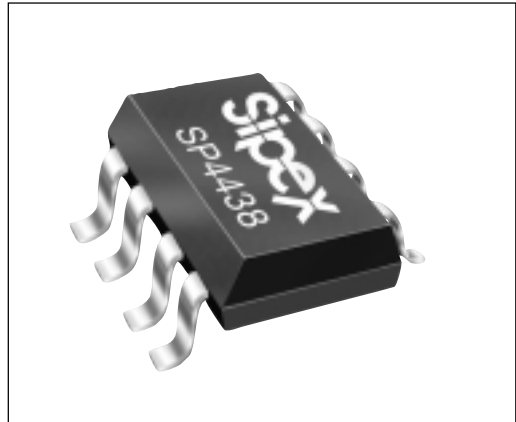


Ultra-Quiet Electroluminescent Lamp Driver For Cellular Phone Applications

- Patent Pending Output Waveshaping
- Waveshaped Output Optimized For Low Acoustic Noise And Maximum Efficiency
- Reduced Supply Current And Standby Current
- Up to 15cd/m² For Cell Phone Sized EL Lamps (2 to 3 sq. in.)
- Waveshaped Output And Low Frequency Operation Minimize Stress On EL Lamp To Extend Its Lifetime
- Uses 820μH, Sub-2mm Coils
- Gradual Rising And Falling Edges Minimizes EMI
- +2.7V To +3.3V Battery Operation
- Space-Saving 8-pin MSOP package

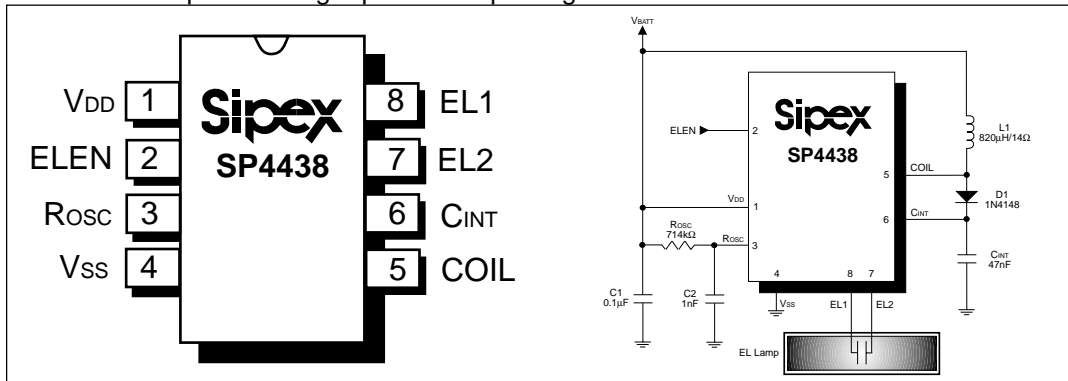


APPLICATIONS

- Cellular Radios
- Wireless Communication Products

DESCRIPTION

The SP4438 device is a low noise, high voltage output DC-AC inverter designed to drive electroluminescent lamps to backlight liquid crystal display and keypads used in cellular phones, cordless phones, 2-way radios, and other wireless communication products. The output waveform of the SP4438 device is ideal for cell phone applications requiring low acoustic noise performance. One external resistor is used to set the internal oscillator frequency and one inductor is required to generate the high voltage AC output to drive an EL lamp up to 3 square inches in size. The SP4438 operates from a +3.0V battery source and has a low power standby mode that draws less than 1μA, making it ideal for low-power cellular applications. All input pins are ESD protected with internal diodes to V_{DD} and V_{SS} . The SP4438 is offered in a space-saving 8-pin MSOP package.



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.

Supply Voltage (V_{DD} to V_{SS}).....-0.3V, +5V
 Operating Temperature.....-40°C to +85°C
 Storage Temperature.....-65°C to +150°C

Power Dissipation Per Package
 8-pin MSOP
 (derate 4.85mW/°C above +70°C).....400mW



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.

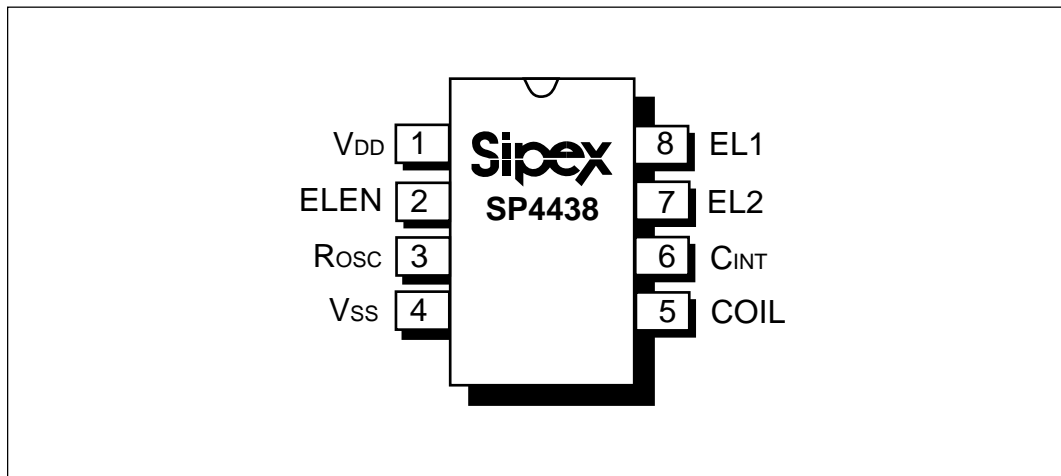
SPECIFICATIONS

$V_{DD} = +2.7V$ to $+3.3V$, $L_{COIL} = 820\mu H/14\Omega$, $R_{OSC} = 714k\Omega$, EL Lamp Load = $(8nF + 2.5k\Omega)/1M\Omega$, and $T_{AMB} = -40^\circ C$ to $+85^\circ C$. $T_{AMB} = 25^\circ C$ for typical values unless otherwise noted.

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
INPUT CHARACTERISTICS					
Supply Voltage, V_{DD}	2.7	3.0	3.3	V	
Supply Current, $I_{COIL} + I_{DD}$			30	mA	$V_{DD} = +3.0V$
Coil Voltage, V_{COIL}	V_{DD}		9	V	
ELEN Input Voltage, V_{ELEN} LOW: EL OFF HIGH: EL ON	-0.25 $V_{DD} - 0.25$	0 V_{DD}	0.25V $V_{DD} + 0.25$	V	
ELEN Input Impedance	1	3		M Ω	
Shutdown Current, $I_{SD} = I_{COIL} + I_{DD}$			1	μA	$V_{ELEN} = LOW, V_{DD} = +3.0V$
INDUCTOR DRIVE					
Coil Frequency, f_{COIL}	26 23	32	43 45	kHz	$R_{OSC} = 714k\Omega, T_{AMB} = +25^\circ C$ $T_{AMB} = -40^\circ C$ to $+85^\circ C, V_{DD} = +3.0V$
Coil Duty Cycle		90		%	
Peak Coil Current, $I_{PK-COIL}$			100	mA	
EL LAMP OUTPUT					
EL Lamp Frequency, f_{LAMP}	190 175	250	336 348	Hz	$T_{AMB} = +25^\circ C, V_{DD} = +3.0V$, with load $T_{AMB} = -40^\circ C$ to $+85^\circ C$
Peak to Peak Output Voltage, V_{P-P}	130 120	145 140		V_{P-P}	$T_{AMB} = +25^\circ C, V_{DD} = +3.0V$, with load $T_{AMB} = -40^\circ C$ to $+85^\circ C$
Audible Noise		26		dB _{SPL}	$T_{AMB} = +25^\circ C, V_{DD} = +3.0V$, NOTE 1
Rise Time	.55	0.8	1.0	ms	$T_{AMB} = +25^\circ C, V_{DD} = +3.0V$, with load, measured from 10% to 90%

