描述

MX61165T 器件配备 40V 额定值的集成开关 FET，是一款可驱动串联 LED 的升压转换器。该升压转换器运行在 1.2MHz 固定开关频率下，开关电流限制为 1.4A，允许在普通照明条件下使用高亮度 LED。通过外部传感器电阻器 Rset 来设置 LED 的默认电流，可将反馈电压调节至 200mV，如下面的典型应用图中所示。在运行过程中，可以将脉宽调制信号应用于 CTRL 引脚，通过该引脚占空比可以调节反馈基准电压。MX61165T 在调光过程中 LED 电流不会突变，因此不会在输出电容器上产生可闻噪声。为了提供最大保护，该器件具备集成 LED 开路保护功能，以防止 MX61165T 在 LED 开路条件下输出超过最大绝对电压额定值。

特性

- ♦ 3V 到 20V 输入电压范围
- ♦ PWM亮度调节
- ♦ 1.2MHz开关频率的1.4A开关FET
- ♦ 38V开路电压保护
- ♦ 200mV基准电压
- ♦ 6-Pin SOT23-6

应用

高亮度LED照明

视频监控摄像头

显示屏

控制面板

工业PC

烤箱

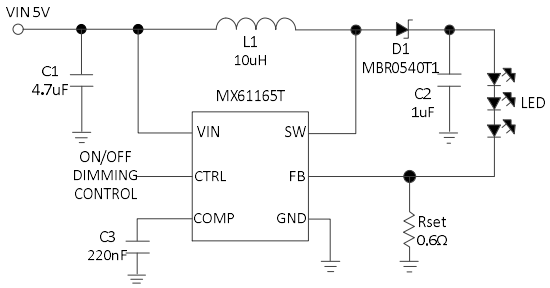
冰箱

EPOS

指示标志

红外LED驱动器

典型应用



通用信息

订购信息

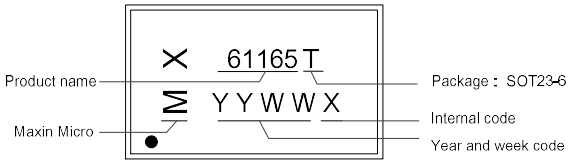
产品信号	描述
MX61165T	SOT23-6
MPQ	3000pcs

极限值

参数	值
VIN、CTRL	-0.3 to 24V
FB	-0.3 to 7V
COMP	-0.3 to 3V
SW	-0.3 to 40V
Junction temperature	150℃
Storage temperature, Tstg	-40 to 150℃
Leading temperature （soldering，10secs）	260℃
ESD Susceptibility HBM	±2000V

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

丝印信息



推荐使用范围

Symbol	Parameter	Range
VIN、CTRL	POWER supply	3-20V
SW		0-38V
Junction temperature		-40~125℃
$P_{D\ MAX}$	Power dissipation	0.59W

GENERAL DESCRIPTION

With a 40V rated integrated switch FET, the MX61165T device is a boost converter that drives LEDs in series. The boost converter runs at a 1.2MHz fixed switching frequency with 1.4A switch current limit, allowing the use of a high-brightness LED in general lighting. 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 drawing below. A pulse-width-modulation (PWM) signal can be applied to the CTRL pin through which the duty cycle determines the feedback reference voltage. In PWM mode, the MX61165T device 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 MX61165T device to prevent the output from exceeding its absolute maximum voltage ratings during open LED conditions.

FEATURES

- ♦ 3V to 20V input voltage range
- ♦ PWM dimming
- ♦ 1.4A switching FET with 1.2MHz switching frequency
- ♦ 38V open-circuit protection
- ♦ 200mV reference voltage
- ♦ 6-Pin SOT23-6

