

This application note covers the MIC4826/7 Electroluminescent (EL) lamp drivers and designing with EL lamps.

Electroluminescent Displays - The Basics

The design of an EL lamp circuit begins with the selection of a lamp. A typical lamp will exhibit a capacitance on the order of 2nF to 3.5nF per square inch. When a high voltage AC signal is applied across the electrodes of an EL lamp, an electric field is generated across the plates of the lamp. This electric field excites the phosphor atoms to a higher energy state. When the electric field is removed, the atoms fall back to a lower energy state, emitting photons as visible light. The wavelength of the emitted light is determined by the type of phosphor used and the frequency of the excitation voltage. Figure 1 shows a typical bridge configuration that is applied to the EL electrodes to generate the AC signal. Typical AC voltages applied to the EL lamp are 50V to 250 V_{PK-PK}, with a frequency of 50Hz to 1KHz.

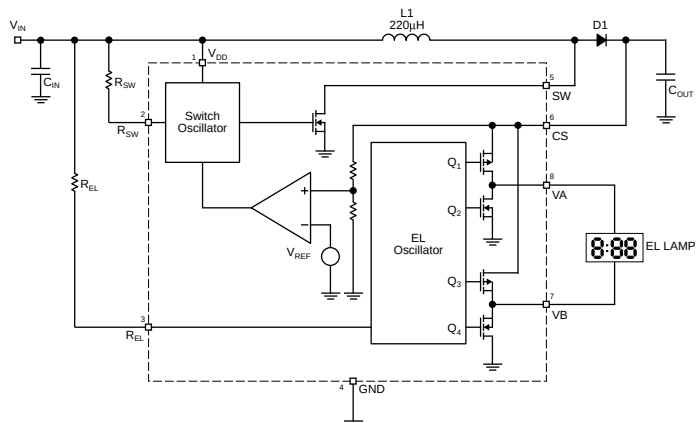


Figure 1. MIC4826/7 Block Diagram

The basic AC signal applied to the EL lamp across VA and VB, the two electrode pins, can be seen in Figure 2.

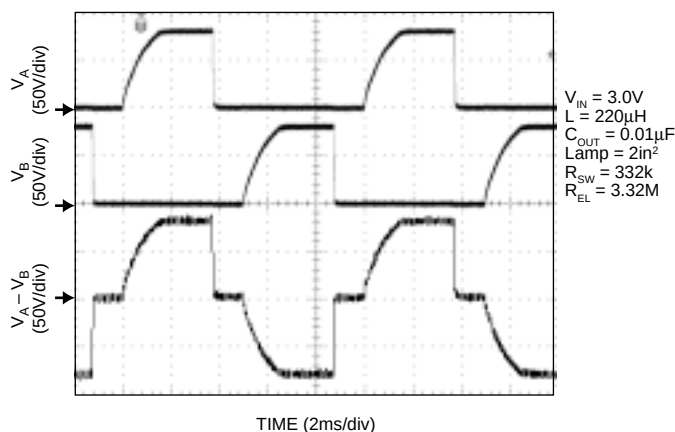


Figure 2. Typical AC Signal Applied to EL lamp

With most phosphors, the spectrum of emitted light will tend to shift towards blue with an increase in excitation frequency. Color can be controlled by selecting the phosphor type, by adding fluorescent dyes in the phosphor layer, by using a color filter over the lamp, or a combination of these processes. EL lamp brightness increases approximately with the square of applied voltage. Increasing frequency, in addition to affecting hue, will also increase EL lamp brightness, but with a more linear relationship. Many EL lamp manufacturers provide performance characteristics informing designers on the relationships of frequency, voltage, and EL lamp brightness for their EL lamps.

Increased voltage and/or frequency, however, adversely affect lamp life. Higher frequencies generally decrease lamp life more so than increased voltages. EL lamps, unlike other types of light sources, do not abruptly fail. Instead, their brightness gradually decreases through use. Due to the nature of the devices that EL lamps are used in, this is normally not a concern.

The MIC4826 and MIC4827 allow the user to select the EL frequency and voltage driving the lamp to give the user maximum flexibility during the design process.

