

## Low Input Voltage, 160 V<sub>PP</sub> Output Voltage, EL Driver

### Features

- 1.8V to 5.5V DC Input Voltage
- 160 V<sub>PP</sub> Regulated AC Output Waveform
- Independently Adjustable EL Lamp Frequency
- Independently Adjustable Boost Converter Frequency
- 0.1  $\mu$ A Shutdown Current

### Applications

- LCD Panel Backlight
- Cellular Phones
- PDAs
- Pagers
- Calculators
- Remote Controls
- Portable Phones

### General Description

The MIC4826 is a high output voltage, DC to AC converter, designed for driving EL (Electroluminescent) lamps. The device operates from an input voltage range of 1.8V to 5.5V, making it suitable for 1-cell Li Ion and 2- or 3-cell alkaline/NiCad/NiMH battery applications. The MIC4826 converts a low voltage DC input to a 160 V<sub>PP</sub> AC output signal that drives the EL lamp.

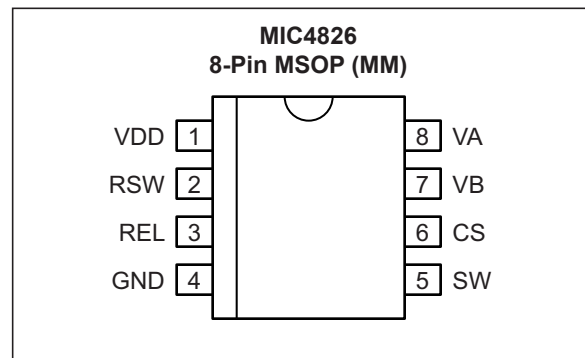
The MIC4826 is comprised of two stages: a boost stage, and an H-bridge, lamp driver, stage. The boost stage steps the input voltage up to +80V. The H-bridge stage then alternately switches the +80V output to each terminal of the EL lamp, thus creating a 160 V<sub>PP</sub> AC signal to drive the EL lamp and generate light.

The MIC4826 features separate oscillators for the boost and H-bridge stages. External resistors independently set the operating frequency of each stage. This flexibility allows the EL lamp circuit to be optimized for maximum efficiency and brightness.

The MIC4826 uses a single inductor and a minimum number of external components, making it ideal for portable, space sensitive applications.

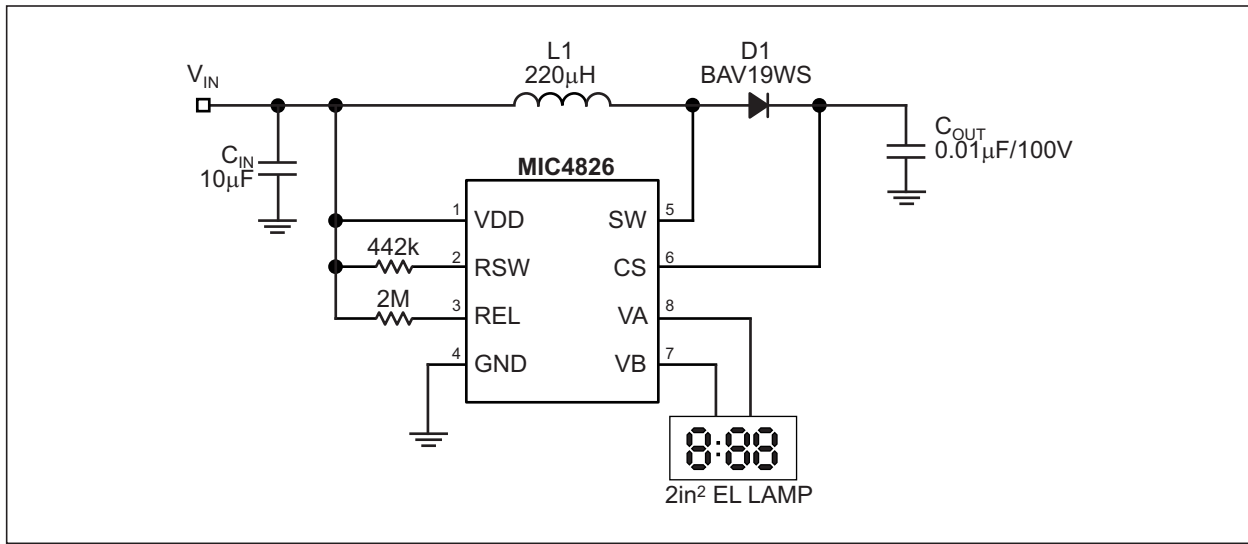
The MIC4826 is available in an 8-pin MSOP package with an ambient temperature range of -40°C to +85°C.

