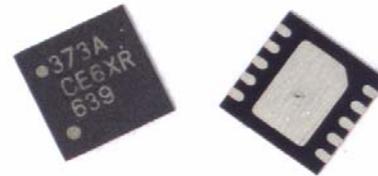


D373A Electroluminescent Lamp Driver IC

Features

- Flexible Wave Shaping Capability
- High Efficiency
- External Clock Compatible
- High Voltage AC Output
- High Performance With Low-profile Coils
- Available in Lead-Free (Pb-free) DFN Package



DFN-10

Applications

- Cellular Phones and Handsets
- Data Organizers/PDAs
- Monochrome LCDs
- Remote Controls
- DFLX™ Keypad

Rogers DUREL® D373A IC driver is part of a family of highly integrated EL drivers based on Rogers' patented three-port (3P) topology, which offers built-in EMI shielding. This high-performance device uses a proprietary circuit design for programmable wave-shaping for low-noise performance in applications that are sensitive to audible and electrical noise.

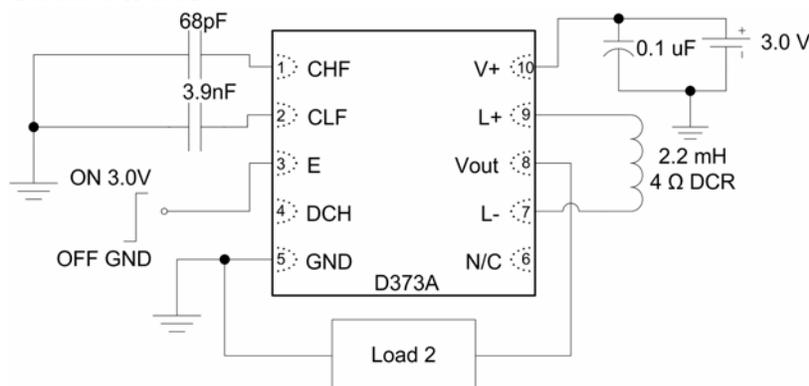
Lamp Driver Specifications:

(Using Standard Test Circuit at Ta=25°C unless otherwise specified)

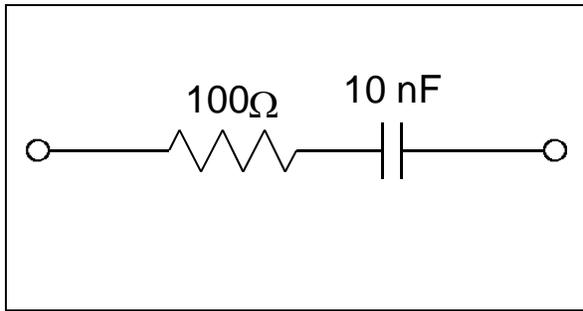
Parameter	Symbol	Minimum	Typical*	Maximum	Unit	Comments
Standby Current	$I_{(V+)}$		5	1000	nA	E=GND
Supply Current	I		15	18	mA	E=3.0V
Enable Current	I_{ena}		15		uA	E=3.0V
Output Voltage	V_{out}	160	188	220	Vpp	Peak-to-Peak voltage
Lamp frequency	LF	190	260	330	Hz	CLF=3.9nF
Inductor Frequency	HF		23		Khz	CHF=68pF

* Note - Typical values should not be used for specification limits.

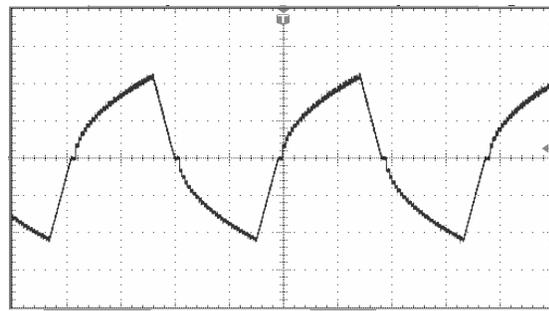
Standard Test Circuit



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Load 2*



Typical Output Waveform

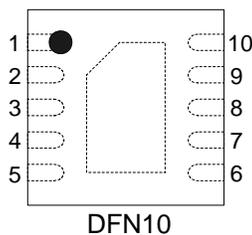
*Load 2 approximates a 3in² EL lamp.

Absolute Maximum Ratings:

Parameter	Symbol	Minimum	Maximum	Unit	Comments
Supply voltage Operating Range Withstand Range	V+	2.0 -0.5	6.5 9.0	V	E = V+ E = GND
Enable voltage	E	-0.5	(V ₊) + 0.5	V	
Output Voltage	V _{OUT}		220	V _{pp}	Peak-to-peak Voltage
CHF Voltage	V _{CHF}	0	(V ₊) + 0.3	V	External clock input
CLF Voltage	V _{CLF}	0	(V ₊) + 0.3	V	External clock input
Operating temperature	T _a	-40	85	°C	
Storage temperature	T _s	-65	150	°C	

Note: The above table reflects stress ratings only. Functional operation of the device at these ratings or any other above those indicated in the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

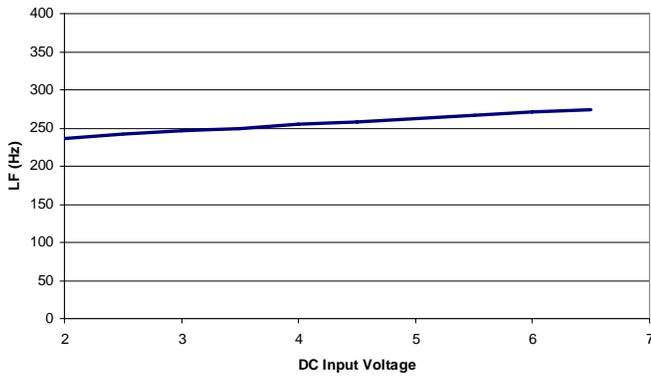
Physical Data:



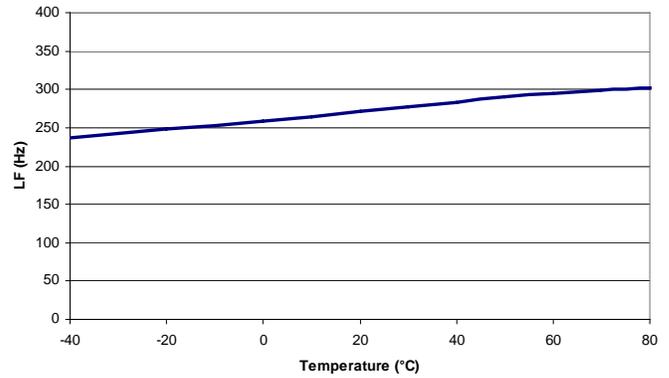
PIN #	NAME	FUNCTION
1	CHF	High frequency oscillator capacitor/clock input
2	CLF	Lamp frequency capacitor/clock input
3	E	System enable; Wave-shaping resistor control
4	DCH	Wave-shaping discharge control
5	GND	System ground connection
6	N/C	No Connect
7	L-	Negative input to inductor
8	VOUT	High voltage AC output to lamp
9	L+	Positive input to inductor
10	V+	DC power supply input

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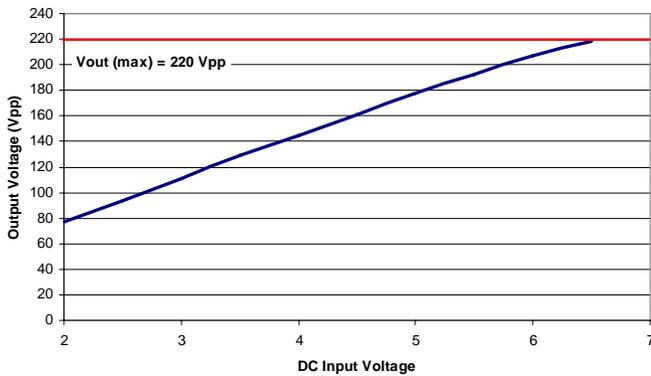
Typical Performance Characteristics



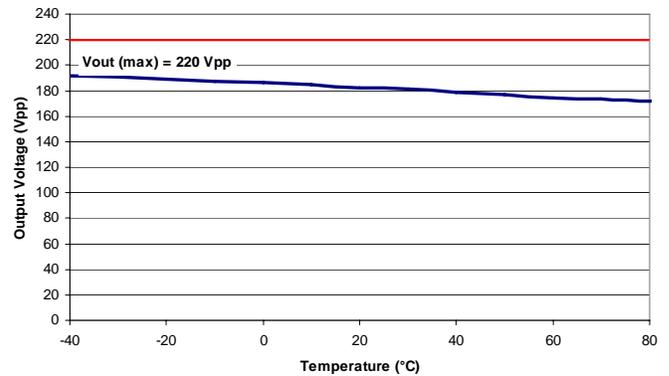
Output Frequency vs. DC Supply Voltage



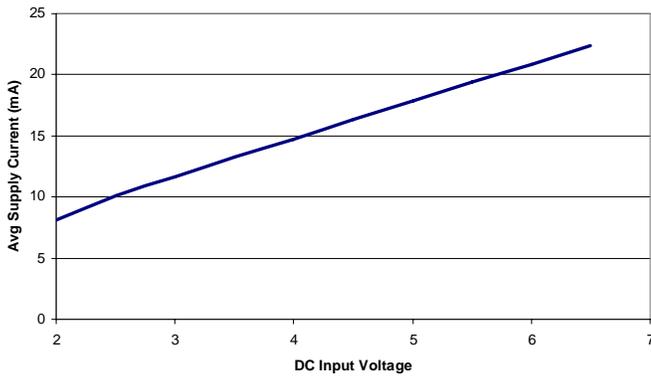
Output Frequency vs. Ambient Temperature



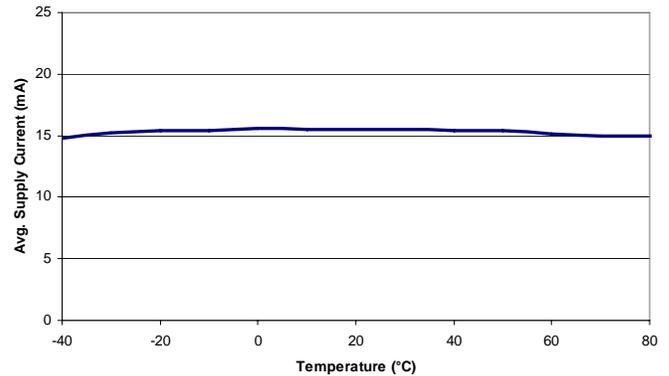
Output Voltage vs. DC Supply Voltage



Output Voltage vs. Ambient Temperature



Supply Current vs. DC Supply Voltage

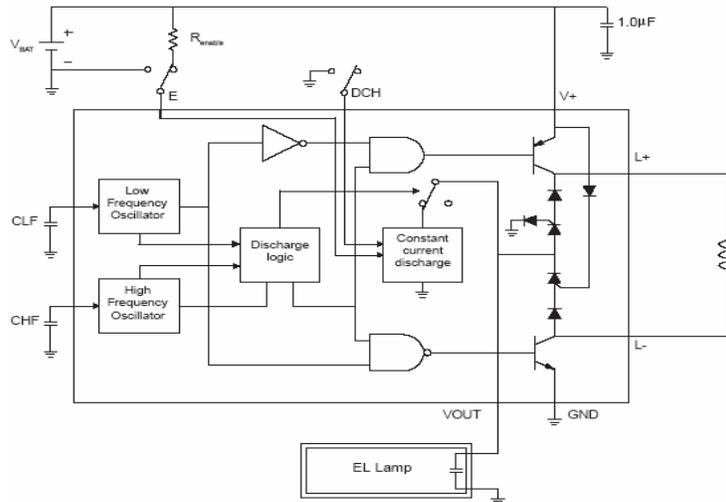


Supply Current vs. Ambient Temperature

Note: Load B and a 3.3mH inductor used to obtain wider statistical measurements.
 Note: The coil used to obtain the temperature sweep was 5.6mH

