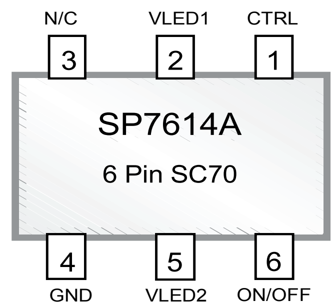
# SP7612 SP7614

## 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 < 0.01µA
- Tiny, RoHS Compliant Lead-Free Packages: SC-70




| Part # | Channels | Maximum Steady State Current per LED |
|---|---|---|
| SP7612 | 3 | 40mA |
| SP7614 | 2 | 80mA |

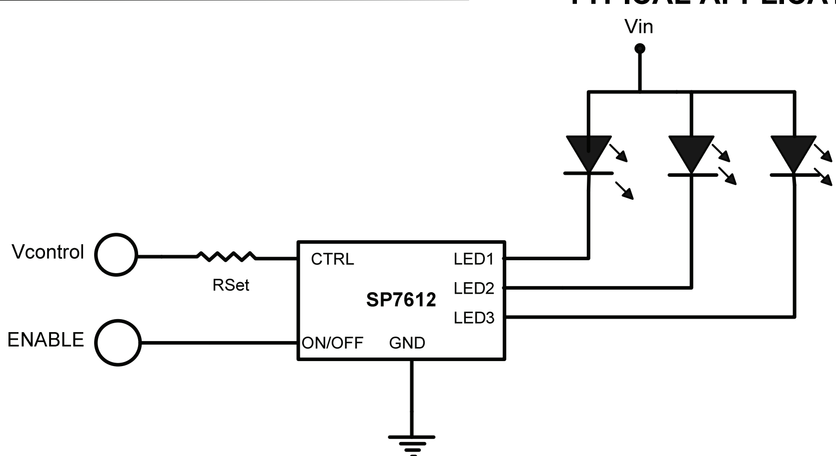
### APPLICATIONS

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

### DESCRIPTION

The SP7612/4 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 SP7612 is capable of driving three LEDs, while the SP7614 can drive two 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 SP7612 and SP7614 feature Enable pins for flexible on/off control and PWM dimming. SP7612/4 has extremely low (0.01uA typical) shutdown current, prolonging the battery life and giving the longest standby period possible in today's modern design. It is available in a small footprint 6-pin SC-70 package.

### TYPICAL APPLICATION SCHEMATIC




**SP7612 Typical application**

## 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 ($I_{OUT}$) (SP7612)........ 40mA
Output Current ($I_{OUT}$) (SP7614)........ 80mA
Power Dissipation per Package - 6-pin SC-70 at $T_A$ =85°C........ 190mW
Junction Temperature ........ +150°C
Storage Temperature........ -55°C to +150°C
ESD Level........ 4kV HBM
ESD Level........ 1kV CDM

## ELECTRICAL SPECIFICATIONS

Specifications are at $T_A$=25°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 | | 85 | ºC | | |
| Output Current Multiplication Ratio in Linear Region (Note1) | SP7612 | 140 | 200 | 260 | | | ISET = 100µA VLED = 300mV |
| | SP7614 | | | | | | ISET = 100µA VLED = 150mV |
| Output Current Multiplication Ratio in Saturation (Note1) | SP7612 | 365 | 435 | 505 | | | ISET = 25µA VLED = 0.5V |
| | SP7614 | 730 | 870 | 1010 | | | |
| LED to LED Current Matching | | -3 | 0.8 | 3 | % | ♦ | ISET = 100µA VLED = 300mV |
| Current in OFF Mode | | | 0.01 | 1 | µA | ♦ | VENABLE = 0.0V |
| Min. ENABLE ""ON Voltage" (Note 2) | | 3 | | | V | ♦ | ISET = 150µA |
| Max. ENABLE ""OFF Voltage" (Note 2) | | | | 0.5 | V | ♦ | |

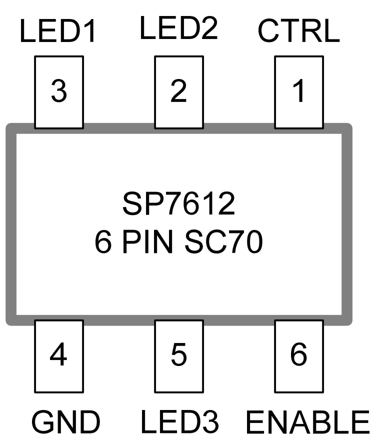
Note 1: Output current Multiplication Ratio ($I_{LED}/I_{SET}$) is not linear. For actual ratio and $I_{LED}$ please refer to typical performance characteristics on pages 4 through 7.
Note 2: ENABLE "ON" is $V_{ON/OFF}$ where $I_{LED1}$ > 20mA @ $V_{LED1}$ = 0.3V.
ENABLE "OFF" is V where I < 1µA @ V > 0.3V.

