WD3149

High Efficiency, 38V Step-Up White LED Driver in Tiny Thin Package

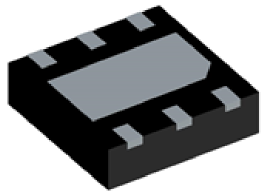
Http//: www.sh-willsemi.com

Descriptions

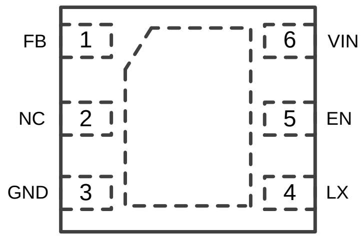
The WD3149 is a constant current, high efficiency LED driver. Internal MOSFET can drive up to 10 white LEDs in series with 1.5A current limit and 38V OVP. The device operates at 1.1MHz fixed switching frequency to reduce output ripple, improve conversion efficiency, and allows for the use of small external components.

The default Full-Scale White LED current is set by an external sensor resistor with regulated 200mV feedback voltage, as shown in typical application. During operation, the LED current can be controlled using the Pulse Width Modulation (PWM) signal applied on the EN pin, through which the PWM Duty-Cycle determines the White LED current. For maximum protection, the device features integrated open LED protection to prevent IC damage as the result of white LED disconnection.

The WD3149 is available in DFN 2mm x 2mm -6L package. Standard product is Pb-free and Halogen-free.



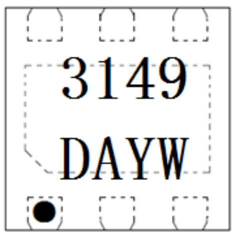
DFN 2x2–6L (Bottom View)



Pin configuration (Top view)

Features

- Input voltage range : 2.7~5.5V
- Open LED Protection : 38V (Typ.)
- Reference Voltage : 200mV (±5%)
- Switching frequency : 1.1MHz (Typ.)
- Efficiency : Up to 91%
- Main switch current limit : 1.5A (Typ.)
- PWM Dimming frequency : 20KHz to100KHz
- PWM Dimming Duty : 0.3%~100%



3149 = Device code
DA = Special code
Y = Year code
W = Week code

Marking

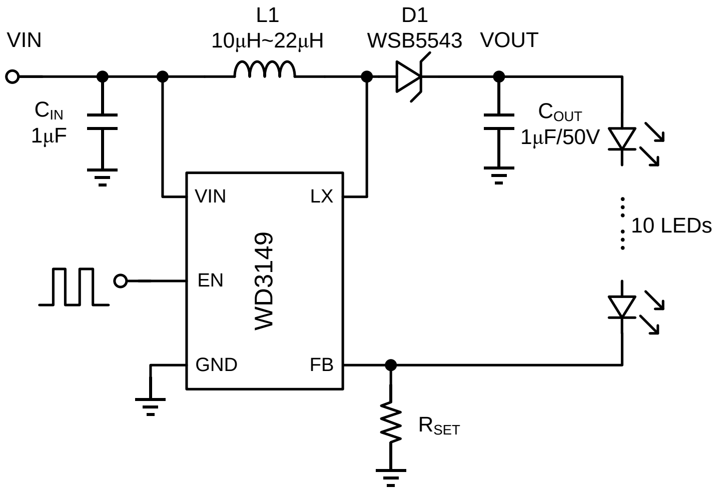
Applications

- Smart Phones
- Tablets
- Portable games

Order information

Device	Package	Shipping
WD3149D-6/TR	DFN2x2-6L	3000/Reel&Tape

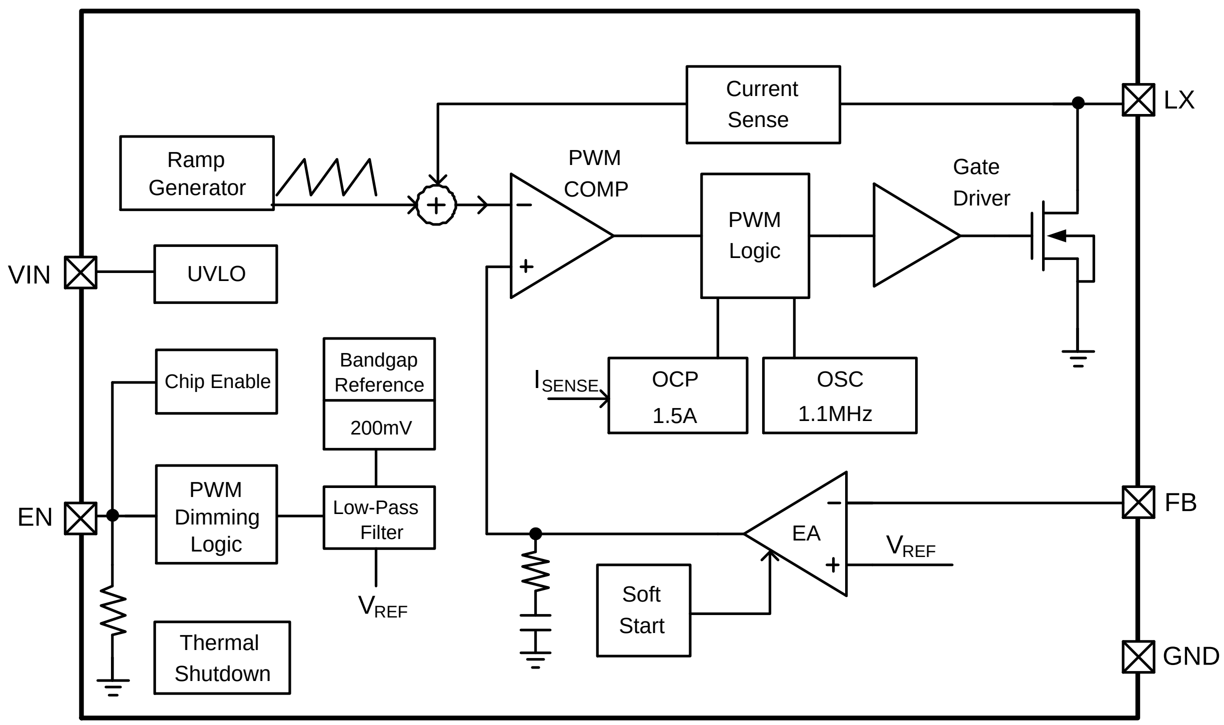
Typical applications



Pin descriptions

Symbol	Pin No.	Descriptions
FB	1	Feedback
NC	2	No Connection
GND	3	Ground
LX	4	Switch Output
EN	5	Enable, Active High
VIN	6	Power Supply