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Block Diagram of the Driver Circuitry



Theory of Operation

Electroluminescent (EL) lamps are essentially capacitors with one transparent electrode and a special phosphor material in the dielectric. The phosphor glows when a strong AC voltage is applied across the EL lamp electrodes. The required AC voltage is typically not present in most systems and must be generated from a low voltage DC source. Rogers developed its patented three-port (3P) switch-mode inverter circuit to convert the available DC supply to an optimal drive signal for high brightness and low-noise EL lamp applications. Rogers' 3P topology offers the simplicity of a single DC input, single AC output, and a shared common ground that provides an integrated EMI shielding.

The D373A IC drives the EL lamp by repeatedly pumping charge through an external inductor with current from a DC source and discharging into the capacitance of the EL lamp load. With each high frequency (HF) cycle, the voltage on the lamp is increased. At a period specified by the lamp frequency (LF) oscillator, the voltage on the lamp is discharged to ground and the polarity of the inductive charging is reversed. By this means, an alternating positive and negative voltage is developed at the single output lead of the device to one of the electrodes of the EL lamp. The other lamp electrode is commonly connected to a ground plane, which can then be considered as electrical shielding for any underlying circuitry in the application.

The EL driving system is divided into several parts: on-chip logic and control, on-chip high voltage output circuitry, discharge logic circuitry, and off-chip components. The on-chip logic controls the lamp operating frequency (LF), as well as the inductor switching frequency (HF), and HF and LF duty cycles. These signals are combined and buffered to regulate the high voltage output circuitry. The output circuitry handles the power through the inductor and delivers the high voltage to the lamp. The integrated discharge logic circuit enables the low-noise functionality of this EL driver with four levels of discharge slopes on the output waveform. The selection of off-chip components provides a degree of flexibility to accommodate various lamp sizes, system voltages, and brightness levels. Since a key objective for EL driver systems is to save space and cost, required off-chip components are kept to a minimum.

Rogers provides a D373A IC Designer's Kit, which includes a printed circuit evaluation board intended to aid you in developing an EL lamp driver configuration that meets your requirements using the D373A IC. A section on designing with the D373A IC is included in this datasheet to serve as a guide to help you select the appropriate external components to complete your D373A EL driver system.

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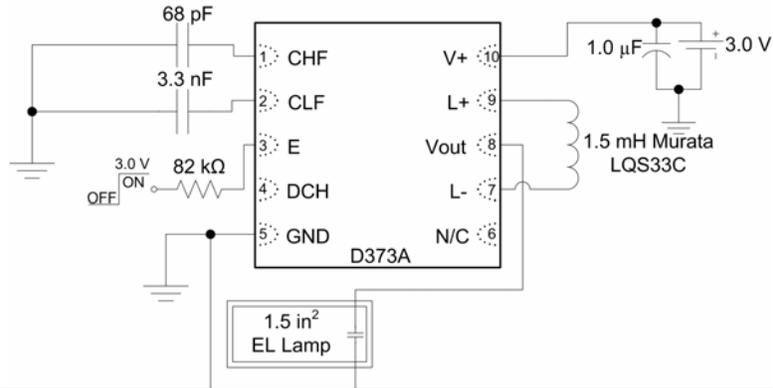
Reference D373A EL Driver Configurations

Typical D373A IC configurations for driving EL lamps in various applications are shown below. The expected system outputs, such as lamp luminance; lamp output frequency and voltage; and average supply current draw, for the various sample configurations are also shown with each respective figure.

3.0V Handset LCD

Typical Output

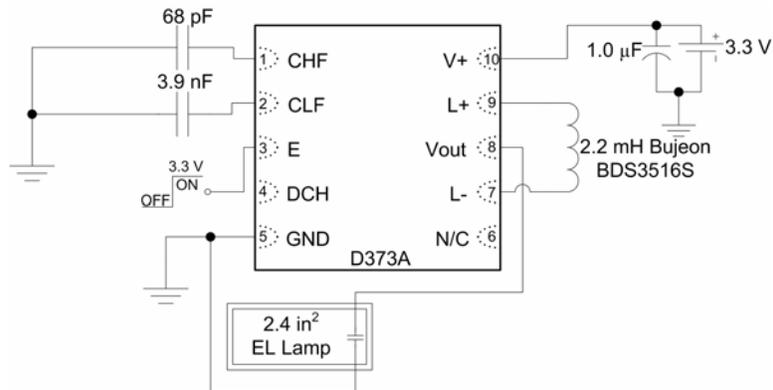
Luminance = 5.0 fL (17 cd/m²)
 Lamp Frequency = 330 Hz
 Supply Current = 19 mA
 Vout = 210 Vpp
 Load: 1.5 in² (950 mm²)
 DUREL 3 Green EL



3.3V Handset LCD + Keypad

Typical Output

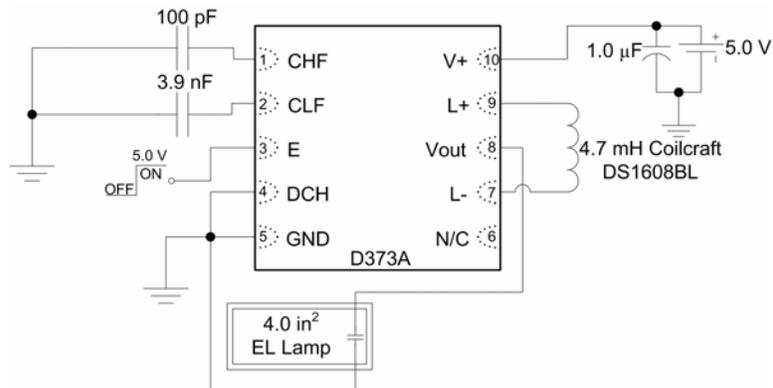
Luminance = 6.5 fL (22 cd/m²)
 Lamp Frequency = 270 Hz
 Supply Current = 15 mA
 Vout = 190 Vpp
 Load: 2.4 in² (1550 mm²)
 DUREL 3 Green EL



