SY22142B

28V, Single Channel Boost LED Controller With DC Dimming

General Description

The SY22142B boost LED controller operates over a wide input voltage range from 9V to 28V using a pseudo constant frequency control architecture. It is targeted for white LED applications, and integrates a compensation network for a minimal solution footprint. It features a PWM dimming function for accurate LED analog current control.

The SY22142B provides comprehensive protection including output over voltage protection (OVP), over current protection (OCP), LED open/short protection, LED cathode short to GND protection, inductor and diode short/open protection, and thermal shutdown protection.

The SY22142B is available in a compact SOT23-6 package.

Features

- Wide Input Voltage Range: 9V-28V
- Fixed 120KHz Switching Frequency
- Frequency Foldback When Dimming is Applied
- 10k~100kHz PWM Signal To Achieve DC Dimming
- Output Over Voltage Protection (OVP)
- Over Current Protection (OCP)
- LED Open/Short Protections
- LED Cathode Short To GND Protection
- Inductor Short And Diode Open/Short Protections
- Thermal Shutdown Protection (OTP)
- Compact Package: SOT23-6

Applications

- LCD TV Backlight
- LCD Monitor Backlight

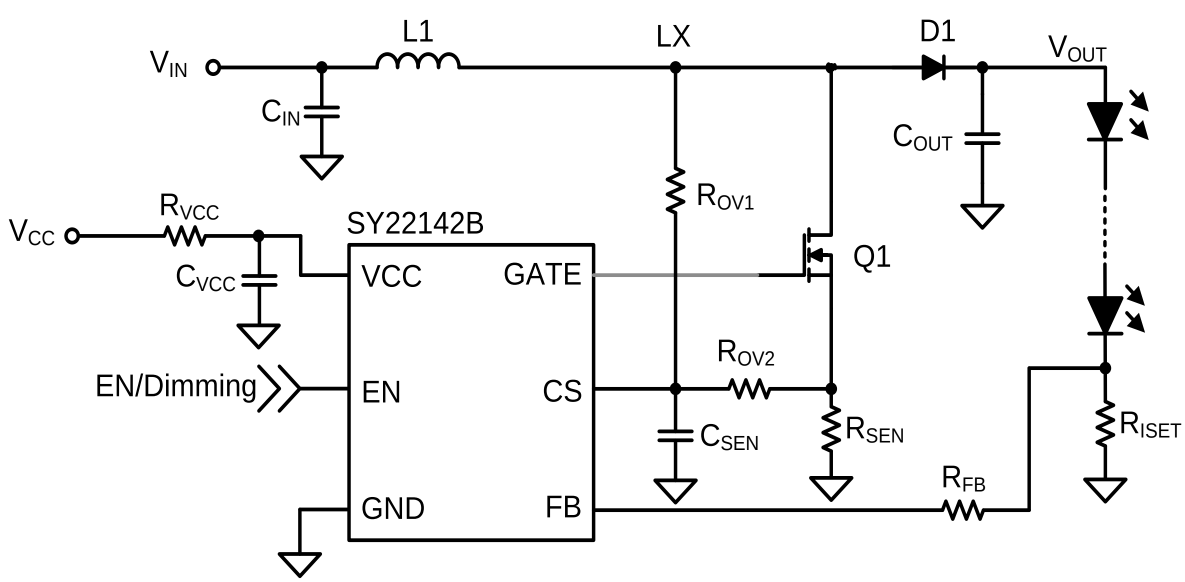


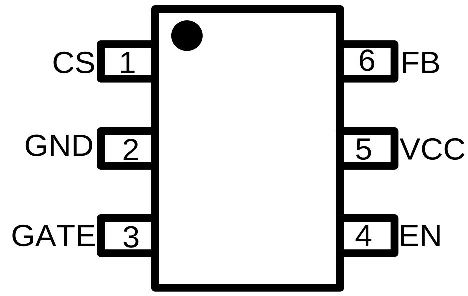
Figure 1. Schematic

Ordering Information

Ordering Part Number	Package type	Top Mark
SY22142BABC	SOT23-6 RoHS Compliant and Halogen Free	**Tf *xyz***

x=year code, y=week code, z= lot number code

Pinout (top view)



Pin No	Pin Name	Pin Description
1	CS	Dual function pin. For inductor current sensing, the maximum current sense voltage is 0.2V. For output voltage sensing during switch turn off, the overvoltage threshold is 1.2V.
2	GND	Power ground.
3	GATE	External MOSFET GATE driver. Connect to the gate of the boost MOSFET with a resistor.
4	EN	Multiple function pin. For chip enable, make sure the minimum high time >200ns and chip is turned off after 3.2ms EN low time delay; For DC dimming, a PWM signal with frequency higher than 10KHz and minimum PWM high time longer than 200ns is required.
5	VCC	Power supply pin. Decouple this pin to ground with a ceramic capacitor of at least 1µF.
6	FB	Feedback pin. LED current: I_{LED} = 0.4V/R_{ISET}.

