5.5V 1A 1.5MHz Sync Constant Current LED Driver

Features

- 2.5V to 5.5V Input Voltage Range
- 1A Continuous Output Current
- 1.5MHz Switching Frequency
- LED Open Load Protection
- Built-in Over Current Limit
- Input Over Voltage Protection
- PFM Mode for High Efficiency in Light Load
- Internal Soft-Start
- PWM Brightness Control on Enable
- 100mV Low Feedback Voltage
- No Schottky Diode Required
- Over Temperature Protected
- Low Quiescent Current: 40μA
- LED Short Protection
- Available in SOT23-5 package
- -40°C to +85°C Temperature Range

Applications

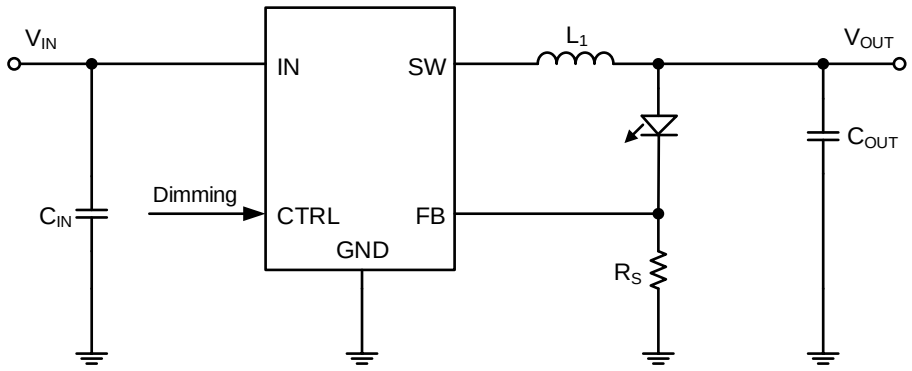
- LED Drivers
- Industrial Lighting
- LED Flashlights
- Digital Still and Video Cameras

General Description

The 7010 is a 1A constant current LED driver designed to provide a simple, high efficiency solution for driving high power LEDs. With a 100mV reference voltage feedback control to minimize power dissipation, an external resistor sets the current as needed for driving various types of LEDs. Supply current with no load is 40uA and drops to <1uA in shutdown. The 2.5V to 5.5V input voltage range makes the RY7010 ideally suited for single Li-Ion battery powered applications. 100% duty cycle provides low dropout operation, extending battery life in portable systems. PWM/PFM mode operation provides very low output ripple voltage for noise sensitive applications. Switching frequency is internally set at 1.5MHz, allowing the use of small surface mount inductors and capacitors. Additional features include user accessible CTRL pin for enabling and PWM dimming of LEDs, thermal shutdown, cycle-by-cycle current limit and overcurrent protection.

The RY7010 requires a minimal number of readily available, external components and is available in a space saving SOT23-5 package.

Typical Application Circuit



Basic Application Circuit

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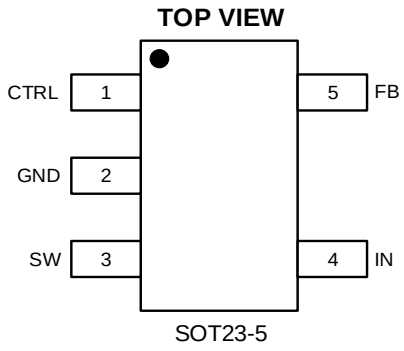
Pin Description

Pin Configuration



Top Marking: JMYLL (device code: JM, Y=year code, LL= lot number code)

Pin Description

Pin	Name	Function
1	CTRL	CTRL pin is a multi-functional pin which can be used for enable control and PWM dimming. Should not be left floating.
2	GND	Ground Pin
3	SW	Power Switch Output. It is the switch node connection to Inductor. This pin connects to the drains of the internal P-ch and N-ch MOSFET switches.
4	IN	Power Supply Input. Must be closely decoupled to GND with a 22μF or greater ceramic capacitor.
5	FB	Feedback Reference Voltage Pin. Series connect a resistor R_S between LED and ground as a current sense. Sense the current feedback voltage to set the current rating.

