KTD257M

39V/26V Step-Up LED Driver with Wide Range PWM Control

Features

- Wide output range: up to 10 series LEDs
- Integrated 40V high current switch (0.9A limit)
- V_{IN}: 2.7V to 5.5V
- High efficiency PWM converter (up to 90%)
- Low 200mV feedback voltage
- LED open-circuit (OVP) protection
  - KTD257M: 39V
- High switching frequency
  - KTD257M: 900kHz
- PWM dimming frequency: 100Hz~200kHz
- Simple, small solution size
- Integrated Softstart
- < 1 µA shutdown current
- Small TSOT23-6 Package
- RoHS and Green compliant
- -40°C to +85°C Temperature Range

Applications

- LED backlighting
- Mobile Phones
- Handheld Devices
- Digital Photo Frames
- Automotive Navigation

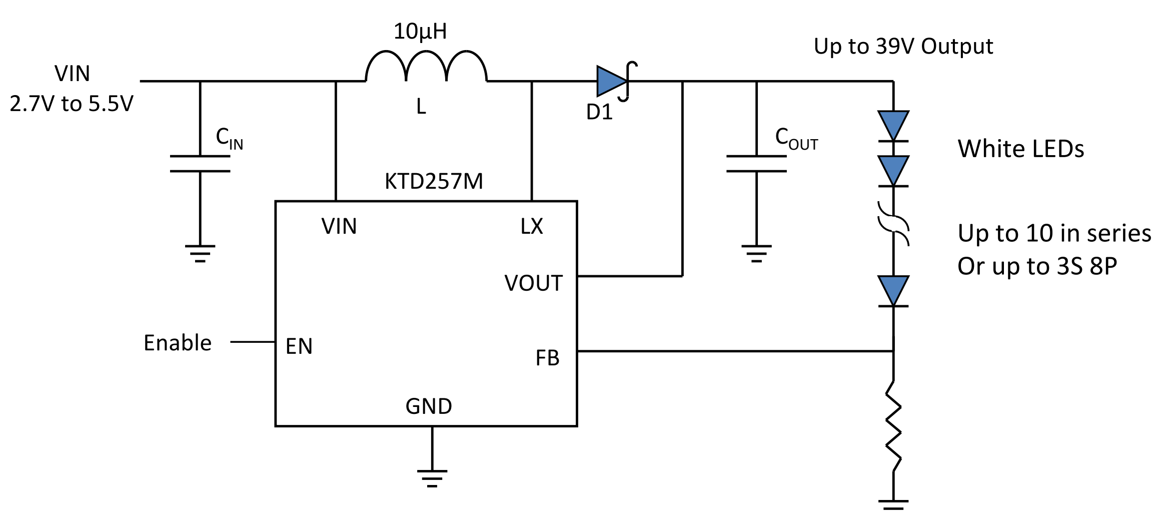
Brief Description

The KTD257M is a versatile constant current LED driver with a high efficiency DC-DC step up "boost" converter architecture. The low-side power MOSFET is integrated in the device, minimizing the total number of external components. Unique technology and high 0.9A current limit allow KTD257M to drive up to 39V output (10 LEDs in series). Alternatively, KTD257M can deliver 160mA total current with 3 series LEDs per string. It can also maximize the current capability while achieving high conversion efficiency. The optimized 900kHz switching frequency results in small external component size. The driver allows wide range of PWM dimming frequency through EN pin.

Various protection features are built into the KTD257M, including cycle-by-cycle input current limit protection, LED open-circuit (output over voltage) protection and thermal shutdown protection. The leakage current in shutdown mode is less than 1µA.

The KTD257M is available in a RoHS and Green compliant 6-lead TSOT23 package.

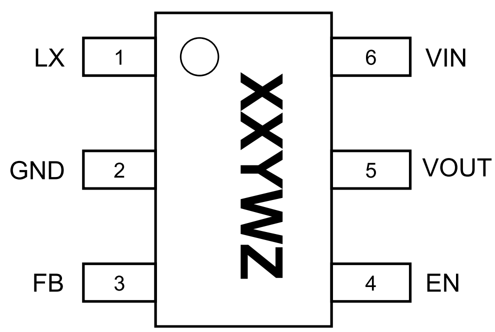
Typical Application



Pin Descriptions

Pin #	Name	Function
1	LX	Converter switching node
2	GND	Converter/IC ground
3	FB	Output feedback pin regulated at 0.2V
4	EN	IC enable and PWM dimming control pin. A logic High signal enables converter. A PWM signal on this pin controls LED average conduction current.
5	VOUT	Converter output and over-voltage protection sensing pin
6	VIN	IC supply voltage

TSOT23-6
(Top View)



Top Mark

TSOT23-6 Package

(2.90mm x 2.80mm x 0.85mm)

XX = Device ID Code, YW = Date Code, Z = Serial Number

Absolute Maximum Ratings[1]

(T_A = 25°C unless otherwise noted)

