

**Patent Pending**

**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
- ▶ 3x3 QFN-12 package
- ▶ Split supply capability

**Applications**

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

**General Description**

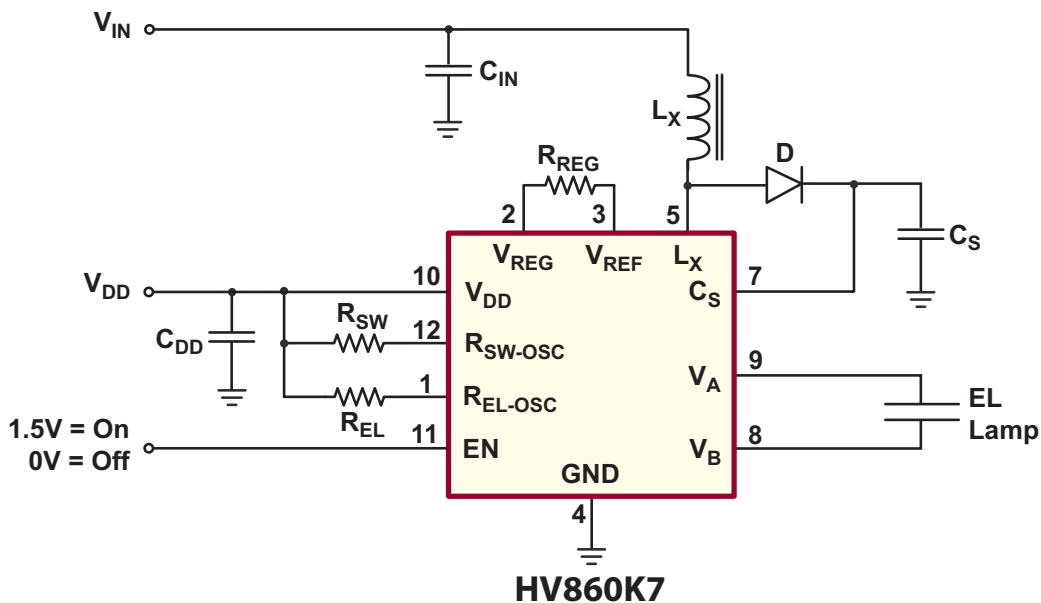
The Supertex HV860 is a high voltage driver designed for driving Electroluminescent, (EL), lamps of up to 5 square inches. The input supply voltage range is from 2.5V to 4.5V. The device uses a single inductor and a minimum number of passive components. Using the internal reference voltage, the regulated output voltage is at a nominal voltage of 110V. The EL lamp will therefore see ±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 R<sub>SW-OSC</sub> pin and the supply pin V<sub>DD</sub>. The EL lamp driver frequency is set by an external resistor connected between R<sub>EL-OSC</sub> pin and V<sub>DD</sub> pin. An external inductor is connected between the L<sub>X</sub> and V<sub>DD</sub> pins or V<sub>IN</sub> for split supply applications. A 3.0nF capacitor is connected between C<sub>S</sub> and ground. The EL lamp is connected between V<sub>A</sub> and V<sub>B</sub>.

The switching MOSFET charges the external inductor and discharges it into the capacitor at C<sub>S</sub>. The voltage at C<sub>S</sub> will start to increase. Once the voltage at C<sub>S</sub> reaches a nominal value of 110V, the switching MOSFET is turned OFF to conserve power. The outputs V<sub>A</sub> and V<sub>B</sub> are configured as an H bridge and are switching in opposite states to achieve ±110V across the EL lamp.

EL lamp dimming can be accomplished by changing the input voltage to the V<sub>REG</sub> pin. The V<sub>REG</sub> pin allows an external voltage source to control the V<sub>CS</sub> amplitude. The V<sub>CS</sub> voltage is approximately 87 times the voltage seen on V<sub>REG</sub>.

**Typical Application Circuit**



## Ordering Information

Device	Package Option
	QFN-12
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 QFN-12	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.

