White LED Driver with PWM Brightness Control in Small Packages

1 FEATURES

- **Input Voltage Range: 2.7V to 20V**
- **30V Open LED Protection**
- **200mV Reference Voltage**
- **550kΩ Pull-Down Resistor on CTRL Pin**
- **PWM Brightness Control**
- **10kHz to 100kHz PWM Dimming Frequency Range**
- **Dimming Stable in More than 1:500 PWM Range**
- **Soft-Start Function**
- **Up to 90% Efficiency**
- **-40°C to +85°C Operating Temperature Range**
- **Available in the Green SOT23-6 Package**

2 APPLICATIONS

- **Cellular Phones**
- **Portable Media Players**
- **Ultra Mobile Devices**
- **GPS Receivers**
- **White LED Backlighting for Media Form Factor Display**

3 DESCRIPTIONS

With a 30V rated integrated switch FET, the RS3750 is a boost converter that drives LEDs in series. The boost converter runs at 1150kHz fixed switching frequency to reduce output ripple, improve conversion efficiency, and allows for the use of small external components.

The default white LED current is set with the external sensor resistor RSET, and the feedback voltage is regulated to 200mV, as shown in the typical application. During the operation, the LED current can be controlled using PWM signal through the CTRL pin. The duty cycle of pulse width modulation (PWM) signal determines the feedback reference voltage. In PWM mode, the RS3750 does not burst the LED current; therefore, it does not generate audible noises on the output capacitor. For maximum protection, the device features integrated open LED protection that disables the RS3750 to prevent the output voltage from exceeding the IC's absolute maximum voltage ratings during open LED conditions.

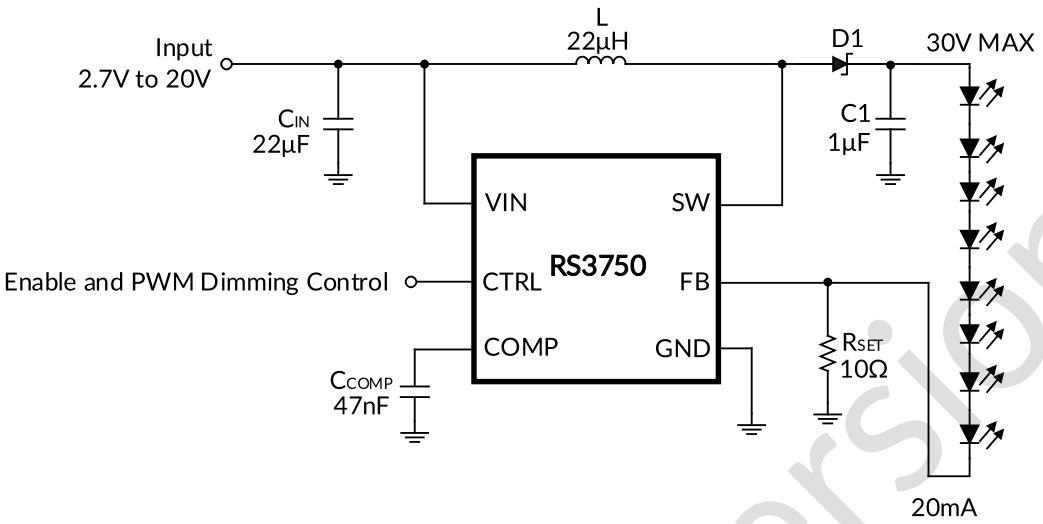
The RS3750 is available in Green SOT23-6 packages. It operates over an ambient temperature range of -40°C to +85°C.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS3750	SOT23-6	2.90mm×1.60mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

4 TYPICAL APPLICATION



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5 REVISION HISTORY

Note: Page numbers for previous revisions may different from page numbers in the current version.