NOTE 1: Audible Noise is measured inside an acoustic sound chamber. The Sound Level Meter is a B&K Mediator 2238, A-weighted with Condenser Mic type 4188 positioned 1/4 inch above the lamp in an 8 cubic inch volume. See Figure 5 on page 6.

PINOUT



PIN ASSIGNMENTS

Pin 1 — V_{DD} — Positive Battery Power Supply. Connect such that $+2.7\text{V} < V_{\text{DD}} < +3.3\text{V}$.

Pin 2 — ELEN — Electroluminescent Lamp Enable. When driven HIGH, this input pin enables the EL driver outputs for EL1 and EL2. This pin has an internal pulldown resistor.

Pin 3 — R_{OSC} — Oscillator Resistor. Connecting a resistor to this input pin sets the frequency of the internal clock.

Pin 4 — V_{SS} — Power Supply Common. Connect to the lowest circuit potential, typically ground.

Pin 5 — COIL — The inductor for the EL lamp is connected from V_{DD} to this input pin.

Pin 6 — C_{INT} — Integrating Capacitor. An integrating capacitor (47nF typical) 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 C_{INT} increases the light output of the EL lamp.

Pin 7 — EL2 — Electroluminescent Lamp Output 2. This is a high voltage lamp driver output pin to connect to the EL lamp.

Pin 8 — EL1 — Electroluminescent Lamp Output 1. This is a high voltage lamp driver output pin to connect to the EL lamp.

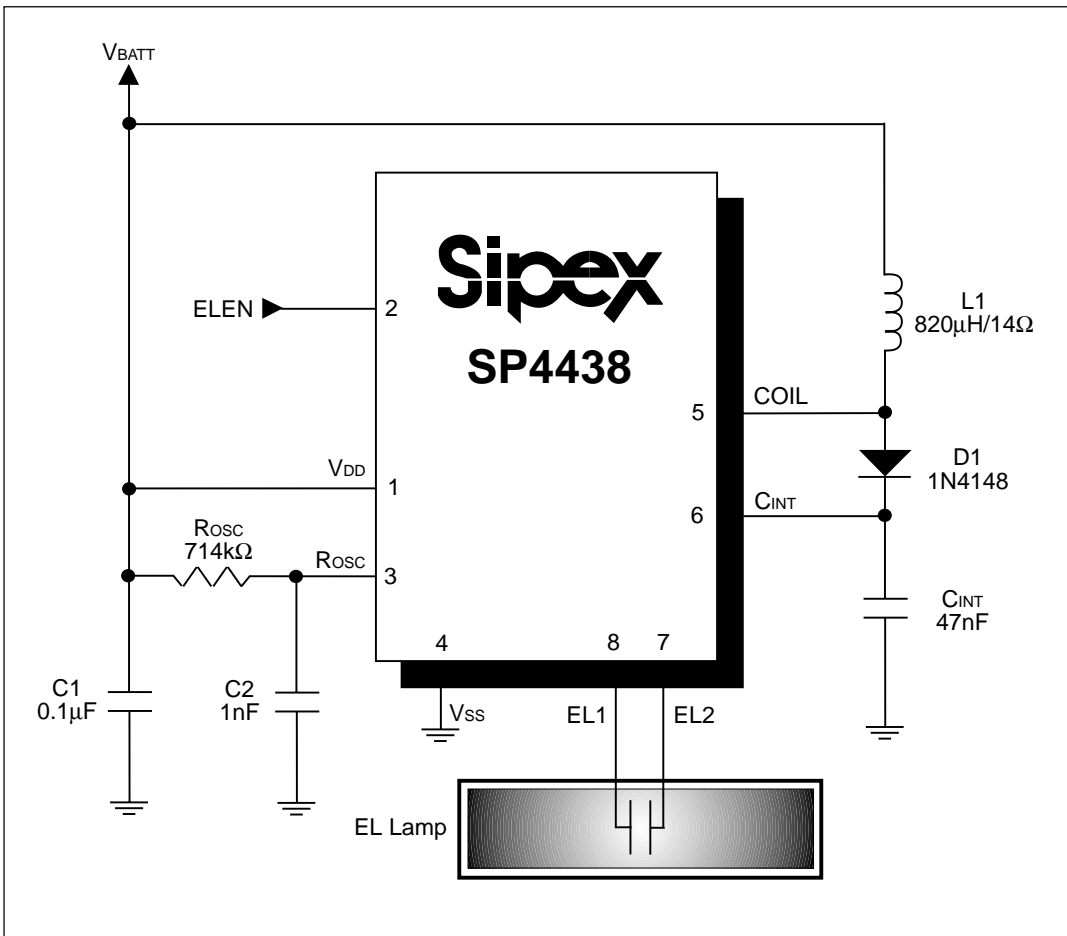


Figure 1: Typical Operating Circuit for the SP4438.
Note: C1 should be close to L1.

