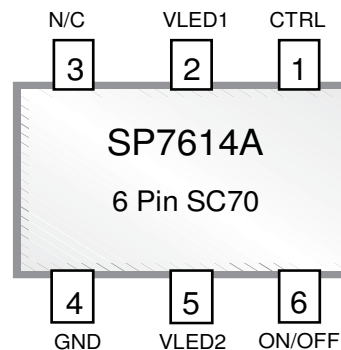


2-4 Channel Low Dropout Linear LED Driver

FEATURES

- LED Drivers for parallel connected LEDs
 - No EMI, no switching noise
 - Integrated current matching
 - PWM and Analog brightness control
 - Enable/Shutdown control
 - Shutdown current < 0.01 μ A
 - Tiny, RoHS Compliant Lead-Free
- Package: SC-70



Pinouts for SP7611A and SP7612A on page 3

Part #	Channels	Maximum Steady State Current per LED
SP7611A	4	40mA
SP7612A	3	40mA
SP7614A	2	80mA

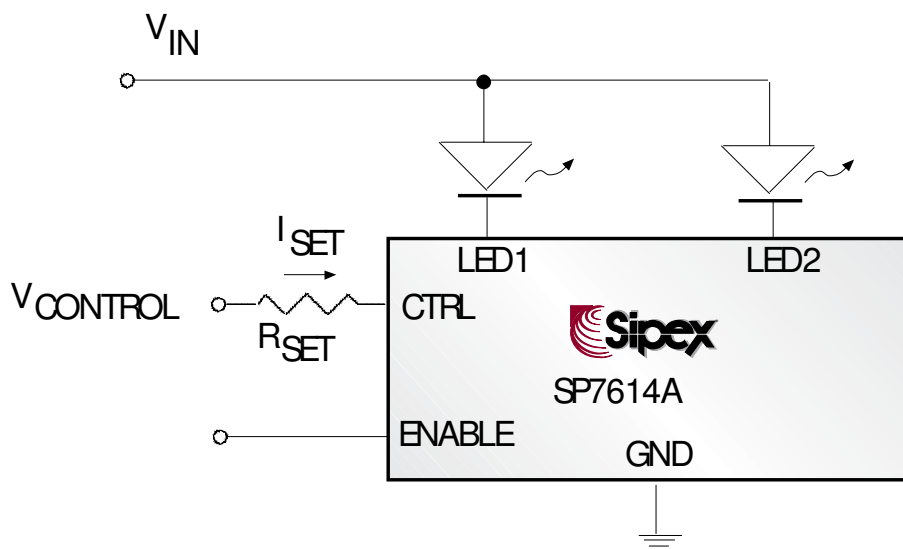
APPLICATIONS

- Ultra low cost Handsets
- PDA, DSC, MP3 players
- Handheld Computers
- LCD Display Modules
- Keyboard Backlight
- LCD Backlight

DESCRIPTION

The SP761X driver family provides a simple solution for a matched current source for any color LED. The current in the LEDs can be programmed by an external resistor. The SP7611A is capable of driving four LEDs, while the SP7612A can drive three LEDs. The SP7614A is designed to drive two high current LEDs. LED1 should always be connected to an LED and never left open in order to have the other LEDs driven with a matched current to LED1. The SP7612A and SP7614A feature Enable pins for flexible on/off control and PWM dimming. SP7612A/4A has extremely low (0.01 μ A typical) shutdown current, prolonging the battery life and giving the longest standby period possible in today's modern design. SP761X driver family is available in a small footprint 6-pin SC-70 package.

TYPICAL APPLICATION SCHEMATIC



ABSOLUTE MAXIMUM RATINGS

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

V_{LED1} , V_{LED2} , V_{LED3} , V_{LED4} and ENABLE Voltage to GND.....	-0.3V to 6V
CTRL Voltage to GND	0.5V
Output Current (I_{OUT}).....(SP7611A and 7612A).....	40mA
Output Current (I_{OUT}).....(SP7614A).....	80mA
Power Dissipation per Package - 6-pin SC-70 at $T_A=85^\circ\text{C}$	190mW
Junction Temperature	+150 $^\circ\text{C}$
Storage Temperature.....	-55 $^\circ\text{C}$ to +150 $^\circ\text{C}$
ESD Level.....	4kV HBM
ESD Level.....	1kV CDM

ELECTRICAL SPECIFICATIONS

Specifications are at $T_A=25^\circ\text{C}$, $V_{IN} = 3.3$ to 5.5, ENABLE = V_{IN} , ♦ denotes the specifications which apply over the full operating temperature range, unless otherwise specified.

