Preliminary – **LD6105**

1.2MHz White LED Drivers with Built-in Schottky

Features

- Inherently Matched LED Current
- Drives Up to Six LEDs from a 3.6V Supply
- No External Schottky Diode Required
- 1.2MHz Switching Frequency
- V_{IN} Range: 2.7V to 16V
- VOUT(MAX) = 30V
- Automatic Soft-Start
- Open LED Protection
- High Efficiency: 81%
- Requires Only 0.22µF Output Capacitor
- Low Profile (1mm) SOT-23

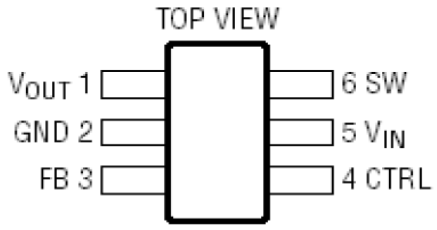
Applications

- Cellular Phones
- PDAs, Handheld Computers
- Digital Cameras
- MP3 Players
- GPS Receivers

General Description

The LD6105 are step-up DC/DC converters designed to drive up to six LEDs in series from a Li-Ion cell. Series connection of the LEDs provides identical LED currents and eliminates the need for ballast resistors. These devices integrate the Schottky diode required externally on competing devices. Additional features include output voltage limiting when LEDs are disconnected, one-pin shutdown and dimming control. The LD6105 has internal soft-start. The LD6105 switches at 1.2MHz, allowing the use of tiny external components. Constant frequency switching results in low input noise and a small output capacitor. Just 0.22µF is required for 3-, 4- or 5-LED applications. The LD6105 are available in the low profile (1mm) 6-lead SOT-23 package.

Package Pin Out

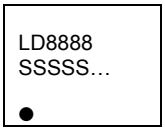


Ordering Information

		Packing Options	
Part No.	Package	Tube (TU)	Tape & Re l (TR)
LD6105	SOT23-6	LD6105L3-TU	LD6105L3-TR

- Package material default is “Green” package.

Product Marking



- ✧ Line 1 – “LD” is a fixed character
  8888: product name
- ✧ Line 2 – SSSSS…: lot number

Absolute Maximum Ratings

Parameter	Maximum	Unit
Input Voltage (V_{IN})	16	V
SW Voltage	36	V
FB Voltage	2	V
CTRL Voltage	10	V
Operating Temperature Range	0 to 70	°C
Maximum Junction Temperature	125	°C
Storage Temperature Range	– 65 to 150	°C

The values beyond the boundaries of absolute maximum rating may cause the damage to the device. Functional operation in this context is not implied. Continuous use of the device at the absolute rating level might influence device reliability. All voltages have their reference to device ground.

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

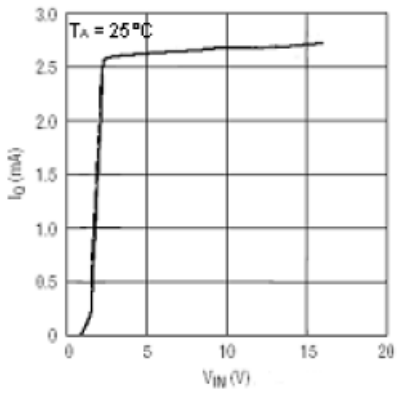
Electrical Characteristics

The * denotes the specifications which apply over the full operating temperature range, otherwise specifications are at T_A = 25°C. V_{IN} = 3V, V_{CTRL} = 3V, unless otherwise noted.

