SP4403
Electroluminescent Lamp Driver

DESCRIPTION
The SP4403 is a high voltage output DC-AC inverter specifically designed to drive electroluminescent lamps to backlight liquid crystal displays, keypads, and backlit readouts used in battery operated portable equipment. The SP4403 will operate from a 1.8V-6.0V power supply. The SP4403 is capable of supplying up to more than 160 \( V_{pp} \) signals, making it ideal for driving electroluminescent lamps. One external inductor is required to generate the high voltage, and one external capacitor is used to select the oscillator frequency. The device could be used in low power portable products, such as PDA’s, pagers, cellular phones, and other portable applications using LCDs in dim or low light environments. The SP4403 is offered in die form and 8-pin SOP packages.

FEATURES
- 1.8V-6.0V Battery Operation
- High Voltage Output, Low power consumption
- Internal Oscillator
- Uses Small 680µH or 1mH Coil
- Pin-Pin replacement of Sipex SP4422A, SP4423, Functional replacement of : SP4403, IMP803, D340B, D355B

APPLICATIONS
- PDA
- Pagers
- Cellular Phones
- Remote Controls
- Handheld Computers
- Handheld GPS Units
- LCD Module

Ordering Information

<table>
<thead>
<tr>
<th>PART NO.</th>
<th>TEMP. RANGE (°C)</th>
<th>PACKAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SP4403EM</td>
<td>-40 – 85 °C</td>
<td>8-Pin SOP</td>
</tr>
<tr>
<td>SP4403EMT</td>
<td>-40 – 85 °C</td>
<td>8-Pin TSSOP</td>
</tr>
<tr>
<td>SP4403EU</td>
<td>-40 – 85 °C</td>
<td>8-Pin MSOP</td>
</tr>
<tr>
<td>SP4403EX</td>
<td>-40 – 85 °C</td>
<td>Dice</td>
</tr>
</tbody>
</table>

ABSOLUTE MAXIMUM RATING
- \( V_{DD} \): 6.5V
- \( HON \) (pin1): -0.3V to \( V_{DD} + 0.3V \)
- Lamp Output (\( V_{pp} \)): 250V
- Power Dissipation: 500mW

ELECTRICAL SPECIFICATIONS
(T= 25°C; \( V_{DD} = 3.0V \), Lamp Capacitance = 10nF, Coil = 2.2mH (R = 11Ω), \( C_{OSC} = 270pF \) unless otherwise noted)

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNIT</th>
<th>CONDITIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Voltage, ( V_{DD} )</td>
<td>1.8</td>
<td>3.0</td>
<td>6.0</td>
<td>V</td>
<td>( V_{DD} = 3.0V, V_{HON} = 3.0V ) ( V_{DD} = 6.0V, V_{HON} = 6.0V )</td>
</tr>
<tr>
<td>Supply Current, ( I_{COIL} + I_{DD} )</td>
<td>20</td>
<td>30</td>
<td>45</td>
<td>mA</td>
<td>( V_{DD} = 3.0V, V_{HON} = 3.0V ) ( V_{DD} = 6.0V, V_{HON} = 6.0V )</td>
</tr>
<tr>
<td>Coil Voltage, ( V_{COIL} )</td>
<td>( V_{DD} )</td>
<td>6.0</td>
<td>V</td>
<td>( V_{DD} = 3.0V )</td>
<td></td>
</tr>
<tr>
<td>( HON ) Input Voltage, ( V_{HON} )</td>
<td>LOW: ( EL ) off</td>
<td>( -0.25 )</td>
<td>( 0 )</td>
<td>( V_{DD} - 0.25 )</td>
<td>( V_{DD} )</td>
</tr>
<tr>
<td>( HON ) Current, ( EL ) On</td>
<td>( 8 )</td>
<td>( 40 )</td>
<td>µA</td>
<td>( V_{HON} = V_{DD} = 3.0V )</td>
<td></td>
</tr>
<tr>
<td>Shutdown Current, ( I_{SID} = I_{COIL} + I_{DD} )</td>
<td>( 0.03 )</td>
<td>1</td>
<td>µA</td>
<td>( V_{DD} = 3.0V, V_{HON} = 0V )</td>
<td></td>
</tr>
</tbody>
</table>

INDUCTOR DRIVE
- Coil Frequency, \( f_{COIL} = f_{LAMP} \times 32 \) | 9.6 | kHz |
- Coil Duty Cycle | 85 | % |

EL LAMP OUTPUT
- EL Lamp Frequency, \( f_{LAMP} \) | 200 | 350 | 600 | Hz | \( V_{DD} = 3.0V \) |
- Peak to Peak | 160 | 180 | Vpp | \( V_{DD} = 3.0V \) |

*This data sheet specifies environmental parameters, final test conditions and limits as well suggested operating conditions.

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 – \( CC_{II} \)- Coil input, connect coil from \( V_{DD} \) to pin 3.
- Pin 4 – \( EL_{2} \)- Lamp drive output 2, connect to \( EL_{1} \) lamp.
- Pin 5 – \( EL_{1} \)- Lamp drive output 1, connect to \( EL_{2} \) lamp.
- Pin 6 – \( V_{DD} \)- Power supply for driver, connect to system \( V_{DD} \).
- Pin 7 – \( Cap_{1} \)- Capacitor input 1, connect to \( C_{OSC} \).
- Pin 8 – \( Cap_{2} \)- Capacitor input 2, connect to \( C_{OSC} \).
SP4403

