

## Low Noise, Dimmable EL Lamp Driver

### Features

- ▶ Adjustable output regulation for dimming
- ▶ 220V<sub>PP</sub> output voltage for higher brightness
- ▶ Single cell lithium ion compatible
- ▶ 150nA shutdown current
- ▶ Separately adjustable lamp and converter frequencies
- ▶ 3x3mm 12-Lead QFN package
- ▶ Split supply capability

### Applications

- ▶ Mobile cellular phone keypads
- ▶ PDAs
- ▶ Handheld wireless communication products
- ▶ Global Positioning Systems (GPS)

### General Description

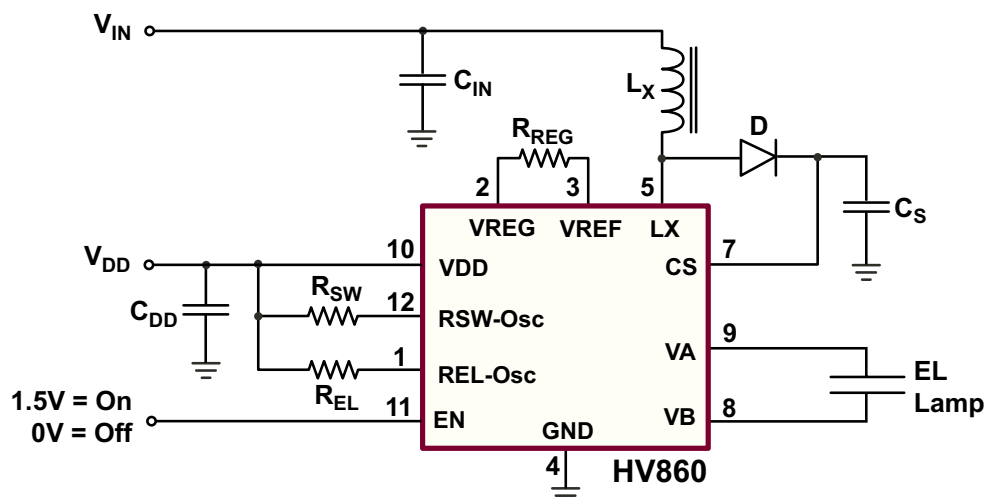
The Supertex HV860 is a high voltage driver designed for driving Electroluminescent, (EL), lamps of up to 5 square inches. The input supply voltage range is from 2.5 to 4.5V. The device uses a single inductor and a minimum number of passive components. Using the internal reference voltage, the regulated output voltage is at a nominal voltage of 110V. The EL lamp will therefore see  $\pm 110V$ . An enable pin, (EN), is available to turn the device on and off via a logic signal.

The HV860 has two internal oscillators, a switching MOSFET, and a high voltage EL lamp driver H-bridge. The frequency for the switching MOSFET is set by an external resistor connected between the RSW-Osc pin and the supply pin VDD. The EL lamp driver frequency is set by an external resistor connected between REL-Osc pin and VDD pin. An external inductor is connected between the LX and VDD pins or VIN for split supply applications. A 3.0nF capacitor is connected between CS and ground. The EL lamp is connected between VA and VB.

The switching MOSFET charges the external inductor and discharges it into the capacitor at CS. The voltage at CS will start to increase. Once the voltage at CS reaches a nominal value of 110V, the switching MOSFET is turned OFF to conserve power. The outputs VA and VB are configured as an H bridge and are switching in opposite states to achieve  $\pm 110V$  across the EL lamp.

EL lamp dimming can be accomplished by changing the input voltage to the VREG pin. The VREG pin allows an external voltage source to control the VCS amplitude. The VCS voltage is approximately 87 times the voltage seen on VREG.