VERSION	Change Date	Change Item
A.0	2023/11/17	Preliminary version completed
A.0.1	2024/04/10	1. Update ESD Ratings 2. Update V_{CTRLH} PARAMETER
A.0.2	2024/08/28	1. Update TYPICAL APPLICATION 2. Update Electrical Characteristics 3. Update Typical Performance Characteristics Figure 6,7

6 PACKAGE/ORDERING INFORMATION (1)

PRODUCT	ORDERING NUMBER	TEMPERATURE RANGE	PACKAGE LEAD	PACKAGE MARKING (2)	MSL(3)	PACKAGE OPTION
RS3750	RS3750YH6	-40°C ~+85°C	SOT23-6	3750	MSL3	Tape and Reel, 3000

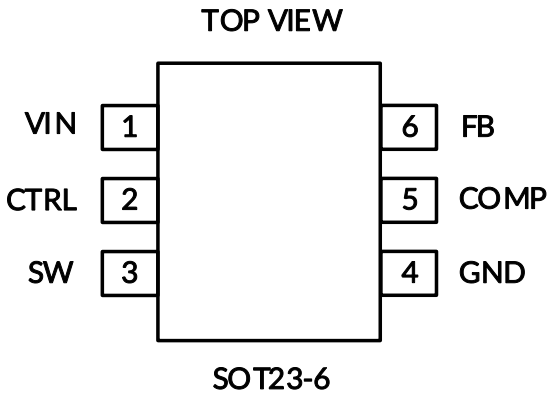
NOTE:

(1) This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the right-hand navigation.

(2) There may be additional marking, which relates to the lot trace code information (data code and vendor code), the logo or the environmental category on the device.

(3) RUNIC classify the MSL level with using the common preconditioning setting in our assembly factory conforming to the JEDEC industrial standard J-STD-20F. Please align with RUNIC if your end application is quite critical to the preconditioning setting or if you have special requirement.

7 PIN CONFIGURATIONS



PIN DESCRIPTION

PIN	NAME	I/O (1)	DESCRIPTION
SOT23-6			
1	VIN	I	Input Supply Pin. Connect VIN to a supply voltage between 2.7V and 20V.
2	CTRL	I	Control Pin of the Boost Regulator. It is a multi-functional pin which can be used for enable and PWM dimming control.
3	SW	I	Switching Node of the IC. Connect the inductor between the VIN and SW pin. This pin is also used to sense the output voltage for open LED protection.
4	GND	G	Ground.
5	COMP	O	Output of the Transconductance Error Amplifier. Connect an external capacitor to this pin to compensate the converter.
6	FB	I	Feedback Pin for Current. Connect the sense resistor from FB to GND.

(1) I=Input, O=Output, G=Ground.

8 SPECIFICATIONS

8.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

			MIN	MAX	UNIT
V_{IN}	Supply voltage on VIN		-0.3	24	V
V_{CTRL}	Voltage on CTRL		-0.3	6	V
V_{FB}	Voltages on FB		-0.3	3	V
V_{COMP}	Voltages on COMP		-0.3	3	V
V_{SW}	Voltage on SW		-0.3	36	V
θ_{JA}	Package thermal impedance (2)	SOT23-6		200	°C/W
T_J	Junction temperature (3)		-40	150	°C
T_{stg}	Storage temperature		-65	150	°C
T_L	Lead Temperature (Soldering,10secs)			260	°C

(1) Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) The package thermal impedance is calculated in accordance with JESD-51.

(3) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$. All numbers apply for packages soldered directly onto a PCB.

8.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-Body Model (HBM), MIL-STD-883K METHOD 3015.9	±4000	V
		Charged-Device Model (CDM), ANSI/ESDA/JEDEC JS-002-2022	±1000	

ESD SENSITIVITY CAUTION

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

8.3 Recommended Operating Rating

		MIN	MAX	UNIT
V_{IN}	Supply voltage range	2.7	20	V
T_A	Operating Temperature	-40	85	°C

8.4 Electrical Characteristics

(V_{IN}=3.6V, V_{CTRL}=V_{IN}, C_{IN}=22μF, Full=-40°C to +85°C, T_A = +25°C, unless otherwise noted.) (1)