Symbol	Description	Value	Units
VIN	Input voltage	-0.3 to 6.0	V
LX, VOUT	High voltage nodes	-0.3 to 44	V
FB, EN	Other pins	-0.3 to VIN+0.3	V
T_J	Operating Temperature Range	-40 to 150	°C
T_S	Storage Temperature Range	-65 to 150	°C
T_{LEAD}	Maximum Soldering Temperature (at leads, 10 sec)	300	°C

Thermal Capabilities

Symbol	Description	Value	Units
θ_{JA}	Thermal Resistance – Junction to Ambient[2]	190	°C/W
P_D	Maximum Power Dissipation at $T_A \leq 25°C$	0.526	W
ΔP_D/°C	Derating Factor Above T_A = 25°C	-5.26	mW/°C

Ordering Information

Part Number	OVP Threshold (nominal)	Marking[3]	Operating Temperature	Package
KTD257MEHD-TR	39V	EDYWZ	-40°C to +85°C	TSOT23-6

1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum rating should be applied at any one time.

2. Junction to Ambient thermal resistance is highly dependent on PCB layout. Values are based on thermal properties of the device when soldered to an EV board.

3. ED = Device ID Code, YW = Date Code, Z = Serial Number.

Electrical Characteristics[4]

Unless otherwise noted, T_A = 25°C, VIN = 3.6V

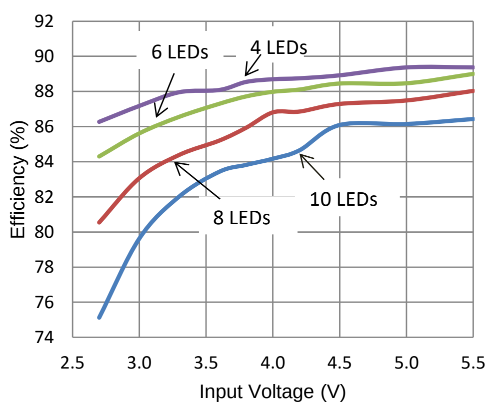
Symbol	Description	Conditions	Min	Typ	Max	Units
IC Supply						
V_{IN}	Input operating range		2.7		5.5	V
UVLO	Input under voltage lockout	Rising edge		2.5	2.65	V
$UVLO_{HYST}$	UVLO hysteresis			0.15		V
I_Q	IC quiescent current (non switching)	FB = 0.4V		0.28	0.5	mA
	IC operating current (switching)	FB = 0V		0.7	1.65	mA
I_{SHDN}	VIN pin shutdown current	EN = GND		0.1	1.0	µA
Step-Up Converter						
V_{FB}	FB pin accuracy		0.18	0.2	0.22	V
I_{FB}	FB pin bias current				0.1	µA
$R_{DS(ON)}$	NMOS on-resistance			0.65	1.1	Ω
I_{LX}	LX pin leakage current			0.1		µA
I_{LIM}	Peak NMOS current limit			0.9		A
F_{SW}	Oscillator frequency			0.9		MHz
D_{max}	Maximum duty cycle		92	95		%
OVP	Over voltage threshold	Measured at VOUT pin		39		V
T_S	Start-up time			400		µs
Control						
V_{TH-L}	Logic low threshold				0.4	V
V_{TH-H}	Logic high threshold		1.4			V
T_{OFF}	EN low to shutdown time			3		ms
F_{EN}	Dimming frequency		0.1		200	kHz
D_{PWM_MIN}	PWM dimming duty cycle resolution	f_{DIM} = 5kHz	1			%
		f_{DIM} = 30kHz	1			
T_{J-TH}	IC junction thermal shutdown threshold			150		°C
	IC junction thermal shutdown hysteresis			15		°C

4. The KTD257M is guaranteed to meet performance specifications over the –40°C to +85°C operating temperature range by design, characterization and correlation with statistical process controls.

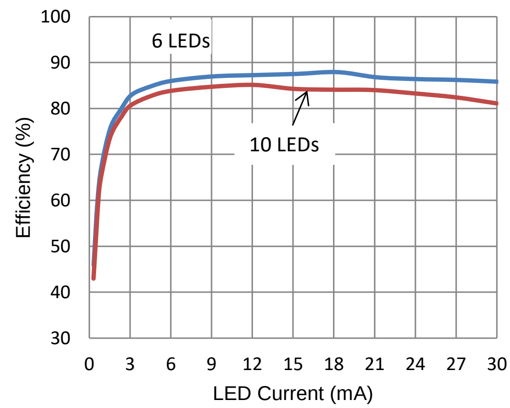
Typical Characteristics

V_{IN} = 3.6V, L = 10µH, C_{IN} = 10µF, C_{OUT} = 0.47µF with 10 LEDs in series at 20mA, T_{AMB} = 25° C unless otherwise specified.