APPLICATIONS

High-brightness LED lighting

Video surveillance cameras

Displays

Control panels

Industrial PCs

Ovens

Thermostat display

Refrigerators

EPOS

IR LED Driver

GENERAL INFORMATION

Ordering information

Part Number	Description
MX66100T	SOT23-6
MPQ	3000pcs

Package dissipation rating

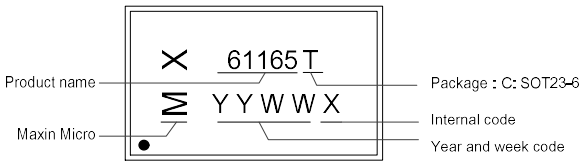
Package	RθJA（℃/W）
SOT23-6	200

Absolute maximum ratings

Parameter	Value
VIN、CTRL	-0.3 to 24V
FB	-0.3 to 7V
COMP	-0.3 to 3V
SW	-0.3 to 40V
Junction temperature	150℃
Storage temperature, Tstg	-40 to 150℃
Leading temperature （soldering，10secs）	260℃
ESD Susceptibility HBM	±2000V

Stresses beyond those listed in Absolute Maximum Ratings may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect reliability. Functional operation of the device at any conditions beyond those indicated in the Recommended Operating Conditions section is not implied.

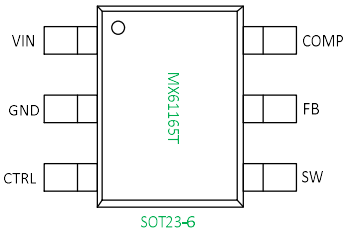
Marking information



Recommended operating condition

Symbol	Parameter	Range
VIN、CTRL	POWER supply	3-20V
SW		0-38V
Junction temperature		-40~125℃
P_{D_MAX}	Power dissipation	0.59W