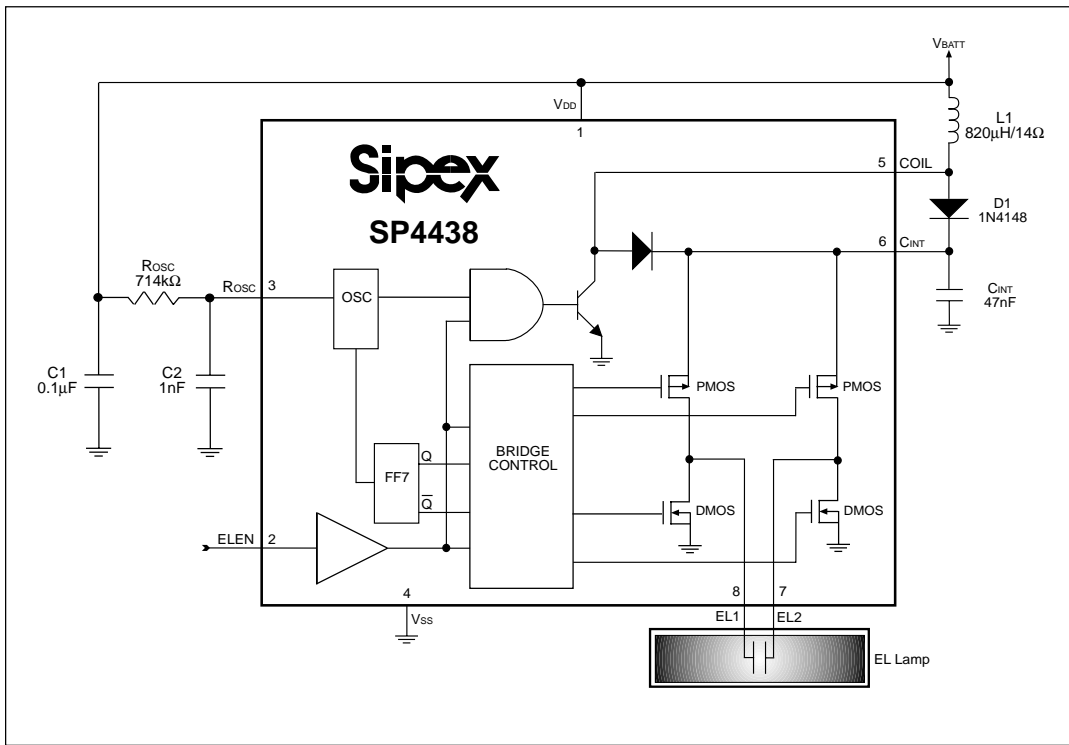


Figure 2: Internal Block Diagram of the SP4438

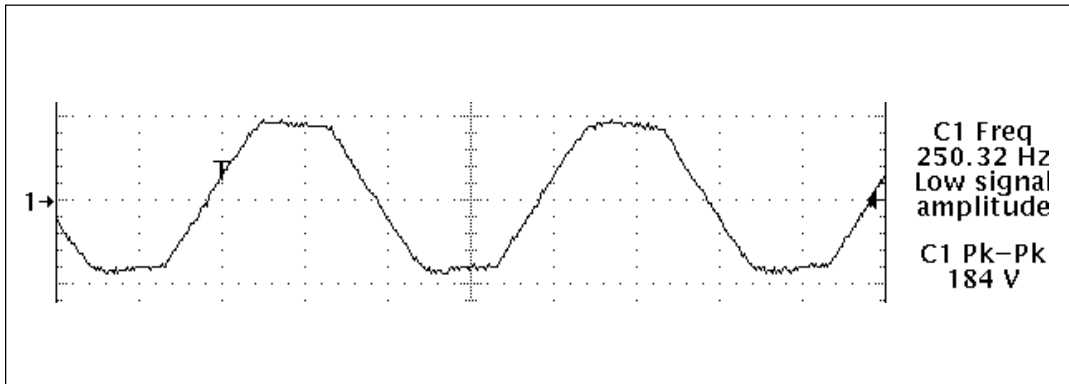


Figure 3: EL Differential Output Waveform of the EL1 and EL2 Outputs of the SP4438