Block diagram



Absolute maximum ratings

Parameter	Symbol	Value	Unit
VIN pin voltage range	V_{IN}	-0.3～6.5	V
EN pin voltage range	V_{EN}	-0.3～V_{IN}	V
LX pin voltage range	V_{LX}	-0.3～45	V
FB pin voltage range	V_{FB}	-0.3～40	V
Power Dissipation – DFN-2x2-6L (Note 1)	P_D	1.5	W
Power Dissipation – DFN-2x2-6L (Note 2)		0.7	W
Junction to Ambient Thermal Resistance – DFN-2x2-6L (Note 1)	$R_{\theta JA}$	65	ºC/W
Junction to Ambient Thermal Resistance – DFN-2x2-6L (Note 2)		140	ºC/W
Junction temperature	T_J	150	ºC
Lead temperature(Soldering, 10s)	T_L	260	ºC
Operation temperature	Topr	-40 ~ 85	ºC
Storage temperature	Tstg	-55 ~ 150	ºC

These are stress ratings only. Stresses exceeding the range specified under “Absolute Maximum Ratings” may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Note 1: Surface mounted on FR-4 Board using 1 square inch pad size, dual side, 1oz copper
Note 2: Surface mounted on FR-4 board using minimum pad size, 1oz copper

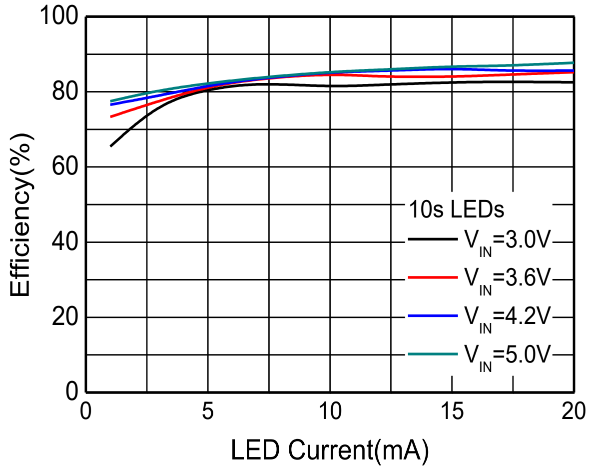
Electronics Characteristics

(T_a=25ºC, V_{IN}=3.6V, V_{EN}=V_{IN}, C_{IN}=C_{OUT}=1uF, unless otherwise noted)

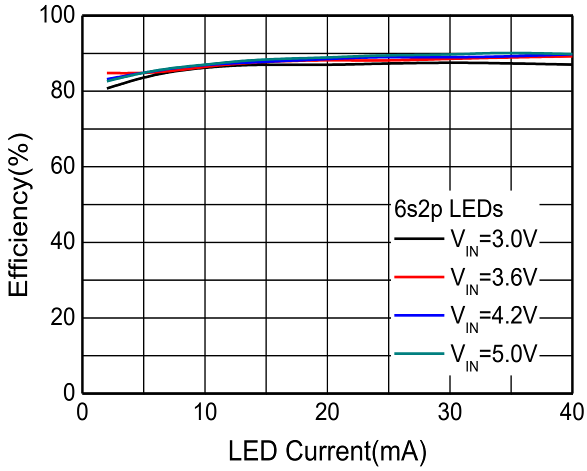
Parameter	Symbol	Test Condition	Min	Typ	Max	Units
Operation Voltage Range	V_{IN}		2.7	--	5.5	V
Under Voltage Lockout	V_{UVLO}	V_{IN} Rising	1.8	2.3	2.5	V
UVLO Hysteresis	$V_{UVLO-HYS}$			0.15		V
Open LED Protection Threshold	V_{OLP}		36	38	40	V
Quiescent Current	I_Q	No Switching		0.2	1	mA
Supply Current	I_S	Switching		1.2	3	mA
Shutdown Current	I_{SD}	V_{EN} < 0.4V			1	μA
Operation Frequency	f_{OSC}		0.9	1.1	1.3	MHz
Maximum Duty Cycle	D_{MAX}		91	93		%
PWM Dimming Clock Rate		Recommended	20		100	KHz
PWM Dimming Duty Cycle			0.3		100	%
Feedback Reference	V_{REF}	100% Full Scale	190	200	210	mV
		1% Dimming Duty		2.4		
		0.3% Dimming Duty		1		
On Resistance	R_{ON}	I_{LX}=100mA		0.4		Ω
Current Limit	I_{LIM}			1.5		A
EN Threshold Voltage	V_{ENL}				0.4	V
	V_{ENH}		1.5			V
EN Pull-down Resistance	R_{EN}			1		MΩ
Thermal Shutdown Temperature	T_{SD}			160		°C
TSD Hysteresis	T_{SD-HYS}			30		°C
Shutdown Delay	t_{SHDN}			1		ms

Typical Characteristics

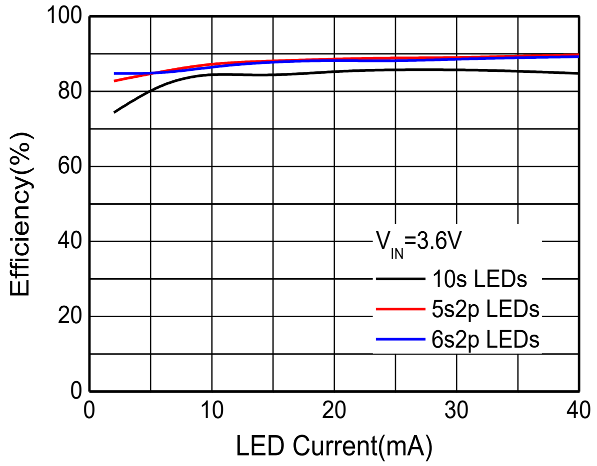
(Ta=25°C, V_{IN}=3.6V, V_{EN}=V_{IN}, C_{IN}=C_{OUT}=1µF, L=10µH, 10 LEDs, unless otherwise noted)