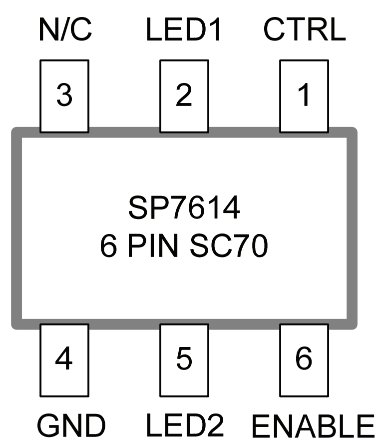
## PIN DESCRIPTION

**SC70 Package**

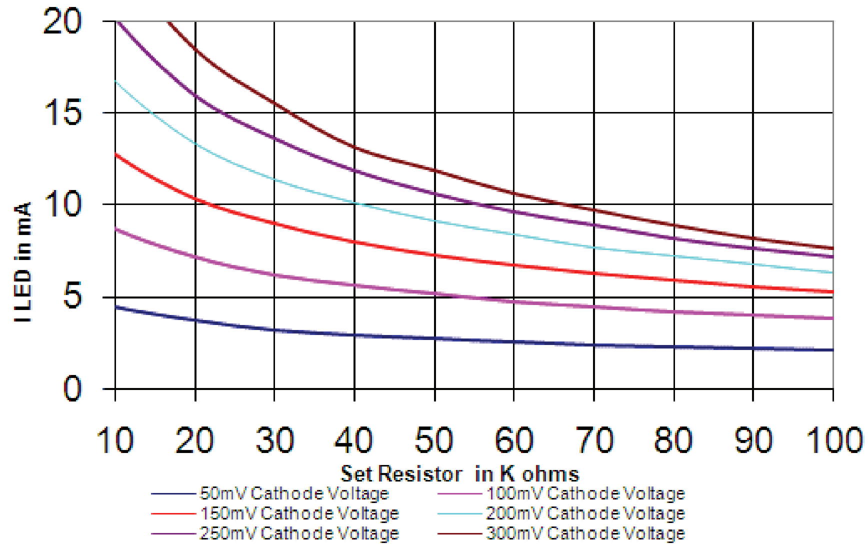
| Pin # | Pin Name | | DESCRIPTION |
|---|---|---|---|
| | **SP7612** | **SP7614** | |
| 1 | C T R L | C T R L | Sets L E D Current |
| 2 | L E D 2 | L E D 1 | Connect to Cathode of L E D |
| 3 | L E D 1 | N C | Connect to Cathode of L E D |
| 4 | GND | GND | Ground |
| 5 | L E D 3 | L E D 2 | Connect to Cathode of L E D |
| 6 | ENABLE | ENABLE | Chip ON/ OFF Disable |