5.0V PDA

Typical Output

Luminance = 5.5 fL (19 cd/m²)
 Lamp Frequency = 285 Hz
 Supply Current = 15 mA
 Vout = 200 Vpp
 Load: 4 in² (2580 mm²) DUREL 3 Green EL



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Designing with A D373A IC Driver

I. Lamp Frequency Capacitor (CLF) Selection

Selecting the appropriate value of lamp frequency capacitor (CLF) for the low frequency oscillator will specify the output frequency of the D373A EL driver. Lamp frequencies of 200-500Hz are typically used. Figure 1 graphically represents the inversely proportional relationship between the CLF capacitor value and the oscillator frequency. In this example at $V_+ = 3.0V$, $LF = 1150 \text{ nF-Hz/CLF}$.

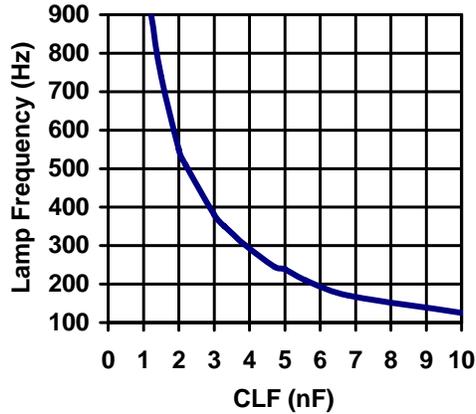


Figure 1: Typical Lamp Frequency vs. CLF Capacitor

Alternatively, the lamp frequency may also be controlled with an external clock signal with a typical duty cycle of 75%. There is an internal frequency divider in the device so that the output lamp frequency will be half of the input clock signal. For example, if a 500Hz input clock signal is used, the resulting lamp frequency will be 250Hz. The clock signal input voltage should not exceed V_+ .

The selection of the CLF value can also affect the brightness of the EL lamp because of its control of the lamp frequency (LF). Although input voltage and lamp size can change EL lamp frequency as well, LF mainly depends on the CLF value selected or the frequency of the input clock signal to CLF. Figure 2 shows typical brightness of a D373A IC circuit with respect to lamp frequency. In this example, the inductor and CHF values were kept constant while varying LF.

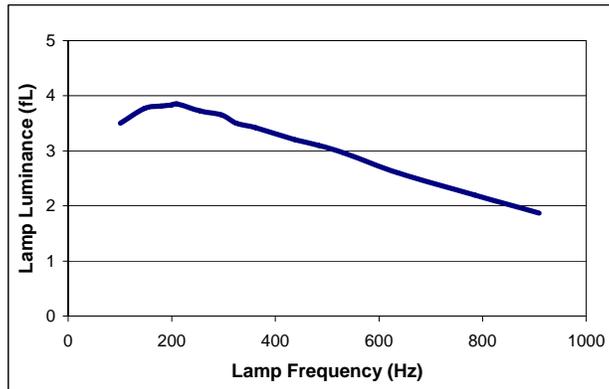


Figure 2: Luminance vs. Lamp Frequency
($V_+ = 3.0V$, 2.4 in^2 DUREL 3 Green EL Lamp Load)

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II. High Frequency Capacitor (CHF) Selection

Selecting the appropriate value of capacitor for the high frequency oscillator (CHF) will set the inductor switching frequency of the D373A IC. High inductor frequency allows for more efficient use of inductor coils with lower values. However, care must be taken that the charge pumping does not reach a continuous mode at very high frequency when the voltage is not efficiently transferred to the lamp load. Figure 3 graphically represents the effect of the CHF value on the oscillator frequency at $V_+ = 3.0V$.

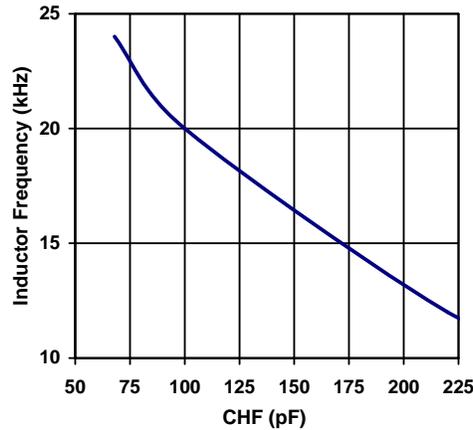


Figure 3: Typical Inductor Frequency vs. CHF Capacitor

The inductor switching frequency may also be controlled with an external clock signal. The inductor will charge during the low portion of the clock signal and discharge into the EL lamp during the high portion of the clock signal. The positive duty cycle used for the external high frequency clock signal is usually between 15%-75%, with a typical value of 15%-20% for maximum brightness. The clock signal input voltage should not exceed V_+ .

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III. Inductor (L) Selection

The inductor value and inductor switching frequency have the greatest impact on the output brightness and current consumption of the EL driver. Figures 4 and 5 show the dependence of brightness and current draw of a D373A IC circuit on coil values and CHF values for two sample EL lamp sizes and input voltages. The CLF value was modified in each case such that the output voltage was approximately 190Vpp. Please note that the DC resistance (DCR) of inductors with the same nominal inductance value may vary with manufacturer and inductor type. Therefore, inductors made by a different manufacturer may yield different outputs, but the trend of the different curves should be similar.

