

## Four Channel White LED Driver

### Description

The SN3226 is a low noise, constant frequency charge pump DC/DC converter for white LED applications. The SN3226 is capable of driving up to four channels of LEDs at preset 20mA per channel from a 2.7V to 5.5V input. The current sinks may be operated individually or in parallel for driving higher current LEDs. Only one 0.22 $\mu$ F flying capacitors and two small 1 $\mu$ F capacitors (at Vcc and Vout) make this part ideally suited for small, battery-powered applications.

The serial digital input is used to enable, disable, and set current for each LED with 14 settings down to 1.8mA. Each output of the SN3226 is equipped with built-in soft-start circuitry prevents excessive inrush current during start-up. A low-current shutdown feature disconnects the load from the input and reduces quiescent current to less than 1 $\mu$ A.

The SN3226 is available in a Pb-free, space-saving 3.00 $\times$ 3.0mm 10-pin DFN10 package.

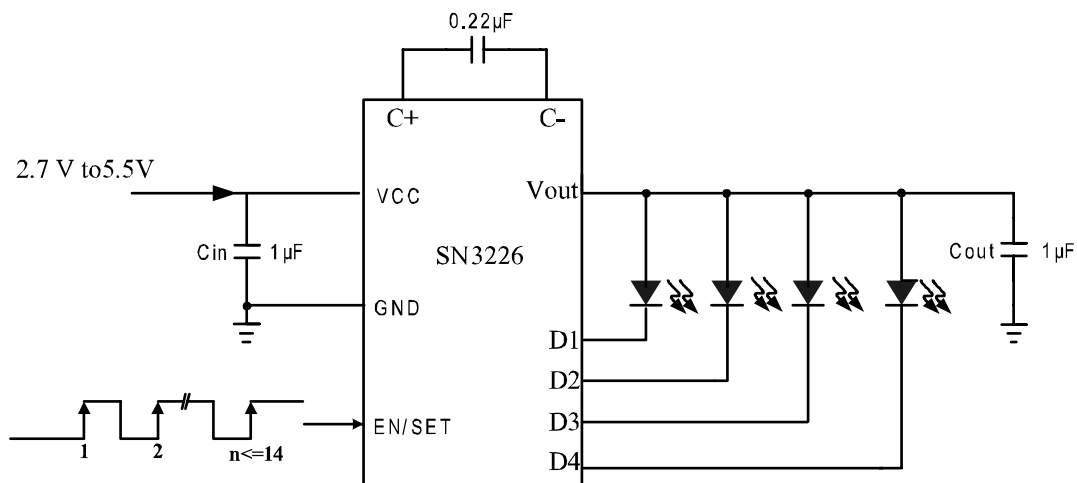
### Features

- $V_{IN}$  Range: 2.7V to 5.5V
- Fully Programmable Current with Single Wire  
——14 Current Levels
- Drives up to Four Channels of LEDs
- No Inductors, Low Noise Operation
- Small Application Circuit
- Built-In Thermal Protection
- Automatic Soft Start
- $I_Q < 1\mu A$  in Shutdown
- 3.0 $\times$ 3.0mm DFN10 Package

### Applications

- Cell Phone/Smart Phone/PDA
- Mp3/Mp4/PMP
- White LED Backlighting

### Typical Application Circuit



## Pin Configurations

Package	Pin Configurations(Top View)
DFN10	

## Pin Description

PIN	PIN	DESCRIPTION
Vcc	1	Power supply input, Requires 1uF capacitor connect between this pin and ground pin
C+	2	Flying capacitor positive terminal
C-	3	Flying capacitor negative terminal
GND	4	Ground.
EN/SET	5	Serial digital input, control the output current
D4:D2	6,7,8	White LED channel 4:2
D1	9	White LED channel 1, this channel must be used
Vout	10	Charge pump output to drive load circuits, Requires 1uF capacitor connected between this pin and ground pin
Thermalpad		Connect to GND

## Ordering Information

Order Number	Package Type	Operating Temperature range
SN3226JIR1	DFN-10	-40°C to 85°C

SN3226	□	□	□	□	
					Lead Free Code
				1	1: Lead Free
					Packaging
				R	R: Tape & Reel
					Operating temperature range
				I	I: Industry Standard
					Package type
				J	J: DFN

