

Electroluminescent Lamp Driver

- 2.2 V- 3.6 V Battery Operation
- 50 nA Maximum Standby Current (10 nA typical)
- High Voltage Output Typical 160 V_{pp}
- External Oscillator Required
- Enable Control Pin

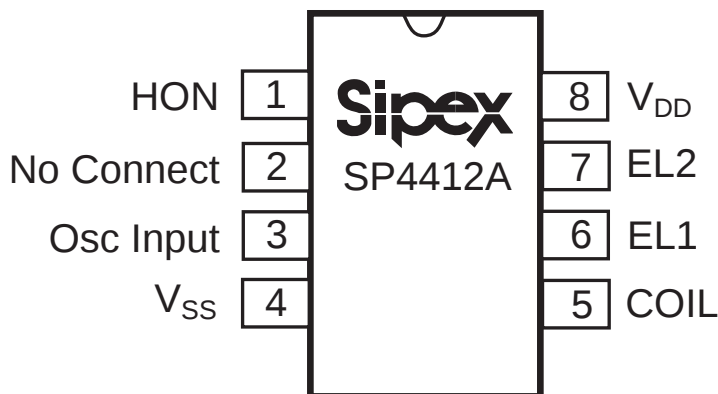
APPLICATIONS

- Watches
- Pagers
- Backlit LCD Displays



DESCRIPTION

The **SP4412A** is a high voltage output DC-AC converter that can operate from a 2.2V-3.6V power supply. The **SP4412A** is capable of supplying up to 250 V_{pp} signals, making it ideal for driving small electroluminescent lamps. The device features 10 nA (typical) standby current, for use in low power portable products. An inductor is used to generate the high voltage, and an external oscillator is needed as a clock source. The **SP4412A** is offered in an 8-pin narrow SOIC package or an 8-pin μ SOIC package. For delivery in die form, please consult the factory.



SP4412A 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}	5.0 V
Input Voltages/Currents	
HON (pin 1).....	-0.5V to (V_{DD} +0.5V)
COIL (pin 3).....	60mA
Lamp Outputs.....	250V _{PP}
Storage Temperature.....	-65°C to +150°C

Power Dissipation Per Package

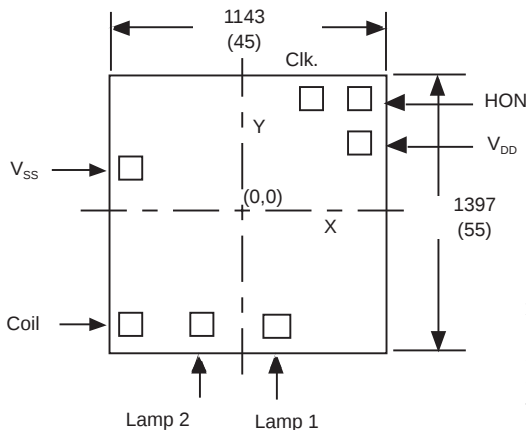
8-pin NSOIC (derate 6.14mW/°C above +70°C).....	500mW
8-pin μ SOIC (derate 4.85mW/°C above +70°C).....	390mW

SPECIFICATIONS

T= 25°C; V_{DD} = 3.0V; Lamp Capacitance = 2000pF; Coil = 30 mH at 125 Ohms; External Oscillator = 32768Hz (unless otherwise noted).

