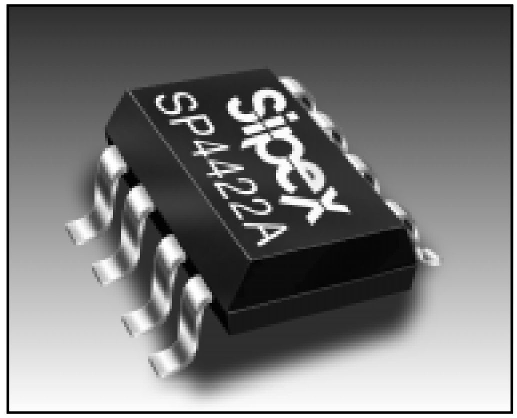
SP4422A

Electroluminescent Lamp Driver

- 2.2V-5.0V Battery Operation
- 50nA Typical Standby Current
- High Voltage Output 160 V_{PP} typical
- Internal Oscillator

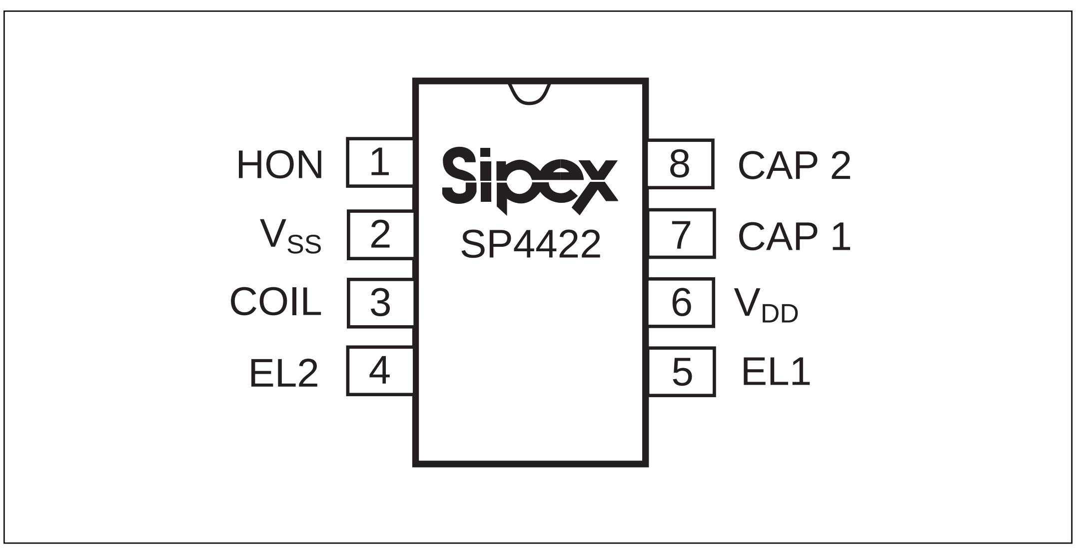
APPLICATIONS

- PDAs
- Cellular Phones
- Remote Controls
- Handheld Computers



DESCRIPTION

The **SP4422A** is a high voltage output DC-AC converter that can operate from a 2.2V-5.0V power supply. The **SP4422A** is capable of supplying up to 220 V_{PP} signals, making it ideal for driving electroluminescent lamps. The device features 50 nA (typical) standby current, for use in low power portable products. One external inductor is required to generate the high voltage, and one external capacitor is used to select the oscillator frequency. The **SP4422A** is offered in an 8-pin narrow and 8-pin micro SOIC packages. For delivery in die form, please consult the factory.



SP4422A Block Diagram

ABSOLUTE MAXIMUM RATINGS

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

V_{DD}..7.0V
Input Voltages/Currents
HON (pin1)...-0.5V to (V_{DD}+0.5V)
COIL (pin3)...60mA
Lamp Outputs...230V_{PP}
Storage Temperature..-65˚C to +150˚C

Power Dissipation Per Package

8-pin NSOIC (derate 6.14mW/°C above +70°C)..................500mW
8-pin µSOIC (derate 4.85mW/°C above +70°C)...................390mW

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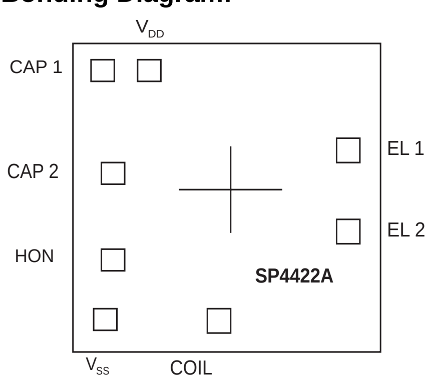
SPECIFICATIONS

(T= 25°C; V_{DD} = 3.0V; Lamp Capacitance = 17nF with 100Ω Series resistor; Coil = 5mH (R_S = 18Ω); C_{OSC} = 100pF unless otherwise noted)

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
Supply Voltage, V_{DD}	2.2	3.0	5.0	V	
Supply Current, I_{COIL}+I_{DD}		20 40	30 60	mA	V_{DD}=3.0V, V_{HON}=3.0V V_{DD}=5.0V, V_{HON}=5.0V
Coil Voltage, V_{COIL}	V_{DD}		5.0	V	
HON Input Voltage, V_{HON} LOW: EL off HIGH: EL on	 -0.25 V_{DD}-0.25	 0 V_{DD}	 0.25V V_{DD}+0.25	V	
HON Current, EL on		25	60	µA	$V_{DD} \leq V_{HON} \leq 3V$
Shutdown Current, I_{SD}=I_{COIL}+I_{DD}		50 0.3	500	nA µA	V_{DD}=3.0V, V_{HON}=LOW V_{DD}=5.0V, V_{HON}=LOW
INDUCTOR DRIVE					
Coil Frequency, f_{COIL}=f_{LAMP}x32		11.2		kHz	
Coil Duty Cycle		94		%	
Peak Coil Current, $I_{PK\text{-}COIL}$			60	mA	Guaranteed by design.
EL LAMP OUTPUT					
EL Lamp Frequency, f_{LAMP}	250 200	352	450 600	Hz	T_{AMB}=+25°C, V_{DD}=3.0V T_{AMB}=-40°C to +85°C, V_{DD}=3.0V
Peak to Peak Output Voltage	60 70 110 180	80 140 200		V_{PP}	T_{AMB}=+25°C, V_{DD}=2.2V T_{AMB}=-40°C to +85°C, V_{DD}=3.0V T_{AMB}=+25°C, V_{DD}=3.0V T_{AMB}=+25°C, V_{DD}=5.0V

This data sheet specifies environmental parameters, final test conditions and limits as well suggested operating conditions. For applications which require performance beyond the specified conditions and or limits please consult the factory.