Order Information (1)

Marking	Part No.	Model	Description	Package	T/R Qty.
JMYLL	70380052	RY7010	RY7010 Sync Constant Current LED Driver, 2.5-5.5V, 1A, 1.5MHz, VFB 0.1V, SOT23-5	SOT23-5	3000PCS

Note (1): All RYCHIP parts are Pb-Free and adhere to the RoHS directive.

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Specifications

Absolute Maximum Ratings (1) (2)

Item	Min	Max	Unit
V_{IN} voltage	-0.3	6	V
EN voltage	-0.3	6	V
SW voltage	-0.3	6.3	V
SW voltage (10ns transient)	-5	8	V
FB voltage	–0.3	6	V
Power dissipation (3)	Internally Limited		
Operating junction temperature, T_J	-40	150	°C
Storage temperature, T_{stg}	–55	150	°C
Lead Temperature (Soldering, 10sec.)		260	°C

Note (1): Exceeding these ratings may damage the device.

Note (2): The device is not guaranteed to function outside of its operating conditions.

Note (3): The maximum allowable power dissipation is a function of the maximum junction temperature, $T_{J(MAX)}$, the junction-to-ambient thermal resistance, $R_{\theta JA}$, and the ambient temperature, T_A. The maximum allowable power dissipation at any ambient temperature is calculated using: $P_{D\,(MAX)} = (T_{J(MAX)} - T_A)/R_{\theta JA}$. Exceeding the maximum allowable power dissipation causes excessive die temperature, and the regulator goes into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage. Thermal shutdown engages at T_J=160°C (typical) and disengages at T_J= 130°C (typical).

ESD Ratings

Item	Description	Value	Unit
$V_{(ESD\text{-}HBM)}$	Human Body Model (HBM) ANSI/ESDA/JEDEC JS-001-2014 Classification, Class: 2	±2000	V
$V_{(ESD\text{-}CDM)}$	Charged Device Mode (CDM) ANSI/ESDA/JEDEC JS-002-2014 Classification, Class: C0b	±200	V
$I_{LATCH\text{-}UP}$	JEDEC STANDARD NO.78E APRIL 2016 Temperature Classification, Class: I	±150	mA

Recommended Operating Conditions

Item	Min	Max	Unit
Operating junction temperature (1)	–40	125	°C
Operating temperature range	-40	85	°C
Input voltage V_{IN}	2.5	5.5	V
Output current	0	1	A

Note (1): All limits specified at room temperature (TA = 25°C) unless otherwise specified. All room temperature limits are 100% production tested. All limits at temperature extremes are ensured through correlation using standard

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Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

Thermal Information

Item	Description	Value	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance (1)(2)	180	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	130	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	45	°C/W
ψ_{JT}	Junction-to-top characterization parameter	35	°C/W
ψ_{JB}	Junction-to-board characterization parameter	45	°C/W

Note (1): The package thermal impedance is calculated in accordance to JESD 51-7.

Note (2): Thermal Resistances were simulated on a 4-layer, JEDEC board

Electrical Characteristics (1)(2)

V_{IN}=5V, T_A=25°C, unless otherwise specified.

Parameter	Conditions	Min.	Typ.	Max.	Unit
Input Voltage Range		2.5		5.5	V
Supply Current (Quiescent)	V_{CTRL} =High, V_{FB}=110%		40	80	μA
Supply Current (Shutdown)	V_{CTRL} =0 or CTRL = GND		0.1	1.0	μA
Feedback Voltage		0.097	0.100	0.103	V
High-Side Switch On-Resistance	I_{SW}=100mA		300		mΩ
Low-Side Switch On-Resistance	I_{SW}=-100mA		200		mΩ
Upper Switch Current Limit		2			A
Over Voltage Protection Threshold			6		V
Switching Frequency			1.5		MHz
Maximum Duty Cycle	V_{FB}=90%		100		%
CTRL Rising Threshold		2.5			V
CTRL Falling Threshold				0.8	V
Under-Voltage Lockout Threshold	Wake up V_{IN} Voltage		2.3	2.45	V
	Shutdown V_{IN} Voltage	1.75	1.9		V
	Hysteresis V_{IN} voltage		400		mV
Soft Start			1		mS
Thermal Shutdown			160		℃
Thermal Hysteresis			30		℃

Note (1): MOSFET on-resistance specifications are guaranteed by correlation to wafer level measurements.

Note (2): Thermal shutdown specifications are guaranteed by correlation to the design and characteristics analysis.