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
Supply Voltage, V_{DD}	2.2	3.0	3.6	V	
Supply Current, $I_{COIL}+I_{DD}$		5	2.0	mA	$V_{HON}=V_{DD}=3V$
Coil Voltage, V_{COIL}	V_{DD}		3.6	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	1	10	100	μ A	
Shutdown Current, $I_{SD}=I_{COIL}+I_{DD}$		10	50	nA	$V_{HON}=0V$
INDUCTOR DRIVE					
Coil Frequency, $f_{COIL}=f_{LAMP}\times 32$		8192		Hz	Input Oscillator=32768Hz
Coil Duty Cycle		75		%	
Peak Coil Current, $I_{PK-COIL}$			60	mA	Guaranteed by design.
EL LAMP OUTPUT					
EL Lamp Frequency, f_{LAMP}		256		Hz	Input Oscillator=32768Hz
Peak to Peak Output Voltage	120	160		V_{PP}	

BONDING DIAGRAM



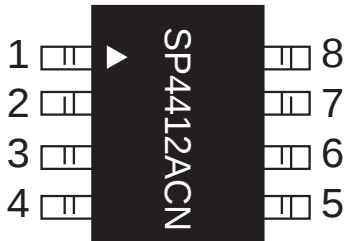
Measured from center of Pads.

PIN	X	Y
CLK	218.5	555.5
HON	418.5	555.5
V_{DD}	418.5	339.5
EL2	-178.0	-555.5
EL1	95.5	-555.5
COIL	-416.0	-555.5
V_{SS}	-416.0	219.0

NOTES:

1. Dimensions are in microns unless otherwise noted (mils)
2. Bonding pads are 125 x 125 microns typical
3. Outside dimensions are maximum including scribe area
4. Die thickness is 15 mils +/- 1
5. Pad center coordinates are relative to the die center.

PIN DESCRIPTION



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

Pin 2 – NC

Pin 3 – Oscillator clock input

Pin 4 – V_{SS} - Power supply common, connect to ground.

Pin 5 – Coil - Coil input, connect coil from V_{DD} to Pin 3.

Pin 6 – Lamp- Lamp driver output1, connect to EL lamp.

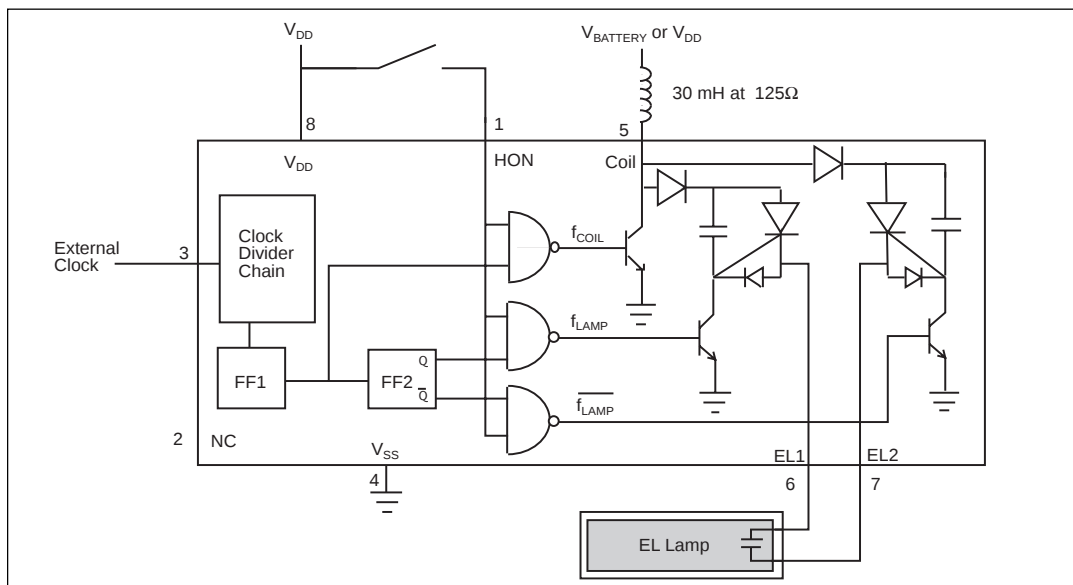
Pin 7 – Lamp- Lamp driver output2, connect to EL lamp.

Pin 8 – V_{DD} - Positive supply.