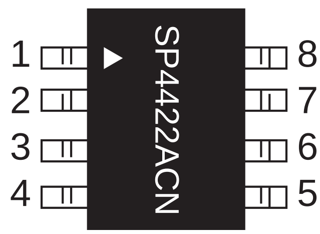
Bonding Diagram:



PAD	X	Y
EL1	556.5	179.0
EL2	556.2	-151.0
COIL	-19.5	-517.0
V_{SS}	-568.0	-517.0
HON	-549.0	-256.5
CAP2	-549.0	93.5
CAP1	-568.0	-516.5
V_{DD}	-349.0	517.0

NOTES:
1. Dimensions are in Microns unless otherwise noted.
2. Bonding pads are 125x125 typical
3. Outside dimensions are maximum, including scribe area.
4. Die thickness is 10mils +/- 1.
5. Pad center coordinates are relative to die center.
6. Die size 1447 x 1346 (57 x 53 mils).

PIN DESCRIPTION



Pin 1 – HON- Enable for driver operation, high = active; low = inactive.

Pin 2 – V_{SS}- Power supply common, connect to ground.

Pin 3 – Coil- Coil input, connect coil from V_{DD} to pin 3.

Pin 4 – Lamp- Lamp driver output2, connect to EL lamp.

Pin 5 – Lamp- Lamp driver output1, connect to EL lamp.

Pin 6 – V_{DD}- Power supply for driver, connect to system V_{DD}.

Pin 7 – Cap1- Capacitor input 1, connect to C_{OSC}.

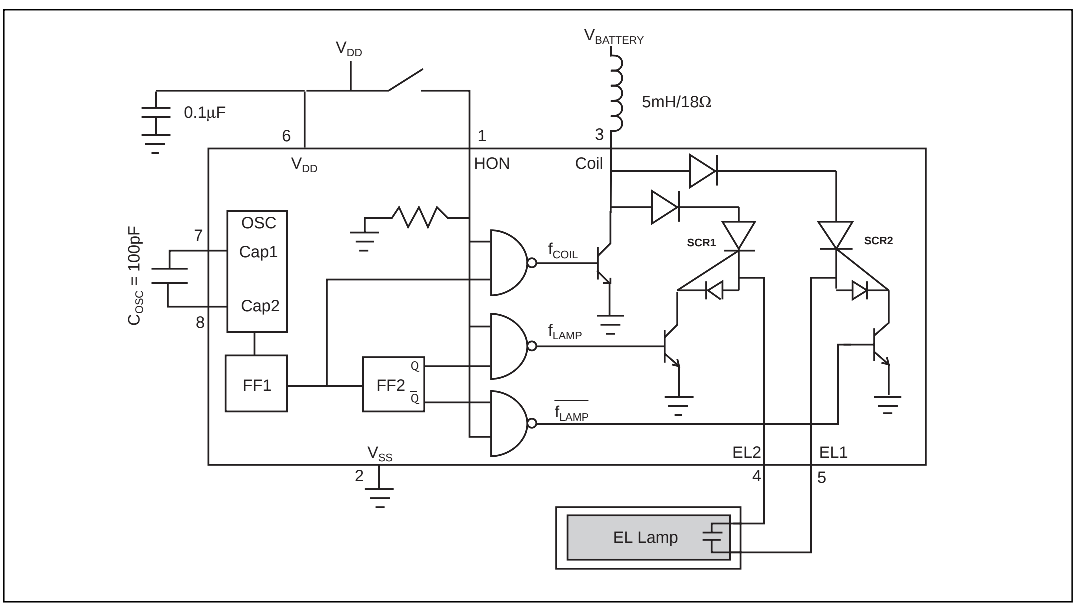
Pin 8 – Cap2- Capacitor input 2, connect to C_{OSC}.

THEORY OF OPERATION

The **SP4422A** is made up of three basic circuit elements, an oscillator, coil, and switched H-bridge network. The oscillator provides the device with an on-chip clock source used to control the charge and discharge phases for the coil and lamp. An external capacitor connected between pins 7 and 8 allows the user to vary the oscillator frequency from 32kHz to 400kHz. The graphs on page 6 show the relationship between C_{OSC} and lamp output voltage. In general, increasing the C_{OSC} capacitor will increase the lamp output.

The suggested oscillator frequency is 90kHz (C_{OSC}=100pF). The oscillator output is internally divided to create two internal control signals, f_{COIL} and f_{LAMP}. The oscillator output is internally divided down by 8 flip flops, a 90kHz signal will be divided into 8 frequencies; 45kHz, 22.5kHz, 11.2kHz, 5.6kHz, 2.8kHz, 1.4kHz, 703Hz, and 352Hz. The third flip flop output (8kHz) is used to drive the coil (see ***figure 2*** on ***page 9)*** and the eighth flip flop output (250Hz) is used to drive the lamp. Although the oscillator frequency can be varied to optimize the lamp output, the ratio of f_{COIL}/f_{LAMP} will always equal 32.