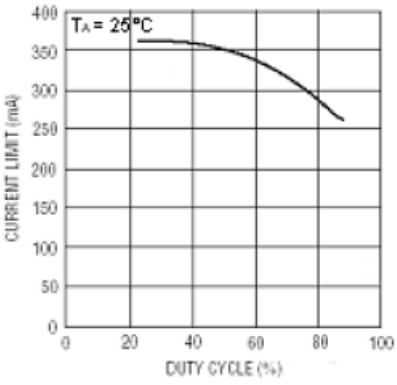
Parameter	Condition		Min	Typ.	Max	Unit
Minimum Operating Voltage			2.7	–	–	V
Maximum Operating Voltage			–	–	16	V
Feedback Voltage	0°C ≤ T_A ≤ 85°C		188	200	212	mV
FB Pin Bias Current			10	35	100	nA
Supply Current	Not Switching CTRL = 0V		1.9	2.6	3.3	mA
			2.0	3.2	5.0	μA
Switching Frequency			0.8	1.2	1.6	MHz
Maximum Duty Cycle		*	90	93	–	%
Switch Current Limit		*	225	340	–	mA
Switch V_{CESAT}	I_{SW} = 250mA		–	300	–	mV
Switch Leakage Current	V_{SW} = 5V		–	0.01	5	μA
V_{CTRL} for Full LED Current			1.8	–	–	V
V_{CTRL} to Enable Chip		*	150	–	–	mV
V_{CTRL} to Shut Down Chip		*	–	–	50	mV
CTRL Pin Bias Current			48	64	80	μA
Soft-Start Time			–	600	–	μS
Schottky Forward Drop	ID = 150mA		–	0.7	–	V
Schottky Leakage Current	V_R = 30V		–	–	4	μA

TYPICAL PERFORMANCE CHARACTERISTICS

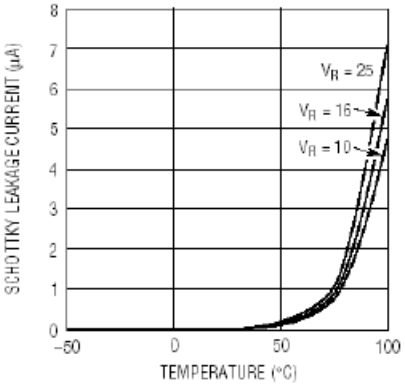
Quiescent Current (CTRL = 3V)



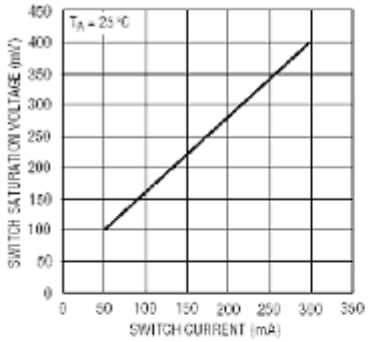
Switching Current Limit



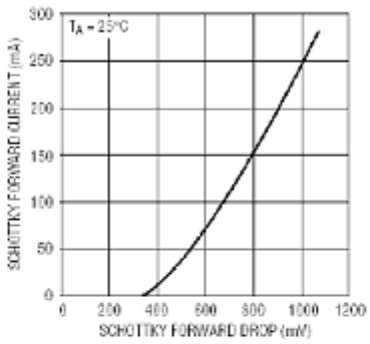
Schottky Leakage Current



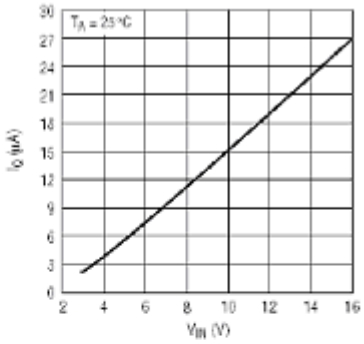
Switch Saturation Voltage (V_{CESAT})



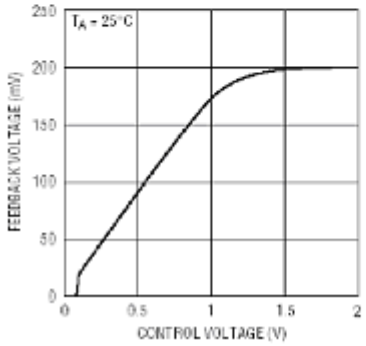
Schottky Forward Voltage Drop



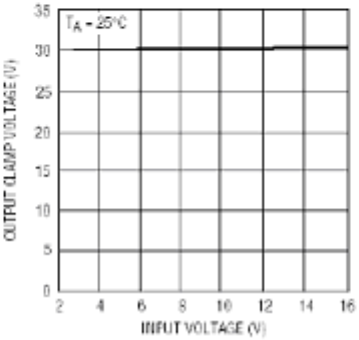
Shutdown Quiescent Current (CTRL = 0V)