THEORY OF OPERATION

The **SP4412A** is made up of three basic circuit elements, a divider chain, a coil, and a switched H-bridge network. The countdown chain provides the circuit with a clock source used to control the charge and discharge phases for the coil and lamp. An external oscillator is required and is delivered to pin 3 of the SO-8 package or to the "Osc in" pad of the bare die. The chart on page 6 shows the effect of variations in coil values used. If a clock frequency other than 32kHz is used, the output of the driver as well as the amount of current used, will be effected.

The suggested oscillator frequency is 32,768Hz. This clock frequency is internally divided to create two internal control signals, f_{COIL} and f_{LAMP} . The output is internally divided down by 7 flip flops; therefore, a 32,768Hz signal will be divided into the following frequencies; 32, 16, 8, 4, 2, 1, 0.5 and 0.25kHz. The second flip flop output (8 kHz) is used to drive the coil (see **figure 2** on **page 7**) and the seventh flip flop output (256 Hz) 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.



SP4412A Schematic

The external clock should have a 50% duty cycle and range from $V_{DD} - 1V$ to ground. The maximum external clock frequency is 128 kHz.

The coil is an external component connected from $V_{BATTERY}$ to pin 5 of the **SP4412A**. Energy is developed in the coil according to the equation $E_L = 1/2LI^2$ where the current I is defined as $I = (V_{BATTERY} - IR - V_{OL})/R_T$. In order to maximize the energy produced by the coil, $V_{BATTERY}$ should represent the largest voltage in the system (up to a maximum of 3.6 v); $V_{BATTERY} = 3.0$ VDC with a 35mH/125 Ω coil is a typical example. It is not necessary that $V_{DD} = V_{BATTERY}$. The coil operation is a function of the core material and winding used -- performance variances may be noticeable from different coil suppliers even though the values are the same. The **Sipex SP4412A** is final tested using a 35 mH/135 ohm coil. For suggested coil sources see *page 8*.

The f_{COIL} signal controls a switch that connects the end of the coil at pin 5 to ground or to open circuit. The f_{COIL} signal is a 94% duty cycle square wave, switching at 1/4 the oscillator frequency, (for a 32 kHz oscillator f_{COIL} is 8 kHz). 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 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 shorter (see *figure 1 on page 7*).

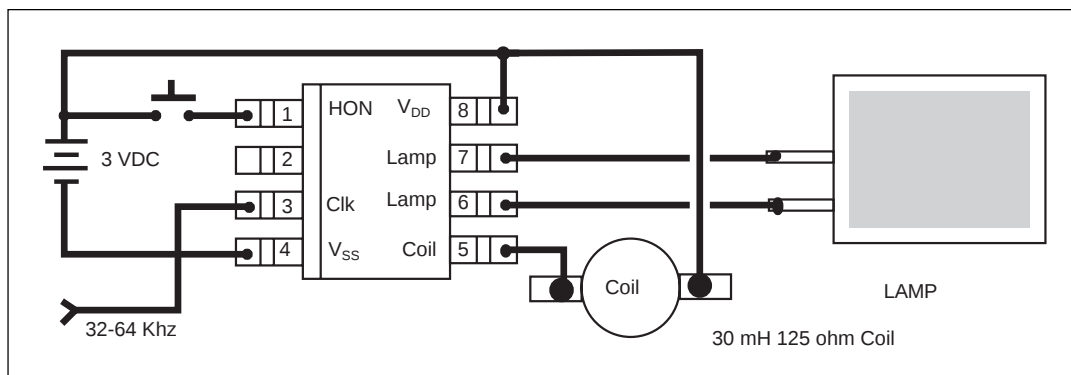
The H-bridge consists of two SCR structures that act as high voltage switches. These two switches control the polarity of how the lamp is charged. The SCR switches are controlled by the f_{LAMP} signal which is the oscillator frequency divided by 128. For a 32kHz oscillator, $f_{LAMP} = 250Hz$.