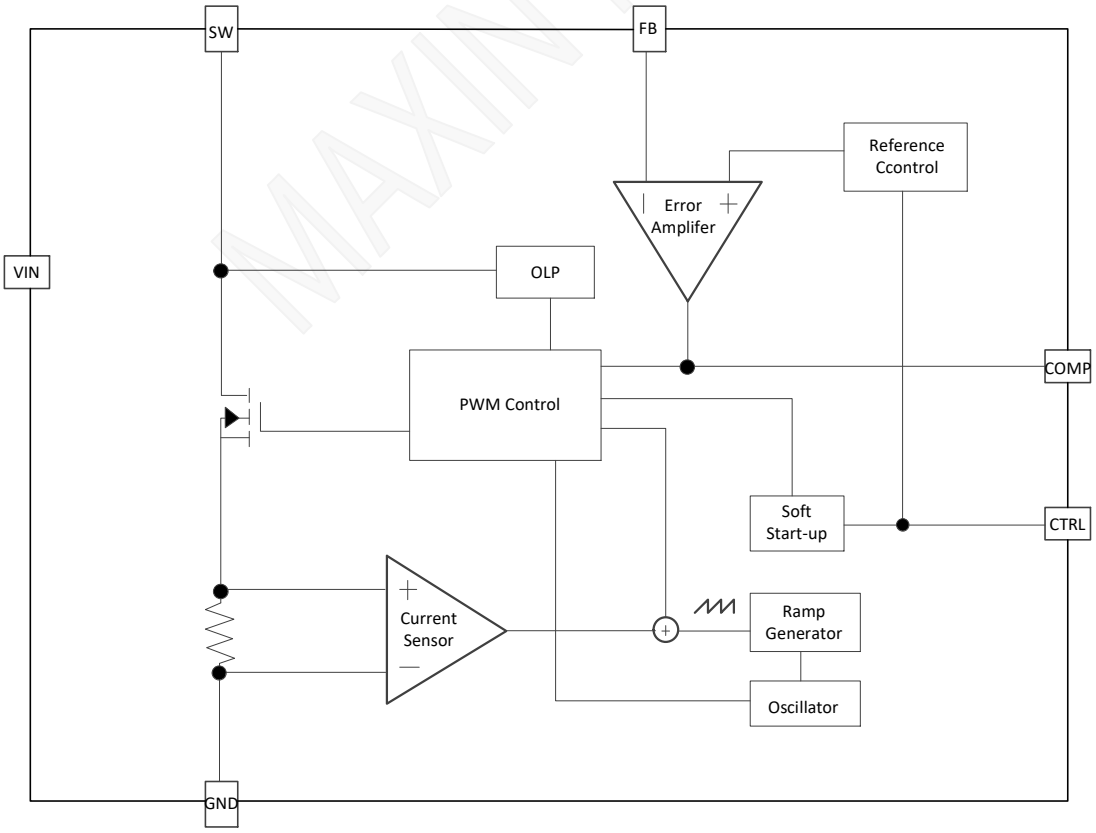
Terminal Assignments



Pin information

PIN name		Description
1	VIN	The input supply pin for the IC. Connect VIN to a supply voltage between 3V and 20V.
2	GND	Ground.
3	CTRL	Control pin of the boost converter. It is a multifunctional pin which can be used for enable control and PWM dimming. Don't leave this pin floating.
4	SW	This is the switching node of the device. Connect the switched side of the inductor to SW. This pin is also used to sense the output voltage for open LED protection.
5	FB	Feedback pin for current. Connect the sense resistor from FB to GND.
6	COMP	Output of the transconductance error amplifier. Connect an external capacitor to this pin to compensate the converter.

Block Diagram

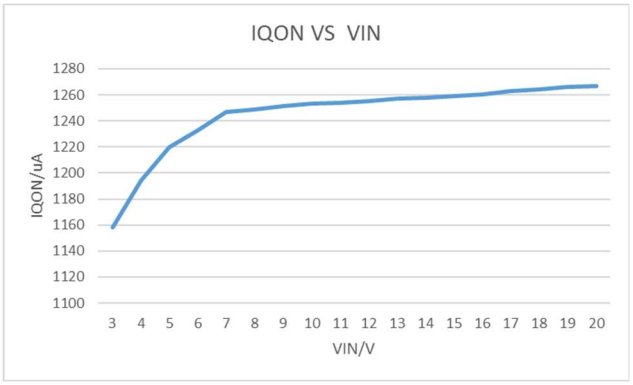


Electrical characteristics

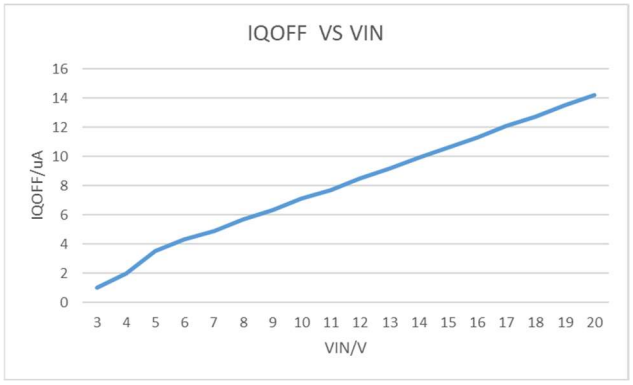
（TA=25℃，VIN=5V，CTRL=5V, unless otherwise noted）

Symbol	Parameter	Test condition	Min	Typ.	Max	Unit
POWER SUPPLY						
UVLO_VIN	Undervoltage lockout threshold	VIN falling	2.1	2.3	2.5	V
V_{hys}	Undervoltage lockout Hysterisis			150		mV
I_{Q_VIN}	VIN Quiescent current	Device PWM switching no load		1.2	2.3	mA
I_{SD_VIN}	VIN Shutdown current	CTRL=GND		10	20	μA
ENABLE CONTROL						
I_{ON}	CTRL pin leakage, Enabled		-100	0	100	nA
V_{CTRL_H}	Active threshold	VIN=3V ~ 20V	1	1.2		V
V_{CTRL_L}	Off threshold	VIN=3V ~20V		1	1.1	V
R_{CTRL}	Smart pulldown resistance		3	5	10	MΩ
VOLTAGE AND CURRENT CONTROL						
V_{REF}	Feedback regulation voltage		190	200	210	mV
$V_{REF-PWM}$	Feedback regulation voltage under Brightness control	V_{FB}=100mV	90	100	110	mV
		V_{FB}=50mV	45	50	55	mV
I_{FB}	Voltage feedback input bias current	V_{FB}=200mV			5	μA
fs	Oscillator frequency		1	1.2	1.5	MHz
Dmax	Maximum duty cycle			90%		
I_{sink}	Comp pin sink current		90	100	110	μA
I_{source}	Comp pin source current		10	15	25	μA
POWER SWITCH						
R_{ON}	RDS(ON) N-channel MOSFET on-resistance	VIN=3.6V		0.4	0.6	Ω
		VIN=3.0V			0.7	Ω
I_{LN_NFET}	N-channel leakage current	V_{SW}=35V, TA=25°C	0		1	μA
OC AND OLP						
ILIM	N-Channel MOSFET current limit	D = Dmax	1.1	1.3	1.6	A
$ILIM_{Start}$	Start-up current limit	D = Dmax		0.7		A
V_{OVP}	Open LED protection threshold	Measured on the SW pin		38		V
tss	Soft start time			20		ms