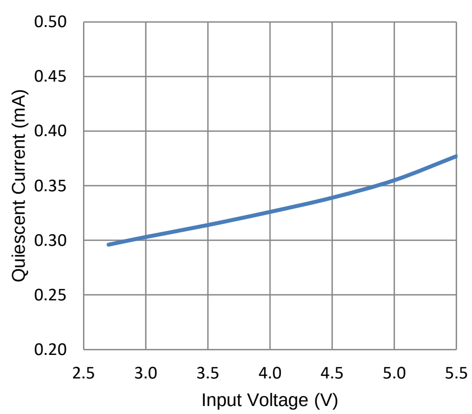
Efficiency vs. Input Voltage



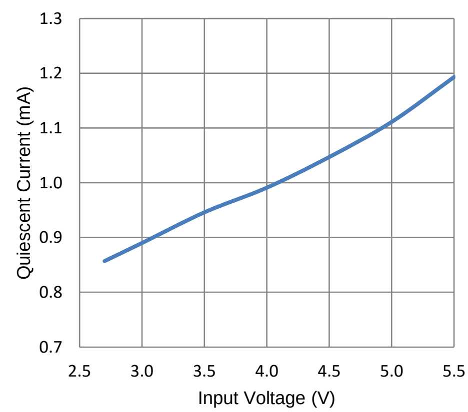
Efficiency vs. LED Current



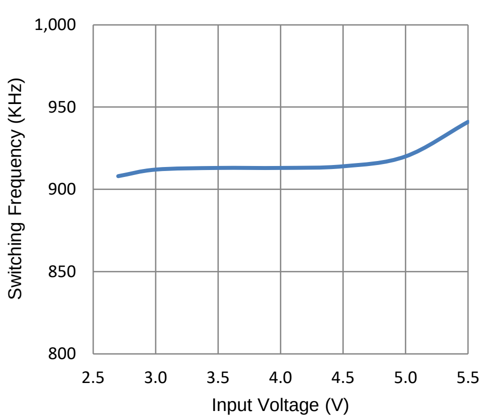
Operating Current (non-switching)



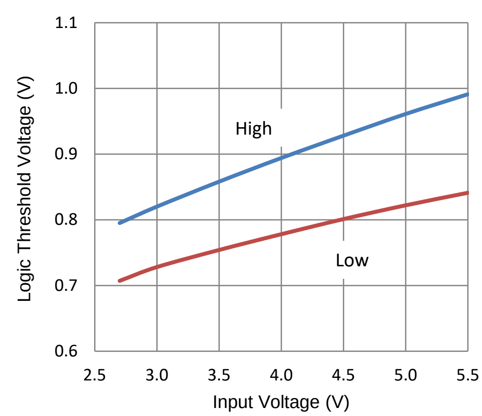
Operating Current (switching)



Switching Frequency



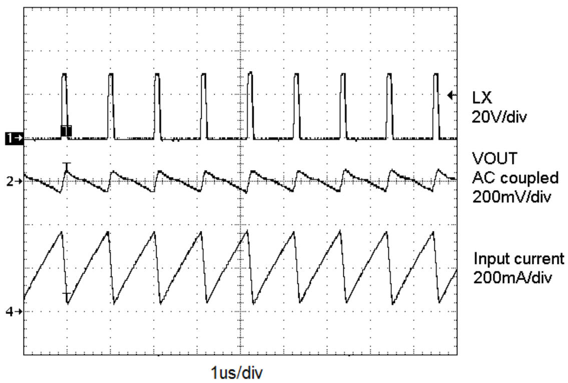
EN Logic Threshold Voltage



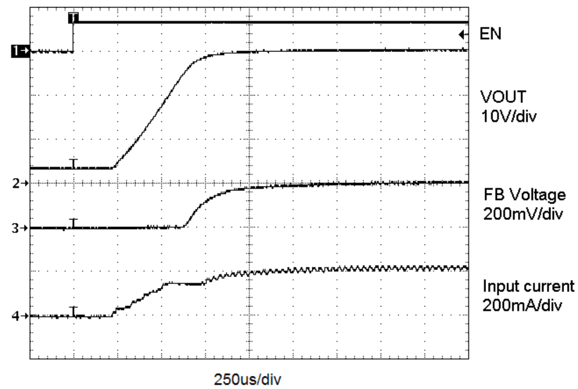
Typical Characteristics (continued)

V_{IN} = 3.6V, L = 10µH, C_{IN} = 10µF, C_{OUT} = 0.47µF with 10 LEDs in series at 20mA, T_{AMB} = 25° C unless otherwise specified.

