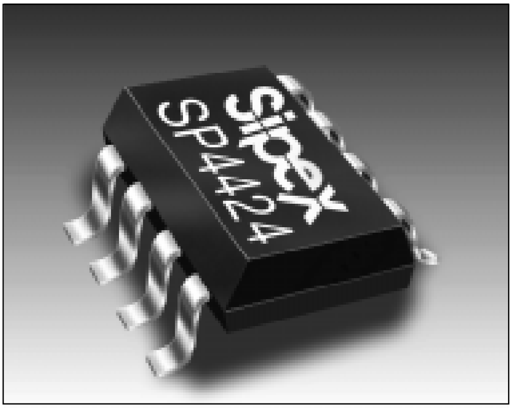
# Electroluminescent Lamp Driver
# Dual Oscillators

- DC to AC Inverter for EL Backlit Display Panels
- 2.2V - 5.0V Battery Operation
- Dual Oscillator Operation for Application Flexibility
- Low Current Standby Mode

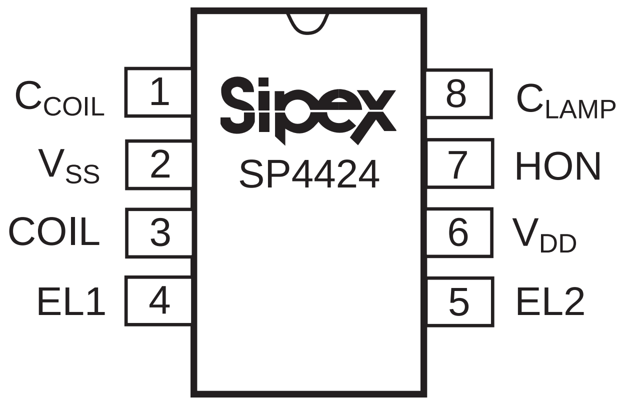



**APPLICATIONS**

- PDAs
- Cellular Phones
- Remote Controls
- Hand Held Computers

## DESCRIPTION

The **SP4424** is a high voltage output DC-AC converter that can operate from a single battery supply voltage as low as 2.2V. The **SP4424** is capable of supplying up to 220 $V_{PP}$ signals, making it ideal for driving electroluminescent lamps. The device features 5µA (maximum) standby current, for use in low power portable products. An inductor is used to generate high voltage pulses, and two external capacitors are used to select the inductor and the lamp oscillator frequencies. The **SP4424** is offered in both an 8-pin narrow SOIC and 8-pin micro SOIC packages. For delivery in die form, please consult the factory.




*SP4424 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.

$V_{DD}$.......................................................................................................7.0
V Input Voltages/Currents
HON (pin1)..............................................................-0.5V to ($V_{DD}$+0.5V)
COIL (pin3).................................................................................60mA
Lamp Outputs...........................................................................230$V_{PP}$
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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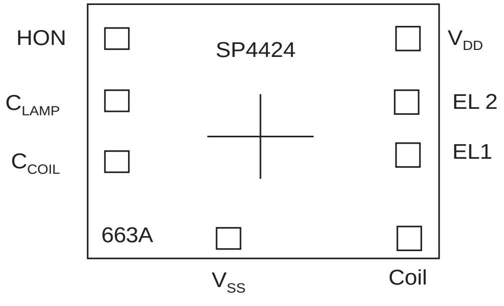
## SPECIFICATIONS