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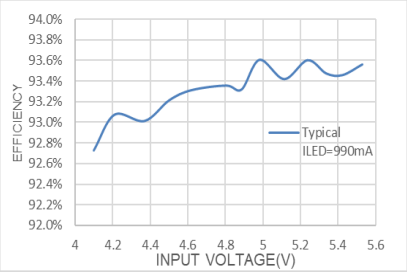
Typical Performance Characteristics (1)(2)

Note (1): Performance waveforms are tested on the evaluation board.

Note (2): V_{IN} =5V, V_{OUT}=1 Series 3 Parallel LED, T_A = +25ºC, unless otherwise noted.

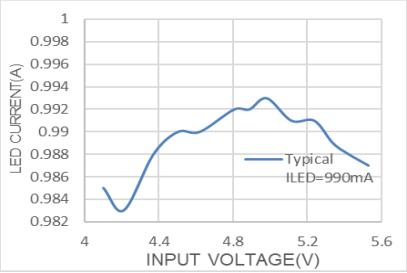
Efficiency vs. Input Voltage

V_{OUT}=1 Series 3 Parallel LED



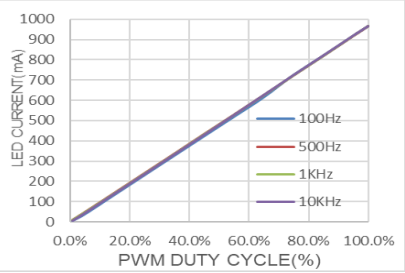
LED Current vs. Input Voltage

V_{OUT}=1 Series 3 Parallel LED



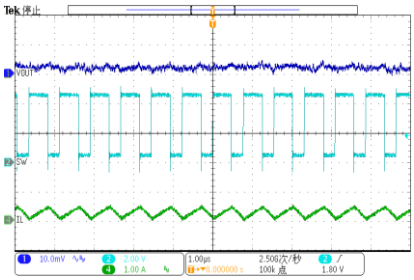
LED Current vs. PWM Duty Cycle

V_{OUT}=1 Series 3 Parallel LED



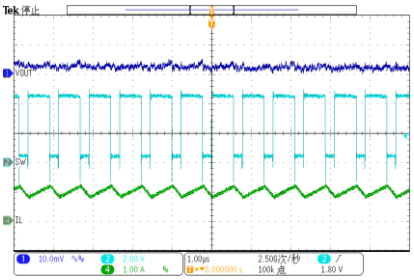
Steady State

ILED=0.2A



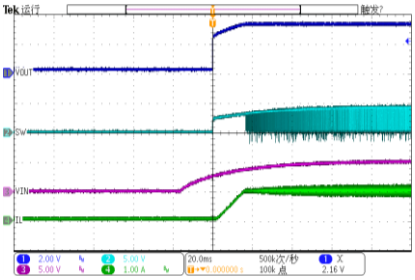
Steady State

ILED=1A



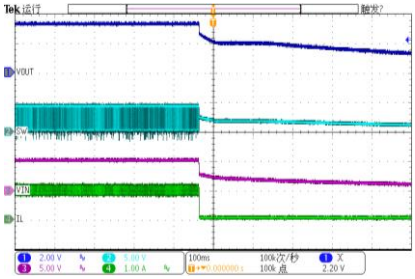
V_{IN} Start-Up

ILED=1A



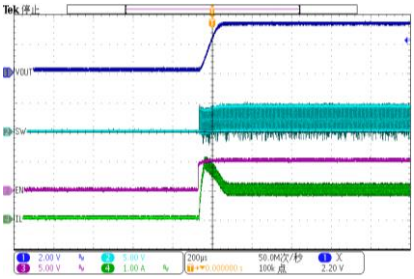
V_{IN} Shut-Down

ILED=1A



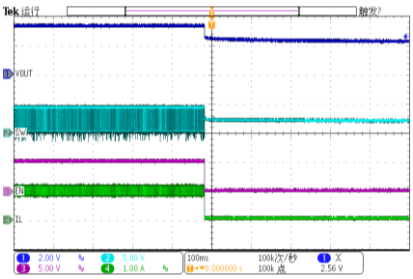
Enable Start-Up

V_{IN}=5V, ILED=1A



Enable Shut-Down

V_{IN}=5V, ILED=1A



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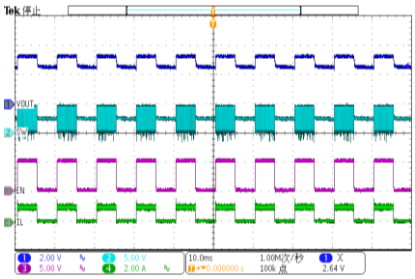
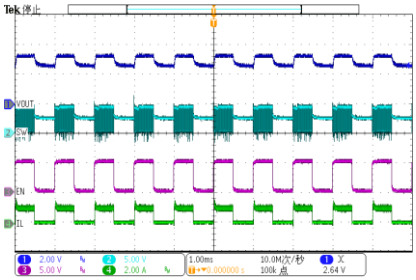
Dimming Operation