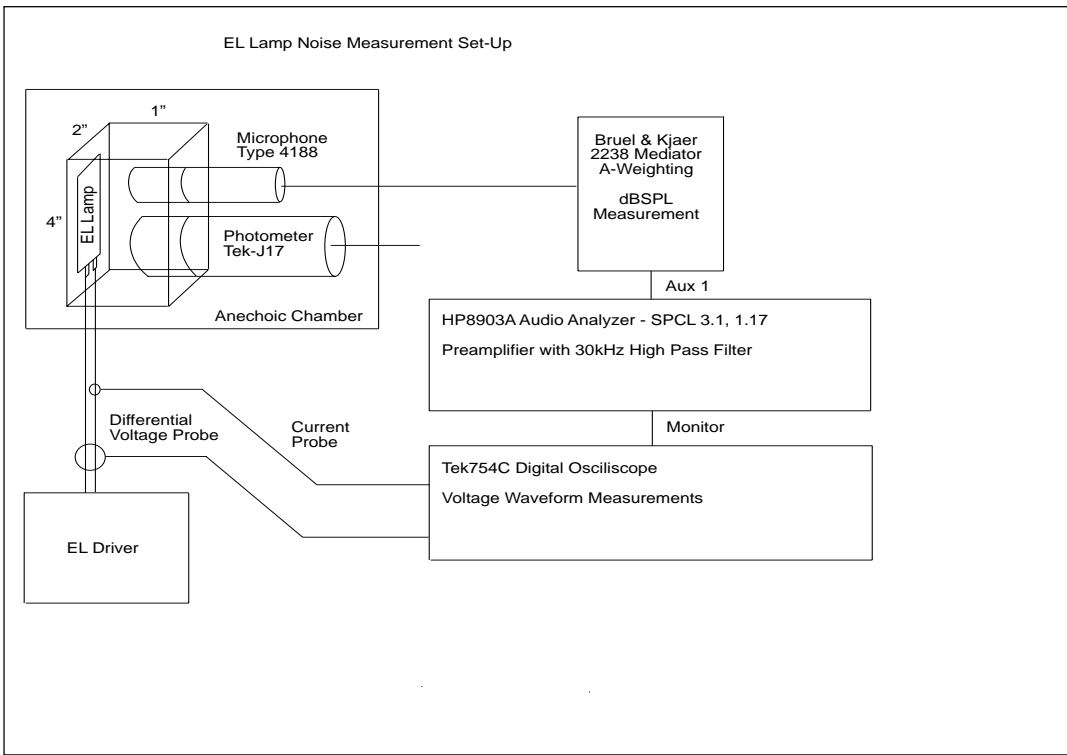


Figure 4: Dual Supply Application Circuit for the SP4438

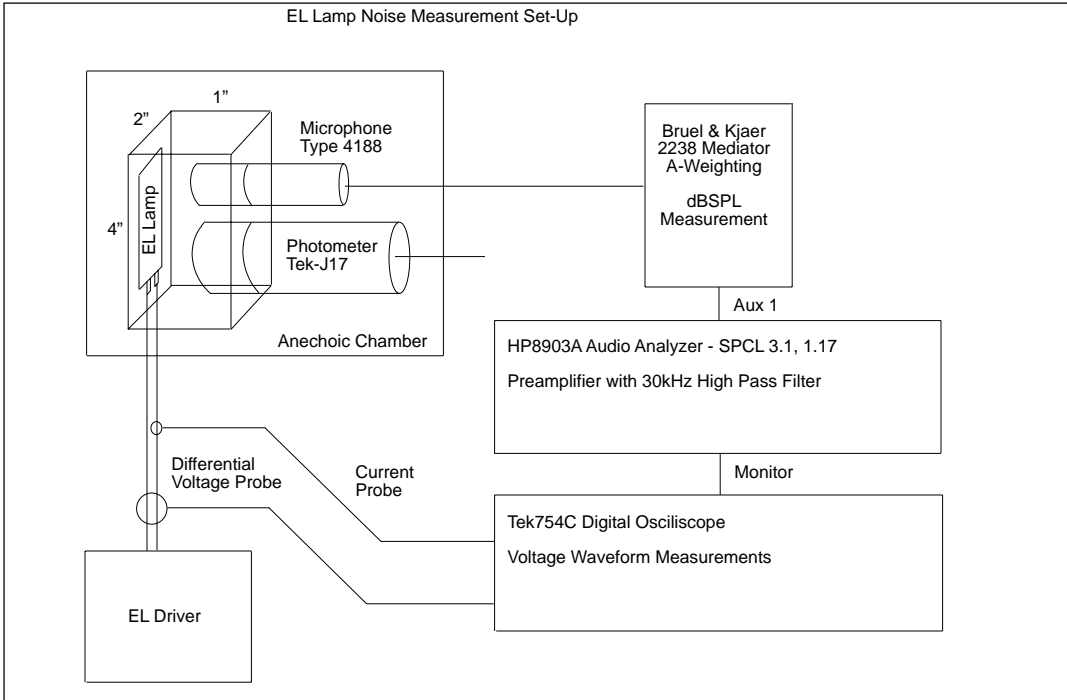


Figure 5. Electroluminescent Lamp Noise Measurement Setup for the SP4438

DESCRIPTION

The SP4438 Electroluminescent Lamp Driver is a low-cost low voltage device ideal for the replacement of LED backlighting designs in cell phones, PDAs and other portable designs desiring low acoustic noise. The SP4438 contains a DC-AC inverter that can produce an AC output of $145V_{p-p}$ (typical) from a +2.7V to +3.3V input voltage. An internal block diagram of the SP4438 can be found in *Figure 2*.

The SP4438 is built on Sipex's dielectrically isolated BiCMOS process that provides the isolation required to separate the high voltage AC signal used to drive the EL lamp from the low voltage logic and signal processing circuitry. This ensures latch-up free operation in the interface between the low voltage CMOS circuitry and the high voltage bipolar circuitry. The SP4438 is ideal for applications driving EL lamps to backlight LCD displays and keypads, used in cellular radios.

A total of only six external components are required for the standard operation of the SP4438: an inductor, a fast recovery diode, three capacitors and a resistor. A diagram of the SP4438 in a typical application can be found in *Figure 1*.

Electroluminescent Technology

An EL lamp is a strip of plastic that is coated with a phosphorous material which emits light (fluoresces) when a (>40V) AC signal is applied across it. Long periods of DC voltages applied to the lamp tends 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 offers low power single chip driver circuits specifically designed to drive small to medium sized electroluminescent panels.

Market Applications

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 consume less power than LEDs or incandescent bulbs making them ideal for battery powered products. Also, EL lamps are able to evenly light an area without creating any undesirable "hot spots" in the display.

THEORY OF OPERATION

The SP4438 is a DC-AC inverter made up of: 1. The Oscillator/Frequency Divider, 2. The Coil/Boost Converter, 3. The Switched H-bridge Network, and 4. The Precision Bridge Control Logic. Further details of each element follow.

The Oscillator/Frequency Divider

The oscillator provides the SP4438 with an on-chip clock used to control the coil switch (f_{COIL}) and the H-bridge network (f_{LAMP}). Although the oscillator frequency can be varied to optimize the lamp output, the ratio of f_{COIL}/f_{LAMP} will always equal 128.

Figure 2 shows the oscillator output driving the coil and through 7 flip flops, driving the lamp. The suggested oscillator frequency is 32kHz for f_{COIL} . The oscillator output is internally divided down by 7 flip flops to create a second internal control signal at 250Hz for f_{LAMP} .

The Coil/Boost Converter

The supply V_{COIL} can range from +2.7V to +9V. See figure 4 on page 6. V_{COIL} should be chosen such that I_{COIL} does not exceed the maximum coil current specification. The majority of the current goes through the coil and is typically much greater than I_{DD} .

The inductor is an external component connected from V_{COIL} to the COIL pin of the SP4438. Energy is stored in the coil according to the equation

$$E_L = 1/2 \times L \times I_p^2$$

where I_p , to the first approximation, is the product

$$I_p = (t_{ON}) \times ((V_{BATT} - V_{CE})/L)$$

where t_{ON} is the time it takes for the coil to reach its peak current, V_{CE} is the voltage drop across the internal NPN transistor and L is the