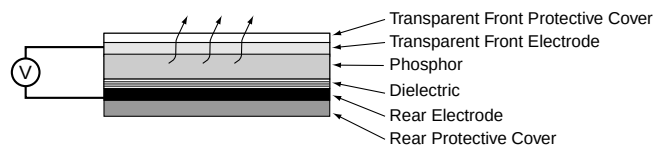


Figure 3. Typical EL Lamp Construction

How the MIC4826/7 Drives the EL Display

To generate the high voltages needed for driving EL lamps, MICREL drivers employ switch-mode converters using a boost converter to generate the high voltages needed. Following the boost converter is an H-bridge driver, this applies the peak-to-peak voltage across the EL lamp at a user selectable frequency. The MIC4826 provides 160 V_{PP} while the MIC4827 provides 180V_{PP} for bigger EL lamps. Figure 1 shows the internal block diagram of the MIC4826 and MIC4827. The CS pin is the high voltage output of the boost converter, which is half the peak-to-peak voltage across the EL lamp. The second stage is the H-bridge circuit that switches the boost voltage across the EL lamp. Both the switching frequency of the boost converter and the switching frequency of the EL lamp can be adjusted independently.

MIC4826/7 Basic Operation

The MIC4826 is a high voltage EL driver with an AC output voltage of 160V peak-to-peak. The MIC4827 is a higher voltage EL driver with an AC output voltage of 180V peak-to-peak. Both parts are capable of driving EL lamps up to 6 in² (typically). Input supply current for the MIC4826/7 are typically 21μA. The MIC4826 and MIC4827 have a shutdown current of 100nA. Both high voltage EL drivers have two internal oscillators to control the switching MOSFET and the H-bridge driver. The internal oscillators' frequency can be individually programmed through the external resistors to maximize the efficiency and the brightness of the lamps.

Referring to Figure 1, initially power is applied to V_{DD}. 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_{OUT}+V_{D1}. The energy in the inductor is then discharged into the C_{OUT} 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, VA and VB switch in opposite states to achieve a 160V peak-to-peak AC output signal for the MIC4826 and 180V peak-to-peak for the MIC4827. The external resistor that connects to the R_{EL} pin determines the EL frequency.

Switching Frequency

The switching frequency of the converter is controlled via an external resistor between R_{SW} pin and V_{DD} pin of the device. The switching frequency increases as the resistor value decreases. The switching frequency range is 8kHz to 200kHz, with an accuracy of ±20%. By using the below equation and a known value resistor, the switching frequency can be determined.

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

There is a trade off in inductor size versus system efficiency. Normally EL displays are in portable equipment and size is of the utmost importance. A typical switching frequency recommended is 108kHz, giving a recommended typical inductor value of 220μH. See the "Pre-designed Circuits" section for complete information.

EL Frequency

The EL lamp frequency is controlled via an external resistor connected between R_{EL} pin and V_{DD} pin of the device. As the resistor value decreases the lamp frequency increases. The EL frequency range is 60Hz to 1000Hz, with an accuracy of ±20%. By using the below equation and a known value resistor, the EL frequency can be determined.

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

A typical EL frequency for a portable device is 100 to 400Hz, depending on display size and type.

Inductor Selection

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 inductor saturation, or the input voltage should be increased. Typically, inductor values ranging from 220μH to 560μH can be used. Murata offers the LQH3C series up to 560μH and LQH4C series up to 470μH, with low DC resistance. A 220μH Murata (LQH4C221K04) inductor is recommended for driving a lamp size of 3 square inches. It has a maximum DC resistance of 4.0Ω.

Diode

The application circuits specify the 1N4148 or equivalent. It has a forward current of 100mA and a typical forward voltage of 930mV. For applications that are not cost driven, a fast switching diode with lower forward voltage and higher reverse voltage can be used to enhance the efficiency.

Output Capacitor

Low ESR capacitors should be used at the regulated boost output (CS pin) of the MIC4826/7 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 0.015μF at 100V, with a X7R temperature coefficient in 0805 surface-mount package. Typically, values ranging from 0.01μF to 0.1μF at 100V can be used for the regulated boost output capacitor.

