{DD}	$\Delta V_{DD,load}$	$I_{DD(ext)}$ = 0 – 0.6mA, 500pF at GATE; DIM = VDD	0		100	mV
V_{DD} undervoltage lockout threshold	UVLO	V_{DD} rising	5.25	5.5	5.75	V
V_{DD} undervoltage lockout hysteresis	ΔUVLO	V_{DD} falling		500		mV
Maximum input current	$I_{IN,MAX}$	VIN = 8V, $I_{DD(ext)}$= 0, 500pF at GATE;DIM = VDD		0.8		mA
Average Current Sense Logic						
Current sense reference voltage	V_{CS}		271		283	mV
DIM-to-CS voltage ratio	$A_{V(DIM)}$		0.182		0.188	
DIM-to-CS voltage offset	$AV_{DIM(OFFSET)}$	Offset = $V_{CS} – A_{V(DIM)} \cdot V_{DIM}$ V_{DIM}=1.2V	0		15	mV
CS threshold temp regulation					5	mV
DIM input voltage, shutdown	$V_{DIM(OFF)}$			150		mV
DIM input voltage, enable	$\Delta V_{DIM(OFF)}$			200		mV
Current sense blanking interval	T_{BLANK}		150		320	ns
Minimum steady-state duty cycle	$T_{ON(min)}$	CS=V_{CS} + 30mV			1000	ns
Short Circuit Protection						
Hiccup threshold voltage	V_{CS}		495	550	605	mV
Current limit delay CS - GATE	T_{DELAY}	CS=V_{CS} + 30mV			150	ns
Short circuit hiccup time	T_{HICCUP}		450	550	650	us
Minimum on-time (short circuit)	$T_{ON(min)}$	CS=V_{DD}			600	ns
GATE Driver						
GATE sourcing current	I_{SOURCE}	V_{GATE} = 0V, V_{DD} = 7.5V	165			mA
GATE sinking current	I_{SINK}	V_{GATE} = V_{DD}, V_{DD} = 7.5V	165			mA
GATE output rise time	t_{RISE}	C_{GATE} = 500pF, V_{DD} = 7.5V		30	50	ns
GATE output fall time	t_{FALL}	C_{GATE} = 500pF, V_{DD} = 7.5V		30	50	ns

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
OFF-Time						
Maximum off-time	$T_{OFF(MAX)}$			60		us

Notes:

$$T_{OFF} = \frac{0.6 \times L \times I_{LED(AVG)}}{V_{LED(MAX)}}$$

Function Description

Input Voltage Regulator

The FP7179 can be powered directly from its VIN pin and can work from 8.5 - 450VDC at its VIN pin. When a voltage is applied at the VIN pin, the FP7179 maintains a constant 7.5V at the VDD pin. This voltage is used to power the IC and any external resistor dividers needed to control the IC. The VDD pin must be bypassed by a low ESR capacitor to provide a low impedance path for the high frequency current of the output GATE driver.

The FP7179 can also be operated by supplying a voltage at the VDD pin greater than the internally regulated voltage. This will turn off the internal linear regulator of the IC and the FP7179 will operate directly off the voltage supplied at the VDD pin. Please note that this external voltage at the VDD pin should not exceed 8.5V.

Although the VIN pin of the FP7179 is rated up to 450V, the actual maximum voltage that can be applied is limited by the power dissipation in the IC. For example, if an 6-pin SOT23-6 (junction to ambient thermal resistance Rθ,j-a = 220°C/ W) FP7179 draws about I_{IN} = 1mA from the VIN pin, and has a maximum allowable temperature rise of the junction temperature limited to about ΔT = 100°C, the maximum voltage at the VIN pin would be:

$$V_{IN(MAX)} = \frac{\Delta T}{R_{\theta,j\ a}} \times \frac{1}{I_{in}} = \frac{100^{o}C}{220^{o}C/W} \times \frac{1}{1mA} = 455V$$

In these cases, to operate the FP7179 from higher input voltages, a Zener diode can be added in series with the VIN pin to divert some of the power loss from the FP7179 to the Zener diode. In the above example, using a 100V Zener diode will allow the circuit to easily work up to 450V.The input current drawn from the VIN pin is represented by the following equation:

$$I_{IN} \approx 0.5mA + Q_G \times f_S$$

In the above equation, f_S is the switching frequency and QG is the GATE charge of the external FET (which can be obtained from the datasheet of the FET).