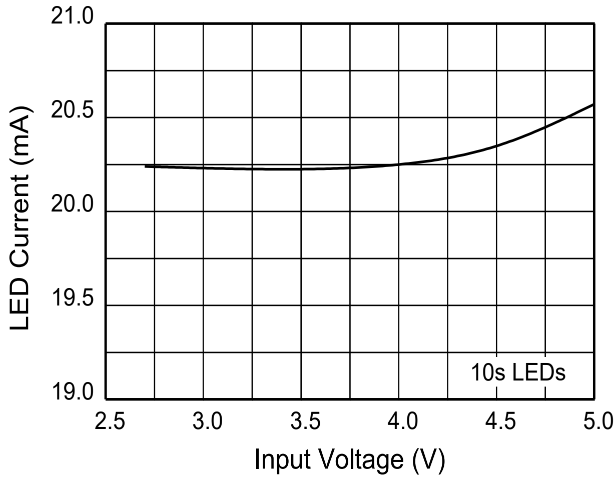
Efficiency vs. LED Current



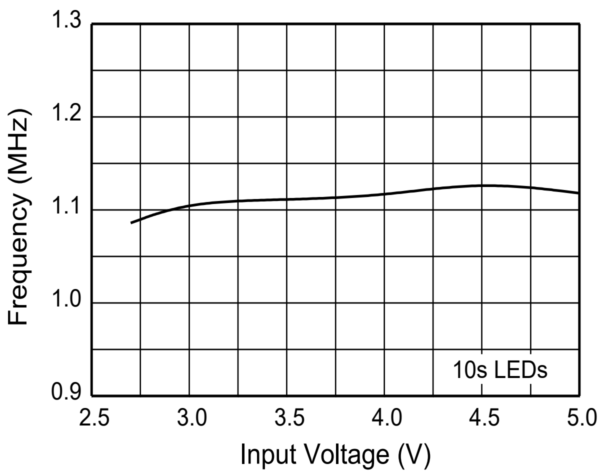
Efficiency vs. LED Current



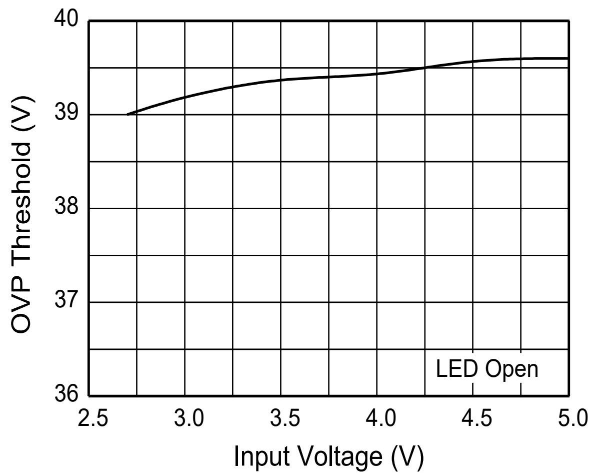
Efficiency vs. LED Current



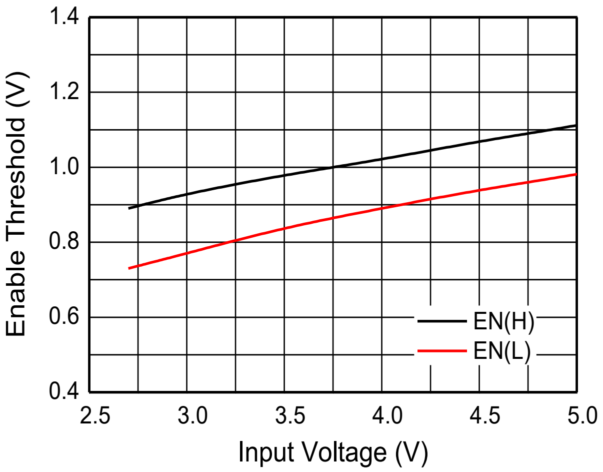
LED Current vs. VIN



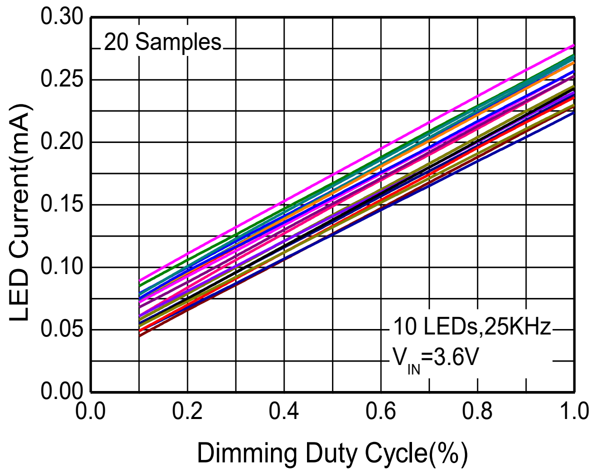
Frequency vs. VIN



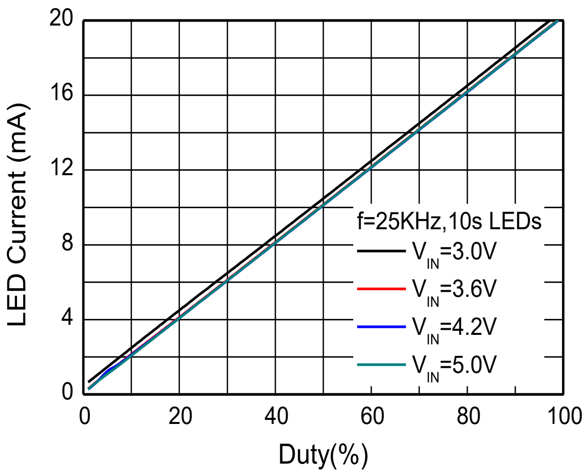
OVP Threshold vs. VIN



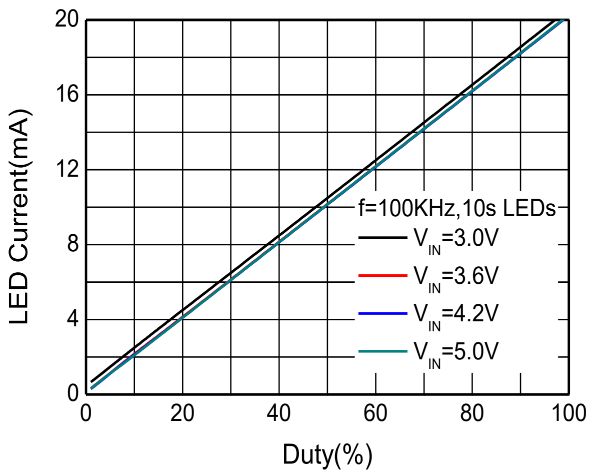
Enable Threshold vs. VIN



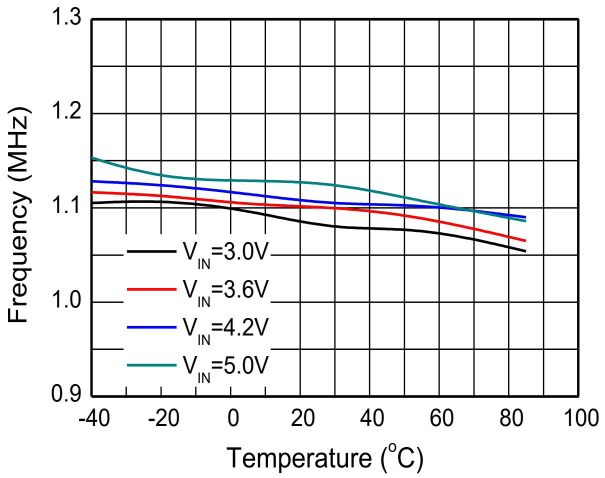
LED Current Dimming Linearity



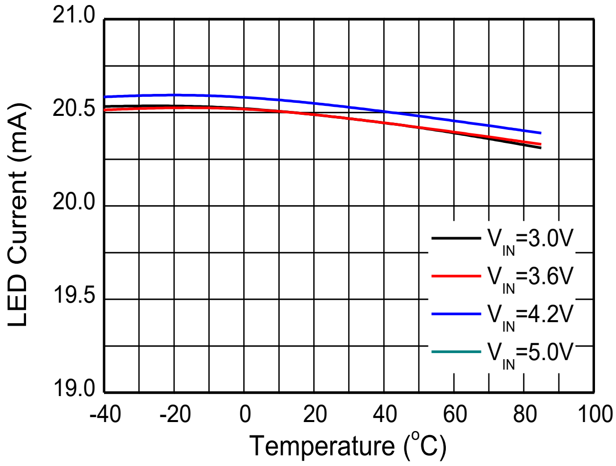
LED Current vs. Duty



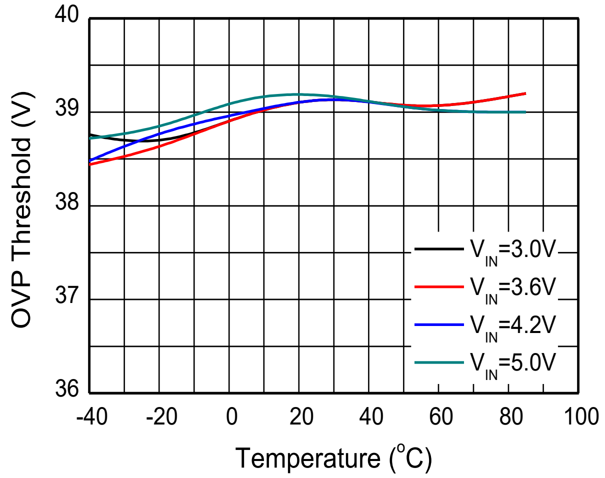
LED Current vs. Duty



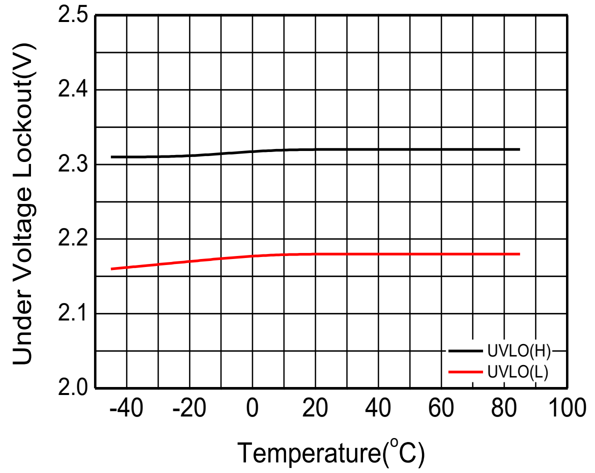
Frequency vs. Temperature



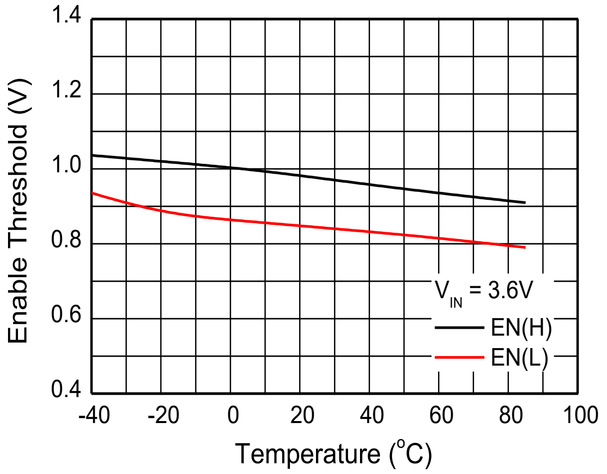
LED Current vs. Temperature



