HV860

Low-Noise Dimmable EL Lamp Driver

Features

- Adjustable Output Regulation for Dimming
- 220 V_{PP} Output Voltage for Higher Brightness
- Single-cell Lithium Ion-compatible
- 150 nA Shutdown Current
- Separately Adjustable Lamp and Converter Frequencies
- Split Supply Capability

Applications

- Mobile Cellular Phone Keypads
- Personal Digital Assistant (PDA)
- Handheld Wireless Communication Products
- Global Positioning Systems (GPS)

General Description

The HV860 is a high-voltage driver designed for driving Electroluminescent (EL) lamps of up to 5 in^2. 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. By using an internal voltage reference, 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 on and turn off the device via a logic signal.

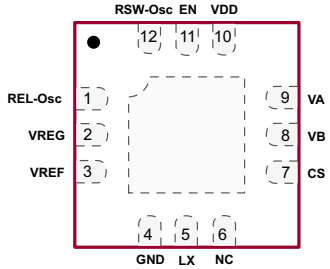
The HV860 has two internal oscillators, a switching MOSFET, and a high-voltage EL lamp driver H-bridge. The frequency for the switching MOSFET is set by an external resistor connected between the RSW-Osc pin and the supply pin, VDD. The EL lamp driver frequency is set by an external resistor connected between REL-Osc pin and VDD pin. An external inductor is connected between the L_X and VDD pins or VIN for split supply applications. A 3 nF capacitor is connected between C_S 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 C_S. The voltage at C_S will start to increase. Once the voltage at C_S 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 ±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 V_{CS} amplitude. The V_{CS} voltage is approximately 87 times the voltage seen on V_{REG}.

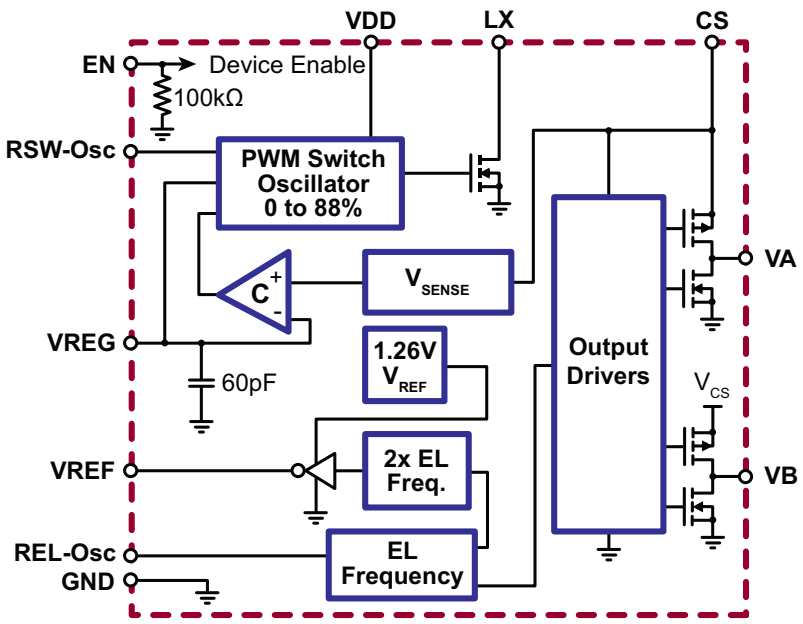
Package Type

12-lead WQFN
(Top view)

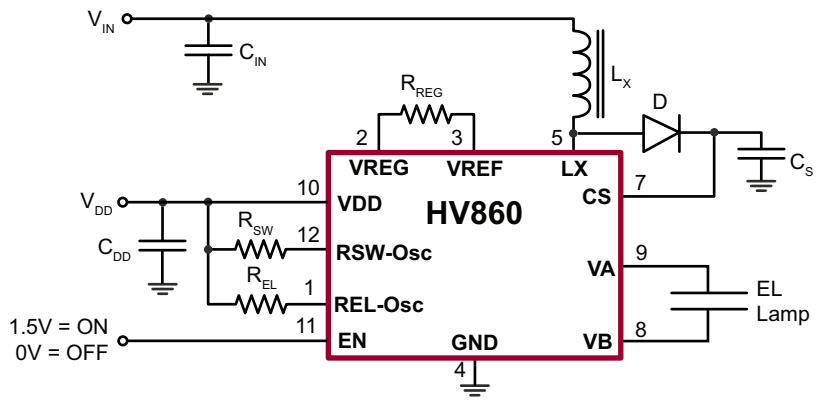


See Table 2-1 for pin information.