The on-chip oscillator of the **SP4422A** can be overdriven with an external clock source by removing the C_{OSC} capacitor and connecting a



SP4422A Schematic

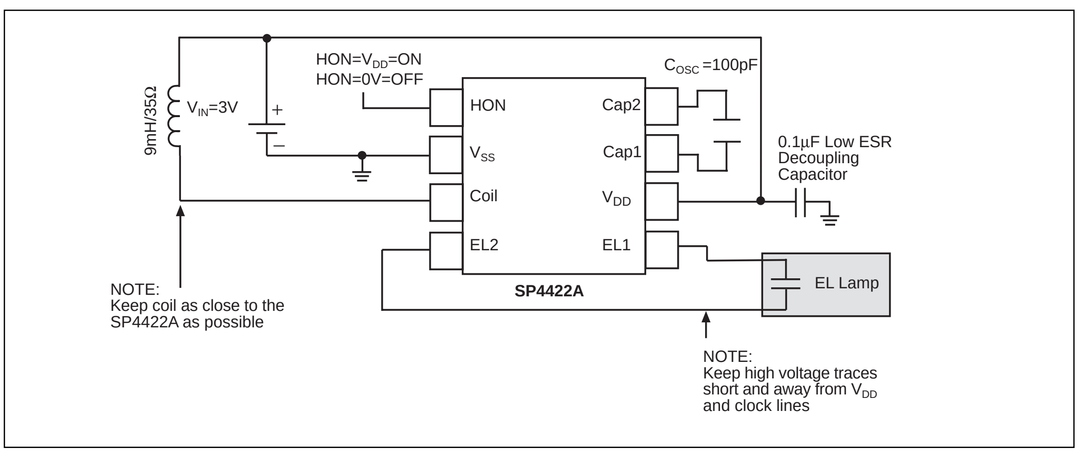
clock source to pin 8. The clock should have a 50% duty cycle and range from V_{DD}-1V to ground. An external clock signal may be desirable in order to synchronize any parasitic switching noise with the system clock. The maximum external clock frequency that can be supplied is 400kHz.

The coil is an external component connected from $V_{BATTERY}$ to pin 3 of the **SP4422A**. Energy is stored in the coil according to the equation $E_L=1/2LI^2$, where I is the peak current flowing in the inductor. The current in the inductor is time dependent and is set by the "ON" time of the coil switch: $I=(V_L/L)t_{ON}$, where V_L is the voltage across the inductor. At the moment the switch closes, the current in the inductor is zero and the entire supply voltage (minus the V_{SAT} of the switch) is across the inductor. The current in the inductor will then ramp up at a linear rate. As the current in the inductor builds up, the voltage across the inductor will decrease due to the resistance of the coil and the "ON" resistance of the switch: $V_L=V_{BATTERY}-IR_L-V_{SAT}$. Since the voltage across the inductor is decreasing, the current ramp-rate also decreases which reduces the current in the coil at the end of t_{ON} the energy stored in the inductor per coil cycle and therefore the light output. The other important issue is that maximum current (saturation current) in the coil is set by the design and manufacturer of the coil. If the parameters of the application such as $V_{BATTERY}$, L, RL or ton cause the current in the coil to increase beyond its rated I_{SAT}, excessive heat will be generated and the power efficiency will decrease with no additional light output. The **Sipex SP4422A** is final tested using a 5mH/18Ω coil from Hitachi Metals. For suggested coil sources see ***page 10***.

The supply V_{DD} can range from 2.2 to 5.0V. It is not necessary that $V_{DD} = V_{BATTERY}$. $V_{BATTERY}$ should not exceed max coil current specification. The majority of the current goes through the coil and is typically much greater than I_{DD}.

The f_{COIL} signal controls a switch that connects the end of the coil at pin 3 to ground or to open circuit. The f_{COIL} signal is a 94% duty cycle signal switching at 1/8 the oscillator frequency. For a 64kHz oscillator f_{COIL} is 8kHz. During the time when the f_{COIL} signal is high, the coil is connected from $V_{BATTERY}$ to ground and a charged magnetic field is created in the coil. During the low part of f_{COIL}, the ground connection is switched open, the field collapses and the energy in the inductor is forced to flow toward the high voltage H-bridge switches. f_{COIL} will send 16 of these charge pulses (see ***figure 2*** on ***page 9***) to the lamp, each pulse increases the voltage drop across the lamp in discrete steps. As the voltage potential approaches its maximum, the steps become smaller (see ***figure 1*** on ***page 9***).

The H-bridge consists of two SCR structures that act as high voltage switches. These two switches control the polarity of how the lamp is charged. The SCR switches are controlled by the f_{LAMP} signal which is the oscillator frequency divided by 256. For a 64kHz oscillator, f_{LAMP}=256Hz.



Typical SP4422A Application Circuit

When the energy from the coil is released, a high voltage spike is created triggering the SCR switches. The direction of current flow is determined by which SCR is enabled. One full cycle of the H-bridge will create 16 voltage steps from ground to 80V (typical) on pins 4 and 5 which are 180 degrees out of phase from each other (see ***figure 3*** on ***page 9***. A differential representation of the outputs is shown in ***figure 4*** on ***page 9***.

Layout Considerations

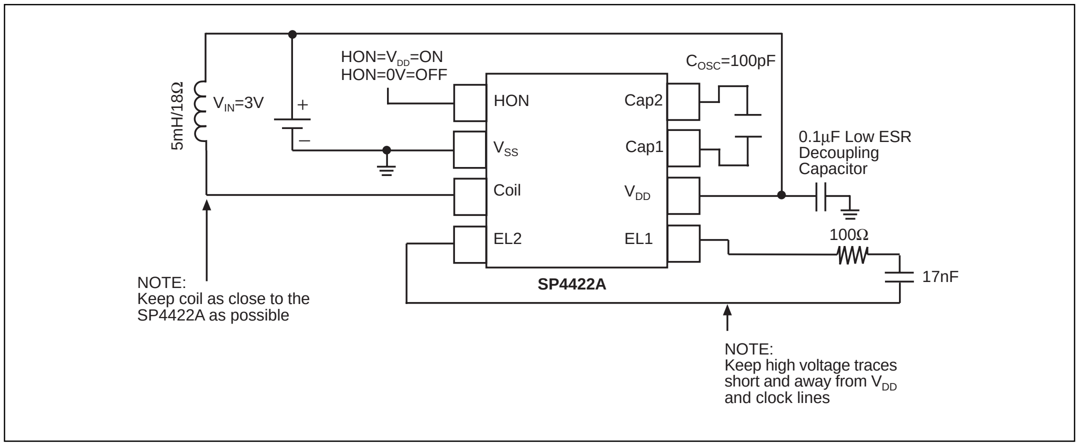
The **SP4422A** circuit board layout must observe careful analog precautions. For applications with noisy voltage power supplies a 0.1µF low ESR decoupling capacitor must be connected from V_{DD} to ground. Any high voltage traces should be isolated from any digital clock traces or enable lines. A solid ground plane connection is strongly recommended. All traces to the coil or to the high voltage outputs should be kept as short as possible to minimize capacitive coupling to digital clock lines and to reduce EMI emissions.