## Electrical Characteristics

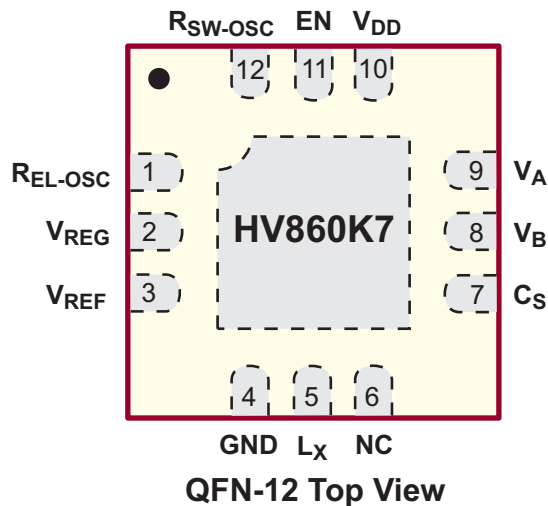
DC Characteristics (Over recommended operating conditions unless otherwise specified  $T_A=25^\circ\text{C}$ )

Symbol	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	-	-	120	V	$V_{DD} = 2.5\text{V to } 4.5\text{V}$
$V_{CS}$	Output regulation voltage	-	95	-	V	$V_{DD} = 2.5\text{V to } 4.5\text{V}, V_{REG} = 1.092\text{V}$
		-	75	-		$V_{DD} = 2.5\text{V to } 4.5\text{V}, V_{REG} = 0.862\text{V}$
		-	55	-		$V_{DD} = 2.5\text{V to } 4.5\text{V}, V_{REG} = 0.632\text{V}$
$V_{REG}$	External input voltage range	0	-	1.26	V	$V_{DD} = 2.5\text{V to } 4.5\text{V}$
$V_{REFH}$	$V_{REF}$ output high voltage	1.18	1.26	1.33	V	$V_{DD} = 2.5\text{V to } 4.5\text{V}$
$I_{DDQ}$	Quiescent $V_{DD}$ supply current	-	-	150	nA	EN = low
$I_{DD}$	Input current going into the $V_{DD}$ pin	-	-	200	$\mu\text{A}$	$V_{DD} = 2.5\text{V to } 4.5\text{V}, R_{EL} = 2.0\text{M}\Omega, R_{SW} = 1.0\text{M}\Omega$
$I_{IN}$	Input current including inductor current	-	-	16	mA	see Figure 2
$f_{EL}$	EL lamp frequency	160	200	240	Hz	$R_{EL} = 2.0\text{M}\Omega$
$f_{SW}$	Switching transistor frequency	76	90	104	kHz	$R_{SW} = 1.0\text{M}\Omega$
D	Switching transistor duty cycle	-	-	88	%	---
$V_{IH}$	Enable input logic high voltage	1.5	-	$V_{DD}$	V	$V_{DD} = 2.5\text{V to } 4.5\text{V}$
$V_{IL}$	Enable input logic low voltage	0	-	0.2	V	$V_{DD} = 2.5\text{V to } 4.5\text{V}$
$I_{IH}$	Enable input logic high current	-	-	1.0	$\mu\text{A}$	$V_{IH} = V_{DD} = 2.5\text{V to } 4.5\text{V}$

## Thermal Resistance

Package	$\theta_{ja}$
QFN-12	60 °C/W

## Pin Configuration



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

## Electrical Characteristics (cont.)

Symbol	Parameter	Min	Typ	Max	Units	Conditions
$I_{IL}$	Enable input logic low current	-	-	-1.0	$\mu\text{A}$	$V_{IL} = 0\text{V}$ , $V_{DD} = 2.5\text{V}$ to $4.5\text{V}$
$C_{IN}$	Enable input capacitance	-	-	15	pF	---