PARAMETER	SYMBOL	TEST CONDITIONS	MIN(2)	TYP(3)	MAX(2)	UNIT
SUPPLY CURRENT						
Input Voltage Range	V_{IN}		2.7		20	V
Operating Quiescent Current into VIN	I_Q	V_{FB} = 400mV		0.87	0.95	mA
Shutdown Current	I_{SD}	V_{CTRL} = GND, V_{IN} = 4.2V			1	μA
Under-Voltage Lockout Threshold	V_{UVLO}	V_{IN} rising		2.4	2.6	V
Under-Voltage Lockout Hysterisis	V_{UVLO_HY}			0.1		V
ENABLE AND REFERENCE CONTROL						
CTRL Logic High Voltage	V_{CTRLH}	V_{IN} = 2.7V to 20V, -40°C ~85°C	1.5			V
CTRL Logic Low Voltage	V_{CTRLL}	V_{IN} = 2.7V to 20V, -40°C ~85°C			0.4	V
CTRL Pull-Down Resistor	R_{CTRL}		450	550	650	KΩ
CTRL Pulse Width to Shutdown	t_{OFF}	CTRL high to low	2.6	2.8	3	ms
POWER SWITCH						
N-Channel MOSFET On-Resistance	$R_{DS(ON)}$	V_{IN} = 3.6V		0.15	0.2	Ω
		V_{IN} = 3.0V			0.2	
N-Channel Leakage Current	I_{LN_NFET}	V_{SW} = 35V, T_A = 25°C			1	μA
VOLTAGE AND CURRENT CONTROL						
Voltage Feedback Regulation Voltage	V_{REF}	V_{IN} = 3.6V	196	200	204	mV
Voltage Feedback Regulation Voltage Under Brightness Control	V_{REF_PWM}	V_{IN}=3.6V, f_{PWM}=10kHz, duty cycle=75%		147		mV
		V_{IN}=3.6V, f_{PWM}=10kHz, duty cycle=50%		97		
		V_{IN}=3.6V, f_{PWM}=10kHz, duty cycle=25%		47		
		V_{IN}=3.6V, f_{PWM}=10kHz, duty cycle=10%		17		
Voltage Feedback Input Bias Current	I_{FB}	V_{FB} = 200mV, -40°C ~85°C		0.01	0.2	μA
Oscillator Frequency	f_S	-40°C ~85°C	900	1150	1400	KHz
Minimum ON Pulse Width	t_{MIN_ON}			40		ns
COMP Pin Sink Current	I_{SINK}			45		μA
COMP Pin Source Current	I_{SOURCE}			45		μA
OVER-CURRENT AND OPEN LED PROTECTION						
N-Channel MOSFET Current Limit	I_{LIM}		1.4	1.65	1.9	A
Open LED Protection Threshold	V_{OVP}	Measured on the SW pin -40°C ~85°C	27	30	33	V
PWM BRIGHTNESS CONTROL						
PWM Dimming Frequency	f_{PWM}	-40°C ~85°C	10		100	KHz
Minimum PWM On-Time			30			ns
Minimum Stable Duty Cycle	D_{MIN}		0.2			%
THERMAL SHUTDOWN						
Thermal Shutdown Threshold	T_{SHDN}			155		°C
Thermal Shutdown Threshold Hysteresis	T_{HYS}			10		°C

(1) Electrical table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device.
(2) Limits are 100% production tested at 25°C. Limits over the operating temperature range are ensured through correlations using statistical quality control (SQC) method.
(3) Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration.