Electroluminescent Technology

What is electroluminescence?
An EL lamp is basically a strip of plastic that is coated with a phosphorous material which emits light (fluoresces) when a high voltage (>40V) which was first applied across it, is removed or reversed. Long periods of DC voltages applied to the material tend to breakdown the material and reduce its lifetime. With these considerations in mind, the ideal signal to drive an EL lamp is a high voltage sine wave. Traditional approaches to achieving this type of waveform included discrete circuits incorporating a transformer, transistors, and several resistors and capacitors. This approach is large and bulky, and cannot be implemented in most hand held equipment. **Sipex** now offers low power single chip driver circuits specifically designed to drive small to medium sized electroluminescent panels. All that is required is one external inductor and capacitor.

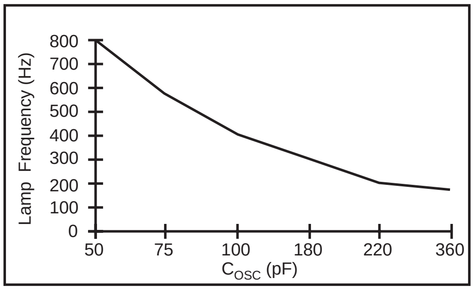
Electroluminescent backlighting is ideal when used with LCD displays, keypads, or other backlit readouts. Its main use is to illuminate displays in dim to dark conditions for momentary periods of time. EL lamps typically consume less than LEDs or bulbs making them ideal for battery powered products. Also, EL lamps are able to evenly light an area without creating "hot spots" in the display.

The amount of light emitted is a function of the voltage applied to the lamp, the frequency at which it is applied, the lamp material used and its size, and lastly, the inductor used. There are many variables which can be optimized for specific applications. **Sipex** supplies characterization charts to aid the designer in selecting the optimum circuit configuration (see ***page 6***).

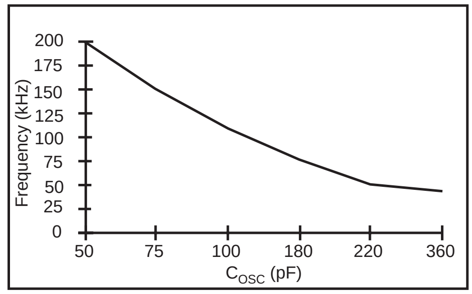


SP4422A Test Circuit

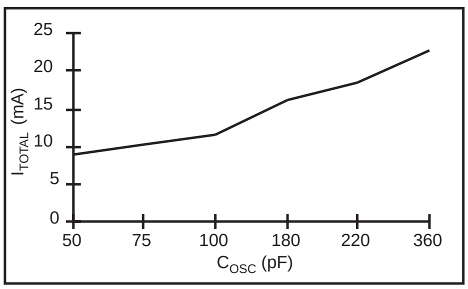
The following performance curves are intended to give the designer a relative scale from which to optimize specific applications. Absolute measurements may vary depending upon the brand of components chosen.



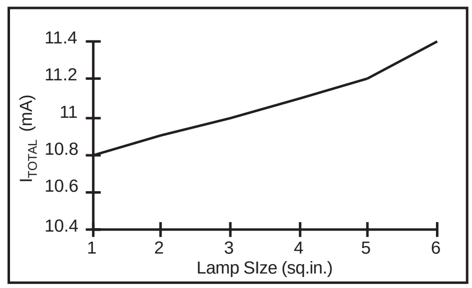
Lamp Frequency vs C_{OSC}
V_{DD}= 3.0V; Coil= 9mH, 35Ω; Lamp=1 sq. in.



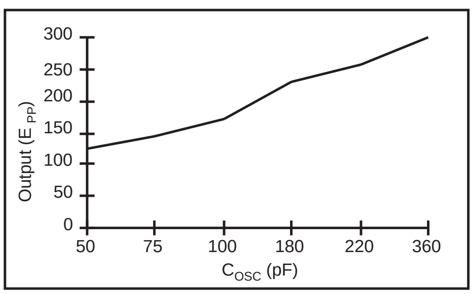
Oscillator Frequency vs C_{OSC}
V_{DD}= 3.0V; Coil= 9mH, 35Ω; Lamp=1 sq. in.



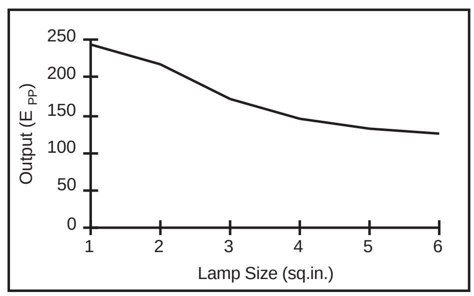
I_{TOTAL} vs C_{OSC}
V_{DD}= 3.0V; Coil= 9mH, 35Ω; Lamp=1 sq. in.