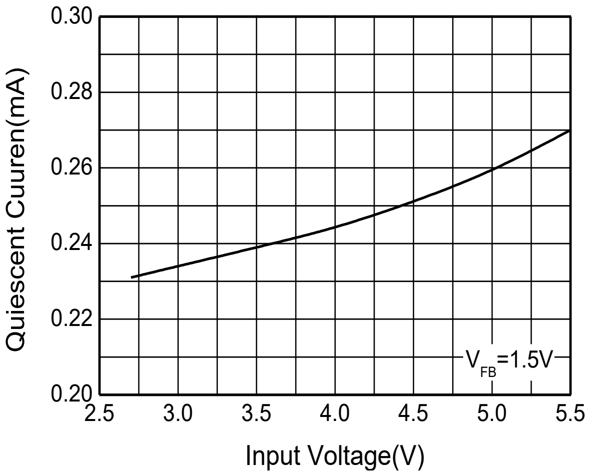
OVP Threshold vs. Temperature



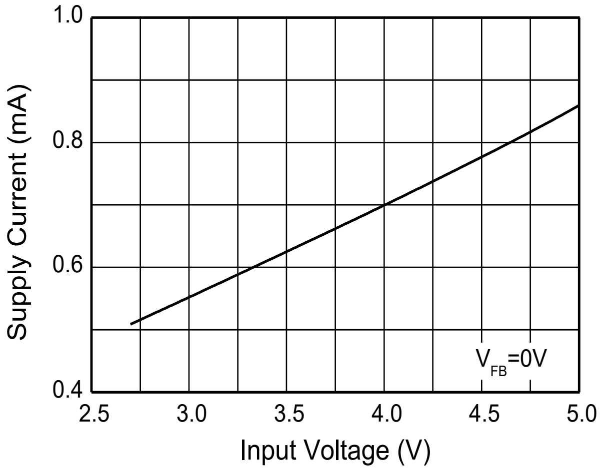
UVLO vs. Temperature



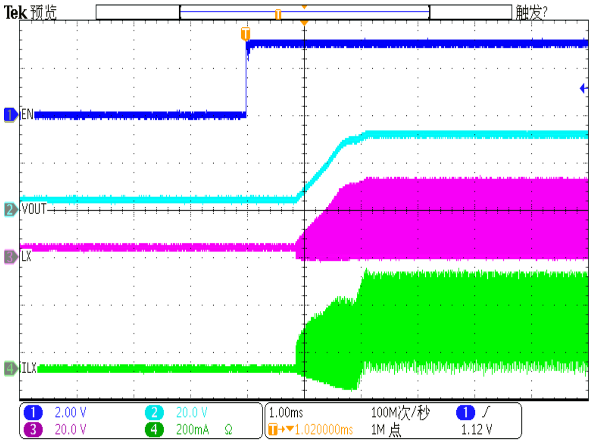
Enable Threshold vs. Temperature



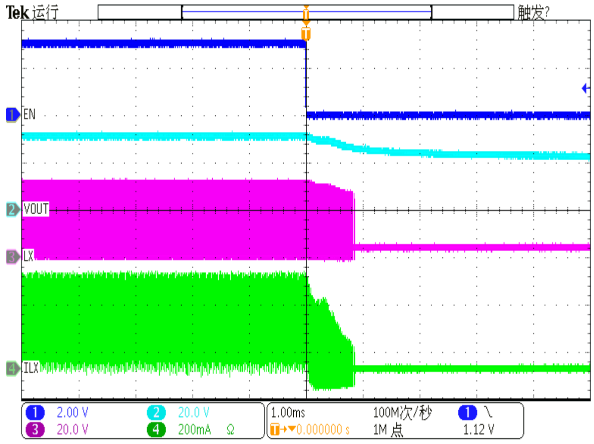
Quiescent Current vs. VIN



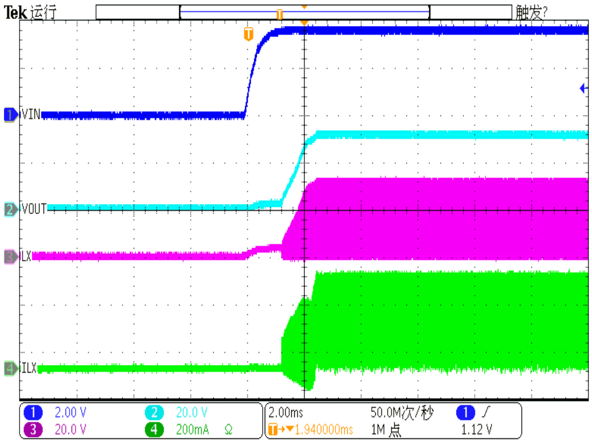
Supply Current vs. VIN



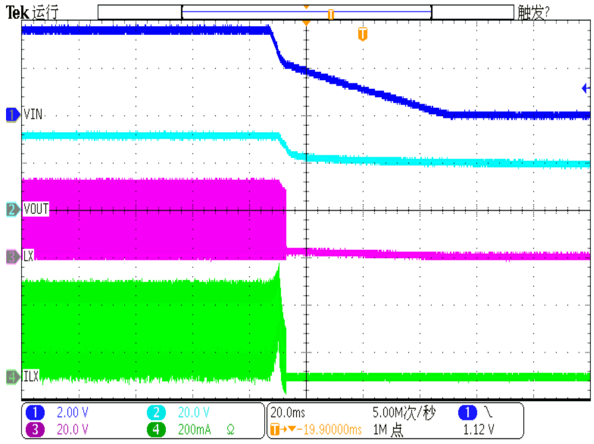
Start-Up from EN



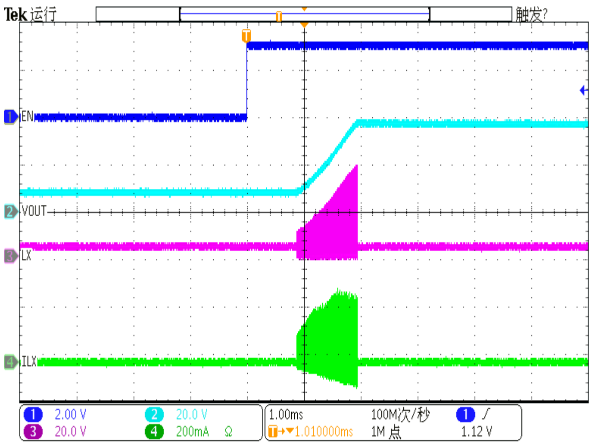
Shut-Down from EN



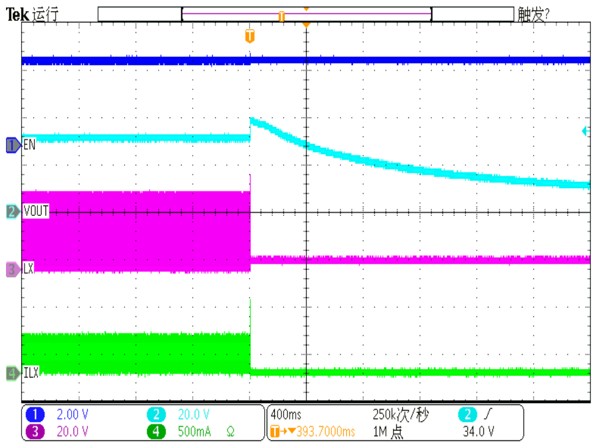
Start-Up from VIN



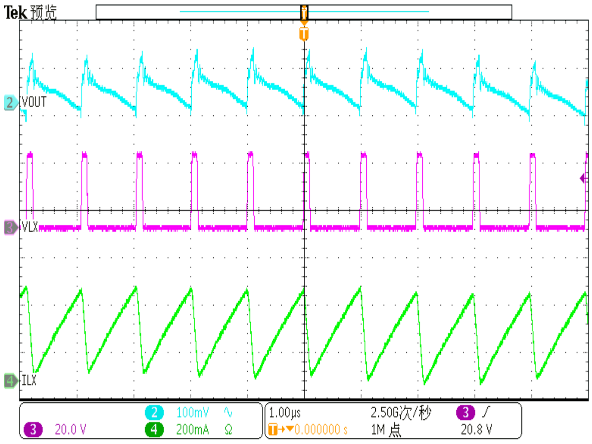
Shut-Down from VIN



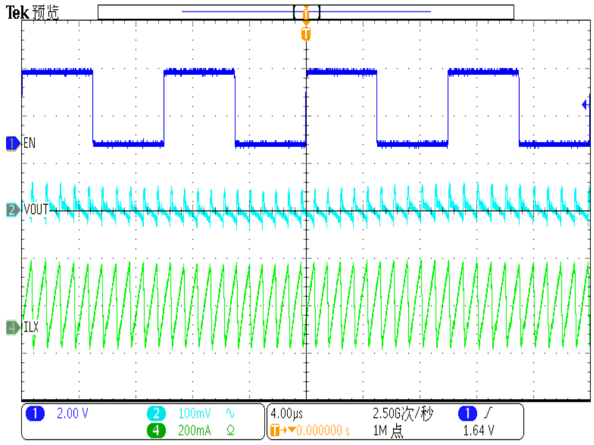
Start-Up with LED Open



Shut-Down with LED Open



Operation Waveforms



PWM Dimming Waveforms

Operation Information

Normal Operation

The WD3149 is a high efficiency, high output voltage boost converter. The device is ideal for driving white LED. The LED connection provides even illumination by sourcing the same output current through all LEDs. The device integrates 38V/1.5A switch FET and operates in pulse width modulation (PWM) with 1.1MHz fixed switching frequency. The beginning of each cycle turns on the Power MOSFET. A slope compensation ramp is added to the current sense amplifier and the result is fed into the positive input of the comparator. When this voltage goes above the output voltage of the error amplifier (EA), the Power MOSFET is turned off. The FB voltage can be regulated to the reference voltage of bandgap with EA block. The feedback loop regulates the FB pin to a low reference voltage (200mV typical), reducing the power dissipation in the current sense resistor.