### Package Type

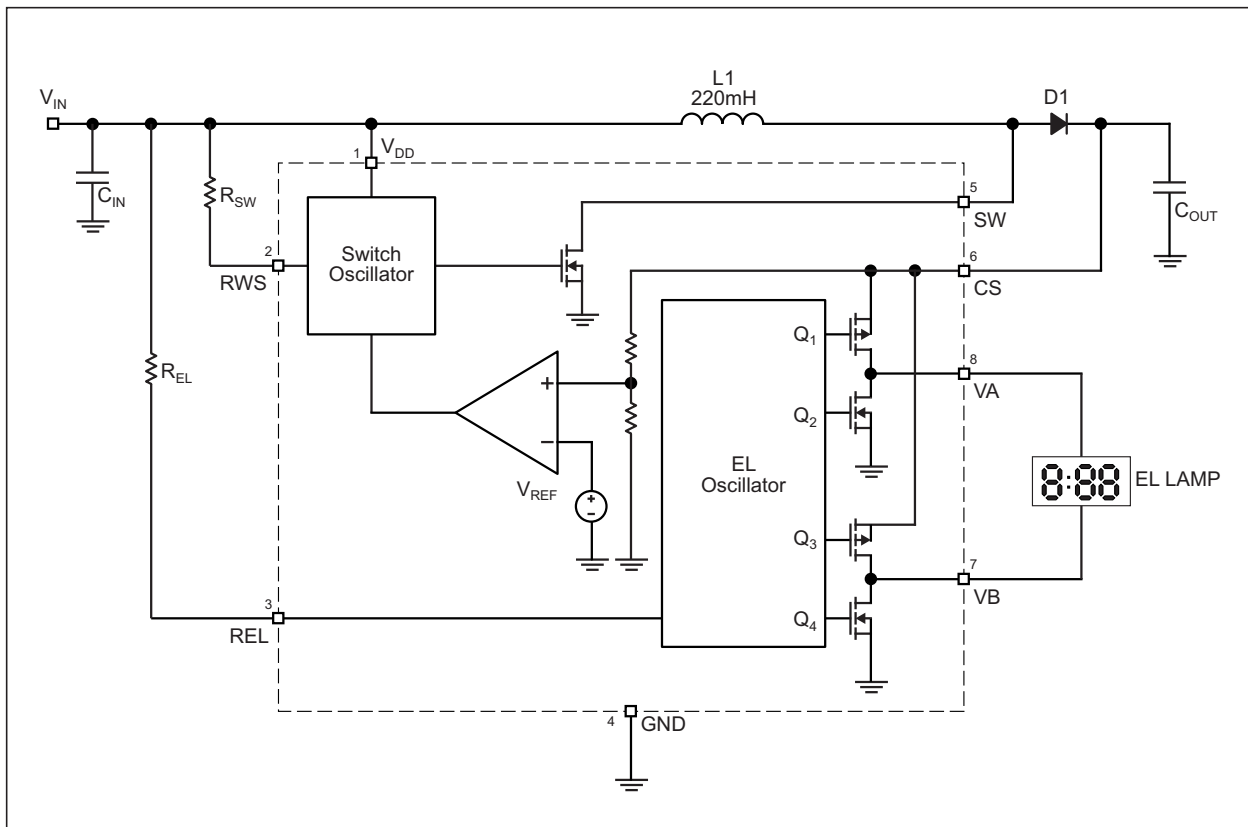


# MIC4826

## Typical Application Circuit



## Functional Block Diagram



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

Supply Voltage ( $V_{DD}$ )	-0.5V to +6V
Output Voltage ( $V_{CS}$ )	-0.5V to +100V
Frequency Control Voltage ( $V_{RSW}$ , $V_{REL}$ )	-0.5V to ( $V_{DD} + 0.3V$ )
Power Dissipation @ $T_A = 85^\circ\text{C}$	200 mW
Storage Temperature ( $T_S$ )	-65°C to +150°C
ESD Rating	(Note 1)

### Operating Ratings ‡

Supply Voltage ( $V_{DD}$ )	+1.8V to +5.5V
Lamp Drive Frequency ( $f_{EL}$ )	60 Hz to 1000 Hz
Switching Transistor Frequency ( $f_{SW}$ )	8 kHz to 200 kHz
Ambient Temperature	-40°C to +85°C
Package Thermal Resistance ( $R_{\theta(JA)}$ , 8-Pin MSOP)	206°C/W

† **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. Specifications are for packaged product only.

‡ **Notice:** The device is not guaranteed to function outside its operating ratings.

**Note 1:** Devices are ESD sensitive. Handling precautions are recommended.

## ELECTRICAL CHARACTERISTICS

**Electrical Characteristics:**  $V_{IN} = V_{DD} = 3.0V$ ,  $R_{SW} = 560\text{ k}\Omega$ ,  $R_{EL} = 1.0\text{ M}\Omega$ ,  $T_A = 25^\circ\text{C}$  unless otherwise noted. **Bold** values indicate  $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$ .

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
On-Resistance of Switching Transistor	$R_{DS(ON)}$	—	3.8	<b>7.0</b>	$\Omega$	$I_{SW} = 100\text{ mA}$ , $V_{CS} = 75V$
Output Voltage Regulation	$V_{CS}$	75	80	85	V	$V_{DD} = 1.8V$ to $5.5V$
		<b>73</b>	—	<b>87</b>	V	—
Output Peak-to-Peak Voltage	$V_A - V_B$	150	160	170	V	$V_{DD} = 1.8V$ to $5.5V$
		<b>146</b>	—	<b>174</b>	V	—
Input Low Voltage (Turn Off)	$V_{EN-L}$	—	—	0.5	V	$V_{DD} = 1.8V$ to $5.5V$
Input High Voltage (Turn On)	$V_{EN-H}$	$V_{DD} - 0.5$	—	—	V	$V_{DD} = 1.8V$ to $5.5V$
Shutdown Current (Note 2)	$I_{SD}$	—	0.01	0.1	$\mu\text{A}$	$R_{SW} = \text{LOW}$ ; $R_{EL} = \text{LOW}$ $V_{DD} = 5.5V$
			—	<b>0.5</b>		
Input Supply Current	$I_{VDD}$	—	21	<b>75</b>	$\mu\text{A}$	$R_{SW} = \text{HIGH}$ ; $R_{EL} = \text{HIGH}$ $V_{CS} = 75V$ ; $V_A$ , $V_B$ OPEN
Boosted Supply Current	$I_{CS}$	—	200	<b>400</b>	$\mu\text{A}$	$R_{SW} = \text{HIGH}$ ; $R_{EL} = \text{HIGH}$ $V_{CS} = 75V$ ; $V_A$ , $V_B$ OPEN
Input Current Including Inductor Current	$I_{IN}$	—	28	—	mA	$V_{IN} = V_{DD} = 1.8V$ . See (Figure 1-1)
$V_A - V_B$ Output Drive Frequency	$f_{EL}$	285	360	435	Hz	—
Switching Transistor Frequency	$f_{SW}$	53	66	79	kHz	—
Switching Transistor Duty Cycle	D	—	90	—	%	—

