

40 WLED Driver with Boost Converter

FEATURES

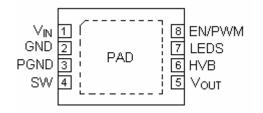
- High efficiency boost converter with the input voltage range from 2.7 to 5.5 V
- No external Schottky Required (Internal synchronous rectifier*)
- 250 mV current sense voltage
- Drives up to 10 LEDs per string or up to 40 LED in 4 strings with 10 LEDs in series at 25 mA
- 0.7 MHz Switching Frequency
- Efficiency greater than 83%
- PWM LED Dimming Control Mode
- Over-voltage, under-voltage, over-current, and over-temperature protection
- Low Shutdown Current (<1 μA)
- Available in 2 x 3 x 0.8 mm 8-pin TDFN package

APPLICATION

- Color Display Backlight
- Portable Navigation and GPS Receivers
- Smart phones
- Digital Photo Frames
- Portable DVD Players
- Multimedia Phones

DESCRIPTION

The LDS8720 is a fixed frequency current mode boost converter with internal synchronous rectifier and cycle-by-cycle switch current limit specifically designed to drive matrix of LEDs in respect with the Table 1. Operation at 0.7 MHz allows use of small value low profile inductor (10 - 33 $\mu H)$ and 1 μF 50 V ceramic capacitor.



The use of integrated synchronous rectifier makes the efficiency dependent on only inductor DC resistance. Under-voltage protection disables the part when $V_{\rm IN}$ voltage reaches 2.0 V

The LDS8720 has thermal shutdown set at 150 $^{\circ}$ C. Above this value, the boost converter stops switching. The part resumes normal operations when temperature drops below 130 $^{\circ}$ C.

The over-current protection provides cycle-by-cycle current limit.

The internal output over-voltage protection prevents damage in the case of a faulty LED disconnect.

The PWM control ensures brightness adjustment with a frequency from 100 Hz up to 30 KHz.

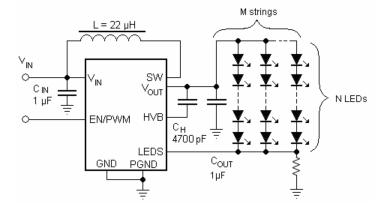
The EN/PWM logic input functions as a chip enable and LED current PWM contol pin.

The device is available in 8-pin TDFN 2 x 3 mm package with a max height of 0.8 mm.

Table 1 Matrix configuration for LDS8720

| Number of strings | Number of LED per string | String Current max, mA, | V _{IN MIN,} V |
|-------------------|-----------------------------|-------------------------------|------------------------|
| 1 - 3 | 10 | 30 | 2.7 |
| 4 | 10 | 25 | 2.7 |
| 5 | 9 | 25 | 2.8 |
| 6 | 8 | 25 | 3.1 |

TYPICAL APPLICATION CIRCUIT



^{*)} Patent pending



ABSOLUTE MAXIMUM RATINGS

| Parameter | Rating | Unit |
|-------------------------------------------------------|-----------------|------|
| V _{IN} voltage | 6 | V |
| V _{OUT} , SW, LEDS, V _{HVB} voltage | 40 | V |
| EN/SET voltage | $V_{IN} + 0.7V$ | V |
| Storage Temperature Range | -65 to +160 | °C |
| Junction Temperature Range | -40 to +125 | °C |
| 8-pin TDFN package Thermal Resistance | 65 | °C/W |
| Soldering Temperature | 300 | °C |

RECOMMENDED OPERATING CONDITIONS

| Parameter | Rating | Unit |
|---------------------------|------------|------|
| V _{IN} | 2.7 to 5.5 | V |
| Ambient Temperature Range | -40 to +85 | °C |

Typical application circuit with external components is shown on page 1.

ELECTRICAL OPERATING CHARACTERISTICS

(Over recommended operating conditions unless specified otherwise) V_{IN} = 3.6V, T_{AMB} = 25°C, C_{IN} = 1 µF, C_{OUT} = 1 µF, L = 22 µH