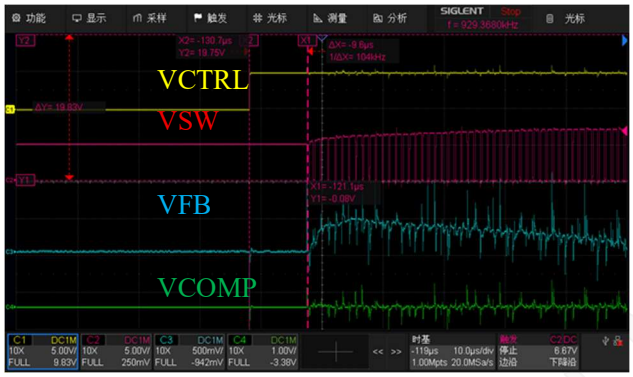
Characteristic plots



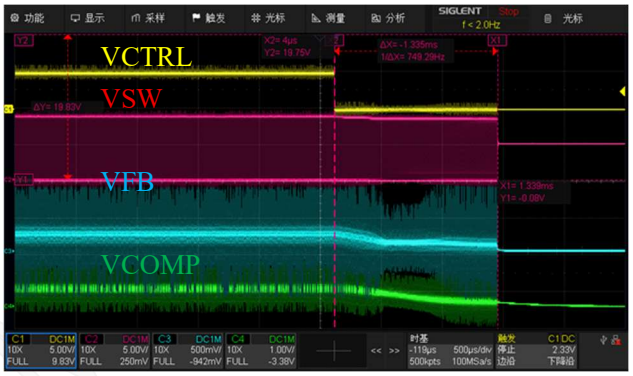
IQON vs VIN



IQOFF vs VIN



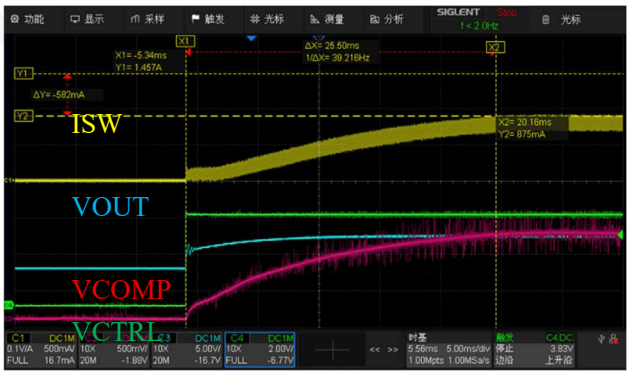
Turn on with CTRL



Turn off with CTRL



Switching Waveform



Start Up

Operation Description

The MX61165T is a high-efficiency, high-output-voltage boost converter in small package size. The device is ideal for driving white LEDs 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/1.4A switch FET and operates in pulse width modulation (PWM) with 1.2MHz fixed switching frequency. 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, 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 (200 mV typical), reducing the power dissipation in the current sense resistor.