Remote Enable

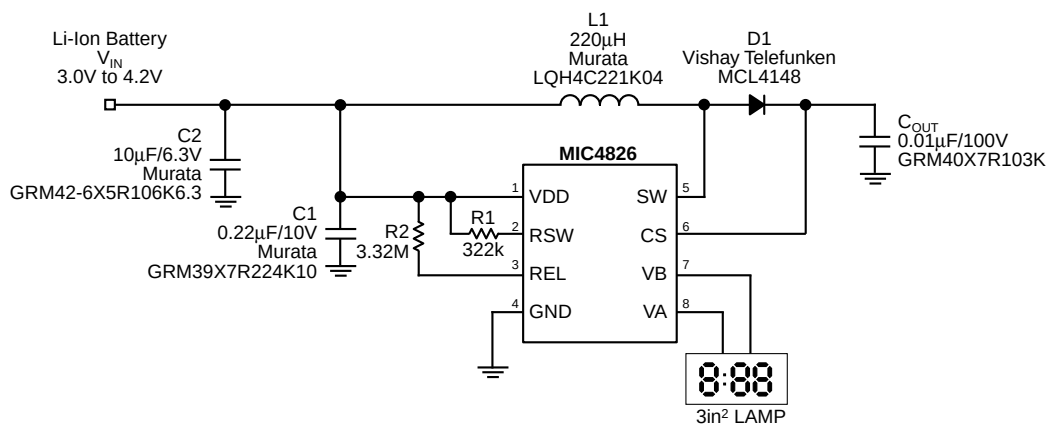
Remote enable is implemented by connecting R_{SW} and R_{EL} to a signal that swings between ground and V_{DD}. When the remote enable is at ground, the power conversion and lamp drive oscillators are halted and the driver becomes disabled. When the remote enable signal is at V_{DD}, the oscillators function normally and the driver is enabled. Since R_{SW} and R_{EL} are typically high resistances, loading of the remote enable signal is minimal. However, to avoid interactions between the power conversion and lamp drive oscillators, the remote enable signal should be from a CMOS output of less than 20KΩ.

Split Supplies

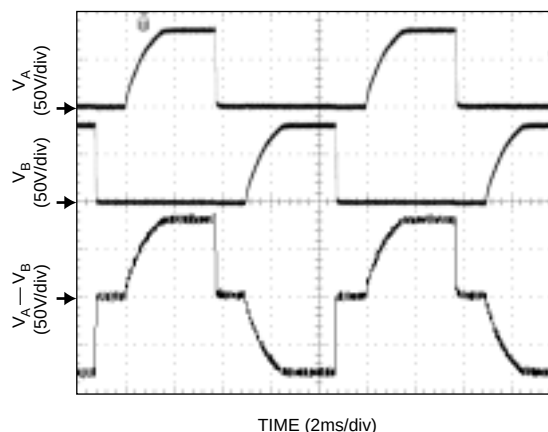
Some applications require a high lamp drive capability but operate from a 1.5V source. The MIC4826/7 family provides high lamp drive, but does not operate directly from a 1.5V source. A technique using split supplies overcomes this

challenge. Many applications that operate from a 1.5V supply employ a voltage booster to provide a nominal 3V. Although this 3V, low current supply usually cannot deliver enough power to drive an EL lamp, a split-supply driver circuit circumvents this obstacle. See Circuit 3 in the “Pre-designed Circuits” section for full information

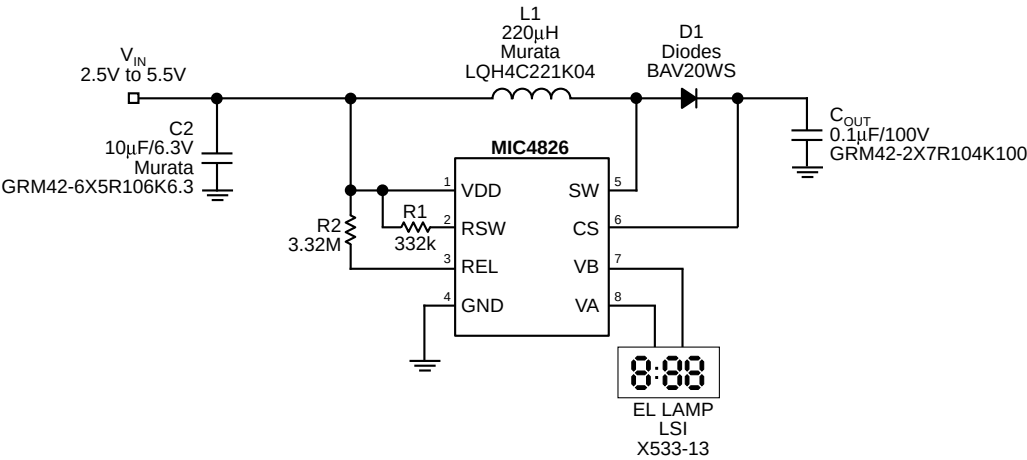
Pre-designed Circuits



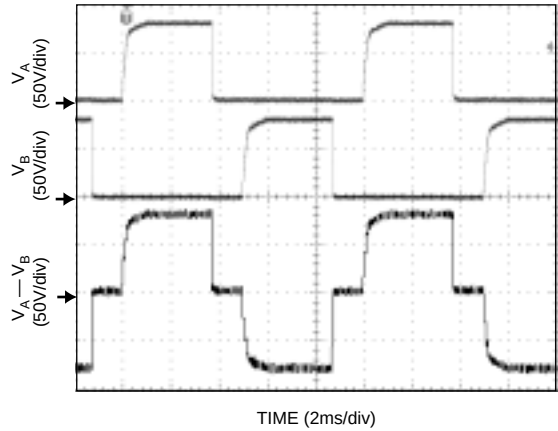
V_{IN}	I_{IN}	$V_A - V_B$	F_{EL}	Lamp Size
3.3V	20mA	160V _{PP}	100Hz	3in ²



