ZSP4425

Electroluminescent Lamp Driver
For 1.5V or 2.2V to 4.5V Applications

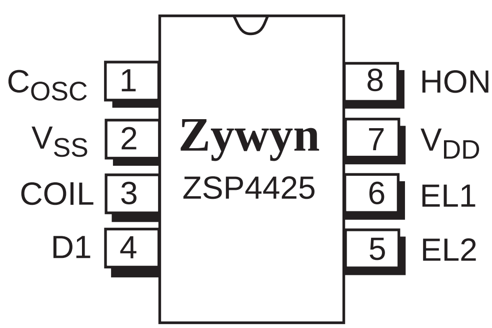
Features

- **Low voltage, single battery operation (1.1VDC ≤ $V_{BATTERY}$ ≤ 1.7VDC), or (2.2VDC ≤ $V_{BATTERY}$ ≤ 4.5VDC)**
- **DC to AC inverter for EL backlit display panels**
- **Externally adjustable internal oscillator**
- **Low current standby mode**

Applications

- **Pagers**
- **Digital watches**
- **MP3 players**
- **Cell Phones**
- **Backlit LCD displays**

Pin Configuration



8-Pin nSOIC/MSOP

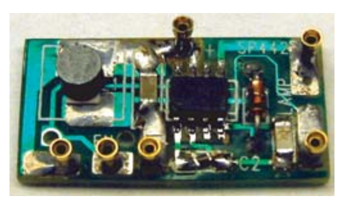
General Description

The ZSP4425 is a high voltage output DC-AC converter that can operate from a single +1.5VDC, +3.0VDC, or +2.2VDC to +4.5VDC power supply. The ZSP4425 is designed with our proprietary high voltage BiCMOS technology and capable of supplying up to $220V_{PP}$ signals, making it ideal for driving electroluminescent lamps. The device features 1µA (typical) standby current for use in low power portable products. One external inductor is required to generate the high voltage charge and one external capacitor is used to select the oscillator and lamp frequencies. The ZSP4425 is offered in both 8-pin narrow SOIC and 8-pin MSOP package. For delivery in die form, please consult the factory.

Ordering Information

Part Number	Temperature Range	Package Type
ZSP4425CN	–40°C to +85°C	8-Pin nSOIC
ZSP4425LCN	–40°C to +85°C	8-Pin nSOIC Green
ZSP4425CU	–40°C to +85°C	8-Pin MSOP
ZSP4425LCU	–40°C to +85°C	8-Pin MSOP Green
ZSP4425CX	0°C to +70°C	Die in Wafflepack
ZSP4425CW	0°C to +70°C	Die in Wafer Form
ZSP4425NEB	n/a	nSOIC Eval. Board
ZSP4425UEB	n/a	MSOP Eval. Board

Please contact the factory for pricing, availabiliy on Tape-and-Reels, and Green Package options.



Please contact the factory for EL driver design support and availability of custom-made evaluation demo boards.

See our web site for Application Note **AN007** regarding requirements for custom-made evaluation demo boards.

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 is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

V_{DD} .... +7.0V

Input Voltages/Currents

HON (pin 1) .... –0.5V to (V_{DD} +0.5V)

COIL (pin 3)..100mA

Lamp Output .... 230V_{PP}

Storage Temperature .... –65°C to +150°C

Operating Temperature .... –40°C to +85°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

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 remove moisture prior to soldering. Zywyn ships product in Dry Vapor Barrier Bags with a humidity indicator card and desiccant pack. The humidity indicator should be below 30%RH.

The information furnished by Zywyn has been carefully reviewed for accuracy and reliability. Its application or use, however, is solely the responsibility of the user. No responsibility of the use of this information become part of the terms and conditions of any subsequent sales agreement with Zywyn. Specifications are subject to change without the responsibility for any infringement of patents or other rights of third parties which may result from its use. No license or proprietary rights are granted by implication or otherwise under any patent or patent rights of Zywyn Corporation.

Electrical Characteristics

T_A = +25°C, V_{DD} = +1.5V, C_{LAMP} = 8200pF with 100Ω series resistance, Coil = 470µH at 4Ω, C_{INT} = 1800pF, C_{OSC} = 180pF, unless otherwise noted.