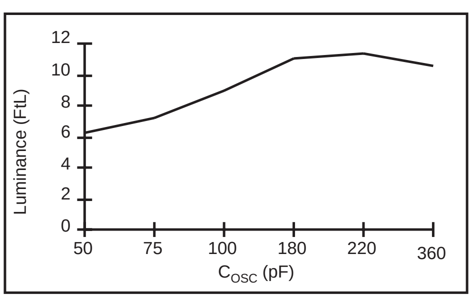
I_{TOTAL} vs Lamp Size
V_{DD}= 3.0V; Coil= 9mH, 35Ω; C_{OSC} = 180pF



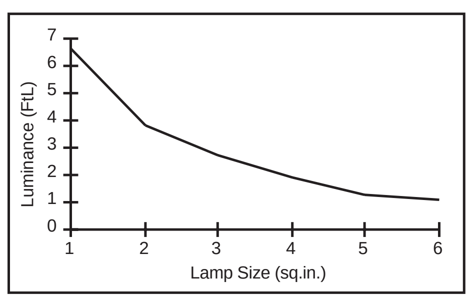
Output Voltage vs C_{OSC}
V_{DD}= 3.0V; Coil= 9mH, 35Ω; Lamp=1 sq. in.



Output Voltage vs Lamp Size.
V_{DD}= 3.0V; Coil= 9mH, 35Ω; C_{OSC}= 180pF

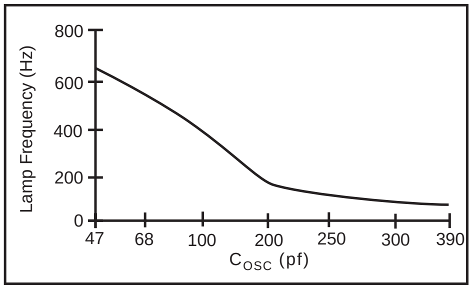


Luminance vs C_{OSC}
V_{DD}= 3.0V; Coil= 9mH, 35Ω; Lamp=1 sq. in.

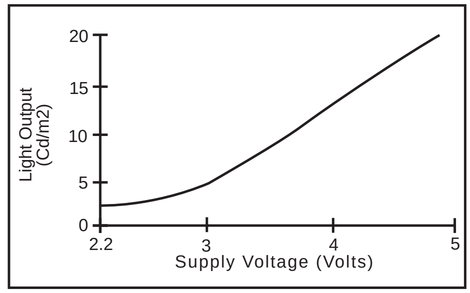


Luminance vs Lamp Size.
V_{DD}= 3.0V; Coil= 9mH, 35Ω; C_{OSC}= 180pF

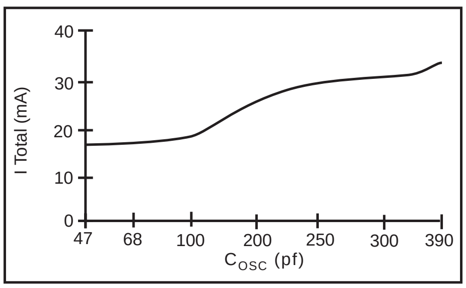
The following performance curves are intended to give the designer a relative scale from which to optimize specific applications. Absolute measurements may vary depending upon the brand of components chosen.



Lamp Frequency vs. C_{OSC}
V_{DD}= 3.0V; Coil= 5mH, 18Ω; Load=10nF



Luminance vs. V_{DD}=Vcoil
V_{DD}=3.0V; Coil=5mH, 18Ω; Load=10nF



I_{TOTAL} vs. C_{osc}
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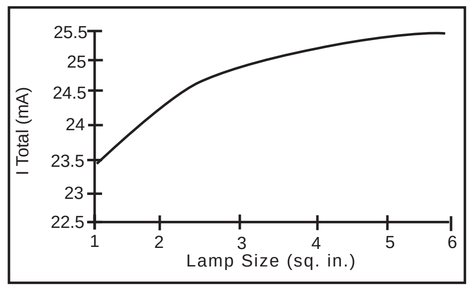
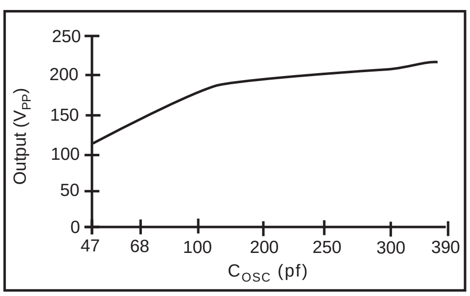
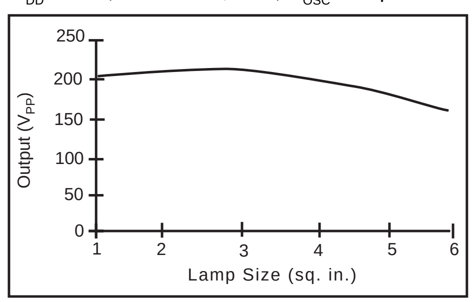


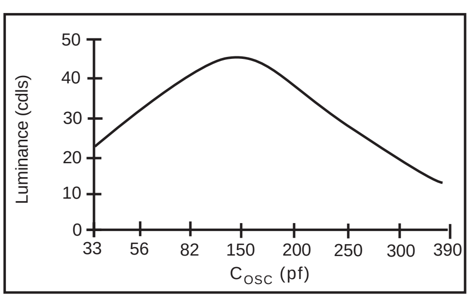
I_{TOTAL} vs. Lamp Size
V_{DD}= 3.0V; Coil= 5mH, 18Ω; C_{OSC}=100pF



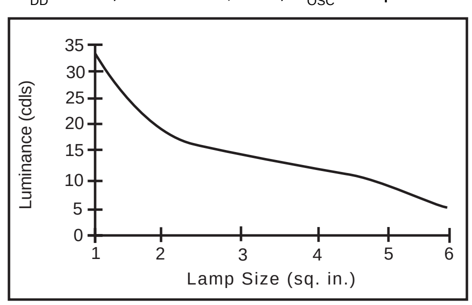
Output Voltage vs. C_{OSC}
V_{DD}= 3.0V; Coil= 5mH, 18Ω; Load=10nF