### Typical Application Circuit



## Ordering Information

| Device | 12-Lead QFN<br>3.00x3.00mm body<br>0.80mm height (max)<br>0.50mm pitch |
|--------|------------------------------------------------------------------------|
| HV860  | HV860K7-G                                                              |

-G indicates package is RoHS compliant ("Green")



## Absolute Maximum Ratings

| Parameter                          | Value           |
|------------------------------------|-----------------|
| $V_{DD}$ , Supply voltage          | -0.5V to 6.0V   |
| Operating temperature              | -40°C to +85°C  |
| Storage temperature                | -65°C to +150°C |
| Power dissipation:                 | 1.6W            |
| $V_{CS}$ , Output voltage          | -0.5V to +120V  |
| $V_{REG}$ , External input voltage | 1.33V           |

Absolute Maximum Ratings are those values beyond which damage to the device may occur. Functional operation under these conditions is not implied. Continuous operation of the device at the absolute rating level may affect device reliability. All voltages are referenced to device ground.

## Thermal Resistance

| Package          | $\theta_{ja}$ |
|------------------|---------------|
| 12-Lead QFN (K7) | 60 °C/W       |

## Recommended Operating Conditions

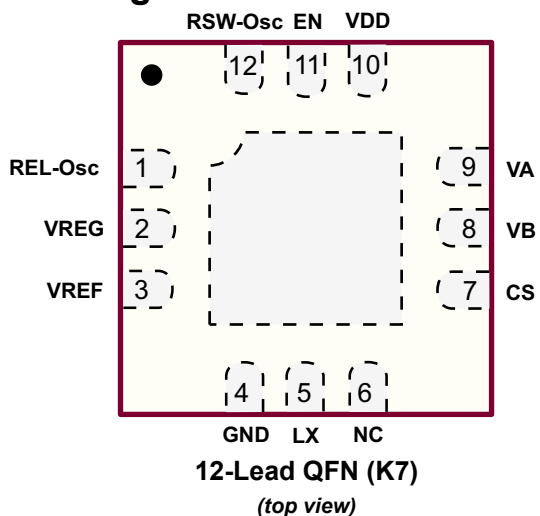
| Sym        | Parameter                | Min | Typ | Max | Units | Conditions |
|------------|--------------------------|-----|-----|-----|-------|------------|
| $V_{DD}$   | Supply voltage           | 2.5 | -   | 4.5 | V     | ---        |
| $f_{SW}$   | Switching frequency      | 40  | -   | 200 | kHz   | ---        |
| $f_{EL}$   | EL output frequency      | 150 | -   | 500 | Hz    | ---        |
| $C_{LOAD}$ | EL lamp capacitance load | 0   | -   | 20  | nF    | ---        |
| $T_A$      | Operating temperature    | -40 | -   | +85 | °C    | ---        |

## Electrical Characteristics

(Over recommended operating conditions unless otherwise specified  $T_A = 25^\circ\text{C}$ )

| Sym          | Parameter                             | Min | Typ | Max | Units    | Conditions                             |
|--------------|---------------------------------------|-----|-----|-----|----------|----------------------------------------|
| $R_{DS(ON)}$ | On-resistance of switching transistor | -   | -   | 6.0 | $\Omega$ | $I = 100\text{mA}$                     |
| $V_{CS}$     | Maximum output regulation voltage     | 90  | -   | 120 | V        | $V_{DD} = 2.5\text{V to } 4.5\text{V}$ |

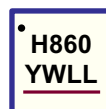
## Pin Configuration



**Note:**

Pads are at the bottom of the package. Center heat slug is at ground potential.