## PINOUTS

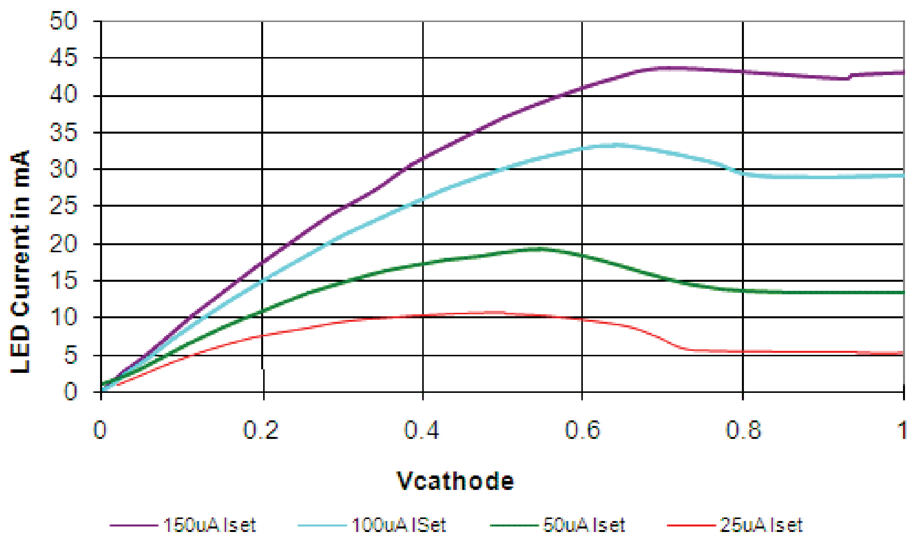


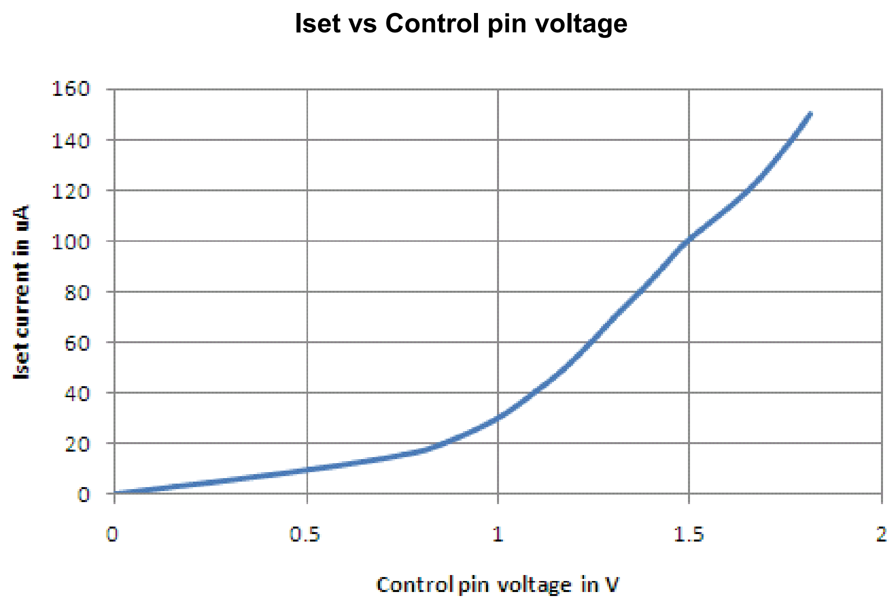
**LED current vs Rset for LED voltage (Vcathode)**
**Vcontrol set to 3V**