Soft Start-up

Soft-start circuitry is integrated into the device to avoid a high inrush current during start-up. After the device is enabled, the voltage at FB pin ramps up to the reference voltage in 20ms. This ensures that the output voltage rises slowly to reduce the input current. Additionally, for the first 5ms after the COMP voltage ramps, the current limit of the switch is set to half of the normal current limit specification. During this period, the input current is kept below 700mA (typical). These two features ensure smooth start-up and minimize the inrush current.

Open LED Protection

Open LED protection circuitry prevents device damage as the result of white LED disconnection. The MX61165T monitors the voltage at the SW pin and FB pin during each switching cycle. The circuitry turns off the switch FET and shuts down the device when both of the following conditions persist for 8 switching clock cycles: (1) the SW voltage exceeds the VOVP threshold, and (2) the FB voltage is less than half of regulation voltage. As a result, the output voltage falls to the level of the input supply. The device remains in shutdown mode until it is enabled by toggling the CTRL pin. The product of the number of external series LEDs and the maximum forward voltage of each LED plus the 200mV reference voltage does not exceed the 38V minimum OVP threshold (NLEDS × VLED(MAX)) + 200mV ≤ 38V.

Undervoltage Lockout

An undervoltage lockout prevents operation of the device at input voltages below typical 2.3V. When the input voltage is below the undervoltage threshold, the device is shutdown and the internal switch FET is turned off. If the input voltage rises by undervoltage lockout hysteresis, the device restarts.

Thermal Shutdown

An internal thermal shutdown turns off the device when the typical junction temperature of 150°C is exceeded. The device is released from shutdown automatically when the junction temperature decreases by 15°C.

Device Functional Modes

Shutdown

The MX61165T device enters shutdown mode when the CTRL voltage is logic low for more than 2.5ms. During shutdown, the input supply current for the device is less than 10μA (maximum). 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.

PWM Brightness Dimming

When the CTRL pin is constantly high, the FB voltage is regulated to 200 mV typically. However, the CTRL pin allows a PWM signal to reduce this regulation voltage; therefore, it achieves LED brightness dimming. The relationship between the duty cycle and FB voltage is shown in the following formula.

$$V_{FB} = \text{Duty} \times 200\text{mV}$$

where

- Duty =duty cycle of the PWM signal
- 200mV=internal reference voltage

The device chops up the internal 200mV reference voltage at the duty cycle of the PWM signal. The pulse signal is then filtered by an internal low pass filter. The output of the filter is

connected to the error amplifier as the reference voltage for the FB pin regulation. Therefore, although a PWM signal is used for brightness dimming, only the LED DC current is modulated, which is often referred as analog dimming. This eliminates the audible noise which often occurs when the LED current is pulsed in replica of the frequency and duty cycle of PWM control. Unlike other methods which filters the PWM signal for analog dimming, MX61165T regulation voltage is independent of the PWM logic voltage level which often has large variations.

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 RSET is calculated using the following Equation.

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

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.

Application Information

Maximum Output Current

The over current limit in a boost converter limits the maximum input current and thus maximum input power for a given input voltage. Maximum output power is less than maximum input power due to power conversion losses. Therefore, the current limit setting, input voltage, output voltage and efficiency can all change maximum current output. The current limit clamps the peak inductor current; therefore, the ripple has to be subtracted to derive maximum dc current. The ripple current is a function of switching frequency, inductor value and duty cycle. The following equations take into account of all the above factors for maximum output current calculation.

$$I_P = \frac{1}{\left[L \times F_S \times \left(\frac{1}{V_{OUT} + V_f - V_{IN}} + \frac{1}{V_{IN}}\right)\right]}$$

where

- I_P = inductor peak to peak ripple
- L = inductor value
- V_f= Schottky diode forward voltage
- Fs= switching frequency
- V_{OUT}= output voltage of the boost converter. It is equal to the sum of VFB and the voltage drop across LEDs.

$$I_{out-max} = \frac{V_{IN} \times \left(I_{ILM} - \frac{I_P}{2}\right)}{V_{OUT}} \times \eta$$

where

- I_{out_max}= Maximum output current of the boost converter
- I_{ILM}= overcurrent limit
- η=efficiency

For instance, when VIN is 3V, 8LEDs output equivalent to VOUT of 26V, the inductor is 22μH, the Schottky Forward voltage is 0.2V, the maximum output current is then 110mA in typical condition. When VIN is 5V, 10 LEDs output equivalent to VOUT of 32V, the inductor is 22μH, the Schottky forward voltage is 0.2V, the Maximum output current is 150mA in typical condition.