(T= 25°C; $V_{DD}$ =3.0V; Lamp Load = 55nF; Coil = 5mH at 18 Ohms; Coil OSC = 220pF, Lamp OSC = 1500pF unless otherwise noted)

| PARAMETER | MIN. | TYP. | MAX. | UNITS | CONDITIONS |
|---|---|---|---|---|---|
| Supply Voltage, $V_{DD}$ | 2.2 | 3.0 | 5.0 | V | |
| Supply Current, $I_{COIL}+I_{DD}$ | | 35 | 50 | mA | $V_{HON}$=3V |
| Coil Voltage, $V_{COIL}$ | $V_{DD}$ | . | 5.0. | V | |
| HON Input Voltage, $V_{HON}$<br>LOW: EL off<br>HIGH: EL on | <br>-0.25<br>$V_{DD}$-0.25 | <br>0<br>$V_{DD}$ | <br>0.25V<br>$V_{DD}$+0.25 | V | |
| HON Current, EL on | | | 10 | µA | internal pulldown, $V_{HON}=V_{DD}$=3V |
| Shutdown Current, $I_{SD}=I_{COIL}+I_{DD}$ | | 1 | 5 | µA | $V_{HON}$=0V |
| **INDUCTOR DRIVE** | | | | | |
| Coil Frequency, $f_{COIL}$ | 3 | 4 | 6 | kHz | |
| Coil Duty Cycle | | 75 | | % | |
| Peak Coil Current, $I_{PK-COIL}$ | | | 60 | mA | Guaranteed by design. |
| **EL LAMP OUTPUT** | | | | | |
| EL Lamp Frequency, $f_{LAMP}$ | 150<br>100 | 200 | 250<br>400 | Hz | $T_{AMB}$=+25°C<br>$T_{AMB}$=-40°C to +85°C |
| Peak to Peak Output Voltage | 60<br>100<br>60<br>120 | 90<br>130<br><br>160 | | $V_{PP}$ | $T_{AMB}$=+25°C, $V_{DD}$=2.2V<br>$T_{AMB}$=+25°C, $V_{DD}$=3.0V<br>$T_{AMB}$=-40°C to +85°C, $V_{DD}$=3.0V<br>$T_{AMB}$=+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.

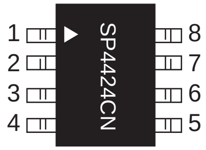
## Bonding Diagram:




| PAD | X | Y |
|---|---|---|
| EL1 | 586.0 | 187.0 |
| EL2 | 586.0 | -143.0 |
| COIL | 586.0 | -376.0 |
| $V_{SS}$ | -80.0 | -417.0 |
| HON | -562.5 | 397.0 |
| CAP2 | -565.0 | -118.0 |
| CAP1 | -562.5 | 114.5 |
| $V_{DD}$ | 588.0 | 417.0 |

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 10 mils +/- 1.
5. Pad center coordinates are relative to die center.
6. Die size 1498 x 1168 ( 59 x 46 mils).

## PIN DESCRIPTION




Pin 1 – $C_{COIL}$- Connect Capacitor from $V_{SS}$ to pin 1 to set coil frequency.

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

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

Pin 4 – EL1- Lamp driver output 1, connect to EL lamp.

Pin 5 – EL2- Lamp driver output 2, connect to EL lamp.

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

Pin 7 – HON- Enable for driver operation, high = active; low = inactive.

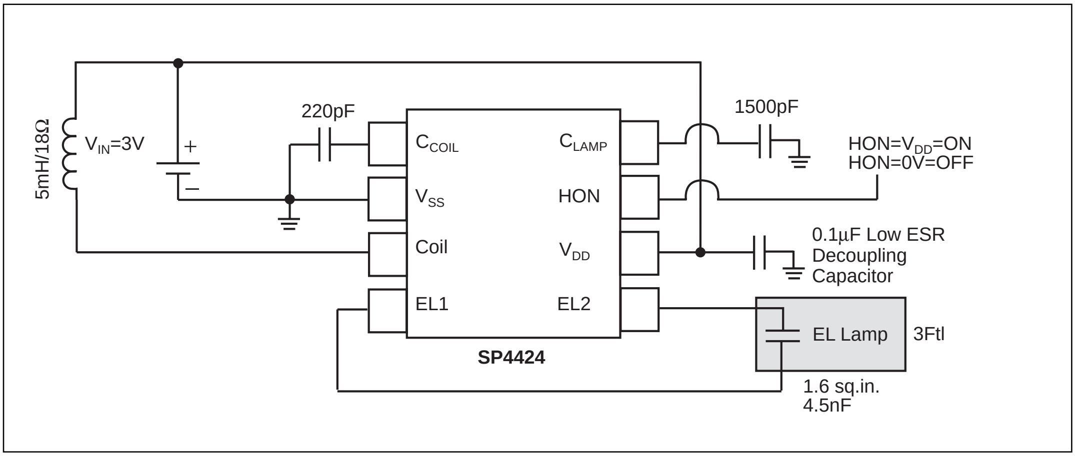
Pin 8 – $C_{LAMP}$- connect Capacitor from $V_{SS}$ to pin 8 to set lamp frequency.