inductance of the coil. When the NPN transistor switch is off, the energy is forced through an internal diode which drives the switched H-bridge network. This energy recovery is directly related to the brightness of the EL lamp output. There are many variations among coils; magnetic material differences, winding differences and parasitic capacitances.

The f_{COIL} signal controls a switch that connects the coil at the COIL pin to ground or to open circuit. The f_{COIL} signal is a 90% duty cycle signal switching at the oscillator frequency, 32kHz. During the time when the f_{COIL} signal is HIGH, the coil is connected from V_{COIL} to ground and a charged magnetic field is created in the coil. When the f_{COIL} signal is LOW, 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.

The Switched H-Bridge Network

Current sources and precision controlled timing of the SP4438 switched H-bridge network are designed to reduce EMI emissions, extend EL lamp life, and reduce the overall power dissipation of the device.

Current sources were added to the high and low side of the H-bridge network to ensure control of the charge and discharge of the EL lamp. The precision MOSFET timing of the SP4438 allows for controlled charging and discharging of the EL lamp to minimize EMI and audible noise. Refer to *Figure 7* for the single ended and differential output waveforms to the EL lamp.

The Precision Bridge Control Circuitry

This circuitry is driven by the internal oscillator to control the timing of the charge and discharge of the EL lamp to eliminate EMI and noise concerns. This control circuitry drives the H-bridge timing. Refer to *Figure 2* for the internal block diagram of the SP4438.

Fine Tuning Performance

Circuit performance of the SP4438 can be improved with some of the following suggestions:

Increase EL Lamp Light Output: By connecting a fast recovery diode from COIL (pin 5) to C_{INT} (pin 6), the internal diode of the switched H-bridge network 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, be used for D1. This circuit connection can be found in *Figure 2*.

Split Power Supplies: Instead of driving both the logic and power circuitry of the SP4438 from a single battery supply, two supplies can be implemented, one to drive the IC and the other to drive the inductor.

The +2.7V to +3.3V power supply is connected to V_{CC} . This power supply can be used to power the oscillator and control logic. The current draw on this power supply will be minimal, typically <1mA for SP4438.

When selecting a separate +2.7V to +9.0V power supply connected to the inductor to drive the IC power circuitry, it is essential that the proper inductor is selected. The peak current draw of the inductor should not exceed maximum conditions over the entire input voltage operating range.

If the inductor selected is too large, the power current may rise too slowly. At low input voltages, this will not allow the peak current to rise to the set peak current trip point. At high input voltages, the power current might rise too quickly and overshoot the set peak current trip point. These conditions will prevent optimal light output at the EL lamp. Excessive currents may permanently affect the normal operation of the SP4438.

Changing the EL Lamp Output Voltage

Waveform: Designers can alter the trapezoidal output voltage waveform to the EL Lamp. Changing the capacitance of the integrating capacitor, C_{INT} , will ideally integrate the output waveform making it appear more sinusoidal. This will minimize any noise inherent to the application.