Functional Block Diagram



Typical Application Circuit



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings(†)

Supply Voltage, V_{DD} ..... –0.5V to 6V
Operating Ambient Temperature Range, T_A ..... –40°C to +85°C
Storage Temperature Range, T_S ..... –65°C to +150°C
Output Voltage, V_{CS} .....–0.5V to +120V
External Input Voltage, V_{REG} 1.33V
Power Dissipation:
12-lead WQFN (3 X 3) 1.6W

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only, and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Input Voltage	V_{DD}	2.5	—	4.5	V	
Switching Frequency	f_{SW}	40	—	200	KHz	
EL Lamp Frequency	f_{EL}	150	—	500	Hz	
EL Lamp Capacitance Load	C_{LOAD}	0	—	20	nF	
Operating Ambient Temperature Range	T_A	–40	—	+85	°C	

ELECTRICAL CHARACTERISTICS

Electrical Specifications: T_A = 25°C unless otherwise specified.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
On-resistance of Switching Transistor	$R_{DS(ON)}$	—	—	6	Ω	I = 100 mA
Maximum Output Regulation Voltage	V_{CS}	90	—	120	V	V_{DD} = 2.5V to 4.5V
Output Regulation Voltage	V_{CS}	—	95	—	V	V_{DD} = 2.5V to 4.5V, V_{REG} = 1.092V
		—	75	—		V_{DD} = 2.5V to 4.5V, V_{REG} = 0.862V
		—	55	—		V_{DD} = 2.5V to 4.5V, V_{REG} = 0.632V
External Input Voltage Range	V_{REG}	0	—	1.33	V	V_{DD} = 2.5V to 4.5V
V_{REF} Output High Voltage	V_{REFH}	1.18	1.26	1.33	V	V_{DD} = 2.5V to 4.5V
Quiescent V_{DD} Supply Current	I_{DDQ}	—	—	150	nA	EN = Low
Input Current going into the V_{DD} Pin	I_{DD}	—	—	250	µA	V_{DD} = 2.5V to 4.5V, R_{EL} = 2 MΩ, R_{SW} = 1 MΩ
Input Current including Inductor Current	I_{IN}	—	16	30	mA	V_{IN} = 3V See Figure 3-1.
Quiescent V_{IN} Supply Current	I_{INQ}	—	—	200	nA	V_{IN} = 4.2V, EN = Low See Figure 3-1.
EL Lamp Frequency	f_{EL}	160	200	240	Hz	R_{EL} = 2 MΩ
Switching Transistor Frequency	f_{SW}	76	90	104	kHz	R_{SW} = 1 MΩ
Switching Transistor Duty Cycle	D	—	—	88	%	
LOGIC INPUTS						
Enable Input Logic High Voltage	V_{IH}	1.5	—	V_{DD}	V	V_{DD} = 2.5V to 4.5V

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Specifications: T_A = 25°C unless otherwise specified.

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Enable Input Logic Low Voltage	V_{IL}	0	—	0.2	V	V_{DD} = 2.5V to 4.5V
Enable Input Logic High Current	I_{IH}	—	—	100	µA	V_{IH} = V_{DD} = 2.5V to 4.5V
Enable Input Logic Low Current	I_{IL}	—	—	–1	µA	V_{IL} = 0V, V_{DD} = 2.5V to 4.5V
Enable Input Capacitance	C_{IN}	—	—	15	pF	

TEMPERATURE SPECIFICATIONS

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
TEMPERATURE RANGE						
Operating Ambient Temperature Range	T_A	–40	—	+85	°C	
Storage Temperature Range	T_S	–65	—	+150	°C	
PACKAGE THERMAL RESISTANCE						
12-lead WQFN	θ_{JA}	—	40	—	°C/W	

2.0 PIN DESCRIPTION

The details on the pins of HV860 are listed in Table 2-1.
Refer to **Package Type** for the location of pins.