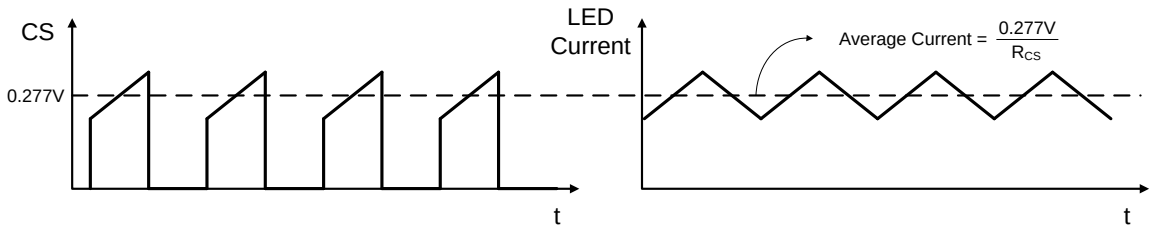
Average Current Control

The LED current is detected using a sense resistor at the CS pin. The feedback operates in a fast open-loop mode. No compensation is required. When the voltage at the DIM input V_{DIM} ≥ 1.5V, output current is programmed simply as:

$$I_{LED}(A)=\frac{0.277V}{R_{CS}(\Omega)}$$

Otherwise:

$$I_{LED}(A)=\frac{V_{LD}(V)\times 0.185}{R_{CS}(\Omega)}$$



The above equations are only valid for continuous conduction of the output inductor. It is a good practice to design the inductor such that the switching ripple current in it is 30~40% of its average peak-to-peak, full load, DC current. Hence, the recommended inductance can be calculated as:

$$L=\frac{V_{IN(DC)}\times V_{LED}-V_{LED}^{2}}{0.6\times I_{LED}\times V_{IN(DC)}\times f}$$

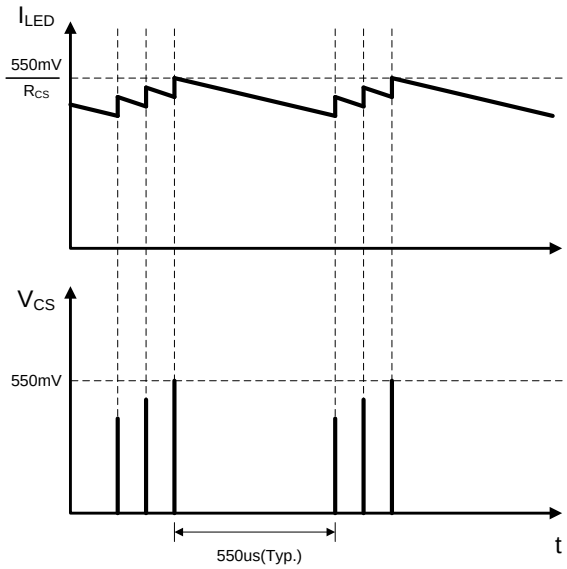
Note: f=switch frequency; $V_{IN(DC)}= V_{AC}\times \sqrt{2}$

GATE Output

The GATE output of the FP7179 is used to drive an external MOSFET. It is recommended that the gate charge QG of the external MOSFET be less than 25nC for switching frequencies ≤100kHz and less than 15nC for switching frequencies >100kHz.

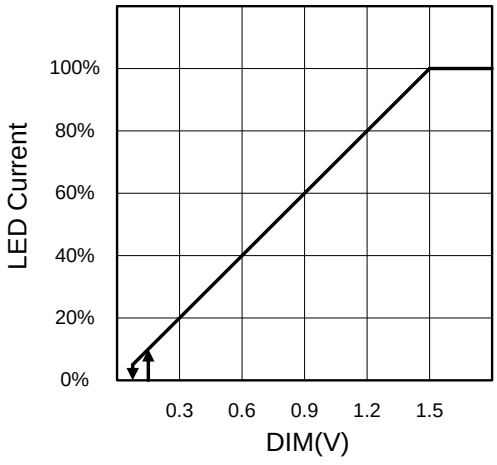
Output Short Circuit Protection

The short circuit protection comparator trips when the voltage at CS exceeds 0.55V. When this occurs, the GATE off-time T_{HICCUP} = 550μs is generated to prevent stair-casing of the inductor current and potentially its saturation due to insufficient output voltage.