## Product Marking



Y = Last Digit of Year Sealed  
W = Code for Week Sealed  
L = Lot Number  
— = "Green" Packaging

Package may or may not include the following marks: Si or

12-Lead QFN (K7)

## Electrical Characteristics (cont.)

| Sym        | Parameter                                | Min  | Typ  | Max      | Units   | Conditions                                                               |
|------------|------------------------------------------|------|------|----------|---------|--------------------------------------------------------------------------|
| $V_{CS}$   | Output regulation voltage                | -    | 95   | -        | V       | $V_{DD} = 2.5$ to $4.5V$ , $V_{REG} = 1.092V$                            |
|            |                                          | -    | 75   | -        |         | $V_{DD} = 2.5$ to $4.5V$ , $V_{REG} = 0.862V$                            |
|            |                                          | -    | 55   | -        |         | $V_{DD} = 2.5$ to $4.5V$ , $V_{REG} = 0.632V$                            |
| $V_{REG}$  | External input voltage range             | 0    | -    | 1.33     | V       | $V_{DD} = 2.5$ to $4.5V$                                                 |
| $V_{REFH}$ | $V_{REF}$ output high voltage            | 1.18 | 1.26 | 1.33     | V       | $V_{DD} = 2.5$ to $4.5V$                                                 |
| $I_{DDQ}$  | Quiescent $V_{DD}$ supply current        | -    | -    | 150      | nA      | EN = Low                                                                 |
| $I_{DD}$   | Input current going into the VDD pin     | -    | -    | 250      | $\mu A$ | $V_{DD} = 2.5$ to $4.5V$ , $R_{EL} = 2.0M\Omega$ , $R_{SW} = 1.0M\Omega$ |
| $I_{IN}$   | Input current including inductor current | -    | 16   | 30       | mA      | $V_{IN} = 3.0V$ . See Figure 1.                                          |
| $I_{INQ}$  | Quiescent $V_{IN}$ supply current        | -    | -    | 200      | nA      | $V_{IN} = 4.2V$ . EN = Low. See Figure 1.                                |
| $f_{EL}$   | EL lamp frequency                        | 160  | 200  | 240      | Hz      | $R_{EL} = 2.0M\Omega$                                                    |
| $f_{SW}$   | Switching transistor frequency           | 76   | 90   | 104      | kHz     | $R_{SW} = 1.0M\Omega$                                                    |
| D          | Switching transistor duty cycle          | -    | -    | 88       | %       | ---                                                                      |
| $V_{IH}$   | Enable input logic high voltage          | 1.5  | -    | $V_{DD}$ | V       | $V_{DD} = 2.5$ to $4.5V$                                                 |
| $V_{IL}$   | Enable input logic low voltage           | 0    | -    | 0.2      | V       | $V_{DD} = 2.5$ to $4.5V$                                                 |
| $I_{IH}$   | Enable input logic high current          | -    | -    | 100      | $\mu A$ | $V_{IH} = V_{DD} = 2.5$ to $4.5V$                                        |
| $I_{IL}$   | Enable input logic low current           | -    | -    | -1.0     | $\mu A$ | $V_{IL} = 0V$ , $V_{DD} = 2.5$ to $4.5V$                                 |
| $C_{IN}$   | Enable input capacitance                 | -    | -    | 15       | pF      | ---                                                                      |