**Note 1:** Specification for packaged product only.

**2:** Shutdown current is defined as the sum of current going into pin 1, 5, and 6 when the device is disabled.

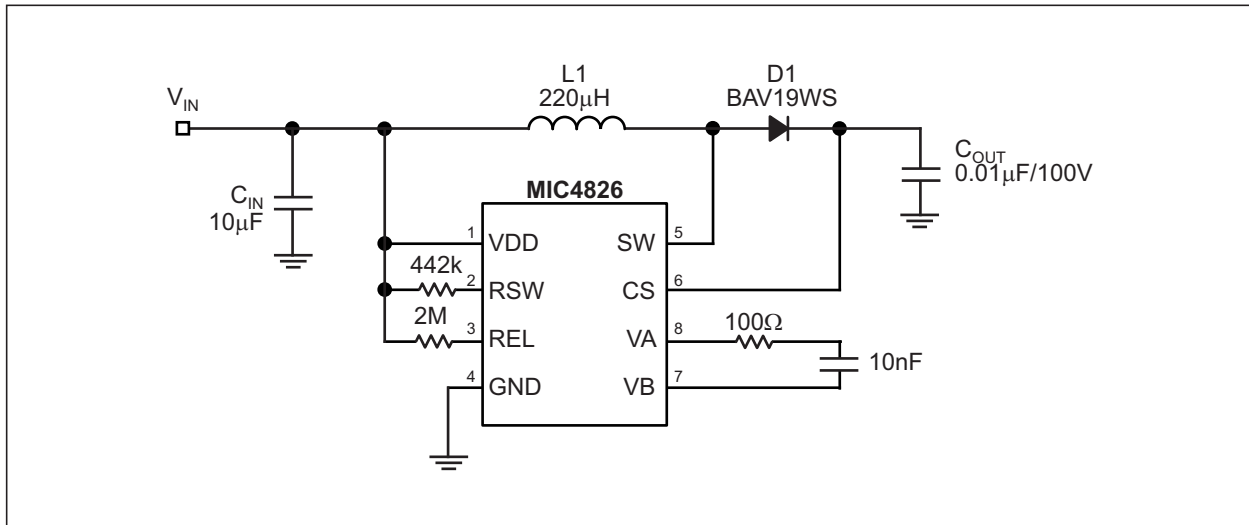
# MIC4826

## TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>Temperature Ranges</b>						
Storage Temperature Range	$T_S$	-65	—	+150	°C	—
Ambient Temperature	$T_A$	-40	—	+85	°C	—
<b>Package Thermal Resistances</b>						
Thermal Resistance 8-Pin MSOP	$\theta_{JA}$	—	206	—	°C/W	—

**Note 1:** The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e.,  $T_A$ ,  $T_J$ ,  $\theta_{JA}$ ).

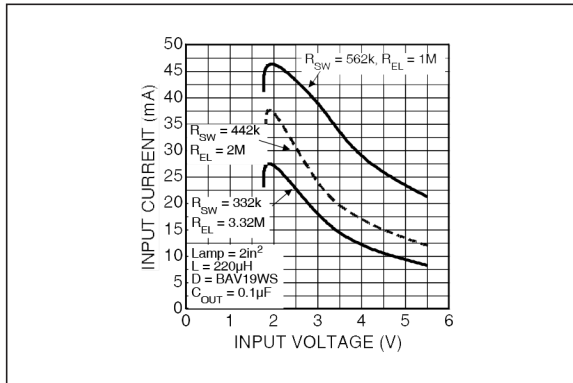
## Test Circuit



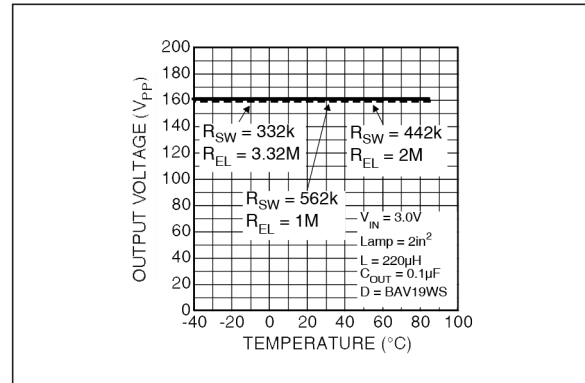
**FIGURE 1-1:** MIC4826 Test Circuit.

## 2.0 TYPICAL PERFORMANCE CURVES

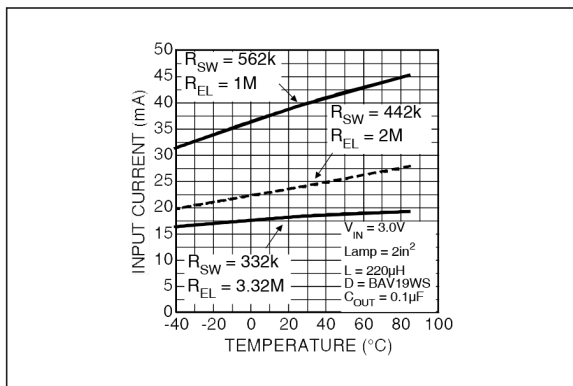
**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.



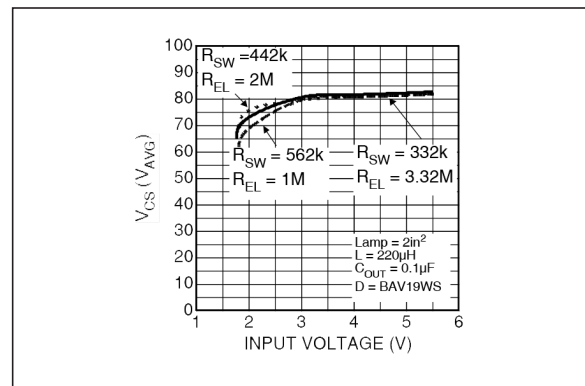
**FIGURE 2-1:** Total Input Current vs. Input Voltage.