Output Voltage vs. Lamp Size.
V_{DD}= 3.0V; Coil= 5mH, 18Ω; C_{OSC}=100pF

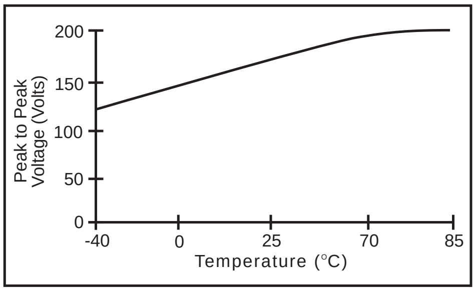


Luminance vs. C_{OSC}
V_{DD}= 3.0V; Coil= 5mH, 18Ω; Load=10nF

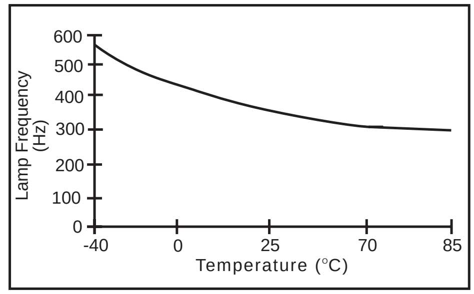


Luminance vs. Lamp Size.
V_{DD}= 3.0V; Coil= 5mH, 18Ω; C_{OSC}=100pF

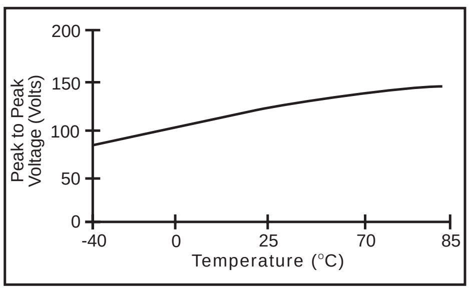
The following performance curves are intended to give the designer a relative scale from which to optimize specific applications. Absolute measurements may vary depending upon the brand of components chosen.



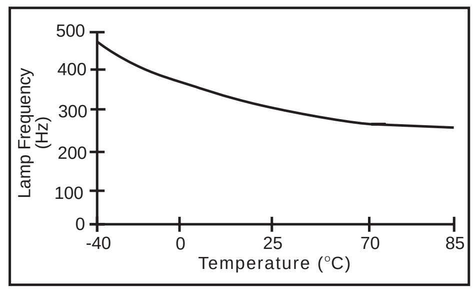
Peak to Peak Voltage vs. Temperature
V_{DD}=3.0V; Coil=5mH/18Ω; C_{OSC}=100pF; Load=10nF



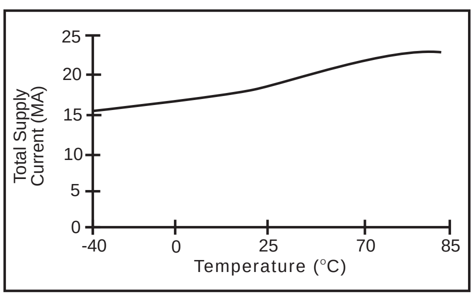
Lamp Frequency vs. Temperature
V_{DD}=3.0V; Coil=5mH/18Ω; C_{OSC}=100pF; Load=10nF



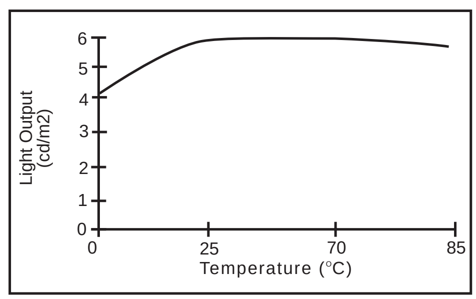
Peak to Peak Voltage vs. Temperature
V_{DD}=2.2V; Coil=5mH/18Ω; C_{OSC}=100pF; Load=10nF



Lamp Frequency vs. Temperature
V_{DD}=2.2V; Coil=5mH/18Ω; C_{OSC}=100pF; Load=10nF



Total Supply Current vs. Temperature
V_{DD}=3.0V; Coil=5mH/18Ω; C_{OSC}=100pF; Load=10nF



Light Output vs. Temperature
V_{DD}=3.0V; Coil=5mH/18Ω; C_{OSC}=100pF; Lamp=6sq.in.