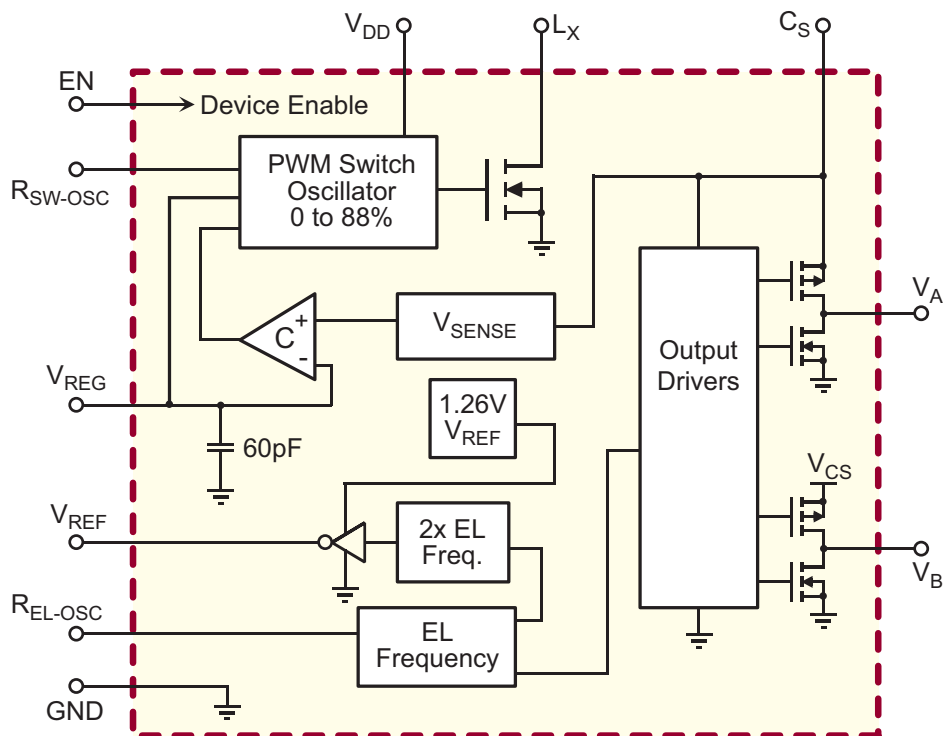
## Recommended Operating Conditions

Symbol	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	200	-	500	Hz	---
$C_{LOAD}$	EL lamp capacitance load	0	-	20	nF	---
$T_A$	Operating Temperature	-40	-	+85	$^{\circ}\text{C}$	---

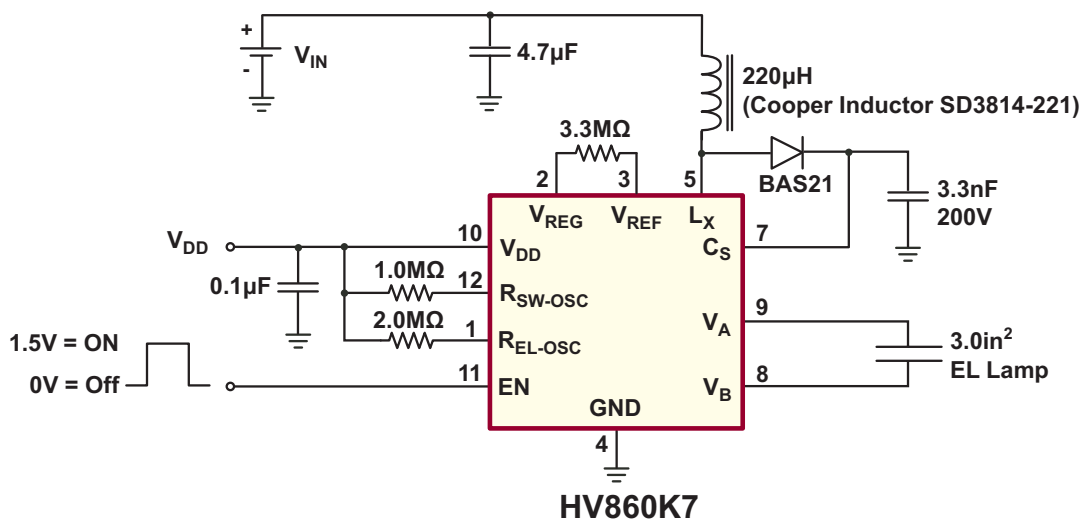
## Pin Configuration and External Component Description