Audio Noise Considerations: A system can have different sources of audio noise. The coil, the filter capacitor, and the EL lamp itself may be a source of audio noise if operated in the audio frequency range.

Designers should select either the coil or coil frequency such that the coil is not in continuous mode as this will greatly decrease efficiency and contribute to noise.

Close attention should be given to the mounting of the filter capacitor where the mounting can act as an amplifier, such as in a speaker box. Film capacitors do not exhibit audio noise concerns but certain ceramic capacitors subjected to a high voltage source can exhibit a piezoelectric effect. This can be a source of concern in the audio range.

The EL lamp itself can also exhibit audible noise as a result of high voltage swings at frequencies within the audio range. Close attention should be given to the physical mounting of the EL lamp to diminish this concern that can generate both EMI and audio noise.

Electromagnetic Interference (EMI) Considerations: Electromagnetic Interference (EMI) concerns are rooted in uncontrolled high voltage swings on the EL lamp. The controlled charging and discharging of the EL lamp by the SP4438 minimizes EMI effects.

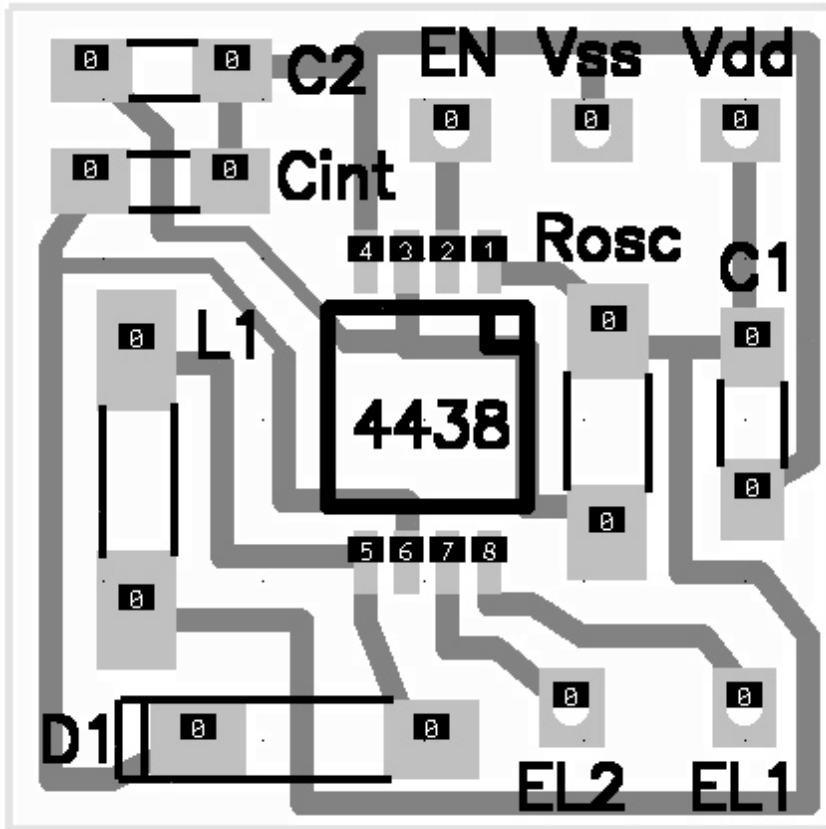
Printed Circuit Board Layout Suggestions: The SP4438's high voltage operation makes PC layout important for minimizing ground bounce and noise. Keep the IC's GND pin and the ground leads of C1 and C_{INT} less than 0.2 in (5mm) apart. Also keep the connections to COIL as short as possible. To maximize output power and efficiency and minimize output ripple voltage, use a ground plane and solder the IC's V_{SS} 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 it is applied, the lamp material and the lamp size. 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 offer retrofitted solutions to the customer's existing LED or non-backlit product for a thorough electrical and cosmetic evaluation. Refer to *Figure 6* for an enlargement and actual size evaluation board layout. Please contact your local Sales Representative for Sipex or the Sipex factory directly to initiate this valued service.

EVALUATION BOARD LAYOUT (ENLARGED)



EVALUATION BOARD LAYOUT (ACTUAL SIZE)



Figure 6. Evaluation Board Layout for the SP4438.

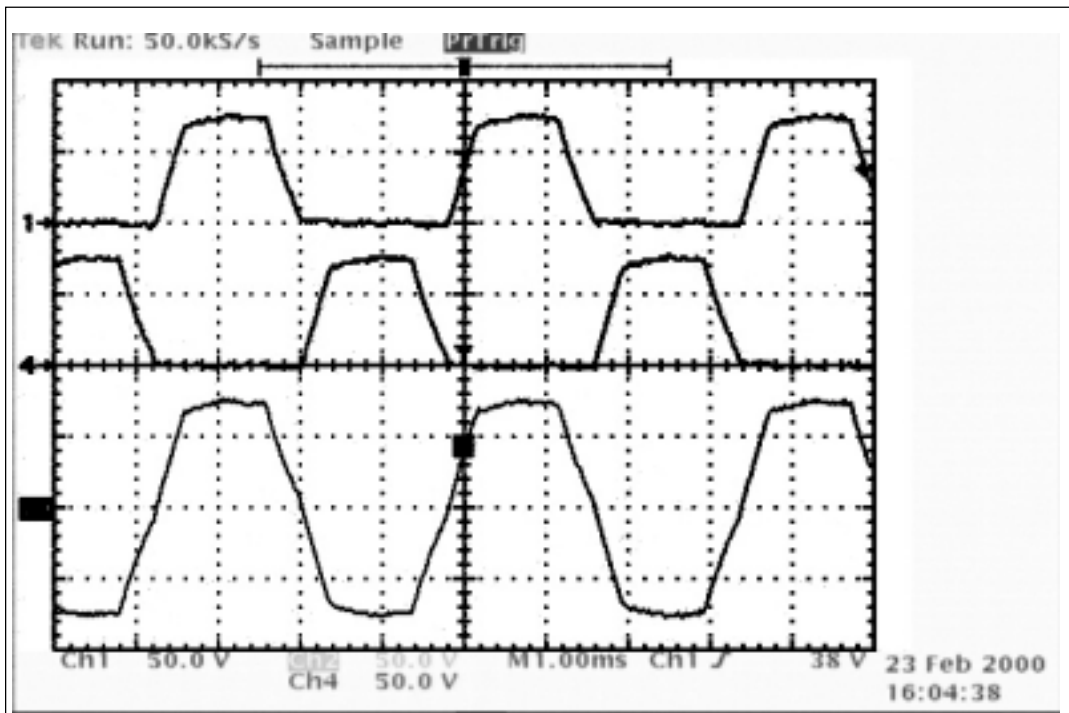


Figure 7. Single Ended and Differential Output Waveforms for the SP4438

CH.1 and CH.2 are single ended waveform SP4438

CH.4 is differential SP4438 waveform.