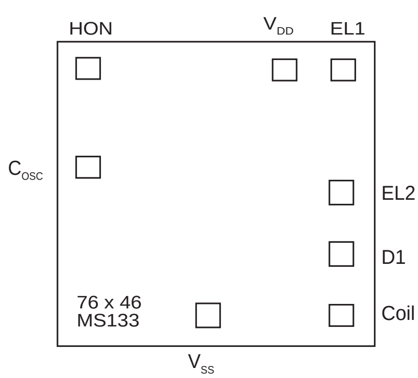
Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{DD}	Supply Voltage	HON ties to V_{DD}; See Figure 2	1.1	1.5	1.7	V
I_{COIL}	Supply Current	V_{HON} = V_{DD} = +1.5V		30	60	mA
V_{COIL}	Coil Voltage		1.1		1.7	V
V_{HON}	HON Input Voltage LOW: EL off HIGH: EL on	HON ties to V_{DD}	 – 0.25 1.1	 0 1.5	 0.25 1.7	V
I_{HON} + I_{DD}	HON+V_{DD} Current	Internal pull-down, V_{HON} = V_{DD} = +1.5V; See Figure 2			3	mA
I_{SD} = I_{COIL}	Shutdown Current	V_{HON} = V_{DD} = 0V: V_{COIL} = +1.5V		1	5	µA
INDUCTOR DRIVE						
f_{COIL} = f_{LAMP} X 64	Coil Frequency			25.6		kHz
	Coil Duty Cycle			90		%
$I_{PK-COIL}$	Peak Coil Current	Guaranteed by design			90	mA
EL LAMP OUTPUT						
f_{LAMP}	EL Lamp Frequency	T_A = +25°C, V_{DD} = +1.5V	250	400	600	Hz
V_{PP}	Peak-to-Peak Output Voltage	T_A = +25°C, V_{DD} = +1.5V	120	160		V

Electrical Characteristics

T_A = +25°C, V_{DD} = +3.0V, C_{LAMP} = 4nF with 100Ω series resistance, Coil = 2mH at 44Ω, C_{INT} = 470pF, C_{OSC} = 180pF, unless otherwise noted.

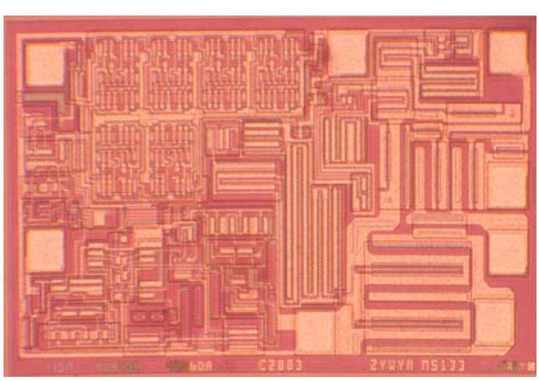
Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{DD}	Supply Voltage		2.2	3.0	4.5	V
$I_{COIL} + I_{DD}$	Supply Current	$V_{HON} = V_{DD}$ = +3.0V		28	35	mA
V_{COIL}	Coil Voltage		V_{DD}		4.5	V
V_{HON}	HON Input Voltage LOW: EL off HIGH: EL on		 – 0.25 V_{DD} – 0.25	 0 V_{DD}	 0.25 V_{DD} + 0.25	V
I_{HON}	HON Current	Internal pull-down, $V_{HON} = V_{DD}$ = +3.0V; See Figure 4		5	20	μA
$I_{SD} = I_{COIL} + I_{DD}$	Shutdown Current	V_{HON} = 0V		1	8	μA
INDUCTOR DRIVE						
$f_{COIL} = f_{LAMP}$ X 64	Coil Frequency			28.8		kHz
	Coil Duty Cycle			90		%
$I_{PK-COIL}$	Peak Coil Current	Guaranteed by design			90	mA
EL LAMP OUTPUT						
f_{LAMP}	EL Lamp Frequency	T_A = +25°C, V_{DD} = +3.0V	300	450	600	Hz
V_{PP}	Peak-to-Peak Output Voltage	T_A = +25°C, V_{DD} = +2.2V T_A = +25°C, V_{DD} = +3.0V	120 170	150 190		V V

Bonding Diagram



Notes:
1. Mask number is MS133.
2. Die size is 76 x 46 mils.
3. Die thickness is 11 mils +/- 1.
4. Bonding pads are 125 x 125 microns.
5. Die substrate down-bonds to Vss (GND).