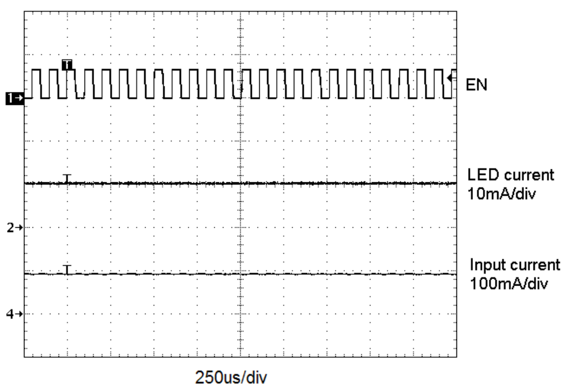
Steady State Switching



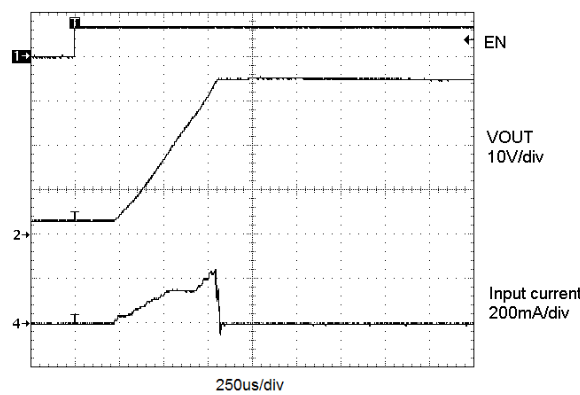
Soft Start Turn On



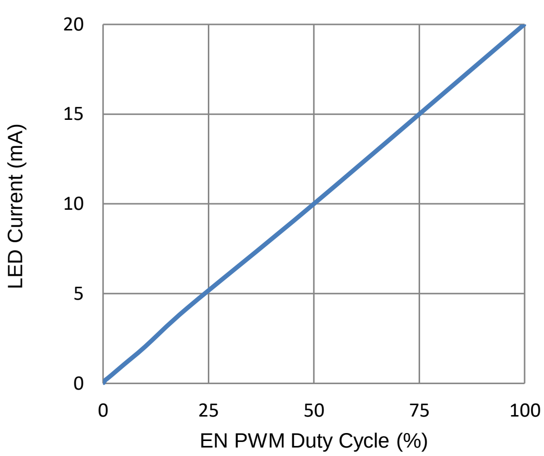
PWM Dimming (10kHz)



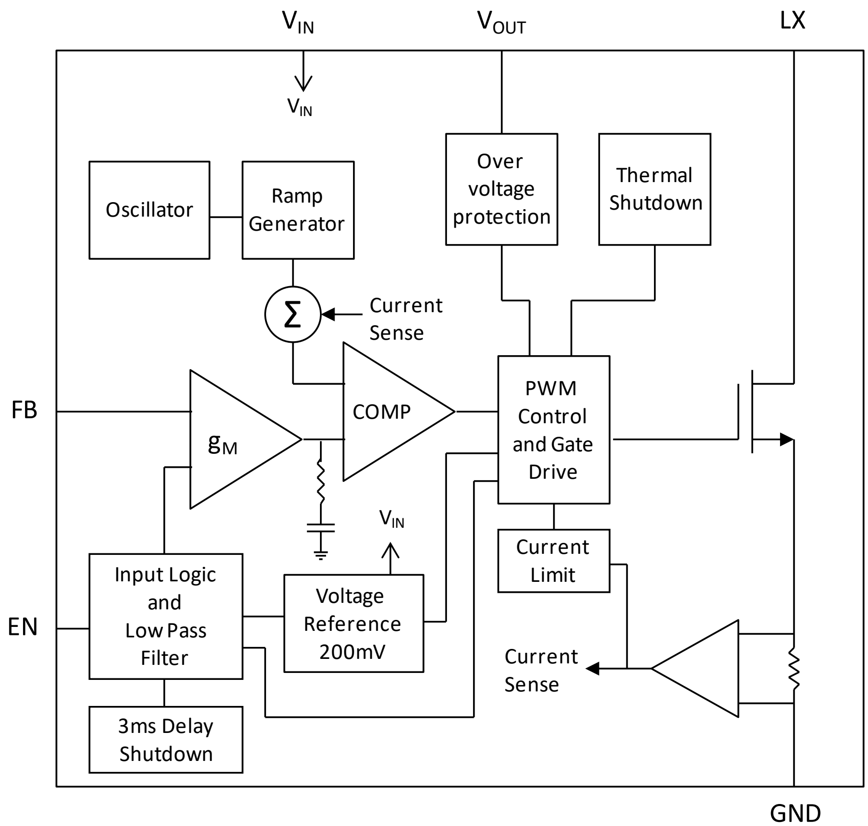
Turn On with LED Open (OVP)



EN PWM Dimming (20kHz)



Functional Block Diagram



Functional Description

The KTD257M uses a constant-frequency current-mode boost converter architecture to control the LED current by regulating the feedback voltage. Please refer to the functional block diagram above for an explanation of KTD257M operation. The beginning of each cycle turns on the Power MOSFET. A slope compensation ramp is added to the output of the current sense amplifier and the result is fed into the positive input of the comparator (COMP). When this voltage goes above the output voltage of the error amplifier (g_M), the Power MOSFET is turned off. The voltage at the output of the g_M block amplifies the difference between the reference voltage and the feedback voltage (FB), so that FB voltage can be regulated to the reference voltage.

The KTD257M has built-in soft-start to limit the inrush current during startup and to limit the amount of overshoot on the output. Protection features in the KTD257M include over-voltage protection (OVP), cycle-by-cycle current limit protection and thermal shutdown. OVP protects in the event where an LED fails open, which forces the feedback voltage to zero. This causes the boost converter to operate in maximum duty cycle mode, ramping up the output voltage. Switching will stop when the output reaches the OVP threshold. The OVP feature protects the IC from damaging itself by exceeding the voltage rating on LX/VOUT pins.