Block Diagram

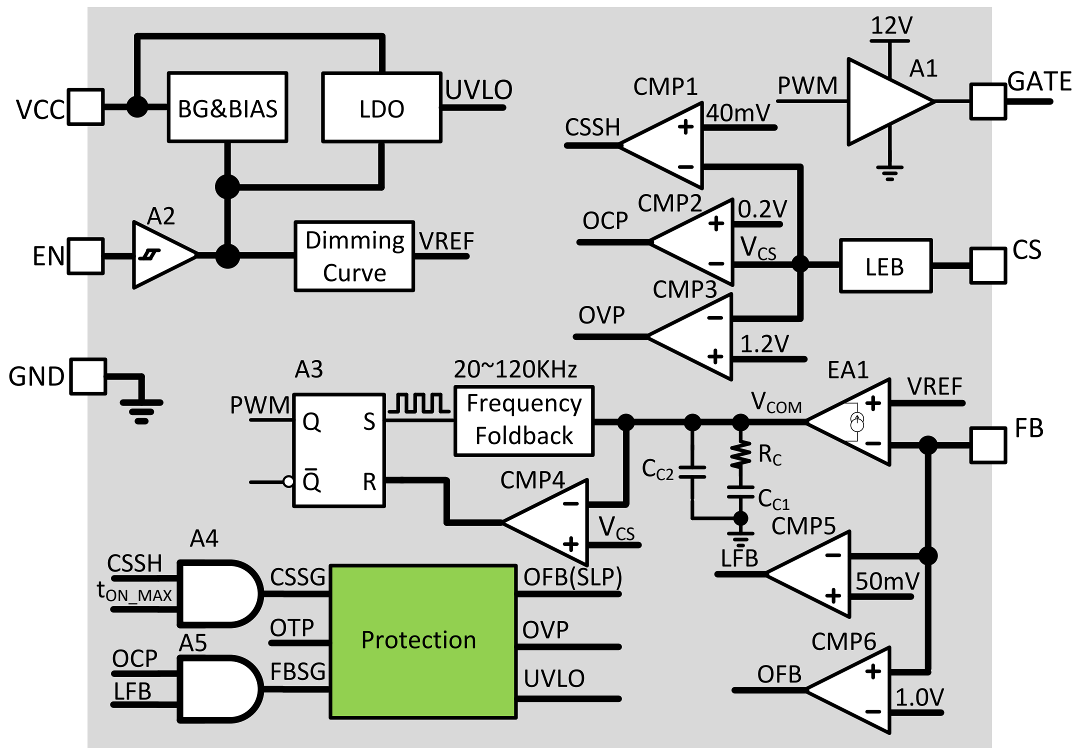


Figure 3. Functional Block Diagram

Absolute Maximum Ratings (1)	Min	Max	Unit
VCC, EN,GATE,FB	-0.3	30	V
CS	-0.3	3.6	
Power Dissipation, PD @ TA = 25°C SOT23-6		0.48	W

Package Thermal Information (2)	Min	Max	Unit
θ_{JA} Junction-to-ambient Thermal Resistance		208	°C/W
θ_{JC} Junction-to-case Thermal Resistance		45	
Junction Temperature Range	-40	150	°C
Lead Temperature (Soldering, 10 sec.)		260	
Storage Temperature Range	-65	150	

Recommended Operating Conditions (3)	Min	Max	Unit
Chip Supply Voltage VCC	9	28	V
EN	2.4	28	V
Ambient Temperature	-40	85	°C

Electrical Characteristics T_A = 25°C,VCC = 12V, C_{VCC}=1uF, unless otherwise specified							
Parameter		Symbol	Test Conditions	Min	Typ	Max	Unit
VCC Pin	Power Supply Range	VCC		9		28	V
	VCC UVLO Rising Threshold	VCC_{UVLO_RISE}				8.99	V
	VCC UVLO Falling Threshold	VCC_{UVLO_FALL}		6.8			V
	UVLO Hysteresis	VCC_{UVLO_HYS}			0.6		V
	Quiescent Current	I_Q	V_{EN}=3.3V, V_{FB}=0.5V		0.48		mA
	Shut Down Current	I_{SD}	V_{EN}=0V		5		uA
FB Pin	Feedback Reference Voltage	V_{FB}	D_{EN}=100%	392	400	408	mV
	Feedback Reference Voltage When D_{EN}=10%	$V_{FB\_10\%}$	D_{EN}=10%, F_{PWM}=10KHz	38	40	42	mV
	LED Short Rising Threshold	V_{FB_LAT}		0.9	1.0	1.1	V
BOOST	BOOST Switching Frequency	F_{SW}		95	120	145	kHz
	Boost Minimum ON Time	t_{ON_MIN}	Note 4		0.4		us
	Boost Maximum ON Time	t_{ON_MAX}		8	13	20	us
	Boost Minimum OFF Time	t_{OFF_MIN}	Note 4		0.1		us
CS Pin	Cycle By Cycle Current Limit Reference	V_{CS_LIM}		180	200	220	mV
	OVP Latch Threshold	V_{CS_OVP}		1.12	1.20	1.28	V
	OVP Latch Blanking Time	t_{OVP_BLK}	Note 4		0.4	1.0	us
EN Pin	EN High Level	V_{EN_HIGH}		2.4			
	EN Low Level	V_{EN_LOW}				0.4	V
GATE Pin	Gate Driver Clamping Voltage	V_{GATE_HIGH}	VCC = 15V,Note 4		12		V
	Gate Driver Sourcing Current	I_{GATE_SOURCE}	Note 4		1.25		A
	Gate Driver Sinking Current	I_{GATE_SINK}		1.4	2.0	2.6	A
Thermal Shut Down	Thermal Shutdown Temperature	T_{SD}	Note 4		150		°C
	Thermal Shutdown Hysteresis	T_{HYS}	Note 4		20		°C

Note 1: Stresses beyond the “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: θ_{JA} is measured in the natural convection at TA = 25°C on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard. Test condition: Device mounted on 2” x 2” FR-4 substrate PCB, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

Note 3: The device is not guaranteed to function outside its operating conditions.

Note 4: Guaranteed by design, not test in mass production

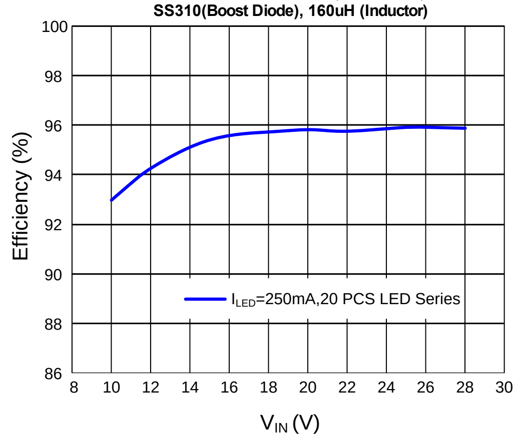
Note 5: Suggest the typical maximum boost duty cycle set to about 88%(8.33us-1us)/8.33us. 1us is the maximum OVP latch blanking time (OVP is detected during boost switching off)

Typical Operation Characteristics

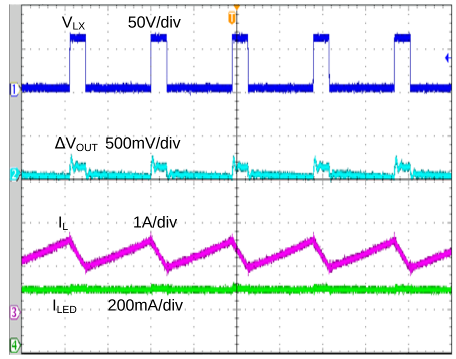
($V_{IN} = V_{CC}$= 12V, I_{LED} = 250mA, 20PCS LED Series)

Efficiency vs. V_{IN}

External Parts:FDD86102(Boost MOS), SS310(Boost Diode), 160uH (Inductor)