## Absolute Maximum Ratings

■ Input Voltage to GND, $V_{IN}$	-----	-0.3 to 6V
■ EN/SET Voltage to GND, $V_{EN/SET}$	-----	-0.3 V to $V_{DD} + 0.3V$
■ Junction Temperature, $T_J$	-----	-40 to 150°C
■ Maximum Soldering Temperature(at lead, 10 sec), $T_{LEAD}$	-----	300°C
■ Maximum Power Dissipation	-----	3.79W
■ Maximum Thermal Resistance $\theta_{JA}$	-----	33°C/W

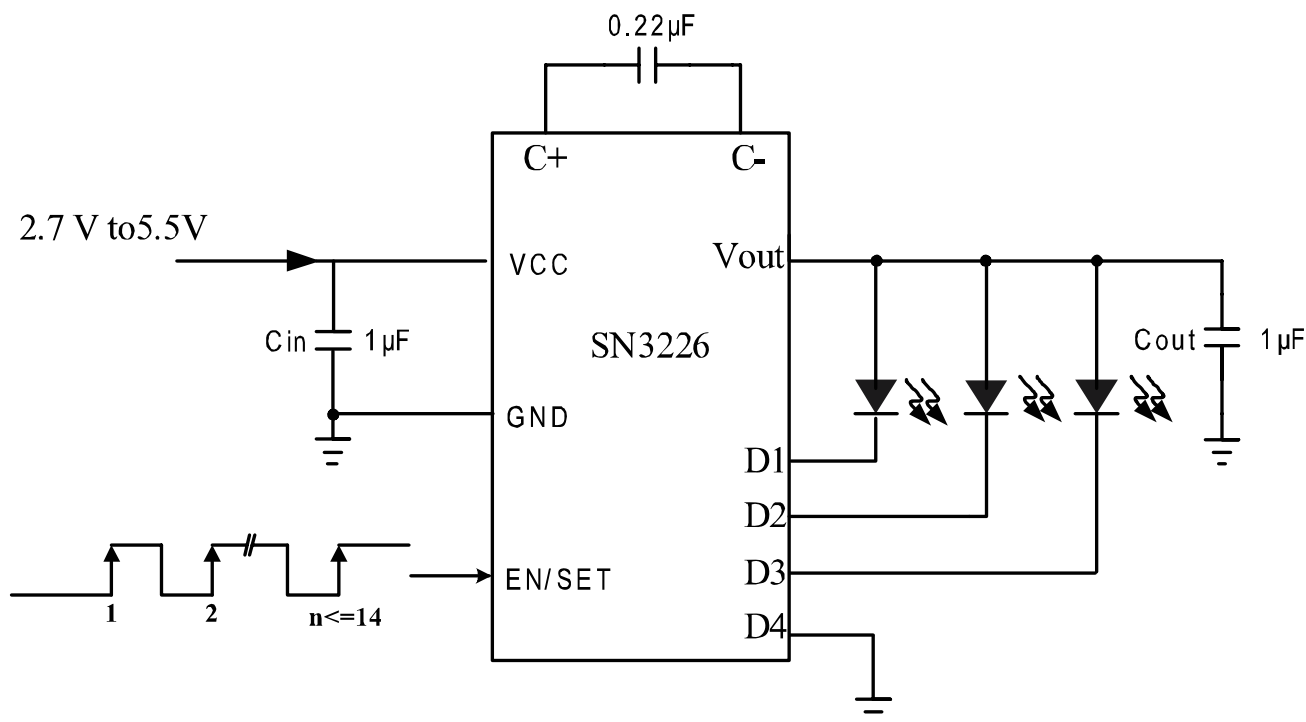
## Electrical Characteristics

$C_{IN} = C_{OUT} = 1.0\mu F$ ;  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise noted.

Typical values are  $T_A = 25^\circ C$ ,  $V_{IN} = 3.6V$ .