## THEORY OF OPERATION

The **SP4424** is made up of four basic circuit elements: two precision oscillators, a coil, and the EL driver IC. The oscillators set the coil and lamp frequencies independently. This allows for the selective setting of the coil / lamp frequency ratio. The coil frequency can be selected for maximum energy transfer per cycle for a given coil value. The coil oscillator is designed to operate at 75% duty cycle and the lamp oscillator is designed for 50% DC, for minimum DC offset across the EL lamp.

An external capacitor connected between pin 8 and $V_{SS}$ allows the user to vary the lamp oscillator frequency from approximately 75Hz (4700 pf) to 350Hz (450 pf). Likewise, an external capacitor connected between pin 1 and $V_{SS}$ allows the user to vary the coil oscillator frequency from approximately 5kHz (390 pf) to 50kHz (22 pf). The graphs on ***page 7*** show the relationship between oscillators ($L_{OSC}$ and $C_{OSC}$) and their respective capacitor values.

The coil is an external component connected from $V_{BATTERY}$ to pin 3 of the **SP4424**. 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




***SP4424 Typical Application***

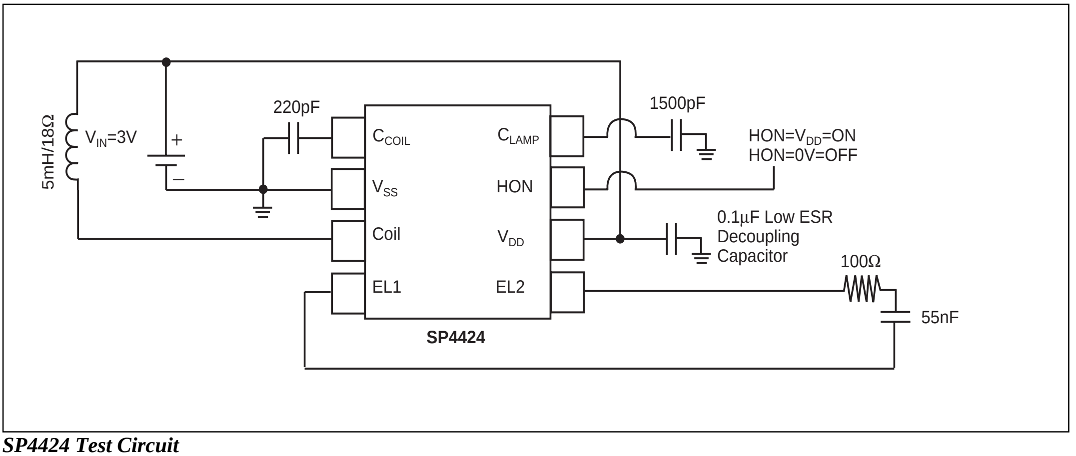
linear rate. As the current in the inductor builds up, the voltage across the inductor will decrease due to the resistance of the coil and the "ON" resistance of the switch: $V_L = V_{BATTERY} - IR_L - V_{SAT}$. Since the voltage across the inductor is decreasing, the current ramp-rate also decreases 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 majority of the current goes through the coil and typically less than 3 mA is required for $V_{DD}$ of the **SP4424**. $V_{DD}$ can range from 2.2V to 5V; it is not necessary that $V_{DD} = V_{BATTERY}$. For example, an unregulated voltage source (3.3V) can be directly connected to the coil, while a regulated voltage source (2.85V) can be connected to the IC $V_{DD}$ pin.