## Block Diagram

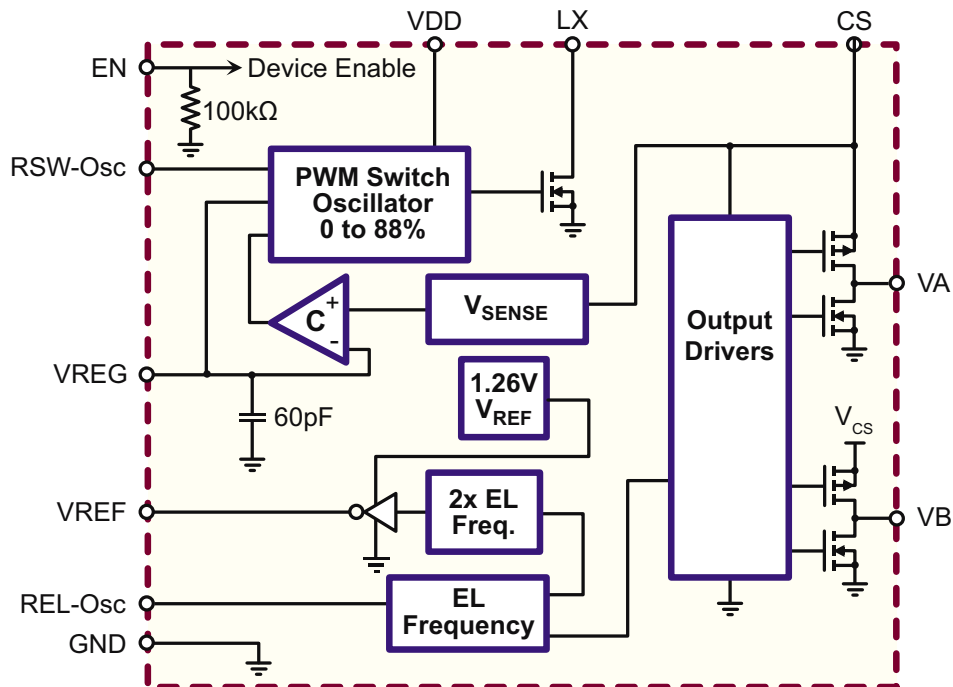
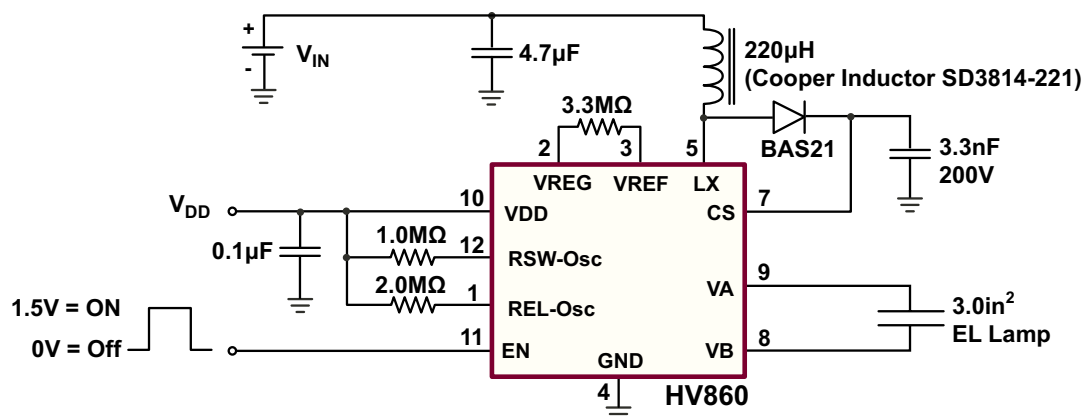
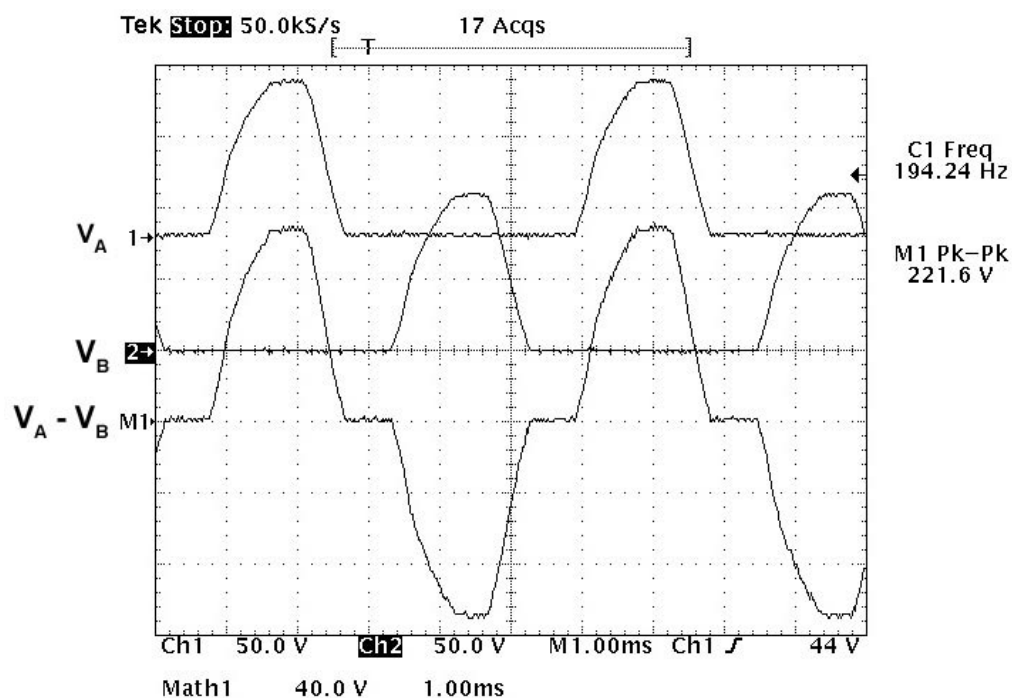