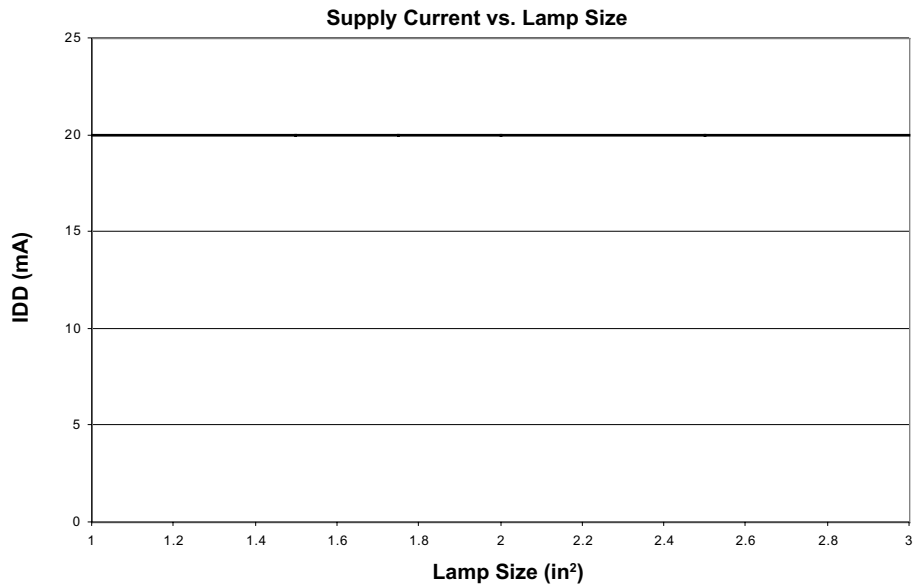


Figure 1

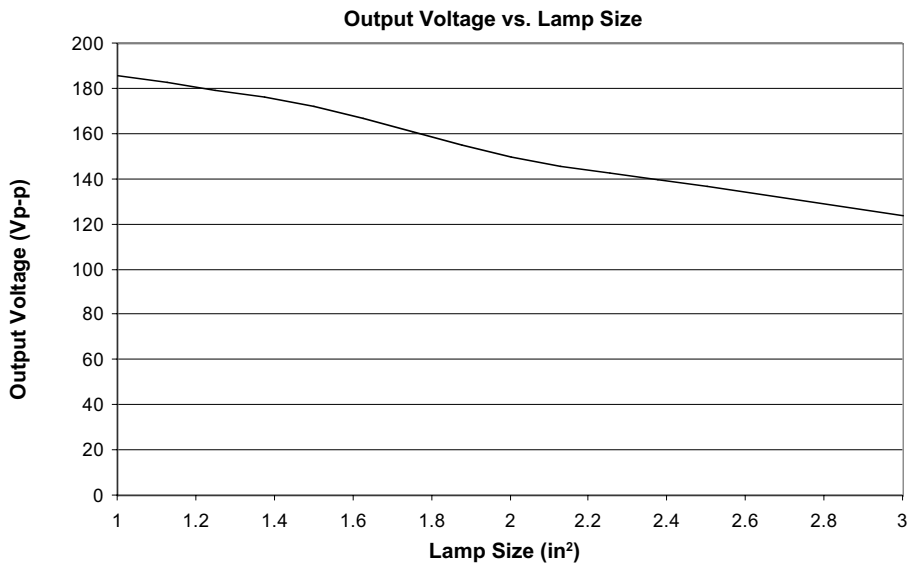


Figure 2

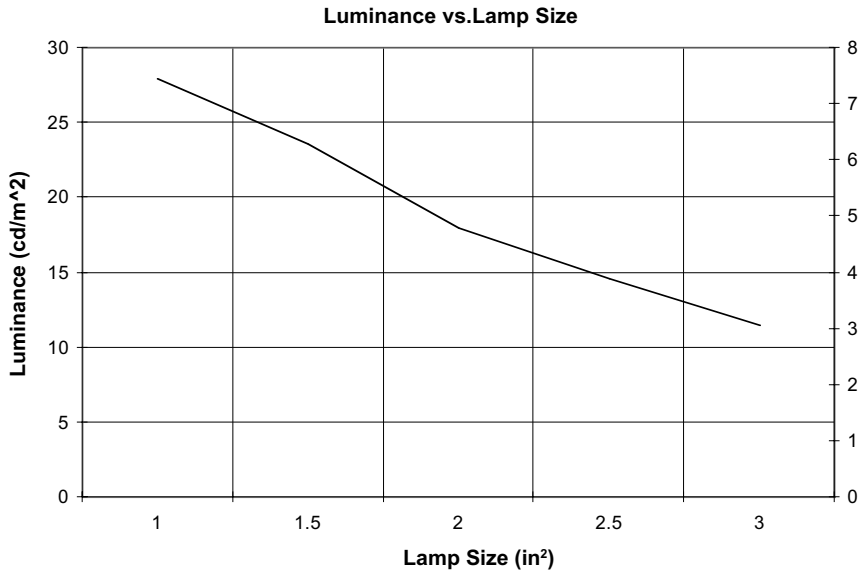


Figure 3

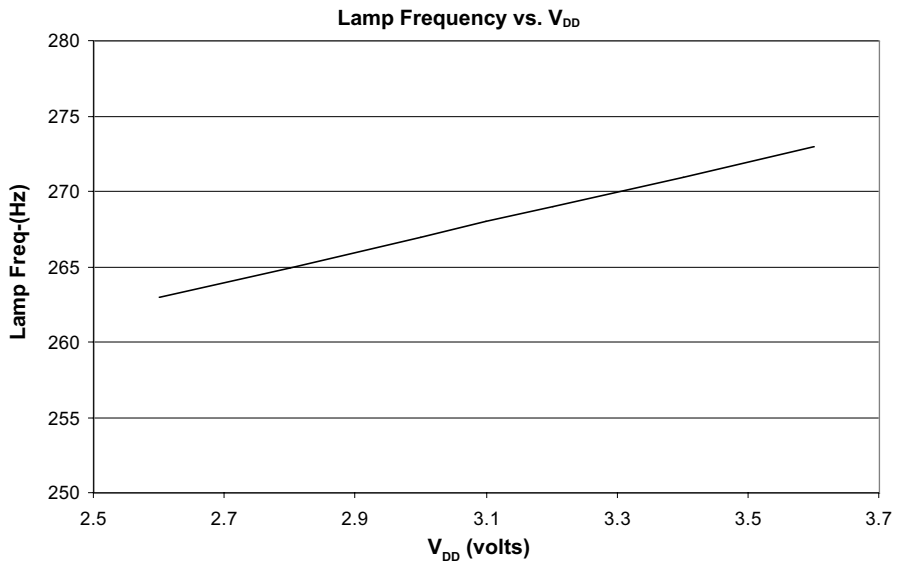
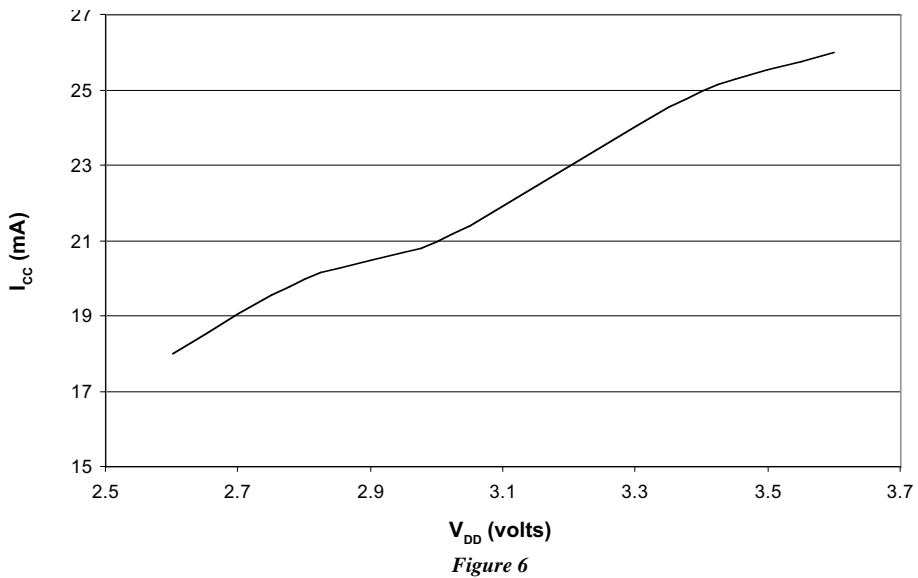
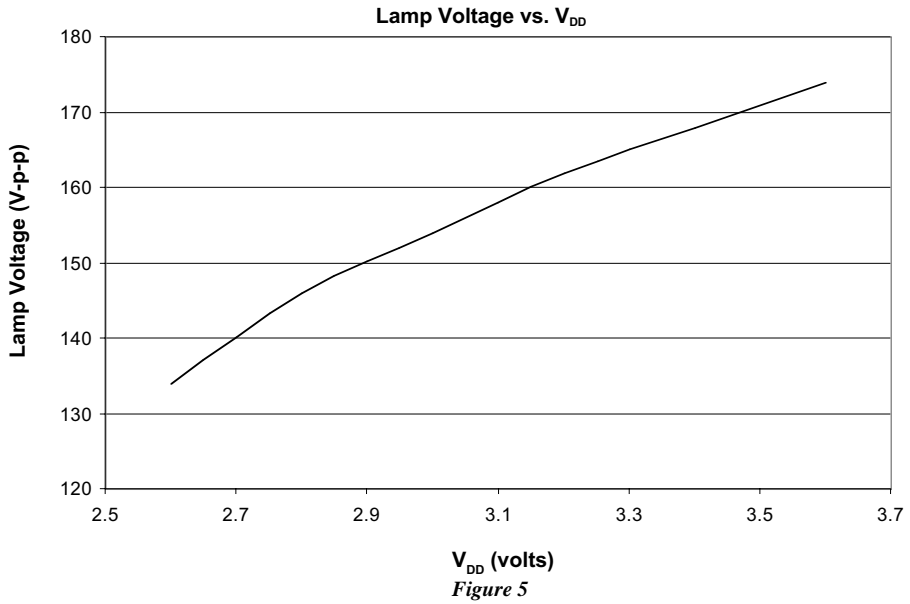