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
<b>Input Power Supply</b>						
$V_{IN}$	Operation Range		2.7		5.5	V
$I_{CC}$	Operating Current	$3.0 \leq V_{IN} \leq 5.5$ , Active, No Load Current		0.3	1	mA
$I_{SHDN}$	Shutdown Current	$V_{EN/SET} = 0V$		0.4	3	uA
$I_{DX}$	$I_{SINK}$ Average Current Accuracy	$I_{SET} = 20mA$ , $T_A = 25^\circ C$	16	19	23	mA
$I_{(D-Match)}$	Current Matching	$V_F : D1 : D4 = 3.6V$		0.8	3.5	%
$V_{TH}$	Transition Threshold at Any $I_{SINK}$ Pin			199		mV
<b>Charge Pump Section</b>						
$T_{SS}$	Soft-Start Time			33		us
$F_{CLK}$	Clock Frequency			710		kHz
<b>EN/SET</b>						
$V_{EN(L)}$	Enable Threshold Low	$V_{IN} = 2.7V$			0.4	V
$V_{EN(H)}$	Enable Threshold High	$V_{IN} = 5.5V$	1.4			V
$T_{EN/SET LO}$	EN/SET Low Time		0.3		75	us
$T_{EN/SET HI\_MIN}$	Minimum EN/SET High Time		50			ns
$T_{EN/SET HI\_MAX}$	Maximum EN/SET High Time				75	us
$T_{OFF}$	EN/SET Off Timeout		500			us
$T_{LAT}$	EN/SET Latch Timeout		500			us
$R_{EN/SET DOWN}$	EN/SET Pull Down Resistor			630		k $\Omega$

## Application Circuit for Less than Four LEDs



**Note:** When less than four LEDs connected, keep the unused pin to GND or floating. But channel D1 (pin 9) must be used!

## Application information

### General Description

The SN3226 charge pump drives up to four white LEDs with regulated constant current for uniform intensity. It achieves 20mA output drive capability over the 1-cell lithium-battery input voltage range. Fixed-frequency switching of 710kHz allows for tiny external components, and the regulation scheme is optimized to ensure low EMI and low input ripple.

### Constant Current Output Level Settings

The constant current source levels for D1 to D4 are set via the serial interface according to a logarithmic scale. For the whole 14 codes, each code is approximately 1.5dB lower than the previous code. In this manner, LED brightness appears linear with each increasing code count. Because the outputs D1 to D4 are true independent constant current sources, the voltage observed on any single given output will be determined by the actual forward voltage ( $V_F$ ) for the LED being driven.

Since the output current sources of the SN3226 are programmable, no PWM (pulse width modulation) or

additional control circuitry is needed to control LED brightness. This feature greatly reduces the burden on a microcontroller or system IC to manage LED or display brightness, allowing the user to "set it and forget it." With its high-speed serial interface (1MHz data rate), the output current of the SN3226 can be changed successively to brighten or dim LEDs, in smooth transitions (e.g., to fade-out) or in abrupt steps, giving the user complete programmability and real-time control of LED brightness.

### Functional Description

The four constant current source outputs (D1 to D4) can drive four individual LEDs with a maximum current of 20mA each. The PCC wire serial interface enables the SN3226 and sets the current source magnitudes.

### PCC wire Serial Interface

The current level magnitude is controlled by Pulse Count Control (PCC wire) serial interface. The interface records rising edges of the EN/SET pin and decodes them into 14 different states. The 14 current level settings available are indicated in Table 1.

Data	Output(mA/Ch)	Data	Output(mA/Ch)
1	20.0	8	6.0
2	17.0	9	5.0
3	14.0	10	4.2
4	12.0	11	3.6
5	10.0	12	3
6	8.6	13	2.4
7	7.0	14	1.8

Table 1: Current Level Settings.

The PCC wire serial interface has flexible timing. Data can be clocked-in at speeds greater than 1MHz, or much slower, such as 15 kHz. After data is submitted, EN/SET is held high to latch the data. Once EN/SET has been held in the logic high state for time  $T_{LAT}$ , the programmed current becomes active and the internal data register is reset to zero. For subsequent current level programming, the number of rising edges corresponding to the desired code must be entered on the EN/SET pin.

### PCC wire Serial Interface Timing

When EN/SET is held low for an amount of time greater than  $T_{OFF}$ , the SN3226 enters into shutdown mode and draws less than  $1\mu A$  from VCC. The internal data register is reset to zero during shutdown.