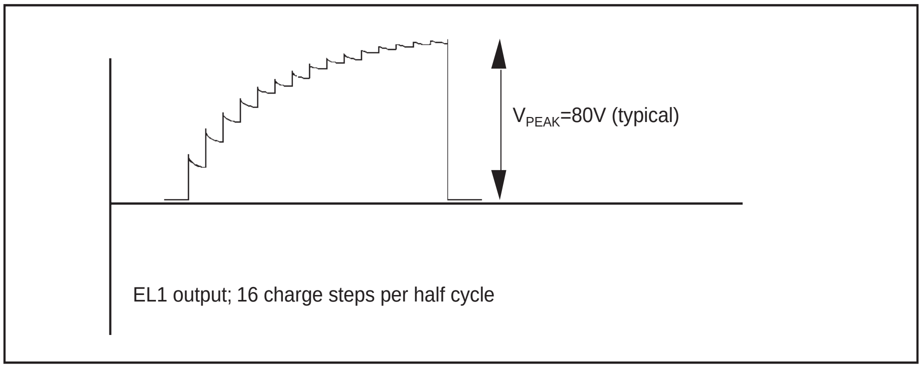


Figure 1. EL output voltage in discrete steps at EL1 output

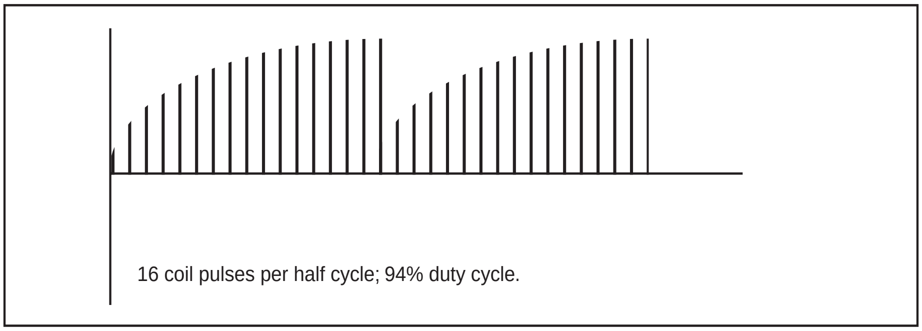


Figure 2. Voltage pulses released from the coil to the EL driver circuitry

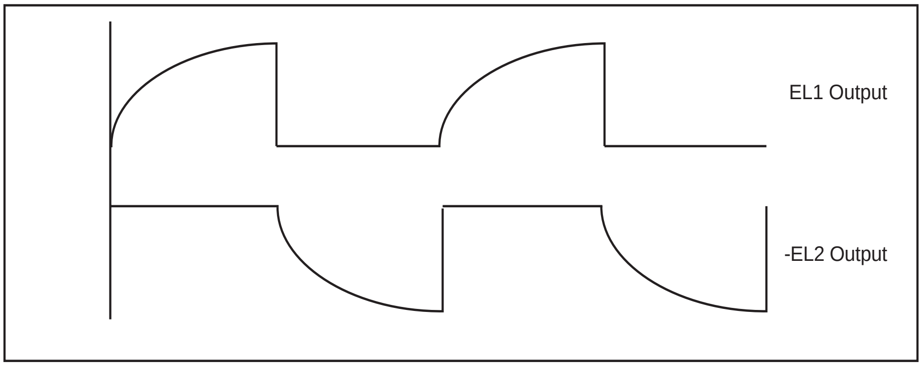


Figure 3. EL voltage waveforms from the EL1 and EL2 outputs

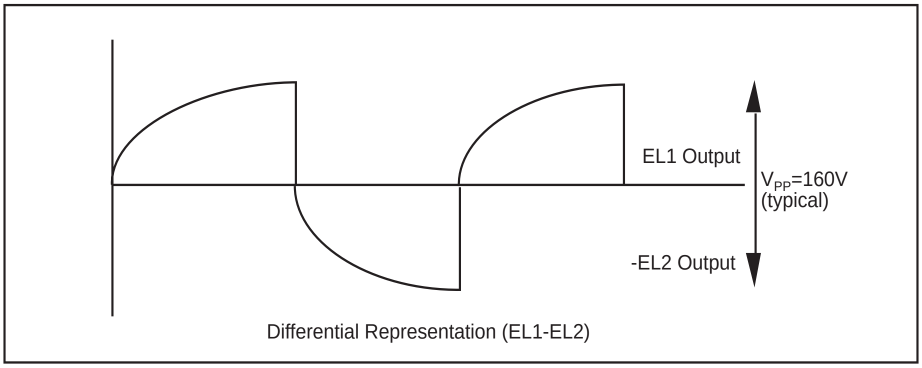
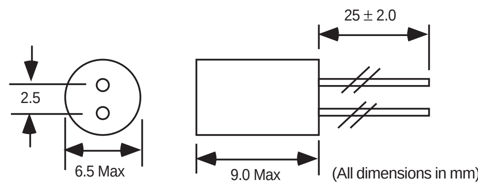


Figure 4. EL differential output waveform of the EL1 and EL2 outputs

The coil part numbers presented in this data sheet have been qualified as being suitable for the SP4422A product. Contact Sipex for applications assistance in choosing coil values not listed in this data sheet.

CTC Coils LTD Hong Kong
Ph: 85-2695-4889
Fax: 85-2695-1842

Mark Technologies:
North American Stocking
distributor for Sankyo and CTC
Ph: 905-891-0165
Fax: 905-891-8534



Model Numbers: CH5070AS-203K-006 (20mH, 65Ω)
Sipex Number: S51208-M-1021-Sipex

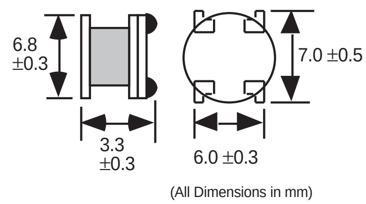
HITACHI METALS Ltd. Japan
Ph: 3-3284-4936
Fax: 3-3287-1945

HITACHI METALS Singapore
Ph: 65-222-3077
Fax: 65-222-5232

HITACHI METALS Hong Kong
Ph: 852-2724-4183
Fax: 852-2311-2093

HITACHI METALS Chicago, IL
Ph: 847-364-7200
Fax: 847-364-7279

Part Numbers:
MD735L902B (9mH ± 20% 41Ω)
MD735L502A (5mH ± 20% 19.8Ω)



Toko Inc. Japan
Ph: 03-3727-1161
Fax: 03-3727-1176

Toko America Inc. USA
Ph: 847-297-0070
Fax: 847-699-7864

Part Numbers:
667MA-472N (4.7mH, 13Ω)

Toko Inc. Singapore
Ph: 255-4000
Fax: 250-8134

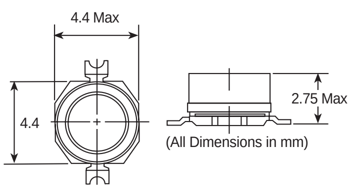
Toko Germany
Ph: 49-7156-96-060
Fax: 49-7156-96-06-26

Toko U.K.
Ph: 1753-854057-9
Fax: 1753-8503-23

Toko Korea
Ph: 0551-50-5500
Fax: 0551-93-1110

Toko France
Ph: 01-4557-4465
Fax: 01-4554-2837

Toko Hong Kong
Ph: 2342-8131
Fax: 2341-9570



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muRata USA
Ph: 770-436-1300
Fax: 770-436-3030