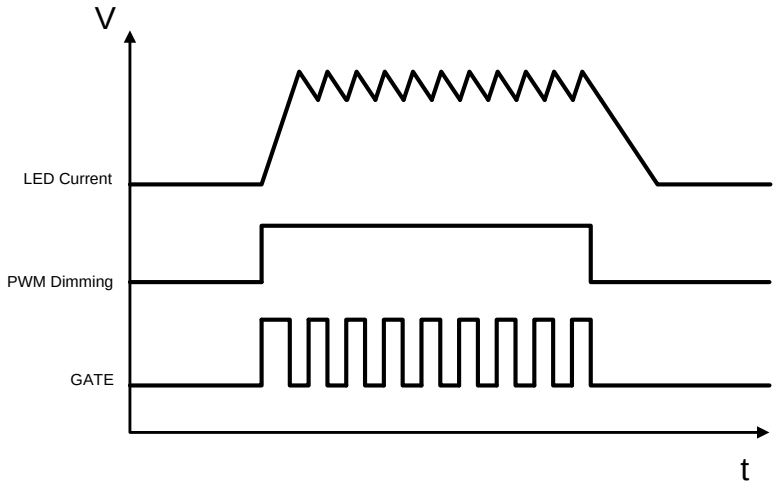
Linear Dimming

When the voltage at DIM falls below 1.5V, the internal 277mV reference to the constant-current feedback becomes overridden by V_{DIM} • 0.185. As long as the current in the inductor remains continuous, the LED current is given by the equation above. However, when V_{DIM} falls below 150mV, the GATE output becomes disabled. The GATE signal recovers, when V_{DIM} exceeds 200mV. This is required in some applications to be able to shut the LED lamp off with the same signal input that controls the brightness.



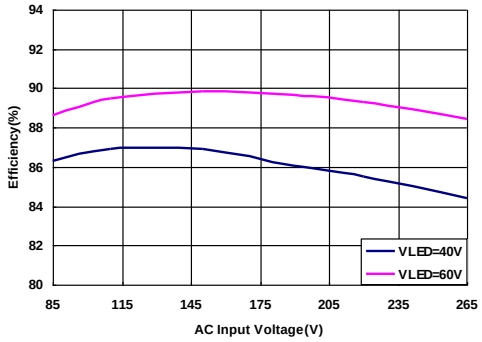
PWM Dimming

Due to the fast open-loop response of the average-current control loop of the FP7179, its PWM dimming performance nearly matches that of the FP7171.

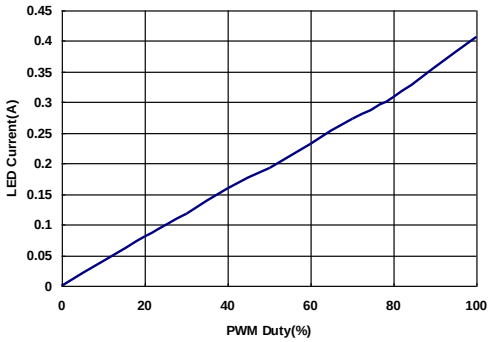


The rising and falling edges are limited by the current slew rate in the inductor. The first switching cycle is terminated upon reaching the 277mV (VDIM • 0.185) level at CS. The circuit is further reaching its steady-state within 1 switching cycles regardless of the switching frequency.