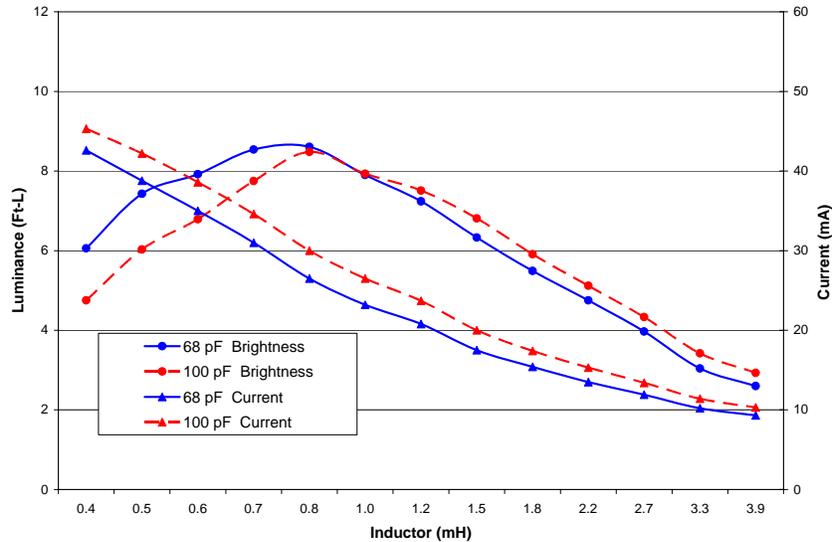


Figure 4: Luminance and current vs. inductor and CHF value.
(Conditions: $V_+=3.0V$, $2in^2$ EL Lamp)

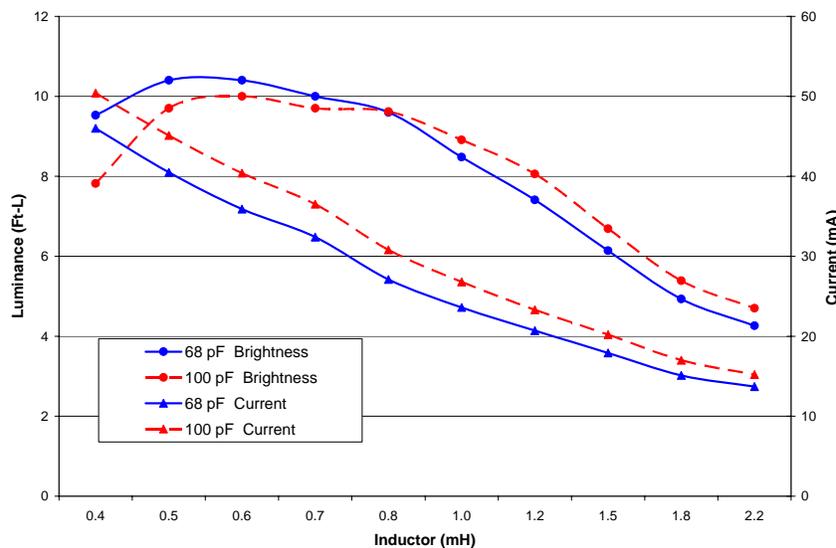


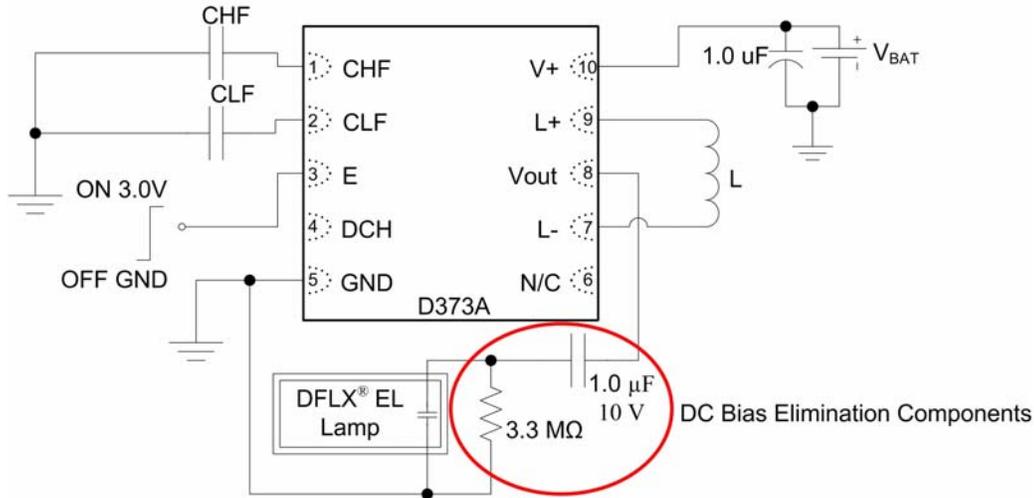
Figure 5: Luminance and current vs. inductor and CHF value.
(Conditions: $V_+=5.0V$, $4in^2$ EL Lamp)

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D373A IC Design Ideas

I. DC Bias Elimination Circuit

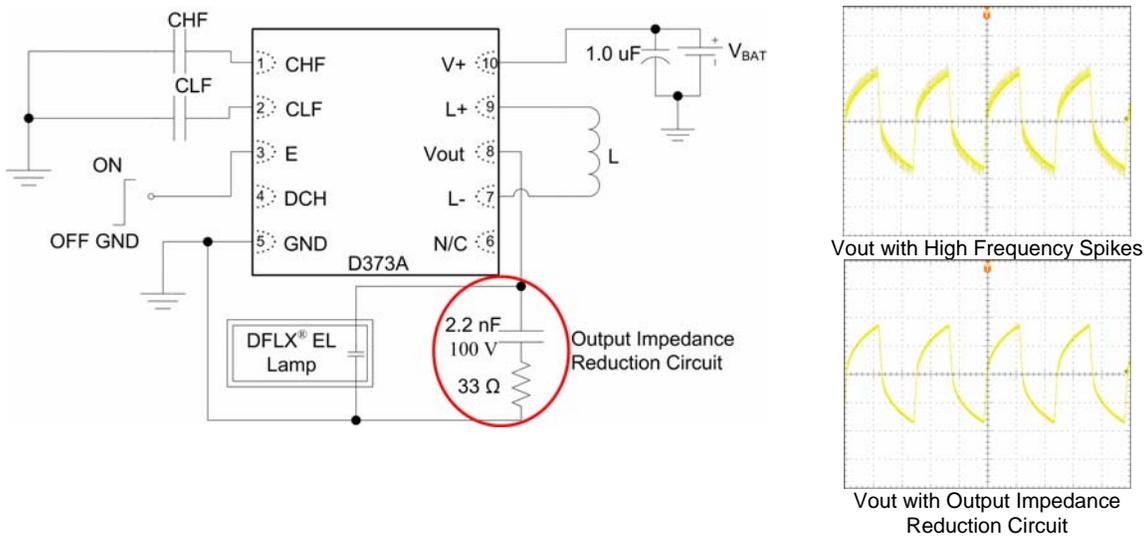
Semiconductor inverters will inherently induce a small DC bias across the electrode of the EL lamp. Elimination of DC bias in specific EL driving systems may improve performance and prolong overall operation of the system. The patented DC bias elimination circuit is a high pass filter connected between the Vout pin and EL lamp as shown below.