Soft-Start

The WD3149 Build-in Soft-Start function limits inrush current while the device turn-on.

Cycle-by-Cycle Current Limit

The WD3149 uses a cycle-by-cycle current limit circuitry to limit the inductor peak current in the event of an overload condition. The current flow through inductor in charging phase is detected by a current sensing circuit. As the value comes across the current limiting threshold the N- MOSFET turns off, so that the inductor will be forced to leave charging stage and enter in discharging stage. Therefore, the inductor current will not increase over the current limiting threshold.

Open LED Protection

Open LED protection circuitry prevents IC damage as the result of white LED disconnection. The WD3149 monitors the voltage at the LX pin and FB pin during each switching cycle. The circuitry turns off the switch FET and shuts down the IC when both of the following conditions persist for 4 switching clock cycles: (1) the LX voltage exceeds the V_{OLP} threshold and (2) the FB voltage is less than 50mV.Then, the WD3149 turns off the power switch FET and shuts down IC until EN or power supply is recycled to enable IC.

UVLO Protection

To avoid malfunction of the WD3149 at low input voltages, an under voltage lockout is included that disables the device, until the input voltage exceeds 2.3V (Typ.).

Shutdown Mode

Drive EN to GND to place the WD3149 in shutdown mode. In shutdown mode, the reference, control circuit, and the main switch turn off. Input current falls to smaller than 1μA during shutdown mode.

Over-Temperature-Protection (OTP)

As soon as the junction temperature (T_J) exceeds 160ºC (Typ.), the WD3149 goes into thermal shutdown. In this mode, the main N-MOSFET is turned off until temperature falls below typically 130ºC. Then the device starts switching again.

Application Information

External component selection for the application circuit depends on the load current requirements. Certain trade-offs between different performance parameters can also be made.

LED Current Setting

The loop of Boost structure will keep the FB pin voltage equal to the reference voltage V_{REF}. Therefore, when R_{SET} connects FB pin and GND, the current flows from V_{OUT} through LED and R_{SET} to GND will be decided by the current on R_{SET}, which is equal to following equation:

$$I_{LED} = \frac{V_{FB}}{R_{SET}} = \frac{200mV}{R_{SET}}$$

Where

I_{LED} = output current of LEDs

V_{FB} = regulated voltage of FB

R_{SET} = current sense resistor

The output current tolerance depends on the FB accuracy and the current sensor resistor accuracy.

Dimming Control

For the brightness dimming control of the WD3149, the IC provides typically 200mV feedback voltage when the EN pin is pulled constantly high. However, EN pin allows a PWM signal to reduce this regulation voltage by changing the PWM duty cycle to achieve LED brightness dimming control.

As shown in Figure 1, the duty cycle of the PWM signal is used to chop the internal 200mV reference voltage. An internal low pass filter is used to filter the pulse signal. And then the reference voltage can be made by connecting the output of the filter to the error amplifier for the FB pin voltage regulation.

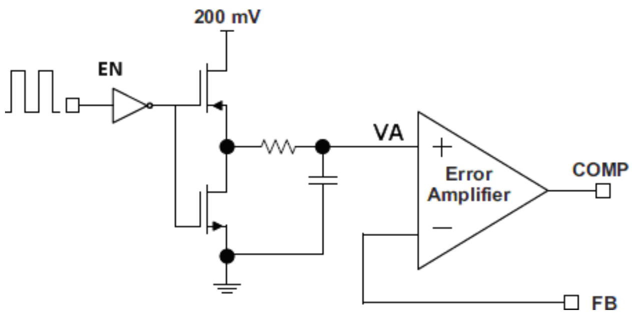


Figure1

Therefore, although a PWM signal is applied for dimming, but only the WLED DC current is modulated. This help to eliminate the audible noise which often occurs when the LED current is pulsed in replica of the frequency and the duty cycle of PWM control. The minimum dimming frequency is limited by EN shutdown delay time. For optimum performance, recommend to select PWM dimming frequency in the range of 20kHz~100kHz. And the recommended minimum PWM Duty Cycle is 0.3% for stable LED driving and no blind dimming.

The EN shutdown delay time is set to 1ms. This means the IC needs to be shutdown by pulling the EN low for 1ms.

Applications for Driving Multiple LED Strings

The WD3149 can drive different WLEDs topology. For example, the Figure 2 shows the 6S2P WLEDs as output load. The total WLEDs current can be set by the R_{SET} which is equal to following equation. With V_{IN} > 3.4V, The WD3149 could drive maximum 3S12P with total 36 LEDs.

$$I_{Total} = \frac{V_{REF}}{R_{SET}}$$

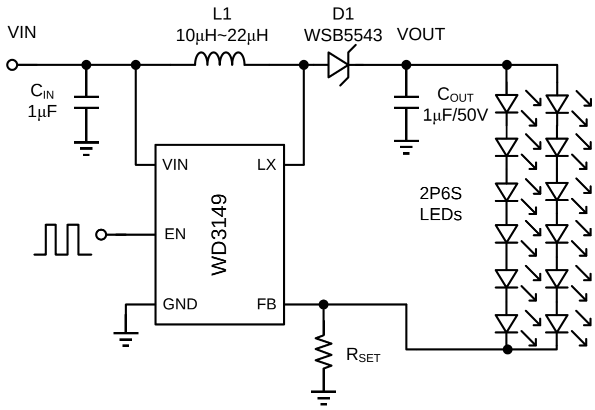


Figure 2

Boost Inductor Selection

The selection of the inductor affects steady state operation as well as transient behavior and loop stability. Inductor values can have ±20% tolerance with no current bias. When the inductor current approaches saturation level, its inductance can decrease 20% to 35% from the 0A value depending on how the inductor vendor defines saturation current. Using an inductor with a smaller inductance value forces discontinuous PWM when the inductor current ramps down to zero before the end of each switching cycle. This reduces the boost converter's maximum output current, causes large input voltage ripple and reduces efficiency. Large inductance value provides much more output current and higher conversion efficiency. The inductor should have low core loss at 1.1MHz and low DCR for better efficiency. For these reasons, the recommended value of inductor for 10 series WLEDs applications is from 10μH to 22μH. A 10μH inductor with Low DCR optimized the efficiency for most application while maintaining low inductor peak to peak ripple.