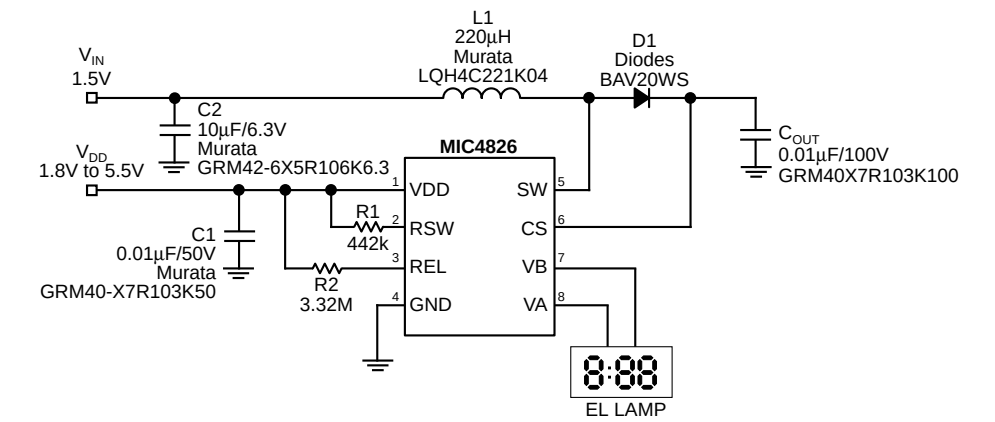
Circuit 1. EL Driver for PDA Application (3in² Lamp)



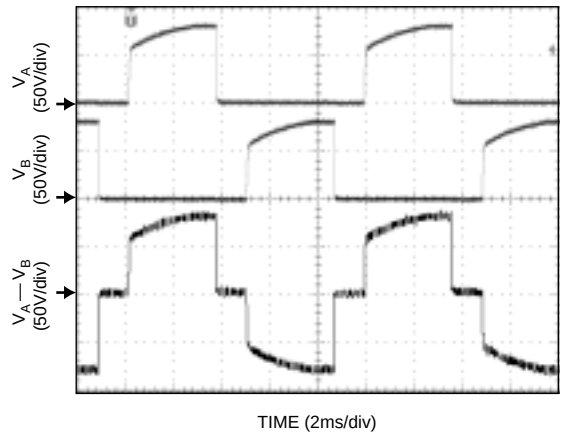
V_{IN}	I_{IN}	$V_A - V_B$	F_{EL}	Lamp Size
3.3V	14mA	160V _{pp}	100Hz	2in ²



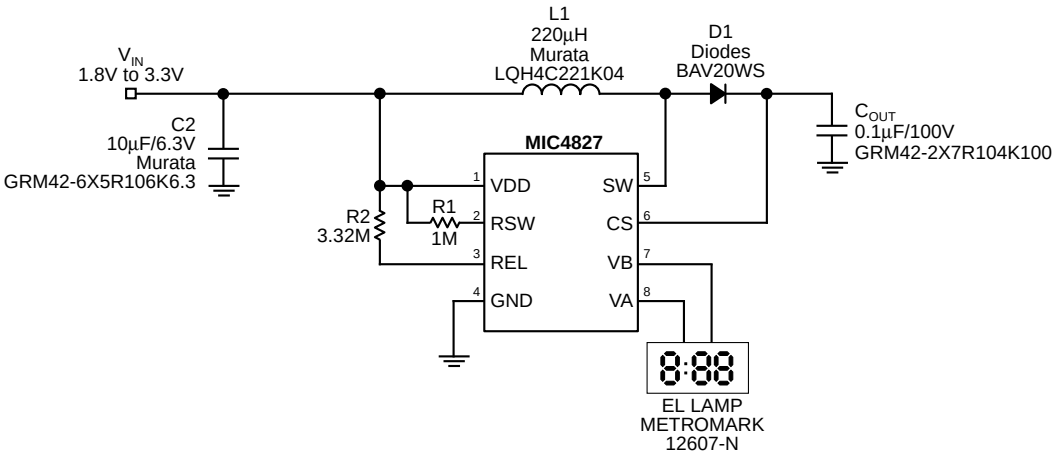
Circuit 2. EL Driver for 2in² Lamp Using 1 Cell Li-Ion Battery or 5V Fixed Input Voltage