Coil performance is also a function of the core material and wire used -- performance variances may be noticeable from different coil suppliers. The Sipex **SP4424** is tested using a 5mH/18Ω coil from Hitachi Metals. For suggested coil sources see ***page 9.***

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 75% duty cycle signal. During the time when the $f_{COIL}$ signal is high, the coil is connected from $V_{BATTERY}$ to ground and a magnetic field is generated in the coil. During the low part of $f_{COIL}$ , the ground connection is switched open, the field collapses and the voltage generated in the inductor is directed to the high voltage H-bridge switches. $f_{COIL}$ will send as many charge pulses as possible in 1 Lamp Cycle. {Number of Coil pulses in 1 lamp cycle =} $\frac{1}{2}$ x $\frac{\text{Coil Freq.}}{\text{Lamp Freq}}$ } (see ***figure 2*** on ***page 6***). 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 6***).

The H-bridge consists of two SCR structures that act as high voltage switches. These two switches control the polarity of the lamp (capacitor) as it is charged. The SCR switches are controlled by the $f_{LAMP}$ signal which is the oscillator frequency divided by 2.

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 a number of voltage steps from ground to 65V (typical) on pins 4 and 5 which are 180 degrees out of phase (see ***figure 3*** on ***page 6***). A differential view of the outputs is shown in ***figure 4*** on ***page 6***.




***SP4424 Test Circuit***

## CIRCUIT LAYOUT CONSIDERATIONS:

The **SP4424** IC incorporates two independent asynchronous oscillators, one of which supplies the signal for switching of the coil transistor which generates the coil charge pulses and the other supplies the clock signal to switch the high voltage H-bridge output circuit.

It is necessary to keep all high voltage signals away from these oscillator clock signals as much as possible as crosstalk between the two signals can cause distortion in the EL drive signal which can result in either low light output or blinking of the EL lamp. It is always recommended that a low ESR decoupling capacitor (0.1 µF or >) be used between the $V_{DD}$ (pin 6) and ground (pin 2). The $V_{SS}$ (gnd) pin should in turn be connected to the system ground plane. If it is connected via a circuit trace, this trace should be as short and as wide as possible.

## 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. 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, power hungry, expensive and bulky, and would be difficult to 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 for use with LCD displays, keypads, or other backlit readouts. Its primary use is to illuminate displays in dim to dark conditions for momentary periods of time. EL lamps typically consume less current 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 level applied to the lamp, the frequency at which it is applied and the lamp size and method of construction . There are many variables which can be optimized for specific applications. **Sipex** supplies custom characterization data to aid the designer in selecting the optimum circuit configuration.