BOUNDING DIAGRAM

<table>
<thead>
<tr>
<th>Pad Name</th>
<th>X(μm)</th>
<th>Y(μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDD</td>
<td>900.5</td>
<td>1998.5</td>
</tr>
<tr>
<td>CAP1</td>
<td>476.5</td>
<td>1998.5</td>
</tr>
<tr>
<td>CAP2</td>
<td>177.5</td>
<td>1989.5</td>
</tr>
<tr>
<td>HON</td>
<td>187.5</td>
<td>1455.5</td>
</tr>
<tr>
<td>VSS1</td>
<td>187.5</td>
<td>423.5</td>
</tr>
<tr>
<td>VSS2</td>
<td>187.5</td>
<td>248.5</td>
</tr>
<tr>
<td>COIL</td>
<td>1778.5</td>
<td>248.5</td>
</tr>
<tr>
<td>N. C.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. C.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL2</td>
<td>1778.5</td>
<td>1447.5</td>
</tr>
<tr>
<td>EL1</td>
<td>1778.5</td>
<td>1638.5</td>
</tr>
</tbody>
</table>

NOTES:
1. Dimensions are in Microns unless otherwise noted.
2. Bonding pads are 125x125 typical
3. Outside dimensions are maximum, including scribe area.
4. Pad center coordinates are relative to die center.
5. Die size 1980 x 2160.
6. VSS1 and VSS2 are connected to VSS supply on PCB.
7. N.C. - no connection.

BLOCK DIAGRAM AND TYPICAL APPLICATION

SP4403 Schematic
THEORY OF OPERATION
The **SP4403** 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. In general, increasing the **COSC** capacitor will increase the lamp output, and reduce the lamp frequency.

The suggested oscillator frequency is 64kHz. The oscillator output is internally divided to create two internal control signals, **fCOIL** and **fLAMP**. The oscillator output is internally divided down by 8 flip flops, a 64kHz signal will be divided into 8 frequencies; 32kHz, 16kHz, 8kHz, 4kHz, 2kHz, 1kHz, 500Hz, and 250Hz. The 3rd flip flop output (8kHz) is used to drive the coil and the 8th 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 **fCOIL**/**fLAMP** will always equal 32.

The on-chip oscillator of the **SP4403** can be overdriven with an external clock source by removing the **COSC** capacitor and connecting a clock source to pin 8. The clock should have a 50% duty cycle and range from VDD-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.

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. **SP4403** 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.

TYPICAL APPLICATION CIRCUIT (good result, high brightness, low current)

**APPLICATION CIRCUIT** (very low power consumption when inductor and capacitor selected as indicated)
**APPLICATION CIRCUIT** (Hold delay, high brightness when inductor and capacitor selected as indicated)

![Application Circuit Diagram]

**Layout Considerations**
The SP4403 circuit board layout must observe careful analog precautions. For applications with noisy voltage power supplies a 1.1\(\mu\)F low ESR decoupling capacitor must be connected from VDD 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.

**Selection of the optimum circuit configuration** (the testing data comes from following curves. EL lamp: 25cm\(^2\), \(V_{DD}=5V\))

<table>
<thead>
<tr>
<th>Result</th>
<th>Coil</th>
<th>Capacitor</th>
<th>Brightness (Lux)</th>
<th>Current (mA)</th>
<th>EL frequency</th>
<th>Efficiency (brightness/Current)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (high brightness, low current)</td>
<td>1mH</td>
<td>180pF</td>
<td>72</td>
<td>55</td>
<td>(~320Hz)</td>
<td>1.3</td>
</tr>
<tr>
<td>Very low current (normal brightness)</td>
<td>2.2mH</td>
<td>220pF</td>
<td>40</td>
<td>30</td>
<td>(~300Hz)</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>2.2mH</td>
<td>240pF</td>
<td>44</td>
<td>33</td>
<td>(~270Hz)</td>
<td>1.3</td>
</tr>
<tr>
<td>Very high light</td>
<td>2.2mH</td>
<td>270pF</td>
<td>50</td>
<td>37</td>
<td>(~220Hz)</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>820(\mu)H</td>
<td>180pF</td>
<td>79</td>
<td>62</td>
<td>(~320Hz)</td>
<td>1.3</td>
</tr>
</tbody>
</table>

As for special requirement, the selection of coil (inductor) and capacitor please refer to the following performance curves. The guide line: the brightness high enough to meet the requirement, to reduce the supply current (lower power consumption). The EL brightness is depending on both EL lamp frequency and IC output voltage. If frequency of white EL lamp is much high, the light will move to slight blue color.

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. SP4403 supplies characterization charts to aid the designer in selecting the optimum circuit configuration.

**EL lamp:** There are two kinds of EL lamp material: normal light and high light, it's better to use high light EL lamp.

**Capacitor (\(C_{osc}\)):** The smaller the \(C_{osc}\) value, the higher EL lamp frequency. Suggest value: 100 – 270pF.

**Coil (inductor):** The selection of coil is very important for EL driver. Energy is stored in the coil. It's not the same coil for different size EL lamp. Generally speaking, if coil is bigger value, the total working current is lower. The resistance of coil is lower, the EL driver can get better result, brightness is higher. Suggest value: 680\(\mu\)H –3.3 mH.

**Voltage \(V_{Vin}\):** High input voltage will result high brightness of EL lamp.
TYPICAL PERFORMANCE CURVES
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 (the size of EL lamp: 25cm², input voltage: VDD=5V).
PACKAGE

8-Pin SOP

Unit: mm

8-Pin TSSOP

Unit: mm
PACKAEGE (continued)

8-Pin MSOP

Unit: mm

2.95 ± 0.2

2.8 ± 0.2

4.0 ± 0.3

0.45 ± 0.2

0.13 ± 0.1

0.65 ± 0.1

0.2 ± 0.1

1.3 ± 0.1

1.1 ± 0.1

0.1 ± 0.1