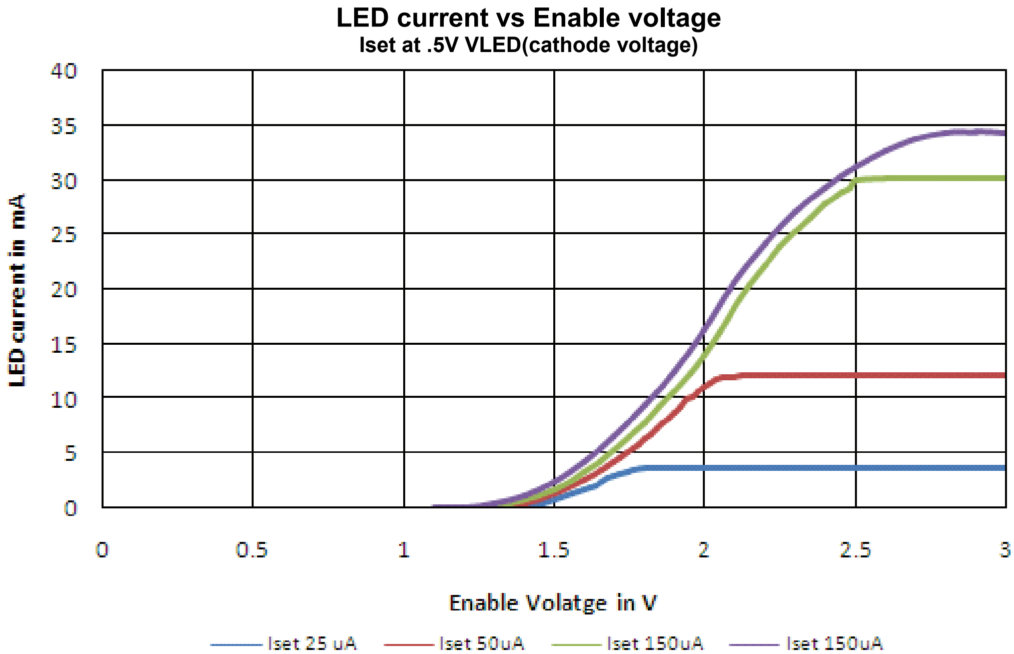



**LED current vs Cathode voltage (VLED)**

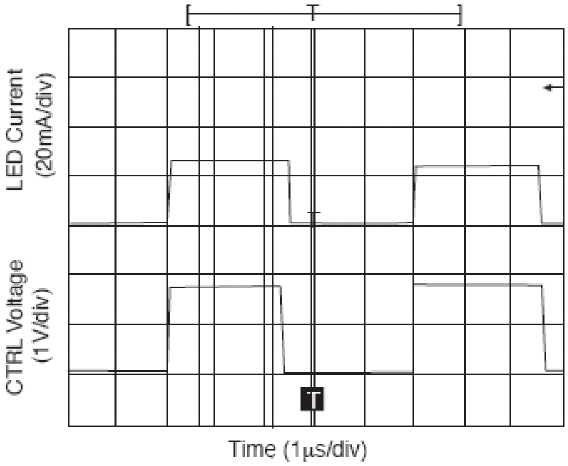


## SP7612 TYPICAL PERFORMANCE CHARACTERISTICS

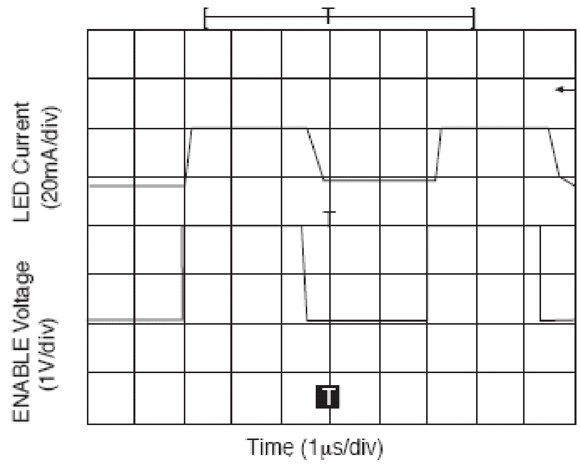


Control Voltage Transient Response

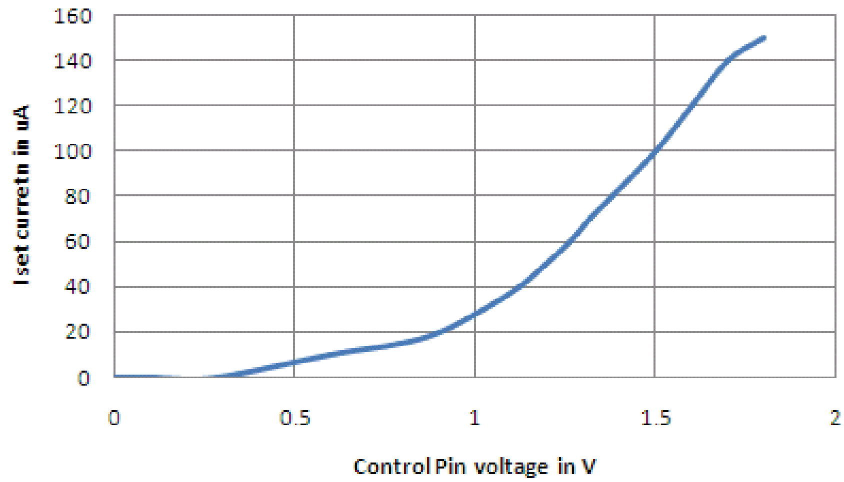



Enable Voltage Transient Response

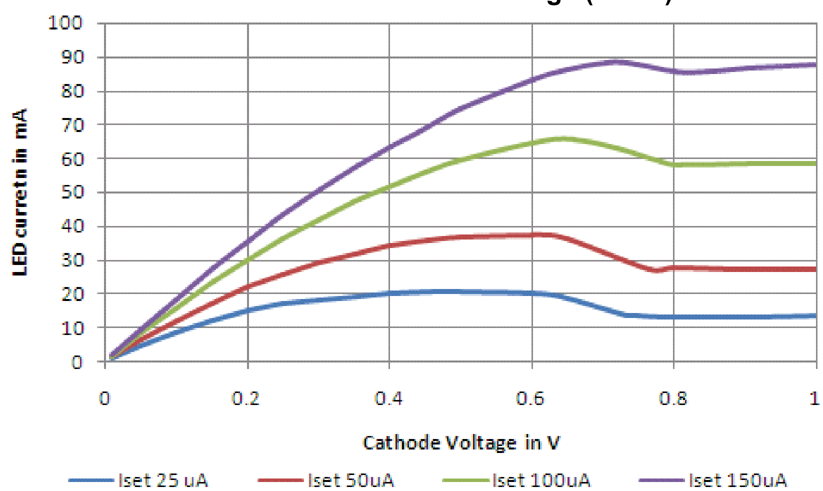


## SP7614 TYPICAL PERFORMANCE CHARACTERISTICS

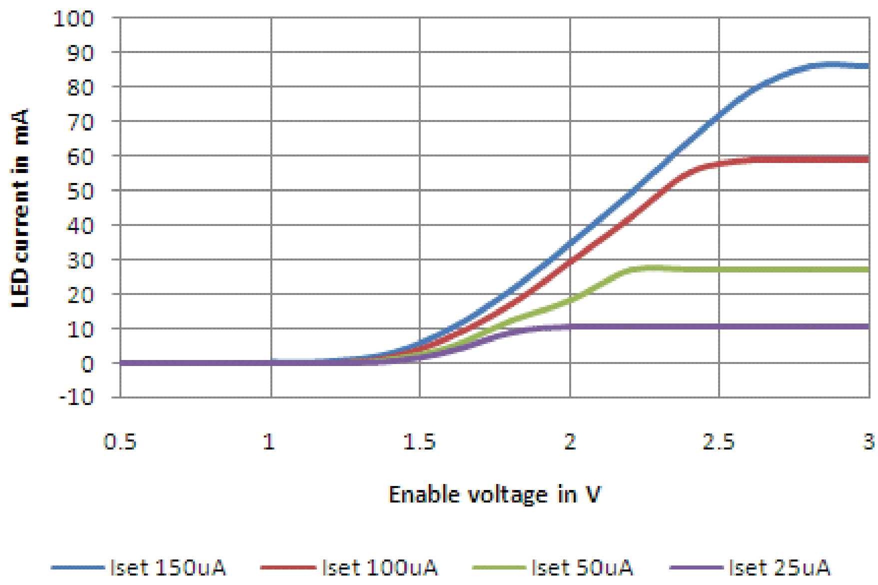
### Iset vs Control pin voltage

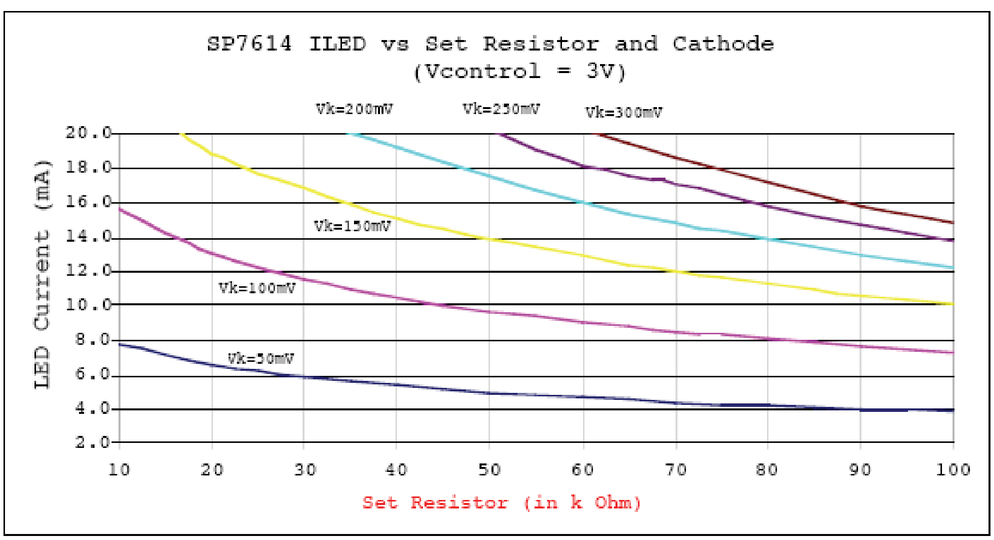


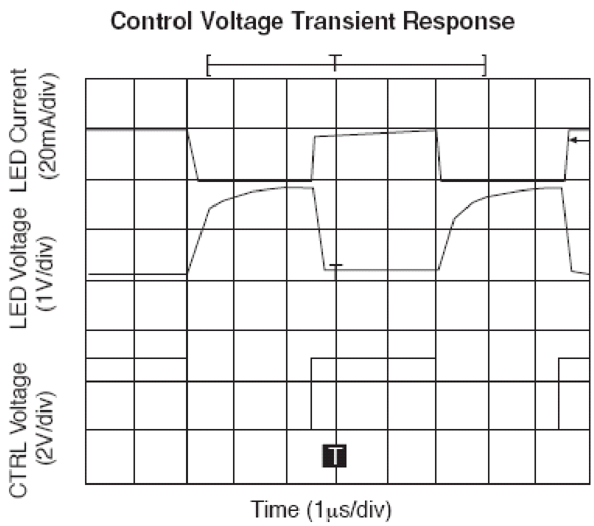

### LED current vs Cathode voltage (VLED)

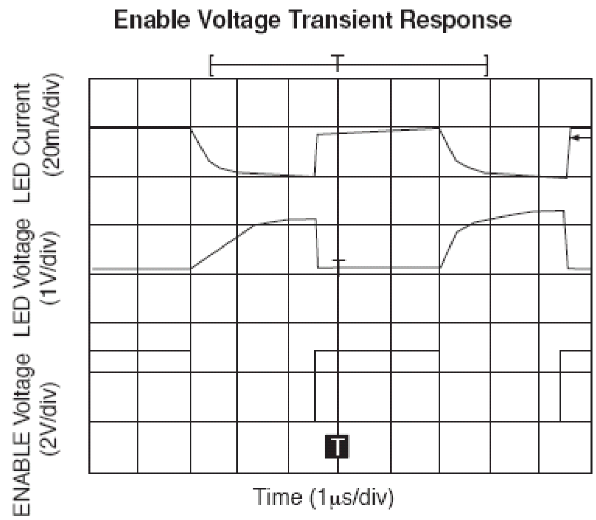


**LED current vs Enable voltage**
**Iset at .5V VLED(cathode voltage)**




Control Voltage Transient Response
LED Current (20mA/div)
LED Voltage (1V/div)
CTRL Voltage (2V/div)
T
Time (1µs/div)


Enable Voltage Transient Response
LED Current (20mA/div)
LED Voltage (1V/div)
ENABLE Voltage (2V/div)
T
Time (1µs/div)

**Setting the LED Current**

The LED current is controlled by $I_{CONTROL}$ and $R_{SET}$ according to the following formula:

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

Gain depends on mode of operation
$V_{CONTROL}$ is the voltage going into $R_{SET}$