Application Information

Inductor Selection

A 10µH to 22µH inductor is recommended for 10/8/6-Series LED applications and 3S8P LED applications. If high efficiency is a critical requirement, a low DCR inductor should be selected. The inductor's saturation current rating should also exceed the peak input current, especially for high load current application (like 3S8P).

Table 1. Recommended Inductor Part Numbers

Application	Inductor Part Number	Value (µH)	DCR (Ω)	Saturation Current (A)	Dimensions (mm)	Manufacturer
20mA, 6-series LEDs	LQH3NPN100NM0	10	0.26	0.55	3.0 x 3.0 x 1.4mm	Murata www.murata.com
20mA, 6-series LEDs	LQH3NPN100NG0	10	0.57	0.5	3.0 x 3.0 x 0.9mm	Murata www.murata.com
20mA, 10-series LEDs	LQH55DN220M03L	22	0.19	1.2	5.7 x 5.0 x 4.7mm	Murata www.murata.com
20mA, 6-series LEDs	LQH3NPN220NG0	22	1.1	0.34	3.0 x 3.0 x 0.9mm	Murata www.murata.com
20mA, 6-series LEDs	CDR7D43MNNP-220N	22	0.085	2.85	7.6 x 7.6 x 4.5mm	Sumida www.sumida.com
20mA, 6-series LEDs	744043220	22	0.185	0.7	4.8 x 4.8 x 2.8mm	Wurth Elektronik www.we-online.com

Capacitor Selection

Small size ceramic capacitors are ideal for KTD257M application. A 10µF input capacitor and a 0.47µF output capacitor are suggested for 10/8/6-Series LED applications. For high output current applications like 3S8P, larger value output capacitors like 2.2µF is recommended to minimize output ripple.

Table 2. Recommended Ceramic Capacitor Vendors

Manufacturer	Website
Murata	www.murata.com
AVX	www.avx.com
Taiyo Yuden	www.t-yuden.com

Diode Selection

Using a schottky diode is recommended in KTD257M applications because of its low forward voltage drop and fast reverse recovery time. The current rating of the schottky diode should exceed the peak current of the boost converter. The voltage rating should also exceed the target output voltage.

Table 3. Recommended Schottky Diode Part Numbers

Application	Schottky Diode Part Number	Forward Voltage (V)	Forward Current (mA)	Reverse Voltage (V)	Manufacturer
20mA, 8/10-series LEDs, 39V OVP	B150	0.75	1000	50	Vishay www.vishay.com

Typical Application Circuits

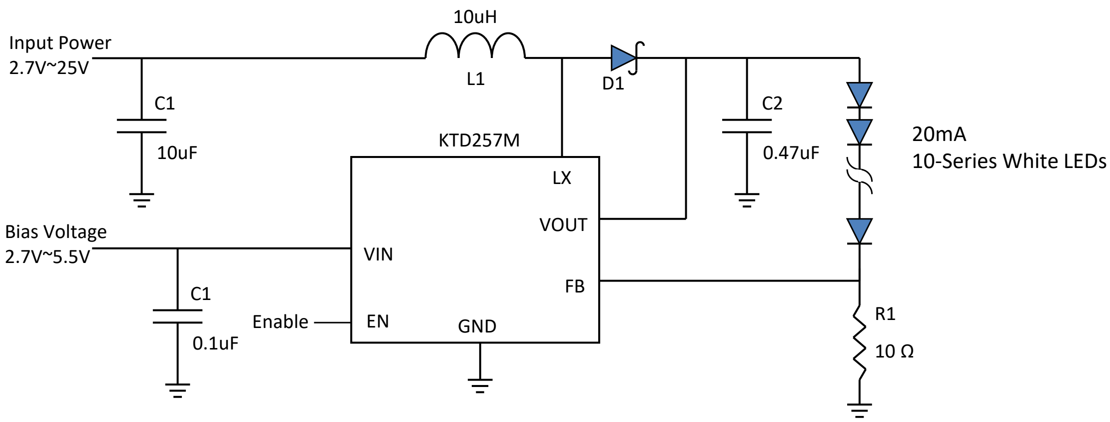


Figure 1. Application Circuit for 10 LEDs in Series with 20mA Current (VIN can be tied to input power rail if less than 5.5V)