Die Photo



Block Diagram

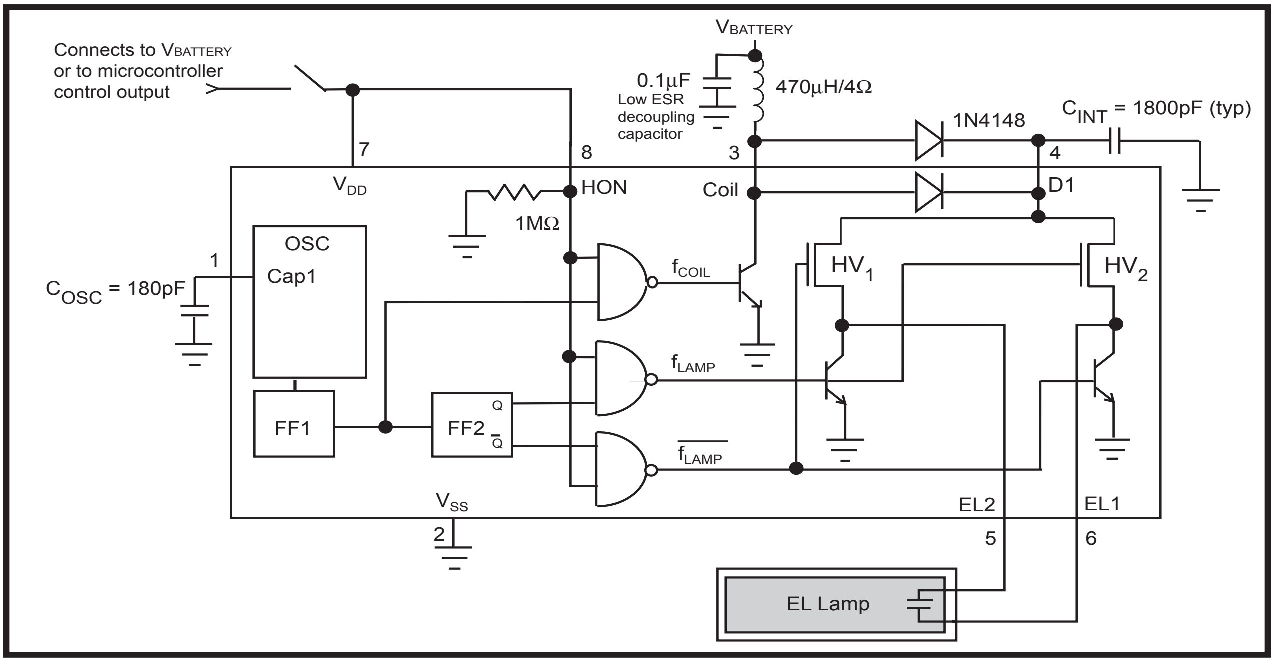


Figure 1. Block Diagram

Pin Description

Pin Number	Pin Name	Pin Function
1	C_{OSC}	Capacitor input 1: Connect capacitor from V_{SS} to this pin to set C_{OSC} frequency.
2	V_{SS}	Power supply common: Connect to ground.
3	COIL	Coil input: Connect coil from V_{DD} to this pin.
4	D1	Diode Cathode connection: C_{INT} (Integrator capacitor), connect capacitor from this pin to ground to minimize coil glitch energy.
5	EL2	Lamp driver output 2: Connect to EL lamp.
6	EL1	Lamp driver output 1: Connect to EL lamp.
7	V_{DD}	Power supply for driver: Connect to system $V_{BATTERY}$ for 2.2~4.5V operation, or tie with HON pin together connects to system $V_{BATTERY}$ for 1.5V operation.
8	HON	Enable for driver operation: high = active; low = inactive.

Circuit Description

The ZSP4425 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 1 and V_{SS} allows the user to vary the oscillator frequency. For a given choice of coil inductance there will be an optimum C_{OSC} capacitor value that gives the maximum light output.

The suggested oscillator frequency is 25.6kHz (C_{OSC} =180pF). The oscillator output is internally divided to create the control signal for f_{LAMP}. The oscillator output is internally divided down by 6 flip-flops, a 25.6kHz signal will be divided into 6 frequency levels: 12.8kHz, 6.4kHz, 3.2kHz, 1.6kHz, 800Hz, and 400Hz. The oscillator output (25.6kHz) is used to drive the coil (see *Figure 2)* and the sixth flip-flop output (300Hz) 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 64.

The coil is an external component connected from $V_{BATTERY}$ to pin 3 of the ZSP4425. $V_{BATTERY}$ =+1.5VDC with a 470µH/4Ω coil are typical conditions. Energy is stored in the coil according to the equation E_L =1/2(LI)^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 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, R_L, or t_{ON} 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 2mA is required for V_{DD} of the ZSP4425. V_{DD} can range from +1.5V, or +2.2V to +4.5V; it is not necessary that $V_{DD} = V_{BATTERY}$. Coils are also a function of the core material and winding used — performance variances may be noticeable from different coil suppliers. The Zywyn ZSP4425 is final tested at 1.5V using a 470µH/4Ω coil from Toko, and a 2mH/44Ω coil from Matsushita at +3V. For suggested coil sources, see *"Coil Manufacturers."*

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 90% duty cycle signal switching at the oscillator frequency. 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 lamp. f_{COIL} will send 32 of these charge pulses (see *Figure 6*) lamp, 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 5*).

The H-bridge consists of two proprietary low on-resistance high voltage switches. These two switches control the polarity of how the lamp is charged. The high voltage switches are controlled by the f_{LAMP} signal which is the oscillator frequency divided by 64. For a 25.6kHz oscillator, f_{LAMP} = 400Hz. When the energy from the coil is released, a high voltage spike is created triggering the high voltage switches. The direction of current flow is determined by which high voltage is enabled. One full cycle of the H-bridge will create a voltage step from ground to 80V (typical) on pins 5 and 6 which are 180 degrees out of phase with each other (see *Figure 7*). A differential view of the outputs is shown in *Figure 8*.