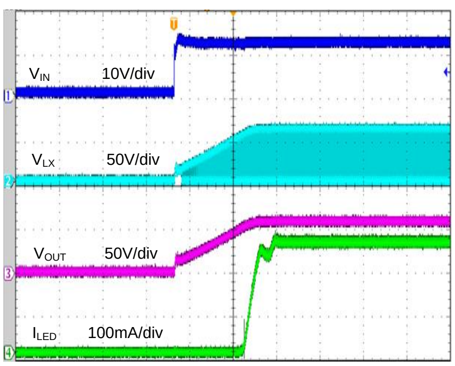


Steady State



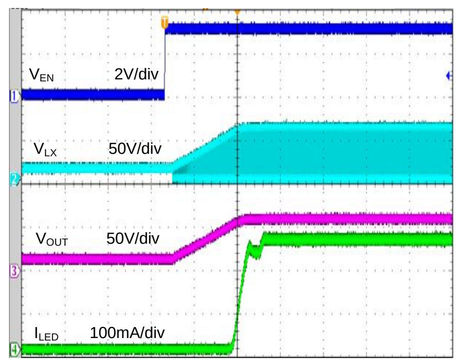
Time (4μs/div)

Startup from V_{IN}



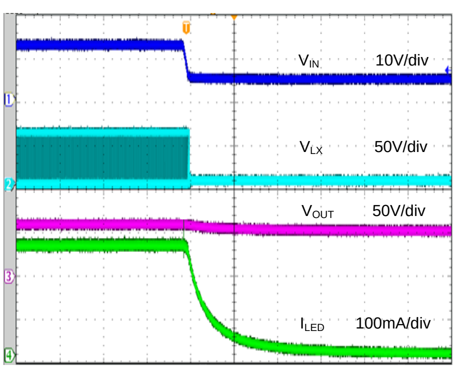
Time (4ms/div)

Startup from EN



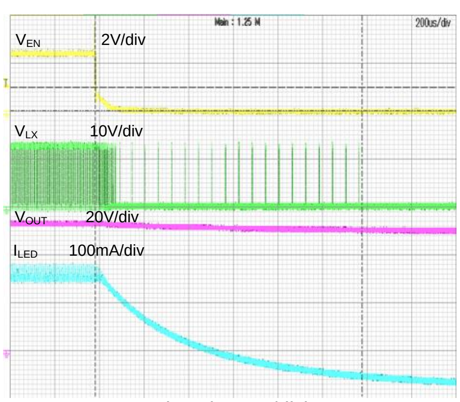
Time (4ms/div)

Shutdown from V_{IN}



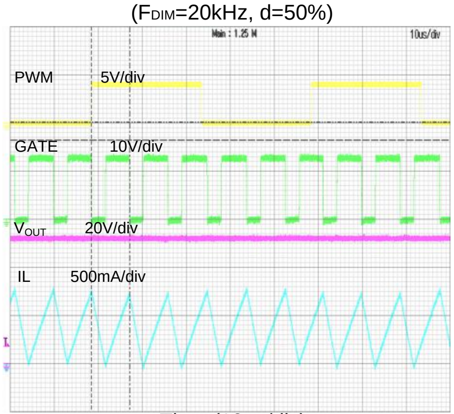
Time (2ms/div)

Shutdown from EN



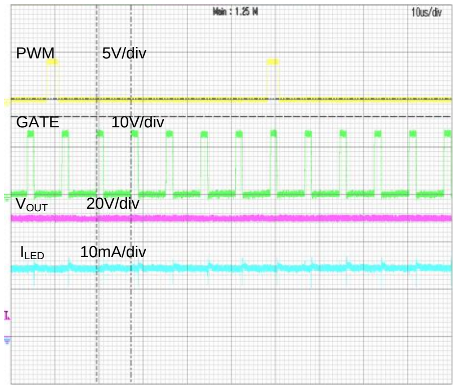
Time (200μs/div)

PWM Dimming
(F_{DIM}=20kHz, d=50%)



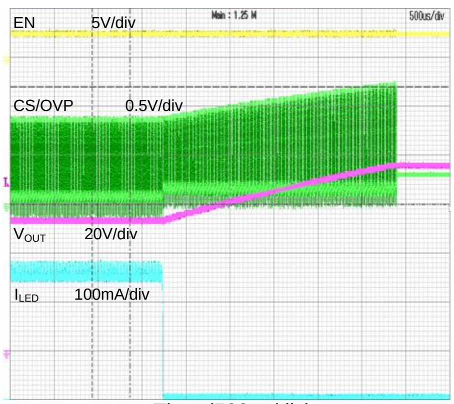
Time (10μs/div)

PWM Dimming
(F_{DIM}=20kHz, d=5%)



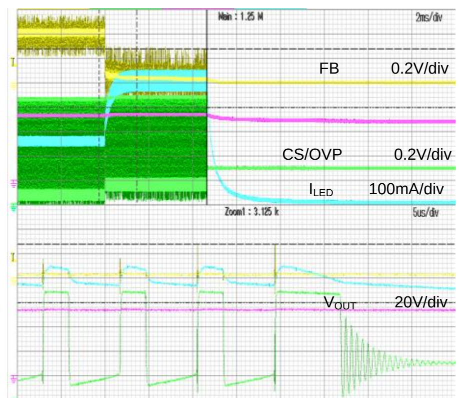
Time (10μs/div)

LED OPEN



Time (500μs/div)

FB Short to GND



Time (2ms/div)

Operation

The SY22142B is a 28V step up controller for constant current LED application. It operates over a wide input voltage range from 9V to 28V in WLED backlight applications.

The chip uses pseudo constant frequency and peak current control architecture without slope compensation to provide loop stability and eliminating sub-harmonic effects.

The integrated compensation reduces the BOM cost and simplifies the design.

The SY22142B supports DC dimming if a PWM signal with a frequency in the range of 10kHz to 100kHz is applied at the EN input. The device converts the input signal to a voltage reference which is used to reduce the LED current.

Comprehensive protection features including output over voltage protection (OVP), cycle by cycle over current protection (OCP), LED open/short protection, LED cathode short to GND protection, inductor and diode short/open protection, and thermal shutdown protection are provided by SY22142B.

Application Information

The steps required for calculating and selecting the external components are shown below:

Current Sensing Resistor R_{ISET}

Choose the proper R_{ISET} to program output current $I_{OUT,MAX}$

$$R_{ISET}=\frac{0.4V}{I_{OUT,MAX}}$$

A high accuracy (0.5%) and good temperature performance (50ppm) resistor is suggested. To prevent the FB pin from being damaged in the event of a short circuit on the output, connecting a resistor (R_{FB}) with a value of 100 Ω is recommended.