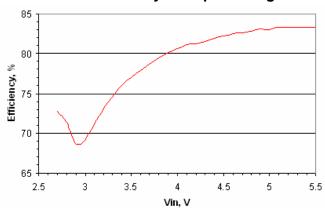
| Name | | • | Conditions | Min | Тур | Max | Units |
|------------------------------|-------------------------------|-----------------------------------------------------------------------------|-----------------------------|-----|-----|-----|-------|
| Quiescent Current | | $V_{IN} = 3.6 \text{ V}, V_{OUT} \text{ open}$ | | 1 | | mA | |
| | | $V_{IN} = 3.6 \text{ V}, I_{LED} = 25 \text{ mA } @ V_{OUT} = 36 \text{ V}$ | | 3 | | | |
| Shutdown | Current | | $V_{IN} = 5.5V$, $EN = 0V$ | | | 1 | μΑ |
| LED Curre | ent Accuracy | | At factory preset value | | ±3 | | % |
| Oscillator | Frequency | | | | 0.7 | | MHz |
| Maximum | Maximum Duty Cycle | | | | 92 | | % |
| NMOSFET Switch On Resistance | | | | 0.3 | | Ω | |
| PMOSFET Switch On Resistance | | | | 1.5 | | Ω | |
| Switch Leakage Current | | | | | 0.1 | μA | |
| Switch Cu | Switch Current Limit | | | | 1.9 | | Α |
| Dropout/C | Dropout/Current sense voltage | | At factory preset value | | 250 | | mV |
| PWM Fred | PWM Frequency | | | 0.1 | | 30 | kHz |
| EN/PWM | Input Resistar | nce (pull down) | | | 250 | | kΩ |
| Pin | Logic Level | High | | 1.4 | | | V |
| | | Low | | | | 0.4 | |
| Thermal S | Thermal Shutdown | | | | 150 | | °C |
| Thermal Hysteresis | | | | 20 | | | |
| Over-Volta | Over-Voltage Protection | | | | 36 | | V |
| Soft Start Time | | | | 1.5 | | ms | |
| Delay Time to Shutdown | | EN = 0 | | 10 | | ms | |

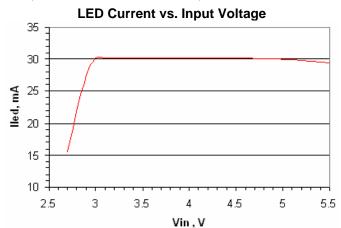


TYPICAL CHARACTERISTICS

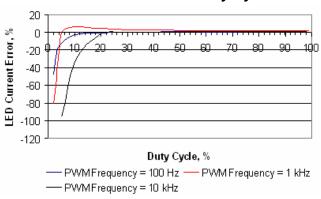
Vin = 3.6V, I_{OUT} = 30mA (1 string with 10 LEDs, C_{IN} = 1 μ F, C_{OUT} = 1 μ F, L = 22 μ H, T_{AMB} = 25°C unless otherwise specified

Power Efficiency vs. Input Voltage

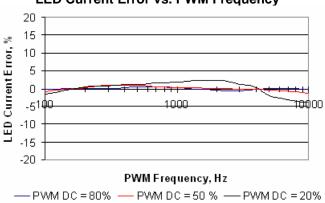




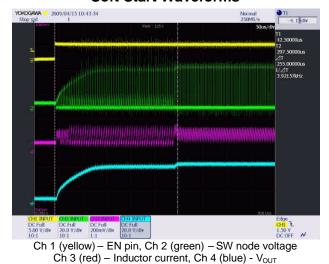
LED Current vs. PWM Duty Cycle



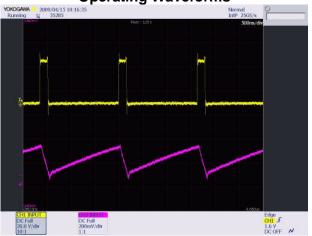
LED Current Error vs. PWM Frequency



Soft Start Waveforms



Operating Waveforms



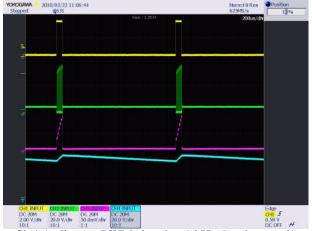
Ch 1 (yellow) - SW node voltage, Ch 3 (red) – Inductor current



TYPICAL CHARACTERISTICS

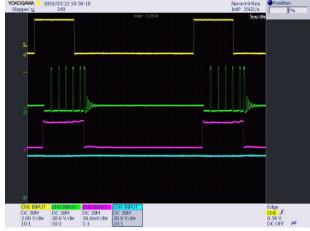
Vin = 3.6V, I_{OUT} = 30mA (10 LEDs per string), C_{IN} = 1 μF, C_{OUT} = 1μF, L = 22 μH, T_{AMB} = 25°C unless otherwise specified