Layout Considerations

The ZSP4425 circuit board layout must observe careful analog precautions. For applications with noisy power supply voltages, a 0.1µF low ESR decoupling capacitor must be connected from V_{DD} 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.

Integrator Capacitor

An integrating capacitor must be placed from pin 4 (D1) to ground in order to minimize glitches associated with switching the coil. A capacitor at this point will collect the high voltage spikes and will maximize the peak-to-peak voltage output. High resistance EL lamps will produce more pronounced spiking on the EL output waveform; adding the C_{INT} capacitor will minimize the peaking and increase the voltage output at each coil step. The value of the integrator capacitor is application specific typical values can range from 500pF to 0.1µF. No integrator capacitor or very small values (500pF) will have a minor effect on the output, whereas a 0.1µF capacitor will cause the output to charge and discharge rapidly creating a square wave output. For most applications an 1800pF integrator capacitor is suitable.

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. Zywyn now offers low power single chip driver circuits specifically designed to drive small to medium sized electroluminescent panels if all that is required is one external inductor fast recovery diode and two capacitors.

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. 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. Both voltage and frequency are directly related to light output. In other words, as the voltage or the frequency of the EL output is increased the light output will also increase. The voltage has a much larger impact on light output than the frequency does. For example, an output signal of 168V_{PP} with a frequency of 500Hz can yield 15Cd/m^2, in the same application a different EL driver could produce 170V_{PP} with a frequency of 450Hz and can also yield 15Cd/m^2. Variations in peak-to- peak voltage and variations in lamp frequency are to be expected, light output will also vary from device-to-device however typical light output variations are usually not visually noticeable.

There are many variables which can be optimized for specific applications.

Typical Application

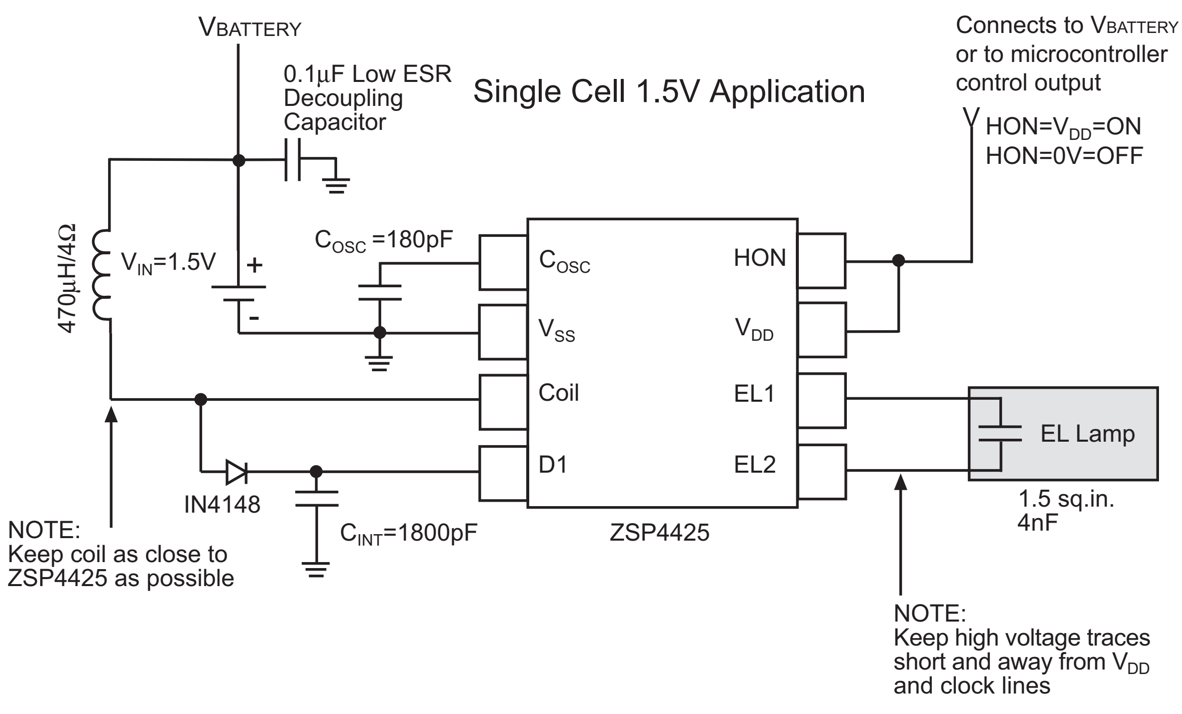


Figure 2. Typical Application Circuit At 1.5V Operation

For 1.5V operation, tie HON (pin 8) and V_{DD} (pin 7) together and connect them to either the system power ($V_{BATTERY}$), or be driven by the output of a microcontroller capable of sourcing 3mA of current to power on the internal V_{DD} logic and enable the HON function of the device.

Contact the factory for additional technical or application support.