8.5 Typical Performance Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

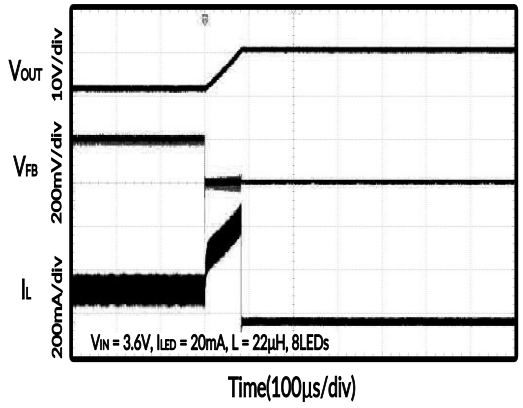


Figure 1. Open LED Protection

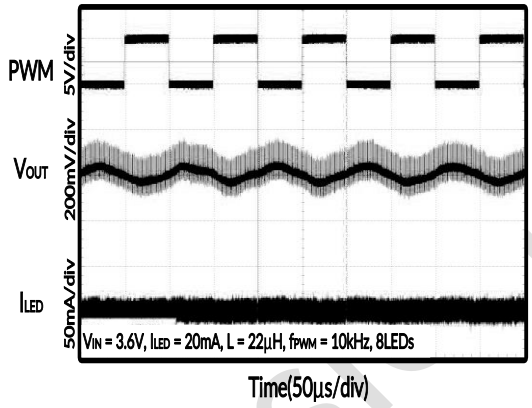


Figure 2. Output Ripple at PWM Dimming

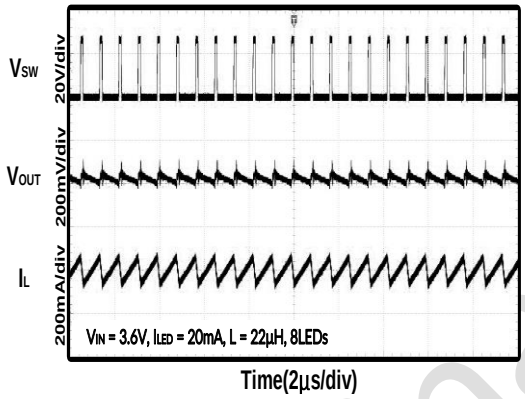


Figure 3. Switching Waveform

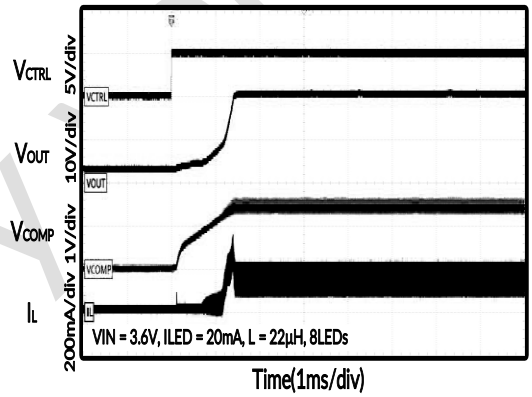


Figure 4. Start-Up

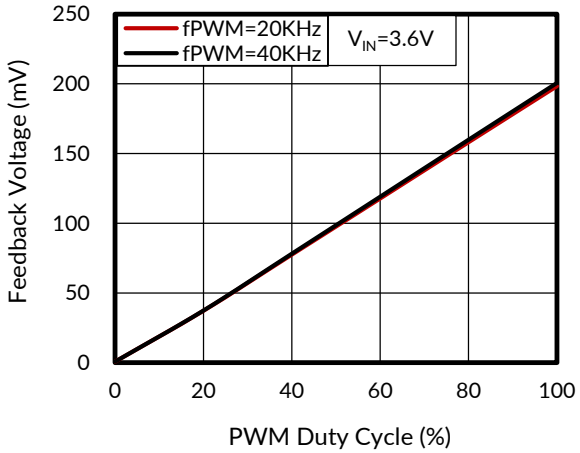


Figure 5. Feedback Voltage vs PWM Duty Cycle

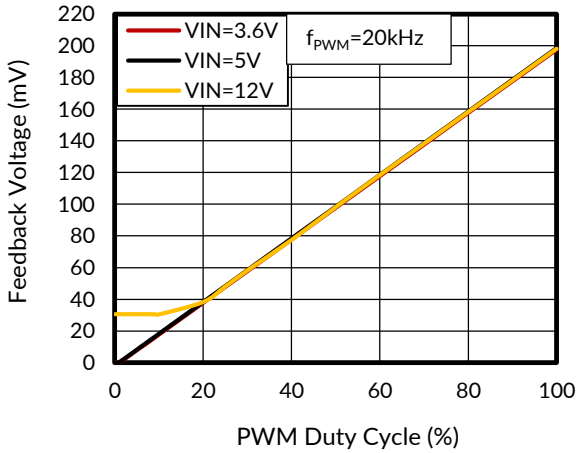


Figure 6. Feedback Voltage vs PWM Duty Cycle

Typical Performance Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

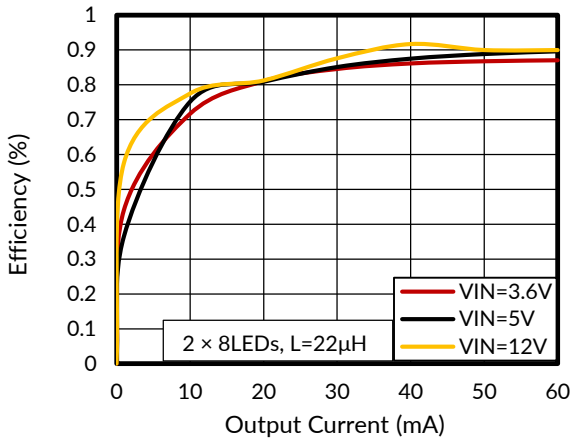


Figure 7. Efficiency vs Output Current

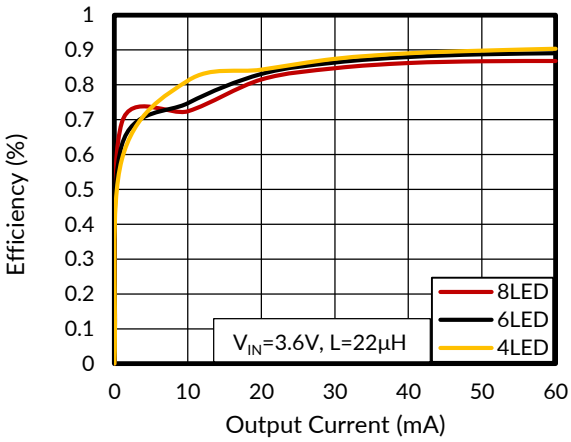


Figure 8. Efficiency vs Output Current

9 DETAILED DESCRIPTION

The RS3750 is a high efficiency, high output voltage boost converter in small package size. The device is ideal for driving white LED in series. The serial LED connection provides even illumination by sourcing the same output current through all LEDs, eliminating the need for expensive factory calibration. The device integrates 40V/1.65A switch FET and operates in pulse width modulation (PWM) with 1150kHz fixed switching frequency. For operation see the FUNCTIONAL BLOCK DIAGRAM. The duty cycle of the converter is set by the error amplifier output and the current signal applied to the PWM control comparator. The control architecture is based on traditional current-mode control; therefore, a slope compensation is added to the current signal to allow stable operation for duty cycles larger than 40%. The feedback loop regulates the FB pin to a low reference voltage (200mV typical), reducing the power dissipation in the current sense resistor.

9.1 Open LED Protection (OLP)

Open LED protection circuitry prevents IC damage as the result of white LED disconnection. The RS3750 monitors the voltage at the SW pin during each switching cycle. The switch FET will be turned off, when the SW voltage exceeds the V_{OVP} threshold for 8 switching clock cycles. When the above condition is met, the protection circuitry will work again.

