

EL Plus Piezo Driver

- Integrated EL Plus Piezo Driver For Portable Electronic Devices
- Reduces System Cost, Size & Component Count
- +2.2V to +6.0V Battery Operation
- A Single External Coil Drives Both the EL Lamp and Piezotransducer Circuitry
- Piezotransducer Can Be Driven By an External Clock or Internal Clock
- A Single Resistor Controls the Internal Oscillator
- DC-to-AC Inverter Produces Up To 200V_{P-P} to Drive EL Lamps
- DC-to-AC Inverter Produces Waveform to Drive Piezotransducer
- Low Current Standby Mode Draws Less than 1 μ A

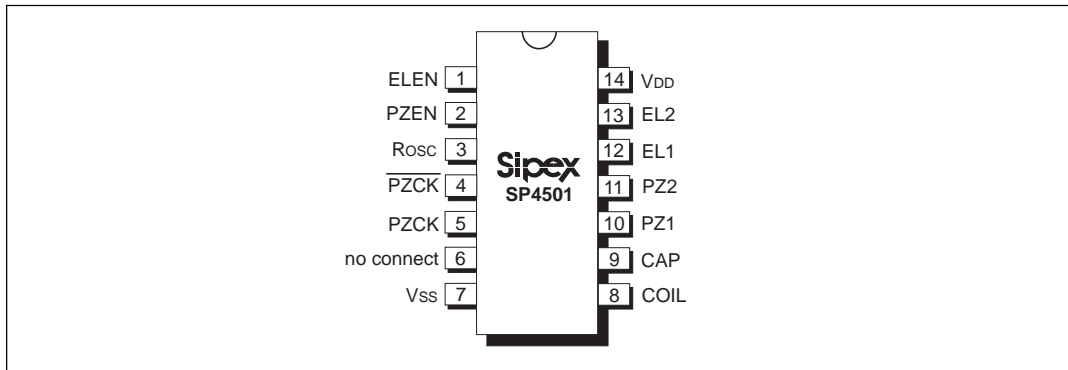


APPLICATIONS

- PDA's
- Pagers
- GPS
- Hand Held Medical Devices

DESCRIPTION

The SP4501 provides designers with both an electroluminescent lamp driver for backlighting and a piezotransducer driver to generate audio alert tones. The integration of an EL lamp driver and a piezotransducer driver in a single cost-effective IC reduces system cost, board space requirements and component count. The SP4501 is ideal for portable applications such as pagers, electronic games, PDAs, medical equipment, and designs with liquid crystal displays, keypads, and backlit readouts. The SP4501 will operate from a +2.2V to +6.0V source. The device features a low power standby mode which draws less than 1 μ A (typical). The frequency of the internal oscillator is set with a single external resistor. The piezotransducer driver can be driven with the internally generated clock signal or an external clock signal provided by the designer. A single inductor is required to generate the high voltage AC used to drive the EL lamp and the piezotransducer. All input pins are ESD protected with diodes to V_{DD} and V_{SS}.



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.

Power Supply, V_{DD}7.0V
 Input Voltages, Logic.....-0.3V to ($V_{DD}+0.3V$)
 Lamp Outputs.....220V_{P-P}
 Operating Temperature.....-40°C to +85°C
 Storage Temperature.....-65°C to +150°C

Power Dissipation Per Package

14-pin SOIC
 (derate 8.33mW/°C above +70°C).....700mW
 14-pin TSSOP
 (derate 9.96mW/°C above +70°C).....800mW



CAUTION:
 ESD (ElectroStatic Discharge) sensitive device. Permanent damage may occur on unconnected devices subject to high energy electrostatic fields. Unused devices must be stored in conductive foam or shunts. Personnel should be properly grounded prior to handling this device. The protective foam should be discharged to the destination socket before devices are removed.

STORAGE CONSIDERATIONS

Storage in a low humidity environment is preferred. Large high density plastic packages are moisture sensitive and should be stored in Dry Vapor Barrier Bags. Prior to usage, the parts should remain bagged and stored below 40°C and 60%RH. If the parts are removed from the bag, they should be used within 48 hours or stored in an environment at or below 20%RH. If the above conditions cannot be followed, the parts should be baked for four hours at 125°C in order to remove moisture prior to soldering. Sipex ships product in Dry Vapor Barrier Bags with a humidity indicator card and desiccant pack. The humidity indicator should be below 30%RH.