Test Circuits

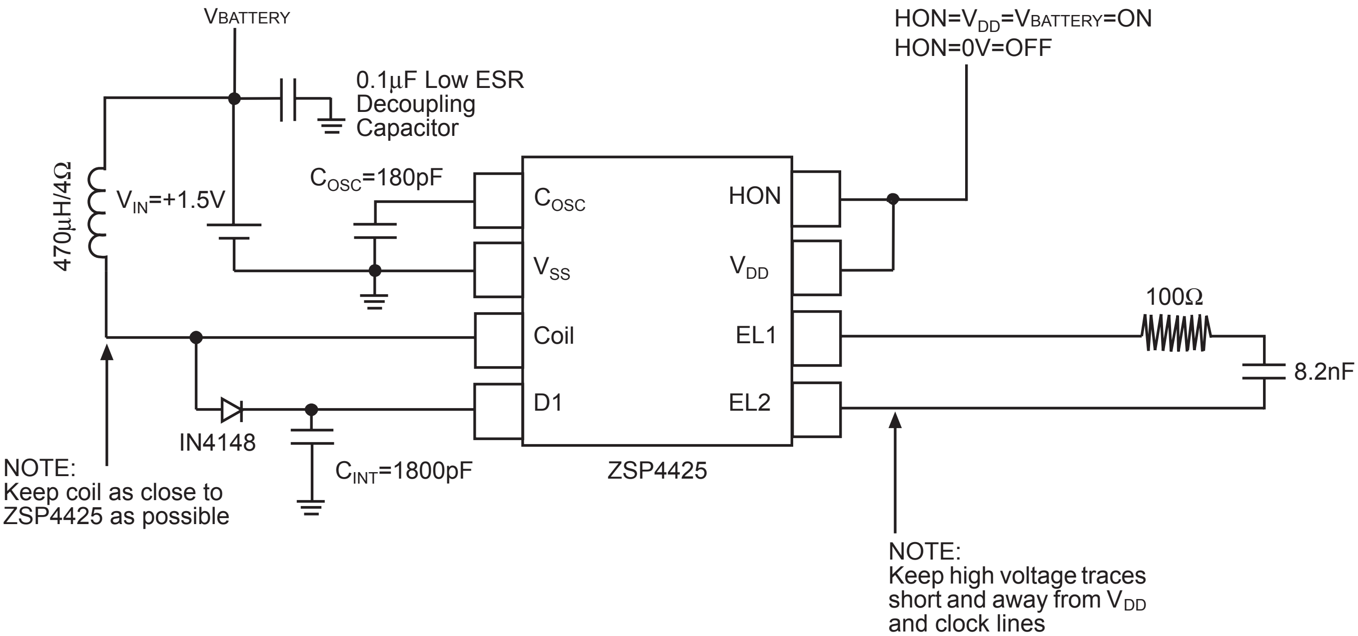


Figure 3. +1.5V Test Circuit

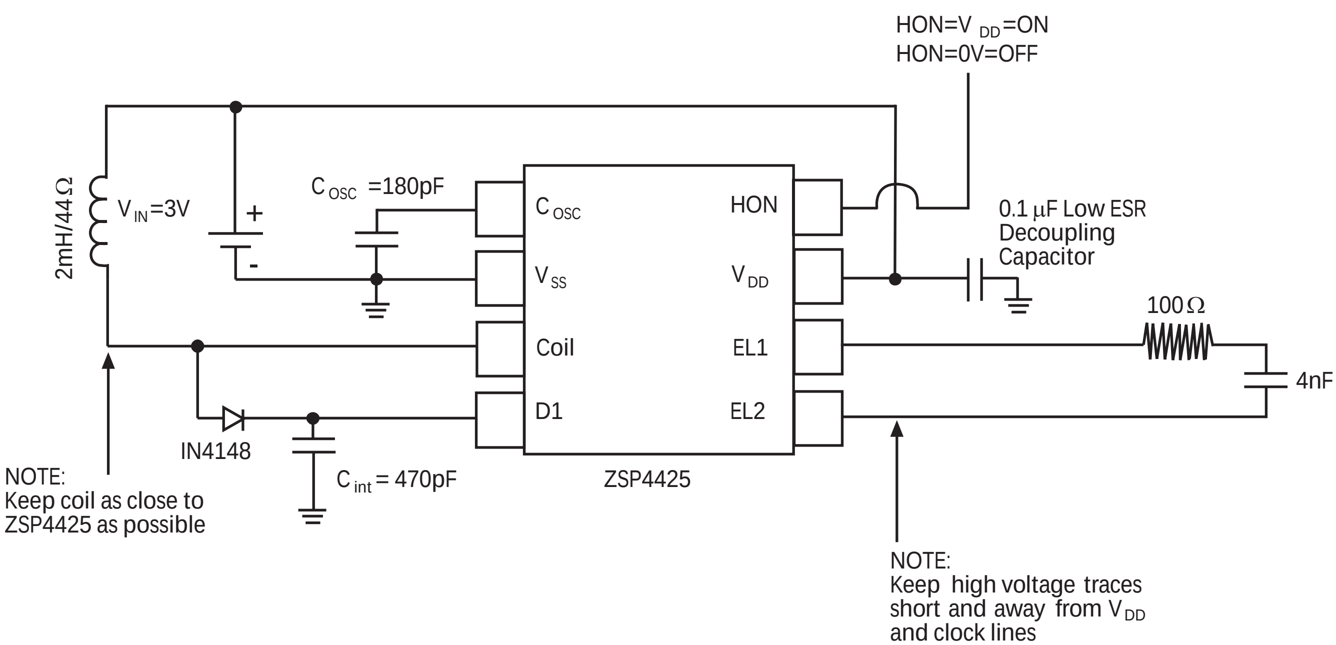


Figure 4. +3.0V Test Circuit

Waveforms

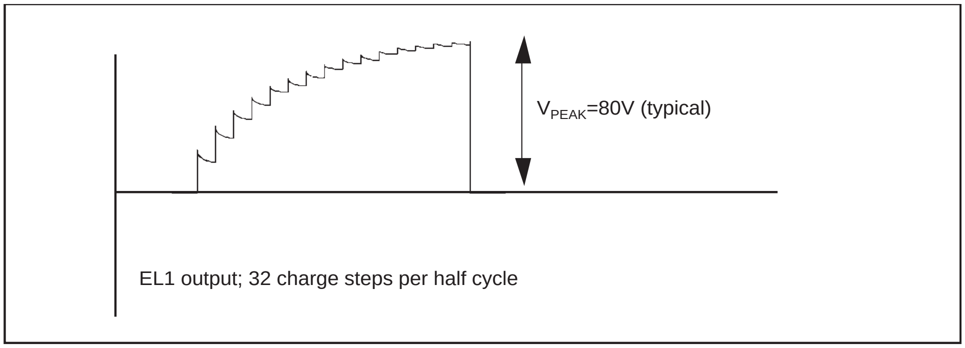


Figure 5. EL Output Voltage in Discrete Steps at EL1 Output