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 6 and 7 which are 180 degrees out of phase with each other (see *figure 3 on page 7*). A differential view of the outputs is shown in *figure 4 on page 7*.

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 handheld 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 an external inductor and an external clock signal.

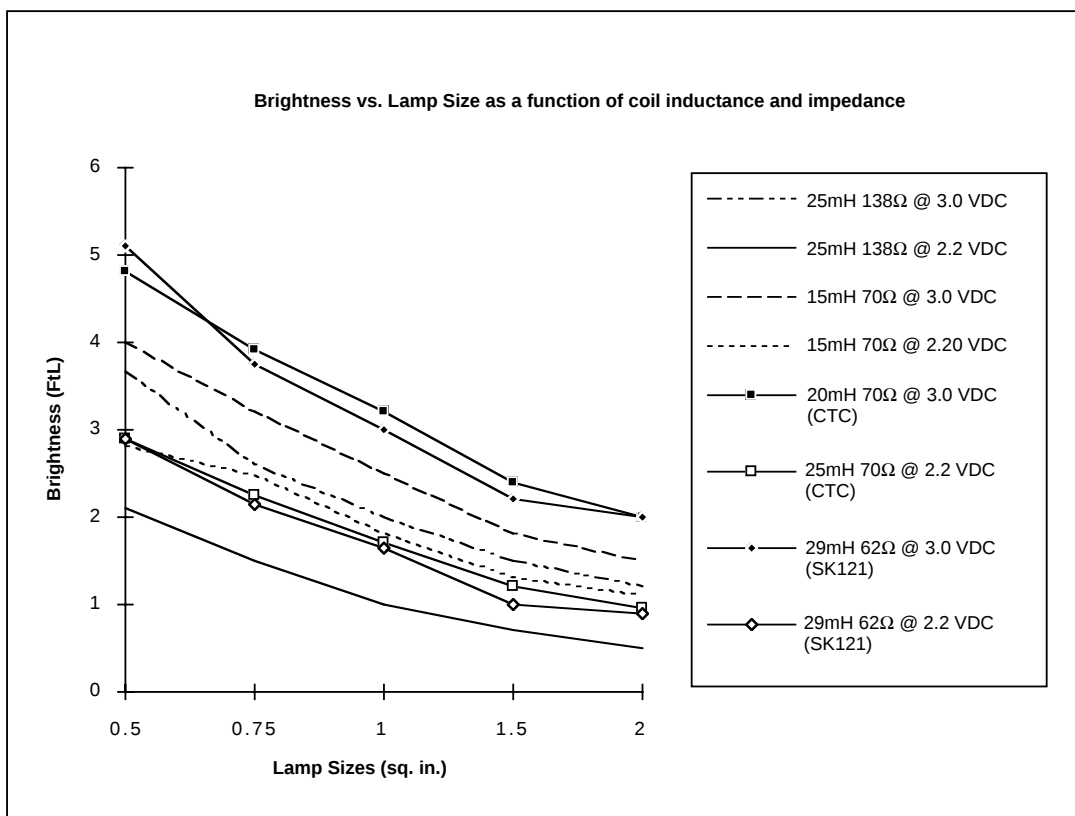


Typical SP4412ACN Application Circuit

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 current than LEDs or incandescent 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*).

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.