### Drive Fewer Than Four LEDs.

When driving fewer than four LEDs, connect the unused pin to GND, but LED1 must be connected. When connected in this manner, the corresponding LED driver is disabled.

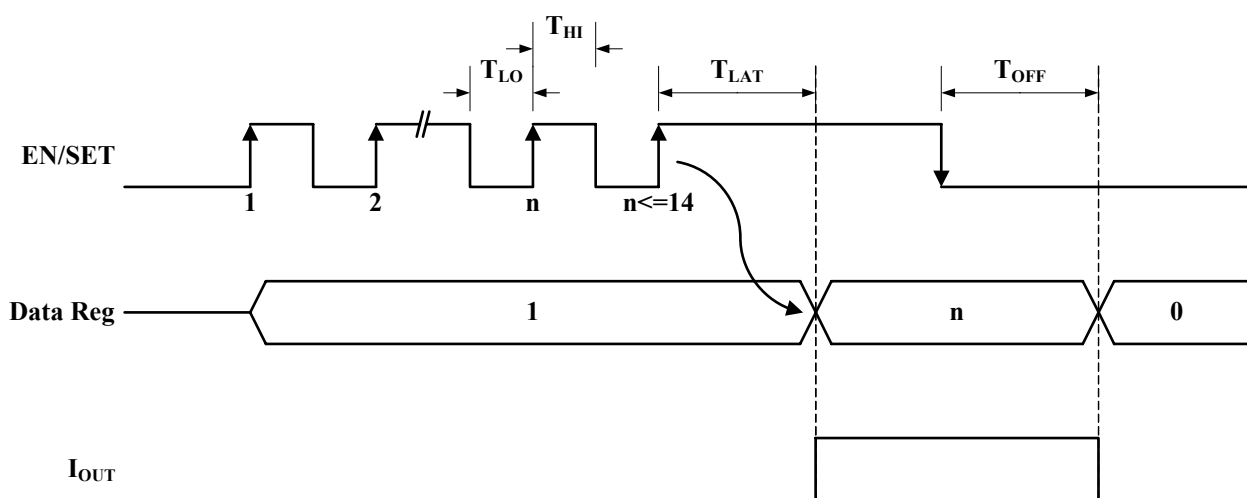
### Device Switching Noise Performance

The SN3226 operates at a fixed frequency of approximately 710 kHz to control noise and limit harmonics that can interfere with the RF operation of cellular telephone handsets or other communication devices. Back-injected noise appearing on the input pin of the charge pump is 60mV peak-to-peak, typically ten times less than inductor-based DC/DC boost converter white LED backlight solutions. The SN3226 soft-start feature prevents noise transient effects associated with inrush currents during start-up of the charge pump circuit.

### Thermal Protection

The SN3226 has a thermal protection circuit that will shut down the chip if the die temperature rises above the thermal limit.

Although the SN3226 is designed for driving white LEDs, the device also can be used to drive most types of LEDs with forward voltage specifications ranging from 2.0V to 4.7V. LED applications may include main and sub-LCD display backlighting, camera photo-flash applications, color (RGB) LEDs, infrared (IR) diodes for remotes, and other loads benefiting from a controlled output current generated from a varying input voltage. Since the D1 to D4 output current sources are matched with negligible voltage dependence, the LED brightness will be matched regardless of the specific LED forward voltage ( $V_F$ ) levels. In some instances (e.g., in high luminous output applications such as photo flash), it may be necessary to drive high- $V_F$  type LEDs. The low dropout current sources in the SN3226 make it capable of driving LEDs with forward voltages as high as 4.7V at full current from an input supply of 2.7V to 5.0V. Outputs can be paralleled to drive high-current LEDs without complication



## Capacitor Selection

Careful selection of the three external capacitors CIN, C1, and COUT is important because they will affect turn-on time, output ripple, and transient performance. Optimum performance will be obtained when low equivalent series resistance (ESR) ceramic capacitors are used. In general, low ESR may be defined as less than 100mΩ. A value of 1μF for all three capacitors is a good starting point when choosing capacitors. If the LED current sources are programmed only for light current levels, then the capacitor size may be decreased.