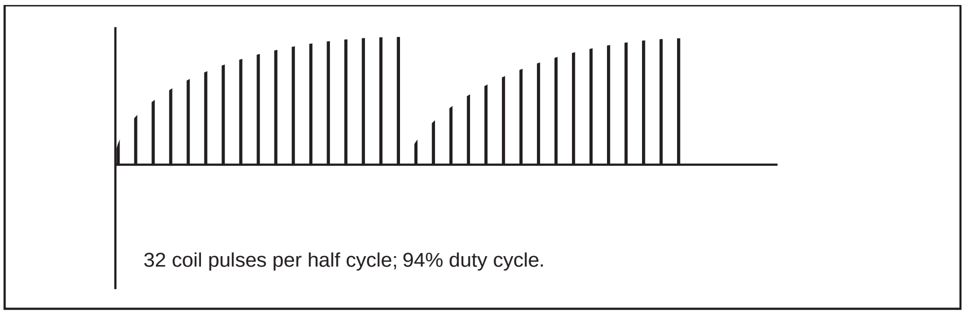


Figure 6. Voltage Pulses Released from the Coil to the EL Driver Circuitry

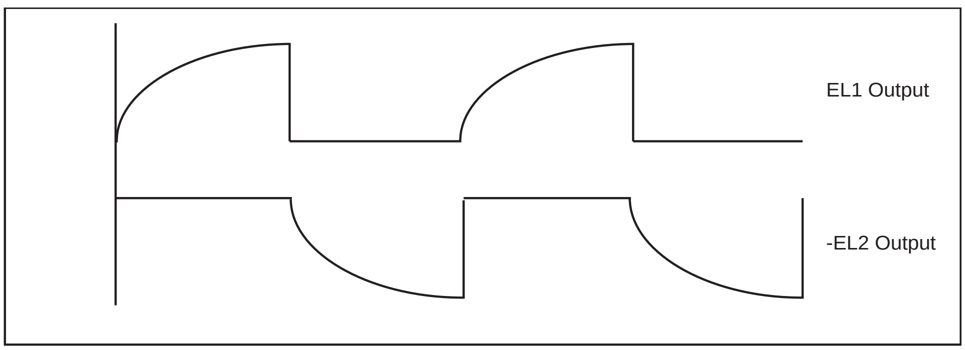


Figure 7. EL Voltage Waveforms from the EL1 and EL2 Outputs