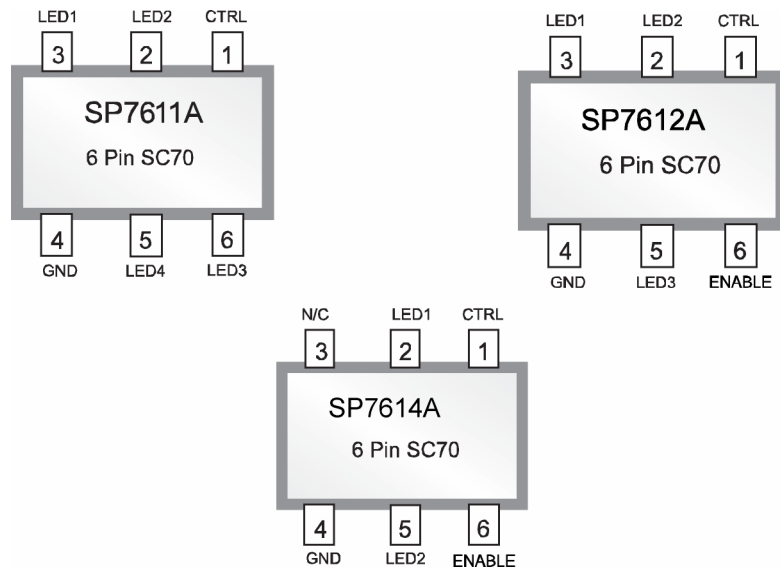
PARAMETER	PART #	MIN	TYP	MAX	UNITS	♦	CONDITIONS
LED Cathode Voltage (VLED)				5.5	V		See graph for LED Current vs. Cathode Voltage
Ambient Temperature		-40	20	85	$^\circ\text{C}$		
Output Current Multiplication Ratio in Saturation (Note1)	SP7611A SP7612A	140	200	260			$I_{SET} = 100\mu\text{A}$ $V_{LED} = 300\text{mV}$
	SP7614A						$I_{SET} = 100\mu\text{A}$ $V_{LED} = 150\text{mV}$
Output Current Multiplication Ratio (Gain) (Note1)	SP7611A SP7612A	365	435	505			$I_{SET} = 25\mu\text{A}$ $V_{LED} = 0.5\text{V}$
	SP7614A	730	870	1010			
LED to LED Current Matching		-3	0.8	3	%	♦	$I_{SET} = 100\mu\text{A}$ $V_{LED} = 300\text{mV}$
Current in OFF Mode			0.01	1	μA	♦	$V_{ENABLE} = 0.0\text{V}$
Min. ENABLE "ON Voltage" (Note 2)	SP7612A SP7614A	3			V	♦	$I_{SET} = 150\mu\text{A}$
Max. ENABLE "OFF Voltage" (Note 2)	SP7612A SP7614A			0.5	V	♦	

Note 1: Output current Multiplication Ratio (I_{LED}/I_{SET}) is not linear. For actual ratio and I_{LED} please refer to typical performance characteristics on page 4 and page 5.

Note 2: ENABLE "ON" is $V_{ON/OFF}$ where $I_{LED1} > 20\text{mA}$ @ $V_{LED1} = 0.3\text{V}$.
ENABLE "OFF" is V where $I < 1\text{A}$ @ $V > 0.3\text{V}$.

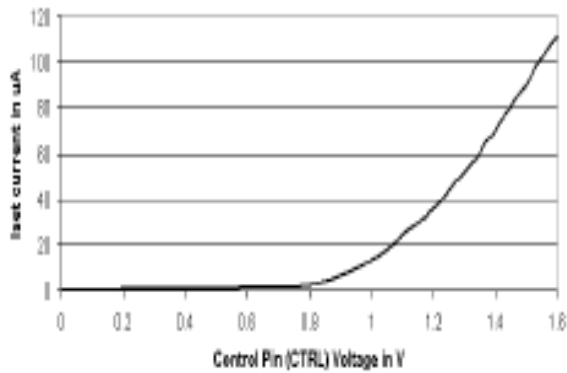
Pin #	Pin Name			DESCRIPTION
	SP7611A	SP7612A	SP7614A	
1	CTRL	CTRL	CTRL	Sets LED Current
2	LED2	LED2	LED1	Connect to Cathode of LED
3	LED1	LED1	NC	Connect to Cathode of LED
4	GND	GND	GND	Ground
5	LED4	LED3	LED2	Connect to Cathode of LED
6	LED3			Connect to Cathode of LED
6		ENABLE	ENABLE	Chip ON/ OFF/ Disable

PINOUTS

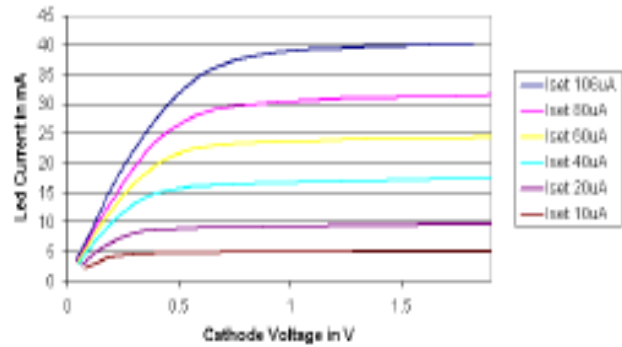


SP7611A/12A TYPICAL PERFORMANCE CHARACTERISTICS

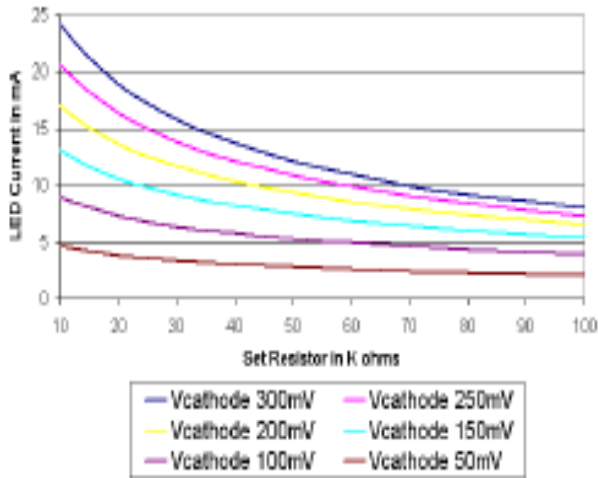
SP7611A/12A Iset vs Control (CTRL) pin Voltage