Figure 1: Typical Application / Test Circuit



## Typical Performance

| $V_{DD}$ | Lamp Size          | $V_{IN}$ | $I_{IN}$ | $V_{CS}$ | $f_{EL}$ | Brightness             |
|----------|--------------------|----------|----------|----------|----------|------------------------|
| 3.0V     | 3.0in <sup>2</sup> | 3.3V     | 19.42mA  | 110V     | 194Hz    | 20.32cd/m <sup>2</sup> |
|          |                    | 3.7V     | 17.95mA  |          |          | 21.40cd/m <sup>2</sup> |
|          |                    | 4.2V     | 16.02mA  |          |          | 21.81cd/m <sup>2</sup> |

Typical Waveform on  $V_A$ ,  $V_B$ , and Differential Waveform  $V_A - V_B$ 

## Split Supply Configuration

The HV860 can also be used for handheld devices operating from a battery where a regulated voltage is available. This is shown in Figure 2. The regulated voltage can be used to run the internal logic of the HV860. The amount of current

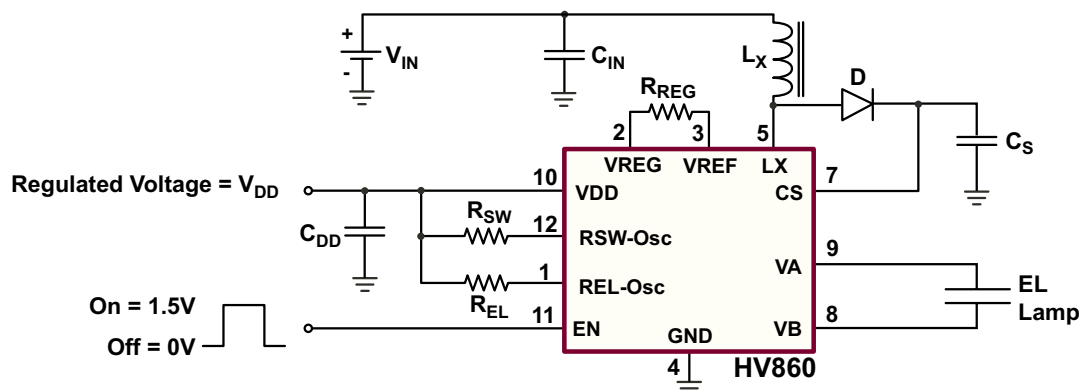
necessary to run the internal logic is 250 $\mu$ A max. Therefore, the regulated voltage could easily provide the current without being loaded down.

## Enable/Disable Configuration

The HV860 can be easily enabled and disabled via a logic control signal on the EN pin as shown in Figure 2. The control signal can be from a microprocessor. When the

microprocessor signal is high the device is enabled, and when the signal is low, it is disabled.