Waveforms at PWM LED Current Regulation



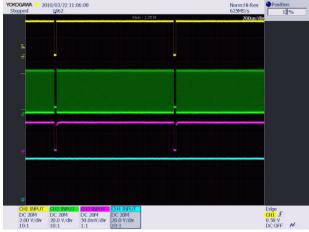
Ch 1 (yellow) – PWM signal at 1 kHz 5% duty cycle C2 (green) – SW node voltage, Ch 3(red) – LED Current. Ch4 (blue) - V_{OUT}

Waveforms at PWM LED Current Regulation



 $\begin{array}{c} \text{Ch 1 (yellow)} - \text{PWM signal at 30 kHz 25\% duty cycle} \\ \text{C2 (green)} - \text{SW node voltage, Ch 3(red)} - \text{LED Current.} \\ \text{Ch4 (blue)} - \text{V}_{\text{OUT}} \end{array}$

Waveforms at PWM LED Current Regulation



 $\begin{array}{c} \text{Ch 1 (yellow)} - \text{PWM signal at 1 kHz 98\% duty cycle} \\ \text{C2 (green)} - \text{SW node voltage, Ch 3(red)} - \text{LED Current.} \\ \text{Ch4 (blue)} - \text{V}_{\text{OUT}} \end{array}$

Waveforms at PWM LED Current Regulation

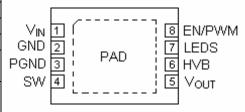


Ch 1 (yellow) – PWM signal at 30 kHz 98% duty cycle C2 (green) – SW node voltage, Ch 3(red) – LED Current. Ch4 (blue) - V_{OUT}



PIN DESCRIPTION

| Pin# | Name | Function |
|--------------------|------------------|-----------------------------------------------------|
| 1 | V_{IN} | Input Voltage, connect to battery or power supply |
| 2 | GND | Analog Ground |
| 3 | PGND | Power Ground |
| 4 | SW | Switch input; Connect inductor terminal to this pin |
| 5 V _{OUT} | V _{OUT} | Output voltage; Connect the LED string anode |
| 5 V OUT | | terminal to this pin. |
| 6 HVB | | High Voltage Bypass; Connect a 470 pF capacitor |
| U | 1100 | between this point and V _{OUT} |
| 7 | LEDS | Current Sense input. Connect LED string cathode |
| | | terminal to this pin |
| 8 | EN/PWM | Device Enable (active high) and Dimming Control |
| PAD | PAD | Connect to GND on the PCB |



Top view: TDFN 8-lead 2 X 3 mm

PIN FUNCTION

 ${
m V_{IN}}$ is the supply pin for the driver. A small 1 $\mu{
m F}$ ceramic bypass capacitor is required between the ${
m V_{IN}}$ pin and ground near the device. The operating input voltage range is from 2.7 V to 5.5 V. If the input supply voltage falls below the under-voltage threshold, switch is disabled, and the device enters shutdown mode.

HVB is the internal high voltage reference point. Connect a 4700 pF capacitor between this point and V_{OUT} .

EN/PWM is the enable and PWM control logic input. Guaranteed levels of logic high and logic low are set at 1.4 V and 0.4 V respectively. When EN/PWM is initially taken high, the device becomes enabled and LED current sets to maximum programmed value.. To place the device into shutdown mode, the EN/PWM pin must be held low for more than 10 ms.

 V_{OUT} is the driver output. Connect it to the LED anode. A ceramic bypass capacitor of 1 μF requires between the V_{OUT} pin and ground near the device.

GND is the ground reference for the analog circuits. The pin must be connected to the ground plane on the PCB. Avoid high currents flowing trough traces connecting this pin with EN/PWM signal source.

PGND is the current return for high current circuits. The pin must be connected to the ground plane on the PCB. Connect GND and PGND as close to the driver as possible.

LEDS is the Current Sense pin that provides internal regulated current sink for LED string. Connect LED string cathode to this pin. This pin enter high-impedance zero current state whenever the device is in shutdown mode.

PAD is the exposed pad underneath the package. For best thermal performance, the pad should be soldered to the PCB and connected to the ground plane



BLOCK DIAGRAM

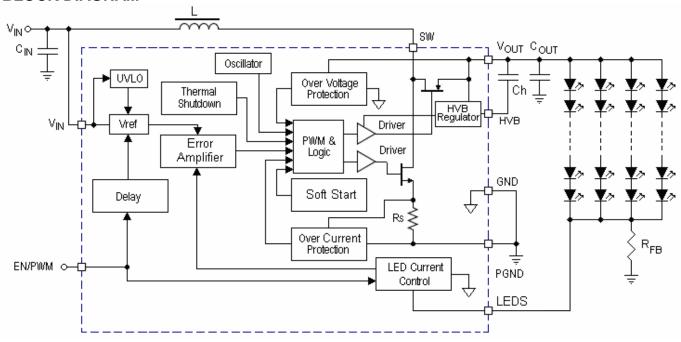


Figure 2. LDS8720 Functional Block Diagram

BASIC OPERATION

At power-up, EN/PWM pin should be logic LOW. The LDS8720 starts operating when EN/PWM pin is asserted logic high. If the input voltage is sufficient to regulate all LED currents, the device remains in operating mode. The low dropout Current regulator performs well at V_{OUT} voltage up to 250 mV above summary LED forward voltage significantly increasing driver's efficiency.