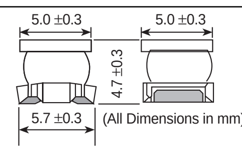
muRata Europe
Ph: 49-9116-6870
Fax: 49-1166-8722-5

muRata Taiwan
Ph: 88-6429-1415-1
Fax: 88-6442-5292-9

muRata Singapore
Ph: 65-758-4233
Fax: 65-753-6181

muRata Hong Kong
Ph: 85-2237-6389-8
Fax: 85-2237-5556-55

Part Numbers:
LQN6C472M04 (4.7mH, 35Ω)
LQN6C103M04 (10mH, 80Ω)



Coilcraft USA
Ph: 847-639-6400
Fax: 847-639-1469

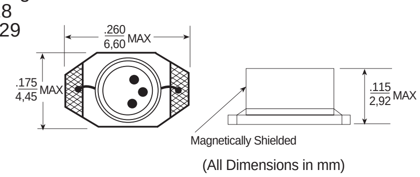
Coilcraft Europe
Ph: 44-01236-730595
Fax: 44-01236-730627

Part Numbers:
DS1608C-106 (10mH, 32Ω)

Coilcraft Taiwan
Ph: 886-2-264-3646
Fax: 886-2-270-0294

Coilcraft Singapore
Ph: 65-296-6933
Fax: 465-296-4463 #382

Coilcraft Hong Kong
Ph: 852-770-9428
Fax: 852-770-0729



EL polarizers/transflector manufacturers

Nitto Denko
San Jose, CA
Phone: (510) 445-5400

Astra Products
Baldwin, NJ
Phone: (516) 223-7500
Fax: (516) 868-2371

EL Lamp manufacturers

Metro Mark/Leading Edge
Minnetonka, MN
Phone: (800) 680-5556
Phone: (612) 912-1700

Midori Mark Ltd.
1-5 Komagata 2-Chome
Taita-Ku 111-0043 Japan
Phone: 81-03-3848-2011

Luminescent Systems Inc. (LSI)
Lebanon, NH
Phone: (603) 643-7766
Fax: (603) 643-5947

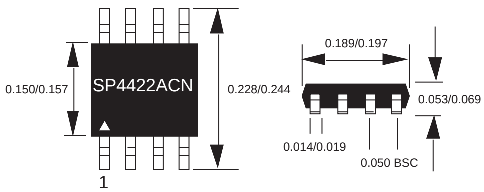
NEC Corporation
Tokyo, Japan
Phone: (03) 3798-9572
Fax: (03) 3798-6134

Seiko Precision
Tokyo, Japan
Phone: (03) 5610-7089
Fax: .) 5610-7177

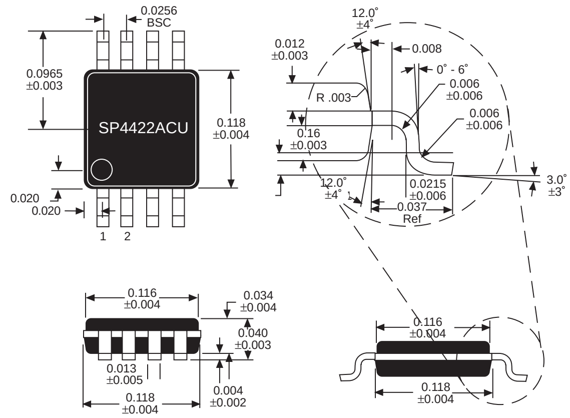
Gunze Electronics
2113 Wells Branch Parkway
Austin, TX 78728
Phone: (512) 752-1299
Fax: (512) 252-1181

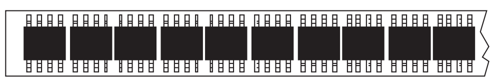
All package dimensions in inches

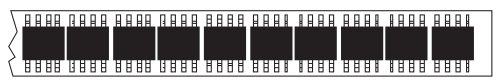
8-pin NSOIC



8-pin μSOIC

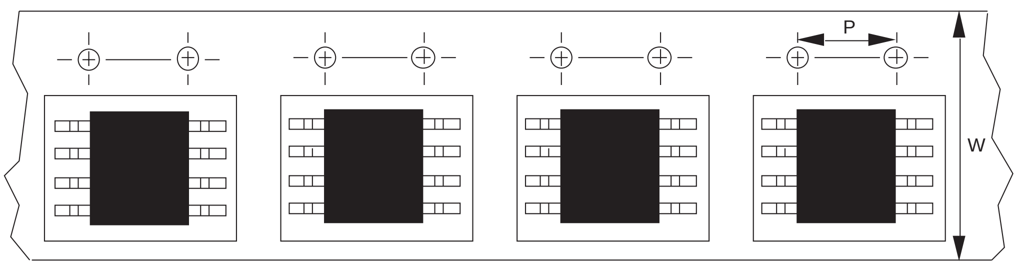






95 SP4422ACN per tube, no minimum quantity

50 SP4422ACU per tube



NSOIC-8 13" reels: P=8mm, W=12mm μSOIC-8 13" reels: P=8mm, W=12mm			
Pkg.	Minimum qty per reel	Standard qty per reel	Maximum qty per reel
ACN	500	2500	3000
ACU	500	2500	3000

ORDERING INFORMATION

Model	Operating Temperature Range	Package Type
SP4422ACN	-40˚C to +85˚C	8-Pin NSOIC
SP4422ACU	-40˚C to +85˚C	8-Pin µSOIC
SP4422ACX	-40˚C to +85˚C	Die
SP4422ANEB	N/A	Evaluation Board
SP4422AUEB	N/A	Evaluation Board

Please consult the factory for pricing and availability on a Tape-On-Reel option.

Sipex Corporation

SIGNAL PROCESSING EXCELLENCE

Sipex Corporation

Headquarters and
Sales Office
22 Linnell Circle
Billerica, MA 01821
TEL: (978) 667-8700
FAX: (978) 670-9001
e-mail: sales@sipex.com

Sales Office
233 South Hillview Drive
Milpitas, CA 95035
TEL: (408) 934-7500
FAX: (408) 935-7600