9.2 Current Program

The FB voltage is regulated by a low 200mV reference voltage. The LED current is programmed externally using a current sense resistor in series with the LED string. The value of the R_{SET} is calculated using Equation 1.

$$I_{LED} = \frac{V_{FB}}{R_{SET}} \quad (1)$$

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.

9.3 Shutdown

The RS3750 enters shutdown mode when the CTRL voltage is logic low for more than 2.6ms. During shutdown, the input supply current for the device is less than 1μA. Although the internal FET does not switch in shutdown, there is still a DC current path between the input and the LEDs through the inductor and Schottky diode. The minimum forward voltage of the LED array must exceed the maximum input voltage to ensure that the LEDs remain off in shutdown. However, in the typical application with two or more LEDs, the forward voltage is large enough to reverse bias the Schottky and keep leakage current low.

9.4 LED Brightness Dimming Mode Selection

The CTRL pin is used for the control input for enable and PWM dimming mode. The range of PWM dimming frequency is from 10kHz to 100kHz, and the recommended minimum PWM duty cycle is 0.1% for no blind dimming. When the CTRL pin is constantly high, the FB voltage is regulated to 200mV typically. However, the CTRL pin allows a PWM signal to reduce this regulation voltage; therefore, it achieves LED brightness dimming.

9.5 Under-Voltage Lockout

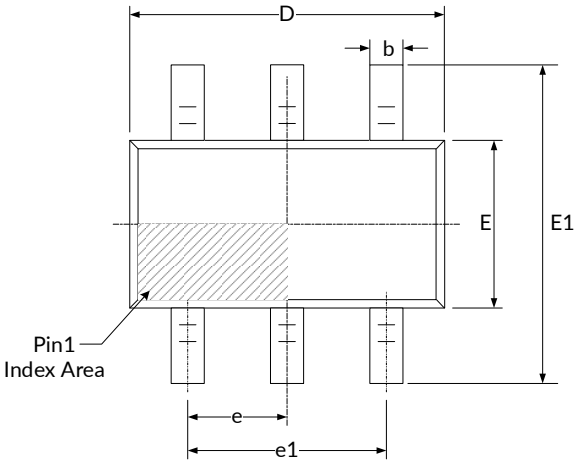
An under-voltage lockout prevents operation of the device at input voltages below typical 2.4V. When the input voltage is below the under-voltage threshold, the device is shutdown and the internal switch FET is turned off. If the input voltage rises by under-voltage lockout hysteresis, the IC restarts.