$V_{CTRL}$ is the voltage at the pin of the device

The voltage $V_{CTRL}$ can be determined using the $I_{SET}$ 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 $I_{SET}$ = $I_{LED}$ / Gain.
Look up the $V_{CTRL}$ pin voltage using $I_{SET}$ on the graph "Ctrl Current vs. Control Voltage".
Once $V_{CTRL}$ is known, use the following formula to find $R_{SET}$. 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 SP7614 and ~435 for SP7612 when the part is operating in the linear region.

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

**$R_{SET}$ Example**

For an SP7614 with $V_{CONTROL}$ of 3V and LED current of 20mA.

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

Using the graph on page 5 in the typical performance section, the $V_{CTRL}$ voltage on the control pin will be about 1.1V, then $R_{SET}$ will be determined by:

$R_{SET}$ = (3V - 1.1V) / 22uA
$R_{SET}$ = 86KΩ

**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 100ºC. 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 $T_J$ is the LED junction temperature,
$T_A$ is the ambient temperature,
$\Theta_{JA}$ 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, SP7612/4 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:

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

The lower the $V_{CATHODE}$ , the higher the system efficiency. Efficiency can be further improved using a higher $V_{IN}$ with more LEDs as shown in example 3. The SP7612/4 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 SP7612/4 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 SP7612/4 series of LED drivers can be used in the applications presented in this document, due to their similar operation.

**Example 1:**
**Drive low $V_F$ white or blue LEDs directly from single cell Li-Ion**

When using white or blue low $V_F$ LEDs, and utilizing the driver's low voltage drop, only 3.4V $V_{IN}$ 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.

$V_{DROP}$ < 0.3V. This is the dropout voltage for the SP7611A.
- $V_F$ = 3.1V. Low $V_F$ white LED forward voltage drop
- $V_{IN}$ (at 20mA) needs to be greater than ($V_{DROP}$+$V_F$)
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 $V_F$ white or blue LEDs from existing bus ~ 4.0V to 5.5V**
High $V_F$ 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 $V_F$ white or blue LEDs with its ultra-low dropout feature. The $V_{IN}$ needs to be only 300mV higher than the highest $V_F$ in the circuit.