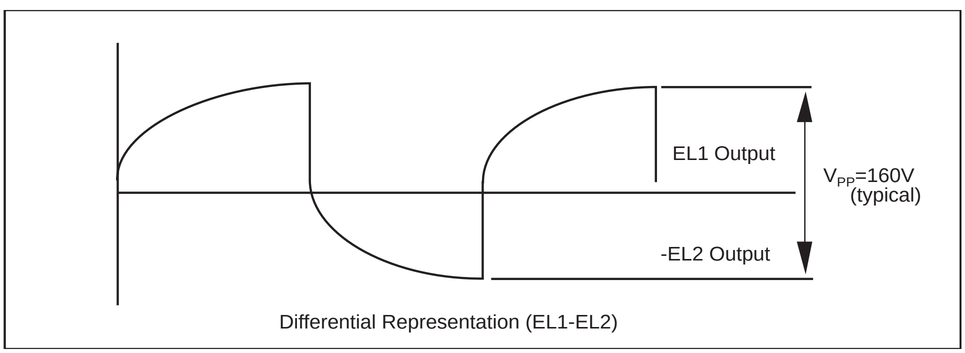
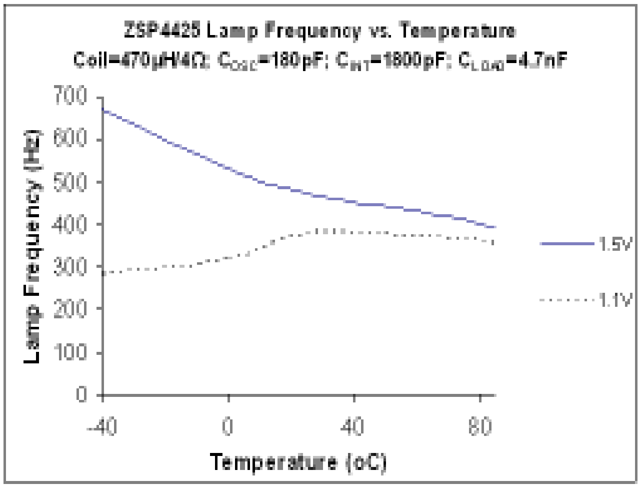
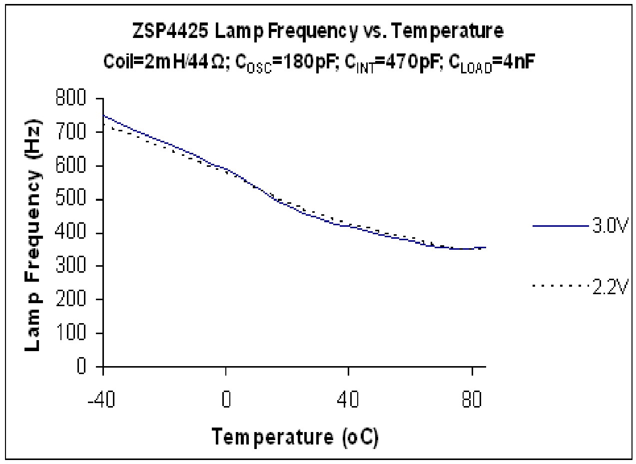
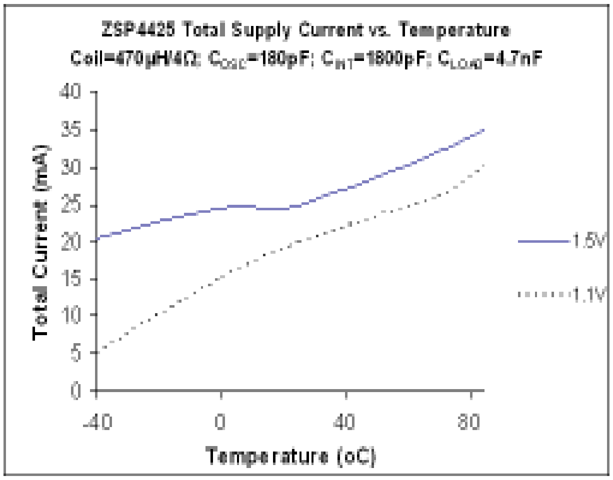


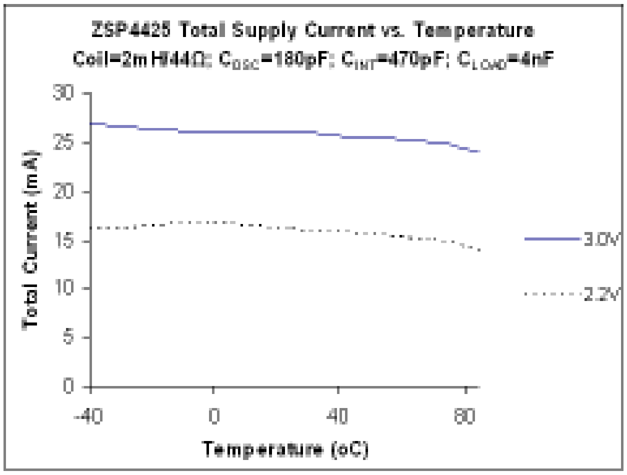
Figure 8. EL Differential Output Waveform of the EL1 and EL2 Outputs