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SPECIFICATIONS

$V_{DD} = +3.0V$, $L = 470\mu H$, $C_{LAMP} = 8nF$, $C_{PZ} = 16nF$, $C_{INT} = 1800pF$, $R_{OSC} = 500k\Omega$, and $T_{AMB} = 25^\circ C$ unless otherwise noted.

| PARAMETER | MIN. | TYP. | MAX. | UNITS | CONDITIONS |
|--|------|----------|------|------------|--|
| Supply Voltage, V_{DD} | 2.2 | 3.0 | 6.0 | V | |
| Supply Current, $I_{COIL}+I_{DD}$ | 28 | 48 | 90 | mA | $L_{COIL} = 470\mu F$ |
| Standby Current | | | 1.0 | μA | |
| Input Voltage for ELEN and PZEN, PZCK, PZCK LOW HIGH | 2.75 | 0 3.0 | 0.25 | V | |
| Input Impedance ELEN and PZCK PZEN and PZCK | | 1 | | M Ω | $V_{ELEN} = 0V$ |
| Inductor Drive | | | | | |
| Coil Frequency, f_{OSC} | 37.0 | 45.7 | 54.7 | kHz | |
| Duty Cycle of f_{OSC} | | 90 | | % | |
| Peak Coil Current | | | 100 | mA | |
| EL Lamp/ Piezo Driver Output | | | | | |
| Piezo Output Voltage, V_{PZ} | | 25 | | V | $f_{piezo} = 3.1kHz$, PZEN = HIGH; $T_{AMB} = +25^\circ C$ $T_{AMB} = -40^\circ C$ to $+85^\circ C$ |
| Lamp Output Voltage, V_{EL} | | 110 | | V | $T_{AMB} = +25^\circ C$ $T_{AMB} = -40^\circ C$ to $+85^\circ C$ |
| EL Lamp Frequency, f_{LAMP} | 289 | 357 | 427 | Hz | $T_{AMB} = +25^\circ C$ $T_{AMB} = -40^\circ C$ to $+85^\circ C$ |
| Piezo Frequency, f_{PZ} | 2.3 | 2.9 | 3.4 | kHz | PZEN = HIGH; $T_{AMB} = +25^\circ C$ $T_{AMB} = -40^\circ C$ to $+85^\circ C$ |

Electroluminescent Technology

An EL lamp consists of a thin layer of phosphorous material sandwiched between two strips of plastic which emits light (fluoresces) when a high voltage AC signal is applied across it. It behaves primarily as a capacitive load. Long periods of DC voltage applied to the material tend to reduce its lifetime. With these conditions in mind, the ideal signal to drive an EL lamp is a high voltage sine wave. Traditional approaches to achieve this type of waveform include 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 offers low power single chip driver circuits specifically designed to drive small to medium sized electroluminescent panels. Sipex EL drivers provide a differential AC voltage without a DC offset to maximize EL lamp lifetime. The only additional components required for the EL driver circuitry are an inductor, resistor and capacitor.

Electroluminescent backlighting is ideal when used with LCD displays, keypads or other backlit readouts. EL lamps uniformly light an area without creating any undesirable "hot spots" in the display. Also, an EL lamp typically consumes less power than LED's or incandescent bulbs in similar lighting situations. These features make EL ideal for attractive, battery powered products.

THEORY OF OPERATION

Coil Switch

The SP4501 has an inductor-based boost converter to generate the high voltage used to drive the EL lamp. Energy is stored in the inductor according to the equation $E_L = 1/2 (LI_{pk}^2)$ where $I_{pk} = (t_{ON}) (V_{BATT} - V_{CEsat}) / L$. An internal oscillator controls the coil switch. During the time the coil switch is on, the coil is connected between V_{DD} and the saturation voltage of the coil switch and a magnetic field develops in the coil. When the coil switch turns off, the switch opens, the magnetic field collapses and the voltage across the coil rises.

The internal diode forward biases when the coil voltage rises above the H-Bridge voltage and the energy enters the EL lamp. Each pulse increases the voltage across the lamp in discrete steps.

As the voltage approaches its maximum, the steps become smaller. (see figure 4).

The brightness of the EL lamp output is directly related to energy recovery in the boost converter. There are many variations among coils such as magnetic core differences, winding differences and parasitic capacitances. For suggested coil suppliers refer to page 10.