Pin #	Name	Description
1	$R_{EL-OSC}$	External resistor from $R_{EL-OSC}$ to $V_{DD}$ 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	$V_{REG}$	Input voltage to set $V_{CS}$ regulation voltage. This pin allows an external voltage source to control the $V_{CS}$ amplitude. EL lamp dimming can be accomplished by varying the input voltage to $V_{REG}$ . The $V_{CS}$ voltage is approximately 87 times the voltage seen on $V_{REG}$ . External resistor $R_{REG}$ , connected between $V_{REG}$ and $V_{REF}$ pins controls the $V_{CS}$ charging rate. The charging rate is inversely proportional to the $R_{REG}$ resistor value.
3	$V_{REF}$	Switched internal reference voltage.
4	GND	Device ground.
5	$L_X$	Drain of internal switching MOSFET. Connection for an external inductor. The inductor $L_X$ 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 $C_S$ . The energy stored in the capacitor is connected 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 $R_{SW}$ ) should be increased to avoid saturation. A 220 $\mu\text{H}$ Cooper (SD3814-221) inductor with 5.5 $\Omega$ series DC resistance is typically recommended. For inductors with the same inductance value, but with lower series DC resistance, lower $R_{SW}$ resistor value is needed to prevent high current draw and inductor saturation.
6	NC	No internal connections to the device.
7	$C_S$	High voltage regulated output. Connection for an external high voltage capacitor to ground
8	$V_B$	$V_B$ side of the EL lamp driver H-bridge. Connection for one of the EL lamp terminals.
9	$V_A$	$V_A$ side of the EL lamp driver H-bridge. Connection for one of the EL lamp terminals.
10	$V_{DD}$	Low voltage input supply pin.
11	EN	Logic input pin. Logic high will enable the device.
12	$R_{SW-OSC}$	External resistor from $R_{SW-OSC}$ to $V_{DD}$ 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.

## Figure 1: Block Diagram



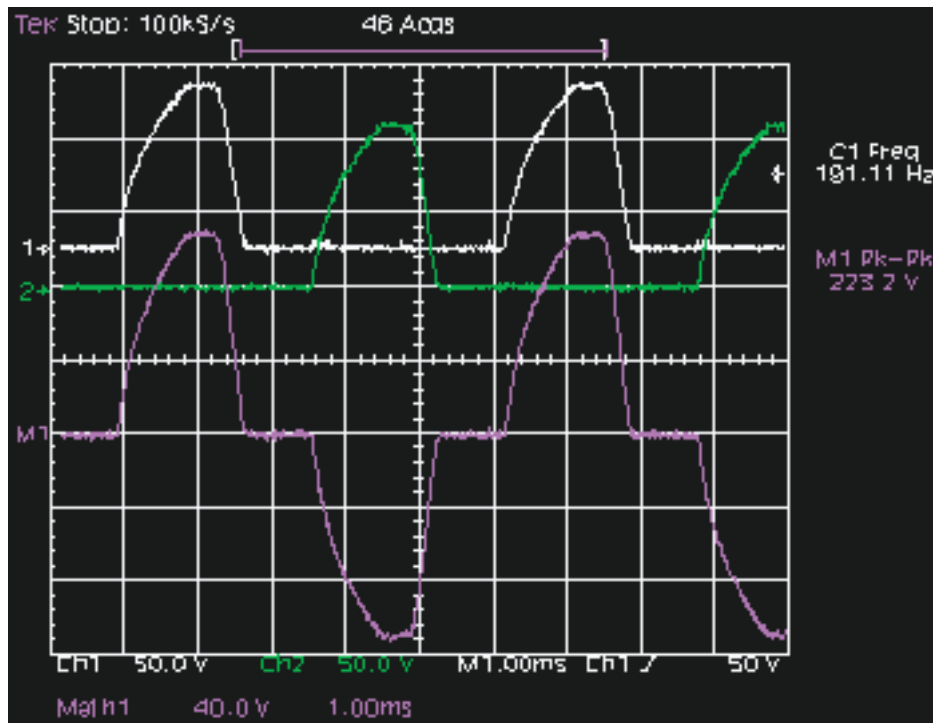
## Figure 2: Typical Application / Test Circuit