Patented

II. Output Impedance Reduction Circuit

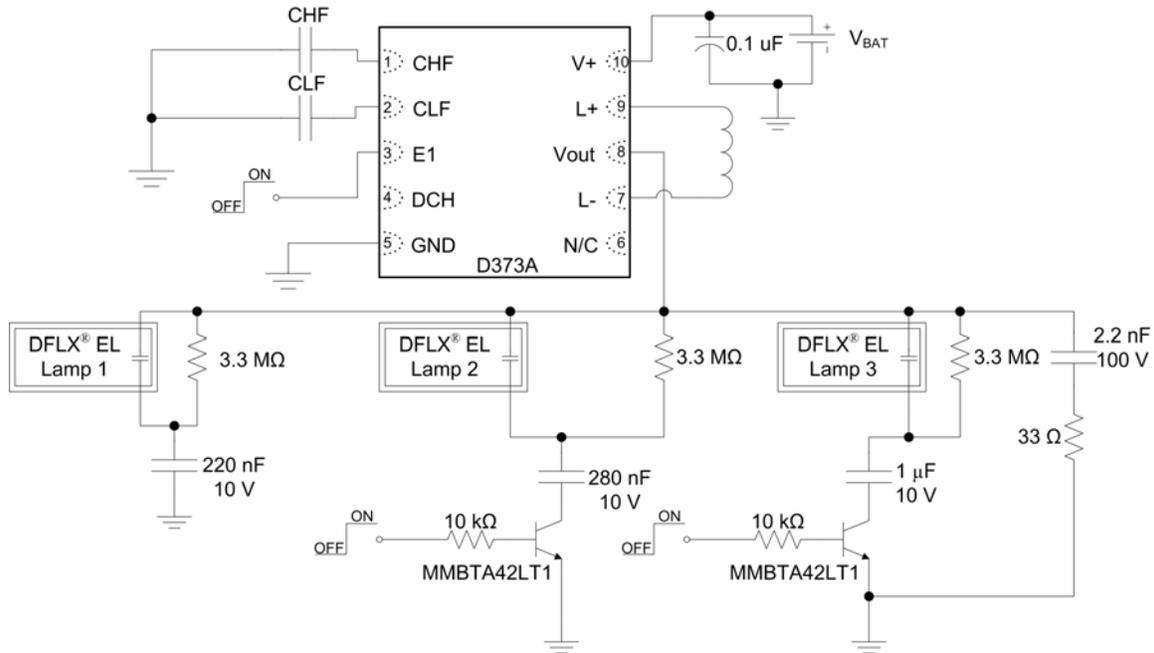
Configuration of an EL driving system with the patented Rogers Durel 3P inverter technology and some types of EL lamps may produce high frequency spikes on the output waveform. These high frequency spikes are caused by high impedance seen at the Vout pin. They can be removed with the addition of parallel capacitive resistive load to the EL lamp as seen in the figure below. Removal of the high frequency spikes may greatly improve the luminance of the EL lamp.



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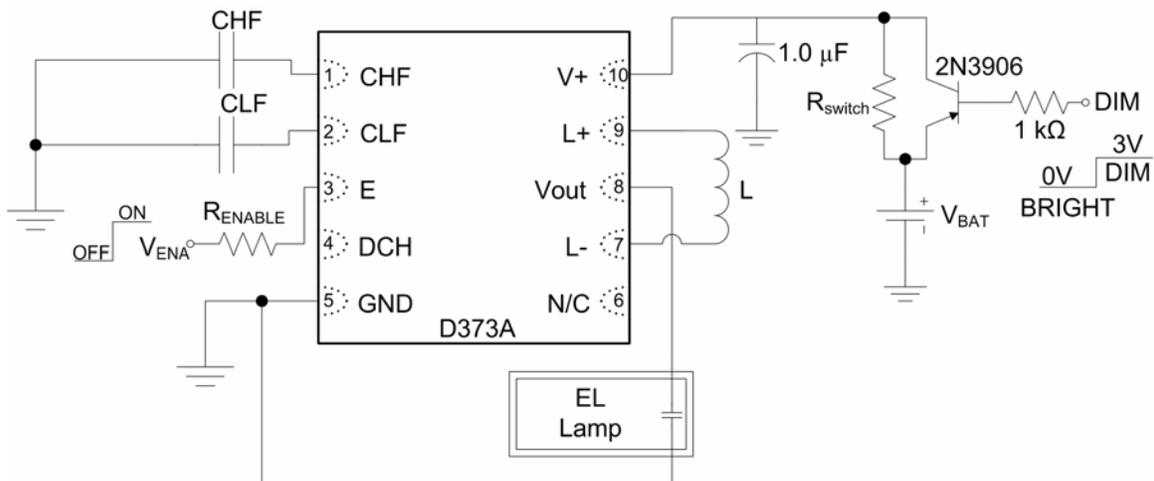
III. Driving Multiple EL Lamps

The D373A IC may be used to drive multiple EL lamp segments. An external transistor switching circuit is used to turn each lamp segment on or off independently or simultaneously. A high signal at the corresponding E input will enable the corresponding lamp segment. In this configuration, EL Lamp 1 is always turned on when the IC is enabled. Otherwise, always make sure that at least one lamp segment is selected to be on when the D373A IC is enabled. Also pictured with this circuit are the DC bias and output impedance reduction circuits.