Oscillator

The internal oscillator generates a high frequency clock used by the boost converter and H-Bridge. An external resistor from VDD to ROSC sets the oscillator frequency. Typically a 500kΩ resistor sets the frequency to 45.7kHz. The high frequency clock directly controls the coil switch. This high frequency clock is divided by 128 to generate a low frequency clock which controls the EL H-Bridge and sets the EL lamp frequency. The high frequency clock is divided by 16 to create a medium frequency clock to drive the piezo H-Bridge. The oscillator has low sensitivity to temperature and supply voltage variations, increasing the performance of the EL driver over the operating parameters.

Dual H-Bridge

The H-Bridge consists of two SCR structures and two NPN transistors that control how the lamp is charged. Setting ELEN to HIGH activates the EL H-Bridge. The EL driver illuminates the lamp by applying the high voltage supply of the boost converter to the lamp terminals through the H-Bridge and then switching the terminal polarity between the high voltage supply and ground at a constant frequency. This applies an AC voltage to the lamp that is twice the peak output voltage of the boost driver. An AC voltage greater than the 40V across the terminals of the lamp is necessary to adequately illuminate the EL lamp. The piezo driver output applies an AC voltage to the piezotransducer in a similar manner. The piezo driver operates in two modes.

A logic HIGH on pin PZEN will enable the piezo driver and apply a waveform to the piezotransducer until PZEN is released. This waveform will produce a tone that is 1/16 the frequency of the internal oscillator. Alternately, an external clock applied to $\overline{\text{PZCK}}$ or PZCK pins will enable the piezo driver and generate a tone at the applied clock frequency.

The external applied clock frequency should be greater than $f_{\text{osc}}/64$. To put the circuit in an inactive state it is required that $\overline{\text{PZCK}}$ remain at logic LOW and PZCK remain at logic HIGH. The piezo driver and the EL driver may be operated simultaneously but with decreased light output from the EL panel.

DESIGN CONSIDERATIONS

Inductor Selection

If limiting peak current draw from the power supply is important, small coil values (<1mH) may need a higher oscillator frequency. Inductor current ramps faster in a lower inductance coil than a higher inductance coil for a given coil switch on time period, resulting in higher peak coil currents.

It is important to observe the saturation current rating of a coil. When this current is exceeded, the coil is incapable of storing any more energy and then ceases to act as an inductor. Instead, the coil behaves according to its series DC resistance. Since small coils (<1mH) have inherently low series DC resistance, the current can peak dramatically through a small coil during saturation. This situation results in wasted energy not stored in the magnetics of the coil but expressed as heating which could lead to failure of the coil.

Generally, selecting a coil with lower series DC resistance will result in a system with higher efficiency and lamp brightness.

Lamp Effects

EL lamp parameters vary between manufacturers. Series DC resistance, lighting efficiency and lamp capacitance per area differ the most overall.

Larger lamps require more energy to illuminate. Lowering the oscillator frequency allows more energy to be stored in the coil during each coil switch cycle and increases lamp brightness. The oscillator frequency can be lowered to a point where the lamp brightness then begins to drop because the lamp frequency must be above a critical frequency (approx. 100Hz) to light. Lamp color is affected by the switching frequency of the EL driver. Green EL lamps will emit a more blue light as EL lamp frequency increases.

Noise Decoupling on Logic Inputs

If ELEN, PZEN, PZCK or $\overline{\text{PZCK}}$ are connected to traces susceptible to noise, it may be necessary to connect bypass capacitors of approximately 10nF between ELEN and VSS, PZEN and VSS, PZCK and VSS, and $\overline{\text{PZCK}}$ and VDD. If these inputs are driven by a microprocessor which provides a low impedance HIGH and LOW signal, then noise bypassing may not be necessary. If some inputs are unused (as PZCK and $\overline{\text{PZCK}}$ may be) then these inputs should be tied to the power supply that sets the input to an inactive state.

Increasing Light Output

EL lamp light output can be improved by connecting a fast recovery diode from the COIL pin to the CAP pin. The internal diode is bypassed resulting in an increase in light output at the EL lamp. We suggest a fast recovery diode such as the industry standard 1N4148.

The optimal value of C_{INT} will vary depending on the lamp parameters and coil value. Lower C_{INT} values can decrease average supply current but higher C_{INT} values can increase lamp brightness. This is best determined by experimentation. A rule of thumb is larger coils (1mH) are paired with a smaller C_{INT} (680pF) and smaller coils (470 μ H) are paired with a larger C_{INT} (1800pF).

Changing the EL lamp Output Voltage Waveform

Designers can alter the sawtooth output voltage waveform to the EL lamp. Increasing the capacitance of the integration capacitor, C_{INT} , will integrate the sawtooth waveform making it

appear more like a square wave.