## Typical Performance

$V_{DD}$	Lamp Size	$V_{IN}$	$I_{IN}$	$V_{CS}$	$f_{EL}$	Brightness
3.0V	3.0in <sup>2</sup>	3.0V	16.17mA	100V (peak)	196Hz	18.2cd/m <sup>2</sup>
		3.5V	14.18mA			19.3cd/m <sup>2</sup>
		4.2V	12.13mA			19.9cd/m <sup>2</sup>

Figure 3: 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 the Figure 4. The regulated voltage can be used to run the internal logic of the HV860. The amount of current

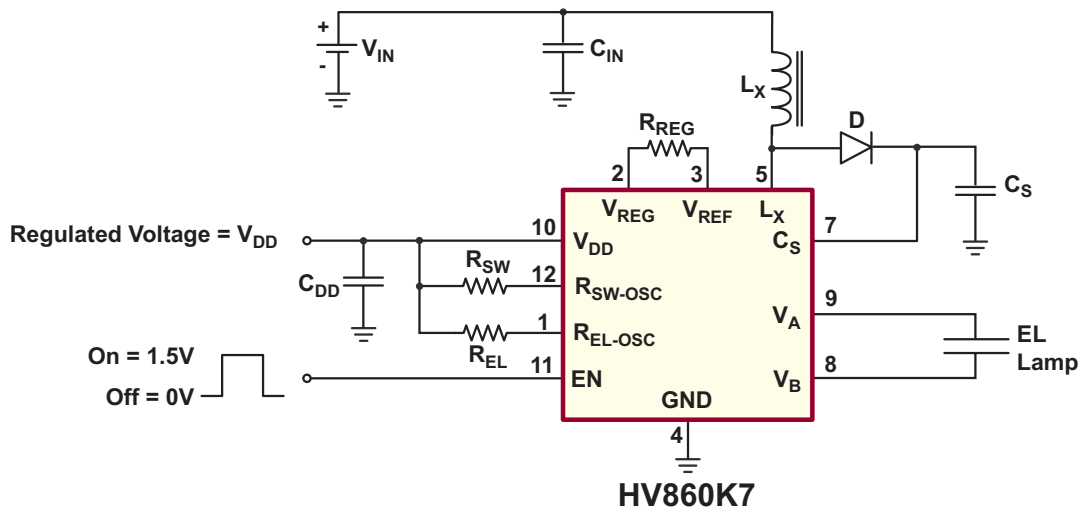
necessary to run the internal logic is 200 $\mu$ A max. Therefore, the regulated voltage could easily provide the current without being loaded down.

### Enable/Disable Configuration

The HV860 can be easily enabled and disabled via a logic control signal on the EN pin as shown in the Figure 4. 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 4: Split Supply and Enable/Disable Configuration