TABLE 2-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1	REL-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 determines an increase in the EL frequency by two.
2	VREG	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 at V_{REG}. The V_{CS} voltage is approximately 87 times the voltage seen on V_{REG}. The 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	VREF	Switched internal reference voltage
4	GND	Device ground
5	LX	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 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 R_{SW}) should be increased to avoid saturation. A 220 µH inductor with 5.5Ω 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	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 100 kΩ internal pull-down resistor to GND.
12	RSW-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.

3.0 APPLICATION INFORMATION

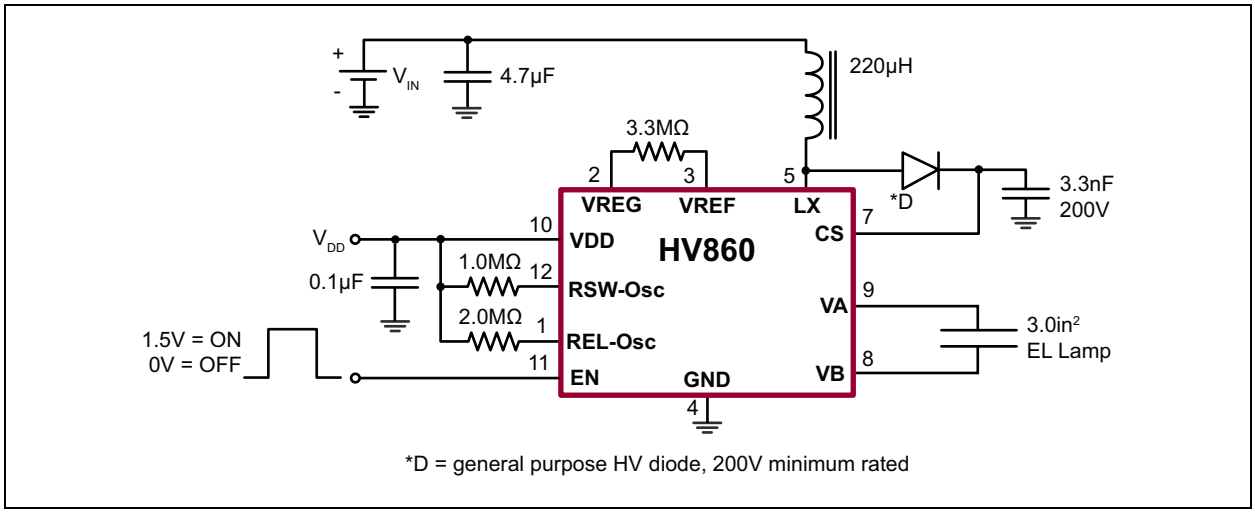


FIGURE 3-1: *Typical Application Circuit/Test Circuit.*

TABLE 3-1: TYPICAL PERFORMANCE

V_{DD} (V)	Lamp Size (in^2)	V_{IN} (V)	I_{IN} (mA)	V_{CS} (V)	f_{EL} (Hz)	Brightness (cd/m^2)
3	3	3.3	19.42	110	194	20.32
		3.7	17.95			21.4
		4.2	16.02			21.81