Printed Circuit Board Layout Suggestions

The EL driver's high-frequency operation makes PCB layout important for minimizing electrical noise. Keep the IC's GND pin and the ground leads of C1 and C_{INT} less than 0.2in (5mm) apart. Also keep the connections to the COIL pin as short as possible. To maximize output power and efficiency and minimize output ripple voltage, use a ground plane and solder the IC's VSS pin directly to the ground plane.

EL Lamp Driver Design Challenges

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

Sipex will perform customer application evaluations, using the customer's actual EL lamp to determine the optimum operating conditions for specific applications. For customers considering an EL backlighting solution for the first time, Sipex is able to provide retrofits to non-backlit products for a thorough electrical and cosmetic evaluation. Please contact your local Sipex sales Representative or the Sipex factory directly to initiate this valuable service.

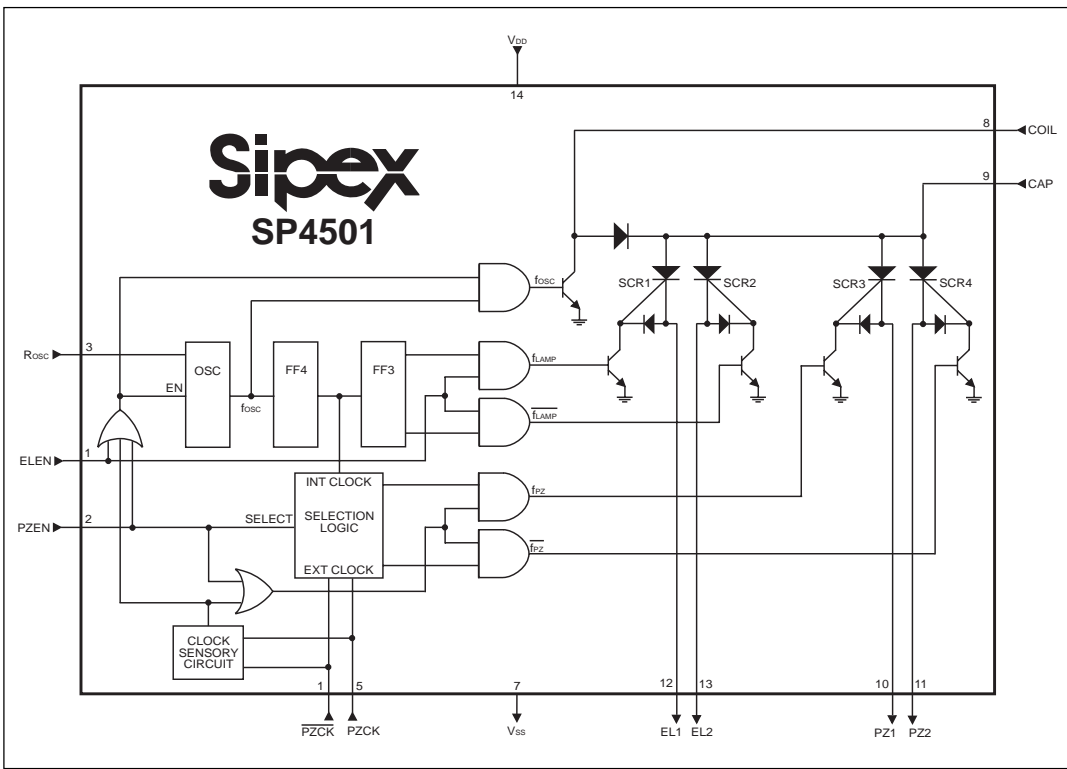


Figure 1: Internal Block Diagram of SP4501

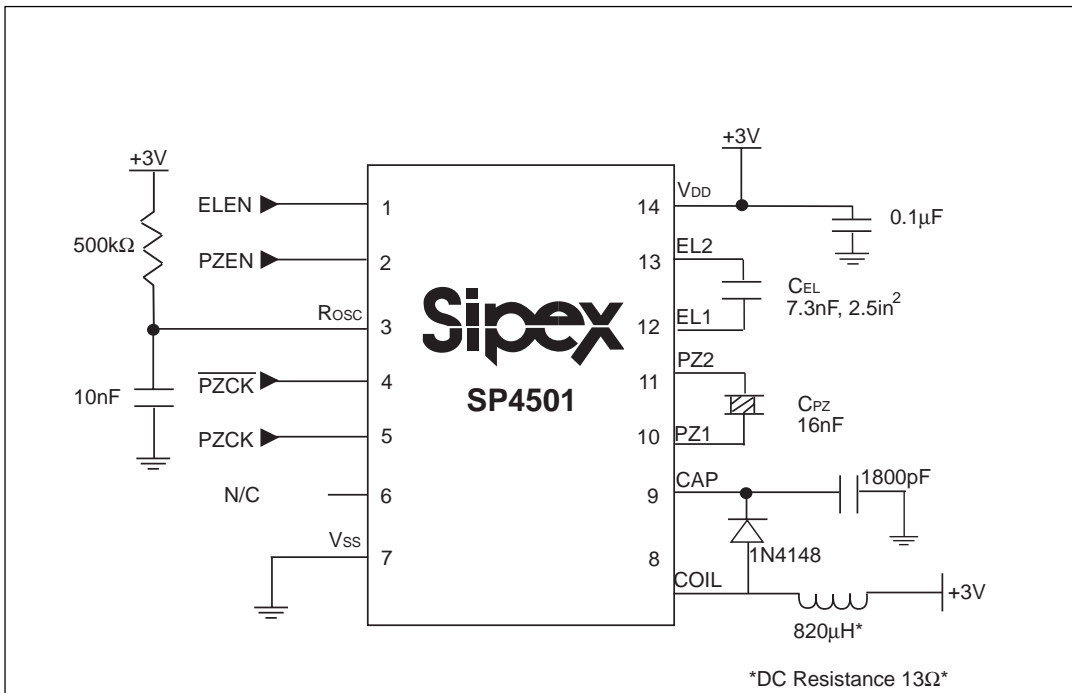


Figure 2: Test Circuit of the SP4501

PERFORMANCE CHARACTERISTICS

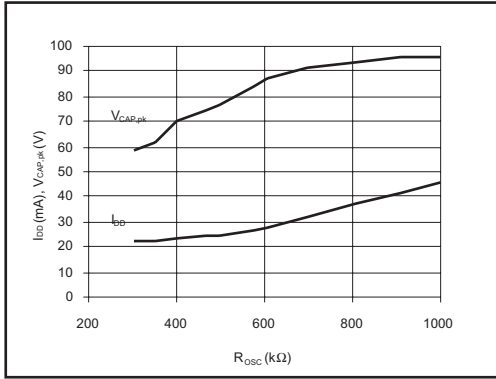


Figure 3: Supply Current and Cap Pin Voltage vs. Oscillator Resistance.

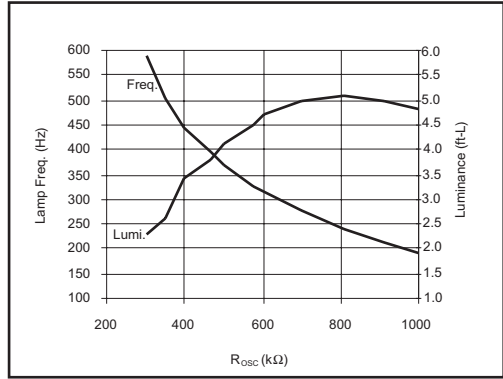


Figure 4: Lamp Frequency and Luminance vs. Oscillator Frequency.

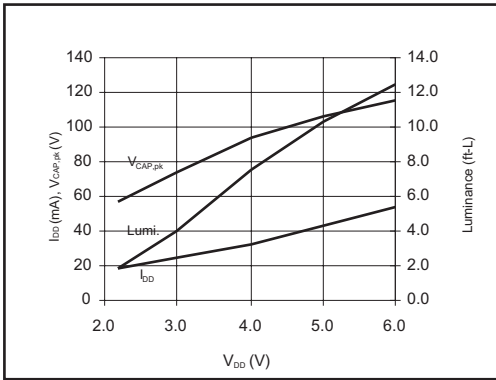


Figure 5: Supply Current and Luminance vs. Supply Voltage.

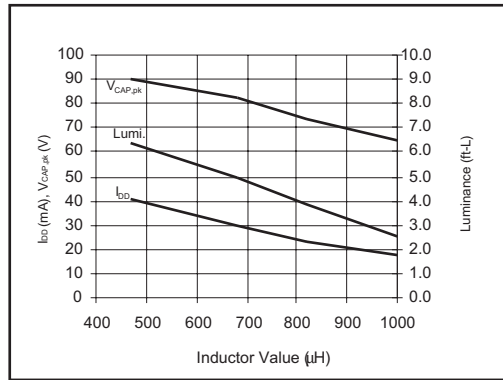


Figure 6: Supply Current and Luminance vs. Inductor Value.