If the input voltage is insufficient or falls to a level where the regulated currents cannot be maintained, the Under-Voltage protection turns device off setting it in shutdown mode.

The LDS8720 has soft start function that prevent high input current spike at device' wake-up.

The EN/PWM pin should be held low for more than 10 ms to completely turn device in low current shutdown mode.

LED Current Setting

The maximum current sink value in the LEDS pin is factory preset at 30 mA. An external resisror R_{FB} should be used to bypass current if more than one string is connected. $R_{FB} = 0.25 \text{ V} / (\text{I x M} - 0.03)$, ohms, where 0.25 V is a feedback voltage, I – is current value per string in ampers, and M is number of strings connected in parallel.

Power dissipated at R_{FB} is equal W = $0.0625/R_{FB}$, watt

In case of three strings with 25 mA current per string R_{FB} = 0.25/(0.025 x 3 - 0.03) = 5.6 Ω , and dissipated power W = 0.0625/5.6 = 0.011 W.

The average LED string current that determines LED brightness may be controlled applying PWM signal to the EN/PWM pin. The maximum PWM frequency is 30 kHz, while frequiencies below 100 Hz are not recommended to avoid visible LED flikering. Duty cycle that determines average LED string current may vary in the range from 5% to 100% at 1 kHz or from 20% to 100% at 30 kHz with high linearity current regulation.

Protection Mode

The output voltage V_{OUT} is limited at about 36 V. This is to prevent the output pin from exceeding its absolute maximum rating if LED string is disconnected or any LED.in string burns out creating open circuitry.

If the die temperature exceeds +150°C, the driver will enter a thermal protection shutdown mode. When the device temperature drops by about 20°C, the device will resume normal operation.



If the input supply voltage falls below the undervoltage threshold, switch is disabled, and the device enters shutdown mode.

LED Selection

The number of the LEDs in string is limited by maximum output voltage that cannot exceed overvoltage protection level. We recommend using not more than 10 LEDs with $V_F \leq 3.6 \text{ V}$ in string if V_{IN} voltage is above 3.0 V and not more that 8 LEDs if V_{IN} may fall up to 2.7 V.

External Components Selection

The LDS8720 requires four external components only. The recommended input capacitor value is between 1.0 and 10uF, while the output capacitor selection is function of desired output ripple, loop stability, and inrush current. We recommend $C_{\text{OUT}} = 1 \, \mu\text{F}$.

The inductor should allow around 20% higher peak current than LDS8720 Switch Current Limit I_{LIM} (see table *Electrical Operating Characteristics* on page 2).

However, the maximum ripple current through inductor I_{R} should not exceed

$$I_{_R} = 2 \!\! \left(I_{_{L\!I\!M}} - \!\! \frac{I_{_{L\!E\!D}} \left(\! NV_{_F} + \! V_{_d} \right)}{V_{_{I\!N}} \eta} \right) \!\! , \, \text{where}$$

V_F - is a LED forward voltage, V N - is number of LEDs per string

Vd - is a current regulator voltage drop = 0.2 V, V_{IN} - is an input voltage, V

We recommend continuous conduction mode for inductor to achieve highest efficiency. That limits I_{R} value as

$$I_{R} < \frac{2I_{LED}\left(NV_{F} + V_{d}\right)}{\eta V_{IV}}$$

Inductor value L is a function of switching frequency, input and output voltage and is determined by following equation:

$$L = \frac{1}{I_R f \bigg(\frac{1}{N V_F + V_d + V_{PM} - V_{IN}} + \frac{1}{V_{IN}} \bigg)} \,, \, \, \text{where} \, \, . \label{eq:lagrangian}$$

 V_{PM} - is a voltage drop across synchronous rectifier (PMOSFET) = 1.5 ohms x $I_{\text{LED}},$ (A),

L - is an inductance, H, and f - is a switching frequency, 700 kHz.

Inductor should have minimum DC resistance to avoid driver's efficiency degradation.