Induction Selection

Selection of the inductor affects steady state operation as well as transient behavior and loop stability. These Factors make it the most important component in power regulator design. There are three important inductor specifications, inductor value, DC resistance and saturation current. Considering inductor value alone is not enough. The inductor value determines the inductor ripple current. Choose an inductor that can handle the necessary Peak current without saturating, according to half of the peak-to-peak ripple current, pause the inductor DC current given by:

$$I_{IN_DC} = \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times \eta}$$

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 maximum output current of the boost convert, causes large input voltage ripple, and reduces efficiency. Large inductance value provides much more output current and higher conversion efficiency. For these reasons, a 10μH to 22μH inductor value range is recommended. A 22μH inductor optimized the efficiency for most application while maintaining low inductor peak to peak ripple.

MX61165T has built-in slope compensation to avoid subharmonic oscillation associated with current mode control.

If the inductor value is lower than 10μH, the slope compensation may not be adequate, and the loop can be unstable. Therefore, customers need to verify the inductor in their application if it is different from the recommended values.

Schottky Diode Selection

The high switching frequency of the MX61165T demands a high-speed rectification for optimum efficiency. Ensure that the average and peak current rating of the diode exceeds the average output current and peak inductor current. In addition, the reverse breakdown voltage of the diode must exceed the open LED protection voltage. The MBR0540 is recommended for MX61165T.

Input and 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). Assuming a capacitor with zero ESR, the minimum capacitance needed for a given ripple can be calculated as shown in the following formula.

$$C_{OUT} = \frac{I_{OUT} \times (V_{OUT} - V_{IN})}{V_{OUT} \times F_S \times V_{ripple}}$$

where

• V_{ripple} = peak-to-peak output ripple

The additional output ripple component caused by ESR is calculated as shown in the following formula.

$$V_{ripple_ESR} = I_{OUT} \times R_{ESR}$$

Due to its low ESR, V_{ripple_ESR} can be neglected for ceramic capacitors, but must be considered if tantalum or electrolytic capacitors are used. Care must be taken when evaluating a ceramic capacitors derating under dc bias, aging and AC signal. For example, larger form factor capacitors (in 1206 size) have self-resonant frequencies in the range of the switching frequency, So the effective capacitance is significantly lower. The dc bias can also significantly reduce capacitance. Ceramic capacitors can loss as much as 50% of its capacitance at its rated voltage. Therefore, leave the margin on the voltage rating to ensure adequate capacitance at the required output voltage. The capacitor in the range of 1μF to 4.7μF is recommended for input side. The output requires a capacitor in the range of 1μF to 10μF. The output capacitor affects the loop stability of the boost regulator. If the output capacitor is below the range, the boost regulator can potentially become unstable.

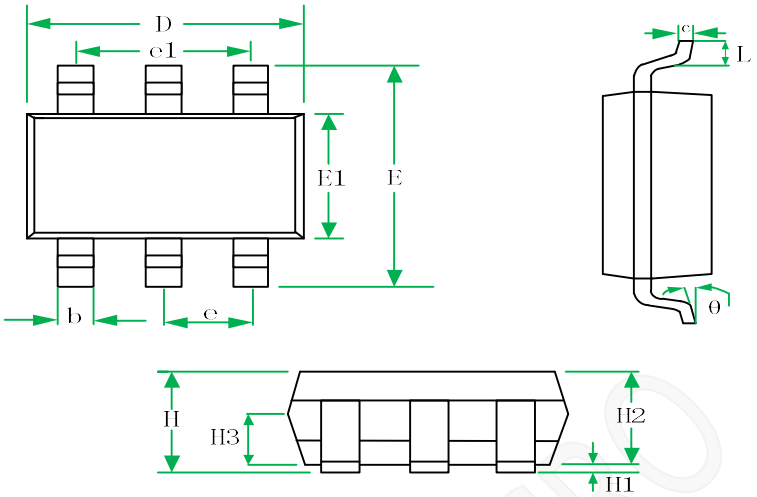
Compensation Capacitor Selection

The compensation capacitor C3 (see Typical Application), connected from COMP pin to GND, is used to stabilize the feedback loop of the MX61165T. A 220nF ceramic capacitor is suitable for most applications.