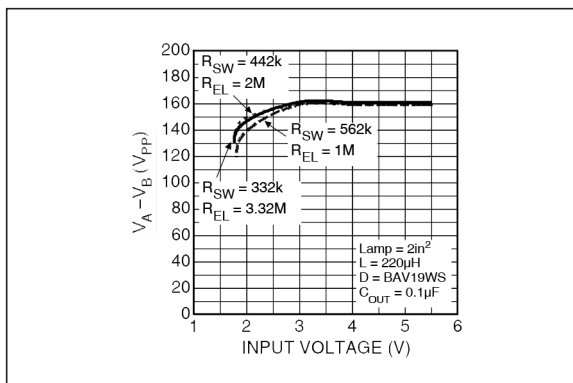
**FIGURE 2-4:** Output Voltage vs. Temperature.



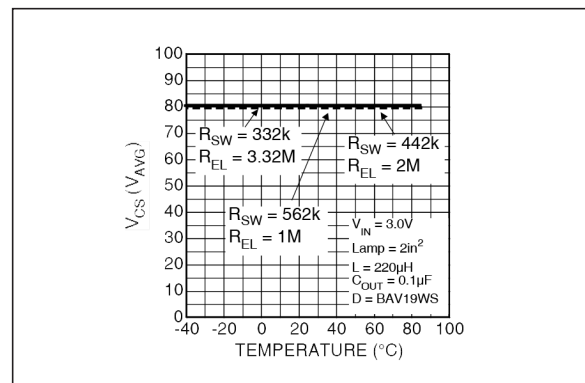
**FIGURE 2-2:** Total Input Current vs. Temperature.



**FIGURE 2-5:** CS Voltage vs. Input Voltage.

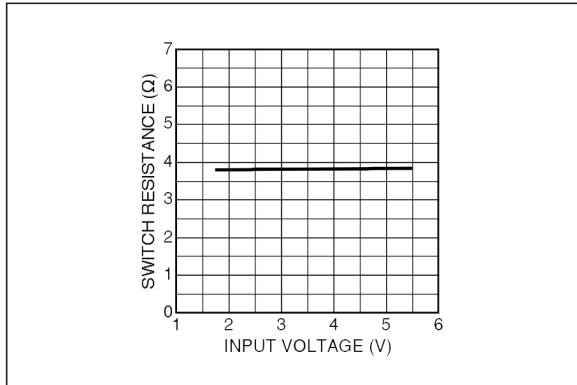


**FIGURE 2-3:** Output Voltage vs. Input Voltage.

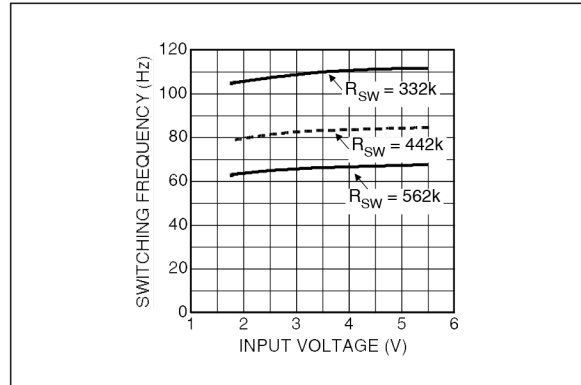


**FIGURE 2-6:** CS Voltage vs. Temperature.

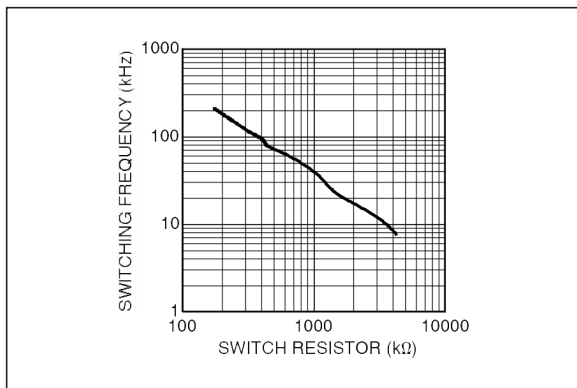
# MIC4826



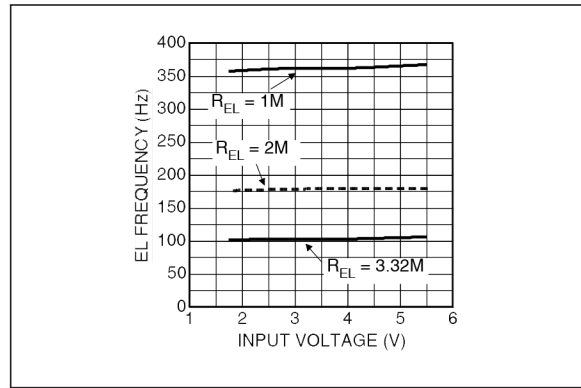
**FIGURE 2-7:** Switch Resistance vs. Input Voltage.



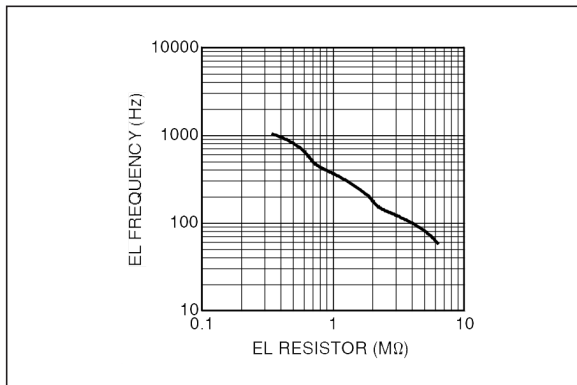
**FIGURE 2-10:** Switching Frequency vs. Input Voltage.