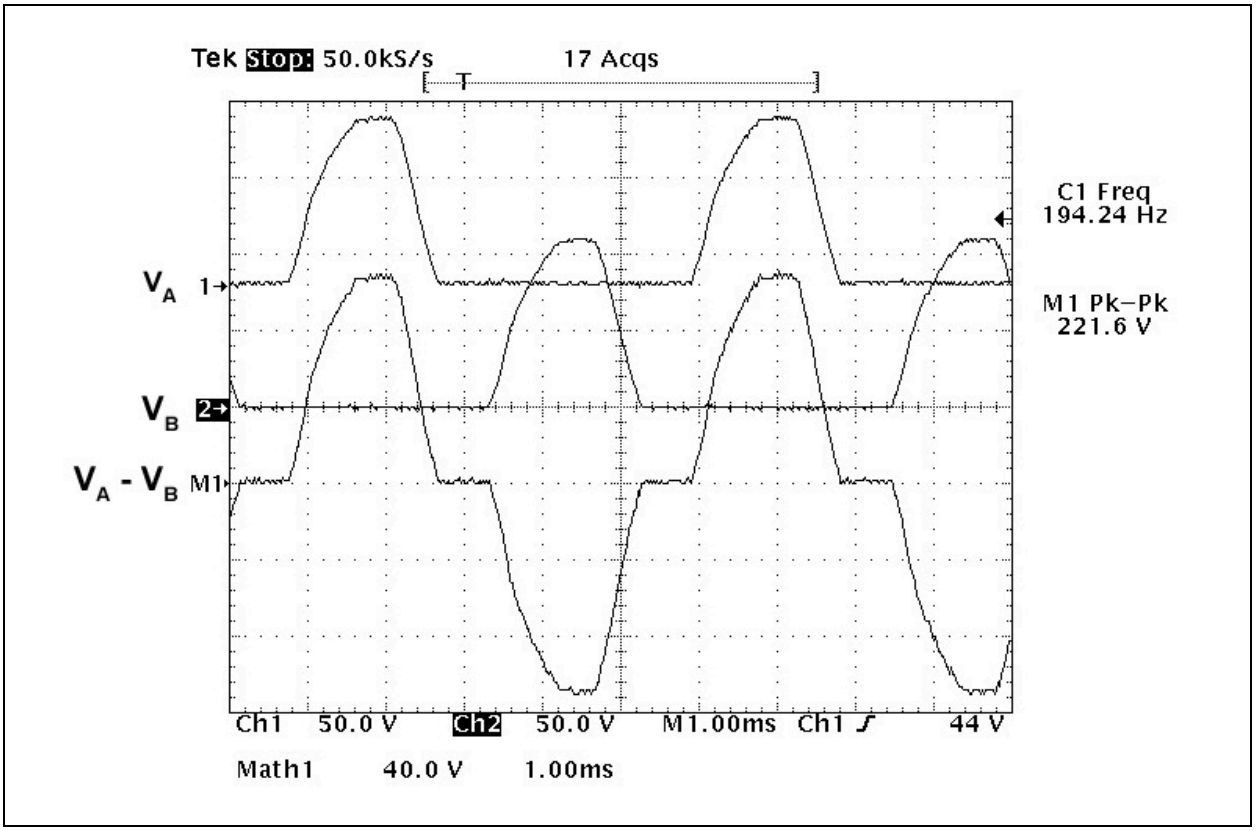


FIGURE 3-2: *Typical Waveform on V_A, VB and Differential Waveform V_A–V_B.*

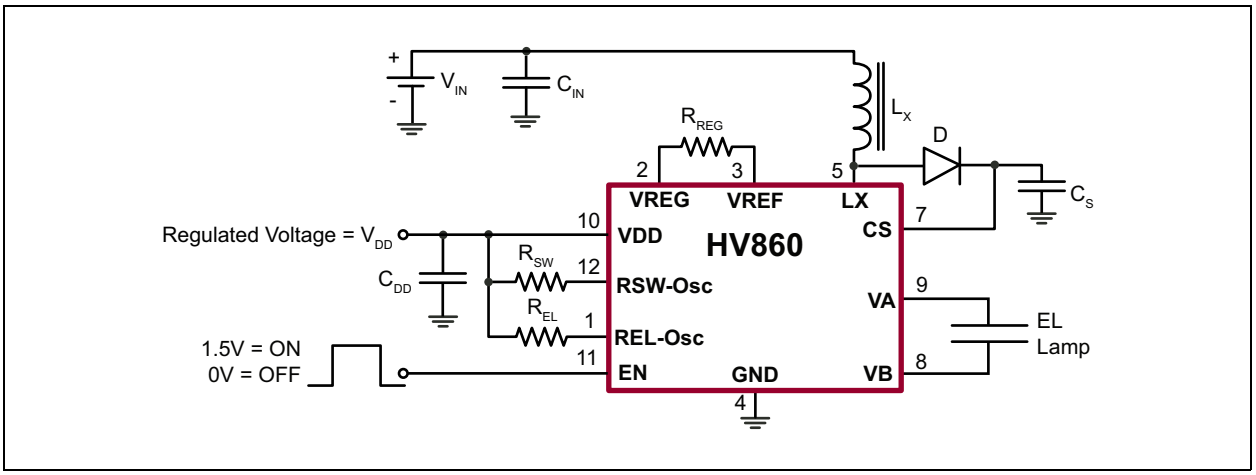


FIGURE 3-3: *Split Supply and Enable/Disable Configuration.*

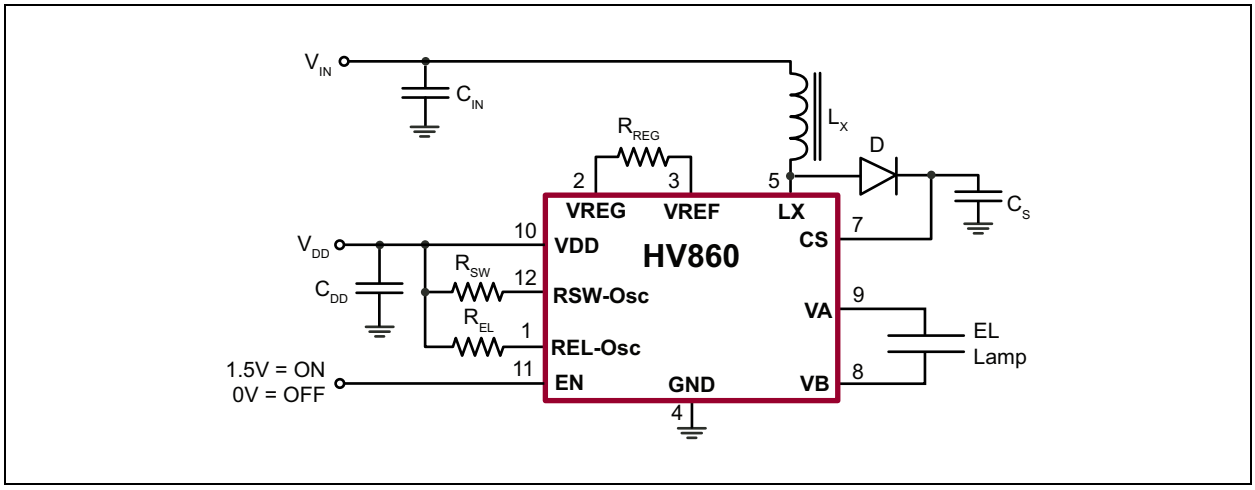


FIGURE 3-4: *Typical Application Circuit for Audible Noise Reduction.*

3.1 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 Typical Application Circuit in Figure 3-3. 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 µA (maximum value). Therefore, the regulated voltage could easily provide the current without being loaded down.

3.2 Enable/Disable Configuration

The HV860 can be easily enabled and disabled via a logic control signal at the EN pin as illustrated in the Typical Application Circuit in Figure 3-3. The control signal can be from a microprocessor. When the microprocessor signal is high, the device is enabled. When the signal is low, it is disabled.

3.3 Audible Noise Reduction

When the EL lamp is lit, the EL lamp emits an audible noise. This is due to the 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 the Typical Application Circuit for Audible Noise Reduction in Figure 3-4.

3.4 Minimizing 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 60 pF capacitor to ground. The 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.

3.5 EL Lamp Dimming Using PWM

Reducing the voltage amplitude at the V_{REG} pin reduces the voltage on the C_S pin, which effectively reduces the peak-to-peak voltage the EL lamp sees. Figure 3-5 illustrates a circuit to dim the lamp by changing the duty cycle of a PWM signal. A 10 kΩ resistor is connected in series with a 3.3 MΩ resistor. An N-channel open-drain PWM signal is used to pull the 10 kΩ 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 20 kHz to 100 kHz.