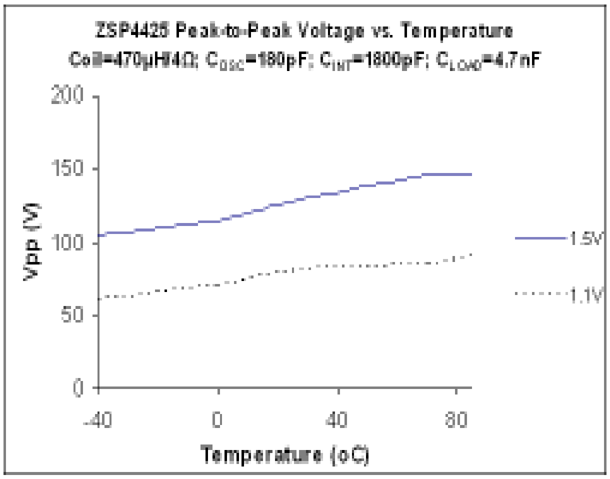
Typical Performance Characteristics

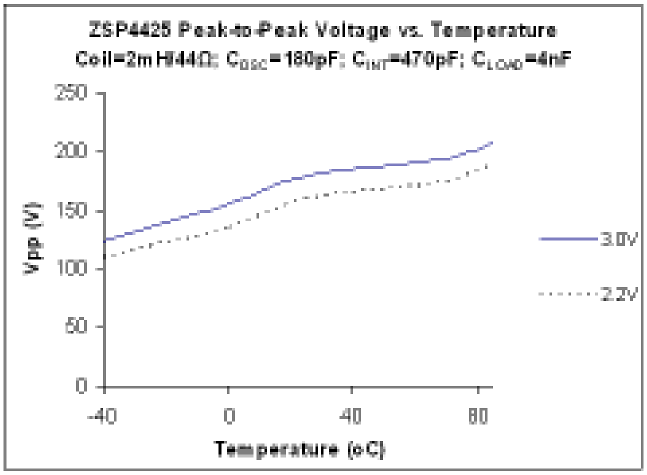












Coil Manufacturers

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

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
Numberg, 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

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

Polarizers/Transflector Manufacturers

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

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

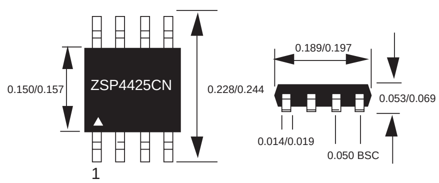
Seiko Precision
Shuzo Abe
1-1, Taihei 4-Chome,
Sumida-ku, Tokyo, 139 Japan
Phone: (03) 5610-7089
Fax: (03) 5610-7177

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

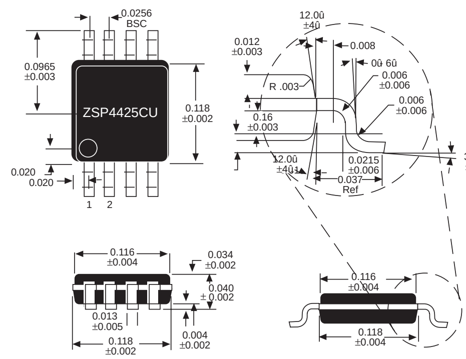
Package Information

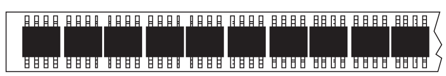
All package dimensions in inches

8-pin nSOIC

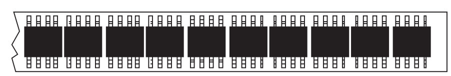


8-pin MSOP

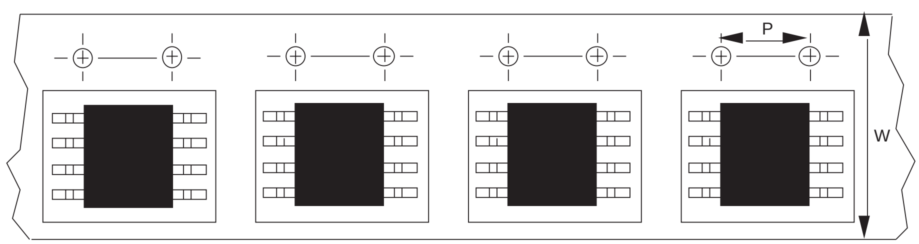




95 ZSP4425CN per tube



50 ZSP4425CU per tube



nSOIC-8 13" reels: P= 8mm, W= 12mm MSOP-8 13" reels: P= 8mm, W= 12mm			
Pkg.	Minimum qty per reel	Standard qty per reel	Maximum qty per reel
CN and CU	500	2500	3000

Zywyn Corporation
Headquarters and Sales Office
1270 Oakmead Parkway, Suite 201 • Sunnyvale, CA 94085 • Tel: (408) 733-3225 • Fax: (408) 733-3206
Email: sales@zywyn.com • www.zywyn.com