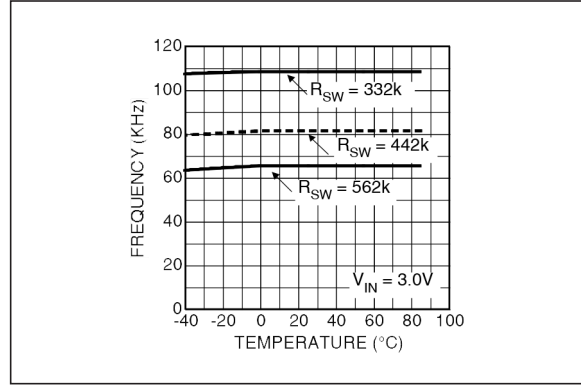
**FIGURE 2-8:** Switching Frequency vs. Switch Resistor.



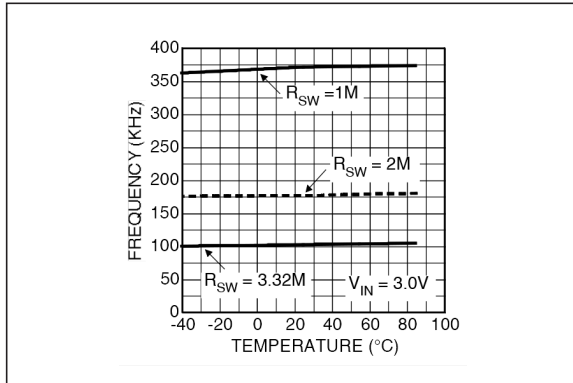
**FIGURE 2-11:** EL Frequency vs. Input Voltage.



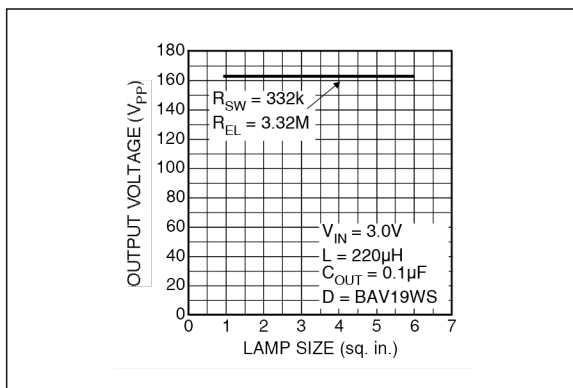
**FIGURE 2-9:** EL Frequency vs. EL Resistor.



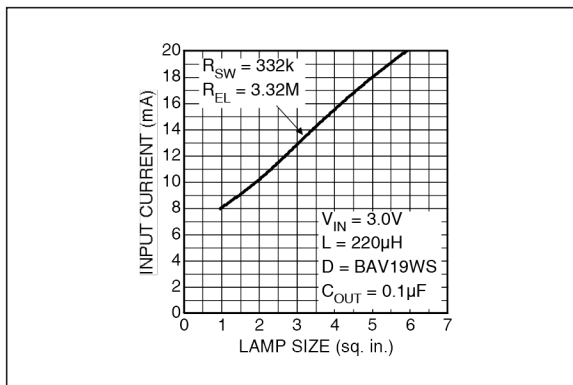
**FIGURE 2-12:** Switching Frequency vs. Temperature.



**FIGURE 2-13:** EL Frequency vs. Temperature.



**FIGURE 2-14:** Output Voltage vs. Lamp Size.



**FIGURE 2-15:** Total Input Current vs. Lamp Size.

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## 3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in [Table 3-1](#).

**TABLE 3-1: PIN FUNCTION TABLE**

Pin Number	Pin Name	Description
1	VDD	Supply (Input): 1.8V to 5.5V for internal circuitry.
2	RSW	Switch Resistor (External Component): Set switch frequency of the internal power MOSFET by connecting an external resistor to $V_{DD}$ . Connecting the external resistor to GND disables the switch oscillator and shutdown the device.
3	REL	EL Resistor (External Component): Set EL frequency of the internal H-bridge driver by connecting an external resistor to $V_{DD}$ . Connecting the external resistor to GND disables the EL oscillator.
4	GND	Ground return.
5	SW	Switch Node (Input): Internal high voltage power MOSFET drain.
6	CS	Regulated Boost Output (External Component): Connect to the output capacitor of the boost regulator and connect to the cathode of the diode.
7	VB	EL Output: Connect to one end of the EL lamp. Polarity is not important.
8	VA	EL Output: Connect to the other end of the EL lamp. Polarity is not important.

## 4.0 FUNCTIONAL DESCRIPTION

See [Section 5.0, Application Information](#) for component selection and pre-designed circuits.

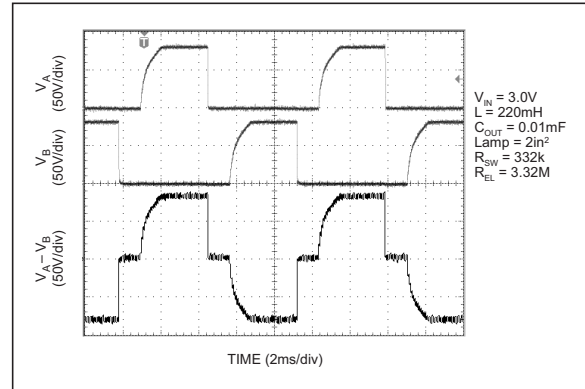
### 4.1 Overview

The MIC4826 is a high voltage EL driver with an AC output voltage of 160V peak-to-peak capable of driving EL lamps up to 6 in<sup>2</sup>. Input supply current for the MIC4826 is typically 21  $\mu$ A with a typical shutdown current of 10 nA. The high voltage EL driver has two internal oscillators to control the switching MOSFET and the H-bridge driver. Both of the internal oscillators' frequencies can be individually programmed through the external resistors to maximize the efficiency and the brightness of the lamps.