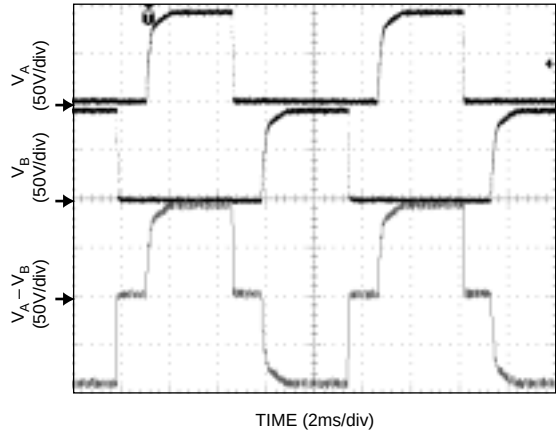
V_{IN}	I_{IN}	V_{DD}	I_{DD}	$V_A - V_B$	F_{EL}	Lamp Size
1.5V	22mA	3.0V	36µA	160V _{PP}	100Hz	1.6in ²



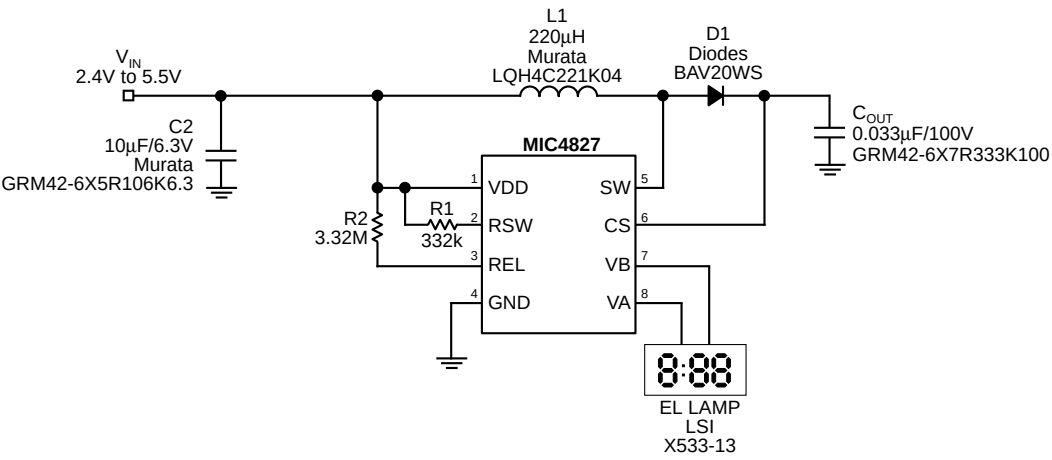
Circuit 3. Split Supply Applications



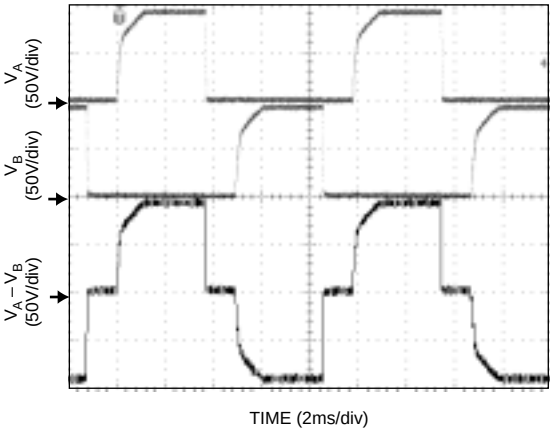
V_{IN}	I_{IN}	$V_A - V_B$	F_{EL}	Lamp Size
3.0V	31mA	180V _{pp}	104Hz	5.3in ²



Circuit 4. EL Driver for Remote Control Lamp
Using 2 Cell Alkaline Batteries



V_{IN}	I_{IN}	$V_A - V_B$	F_{EL}	Lamp Size
3.3V	18mA	180V _{pp}	104Hz	2in ²



Circuit 5. EL Driver for 2in² Lamp with 180V_{pp} Voltage

MICREL INC. 1849 FORTUNE DRIVE SAN JOSE, CA 95131 USA

TEL + 1 (408) 944-0800 FAX + 1 (408) 944-0970 WEB <http://www.micrel.com>

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