- $V_{DROP}$ < 0.3V. Dropout voltage of the SP7611A

- $V_F$ (at 20mA) < 3.3V to 4.0V (High VF)

- $V_{IN}$ (at 20mA) = $V_{DROP}$ + $V_F$ = 3.6V to 4.3V

- $V_{IN}$ (at 5mA typical) ~ 3.3V

Where $V_{IN}$ = Existing bus = 3.3V to 4.3V

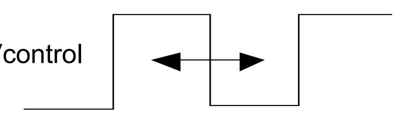
**Key Advantages**
1) No boost circuit needed for the LCD or keyboard backlight.
2) Drivers utilize existing bus.
3) Ultra-low voltage drop provides the full 20mA LED current at the lowest possible voltage level.

**LED Brightness Control**
The SP7612/4 LED Drivers feature analog and PWM controls to give designers flexible brightness control. To determine the value of $R_{SET}$ , use the "$I_{SET}$ vs. $V_{CRTL}$" graph under the Typical Performance Characteristics.

1. SP7612/4
- **Analog using $V_{CONTROL}$**
Set $V_{CONTROL}$ and $R_{SET}$ for LED current

SETTING THE LED CURRENT – page 8

- PWM - Vcontrol

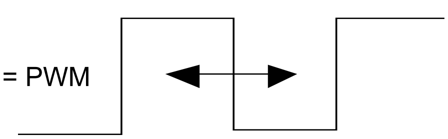


-Amplitude of PWM signal sets maximum LED current
-Pulse width controls current between 0 and maximum LED Set current

- **PWM using Enable**

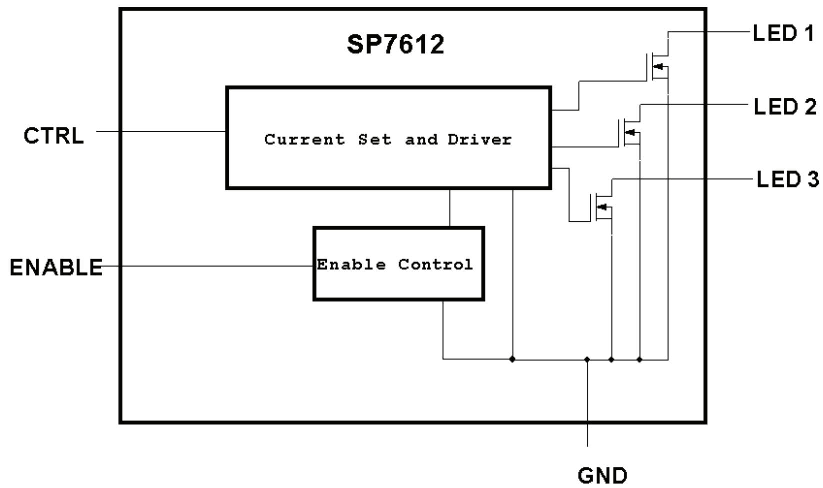
- Set $V_{CONTROL}$ and $R_{SET}$ for LED current
SETTING THE LED CURRENT – page 6

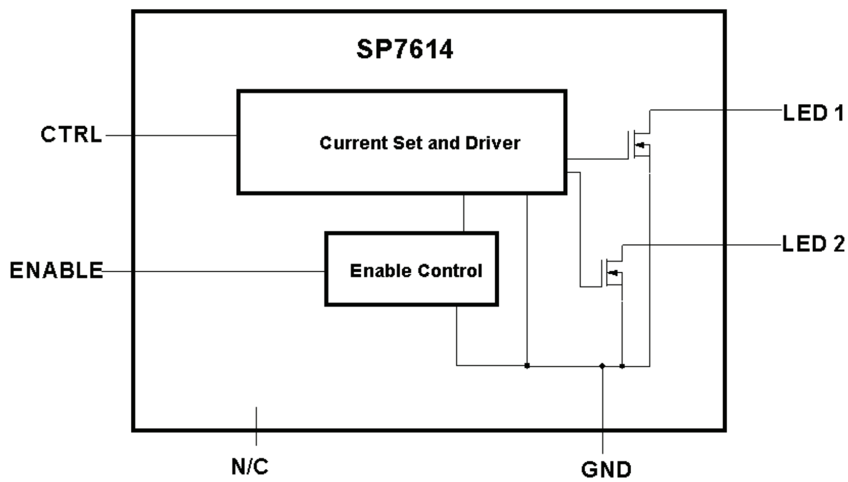
ENABLE = PWM



-Amplitude has no effect on current
-Pulse width controls current between 0 and maximum LED set current