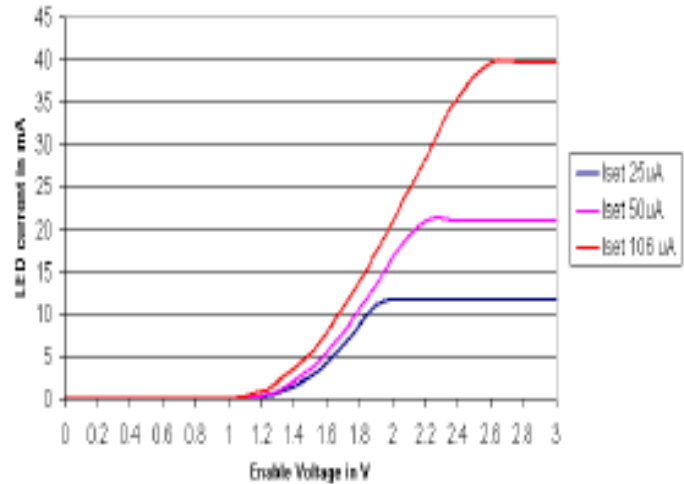
SP7611A/12A LED Current vs Cathode Voltage (VLED)



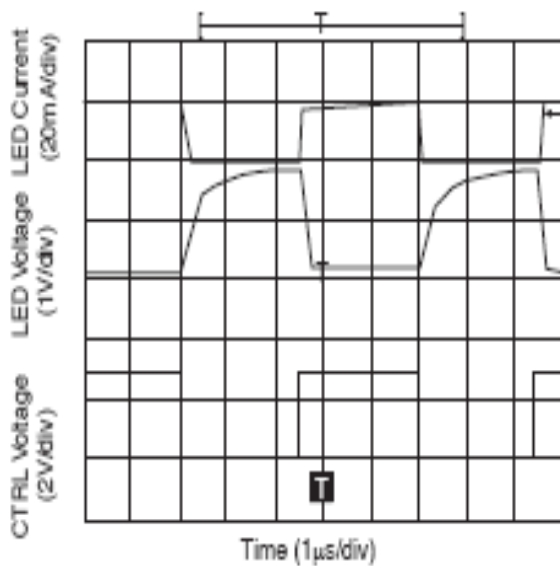
SP7611A/12A vs Set resistor and Cathode Voltage (VLED)
Vcontrol=3V



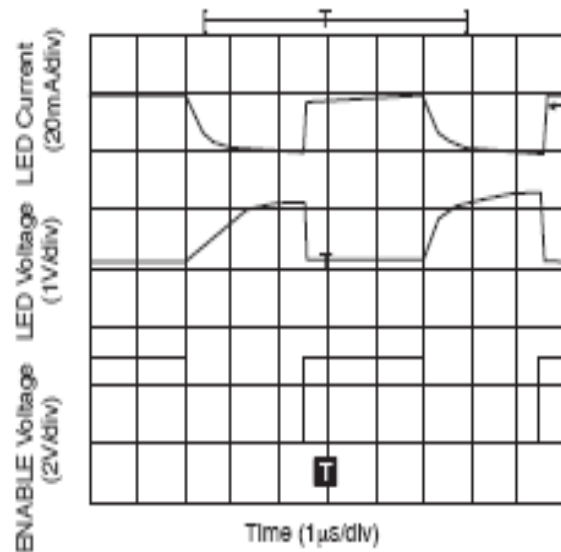
SP7612A LED Current vs Enable Voltage
(per Iset current)