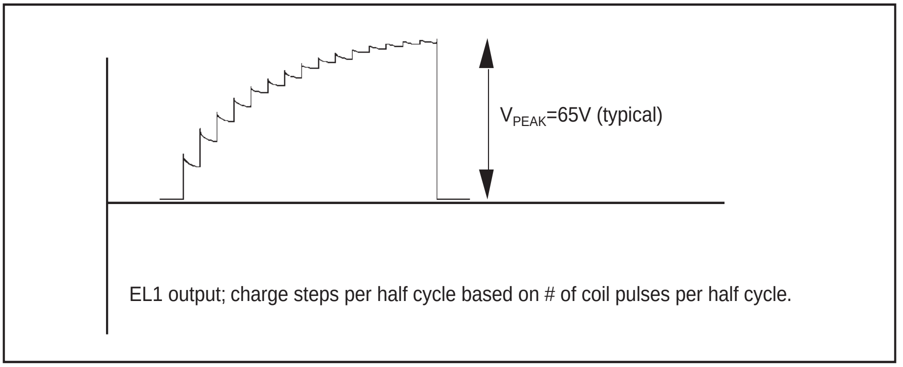



*Figure 1. EL output voltage in discrete steps at EL1 output*

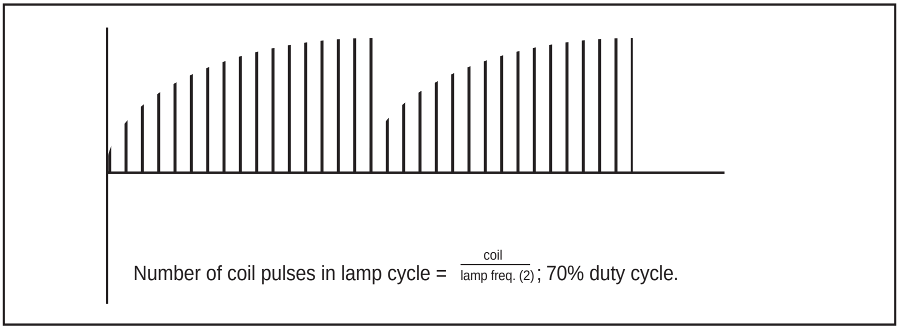



*Figure 2. Voltage pulses released from the coil to the EL driver circuitry*

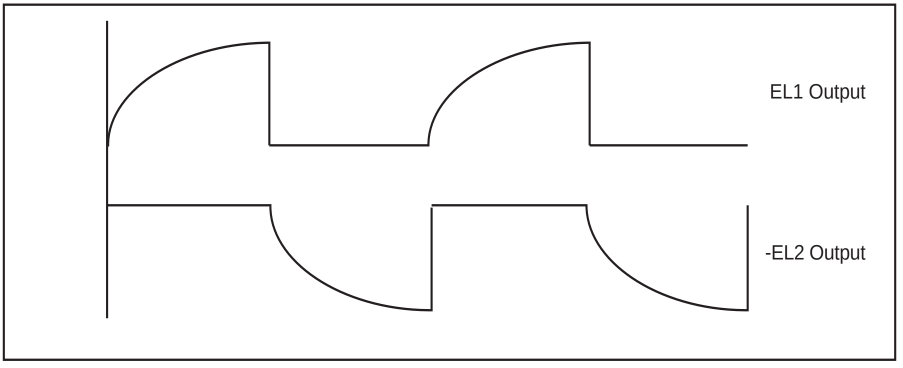



*Figure 3. EL voltage waveforms from the EL1 and EL2 outputs*

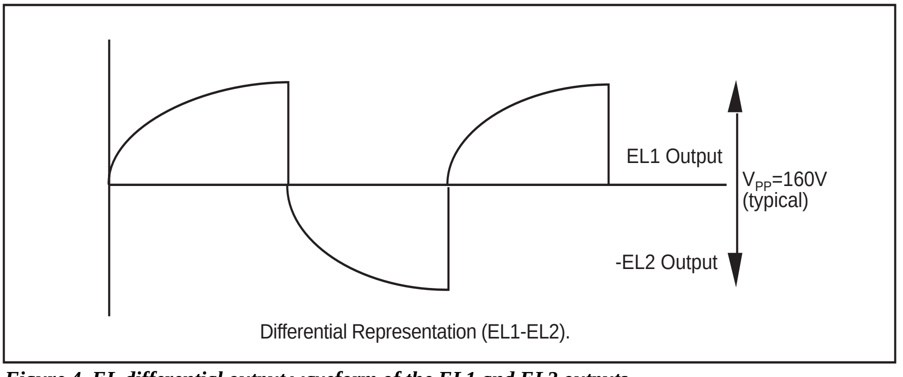
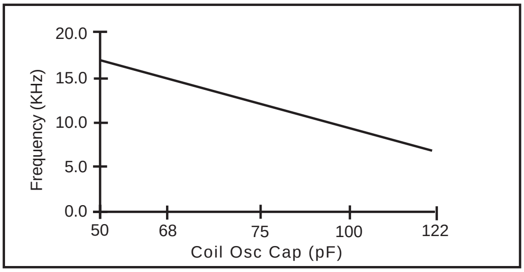
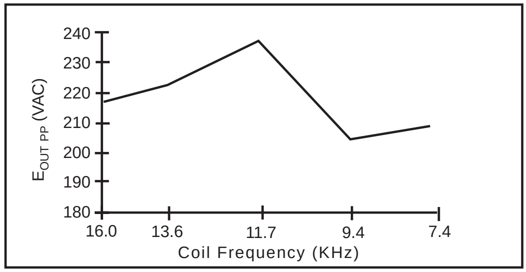