V_{IN}=5V, ILED=1A, f=100Hz



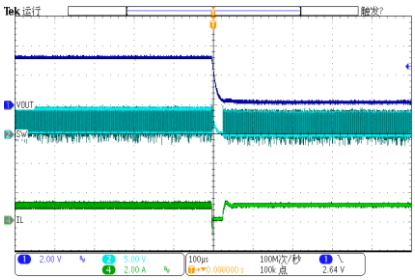
Dimming Operation

V_{IN}=5V, ILED=1A, f=1KHz



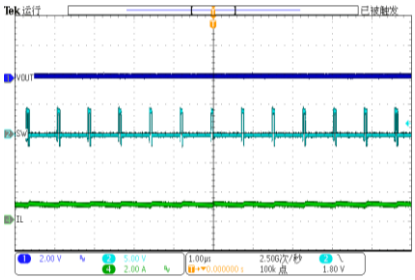
LED+ Short to LED- Entry

V_{IN}=5V



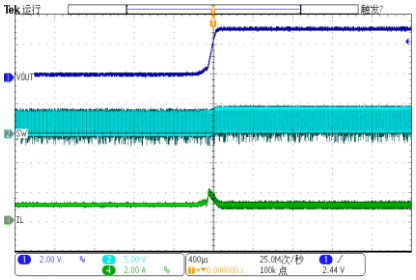
LED+ Short to LED- SteadyState

V_{IN}=5V



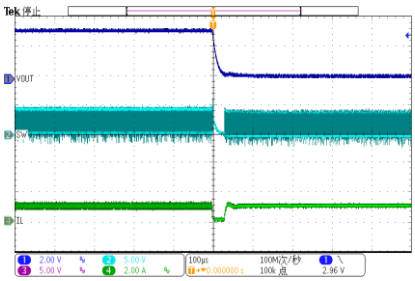
LED+ Short to LED- Recovery

V_{IN}=5V



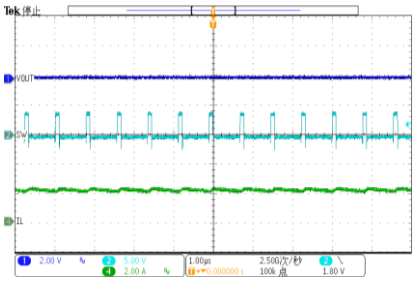
LED+ Short to GND Entry

V_{IN}=5V



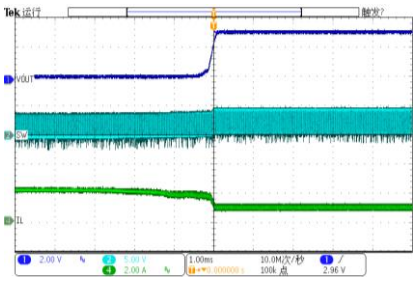
LED+ Short to GND SteadyState

V_{IN}=5V



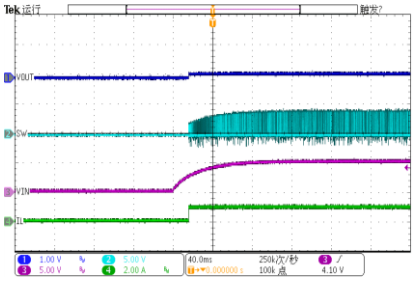
LED+ Short to GND Recovery

V_{IN}=5V



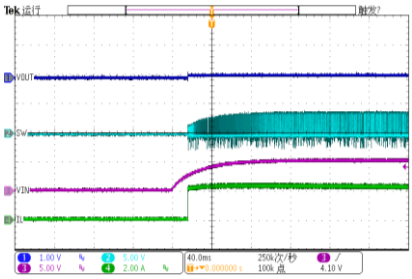
LED+ Short to LED- V_{IN} Up

V_{IN}=5V



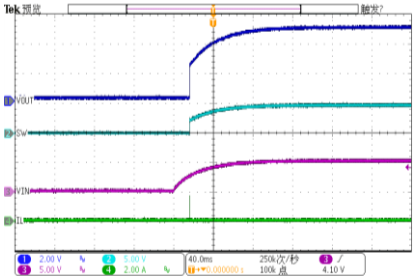
LED+ Short to GND V_{IN} Up

V_{IN}=5V



V_{OUT} Open V_{IN} Up

V_{IN}=5V



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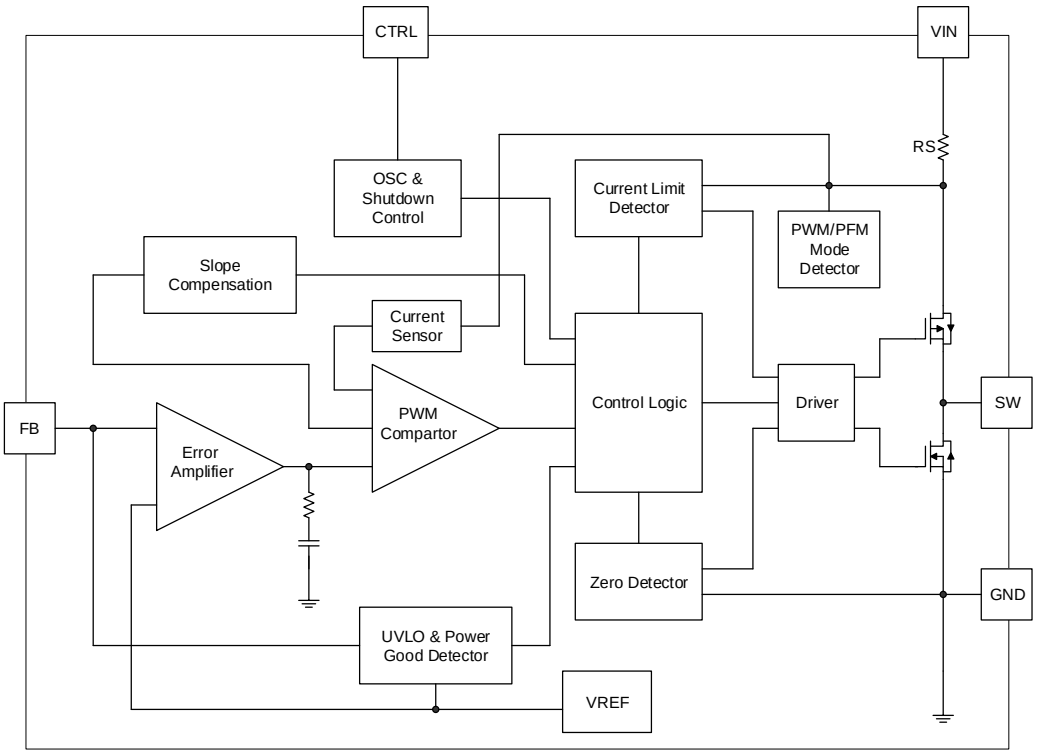
Functional Block Diagram



Block Diagram

Functions Description

Under-Voltage Lockout (UVLO)

Under-voltage lockout (UVLO) protects the chip from operating at an insufficient supply voltage. UVLO protection monitors the internal regulator voltage. When the voltage is lower than UVLO threshold voltage, the device is shut off. When the voltage is higher than UVLO threshold voltage, the device is enabled again.

Enable and PWM Dimming

When the input voltage is above maximal UVLO rising threshold and the CTRL pin is pulled high, the RY7010 is enabled. When the CTRL pin is pulled low, the RY7010 goes into shutdown mode. In shutdown mode, less than 1μA input current is consumed. The CTRL pin allows disabling and enabling of the device as well as brightness control of the LEDs by applying a PWM signal up to typically 1kHz. When a PWM signal is applied, the LED current is turned on when the CTRL is high and off when CTRL is pulled low. Changing the PWM duty cycle therefore changes the LED brightness.