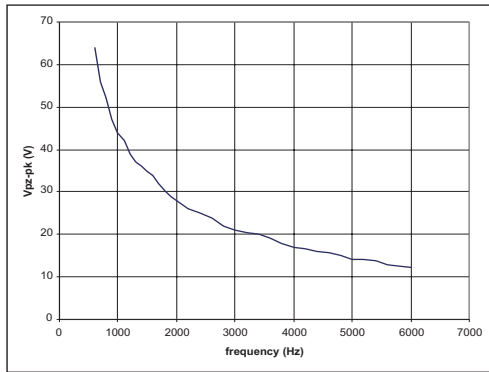


Figure 7: Piezo Output Voltage vs. PZCK Input Frequency.

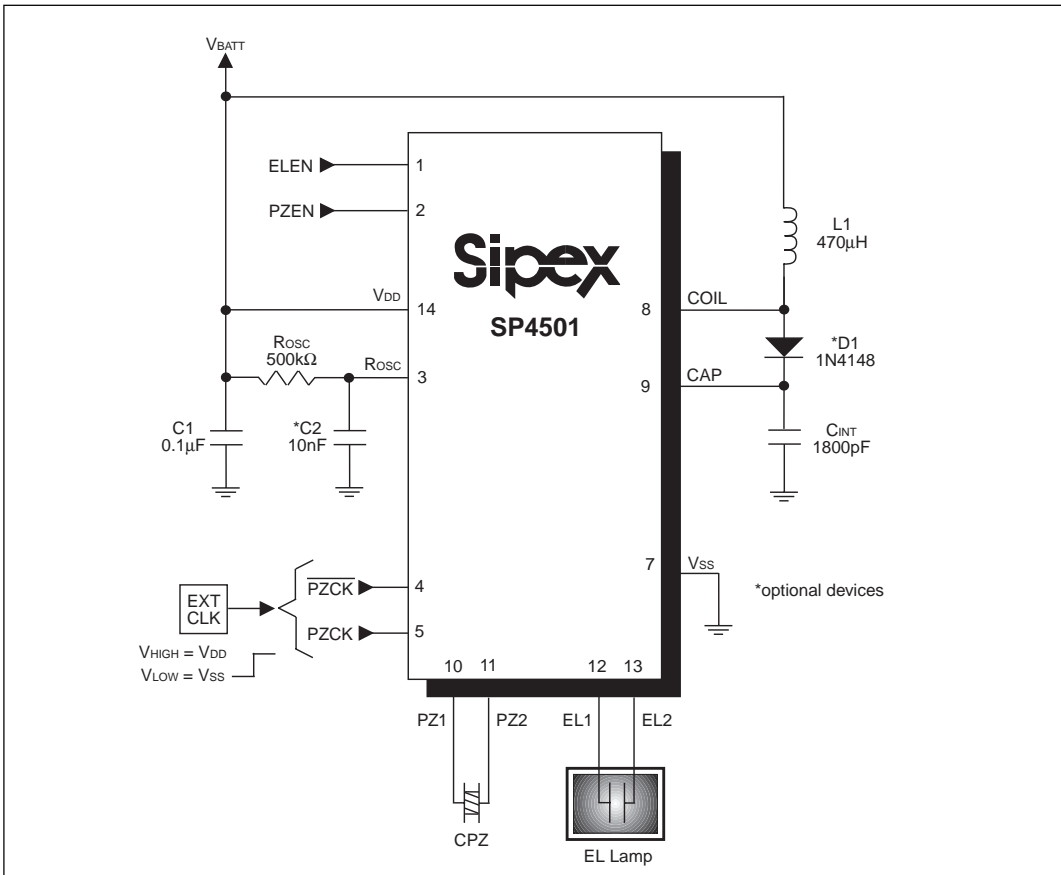


Figure 8: Typical Application Circuit of the SP4501

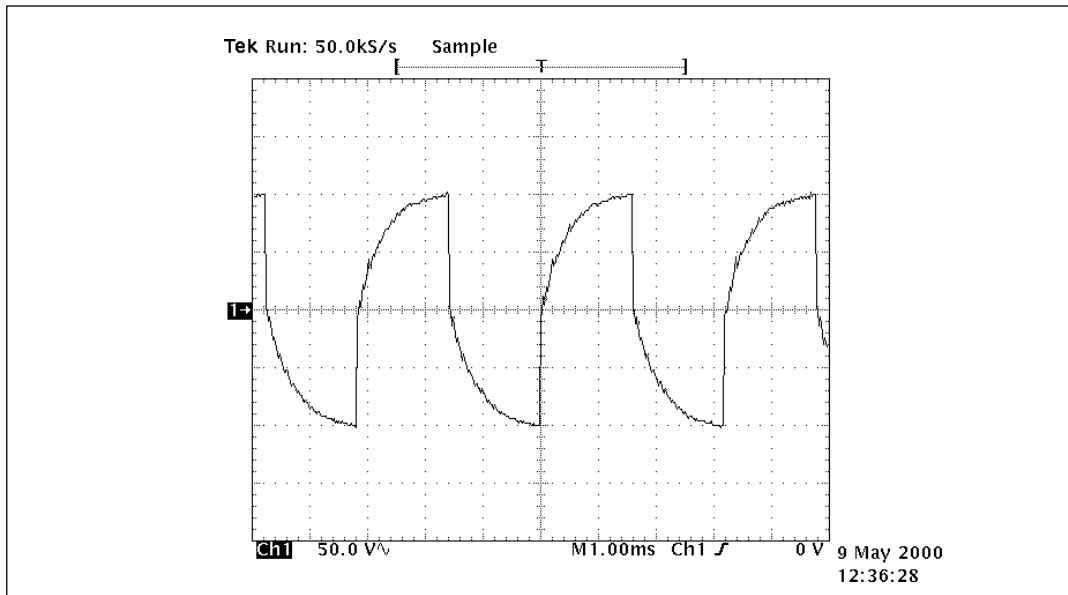


Figure 9: Typical EL Lamp Voltage Waveform

PIN ASSIGNMENTS

Pin 1 — ELEN — Electroluminescent Lamp Enable. When driven HIGH, this input pin enables the EL driver outputs. This pin has an internal pulldown resistor.

Pin 2 — PZEN — Piezo Enable. When this input pin is driven HIGH, the piezo operates at a frequency $f_{OSC}/16$. When this input pin is LOW, the clock signals applied to PZCK or \overline{PZCK} will drive the internal piezo circuitry. This pin has an internal pulldown resistor.

Pin 3 — R_{OSC} — Oscillator Resistor. Connecting a resistor between this pin and V_{DD} sets the frequency of the internal clock.

Pin 4 — \overline{PZCK} — Inverse Piezo Clock. When PZEN is LOW, the internal piezo circuit will operate at the frequency of the clock signal applied to this input pin. For the piezo driver to rest in the inactive mode, it is required that \overline{PZCK} remains at logic HIGH. This pin has an internal pullup resistor.