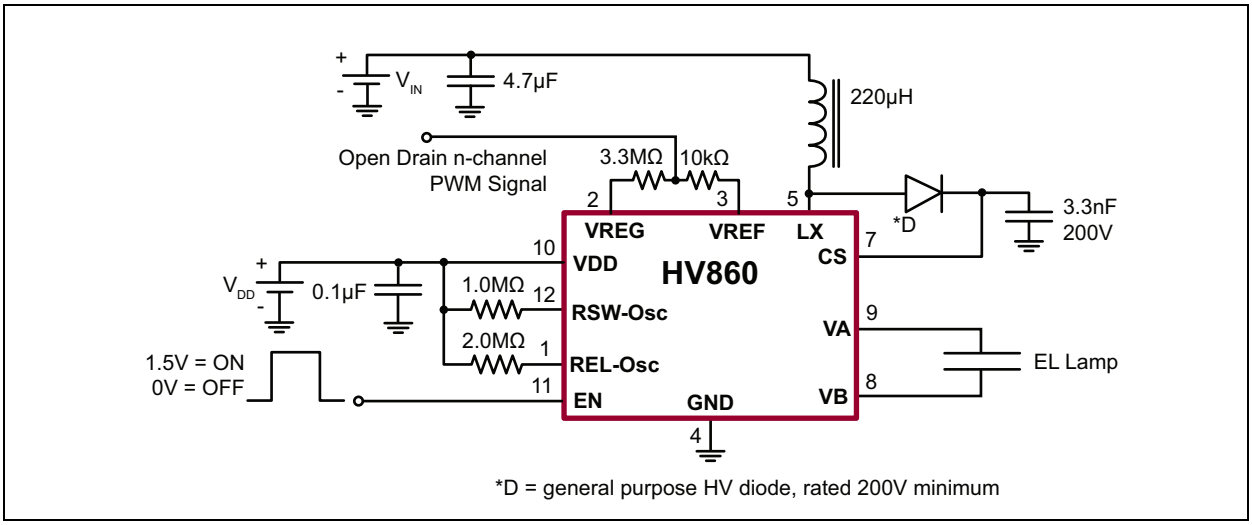


FIGURE 3-5: *PWM Dimming Circuit.*

4.0 PACKAGING INFORMATION

4.1 Package Marking Information

12-lead WQFN

```
XXXXX
YYWW
NNN
```

Example

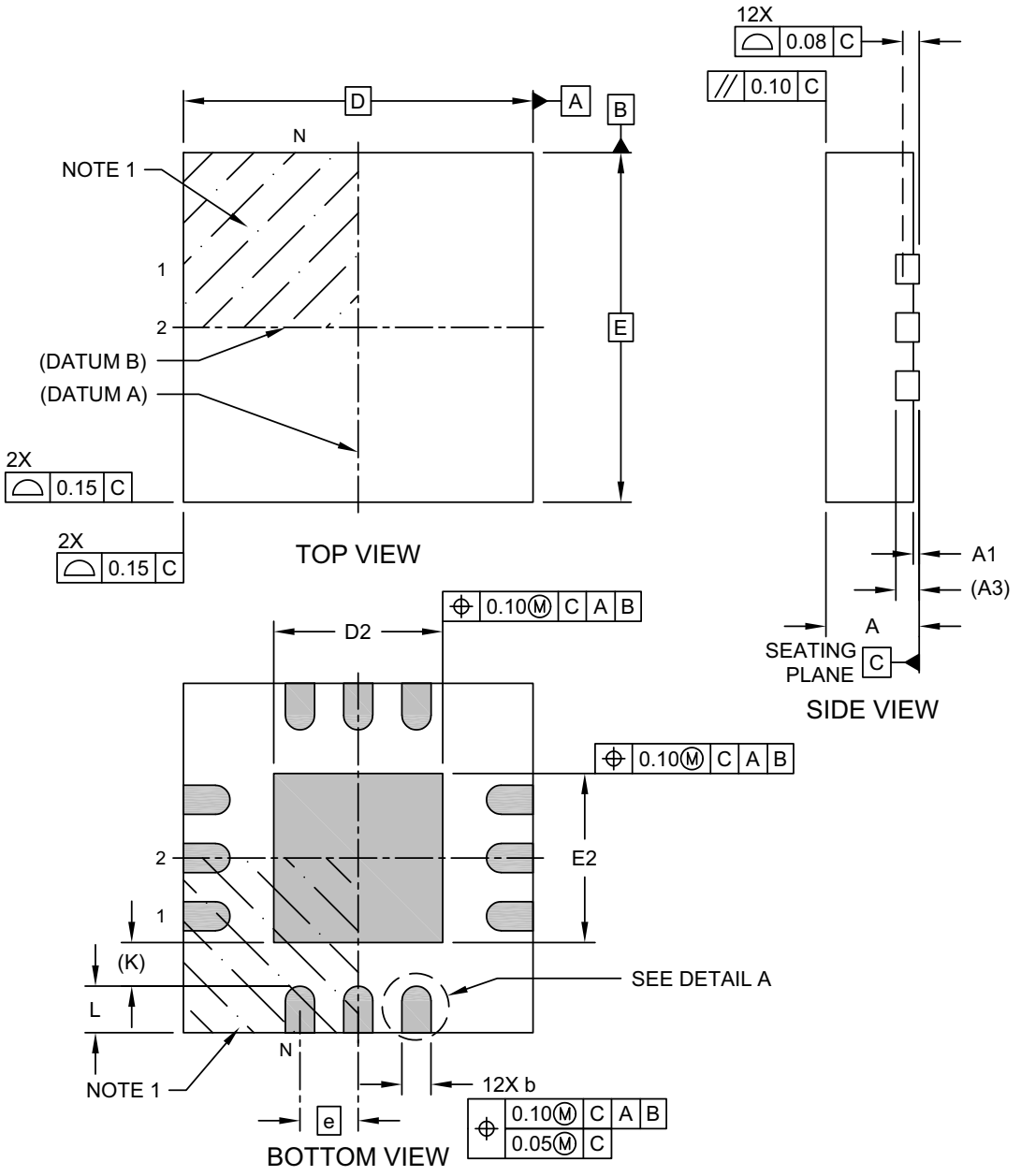
```
H860
2313
321
```

Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for product code or customer-specific information. Package may or not include the corporate logo.