Soft-Start

The RY7010 begins soft start when the CTRL pin is pulled high. at the beginning of the soft start period, the isolation FET is turned on slowly to charge the output capacitor. After the pre-charge phase, the RY7010 starts switching. This is called switching soft start phase. An internal soft start circuit limits the peak inductor current according to the output voltage. The switching soft start phase is about 1ms typically. The soft start function reduces the inrush current during startup.

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Efficiency and Feedback Voltage

The feedback voltage has a direct effect on the converter efficiency. Because the voltage drop across the feedback resistor does not contribute to the output power (LED brightness), the lower the feedback voltage, the higher the efficiency.

Current Limit

The RY7010 uses cycle-by-cycle current limit to protect the internal power switch. During each switching cycle, a current limit comparator detects if the power switch current exceeds 2A (typical), and turns off the switch until the next switching cycle begins.

Thermal Shutdown

Thermal shutdown prevents the chip from operating at exceedingly high temperatures. When the silicon die temperature exceeds 160°C, it shuts down the whole chip. When the temperature falls below its lower threshold (Typ. 130°C) the chip is enabled again.

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Applications Information

Setting the LED Current

The LED current is controlled by the feedback resistor, R_S, in the following table. The current through the LEDs is given by the equation 100mV/R_S. Following table shows the selection of resistors for a given LED current.

I_{LED} (A)	R_S (Ω)
0.1	1
0.2	0.5
0.5	0.2
1	0.1

I_{LED} is average LED current.

Dimming Control

For controlling the LED brightness, the RY7010 can perform the dimming control by applying a PWM signal to CTRL pin. The internal soft start and the wide range dimming frequency can eliminate inrush current and audio noise when dimming. The average LED current is proportional to the PWM signal duty cycle. The magnitude of the PWM signal should be higher than the enable voltage of CTRL pin.

Inductor Selection

The recommended value of inductor for most applications are 2.2μH. Small size and better efficiency are the major concerns for portable device, such as RY7010 used for mobile phone. When selecting the inductor, the inductor saturation current should be rated as high as the peak inductor current at maximum load, and respectively, maximum LED current.

Output Capacitor Selection

The device is designed to operate with a wide selection of ceramic output capacitors. The selection of the output capacitor value is a trade-off between output voltage ripple and capacitor cost and form factor. In general, capacitor values of 22μF up to 44μF can be used. For better voltage filtering, ceramic capacitors with low ESR are recommended. X5R and X7R types are suitable because of their wider voltage and temperature ranges.

Input Capacitor Selection

For good input voltage filtering, low ESR ceramic capacitors are recommended. A 22μF ceramic input capacitor is sufficient for most of the applications. For better input voltage filtering and EMI reduction, this value can be increased. The input capacitor should be placed as close as possible to the input pin of the converter.

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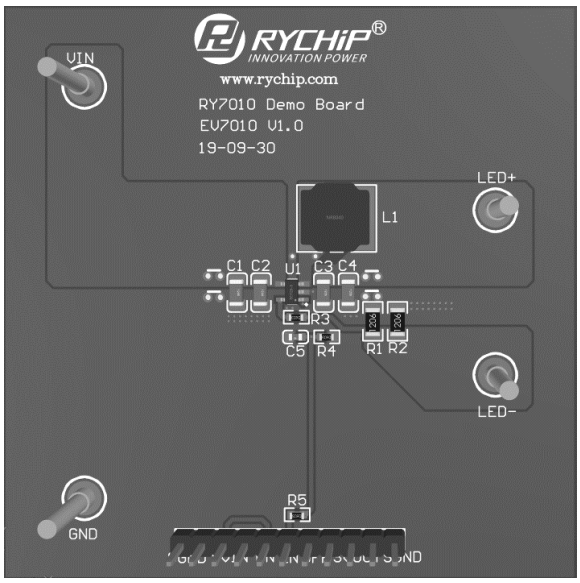
PC Board Layout Consideration

PCB layout is very important to achieve stable operation. It is highly recommended to duplicate EVB layout for optimum performance. If change is necessary, please follow these guidelines for reference.