*Figure 4. EL differential output waveform of the EL1 and EL2 outputs*

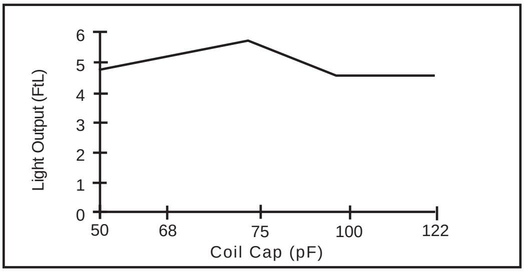
The following performance curves are intended to give the designer a relative scale from which to optimize specific applications. Absolute measurements may vary depending upon the brand of components chosen.



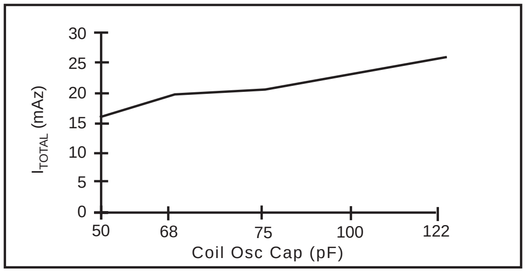

***Coil Frequency vs. Coil Osc Cap Value***



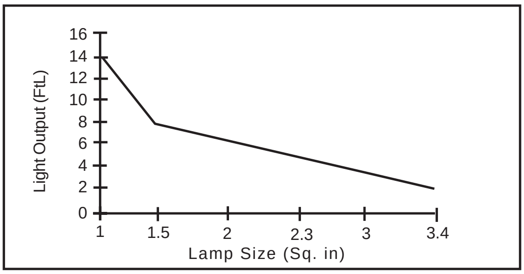

***Coil Frequency vs. $E_{OUT\ PP}$***



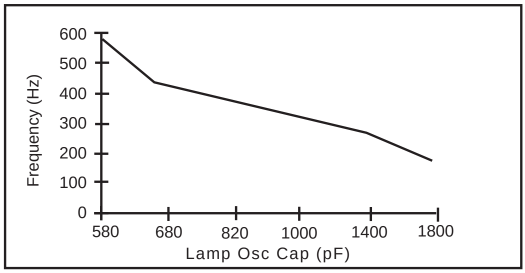

***Coil Cap vs. Light Output***



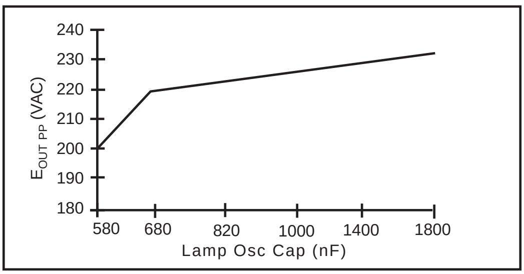

***$I_{TOTAL}$ vs. Coil Osc Cap***



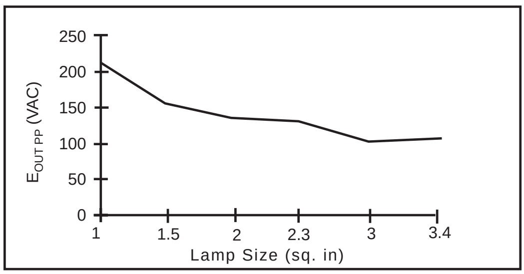

***Lamp Size vs. Light Output***




***Lamp Frequency vs. Lamp Osc Cap Value***

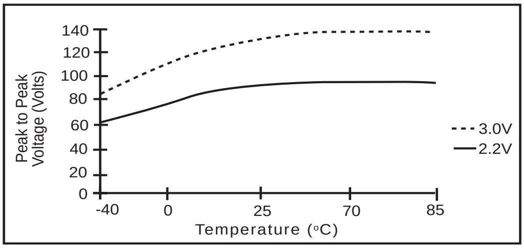



***Lamp Osc Cap vs. $E_{OUT\ PP}$***

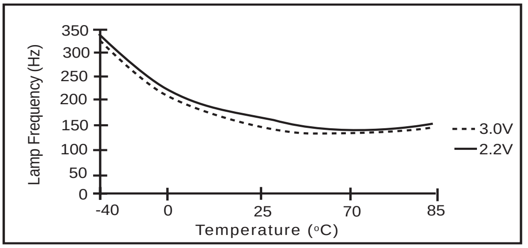



***Lamp Size vs. $E_{OUT\ PP}$***

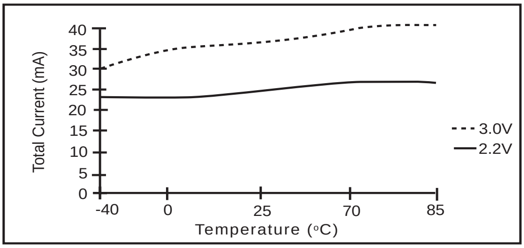
The following performance curves are intended to give the designer a relative scale from which to optimize specific applications. Absolute measurements may vary depending upon the brand of components chosen.



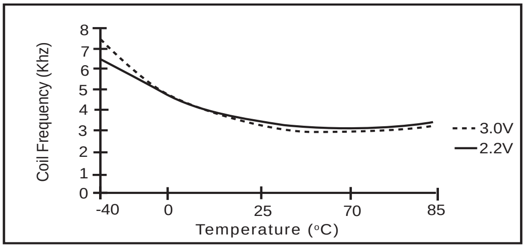