Input Capacitor Selection

Connect the input capacitance from V_{IN} to the reference ground plane. Input capacitance reduces the ac voltage ripple on the input rail by providing a low-impedance path for the switching current of the boost converter. The capacitor in the range of 1μF to 10μF / X7R or X5R is recommended for input side.

Output Capacitor Selection

The output capacitor is mainly selected to meet the requirements for the output ripple and loop stability. This ripple voltage is related to the capacitor's capacitance and its equivalent series resistance (ESR). The recommended minimum capacitor on Output is 1uF/50V, X5R or X7R ceramic capacitor.

Diode Selection

The rectifier diode supplies current path to the inductor when the internal MOSFET is off. Use a schottky with low forward voltage to reduce losses. The diode should be rated for a reverse blocking voltage greater than the output voltage used. The average current rating must be greater than the maximum load current expected, and the peak current rating must be greater than the peak inductor current.

Diode should meet the following requirements:

- Low forward voltage
- High switching speed : 50ns max.
- Reverse voltage : $V_{OUT} + V_F$ or more
- Rated current : I_{PK} or more

PCB Layout Considerations

A good circuit board layout aids in extracting the most performance from the WD3149. A poor one increases the output ripple and degrades the electromagnetic interference (EMI) or electro-magnetic compatibility (EMC) performance. The evaluation board layout is especially optimized for the WD3149. Use this layout for best performance.

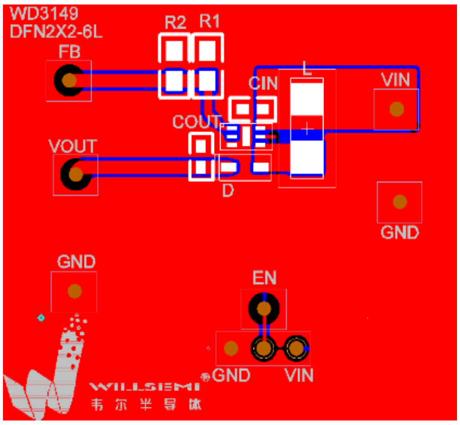


Figure 3, WD3149 PCB Layout Demo

If the layout needs changing, use the following guidelines:

1. Use separated power supply trace and power ground planes from other sensitive blocks.
2. Locate C_{IN} as close to the V_{IN} pin as possible. And connect the lower plate of C_{IN} Close to IC's GND.
3. Route the high current path from C_{IN}, through L to the LX and GND pins as short as possible. And keep high current traces as short and as wide as possible.
4. Route the high current path from L to Diode and C_{OUT} as short as possible. And keep high current traces as short and as wide as possible. Connect the lower plate of C_{OUT} as Close to IC's GND as possible.
5. Avoid routing sensitive trace near this block, especially LX Node. Place a ground plane shield between the traces.
6. Place the R_{SET} resistor as close to FB pin as possible, for the FB is a high impedance input pin which is susceptible to noise and high voltage spike.
7. Avoid routing a long V_{OUT} or FB trace parallel to other sensitive signal. Place a ground plane shield between the traces.

These guidelines should be considered seriously. Additionally, an RC-snubber network could be placed between LX and ground to reduce EMI, which is referred to Figure 6. And the PCB Layout is shown as followed in Figure 4.