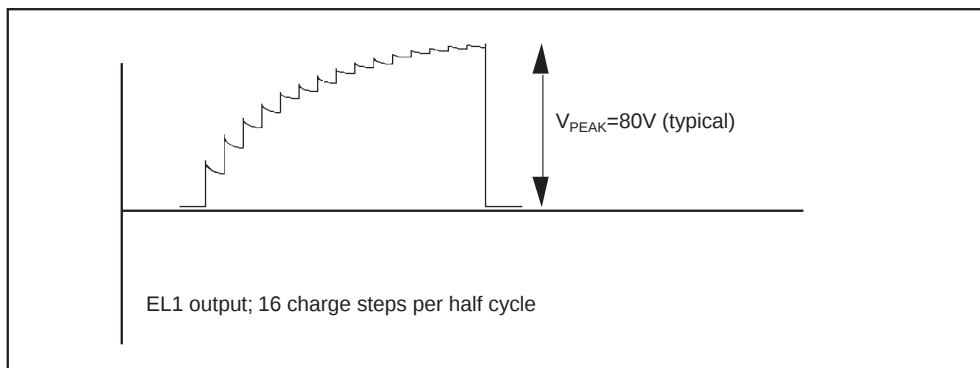


Figure 1. EL output voltage in discrete steps at EL1 output

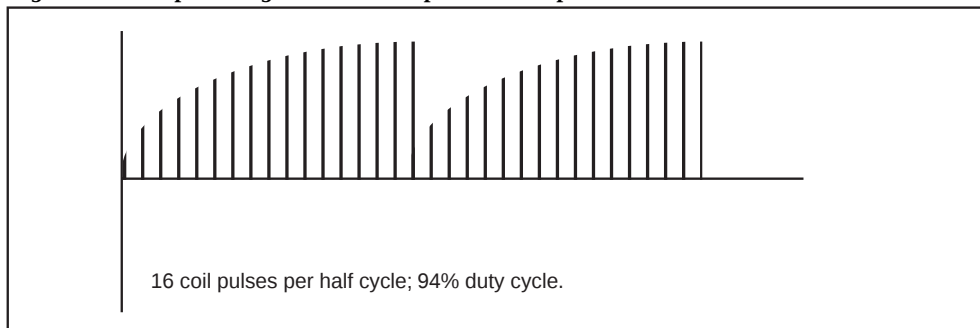


Figure 2. Voltage pulses released from the coil to the EL driver circuitry

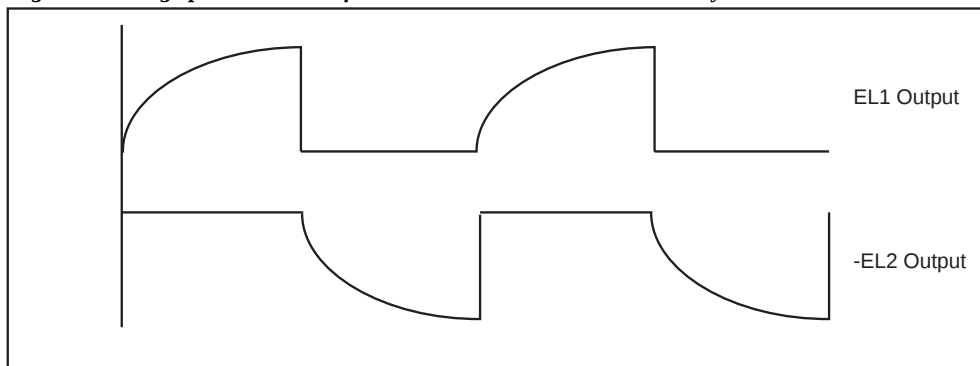


Figure 3. EL voltage waveforms from the EL1 and EL2 outputs

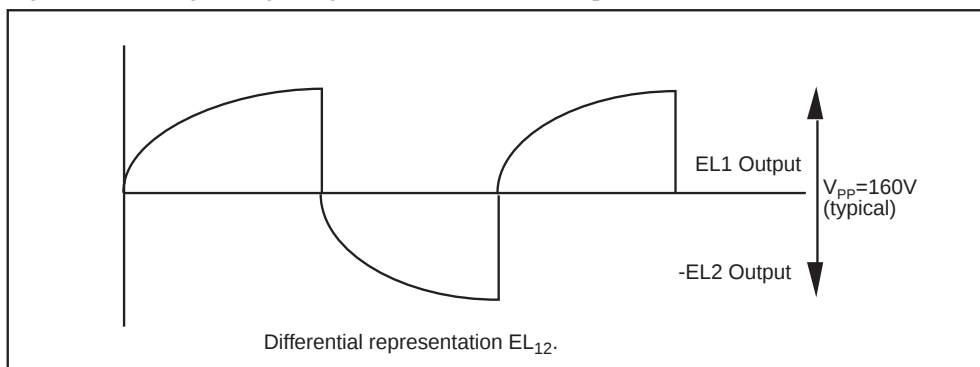


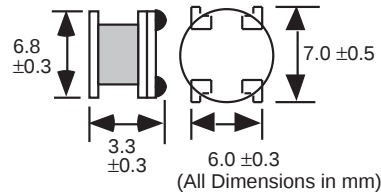
Figure 4. EL differential output waveform of the EL1 and EL2 outputs

HITACHI METALS Ltd.
Kishimoto Bldg.
2-1, Marunouchi 2-Chome,
Chiyoda-Ku, Tokyo Japan
Phone: 3-3284-4936
Fax: 3-3287-1945
Mr. Noboru Abe
Spec.-
9 mH $\pm 30\%$ 42 ohm (Max)
Model: MD 735L902B

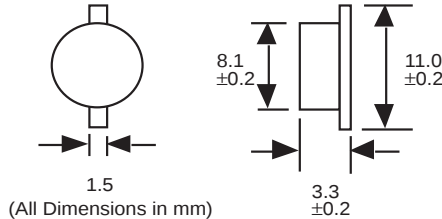
Singapore
Mr Stan kaiko,
Mr. Hiroshi Kai
Ph: 65-222-3077
Fax: 65-222-5232

Hong Kong
Mr Mori Ota
Ph: 852-2724-4183
Fax: 852-2311-2095

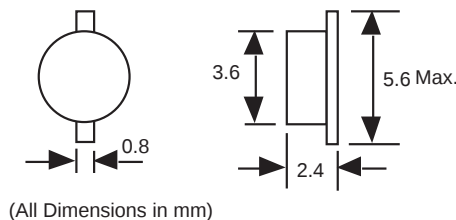
San Jose, CA
Mr. Kent Oda
Ph: 1-800-309-1803