Control Voltage Transient Response

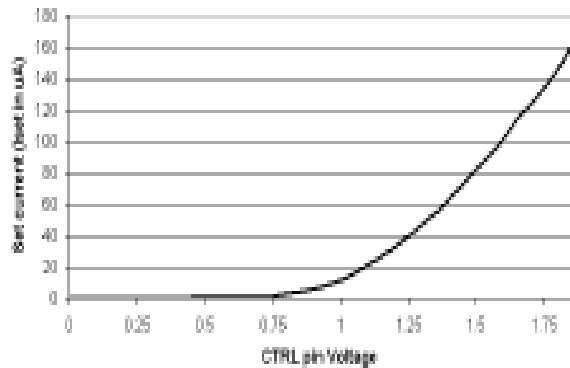


Enable Voltage Transient Response
Not Applicable to SP7611A

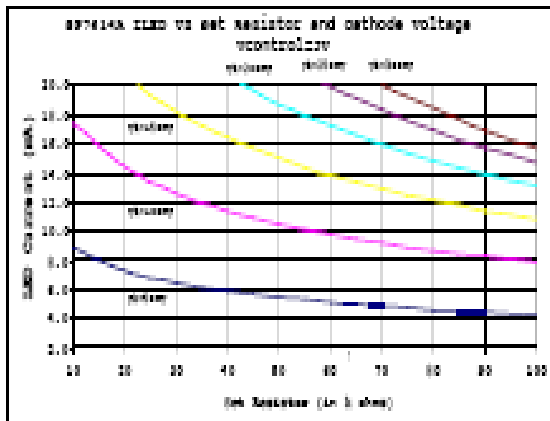
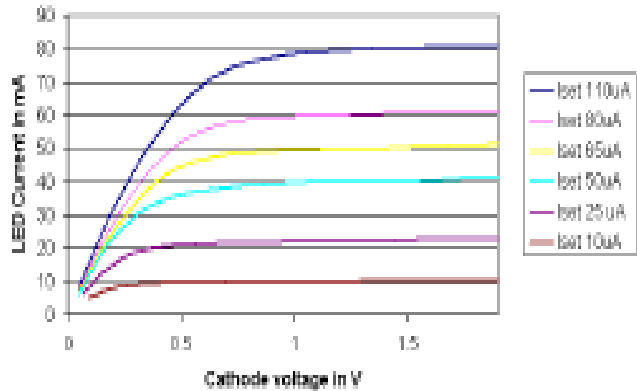


SP7614A TYPICAL PERFORMANCE CHARACTERISTICS

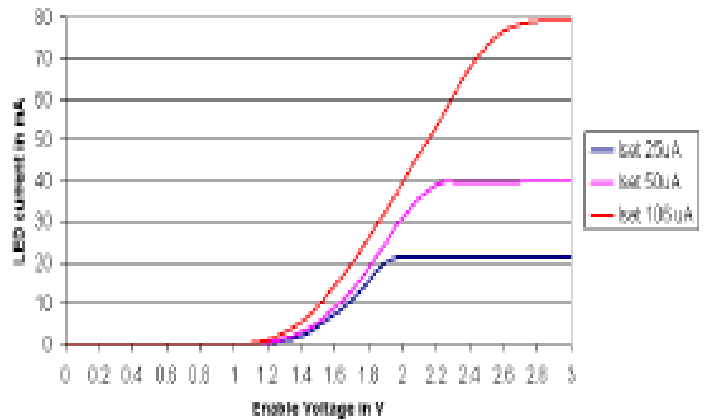
SP7614A Iset vs Control (CTRL) pin Voltage



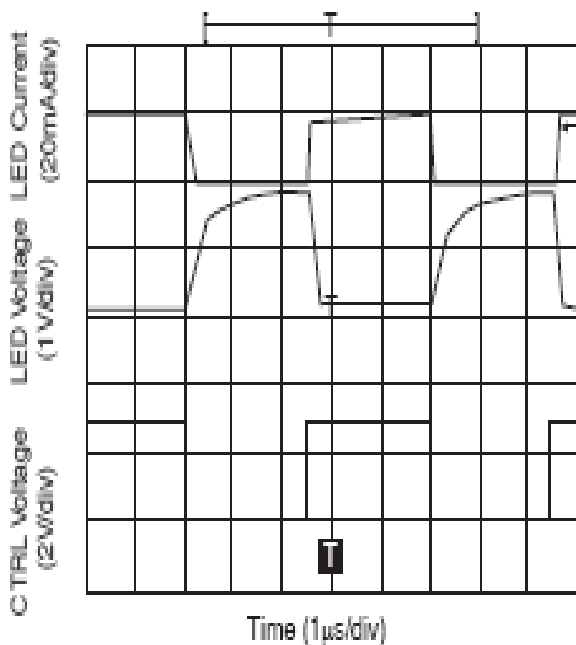
SP7614A LED Current Vs Cathode Voltage



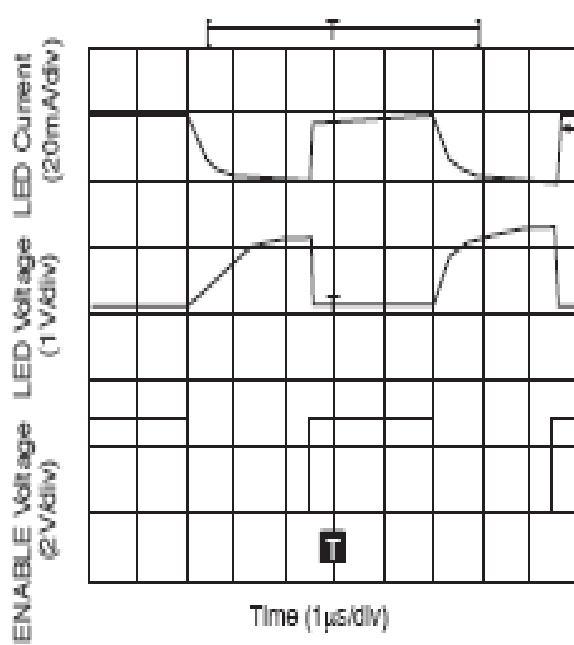
SP7614A LED current vs Enable Voltage (per Iset current)