**Figure 2: Split Supply and Enable/Disable Configuration**

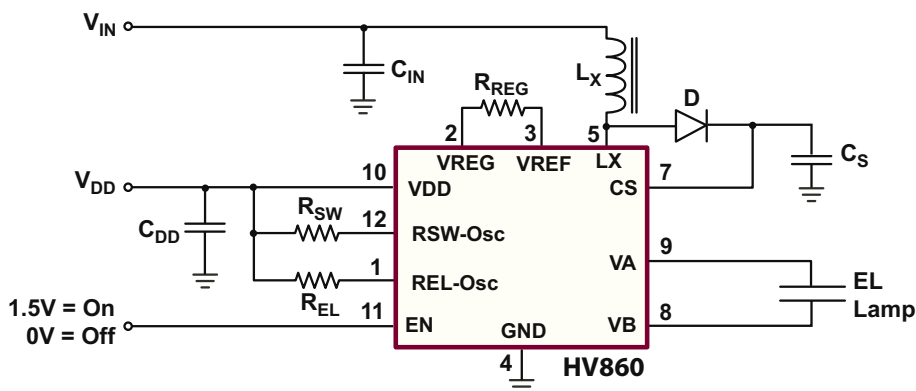


## Audible Noise Reduction

The EL lamp, when lit, emits an audible noise. This is due to EL lamp construction. The audible noise generated by the EL lamp can be a major problem for applications where the EL lamp is held close to the ear, such as cellular phones.

The HV860 employs a proprietary circuit to help minimize the EL lamp's audible noise by using a single resistor,  $R_{REG}$ , as shown in Figure 3.

**Figure 3: Typical Application Circuit for Audible Noise Reduction**



## How to Minimize EL Lamp Audible Noise

The audible noise from the EL lamp can be minimized with the proper selection of  $R_{REG}$ .  $R_{REG}$  is connected between the VREF and VREG pins. VREG has an internal 60pF capacitor

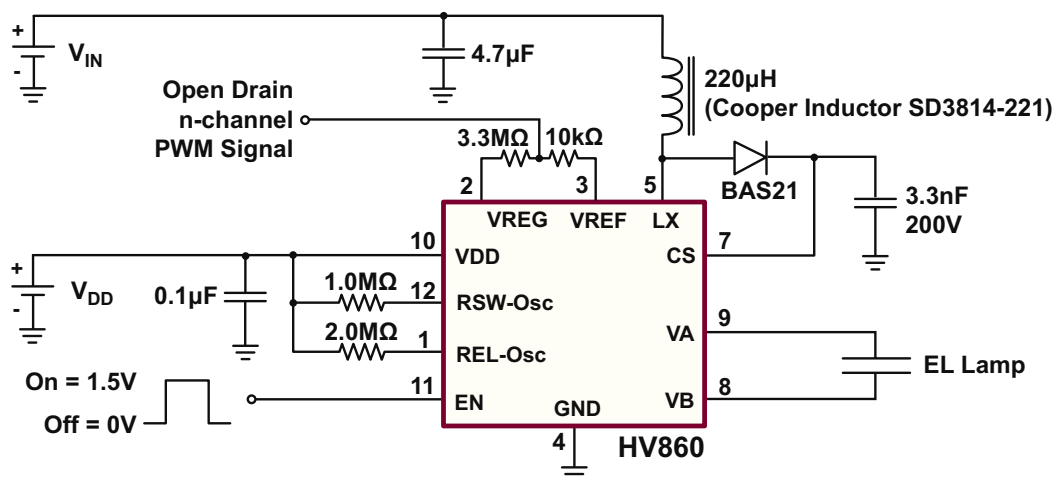
to ground. EL lamp noise can be minimized without much loss in brightness by setting the RC time constant to be approximately 1/12 of the EL frequency's period.