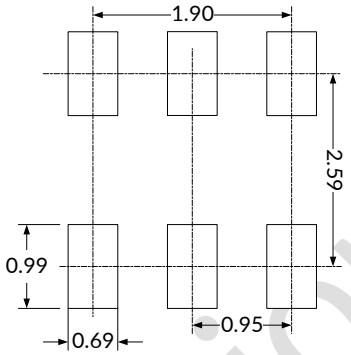
9.6 Thermal Shutdown

An internal thermal shutdown turns off the device when the typical junction temperature of 155°C is exceeded. The device is released from shutdown automatically when the junction temperature decreases by 10°C.

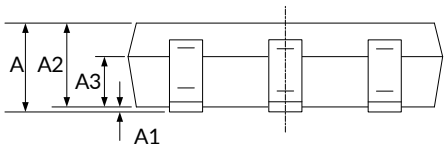
10 PACKAGE OUTLINE DIMENSIONS

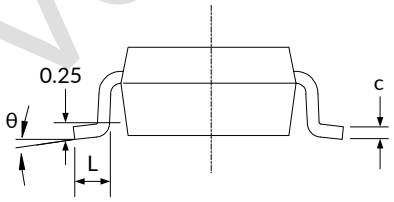
SOT23-6 (2)





RECOMMENDED LAND PATTERN (Unit: mm)





Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)		1.250		0.049
A1	0.020	0.110	0.001	0.004
A2	1.000	1.200	0.039	0.047
A3	0.600	0.700	0.024	0.028
b	0.330	0.410	0.013	0.016
c	0.150	0.190	0.006	0.007
D (1)	2.800	3.000	0.110	0.118
E (1)	1.500	1.700	0.059	0.067
E1	2.600	3.000	0.102	0.118
e	0.850	1.050	0.033	0.041
e1	1.800	2.000	0.071	0.079
L	0.350	0.550	0.014	0.022
θ	0°	8°	0°	8°

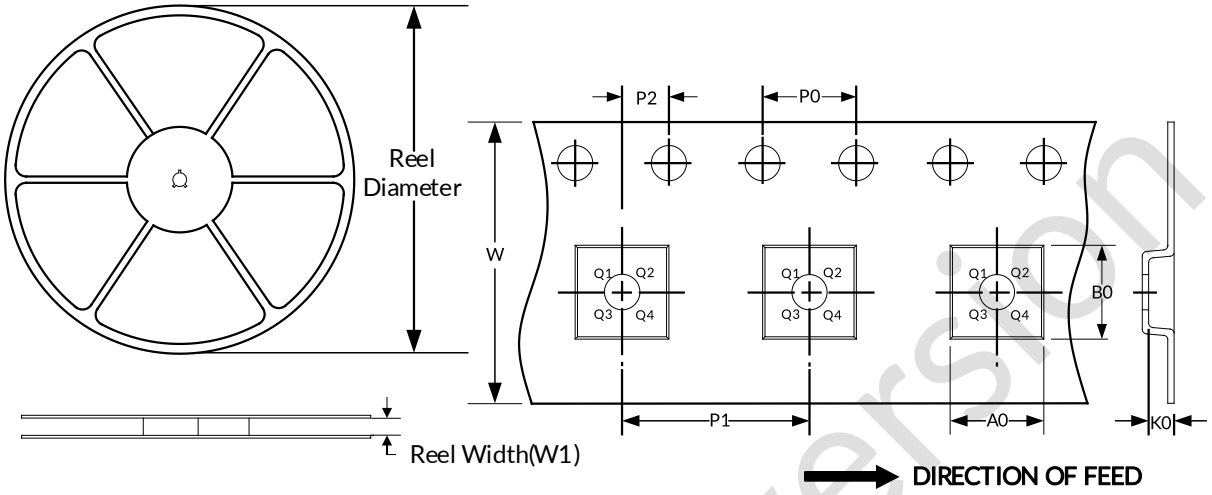
NOTE:

1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. This drawing is subject to change without notice.

11 TAPE AND REEL INFORMATION

REEL DIMENSIONS

TAPE DIMENSION



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
SOT23-6	7”	9.5	3.17	3.23	1.37	4.0	4.0	2.0	8.0	Q3

NOTE:
1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

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