Fx: 408 436-9601



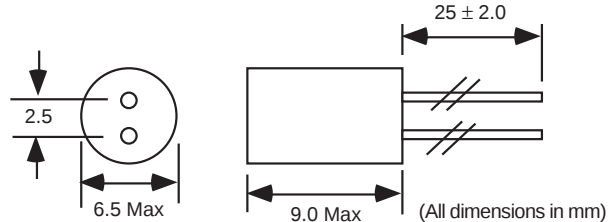
Sankyo Shoji Co. (HK)
RM 28, 9/il Thriving Ind. Centre
Tsuen Wan, N.T.
Hong Kong
Phone: 8522 414 9268
Fax: 8522 413 6040
Contact: Mr. K.M. Chang
Inductance: 29mH $\pm 20\%$
Resistance: 62 Ohms $\pm 10\%$ @ 25°C
Part Number SK-121



Sankyo Shoji Co. (HK)
RM 28, 9/il Thriving Ind. Centre
Tsuen Wan, N.T.
Hong Kong
Phone: 8522 414 9268
Fax: 8522 413 6040
Contact: Mr. K.M. Chang
Inductance: 65mH $\pm 15\text{mH}$
Resistance: 270 Ohms $\pm 15\%$ @ 25°C
Part Number SK-80



CTC Coils LTD (HK)
Flat L-M 14 Fl, Haribest Ind'l Bldg.
45-47 Au Pul Wan Street
Fo Tan Shatin, N.T., Hong Kong
Phone: 85 2695 4889
Fax: 85 2695 1842
Contact: Alfred Wong cc Marine Au
Inductance: 20 mH $\pm 10\%$
Resistance: 65 Ohms Max
Model Number: CH5070AS-203K-006
Sipex No. S51208-M-1021-Sipex



Mark Technology: North American stocking distributor for Sankyo and CTC
Phone: 905-891-0165 FAX: 905-891-8534.