### 4.2 Regulation

Referring to [Figure 4-1](#), initially power is applied to V<sub>DD</sub>. The internal feedback voltage is less than the reference voltage causing the internal comparator to go low which enables the switching MOSFET's oscillator. When the switching MOSFET turns on, current flows through the inductor and into the switch. The switching MOSFET will typically turn on for 90% of the switching frequency. During the on time, energy is stored in the inductor. When the switching MOSFET turns off, current flowing into the inductor forces the voltage across the inductor to reverse polarity. The voltage across the inductor rises until the external diode conducts and clamps the voltage at V<sub>OUT</sub>+V<sub>D1</sub>. The energy in the inductor is then discharged into the C<sub>OUT</sub> capacitor. The internal comparator continues to turn the switching MOSFET on and off until the internal feedback voltage is above the reference voltage. Once the internal feedback voltage is above the reference voltage, the internal comparator turns off the switching MOSFET's oscillator.

When the EL oscillator is enabled, V<sub>A</sub> and V<sub>B</sub> switch in opposite states to achieve a 160V peak-to-peak AC output signal. The external resistor that connects to the REL pin determines the EL frequency.



**FIGURE 4-1:** 108 Hz Typical Output Waveform.

### 4.3 Switching Frequency

The switching frequency of the converter is controlled via an external resistor between R<sub>SW</sub> pin and V<sub>DD</sub> pin of the device. The switching frequency increases as the resistor value decreases. For resistor value selections, see [Figure 2-8](#) or use equation [Equation 4-1](#). The switching frequency range is 8 kHz to 200 kHz, with an accuracy of  $\pm 20\%$ .

**EQUATION 4-1:**

$$f_{SW}(kHz) = \frac{36}{R_{SW}(M\Omega)}$$

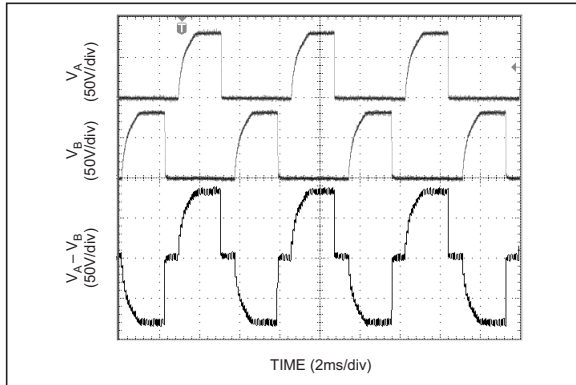
### 4.4 EL Frequency

The EL lamp frequency is controlled via an external resistor connected between REL pin and V<sub>DD</sub> pin of the device. As the lamp frequency increases, the resistor value decreases. For resistor value selections, see [Figure 2-9](#) or use equation [Equation 4-2](#). The EL frequency range is 60 Hz to 1000 Hz, with an accuracy of  $\pm 20\%$ .

**EQUATION 4-2:**

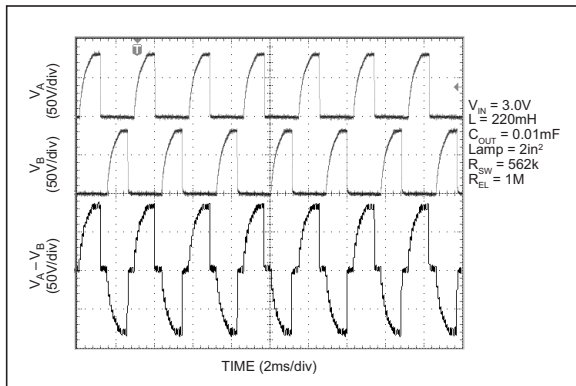
$$f_{EL}(Hz) = \frac{360}{R_{EL}(M\Omega)}$$

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**FIGURE 4-2:** 180 Hz Output Waveform.

In general, as the EL lamp frequency increases, the amount of current drawn from the battery will increase. The color of the EL lamp and the intensity are dependent upon its frequency.



**FIGURE 4-3:** 360 Hz Output Waveform.

## 4.5 Enable Function

The enable function of the MIC4826 is implemented by switching the  $R_{SW}$  and  $R_{EL}$  resistor between ground and  $V_{DD}$ . When  $R_{SW}$  and  $R_{EL}$  are connected to ground, the switch and the EL oscillators are disabled; therefore the EL driver becomes disabled. When these resistors connect to  $V_{DD}$ , both oscillators will function and the EL driver is enabled.

## 5.0 APPLICATION INFORMATION

### 5.1 Inductor

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 (controlled by  $R_{SW}$ ) should be increased to avoid saturation or the input voltage should be increased. Typically, inductor values ranging from 220  $\mu\text{H}$  to 560  $\mu\text{H}$  can be used. Murata offers the LQH3C series up to 560 $\mu\text{H}$  and LQH4C series up to 470  $\mu\text{H}$ , with low DC resistance. A 220  $\mu\text{H}$  Murata (LQH4C221K04) inductor is recommended for driving a lamp size of 3 square inches. It has a maximum DC resistance of 4.0 $\Omega$ .

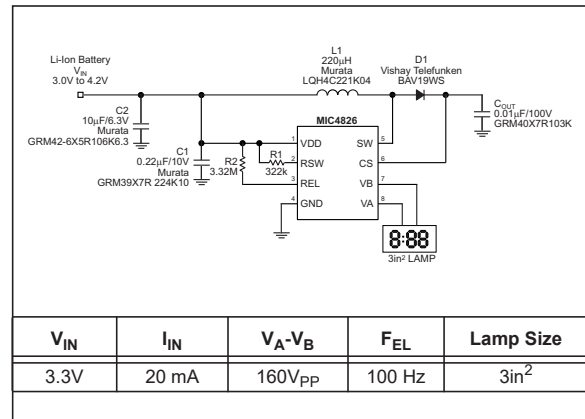
### 5.2 Diode

The diode must have a high reverse voltage (100V) since the output voltage at the CS pin can reach up to 100V. A fast switching diode with lower forward voltage and higher reverse voltage (100V), such as BAV19WS, can be used to enhance efficiency.