The equation for the output capacitor selection is:

$$C_{\it OUT} = rac{(NV_{\it F} + V_{\it d} - V_{\it IN})I_{\it OUT}}{(NV_{\it F} + V_{\it d})V_{\it R}f}$$
 , where

 V_R – is a ripple voltage at the output.

For example:

If $V_{IN}=2.7$ V, N = 9, $V_F=3.3$ V, Vd = 0.25 V, f = 0.7 MHz, $I_{OUT}=90$ mA, (3 strings in parallel x 30 mA) and ripple voltage $V_R=0.1$ V, $C_{OUT}=0.83$ μF so 1 μF is a good choice.

We recommend $C_{OUT} = 1 \mu F$ to achieve better efficiency and driver's stability.

Recommended Layout

In active mode, the driver switches internally at a high frequency. We recommend minimize trace length to all external capacitors and inductor. The input and output ceramic capacitors (X5R or X7R type) should located as close to the device' pins as possible to prevent from EMI distribution

A ground plane should cover the area under the driver IC as well as the bypass capacitors. Short connection to ground on capacitors C_{IN} and C_{OUT} can be implemented with the use of multiple via. A copper area matching the TDFN exposed pad (PAD) must be connected to the ground plane underneath. The use of multiple via improves the package heat dissipation.

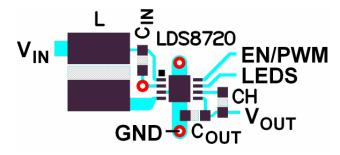
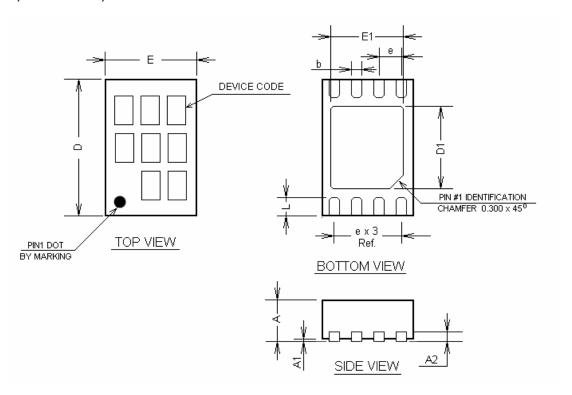


Figure 3. Recommended layout



PACKAGE DRAWING AND DIMENSIONS

8-PIN TDFN, 2mm x 3mm, 0.5mm PITCH



| SYMBOL | MIN | NOM | MAX |
|--------|-------|------------|-------|
| Α | 0.700 | 0.750 | 0.800 |
| A1 | - | 0.000 | 0.050 |
| A2 | | 0.203 Ref. | |
| b | 0.180 | 0.230 | 0.280 |
| D | 2.950 | 3.000 | 3.050 |
| D1 | 1.750 | 1.800 | 1.850 |
| E | 1.950 | 2.000 | 2.050 |
| E1 | 1.550 | 1.600 | 1.650 |
| е | | 0.500 Bsc | |
| L | 0.350 | 0.400 | 0.450 |

Note:

- 1. All dimensions are in millimeters
- 2. Complies with JEDEC Standard MO-220



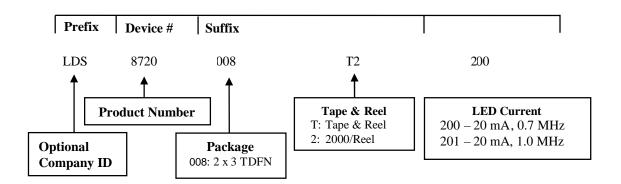
ORDERING INFORMATION

| Part Number | Package | Package Marking |
|------------------------------------|--------------------------------|-----------------|
| LDS8720 008-T2 - 200 ¹⁾ | TDFN - 8 2 x 3mm ²⁾ | 720 |

Notes:

- 1. Maximum LED current is factory preset at 20 mA. Consult factory if other current values are required.
- 2. Matte-Tin Plated Finish (RoHS-compliant)
- 3. Quantity per reel is 2000

EXAMPLE OF ORDERING INFORMATION



Notes:

- 1) All packages are RoHS-compliant (Lead-free, Halogen-free).
- 2) The standard lead finish is Matte-Tin.
- 3) The device used in the above example is a LDS8720 XXX-T2-200 (2x3 TDFN, Tape & Reel, 20 mA LED Current, 0.7 MHz switching frequency).
- 4) For additional package and current options, please contact your nearest IXYS Corp. Sales office.



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