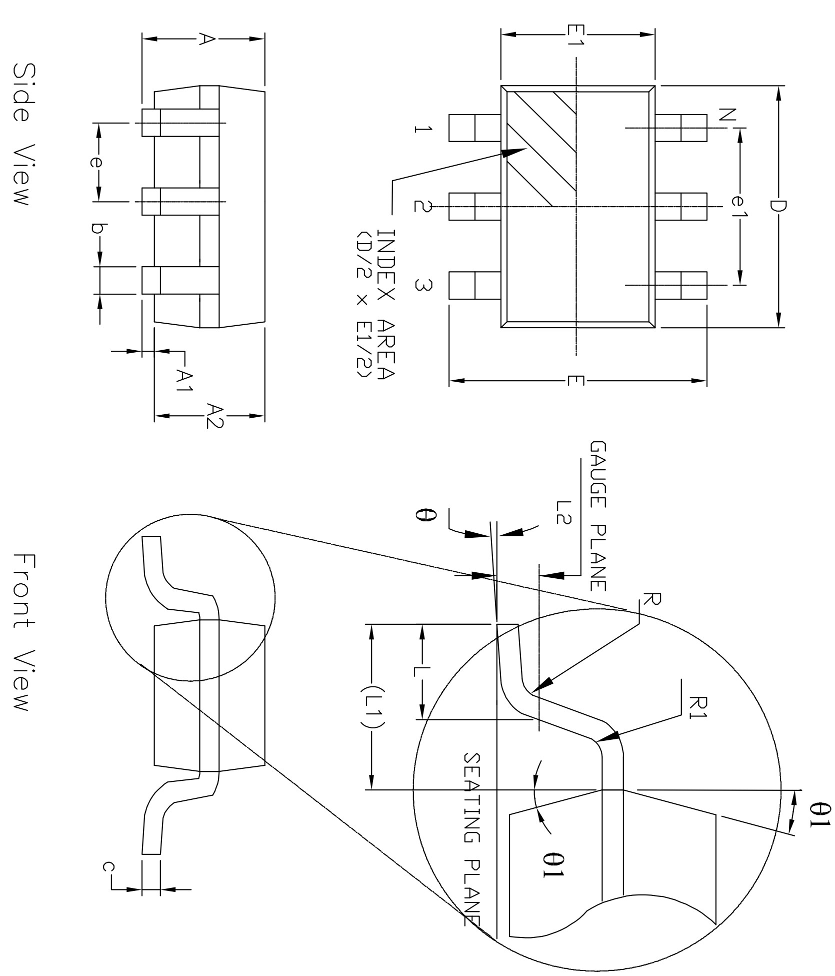
## BLOCK DIAGRAMS



**PACKAGE: 6 PIN SC-70**




| REV. | DISCRIPTION | DATE | APP'D |
|---|---|---|---|
| A | DRAWING ORIGINATION | 10/31/05 | JL |
| B | DRAWING FORMAT MODIFICATION | 07/24/06 | JL |

6 Pin SC-70 JEDEC MO-203 Variation AB

| 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 |
| θ | 0° | 4° | 8° | 0° | 4° | 8° |
| θ1 | 4° | — | 12° | 4° | — | 12° |
| N | 6 | | | 6 | | |

Sipex Solved by

SIPEX 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 | RoHS | Pack Type | Pack Quantity | Status |
|---|---|---|---|---|---|---|
| SP7612EC6-L | -40°C to +85°C | 6 Pin SC70 | Yes | Canister | Any | Active |
| SP7612EC6-L/TR | -40°C to +85°C | 6 Pin SC70 | Yes | Tape & Reel | 3000 | Active |
| SP7614EC6-L | -40°C to +85°C | 6 Pin SC70 | Yes | Canister | Any | Active |
| SP7614EC6-L/TR | -40°C to +85°C | 6 Pin SC70 | Yes | Tape & Reel | 3000 | Active |

/TR = Tape and Reel
Pack quantity is 2500 for SC70

For further assistance:

Email: customersupport@exar.com
EXAR Technical Documentation: http://www.exar.com/TechDoc/default.aspx?

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