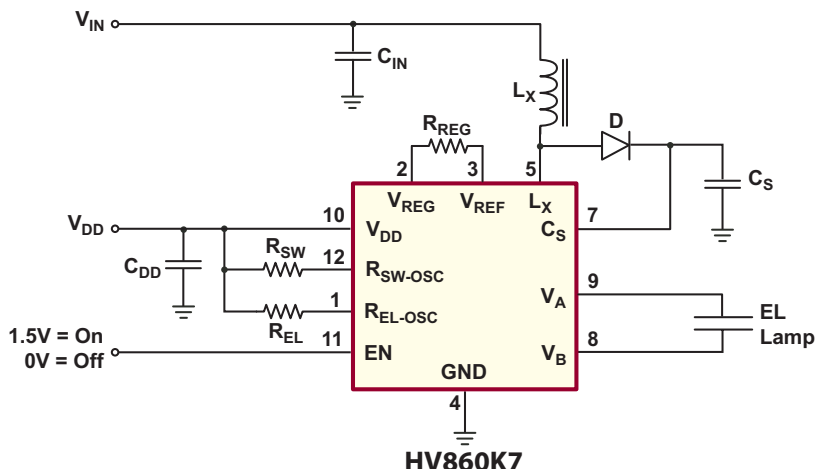


## Audible Noise Reduction

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 5.

**Figure 5: 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  $V_{REF}$  and  $V_{REG}$  pins.  $V_{REG}$  has an internal 60pF capacitor

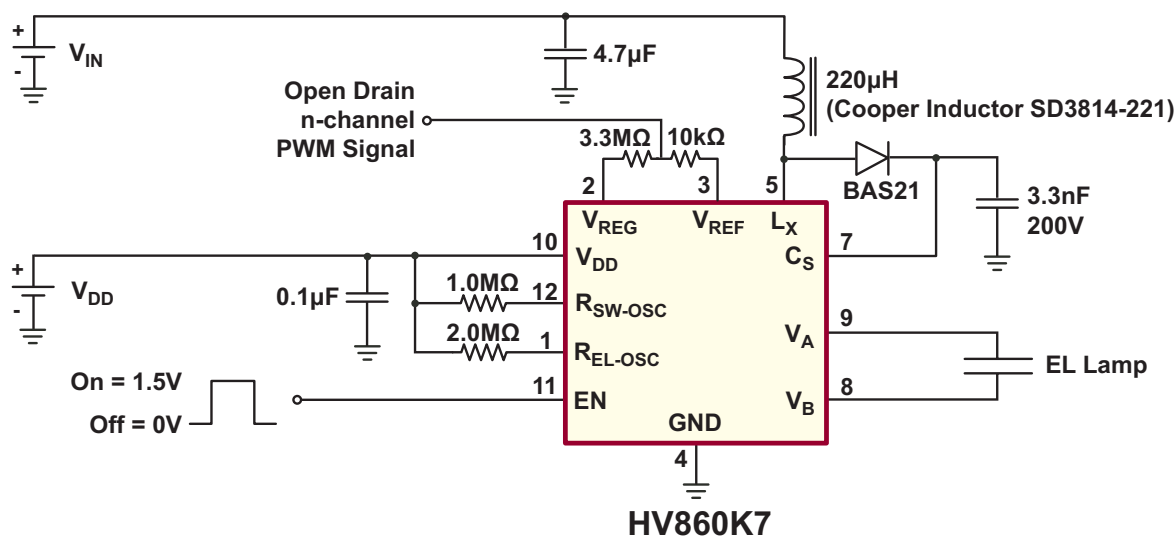
to ground. EL lamp noise can be minimized without much loss in brightness by setting the RC time constant to be approximately 1/12<sup>TH</sup> of the EL frequency's period.