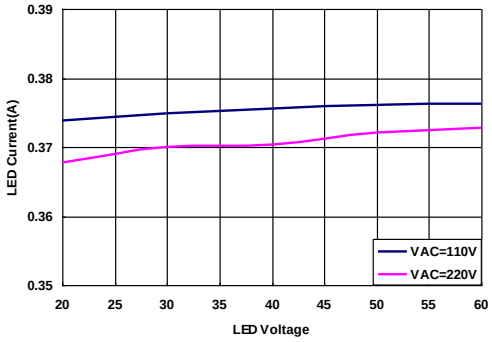
Efficiency



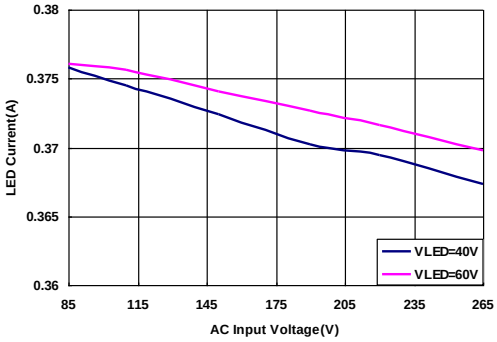
PWM Duty VS LED Current



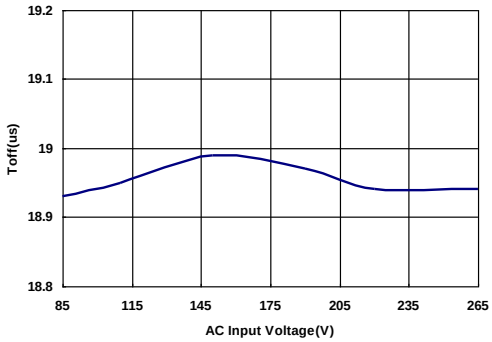
Load Regulation



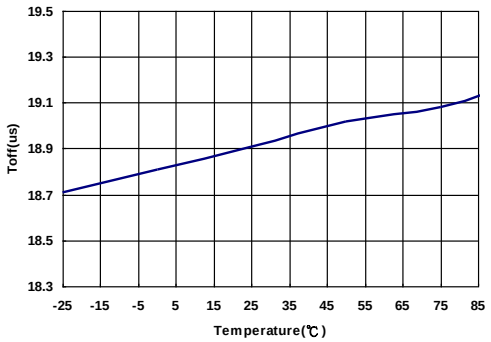
Line Regulation

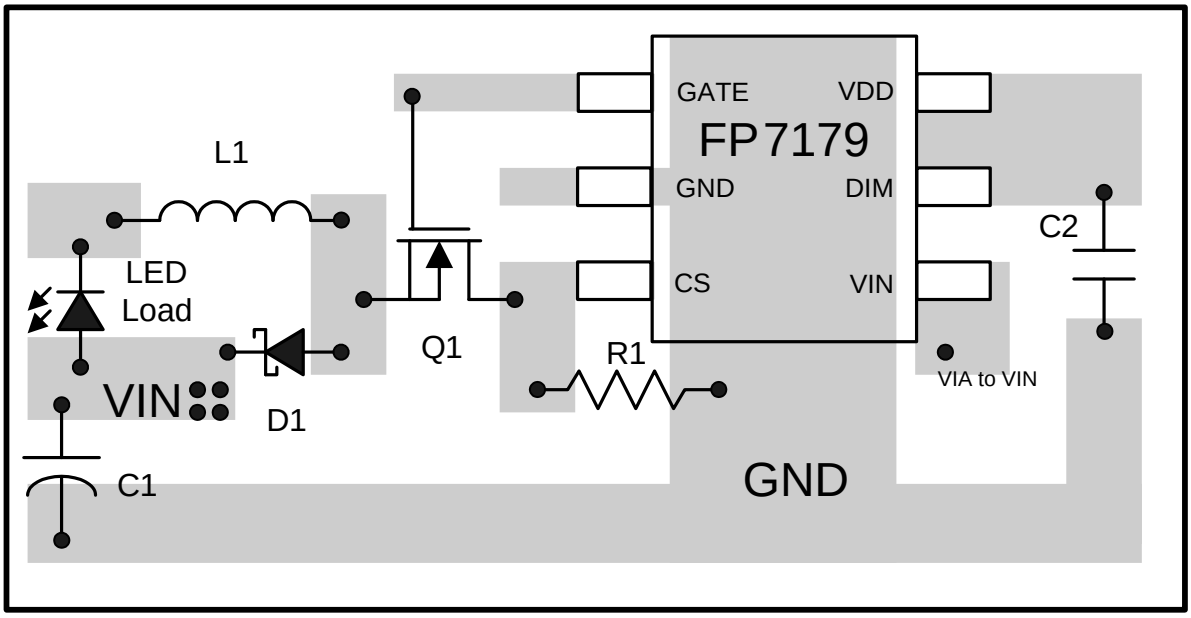


AC Input Voltage VS Toff



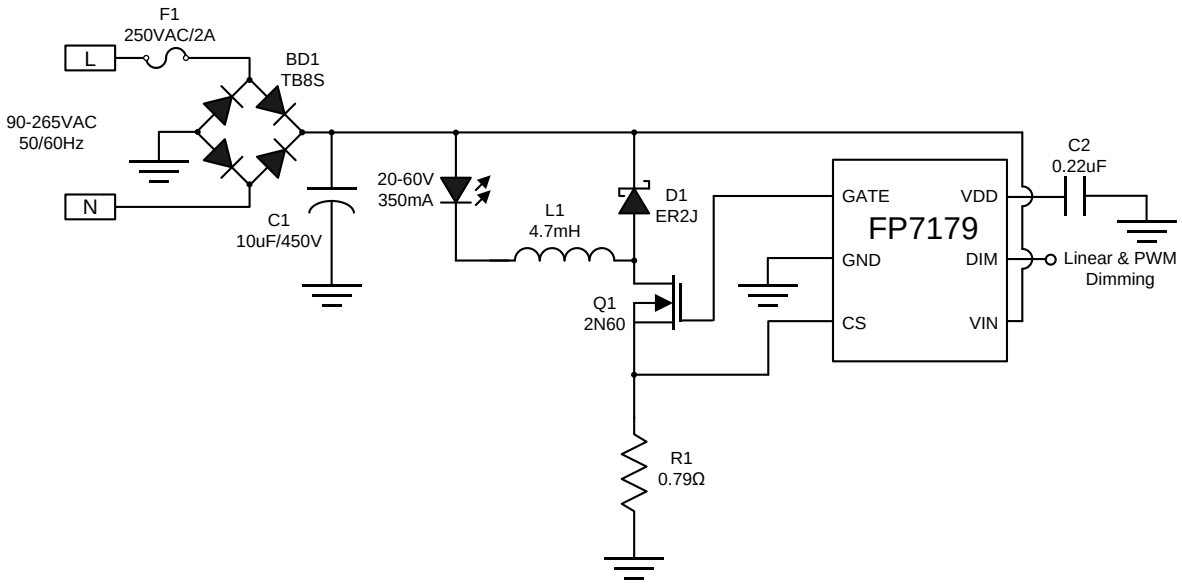
Temperature VS Toff





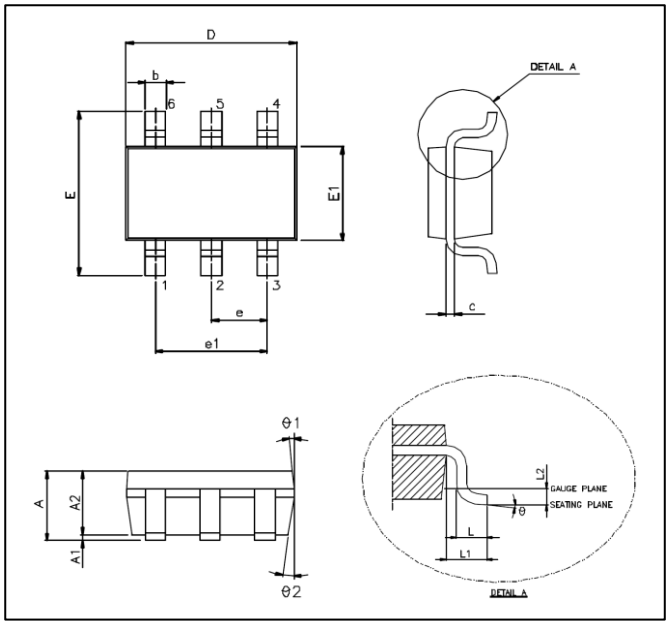
Suggested Layout

Typical Application Circuit



Package Outline

SOT23-6L



Unit: mm

Symbols	Min. (mm)	Max. (mm)
A	1.050	1.450
A1	0.050	0.150
A2	0.900	1.300
b	0.300	0.500
c	0.080	0.220
D	2.900 BSC	
E	2.800 BSC	
E1	1.600 BSC	
e	0.950 BSC	
e1	1.900 BSC	
L	0.300	0.600
L1	0.600 REF	
L2	0.250 BSC	
θ°	0°	8°
θ1°	3°	7°
θ2°	6°	15°

Note:

1. Package dimensions are in compliance with JEDEC outline: MO-178 AB.
2. Dimension “D” does not include molding flash, protrusions or gate burrs.
3. Dimension “E1” does not include inter-lead flash or protrusions.