Figure 4



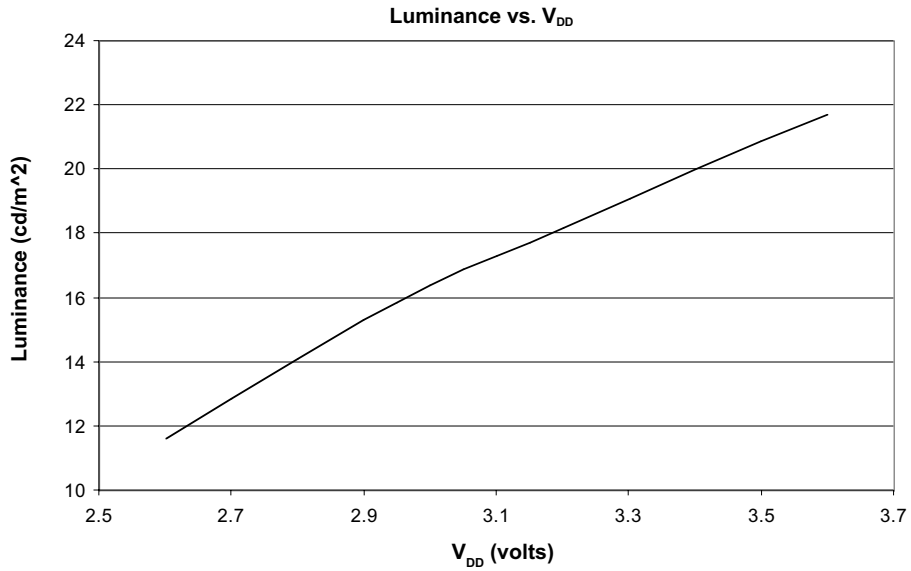


Figure 7

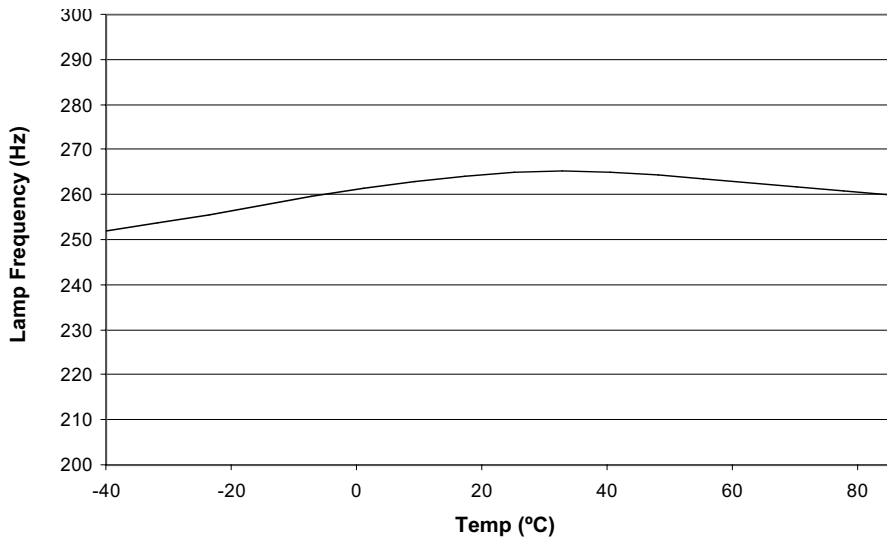


Figure 8

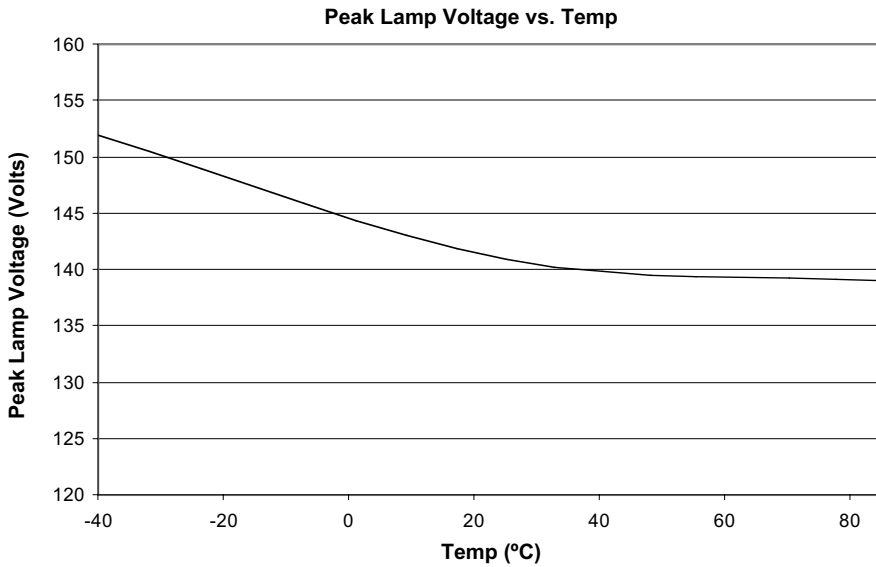


Figure 9

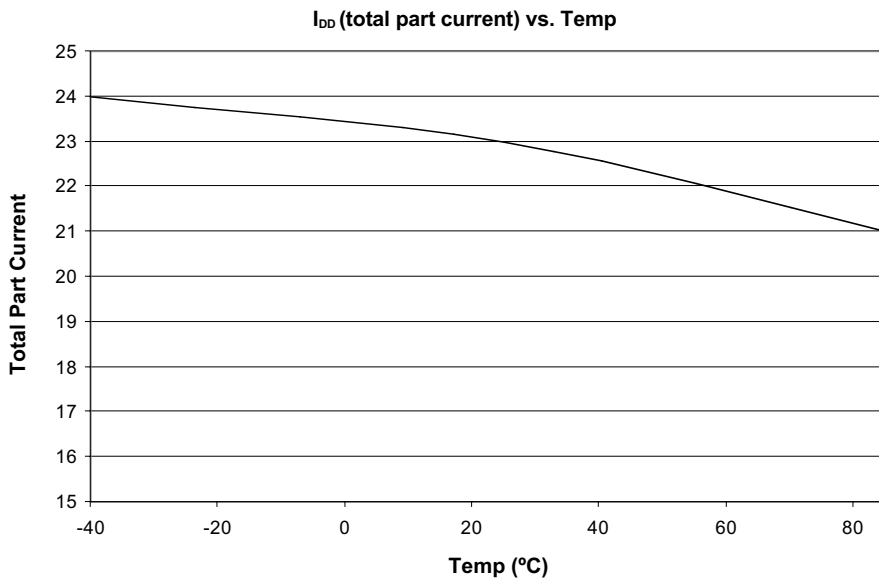


Figure 10

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

Hitachi Metals Ltd. Singapore
78 Shenton Way #12-01,
Singapore 079120
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,
Kowloon, Hong Kong
Phone: 2724-4188
Fax: 2311-2095

Panasonic
6550 Katella Ave
Cypress, CA 90630-5102
Phone: (714) 373-7366
Fax: (714) 373-7323

Sumida Electric Co., LTD.
5999, New Wilke Road,
Suite #110
Rolling Meadows, IL, 60008 U.S.A.
Phone: (847) 956-0666
Fax: (847) 956-0702

Sumida Electric Co., LTD.
4-8, Kanamachi 2-Chrome,
Katsushika-ku, Tokyo 125 Japan
Phone: 03-3607-5111
Fax: 03-3607-5144

Sumida Electric Co., LTD.
Block 15, 996, Bendemeer Road
#04-05 to 06, Singapore 339944
Republic of Singapore
Phone: 2963388
Fax: 2963390

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

Murata
2200 Lake Park Drive, Smyrna
Georgia 30080 U.S.A.
Phone: (770) 436-1300
Fax: (770) 436-3030

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

Murata Taiwan Electronics
225 Chung-Chin Road, Taichung,
Taiwan, R.O.C.
Phone: 011 88642914151
Fax: 011 88644252929

Murata Electronics Singapore
200 Yishun Ave. 7, Singapore
2776, Republic of Singapore
Phone: 011 657584233
Fax: 011 657536181

Murata Hong Kong
Room 709-712 Miramar Tower, 1
Kimberly Road, Tsimshatsui,
Kowloon, Hong Kong
Phone: 011-85223763898
Fax: 011-85223755655

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

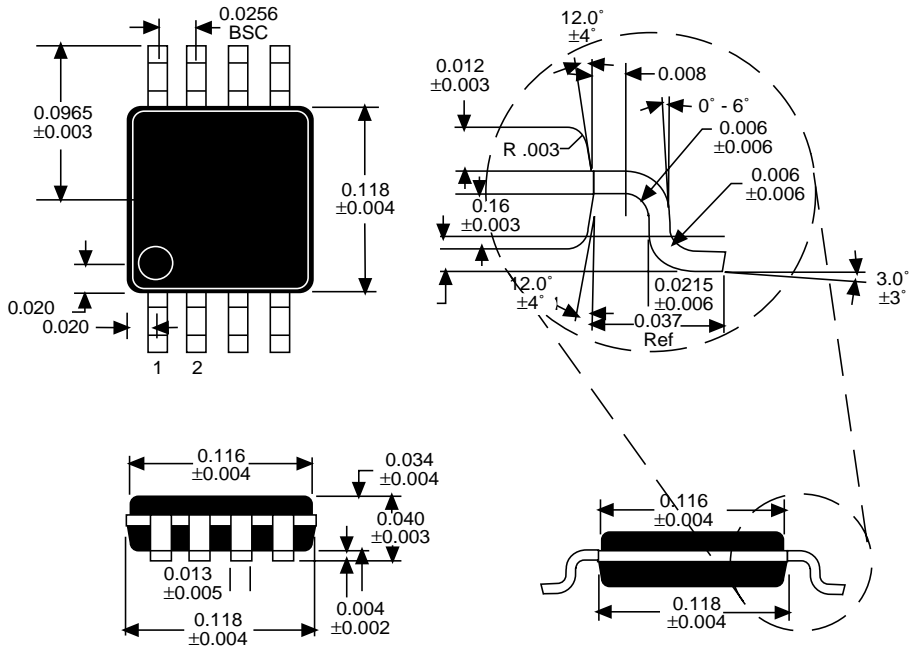
Luminescent Systems inc. (LSI)
101 Etna Road
Lebanon, NH. 03766-9004
Phone: (603) 448-3444
Fax: (603) 448-3452

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

All package dimensions in inches



ORDERING INFORMATION

Model	Operating Temperature Range	Package Type
SP4438EU	-40°C to +85°C	8-Pin MSOP
SP4438UEB		Evaluation Board



SIGNAL PROCESSING EXCELLENCE

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