***Peak to Peak Voltage vs. Temperature***
***$C_{COIL}$=220pF; $C_{LAMP}$=1500pF; Load=55nF***




***Lamp Frequency vs. Temperature***
***$C_{COIL}$=220pF; $C_{LAMP}$=1500pF; Load=55nF***




***Total Current vs. Temperature***
***$C_{COIL}$=220pF; $C_{LAMP}$=1500pF; Load=55nF***



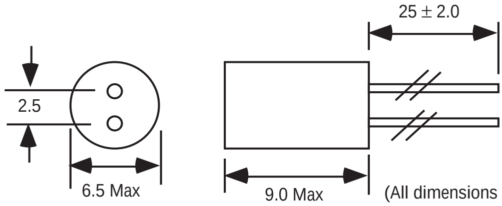

***Coil Frequency vs. Temperature***
***$C_{COIL}$=220pF; $C_{LAMP}$=1500pF; Load=55nF***

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




(All dimensions in mm)

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

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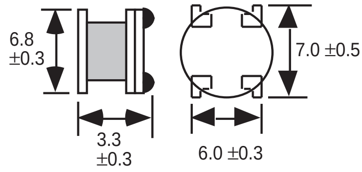
HITACHI METALS Ltd. Japan
Ph: 3-3284-4936
Fax: 3-3287-1945

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

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

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

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




(All Dimensions in mm)

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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

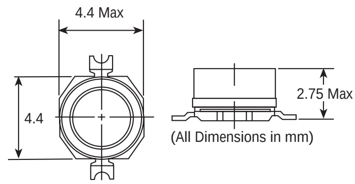
Toko Germany
Ph: 49-7156-96-060
Fax: 49-7156-96-06-26

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

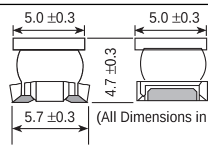
muRata Europe
Ph: 49-9116-6870
Fax: 49-1166-8722-5

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)




(All Dimensions in mm)