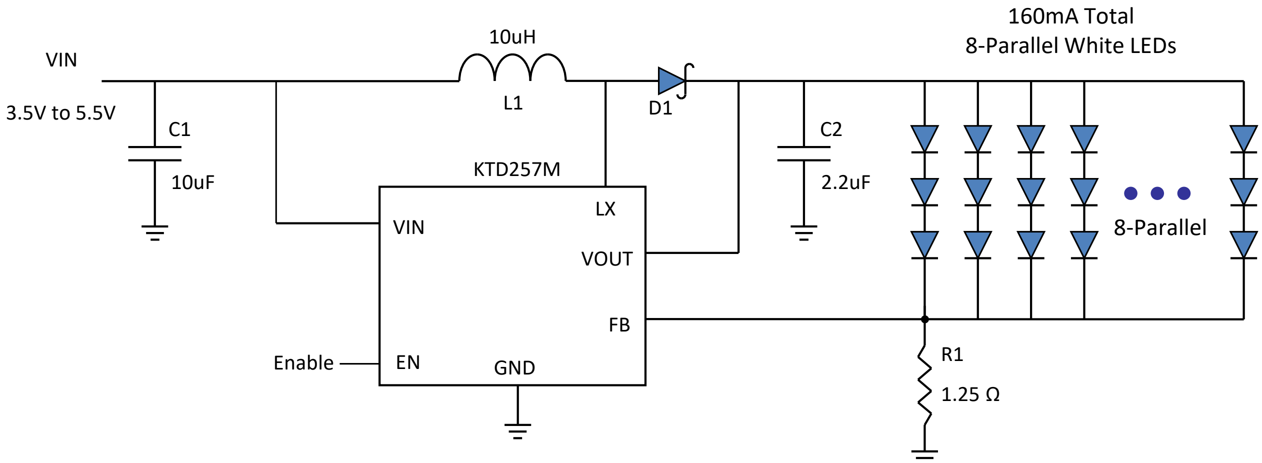


Figure 2. Application Circuit for 24 LEDs at 160mA Total Current (3-Series, 8-Parallel)

LED Current Setting

LED current is determined by the feedback resistor (R1 in Figure 1 and Figure 2 above). The feedback voltage is internally set at 200mV. The LED current is programmed according to the formula I = 200mV/R1. For accurate LED current settings, precision 1% resistors are recommended. The formula and table for R1 selection are shown below.

$$R1 = 200mV / I_{LED}$$

Table 4. Current Setting Resistor (1% Values)

R1 (Ω) 1% Values	Current (mA)
200	1
40.2	5
20.0	10
13.3	15
10.0	20
6.65	30
2.00	100
1.33	150
1.00	200
0.768	260

LED Dimming Control

Below there are five different LED dimming control methods described:

1. Using a PWM Signal to EN Pin

With the PWM signal applied to the EN pin, the KTD257M is correspondingly turned ON or OFF by the PWM signal. The LEDs alternate between zero and full programmed current. The average LED current increases proportionally with the duty cycle of the PWM signal. A 0% duty cycle PWM signal will turn off the KTD257M and corresponds to zero LED current. A 100% duty cycle PWM signal turns on the LEDs continuously at full current. The typical frequency range of the PWM signal is 100Hz to 200kHz.The magnitude of the PWM signal should be higher than the minimum EN voltage HIGH specification. The KTD257M has an internal RC filter which creates a DC average of the PWM duty cycle. The -3dB cutoff frequency of the low pass filter is 360Hz. PWM control signals with low frequencies will not be filtered which means a PWM ripple can pass to the output; however, the average output current is continuously proportional to the PWM control signal regardless of the ripple amplitude. For systems which are sensitive to audible noise, it is recommended to use PWM frequencies greater than 5kHz.

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 should make the current from the variable DC source much smaller than the LED current and much larger than the FB pin leakage current. The formula for LED current is

$$I_{LED} = \left(1 + \frac{R2}{R3}\right) \times \frac{V_{FB}}{R1} - \frac{R2}{R3} \times \frac{V_{DC}}{R1}$$

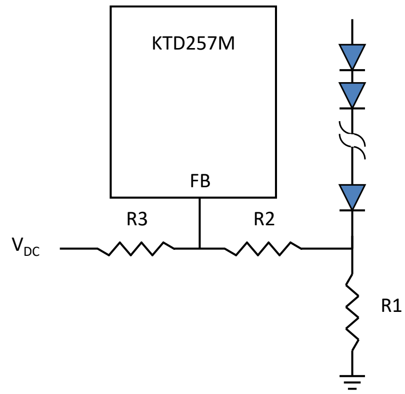


Figure 3. Dimming Control using a DC voltage

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. The circuit is shown in Figure 4. This method can be used for higher frequency PWM signals compared to method #1 above. The magnitude of the PWM signal will affect the final result. The formula for LED current is

$$I_{LED} = \left(1 + \frac{R2}{R3 + R4}\right) \times \frac{V_{FB}}{R1} - \frac{R2}{R3 + R4} \times \frac{A_{PWM} \cdot D_{PWM}}{R1},$$

where APWM is the magnitude of the PWM signal, and DPWM is the duty cycle of the PWM signal. This method doesn't have a PWM frequency upper limit, but the minimum PWM duty cycle requirement must be considered from system standpoint when the PWM frequency is high. The lower limit of the PWM frequency is controlled by the RC filter, PWM frequency should be higher than the cutoff frequency of the RC filter.

The following example in Figure 4 shows the LED current dimming range from 0mA to 22mA. The PWM frequency range can vary from 200Hz to 100kHz. In this example, the PWM signal voltage is 0V to 2.5V, 0% duty cycle results in maximum LED current of 22mA, and 95% duty cycle or more results in 0mA LED current. Figure 5 shows the PWM dimming linearity test result with 1kHz PWM frequency. Figure 6 shows the LED current across a range of PWM frequency.