Control Voltage Transient Response



Enable Voltage Transient Response



SETTING THE LED CURRENT

The LED current is controlled by ICONTROL and RSET according to the following formula:

$$I_{LED} = \text{Gain} \times (V_{CONTROL} - V_{CTRL}) / R_{SET}$$

Gain depends on mode of operation
 VCONTROL is the voltage going into RSET
 VCTRL is the voltage at the pin of the device

The voltage VCTRL can be determined using the ISET vs Control voltage graph located in the typical performance characteristics section. As an example, to set the LED current for an SP761x the procedure is:

Take the LED current and divide it by the Gain to get ISET = ILED / Gain.
 Look up the VCTRL pin voltage using ISET on the graph "Ctrl Current vs. Control Voltage".
 Once VCTRL is known, use the following formula to find RSET. The gain is not linear, the LED current vs. Cathode voltage graph needs to be used to determine gain. Typically, the gain is ~870 for SP7614A and ~435 for SP7611A/12A when the part is operating in the linear region.

$$R_{SET} = (V_{CONTROL} - V_{CTRL}) / I_{SET}$$

RSET Example

For an SP7614A with VCONTROL of 3V and LED current of 20mA.

$$I_{SET} = 20\text{mA}/870 \text{ (870 is the typical gain in linear operation)} = 22\mu\text{A}.$$

Using the graph on page 5 in the typical performance section, the VCTRL voltage on the control pin will be about 1.1V, then RSET will be determined by:

$$R_{SET} = (3\text{V} - 1.1\text{V}) / 22\mu\text{A}$$

$$R_{SET} = 86\text{K}\Omega$$

PWM FUNCTION

The LED's brightness can also be adjusted by driving either the ENABLE or the CTRL pin with a PWM signal. The driving signal frequency should be greater than 100Hz to avoid flickering, increasing to more than 1MHz, if necessary.

TEMPERATURE CONSIDERATIONS

LEDs are very sensitive to temperature. In most cases the maximum allowed junction temperature is 100°C. The case of overtemperature due to power dissipation is de-scribed by the following:

$$T_J = T_A + \Theta_{JA} \times I \times V_F$$

where TJ is the LED junction temperature,
 TA is the ambient temperature,
 ΘJA is the junction to ambient thermal resistance,
 I is the LED current and
 VF is the LED forward voltage.

When the temperature rises and the cathode voltage increases, SP761X reduces the current through LEDs. Refer to "LED Current vs. LED Cathode Voltage" graph under the Typical Performance Characteristics section.

EFFICIENCY

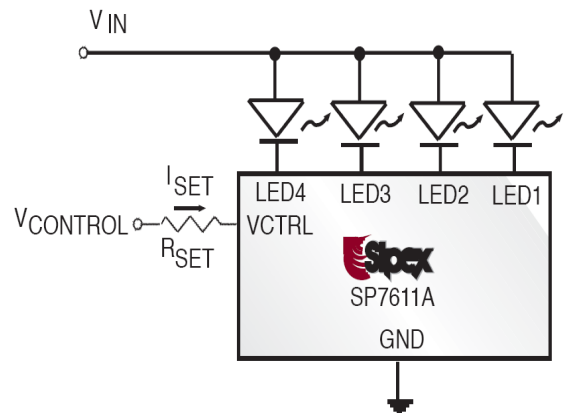
The system efficiency, defined as the ratio between the LED's power and the input supplied power can be calculated as follows:

$$\text{Efficiency} = (V_{IN} - V_{CATHODE}) / V_{IN}$$

The lower the VCATHODE, the higher the system efficiency. Efficiency can be further improved using a higher VIN with more LEDs as shown in example 3. The SP761X driver's low dropout architecture can significantly improve the efficiency compared to using simple ballast resistors.

APPLICATION INFORMATION

The ultra-low voltage drop across the SP761X series of LED drivers allows the devices to drive white, blue, and other color LEDs in a wide range of input voltages. The driver can be used in many

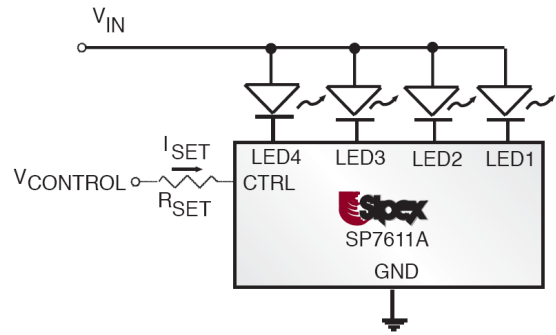


applications. Any of the SP761X series of LED drivers can be used in the applications presented in this document, due to their similar operation.

Example 1:

Drive low VF white or blue LEDs directly from single cell Li-Ion

When using white or blue low VF LEDs, and utilizing the driver's low voltage drop, only 3.4V VIN is needed for the full 20mA LED current. At 3.1V, there is still 5mA of typical current available for the LEDs.



The single cell Li-Ion battery is utilized in many applications like cell phones or digital still cameras. In most cases, the Li-Ion battery voltage level only goes down to 3.0V, and not down to the full discharge level (2.7V) before requesting the charger.

VDROP < 0.3V. This is the dropout voltage for the SP7611A.

- VF = 3.1V. Low VF white LED forward voltage drop
- VIN (at 20mA) needs to be greater than (VDROP+VF)
3.1V+.3V= 3.4V

Key Advantages

- 1) No boost circuit needed for the LCD or keyboard backlight.
- 2) Drivers directly connected to a Li-Ion battery.
- 3) No EMI, no switching noise, no boost converter efficiency loss, 1 capacitor, and no inductor.