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

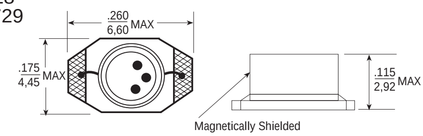
Coilcraft Europe
Ph: 44-01236-730595
Fax: 44-01236-730627

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




(All Dimensions in mm)

## 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

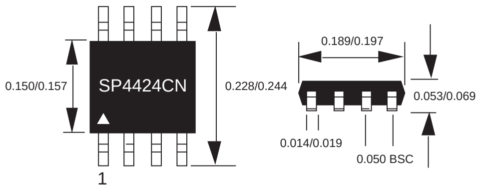
NEC Corporation
Tokyo, Japan
Phone: (03) 3798-9572
Fax: (03) 3798-6134

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

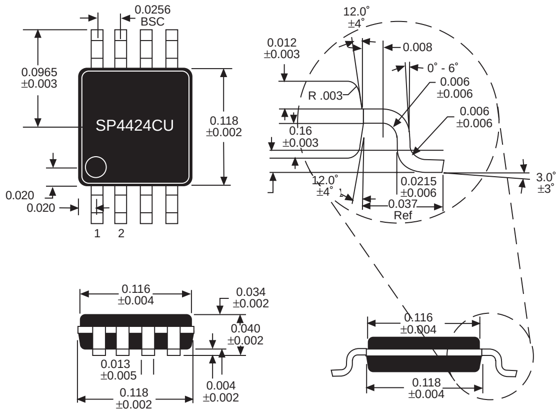
Gunze Electronics
2113 Wells Branch Parkway
Austin, TX 78728
Phone: (512) 752-1299
Fax: (512) 252-1181

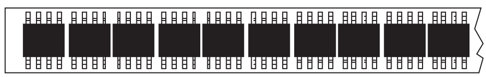
All package dimensions in inches

## 8-pin NSOIC

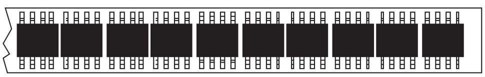



## 8-pin µSOIC

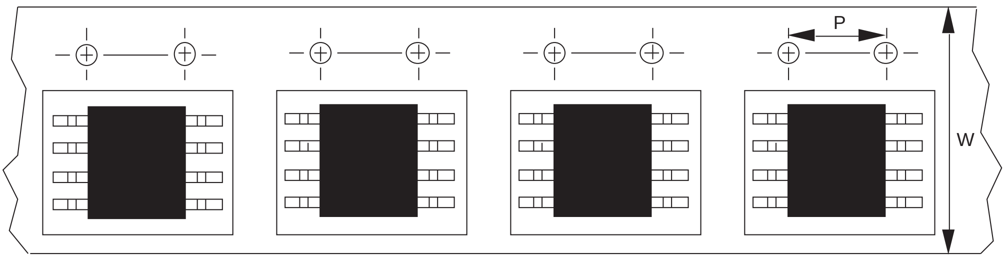


95 SP4424CN per tube, no minimum quantity



50 SP4424CU per tube




| **NSOIC-8 13" reels: P=8mm, W=12mm<br>µSOIC-8 13" reels: P=8mm, W=12mm** | | | |
|---|---|---|---|
| Pkg. | Minimum qty per reel | Standard qty per reel | Maximum qty per reel |
| CN | 500 | 2500 | 3000 |
| CU | 500 | 2500 | 3000 |

## ORDERING INFORMATION

| Model | Operating Temperature Range | Package Type |
|---|---|---|
| SP4424CN | -40˚C to +85˚C | 8-Pin NSOIC |
| SP4424CU | -40˚C to +85˚C | 8-Pin µSOIC |
| SP4424CX | -40˚C to +85˚C | Die |
| SP4424NEB | N/A | NSOIC Evaluation Board |
| SP4424UEB | N/A | µSOIC Evaluation Board |

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

SIGNAL PROCESSING EXCELLENCE

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