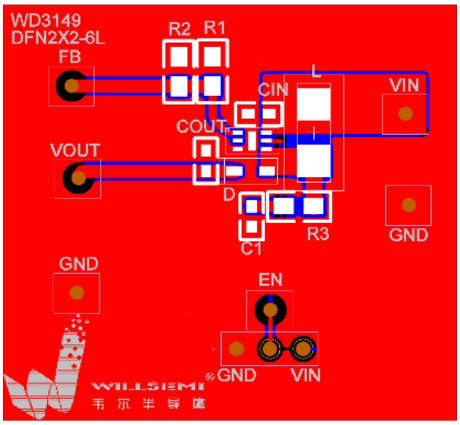


Figure 4, WD3149 PCB Layout with Snubber

Typical Applications

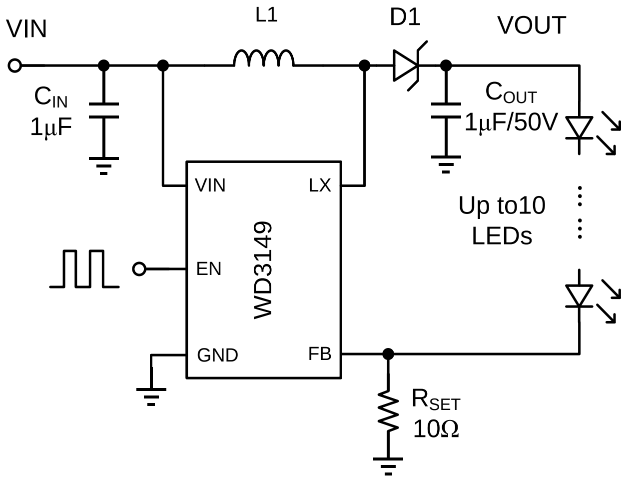


Figure 5, Li-Ion Driver for 10-S White LEDs

Recommendation: L1: 10μH~22μH, saturation current > 1.5A

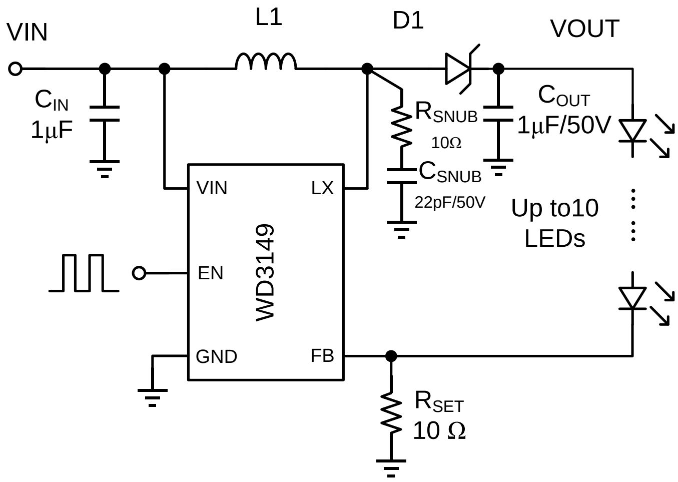


Figure 6, Li-Ion Driver for 10-S White LEDs with Snubber Network to Reduce EMI

Recommendation: L1: 10μH~22μH, saturation current > 1.5A

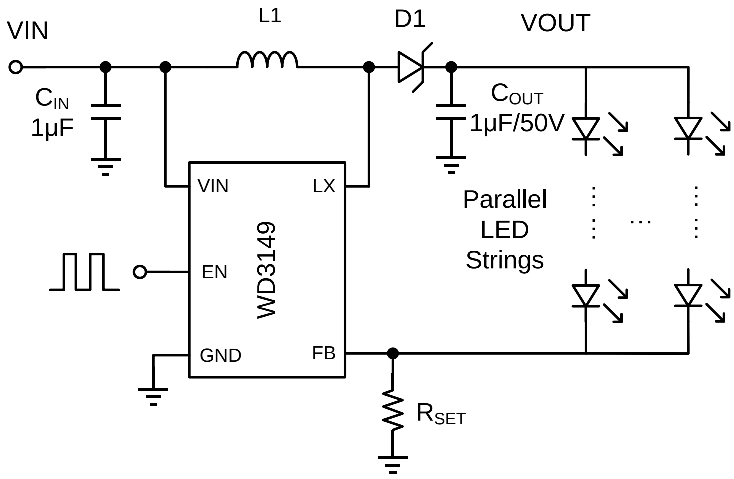
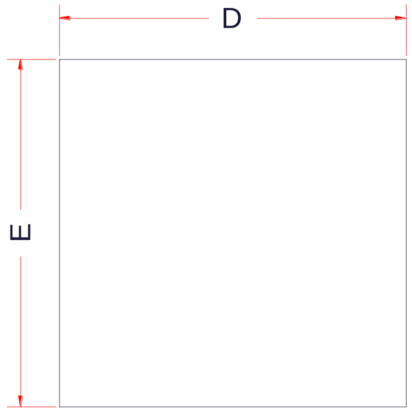


Figure 7, Li-Ion Driver for Parallel White LED Strings

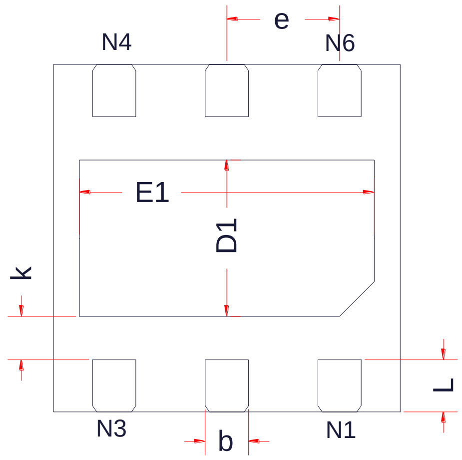
Recommendation: L1: 10μH~22μH, saturation current > 1.5A

PACKAGE OUTLINE DIMENSIONS

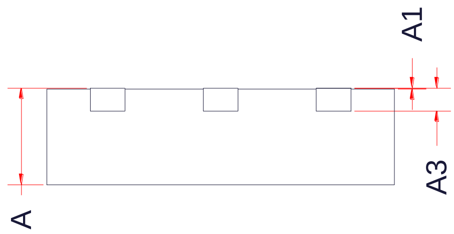
DFN2x2-6L



TOP VIEW



BOTTOM VIEW

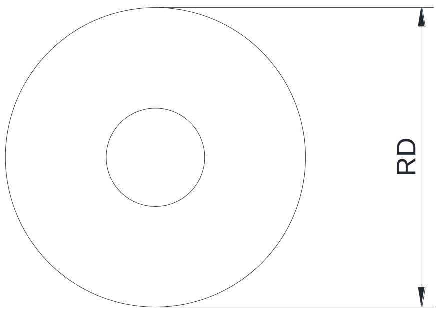


SIDE VIEW

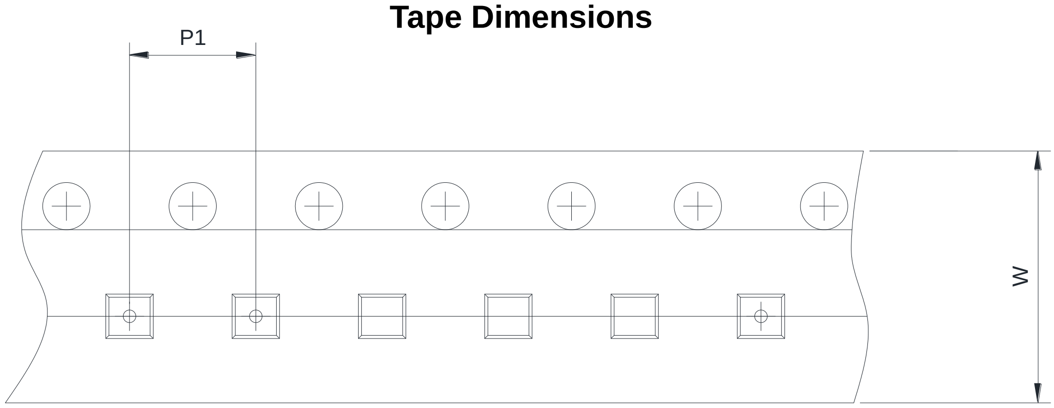
Symbol	Dimensions in Millimeters		
	Min.	Typ.	Max.
A	0.50	0.55	0.60
A1	0.00	-	0.05
A3	0.15Ref.		
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D1	0.86	0.96	1.06
E1	1.55	1.65	1.75
b	0.25	0.30	0.35
e	0.65BSC		
K	0.22Ref		
L	0.22	0.25	0.38

TAPE AND REEL INFORMATION

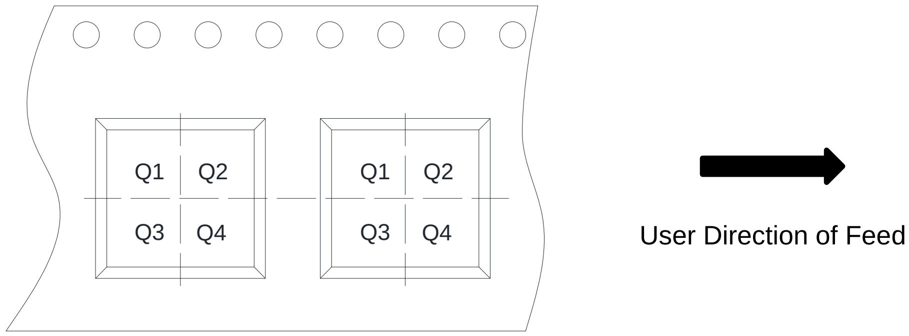
Reel Dimensions



Tape Dimensions



Quadrant Assignments For PIN1 Orientation In Tape



RD	Reel Dimension	☑ 7inch ☐ 13inch
W	Overall width of the carrier tape	☑ 8mm ☐ 12mm ☐ 16mm
P1	Pitch between successive cavity centers	☐ 2mm ☑ 4mm ☐ 8mm
Pin1	Pin1 Quadrant	☑ Q1 ☐ Q2 ☐ Q3 ☐ Q4