Input Capacitor C_{VCC}

The ripple current through input capacitor is calculated as:

$$I_{CIN\_RMS}=\frac{V_{IN}\times(V_{OUT}-V_{IN})}{2\sqrt{3}\times L\times F_{SW}\times V_{OUT}}$$

A typical X7R or better dielectric grade ceramic capacitor with suitable capacitance should be chosen to handle the ripple. Place the ceramic capacitor close to the VCC and GND pins of the device and minimize the loop area formed by C_{VCC} and VCC/GND pin.

Output Capacitor C_{OUT}

The output capacitor is selected to improve the loop stability and handling of the output current ripple. For best performance, it is recommended using a X7R or better capacitor, with a capacitance greater than 10uF. The loop stability has to be considered especially when heavy loads are applied. The minimum required capacitance can be calculated as follows:

$$C_{OUT}=\frac{I_{OUT,MAX}\times(V_{OUT}-V_{IN})}{F_{SW}\times V_{OUT}\times V_{RIPPLE}}$$

where V_{RIPPLE} is the peak-to-peak output ripple. For LED applications, the equivalent resistance of the LED is typically low. The output capacitance should be large enough to attenuate the ripple current through the LED.

Inductor L_1

The inductor current during steady state Continuous Conduction Mode (CCM) is shown below:

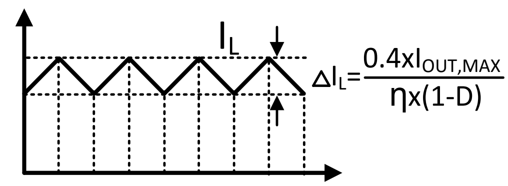


Figure 4. Boost Inductor Operating Waveform

There are several considerations in choosing optimal inductor.

1) Choose the inductance to provide a ripple current that is approximately 40% of the maximum output current. The recommended inductance is calculated as:

$$L=\left(\frac{V_{IN}}{V_{OUT}}\right)^2\times\frac{\eta\times(V_{OUT}-V_{IN})}{0.4\times I_{OUT,MAX}\times F_{SW}}$$

Where F_{SW} is the switching frequency and $I_{OUT,MAX}$ is the full scale LED current, η is the estimated efficiency.

2) The saturation current rating of the inductor must be selected to be greater than the peak inductor current under full load conditions:

$$I_{SAT,MIN}>\left(\frac{V_{OUT}}{V_{IN}}\right)\times\frac{I_{OUT\_MAX}}{\eta}+\frac{(V_{OUT}-V_{IN})}{2\times F_{SW}\times L}\times\left(\frac{V_{IN}}{V_{OUT}}\right)$$

3) The DCR of the inductor and the core loss at the switching frequency must be low enough to achieve the desired efficiency requirement.

4) Verify that the design is stable and phase margin meets the requirements. Follow the steps outlined in the design example.

BOOST MOSFET

Selecting the external MOSFET is based on meeting the current rating, its maximum drain to source voltage, maximum operating frequency and power dissipation. The maximum RMS(CCM) current through the MOSEFT is given by the following equation:

$$I_{MOS\_RMS}=\frac{V_{OUT}\times I_{OUT\_MAX}}{V_{IN}\times\eta}\left(1+\frac{K_{RP}}{2}\right)\times\sqrt{\frac{V_{OUT}-V_{IN}}{V_{OUT}}}\times\sqrt{1-\frac{K_{RP}}{1+\frac{K_{RP}}{2}}+\frac{1}{3}\times\left(\frac{K_{RP}}{1+\frac{K_{RP}}{2}}\right)^2}$$

Where I_L is the peak current of inductor and K_{RP} is the inductor current ripple coefficient.

$$K_{RP} = \frac{\Delta I_L}{\frac{I_{OUT,MAX}}{(1-D)\times\eta}}$$

$\triangle I_L$ is the inductor current ripple and equal to the following formula:

$$\Delta I_L = \frac{K_{RP}\times V_{OUT}\times I_{OUT\_MAX}}{V_{IN}\times\eta}$$

If K_{RP}=0.4 then the I_{MOS_RMS} is calculated as follow:

$$I_{MOS\_RMS} = \frac{1.2\times V_{OUT}\times I_{OUT\_MAX}}{V_{IN}\times\eta}\times\sqrt{\frac{V_{OUT}-V_{IN}}{V_{OUT}}}\times\sqrt{\frac{19}{27}}$$

A low R_{DSON} of MOSFET is suggested to improve the efficiency and thermal performance. Ensure the selected MOSFET breakdown voltage is 20% higher than the boost OVP voltage.

Rectifier Diode

A Schottky diode with low forward voltage drop and fast switching speed is desirable for the application. The voltage rating of the diode must be 50% higher than the boost OVP voltage (to reduce the large reverse current at high ambient temperatures). The diode's average and peak current rating should exceed output current and peak inductor current.

Loop Stability Compensation

Figure 5 shows the main power circuit and control loop. SY22142B uses pseudo constant frequency architecture (calculated constant off time) with peak current control.

To improve the boost control loop stability, the following components are integrated for loop compensation: gm=12.5uA/V and R_C=2Meg C_{C1}=100pF C_{C2}=5pF. A low gm is used to reduce the bandwidth and large zero to improve the phase margin.

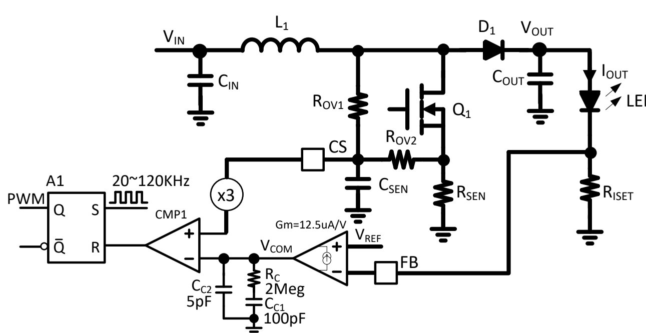


Figure 5. Control Loop Block Diagram

The equivalent circuit based of the control loop shown in the block diagram is shown in figure 6.