## Capacitor Characteristics

Ceramic composition capacitors are highly recommended over all other types of capacitors for use with the SN3226. Ceramic capacitors offer many advantages over their tantalum and aluminum electrolytic counterparts. A ceramic capacitor typically has very low ESR, is lowest cost, has a smaller PCB footprint, and is non-polarized. Low ESR ceramic capacitors help to maximize charge pump transient response. Since ceramic capacitors are non-polarized, they are not prone to incorrect connection damage.

## Equivalent Series Resistance

ESR is an important characteristic to consider when selecting a capacitor. ESR is a resistance internal to a capacitor that is caused by the leads, internal connections, size or area, material composition, and ambient temperature. Capacitor ESR is typically measured in milliohms for ceramic capacitors and can range to more than several ohms for tantalum or aluminum electrolytic capacitors.

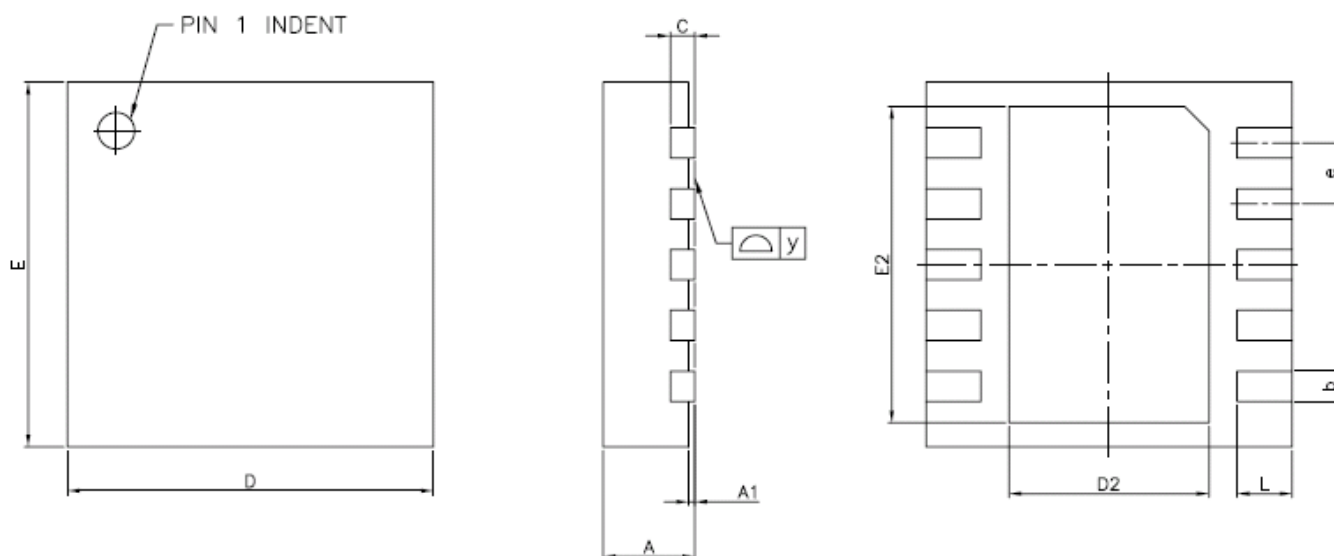
## Ceramic Capacitor Materials

Ceramic capacitors less than 0.1μF are typically made from NPO or C0G materials. NPO and C0G materials generally have tight tolerance and are very stable over temperature. Larger capacitor values are usually composed of X7R, X5R, Z5U, or Y5V dielectric materials. Large ceramic capacitors (i.e., greater than 2.2μF) are often available in low-cost Y5V and Z5U dielectrics, but capacitors greater than 1μF are not typically required for SN3226 applications.

Capacitor area is another contributor to ESR. Capacitors that are physically large will have a lower ESR when compared to an equivalent material smaller capacitor. These larger devices can improve circuit transient response when compared to an equal value capacitor in a smaller package size.

## Package Information

## DFN-10



Symbol	Dimension (mm)		
	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.18	0.25	0.30
c	—	0.20 REF.	—
D	2.90	3.00	3.10
D2	1.59	1.64	1.69
E	2.90	3.00	3.10
E2	2.55	2.60	2.65
e	—	0.50	—
L	0.40	0.45	0.50
y	0.00	—	0.075