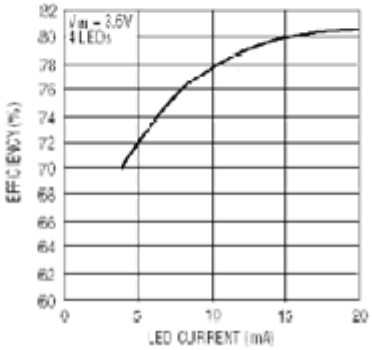
V_{FB} vs V_{CTRL}



Open-Circuit Output Clamp Voltage



Conversion Efficiency



Pin Description

Pin	Name	Description
1	VOUT	Output Pin. Connect to output capacitor and LEDs. Minimize trace between this pin and output capacitor to reduce EMI.
2	GND	Ground Pin. Connect directly to local ground plane.
3	FB	Feedback Pin. Reference voltage is 200mV. Connect LEDs and a resistor at this pin. LED current is determined by the resistance and CTRL pin voltage:
4	CTRL	Dimming Control and Shutdown Pin. Ground this pin to shut down the device. When VCTRL is greater than about 1.8V, full-scale LED current is generated. When VCTRL is less than 1V, LED current is reduced. Floating this pin places the device in shutdown mode.
5	VIN	Input Supply Pin. Must be locally bypassed with a 1μF X5R or X7R type ceramic capacitor.
6	SW	Switch Pin. Connect inductor here.

$$I_{LED} = \frac{1}{R_{FB}} \bullet \left(200mV - 26mV \bullet \ln \left(\frac{\exp\left(\frac{200mV}{26mV}\right)}{\exp\left(\frac{V_{CTRL}(mV)}{5mV \bullet 26mV}\right)} + 1 \right) \right) \quad \text{for } V_{CTRL} > 150mV$$

Block Diagram

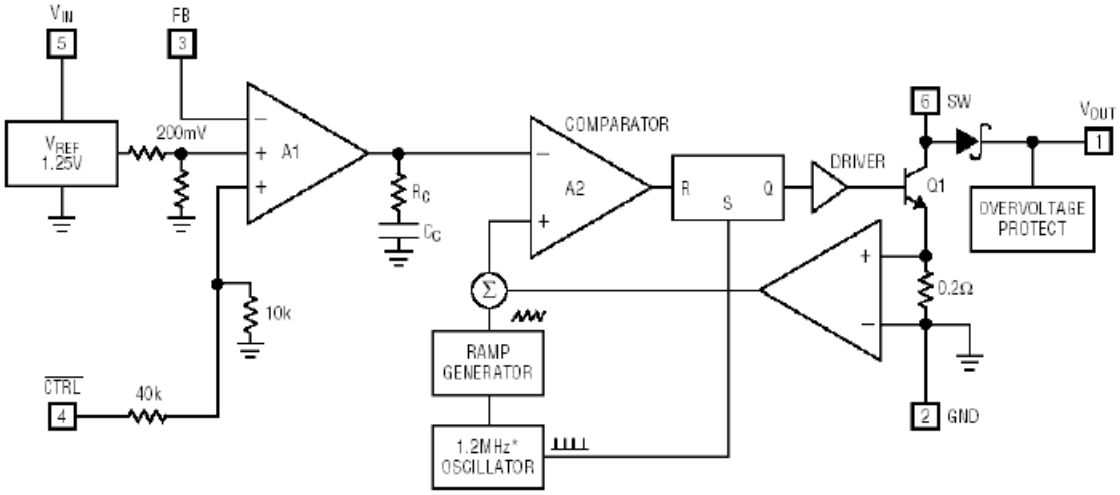
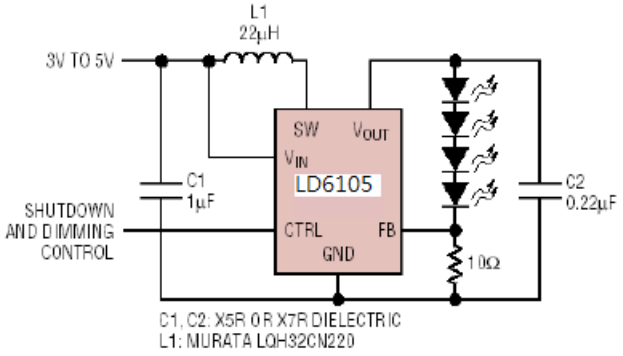