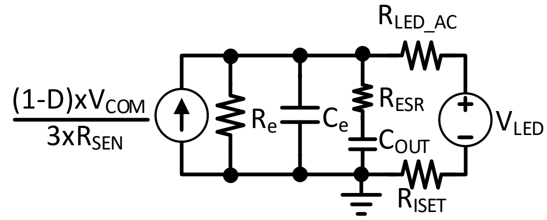


Figure 6. Equivalent Circuit Of SY22142B

The closed loop transfer function is shown in the following equation:

$$G_{CLOSED}(s) = \frac{(1-D)\times R_{ISET}}{3\times R_{SEN}}\times\frac{1}{1+\frac{1}{\omega_2}\times\frac{1}{Q_p}s+(\frac{s}{\omega_2})^2}\times\left(1-\frac{s}{\omega_a}\right)\times\frac{\left(R_{ESR}+\frac{1}{s\times C_{OUT}}\right)}{R_{LED\_AC}+R_{ISET}+R_{ESR}+\frac{1}{s\times C_{OUT}}}\times G_{COM}(s)$$

Where ω_2 and Q_p are the double pole of constant off time, ω_a is the right half zero of the boost in CCM, R_{ESR} is the capacitor parasitic resistance and R_{LED_AC} is the dynamic resistance of LED. R_{LED_AC} can be obtained from the LED datasheet I/V characteristic or by testing.

$$\omega_2 = \frac{\pi}{t_{OFF}},\quad Q_p = \frac{2}{\pi},\quad \omega_a = \frac{\frac{V_O}{I_{OUT,MAX}}\times(1-D)^2}{L_1}$$

$$G_{COM}(s) = \frac{gm\times(s\times R_C\times C_{C1}+1)}{s\times C_{C1}\times\left(s\times R_C\times C_{C2}+1+\frac{C_{C2}}{C_{C1}}\right)}$$

Dimming Performance

The EN pin is used to regulate the output current using the PWM signal. The input PWM signal is filtered by the internal RC as figure 7 shows;

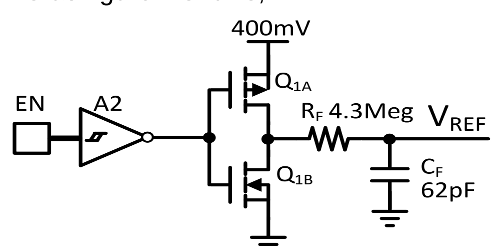


Figure 7. PWM Signal Conditioning

If the PWM high level is higher than 2.4V, the Q_{1A} is turned ON and the C_F is charging; if the PWM low level is lower than 0.4V, the Q_{1B} is turned ON and the C_F is discharging. The programmed LED current is based on the PWM duty-cycle (D_{EN}), and can be calculated using the equation:

$$I_{LED} = \frac{0.4V\times D_{EN}}{R_{ISET}}$$

The SY22142B has good dimming accuracy when the PWM duty-cycle is lower than 10%. The dimming reference of 10% PWM duty is guaranteed between 38mV to 42mV (typical 40mV).

Note: Ensure that the PWM duty-cycle is >1% and PWM high time > 200ns for proper operation during device start-up.

Protection Description

Output overvoltage and open LED protection

The SY22142B detects the CS pin voltage as the boost output voltage when the external MOSFET is turned off during a switching cycle. Choose resistors R_{OV1} and R_{OV2} to program the output voltage protection threshold. V_{OVP} is calculated as:

$$V_{OVP}=1.2V\times\left(1+\frac{R_{OV1}}{R_{OV2}}\right)$$

Make sure the upper resistor (R_{OV1}) does not exceed its power rating when the output voltage reaches the OVP threshold. Ensure the CS pin filtering capacitor C_{SEN} is lower than 27pF(for R_{OV2}=2K) to avoid OCP triggering, which can be caused by the few time to discharge C_{SEN} after MOSFET turns off. If a LED string is open, the FB voltage will be pulled to ground. The boost converter continues increasing the output voltage until the OVP threshold is triggered. If the voltage at the CS pin while the external MOSFET turns off exceeds 1.2V (typical) for four switching cycles, the device will latch off.

Over Current Protection

An external sensing resistor R_{SEN} is used to sense the current flow through the external MOSFET Q_1. The sensed voltage is used for peak current mode control and cycle by cycle peak current limit. Peak current limit will be triggered when the voltage on CS pin exceeds the CS limit reference voltage V_{CS_LIM}=200mV (Typical) after 400ns turn on blanking time. The maximum CS sensing voltage should be about 70% of the CS limit reference voltage during normal operation. Therefore,

$$R_{SEN}=\frac{70\%\times0.2V}{I_L}$$

where I_L is peak current through the MOSFET Q_1

LED Short Protection

If an LED anode and cathode are shorted, the FB voltage will increase from the regulated voltage to a higher value. If the FB voltage exceeds the LED short rising threshold of 1V (typical) and last for at least 500ns, the IC will latch off.

LED Cathode Short To GND Protection

If LED cathode is shorted to GND, the FB voltage will drop. The boost converter continues charging the output voltage until the overvoltage (OVP) threshold is triggered. Under certain conditions, the overcurrent (OCP) protection will be triggered before OVP, so the device may transition to an OCP state and not latch off immediately. If the peak current sensing voltage V_{CS} exceeds 200mV (typical) and the FB voltage is less than 50mV, for 512 switching cycles, the device will latch off.

Inductor and Diode Short Protection

When the Boost inductor or diode are shorted, the current through the MOSFET will increase significantly. The same protection logic as the LED Cathode short to GND is used in this case.

Thermal Shutdown Protection

When the junction temperature reaches 150°C(typical), the device will shut down. The device will restart when the junction temperature falls below 130°C(typical).

Layout Design

To obtain the best efficiency and consider the following guidelines:

1) It is desirable to maximize the PCB copper area connected to the GND pin to achieve the best thermal and noise performance. If the board space allows, a ground plane is highly desirable.

2) C_{VCC} must be close to the pins VCC and GND. The loop area formed by C_{IN} and GND must be minimized.

3) The PCB copper area associated with MOSFET drain must be minimized to reduce radiated noise.

4) The FB pin must not be adjacent to the MOSFET drain or GATE connections on the PCB layout to avoid crosstalk.

The suggested layout for SY22142B is shown in figure 8.