## EL Lamp Dimming using PWM

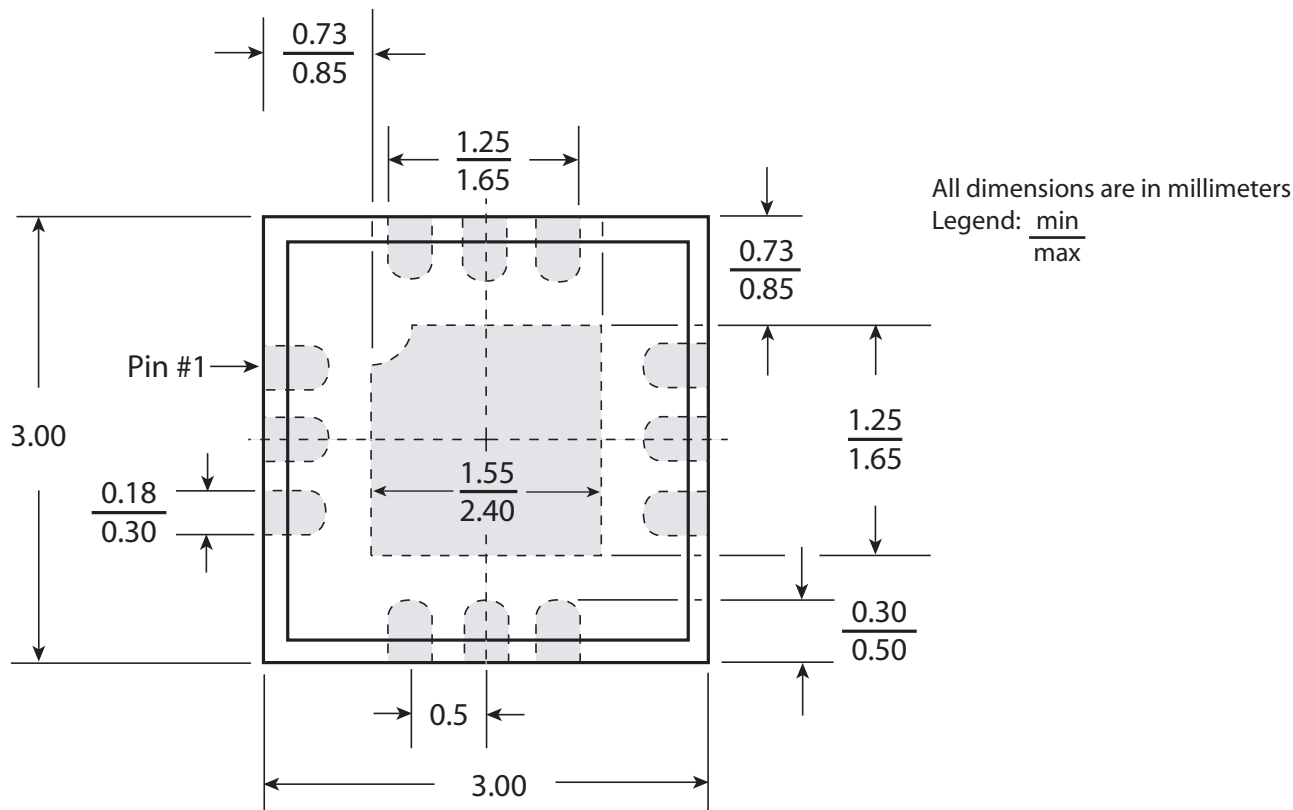
This section describes the method of dimming the EL lamp. Reducing the voltage amplitude at the  $V_{REG}$  pin will reduce the voltage on the  $V_{CS}$  pin, which will effectively reduce the peak the peak voltage the EL lamp sees. Figure 6 shows a circuit to dim the lamp by changing the duty cycle of a PWM signal. A 10kΩ resistor is connected in series with a 3.3MΩ

resistor. An n-channel open drain PWM signal is used to pull the 10kΩ resistor to ground. The effective voltage on the  $V_{REG}$  pin will be proportional to the duty cycle of the PWM signal. The PWM operating frequency can be anywhere between 20kHz to 100kHz.

**Figure 6: PWM Dimming Circuit**



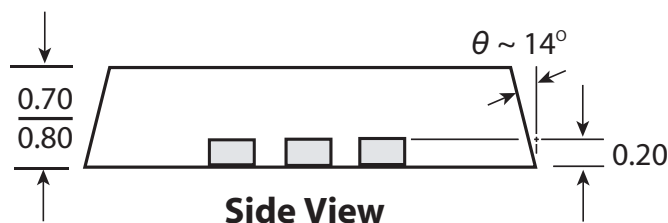
12-Lead QFN Package Outline (K7)



All dimensions are in millimeters

Legend:  $\frac{\text{min}}{\text{max}}$

Top View



Side View

(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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