Layout guidelines

As for all switching power supplies, especially those high frequency and high current ones, layout is an important design step. If layout is not carefully done, the regulator could suffer from instability as well as noise problems. To reduce switching losses, the SW pin rise and fall times are made as short as possible. To prevent radiation of high frequency resonance problems, proper layout of the high frequency switching path is essential. Minimize the length and area of all traces connected to the SW pin, and always use a ground plane under the switching regulator to minimize inter-plane coupling. The loop including the PWM switch, Schottky diode, and output capacitor, contains high current rising and falling in nanosecond and must be kept as short as possible. The input capacitor must be close to both the VIN pin and the GND pin to reduce the device supply ripple.

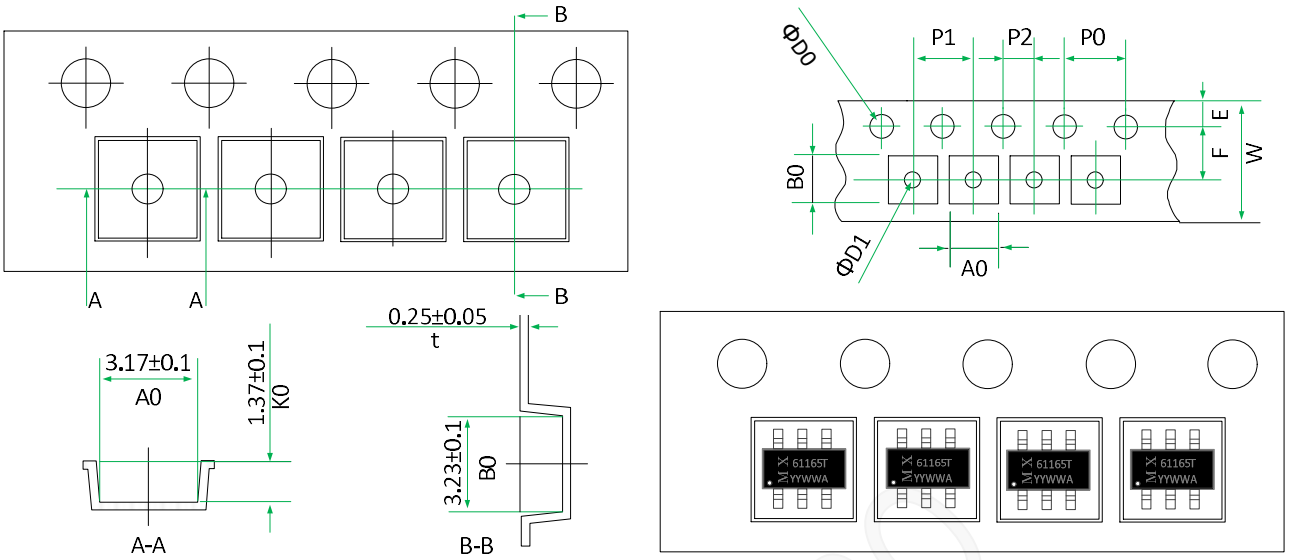
Package information



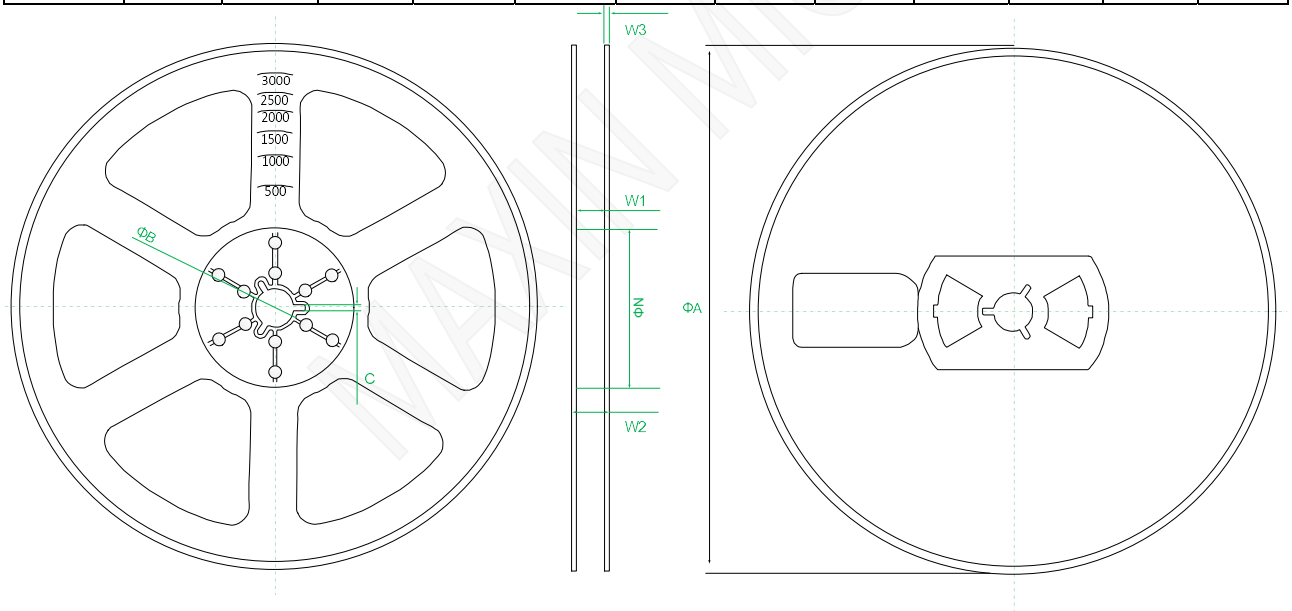
SYMBOL	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
H	1.07	1.16	1.25	0.042	0.046	0.049
H1	0.02	0.06	0.10	0.001	0.002	0.004
H2	1.05	1.10	1.15	0.041	0.043	0.045
H3	0.60	0.65	0.70	0.024	0.026	0.028