12-Lead Very, Very Thin Plastic Quad Flat, No Lead (2PX) - 3x3x0.8 mm Body [WQFN]
Supertex Legacy Package K7

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-302 Rev A Sheet 1 of 2

12-Lead Very, Very Thin Plastic Quad Flat, No Lead (2PX) - 3x3x0.8 mm Body [WQFN]
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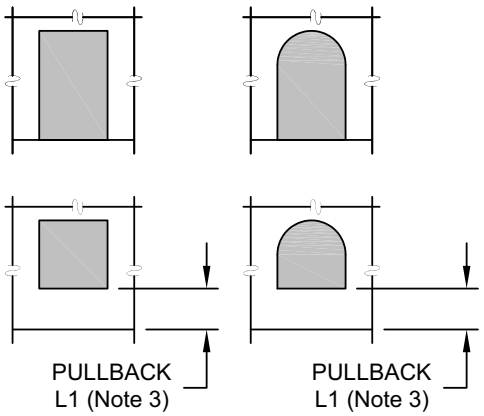
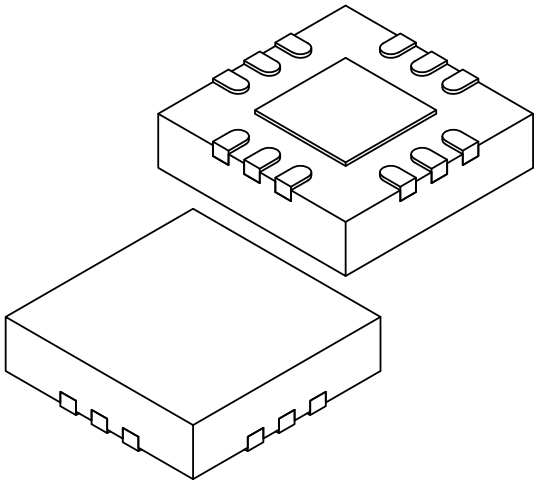
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