Pin 5 — PZCK — Piezo Clock. When PZEN is LOW, the internal piezo circuit will operate at the frequency of the clock signal applied to this input pin. For the piezo driver to rest in the inactive mode, it is required that PZCK remains at logic LOW. This pin has an internal pulldown resistor.

Pin 6 — No connect.

Pin 7 — V_{SS} — Power Supply Ground. Connect to the lowest circuit potential, typically ground

Pin 8 — COIL — Coil. The inductor for the boost converter is connected from V_{BATT} to this pin.

Pin 9 — CAP — Integrator Capacitor. An integrator capacitor connected from this pin to ground filters out any coil switching spikes or ripple present in the output waveform to the EL lamp. Connecting a fast recovery diode from COIL to CAP increases the light output of the EL lamp.

Pin 10 — PZ1 — Piezotransducer Output. Connect this pin to the piezotransducer.

Pin 11 — PZ2 — Piezotransducer Output. Connect this pin to the piezotransducer.

Pin 12 — EL1 — Electroluminescent Lamp Output. Connect this pin to the EL lamp.

Pin 13 — EL2 — Electroluminescent Lamp Output. Connect this pin to the EL lamp.

Pin 14 — V_{DD} — Positive Power Supply. This pin should be bypassed with a $0.1\mu\text{F}$ capacitor.