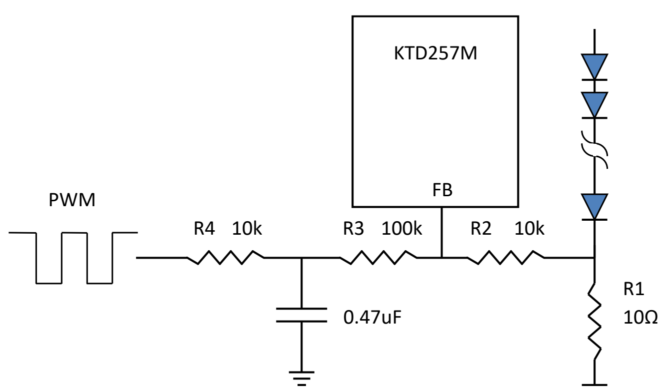


Figure 4. Dimming Control using an RC Filtered PWM Signal

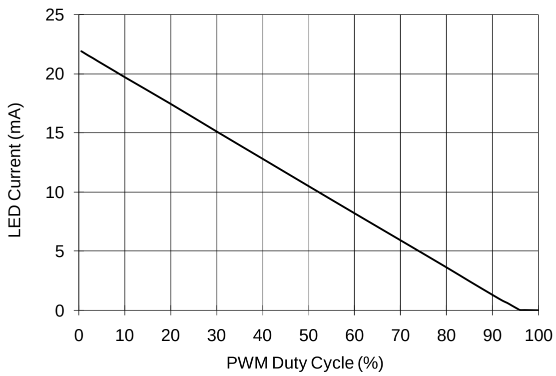


Figure 5. RC Filtered PWM Dimming Linearity (1kHz)

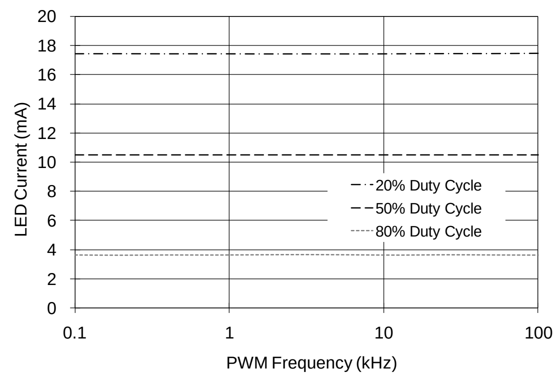


Figure 6. LED Current vs RC Filtered PWM Frequency

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 7. R1 sets the minimum LED current (when the NMOS is off). R3 sets how much the LED current increases when the NMOS is turned on. The $R_{DS(ON)}$ of the NMOS should be much smaller than R3 in this method.

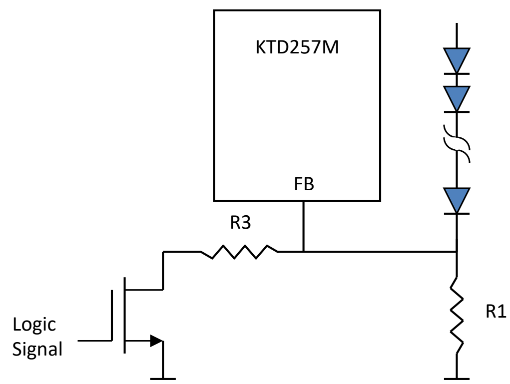


Figure 7. Dimming Control using a Logic Signal

LED Minimum Dimming Current Setting

LED dimming current can be programmed to very low levels by applying a PWM dimming duty ratio. However, due to the internal offset of the LED driver control loop, the LED current's absolute accuracy decreases with lower PWM dimming duty ratio. It is recommended to set the minimum LED dimming PWM duty ratio to at least 15% for reasonable accuracy and device-to-device matching.

Layout Considerations

PCB layout is very important for high frequency switching regulators in order to keep the loop stable and minimize noise. The input capacitor should be very close to the IC to get the best decoupling. For the best performance, an input RC (R = 20Ω, C = 4.7µF) filter is recommended connected to the IC's VIN pin to prevent any interference between the boost converter input and the IC input. It is required for 7 or more LEDs in series. The path of the inductor, schottky diode and output capacitor should be kept as short as possible to minimize noise and ringing. Please see the KTD257M evaluation document for detailed PCB layout guidelines.