Figure 2. LD6105 Block Diagram

Typical Application Circuit



APPLICATIONS INFORMATION

Operation

The LD6105 uses a constant frequency, current mode control scheme to provide excellent line and load regulation. Operation can be best understood by referring to the block diagram in Figure 2. At the start of each oscillator cycle, the SR latch is set, which turns on the power switch Q1. A voltage proportional to the switch current is added to a stabilizing ramp and the resulting sum is fed into the positive terminal of the PWM comparator A2. When this voltage exceeds the level at the negative input of A2, the SR latch is reset turning off the power switch. The level at the negative input of A2 is set by the error amplifier A1, and is simply an amplified version of the difference between the feedback voltage and the reference voltage of 200mV. In this manner, the error amplifier sets the correct peak current level to keep the output in regulation. If the error amplifier's output increases, more current is delivered to the output; if it decreases, less current is delivered. The CTRL pin voltage is used to adjust the reference voltage.

Minimum Output Current

The LD6105 can drive a 3-LED string at 1.5mA LED current without pulse skipping. As current is further reduced, the device will begin skipping pulses. This will result in some low frequency ripple, although the LED current remains regulated on an average basis down to zero. A 22µH inductor is recommended for most LD6105 applications. Although small size and high efficiency are major concerns, the inductor should have low core losses at 1.2MHz and low DCR (copper wire resistance). Some inductors in this category with small size are listed in Table 1. The efficiency comparison of different inductors is shown in Figure 3.

Table 1. Recommended Inductors

PART NUMBER	DCR (Ω)	CURRENT RATING (mA)	MANUFACTURER
LQH32CN220 LQH2MCN220	0.71 2.4	250 185	Murata www.murata.com
ELJPC220KF	4.0	160	Panasonic www.panasonic.com
CDRH3D16-220	0.53	350	Sumida www.sumida.com
LB2012B220M	1.7	75	Taiyo Yuden www.t-yuden.com
LEM2520-220	5.5	125	Taiyo Yuden www.t-yuden.com

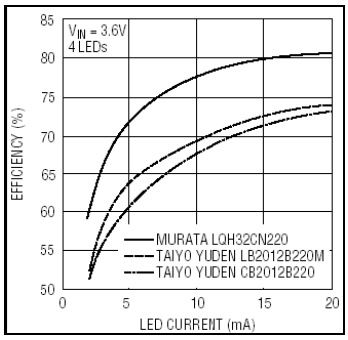


Figure 3. Efficiency Comparison of Different Inductors

Capacitor Selection

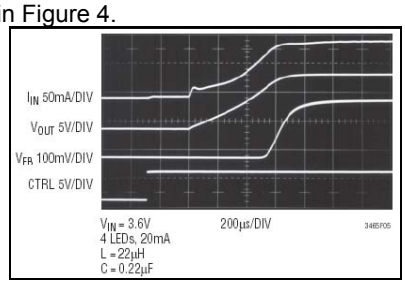
The small size of ceramic capacitors makes them ideal for LD6105 applications. X5R and X7R types are recommended because they retain their capacitance over wider voltage and temperature ranges than other types such as Y5V or Z5U. A 1μF input capacitor and a 0.22μF output capacitor are sufficient for most LD6105.

Table 2. Recommended Ceramic Capacitor Manufacturers

MANUFACTURER	URL
Taiyo Yuden	www.t-yuden.com
Murata	www.murata.com
Kemet	www.kemet.com

Soft-Start

The LD6105 has an internal soft-start circuit to limit the input current during circuit start-up. The circuit start-up waveforms are shown in Figure 4.