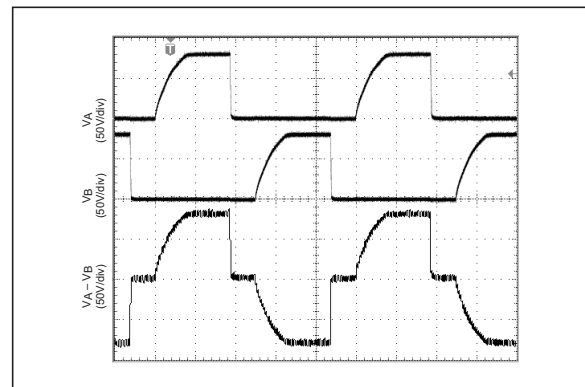
### 5.3 Output Capacitor

Low ESR capacitors should be used at the regulated boost output (CS pin) of the MIC4826 to minimize the switching output ripple voltage. Selection of the capacitor value will depend upon the peak inductor current, inductor size, and the load. MuRata offers the GRM40 series with up to 0.015  $\mu\text{F}$  at 100V, with a X7R temperature coefficient in 0805 surface mount package. Typically, values ranging from 0.01  $\mu\text{F}$  to 0.1  $\mu\text{F}$  at 100V can be used for the regulated boost output capacitor.

## 5.4 Pre-Designed Application Circuits

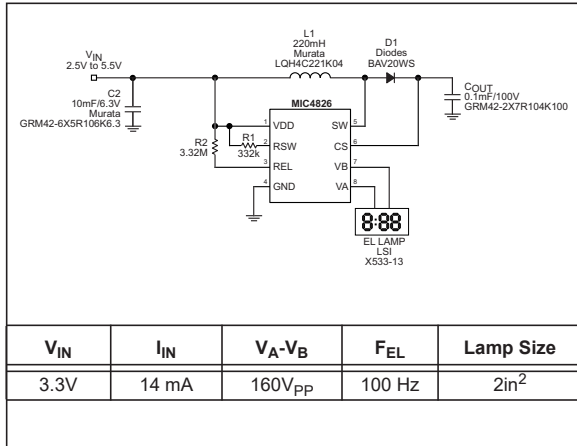


**FIGURE 5-1:** 100 Hz EL Driver for 3in<sup>2</sup> Lamp.

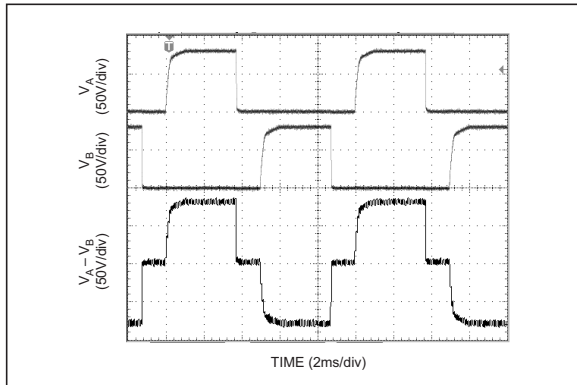


**FIGURE 5-2:** Typical Characteristics for 100 Hz EL Driver for 3in<sup>2</sup> Lamp.

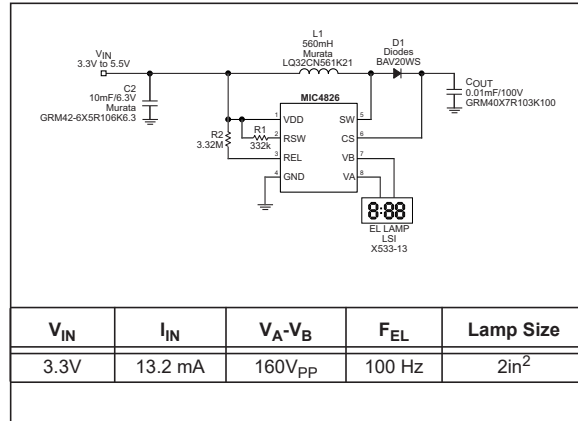
# MIC4826



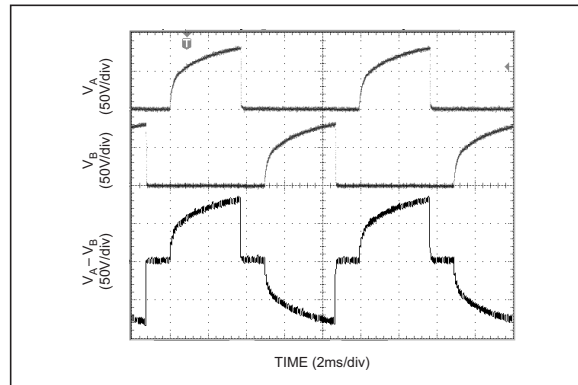
**FIGURE 5-3:** 100 Hz EL Driver for 2in<sup>2</sup> Lamp.



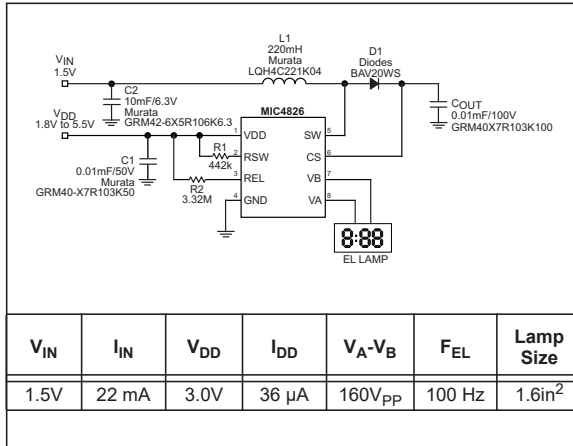
**FIGURE 5-4:** Typical Characteristics for EL Driver for 2in<sup>2</sup> Lamp with  $C_S = 0.1 \mu\text{F}$ .