b	0.30	0.40	0.50	0.012	0.016	0.020
c	0.102	0.152	0.202	0.004	0.006	0.008
D	2.82	2.92	3.02	0.111	0.115	0.119
E	2.65	2.80	2.95	0.104	0.110	0.116
E1	1.50	1.60	1.70	0.059	0.063	0.067
e	0.95BSC			0.037BSC		
e1	1.90BSC			0.075BSC		
L	0.30	0.40	0.50	0.012	0.016	0.020
θ	0	4°REF	8°	0	4°REF	8°

SOT23-6 for MX61165T

Tape and Reel Information (unit in mm)



Symbol	W	E	F	ΦD0	ΦD1	P0	P1	P2	A0	B0	K0	t
MAX	8.10	1.85	3.55	1.60	1.25	4.10	4.10	2.05	3.27	3.33	1.47	0.30
MIN	7.90	1.65	3.45	1.40	1.0	3.90	3.90	1.95	3.07	3.13	1.27	0.20



Symbol	ΦA	ΦN	ΦB	C	W1	W2	W3
MAX	180	56	13.5	2.50	9.9	12	1.8
MIN	176	52	13.0	1.90	8.4		1.0

Restrictions on Product Use

◆ MAXIN micro is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing MAXIN products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such MAXIN products could cause loss of human life, bodily injury or damage to property.

◆ In developing your designs, please ensure that MAXIN products are used within specified operating ranges as set forth in the most recent MAXIN products specifications.

◆ The information contained herein is subject to change without notice.

Version update information

V10 preliminary version

MAXIN MICRO