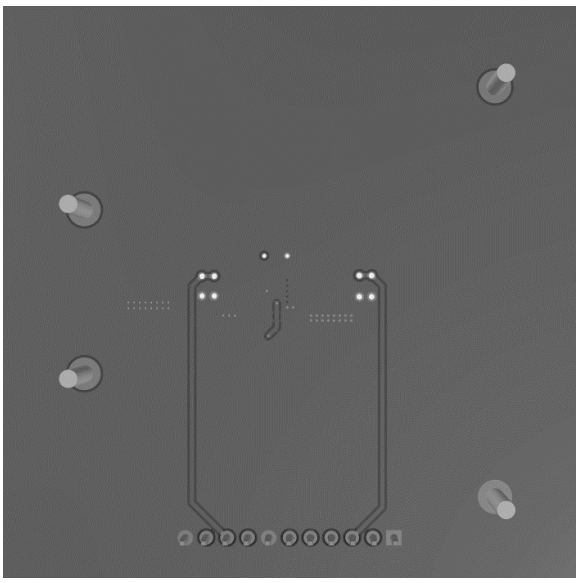
1. Keep the path of switching current short and minimize the loop area formed by Input capacitor, high-side MOSFET and low-side MOSFET.
2. Bypass ceramic capacitors are suggested to be put close to the V_{IN} Pin.
3. Ensure all feedback connections are short and direct. Place the feedback resistors and compensation components as close to the chip as possible.
4. $V_{OUT,}$ SW away from sensitive analog areas such as FB.

Connect IN, SW, and especially GND respectively to a large copper area to cool the chip to improve thermal performance and long-term reliability.

Top Layer



Bottom Layer

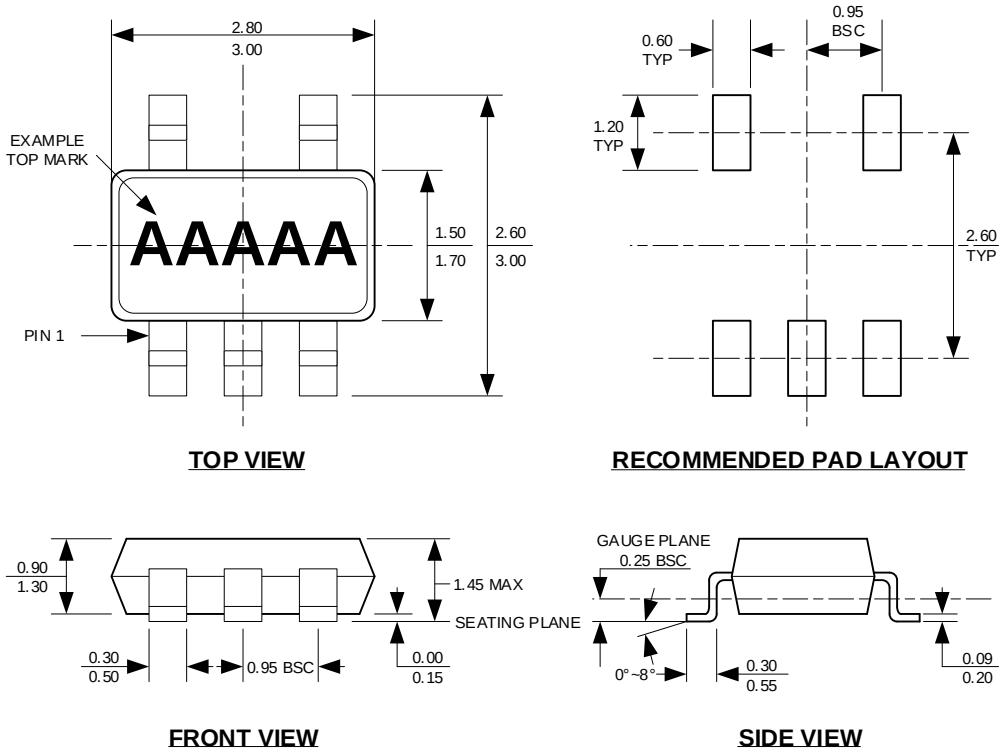


Sample Board Layout

5.5V 1A 1.5MHz Sync Constant Current LED Driver

Package Description

SOT23-5



NOTE:
1. CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
2. PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
3. PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
4. LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
5. DRAWING CONFORMS TO JEDEC MS-012, VARIATION BA.
6. DRAWING IS NOT TO SCALE.