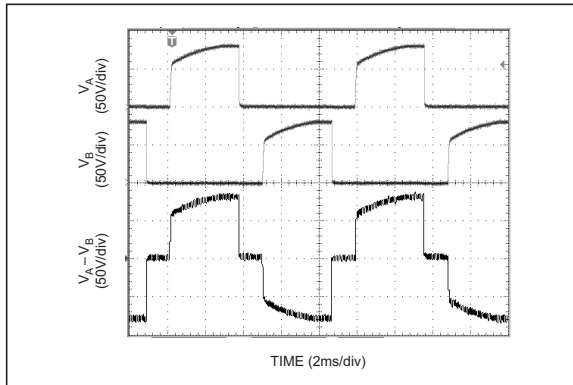
**FIGURE 5-5:** EL Driver for 2in<sup>2</sup> Lamp with 560  $\mu\text{F}$ .



**FIGURE 5-6:** Typical Characteristics for EL Driver for 2in<sup>2</sup> Lamp with 560  $\mu\text{H}$  Inductor.



**FIGURE 5-7:** Typical for Split Power Supplies Applications.



**FIGURE 5-8:** Typical Characteristics for Split Power Supplies Applications.

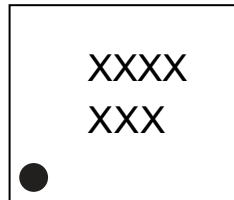
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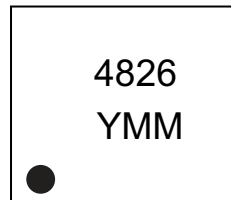
## 6.0 PACKAGING INFORMATION

### 6.1 Package Marking Information

8-Lead MSOP\*



Example



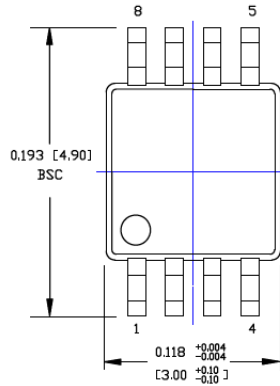
<b>Legend:</b>	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.
	•, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).
<b>Note:</b>	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 customer-specific information. Package may or may not include the corporate logo.	
	Underbar (¯) and/or Overbar (¯) symbol may not be to scale.	

## 8-Lead MSOP Package Outline and Recommended Land Pattern

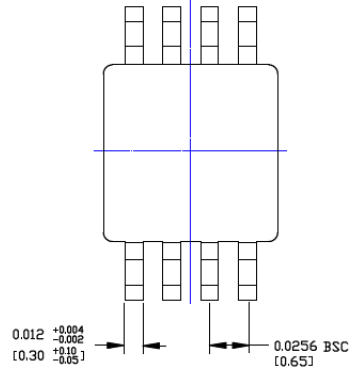
**TITLE**

8 LEAD MSOP PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

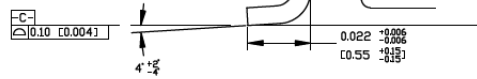
DRAWING #	MSOP-8LD-PL-1	UNIT	INCH [MM]
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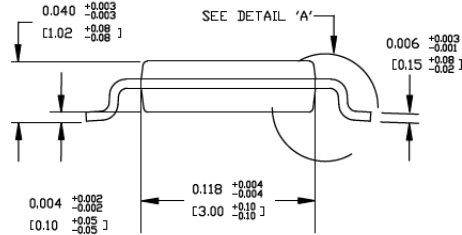
TOP VIEW



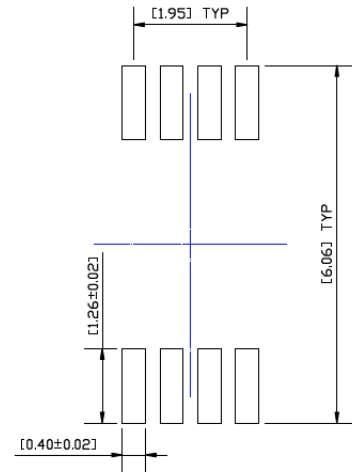
BOTTOM VIEW



DETAIL A



SIDE VIEW



RECOMMENDED LAND PATTERN

**NOTES:**

1. DIMENSIONS ARE IN INCHES [MM].
2. CONTROLLING DIMENSION: MM
3. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS, EITHER OF WHICH SHALL NOT EXCEED 0.008 [0.20] PER SIDE.

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

# MIC4826

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NOTES:

## APPENDIX A: REVISION HISTORY

### Revision A (January 2019)

- Converted Micrel document MIC4826 to Microchip data sheet DS20006134A.
- Minor text changes throughout.

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NOTES:

## PRODUCT IDENTIFICATION SYSTEM

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

<u>PART NO.</u>	<u>X</u>	<u>XX</u>	<u>-XX</u>
Device	Junction Temperature Range	Package	Media Type
<b>Device:</b> MIC4826: Low Input Voltage, 160 V <sub>PP</sub> Output Voltage, EL Driver	<b>Junction Temperature Range:</b> Y = -40°C to +85°C	<b>Package:</b> MM = 8-Lead MSOP	<b>Media Type:</b> Blank = 100/Tube TR = 2,500/Reel

### Examples:

- a) MIC4826YMM: Low Input Voltage, 160 V<sub>PP</sub> Output Voltage, EL Driver, -40°C to +85°C Temperature Range, 8-Lead MSOP Package, 100/Tube
- b) MIC4826YMM-TR: Low Input Voltage, 160 V<sub>PP</sub> Output Voltage, EL Driver, -40°C to +85°C Temperature Range, 8-Lead MSOP Package, 2,500/Reel

**Note 1:** Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

# MIC4826

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NOTES:

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ISBN: 978-1-5224-4047-5



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