Example 2: Drive high VF white or blue LEDs from existing bus ~ 4.0V to 5.5V

High VF LEDs have a forward voltage drop in the range of 3.2V to 4.0V. In order to drive these LEDs with the maximum current of 20mA, enabling maximum brightness usually requires a boost circuit for a single cell Li-Ion power supply. The SP761X series is capable of driving high VF white or blue LEDs with its ultra-low dropout feature. The VIN needs to be only 300mV higher than the highest VF in the circuit.

- VDROP < 0.3V. Dropout voltage of the SP7611A
- VF (at 20mA) < 3.3V to 4.0V (High VF)
- VIN (at 20mA) = VDROP + VF = 3.6V to 4.3V
- VIN (at 5mA typical) ~ 3.3V

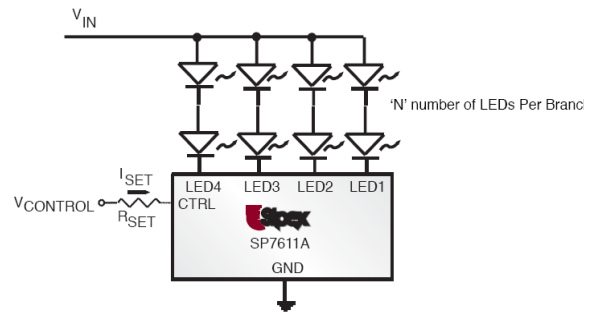
Where VIN = Existing bus = 3.3V to 4.3V

Key Advantages

- 1) No boost circuit needed for the LCD or keyboard backlight.
- 2) Drivers utilize existing bus.
- 3) Ultra-low voltage drop provides the full 20mA LED current at the lowest possible voltage level.

Example 3: Drive white, blue, red, amber LED string

In a boost circuit, or existing voltage bus, the SP761X series of LED drivers can be used to drive a whole string of LEDs and achieve flexible brightness control - whether using analog or PWM.



VDROP = 0.3V. Dropout voltage of the SP7611A

- VIN_MIN = N x VF + VDROP
- VIN_MIN = N x VF + 0.3V

Where VIN_MIN = Existing bus, boost Voltage

'N' number of LEDs Per Branch
VF = Forward voltage of the LED

Key Advantages

- 1) No need for current matching resistors and discrete transistors for brightness control.

LED Brightness Control

The SP761X LED Drivers feature analog and PWM controls to give designers flexible brightness control. To determine the value of RSET, use the "ISET vs. VCRTL" graph under the Typical Performance Characteristics.