EL polarizers/transflector manufacturers

Nitto Denko
Yoshi Shinozuka
56 Nicholson Lane
San Jose, CA. 432-5480

Top Polarizer- NPF F1205DU
Bottom - NPF F4225
or (F4205) P3 w/transflector

Transflector Material
Astra Products
Mark Bogin
P.O. Box 479
Baldwin, NJ 11510
Phone (516)-223-7500
Fax (516)-868-2371

EL Lamp manufacturers

Leading Edge Ind. Inc.
11578 Encore Circle
Minnetonka, MN 55343
Phone 1-800-845-6992

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

Luminescent Systems inc. (LSI)
4 Lucent Drive
Lebanon, NH. 03766
Phone: (603) 643-7766
Fax: (603) 643-5947

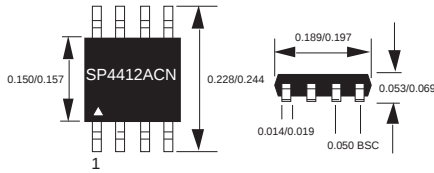
NEC Corporation
Yumi Saskai
7-1, Shiba 5 Chome, Minato-ku,
Tokyo 108-01, Japan
Phone: (03) 3798-9572
Fax: (03) 3798-6134

Seiko Precision
Shuzo Abe
1-1, Taihei 4-Chome,
Sumida-ku, Tokyo, 139 Japan
Phone: (03) 5610-7089
Fax: (03) 5610-7177

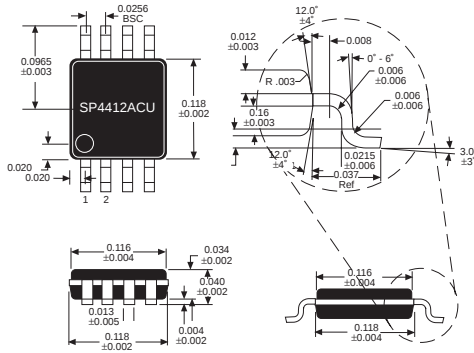
Gunze Electronics
2113 Wells Branch Parkway
Austin, TX 78728
Phone: (512) 752-1299
Fax: (512) 252-1181

All package dimensions in inches

8-pin NSOIC



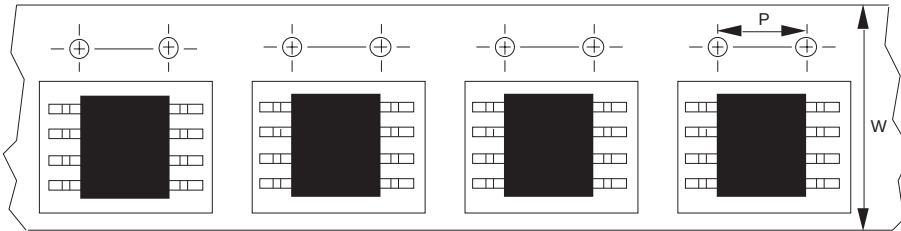
8-pin μ SOIC



95 SP4412ACN per tube, no minimum quantity



50 SP4412ACU per tube



NSOIC-8 13" reels: P=8mm, W=12mm
 μ SOIC-8 13" reels: P=8mm, W=12mm

Minimum qty per reel	Standard qty per reel	Maximum qty per reel
500	2500	3000

ORDERING INFORMATION

Model	Temperature Range	Package Type
SP4412ACN	0°C to +70°C	8-Pin NSOIC
SP4412ACU	0°C to +70°C	8-Pin μ SOIC
SP4412ACX	0°C to +70°C	Die

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



SIGNAL PROCESSING EXCELLENCE

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