IV. Two-level Dimming

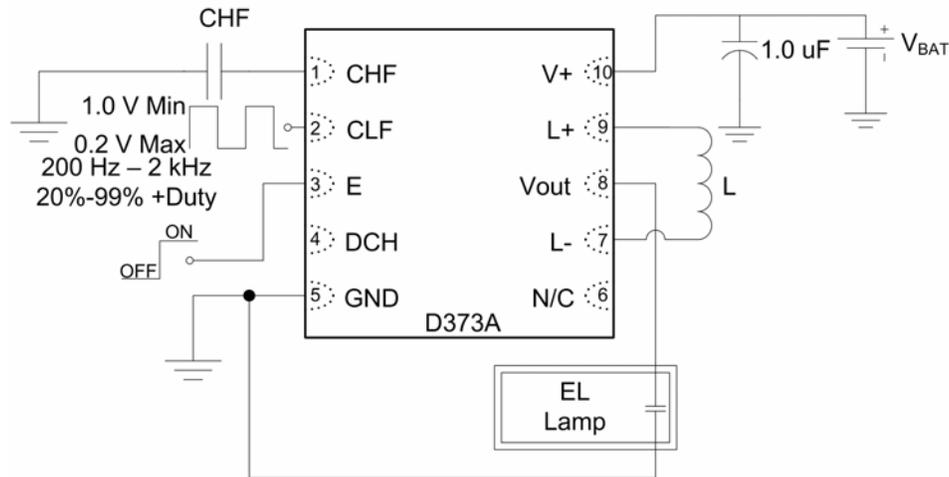
Two level dimming may be achieved as shown in the circuit diagram below. When DIM is low, the external PNP transistor is saturated and the EL lamp runs at full brightness. When DIM is high, the external PNP turns off and the 47Ω resistor reduces the voltage at (V+) and dims the EL lamp.



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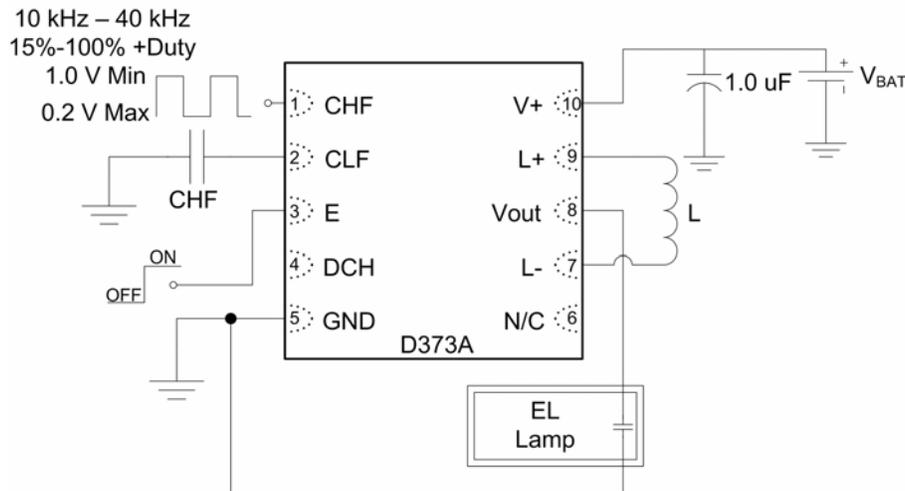
V. Lamp Frequency Control with an External Clock Signal

An external clock signal may be used to control the EL lamp frequency (LF) of the D373A IC instead of using a capacitor. There is an internal frequency divider in the IC so that the output lamp frequency will be half of the input clock signal. For example, if a 500Hz input clock signal is used, the resulting lamp frequency will be 250Hz. The clock signal voltage should not exceed $V+$. A typical duty cycle for the clock input is +75%, but it can also be adjusted within a range of 20% to 99% to control brightness and discharge level. A higher positive duty cycle allows for longer charge time and peak voltage, at the expense of a faster discharge slope and higher noise.



VI. EL Brightness Control through HF Clock Pulse Width Modulation

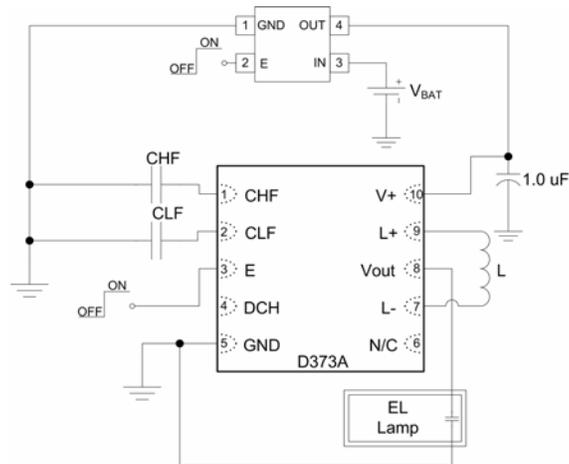
The inductor oscillating frequency may also be controlled on the D373A EL driver using an external clock input to CHF. In addition, pulse-width modulation of the external HF clock signal to the D373 may be used to regulate the brightness of the EL lamp load. High frequency input is typically in the range of 10kHz to 40kHz, with duty cycle in the range of 15% to 100%. In general, a lower HF frequency results in higher brightness and using a lower duty cycle results in higher brightness. The clock signal voltage should not exceed $V+$. Prior to finalization of the circuit, contact Rogers to verify that the frequency, duty cycle, and setup chosen are acceptable for EL driver performance.