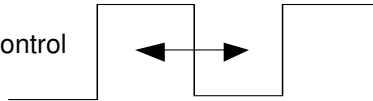
1. SP761X/A

- **Analog using VCONTROL**

Set VCONTROL and RSET for LED current

SETTING THE LED CURRENT – page 6

- PWM - Vcontrol

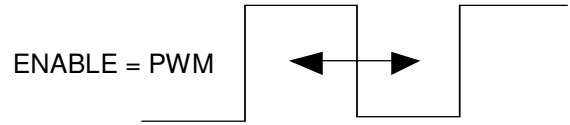


-Amplitude of PWM signal sets maximum LED current

-Pulse width controls current between 0 and maximum LED Set current

- **PWM using Enable**

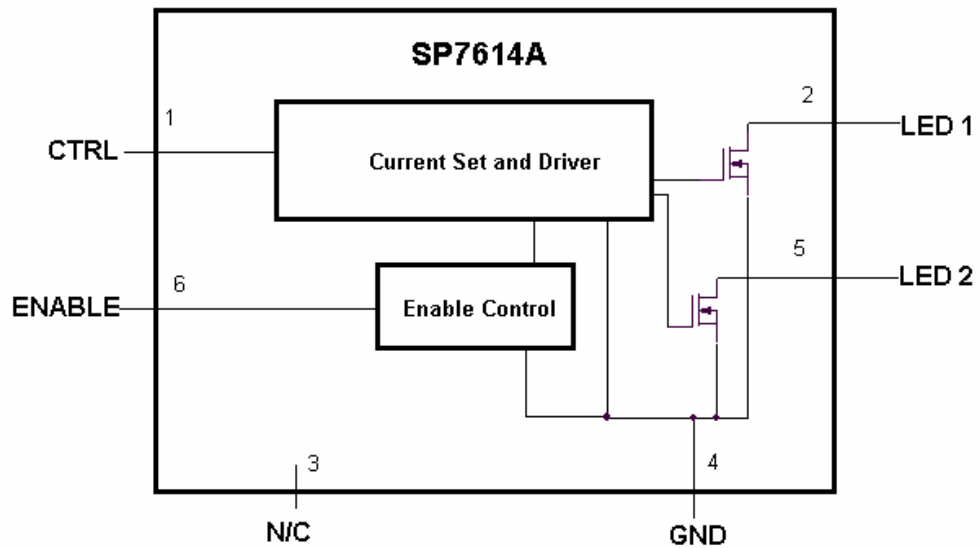
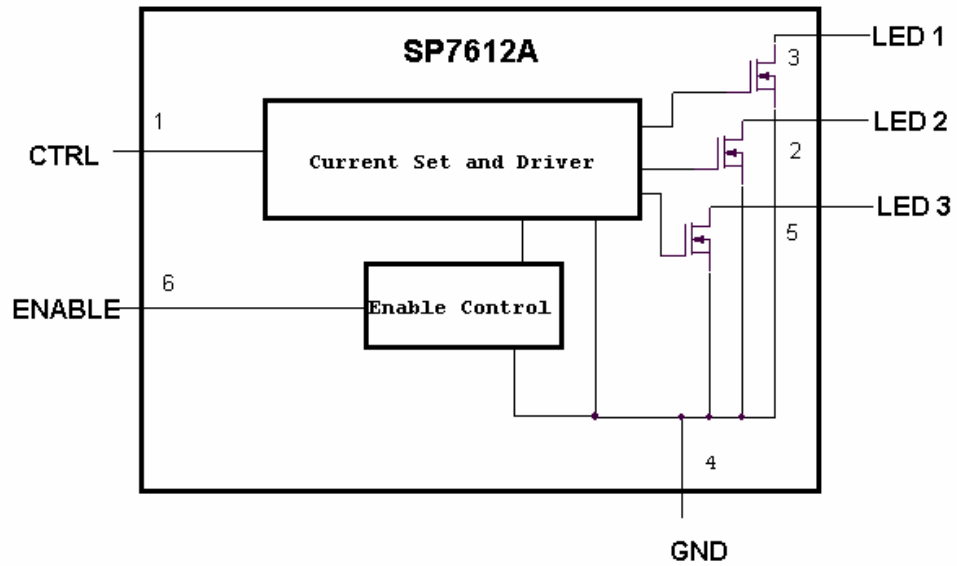
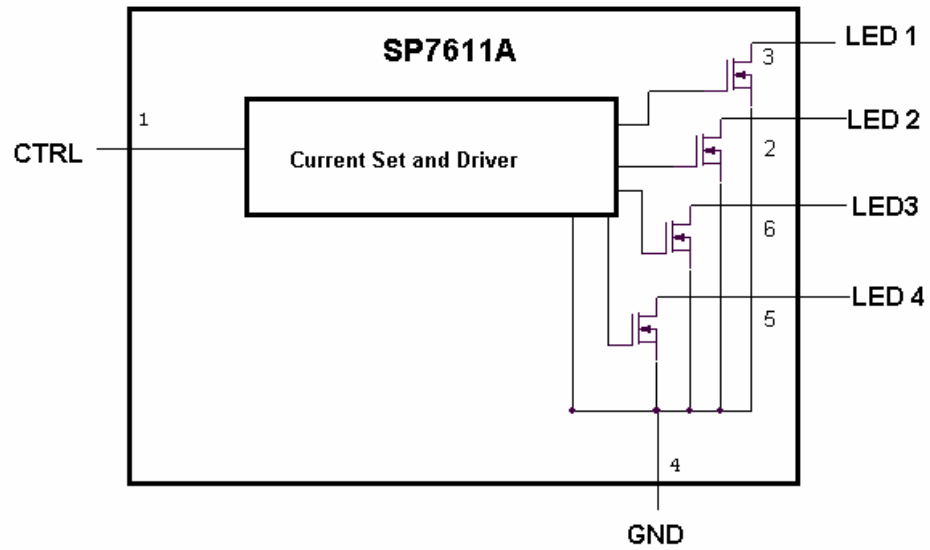
- Set VCONTROL and RSET for LED current
SETTING THE LED CURRENT – page 6