Inrush Current

The LD6105 have a built-in Schottky diode. When supply voltage is applied to the V_{IN} pin, the voltage difference between V_{IN} and V_{OUT} generates inrush current flowing from input through the inductor and the Schottky diode to charge the output capacitor to V_{IN}. The maximum current the Schottky diode in the LD6105 can sustain is 1A. The selection of inductor and capacitor value should ensure the peak of the inrush current to be below 1A.

Table 3 gives inrush peak currents for some component selections.

Table 3. Inrush Peak Current

V_{IN} (V)	r (Ω)	L (μH)	C (μF)	I_P (A)
5	0.5	22	0.22	0.38
5	0.5	22	1	0.70
3.6	0.5	22	0.22	0.26
5	0.5	33	1	0.60

LED Current and Dimming Control

The LED current is controlled by the feedback resistor (R1 in Figure 1) and the feedback reference voltage. $I_{LED} = V_{FB}/R_{FB}$

The CTRL pin controls the feedback reference voltage as shown in the Typical Performance Characteristics. For CTRL higher than 1.8V, the feedback reference is 200mV, which results in full LED current. CTRL pin can be used as dimming control when CTRL voltage is between 200mV to 1.5V. In order to have accurate LED current, precision resistors are preferred (1% is recommended). The formula and table for RFB selection are shown below.

$$R_{FB} = 200mV/_{ILED\text{-}Full} \quad (1)$$

Table 4. R_{FB} Resistor Value Selection

FULL I_{LED} (mA)	R1 (Ω)
5	40.0
10	20.0
15	13.3
20	10.0

APPLICATIONS INFORMATION

The filtered PWM signal can be considered to be an adjustable DC voltage. It can be used to adjust the CTRL voltage source in dimming control. The circuit is shown in Figure 5. The corner frequency of R1 and C1 should be lower than the frequency of the PWM signal. R1 needs to be much smaller than the internal impedance in the CTRL pin, which is 50kΩ. A 5k resistor is suggested.

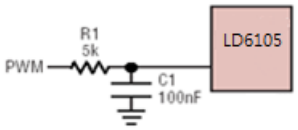
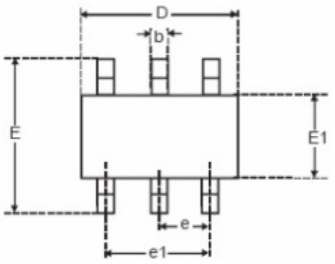


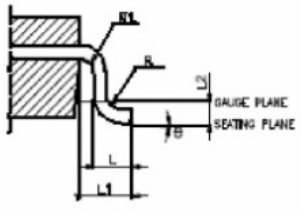
Figure5. Dimming Control Using a Filtered PWM Signal

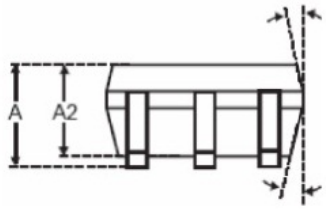
Open-Circuit Protection

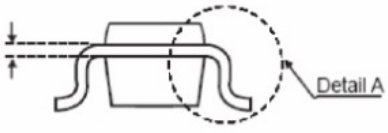
The LD6105 have an internal open-circuit protection circuit. In the cases of output open circuit, when the LEDs are disconnected from the circuit or the LEDs fail, the V_{OUT} is clamped at 30V. The LD6105 will then switch at a very low frequency to minimize the input current. V_{OUT} and input current during output open circuit are shown in the Typical Performance Characteristics.

Package Outline
SOT23-6:









SYMBOLS	MILLMETERS		
	MIN.	NOM.	MAX.
A			1.45
A1			0.15
A2	0.90	1.15	1.30
b	0.30		0.50
c	0.08		0.22
D		2.90 BSC.	
E		2.80 BSC.	
E1		1.60 BSC.	
e		0.95 BSC.	
e1		1.90 BSC.	
L	0.30	0.45	0.60
L1		0.60 REF	
L2		0.25 BSC.	
R	0.10		
R1	0.10		0.25
θ	0°	4°	8°
θ1	5°	10°	15°

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