DETAIL A
ALTERNATE TERMINAL
CONFIGURATIONS



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		12	
Pitch	e		0.50 BSC	
Overall Height	A	0.70	0.75	0.80
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.20 REF	
Overall Length	D		3.00 BSC	
Exposed Pad Length	D2	1.25	1.45	1.65
Overall Width	E		3.00 BSC	
Exposed Pad Width	E2	1.25	1.45	1.65
Terminal Width	b	0.18	0.25	0.30
Terminal Length	L	0.30	0.40	0.50
Pullback (Note 3)	L1	–	–	0.15
Terminal-to-Exposed-Pad	K		0.38 REF	

Notes:

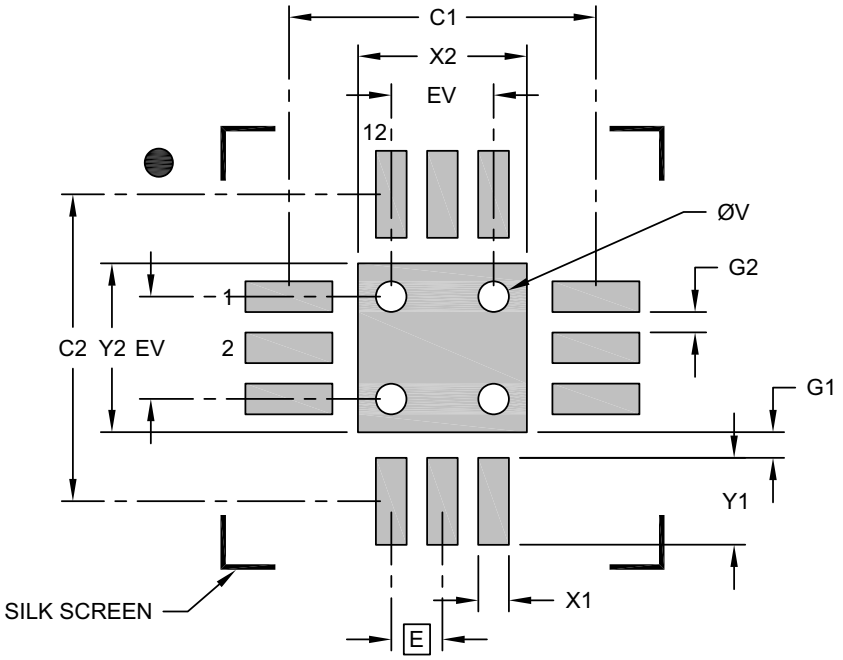
1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. Depending on the method of manufacturing, a maximum of 0.15mm pullback (L1) may be present.
4 Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-302 Rev A Sheet 2 of 2

12-Lead Very, Very Thin Plastic Quad Flat, No Lead (2PX) - 3x3x0.8 mm Body [WQFN]
Supertex Legacy Package K7

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.50 BSC	
Optional Center Pad Width	X2			1.65
Optional Center Pad Length	Y2			1.65
Contact Pad Spacing	C1		3.00	
Contact Pad Spacing	C2		3.00	
Contact Pad Width (Xnn)	X1			0.30
Contact Pad Length (Xnn)	Y1			0.85
Contact Pad to Center Pad (Xnn)	G1	0.25		
Contact Pad to Contact Pad (Xnn)	G2	0.20		
Thermal Via Diameter	V		0.30	
Thermal Via Pitch	EV		1.00	

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-2302 Rev A

APPENDIX A: REVISION HISTORY

Revision A (June 2023)

- Converted Supertex Doc# DSFP-HV860 to Microchip DS20005906A
- Changed the package marking format
- Changed the quantity of the 12-lead WQFN Package from 3000/Reel to 3300/Reel to align packaging specifications with the actual BQM
- Made minor text changes throughout the document

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

PART NO.	XX	-	X	-	X
Device	Package Options		Environmental		Media Type

Device:	HV860	=	Low-Noise Dimmable EL Lamp Driver
Package:	K7	=	12-lead WQFN (3 X 3)
Environmental:	G	=	Lead (Pb)-free/RoHS-compliant Package
Media Type:	(blank)	=	3300/Reel for a K7 Package

Example:

a) HV860K7-G: Low-Noise Dimmable EL Lamp Driver, 12-lead WQFN (3 X 3), 3300/Reel

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Tel: 44-118-921-5800
Fax: 44-118-921-5820