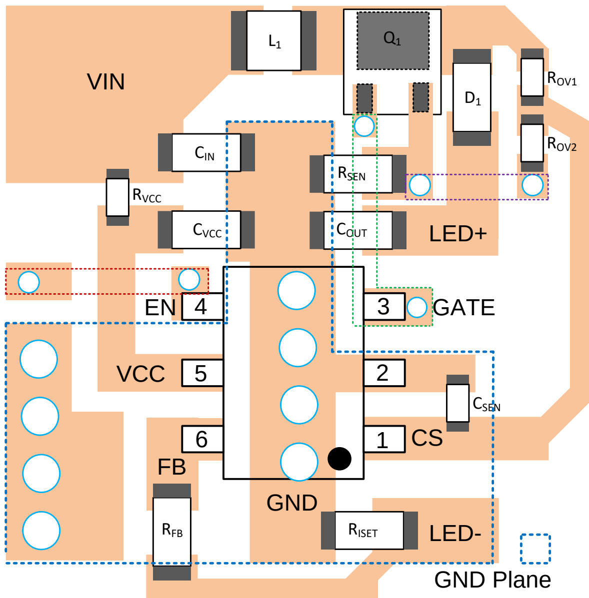


Figure 8. Recommended PCB Layout

Typical Application Schematic

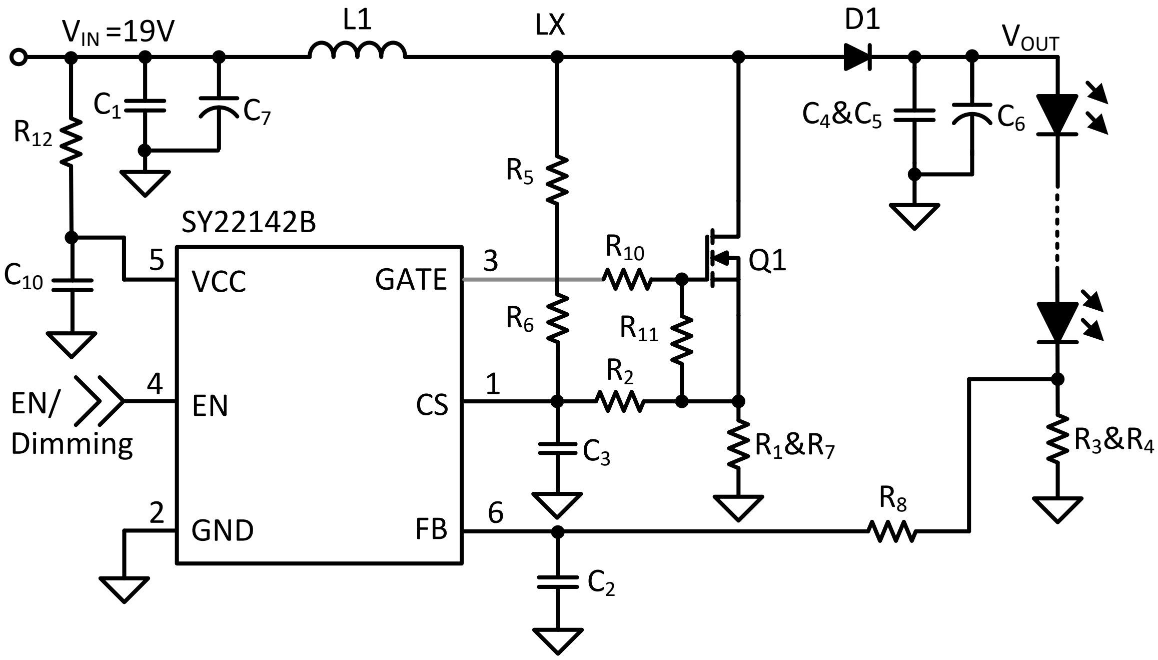


Figure 9. Typical Application Schematic

BOM List

Table1 BOM List

Reference Designator	Description	Part Number	Manufacturer
U1	1-channel LED Boost Controller	SY22142BABC	Silergy
R1,R7	200mΩ /1206,1%	PT1206FR-070R2L	Yageo
R2,R6	1kΩ /0603,1%	RT0603FRE071KL	Yageo
R3	4.7Ω /0603,1%	RT0603FRE074R7L	Yageo
R4	2.4Ω /0603,1%	RT0603FRE072R4L	Yageo
R5	62kΩ /0603,1%	RT0603FRE0762KL	Yageo
R10, R12	1Ω /0603,5%	RC0603JR-E071RL	Yageo
R11	100kΩ /0603,5%	RC0603JR-E07100KL	Yageo
R8	1kΩ/0603,5%	RC0603JR-E071KL	Yageo
C1	10µF/50V/1206,X7T	GRM31CD71H106KE11L	Murata
C2	1nF/50V/0603,C0G	GRM1885C1H102JA01D	Murata
C3	10pF/50V/0603,C0G	GRM1885C1H100JA01D	Murata
C4,C5	1µF/100V/1206,X7R	GRM31CR72A105KA01L	Murata
C6	47µF/100V,EC Cap	860040875002	Wurth Elecktronik
C7	47µF/50V,EC Cap	860020673013	Wurth Elecktronik
C10	1µF/50V/0603,X7T	GRM188D71H105KE01D	Murata
L1	150µH/1.4A,250mΩ	7447714151	Wurth Elecktronik
D1	100V/3A, Schottky Diode	B3100	Diodes
Q1	100V/36A, 24mΩ, NMOS	FDD86102	Fairchild

Design Example Methodology

Table 2 contains the requirements for a boost converter designed using SY22142B LED controller.

Table2 Design Specification

Parameters	MIN	NOM	MAX	UNIT
Input Voltage Range				
Power Supply Range	17	19	21	V
Output Requirements				
V_{LED} LED Voltage		60		V
$I_{OUT,MAX}$ LED Current		250		mA
R_{LED_AC} LED equivalent resistance		20		Ω
Output Voltage Ripple		0.6		V
OVP Voltage		72		V
System Characteristic				
η Efficiency	93%			

Detailed Design

The design starts with selecting an appropriate boost inductance.