## EL Lamp Dimming using PWM

This section describes the method of dimming the EL lamp. Reducing the voltage amplitude at the VREG pin will reduce the voltage on the CS pin, which will effectively reduce the peak to peak voltage the EL lamp sees. Figure 4 shows a circuit to dim the lamp by changing the duty cycle of a PWM signal. A 10k $\Omega$  resistor is connected in series with a 3.3M $\Omega$

resistor. An N-channel open drain PWM signal is used to pull the 10k $\Omega$  resistor to ground. The effective voltage on the VREG pin will be proportional to the duty cycle of the PWM signal. The PWM operating frequency can be anywhere between 20kHz to 100kHz.

**Figure 4: PWM Dimming Circuit**

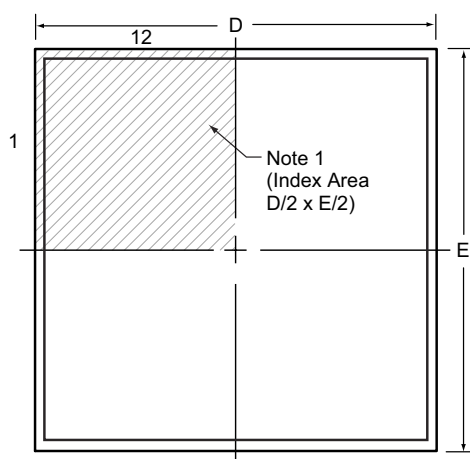


## Pin Configuration and External Component Description

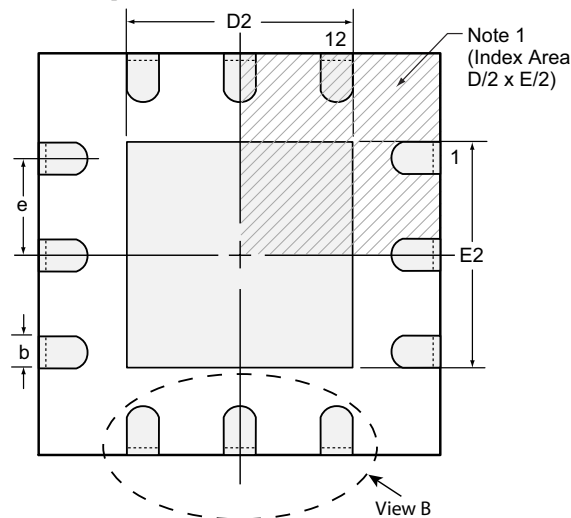
| Pin # | Name    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | REL-Osc | External resistor from REL-Osc to VDD sets the EL frequency. The EL frequency is inversely proportional to the external $R_{EL}$ resistor value. Reducing the resistor value by a factor of two will result in increasing the EL frequency by two.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 2     | VREG    | <p>Input voltage to set <math>V_{CS}</math> regulation voltage. This pin allows an external voltage source to control the <math>V_{CS}</math> amplitude. EL lamp dimming can be accomplished by varying the input voltage at VREG. The <math>V_{CS}</math> voltage is approximately 87 times the voltage seen on VREG.</p> <p>External resistor <math>R_{REG}</math>, connected between VREG and VREF pins controls the <math>V_{CS}</math> charging rate. The charging rate is inversely proportional to the <math>R_{REG}</math> resistor value.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 3     | VREF    | Switched internal reference voltage.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 4     | GND     | Device ground.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| 5     | LX      | <p>Drain of internal switching MOSFET. Connection for an external inductor.</p> <p>The inductor <math>L_x</math> is used to boost the low input voltage by inductive flyback. When the internal switch is on, the inductor is being charged. When the internal switch is off, the charge stored in the inductor will be transferred to the high voltage capacitor <math>C_s</math>. The energy stored in the capacitor is transferred to the internal H-bridge, and therefore to the EL lamp. In general, smaller value inductors, which can handle more current, are more suitable to drive larger size lamps. As the inductor value decreases, the switching frequency of the inductor (controlled by <math>R_{SW}</math>) should be increased to avoid saturation.</p> <p>A 220<math>\mu</math>H Cooper (SD3814-221) inductor with 5.5<math>\Omega</math> series DC resistance is typically recommended. For inductors with the same inductance value, but with lower series DC resistance, lower <math>R_{SW}</math> resistor value is needed to prevent high current draw and inductor saturation.</p> |
| 6     | NC      | No internal connections to the device.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| 7     | CS      | High voltage regulated output. Connection for an external high voltage capacitor to ground                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 8     | VB      | $V_B$ side of the EL lamp driver H-bridge. Connection for one of the EL lamp terminals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 9     | VA      | $V_A$ side of the EL lamp driver H-bridge. Connection for one of the EL lamp terminals.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| 10    | VDD     | Low voltage input supply pin.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| 11    | EN      | Logic input pin. Logic high will enable the device. This pin has an 100k $\Omega$ internal pull-down resistor connected to GND.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 12    | RSW-Osc | External resistor from RSW-Osc to VDD sets the switch converter frequency. The switch converter frequency is inversely proportional to the external $R_{SW}$ resistor value. Reducing the resistor value by a factor of two will result in increasing the switch converter frequency by two.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