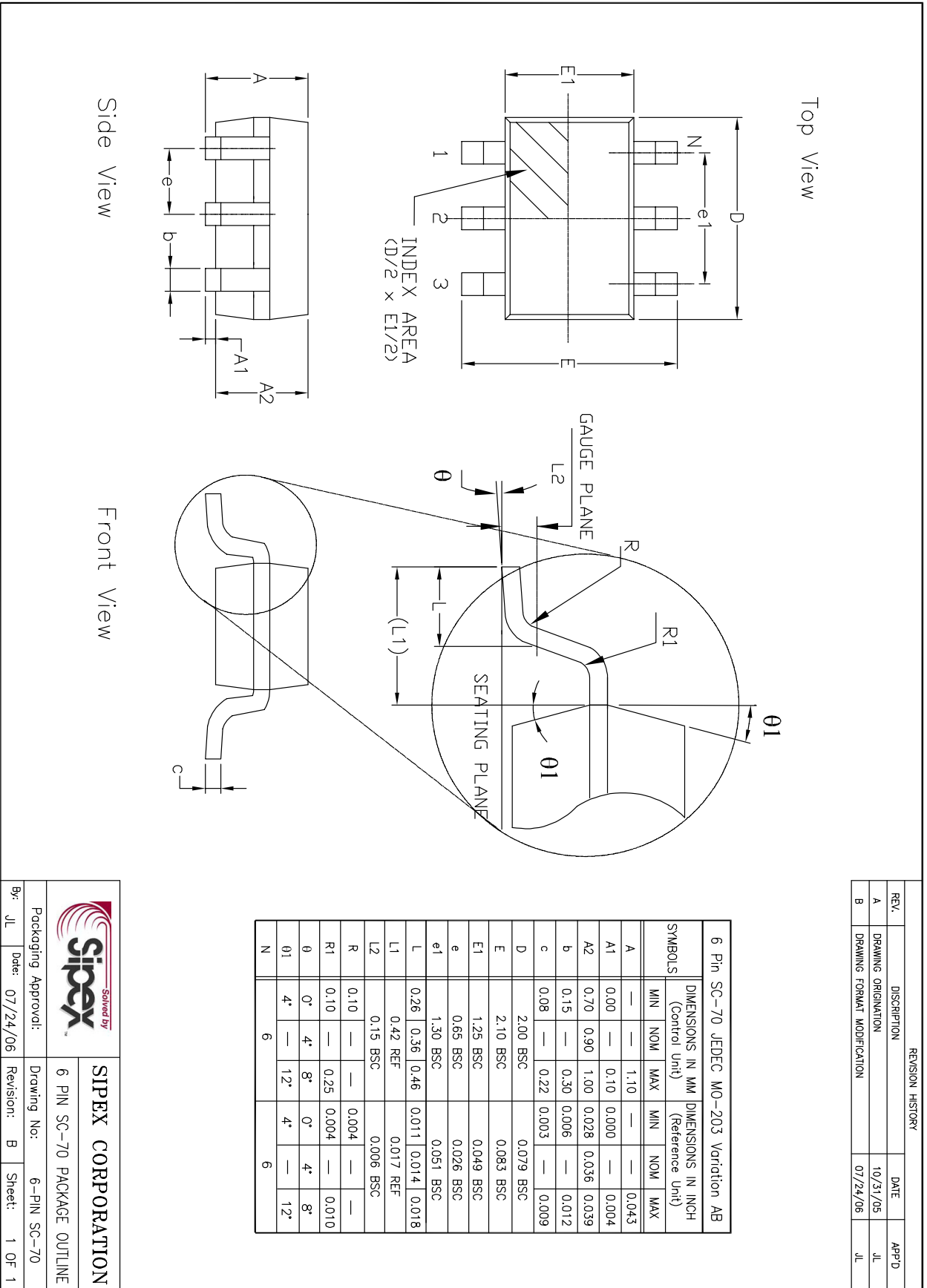


-Amplitude has no effect on current

-Pulse width controls current between 0 and maximum LED set current


BLOCK DIAGRAM





REVISION HISTORY		DATE	APP'D
REV. A	DESCRIPTION DRAWING ORIGINATOR	10/31/05	JL
B	DRAWING FORMAT MODIFICATION	07/24/06	JL

SYMBOLS	DIMENSIONS IN MM (Control Unit)			DIMENSIONS IN INCH (Reference Unit)		
	MIN	NOM	MAX	MIN	NOM	MAX
A	—	1.10	—	—	0.043	—
A1	0.00	0.10	0.000	—	0.004	—
A2	0.70	0.90	1.00	0.028	0.036	0.039
b	0.15	—	0.30	0.006	—	0.012
c	0.08	—	0.22	0.003	—	0.009
D	2.00 BSC			0.079 BSC		
E	2.10 BSC			0.083 BSC		
E1	1.25 BSC			0.049 BSC		
e	0.65 BSC			0.026 BSC		
e1	1.30 BSC			0.051 BSC		
L	0.26	0.36	0.46	0.011	0.014	0.018
L1	0.42 REF			0.017 REF		
L2	0.15 BSC			0.006 BSC		
R	0.10	—	—	0.004	—	—
R1	0.10	—	0.25	0.004	—	0.010
theta	0°	4°	8°	0°	4°	8°
theta1	4°	—	12°	4°	—	12°
N	6			6		


SIPLEX CORPORATION
 6 PIN SC-70 PACKAGE OUTLINE
 Packaging Approval: _____ Drawing No: 6-PIN SC-70
 By: JL Date: 07/24/06 Revision: B Sheet: 1 OF 1

ORDERING INFORMATION

Part Number	Temperature Range	Package Type
SP7611AEC6	-40 °C to +85 °C	6 Pin SC70
SP7611AEC6/TR	-40 °C to +85 °C	6 Pin SC70
SP7612EC6	-40 °C to +85 °C	6 Pin SC70
SP7612EC6/TR	-40 °C to +85 °C	6 Pin SC70
SP7612AEC6	-40 °C to +85 °C	6 Pin SC70
SP7612AEC6/TR	-40 °C to +85 °C	6 Pin SC70
SP7614EC6	-40 °C to +85 °C	6 Pin SC70
SP7614EC6/TR	-40 °C to +85 °C	6 Pin SC70
SP7614AEC6	-40 °C to +85 °C	6 Pin SC70
SP7614AEC6/TR	-40 °C to +85 °C	6 Pin SC70

Available in Lead Free packaging. To order add "-L" suffix to part number.
Example: SP7614AEC6/TR = standard; SP7614AEC6-L/TR = Lead Free.
/TR = Tape and Reel.
Pack quantity is 2500 for SC70.

**Sipex Corporation**

**Headquarters and
Sales Office**
233 South Hillview Drive
Milpitas, CA95035
tel: (408) 934-7500
FAX: (408) 935-7600

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