Coil Manufacturers

Hitachi Metals
Material Trading Division
2101 S. Arlington Heights Road,
Suite 116
Arlington Heights, IL 60005-4142
Phone: 1-800-777-8343 Ext. 12
(847) 364-7200 Ext. 12
Fax: (847) 364-7279

Hitachi Metals Ltd. Europe
Immernannstrasse 14-16, 40210
Dusseldorf, Germany
Contact: Gary Loos
Phone: 49-211-16009-0
Fax: 49-211-16009-29

Hitachi Metals Ltd.
Kishimoto Bldg. 2-1, Marunouchi
2-chome, Chiyoda-Ku, Tokyo, Japan
Contact: Mr. Noboru Abe
Phone: 3-3284-4936
Fax: 3-3287-1945

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78 Shenton Way #12-01,
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Contact: Mr. Stan Kaiko
Phone: 222-8077
Fax: 222-5232

Hitachi Metals Ltd. Hong Kong
Room 1107, 11/F., West Wing,
Tsim Sha. Tsui Center 66
Mody Road, Tsimshatsui East,
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Fax: 2311-2095

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Georgia 30080 U.S.A.
Phone: (770) 436-1300
Fax: (770) 436-3030

Murata European
Holbeinstrasse 21-23, 90441
Numberg, Postfachanschrift 90015
Phone: 011-4991166870
Fax: 011-49116687225

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Fax: 011 88644252929

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Sumida Electric Co., LTD.
14 Floor, Eastern Center, 1065
King's Road, Quarry Bay,
Hong Kong
Phone: 28806688
Fax: 25659600

Polarizers/transflector Mnfg.

Nitto Denko
Yoshi Shinozuka
Bayside Business Park 48500
Fremont, CA. 94538
Phone: 510 445 5400
Fax: 510 445-5480

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

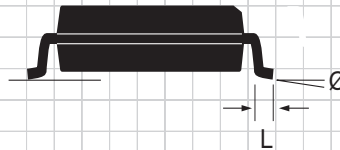
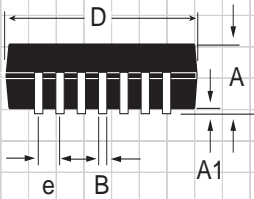
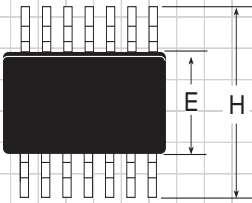
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4 Lucent Dr.
Lebanon, NH. 03766
Phone: (603) 643-7766
Fax: (603) 643-5947

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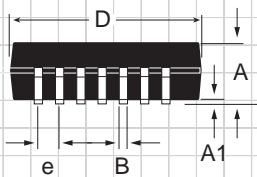
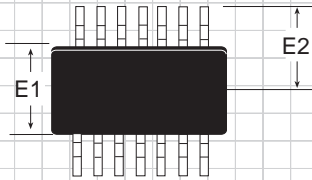
Gunze Electronics
2113 Wells Branch Parkway
Austin, TX 78728
Phone: (512) 752-1299
Fax: (512) 252-1181

PACKAGE: PLASTIC NARROW SMALL OUTLINE (NSOIC)



| DIMENSIONS in. (mm) Minimum/Maximum | 14-PIN |
|---|------------------------------|
| A | 0.053/0.069 (1.346/1.748) |
| A1 | 0.004/0.010 (0.102/0.249) |
| B | 0.014/0.018 (0.360/0.460) |
| D | 0.337/0.344 (8.552/8.748) |
| E | 0.150/0.157 (3.802/3.988) |
| e | 0.050 BSC (1.270 BSC) |
| H | 0.228/0.244 (5.801/6.198) |
| L | 0.016/0.050 (0.406/1.270) |
| Ø | 0°/8° (0°/8°) |

PACKAGE: PLASTIC THIN SMALL OUTLINE (TSSOP)



| DIMENSIONS in inches (mm) Minimum/Maximum | | 14-PIN |
|---|--|----------------------------|
| A | | - /0.043 (/1.10) |
| A1 | | 0.002/0.006 (0.05/0.15) |
| B | | 0.007/0.012 (0.19/0.30) |
| D | | 0.193/0.201 (4.90/5.10) |
| E1 | | 0.169/0.177 (4.30/4.50) |
| e | | 0.026 BSC (0.65 BSC) |
| E2 | | 0.126 BSC (3.20 BSC) |
| L | | 0.020/0.030 (0.50/0.75) |
| Ø | | 0°/8° |

ORDERING INFORMATION

| Model | Temperature Range | Package Type |
|-----------------|----------------------|------------------------|
| SP4501EN | -40°C to +85°C | 14-Pin NSOIC |
| SP4501EY | -40°C to +85°C | 14-Pin TSSOP |
| SP4501NEB | | NSOIC Evaluation Board |



SIGNAL PROCESSING EXCELLENCE

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