a) Calculate the duty cycle D (CCM operation is assumed)

$$D=\frac{V_{OUT}-V_{IN\_MIN}}{V_{OUT}}=\frac{V_{LED}+V_{FB}-V_{IN\_MIN}}{V_{LED}+V_{FB}}=\frac{60+0.4-17}{60+0.4}=0.719 \quad (1)$$

b) Calculate the boundary current mode inductance

$$L_{BCM}=\left(\frac{V_{IN\_MIN}}{V_{OUT}}\right)^2\times\frac{\eta\times(V_{OUT}-V_{IN\_MIN})}{I_{OUT,MAX}\times 2\times F_{SW}}=\left(\frac{17}{60.4}\right)^2\times\frac{\eta\times(60.4-17)}{0.25\times 2\times 120\times 10^3}=53.3uH \quad (2)$$

c) Calculate the inductance assuming the ripple current is about 40% of the maximum output current

$$L=\left(\frac{V_{IN\_MIN}}{V_{OUT}}\right)^2\times\frac{\eta\times(V_{OUT}-V_{IN\_MIN})}{0.4\times I_{OUT,MAX}\times F_{SW}}=\left(\frac{17}{60.4}\right)^2\times\frac{0.93\times(60.4-17)}{0.4\times 0.25\times 120\times 10^3}=266uH \quad (3)$$

d) Calculate the output capacitor based on to the ripple voltage being around 1% of the output voltage:

$$C_{OUT}=\frac{I_{OUT,MAX}\times(V_{OUT}-V_{IN\_MIN})}{F_{SW}\times V_{OUT}\times V_{RIPPLE}}=\frac{0.25\times(60.4-17)}{120\times 10^3\times 60.4\times 0.6}=2.49uF \quad (4)$$

Calculate the minimum boost output capacitor value required to eliminate the compensated zero

$$C_{OUT}=\frac{R_C\times C_{C1}}{R_{LED\_AC}}=\frac{2Meg\times 100pF}{20}=10uF \quad (5)$$

Choose the larger C_{OUT} as the final output capacitor.

e) Calculate the Boost right half zero f_{RHZ} and compensated zero f_{Z_C}

$$f_{RHZ}=\frac{\frac{V_{OUT}}{I_{OUT,MAX}}\times(1-D)^2}{L_1\times 2\pi}=\frac{241.6\times(1-0.719)^2}{266\mu\times 2\pi}=11.40KHz \quad (6)$$

Re-calculate the right half zero for an inductance value of 150uH

$$f_{RHZ}=\frac{\frac{V_{OUT}}{I_{OUT,MAX}}\times(1-D)^2}{L_1\times 2\pi}=\frac{241.6\times(1-0.719)^2}{150\mu\times 2\pi}=20.22KHz \quad (7)$$

Calculate the compensated zero f_{Z_C}

$$f_{Z\_C}=\frac{1}{R_C\times C_{C1}\times 2\pi}=\frac{1}{2Meg\times 100pF\times 2\pi}=0.796KHz \quad (8)$$

If f_{RHZ} is too far way from the compensated zero, set the bandwidth to 1/5 f_{RHZ}

$$BW=\frac{1}{5}\times f_{RHZ}=\frac{1}{5}\times 20.22KHz=4.05KHz \quad (9)$$

f) Calculate the inductor peak current I_L for the chosen inductance L_1=150uH

$$I_L=\left(\frac{V_{OUT}}{V_{IN\_MIN}}\right)\times\frac{I_{OUT\_MAX}}{\eta}+\frac{(V_{OUT}-V_{IN\_MIN})}{2\times F_{SW}\times L_1}\times\left(\frac{V_{IN\_MIN}}{V_{OUT}}\right)=\left(\frac{60.4}{17}\right)\times\frac{0.25}{0.93}+\frac{(60.4-17)}{2\times 120KHz\times 150\mu}\times\left(\frac{17}{60.4}\right)=1.294A \quad (10)$$

g) Calculate the peak current sensing resistor R_{SEN}

$$R_{SEN}=\frac{70\%\times 0.2V}{I_L}=\frac{0.14V}{1.294}=0.108 \quad (11)$$

Select a the final R_{SEN} based on the available values. In this case a a value of 0.1Ω was selected.

h)

i) Calculate the final C_{OUT} for BW=4.05KHz

$$G_{CLOSED}(s)=\frac{(1\text{-}D)\times R_{ISET}}{3\times R_{SEN}}\times\frac{1}{1+\frac{1}{\omega_2}\times\frac{1}{Q_p}s+(\frac{s}{\omega_2})^2}\times\left(1\text{-}\frac{s}{\omega_a}\right)\times\frac{\left(R_{ESR}+\frac{1}{s\times C_{OUT}}\right)}{R_{LED\_AC}+R_{ISET}+R_{ESR}+\frac{1}{s\times C_{OUT}}}\times gm\times\frac{(s\times R_C\times C_{C1}+1)}{s\times C_{C1}\times\left(s\times R_C\times C_{C2}+1+\frac{C_{C2}}{C_{C1}}\right)} \quad (12)$$

C_{C1}=100pF C_{C2}=5pF C_{C1} is 20 times as C_{C2}. R_{ESR} can be 0 if output capacitors are all ceramic.

$$G_{CLOSED}(s)=\frac{(1\text{-}D)\times R_{ISET}}{3\times R_{SEN}}\times\frac{1}{1+\frac{1}{\omega_2}\times\frac{1}{Q_p}s+(\frac{s}{\omega_2})^2}\times\left(1\text{-}\frac{s}{\omega_a}\right)\times\frac{1}{s\times C_{OUT}\times(R_{LED\_AC}+R_{ISET})+1}\times gm\times\frac{(s\times R_C\times C_{C1}+1)}{s\times C_{C1}\times(s\times R_C\times C_{C2}+1)} \quad (13)$$

C_{OUT}=68uF, phase margin is 53 degree larger than 45 degree. Choose a larger C_{OUT} as the final output capacitor.

j) Calculate the final RMS current of inductor and MOSFET.

Re-calculate the inductor current ripple coefficient K_{RP}

$$K_{RP}=\left(\frac{V_{IN}}{V_{OUT}}\right)^2\times\frac{\eta\times(V_{OUT}-V_{IN})}{L\times I_{OUT,MAX}\times F_{SW}}=\left(\frac{17}{60.4}\right)^2\times\frac{0.93\times(60.4-17)}{150\mu\times 0.25\times 120\times 10^3}=0.710 \quad (14)$$

Calculate the RMS current of inductor I_{L_RMS} based on the K_{RP} value:

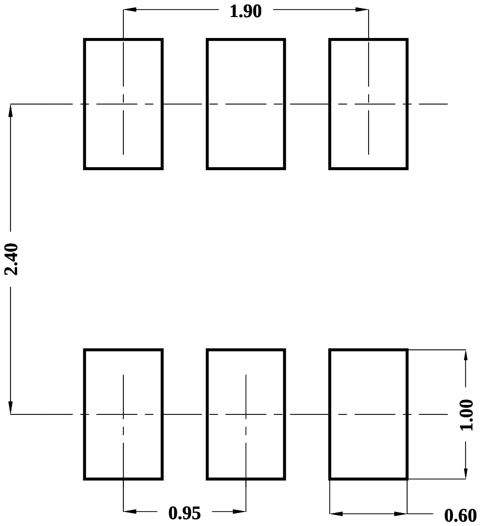
$$I_{L\_RMS} = \frac{V_{OUT} \times I_{OUT\_MAX}}{V_{IN} \times \eta} \times \left(1 + \frac{K_{RP}}{2}\right) \times \sqrt{1 - \frac{K_{RP}}{1 + \frac{K_{RP}}{2}} + \frac{1}{3} \times \left(\frac{K_{RP}}{1 + \frac{K_{RP}}{2}}\right)^2} = \frac{60.4 \times 0.25}{17 \times 0.93} \times \left(1 + \frac{0.710}{2}\right) \times \sqrt{1 - \frac{0.710}{1 + \frac{0.710}{2}} + \frac{1}{3} \times \left(\frac{0.710}{1 + \frac{0.710}{2}}\right)^2} = 0.975A \quad (15)$$

RMS current of MOS I_{MOS_RMS};

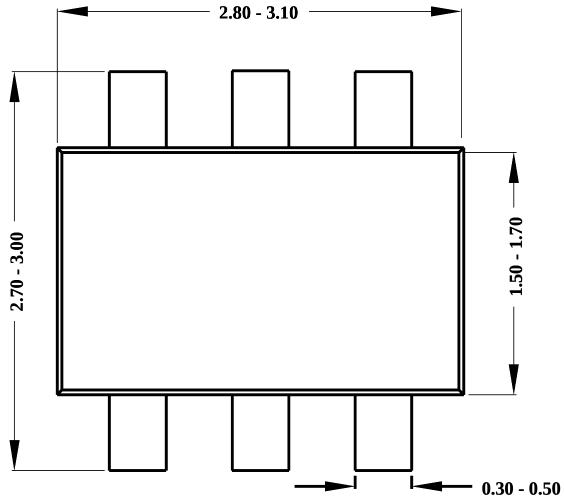
$$I_{MOS\_RMS} = I_{L\_RMS} \times \sqrt{\frac{V_{OUT} - V_{IN}}{V_{OUT}}} = 0.975A \times \sqrt{\frac{60.4 - 17}{60.4}} = 0.826A \quad (16)$$

A MOSFET with a current rating of 2A or higher is recommended.

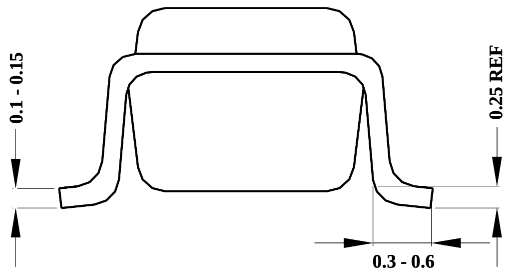
SOT23-6 Package Outline and PCB Layout



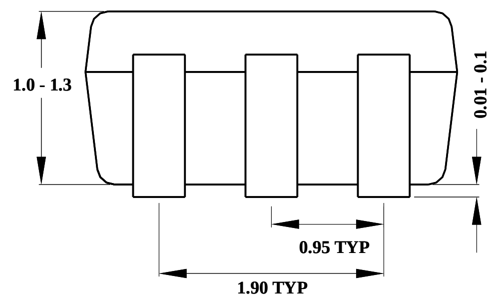
Recommended pad layout
(reference only)



Top view



Side view

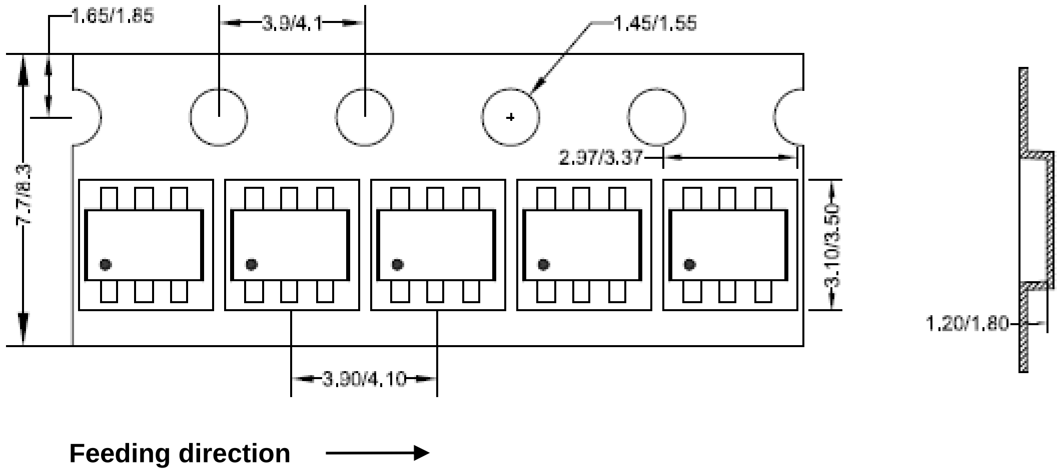


Side view

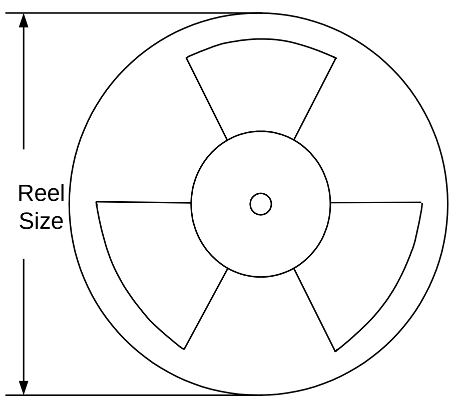
Note: All dimensions are in millimeters and exclude mold flash and metal burr.

Taping and Reel Specification

SOT23-6 taping orientation



Carrier tape and reel specification for packages



Package Types	Tape Width (mm)	Pocket Pitch (mm)	Reel Size (Inch)	Trailer Length (mm)	Leader Length (mm)	Qty per Reel
SOT23-6	**8**	**4**	**7"**	**280**	**160**	**3000**

Others: NA

Revision History

The revision history provided is for informational purpose only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
Mar.6, 2017	Revision 0.9	Initial Release
Jan.6, 2024	Revision 1.0	Production Release

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