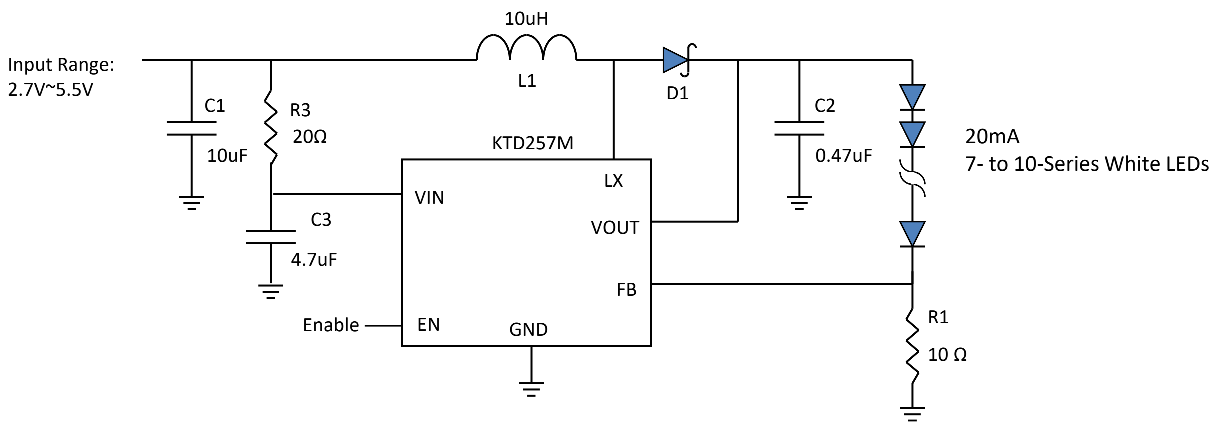


Figure 8. Application Circuit with Input RC Filter (required for 7- to 10-Series LED configuration)

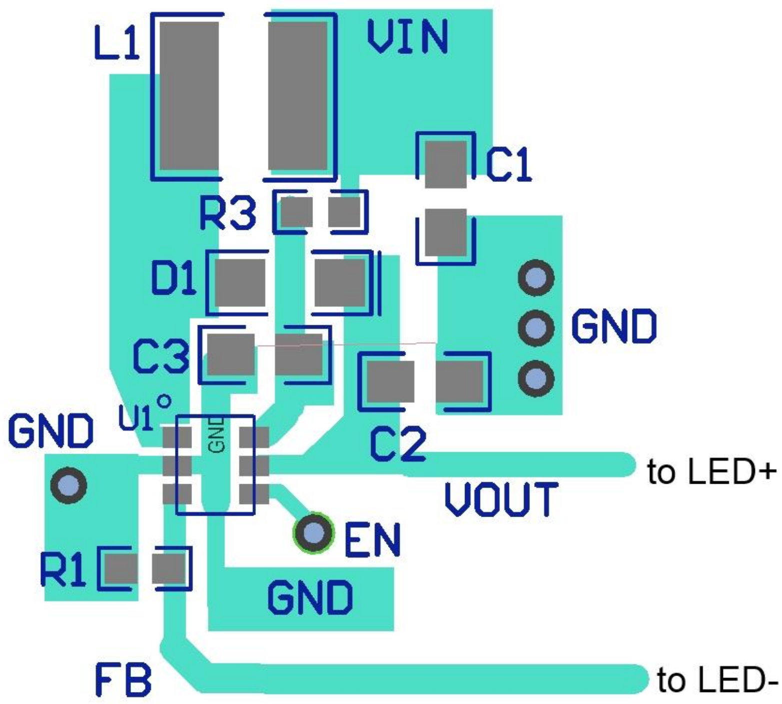
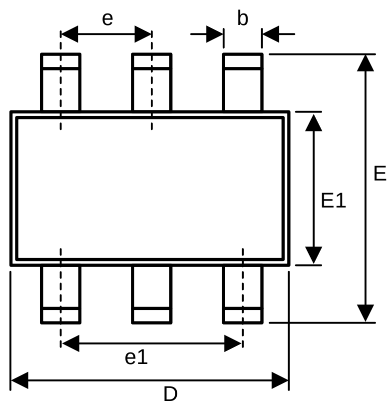


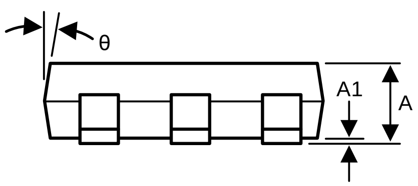
Figure 9. Recommended Layout

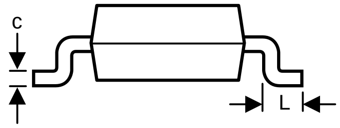
Packaging Information

TSOT23-6 (2.90mm x 2.80mm x 0.85mm)

Top View



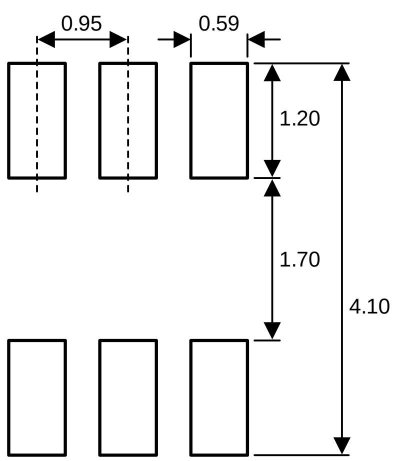




Side View **Side View**

Dimension	mm		
	Min.	Typ.	Max.
A	0.60	0.85	1.10
A1	0.00	0.05	0.19
b	0.30	0.40	0.50
c	0.10	0.15	0.20
D	2.70	2.90	3.10
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	0.95 BSC		
e1	1.90 BSC		
L	0.30	0.45	0.60
θ	4°	–	12°

Recommended Footprint



*Dimensions are in millimeters.