# 12-Lead QFN Package Outline (K7)

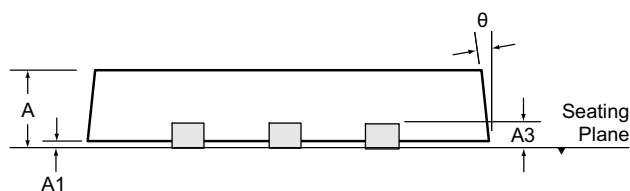
3.00x3.00mm body, 0.80mm height (max), 0.50mm pitch



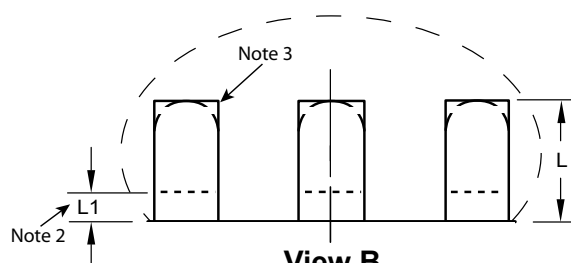
**Top View**



**Bottom View**



**Side View**



**View B**

## Notes:

1. A Pin 1 identifier must be located in the index area indicated. The Pin 1 identifier can be: a molded mark/identifier; an embedded metal marker; or a printed indicator.
2. Depending on the method of manufacturing, a maximum of 0.15mm pullback (L1) may be present.
3. The inner tip of the lead may be either rounded or square.

| Symbol            |     | A    | A1   | A3          | b    | D     | D2   | E     | E2   | e           | L    | L1   | θ   |
|-------------------|-----|------|------|-------------|------|-------|------|-------|------|-------------|------|------|-----|
| Dimension<br>(mm) | MIN | 0.70 | 0.00 | 0.20<br>REF | 0.18 | 2.85* | 1.25 | 2.85* | 1.25 | 0.50<br>BSC | 0.30 | 0.00 | 0°  |
|                   | NOM | 0.75 | 0.02 |             | 0.25 | 3.00  | -    | 3.00  | -    |             | 0.40 | -    | -   |
|                   | MAX | 0.80 | 0.05 |             | 0.30 | 3.15* | 1.65 | 3.15* | 1.65 |             | 0.50 | 0.15 | 14° |

JEDEC Registration MO-220, Variation WEED-5, Issue K, June 2006.

\* This dimension is not specified in the JEDEC drawing.

Drawings not to scale.

Supertex Doc. #: DSPD-12QFNK73X3P050, Version B041309.

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to <http://www.supertex.com/packaging.html>.)

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