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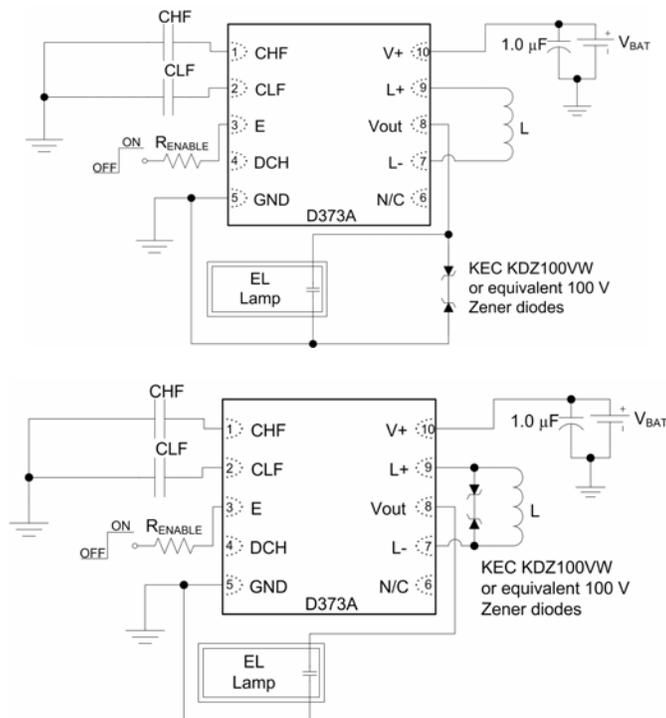
VII. EL Lamp Brightness Regulation

Regulating the DC supply input voltage to the D373A IC will result in a constant brightness level from the EL lamp, regardless of battery voltage. In this example, a voltage regulator is used.



VIII. Output Voltage Limit Control

An EL driver system using the D373A IC driver should be designed such that the output voltage does not exceed the maximum rated value of 220V_{pp}. A pair of zener diodes connected to the output or inductor as shown below is recommended to limit V_{out} to within 200V_{pp} or less. This circuit protects the device from over-voltage when typical performance is near the maximum limit for the D373A IC.



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IX. Solder Re-Flow Recommendations

Profile Feature	Pb-Free Assembly
	Small Body
Average ramp-up rate (T_L to T_P)	3°C/second max.
Preheat -Temperature Min ($T_{S_{min}}$) -Temperature Max ($T_{S_{max}}$) -Time (min to max) (ts)	150°C 200°C 60-180 seconds
$T_{S_{max}}$ to T_L -Ramp-up Rate	3°C/second max.
Time maintained above: Temperature (T_L) -Time (T_L)	217°C 60-150 seconds
Peak Temperature (T_P)	250 +0/-5°C
Time within 5°C of actual Peak Temperature (T_P)	20-40 seconds
Ramp-down Rate	6°C/second max.
Time 25°C to Peak Temperature	8 minutes max.

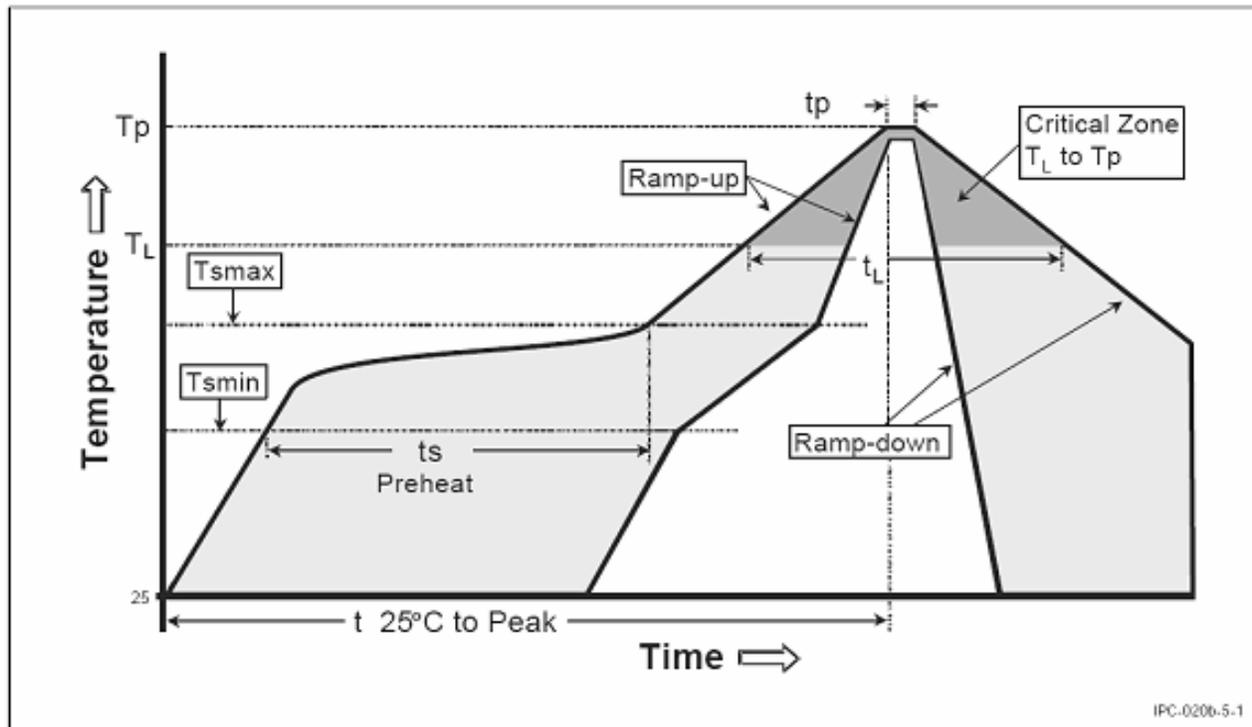


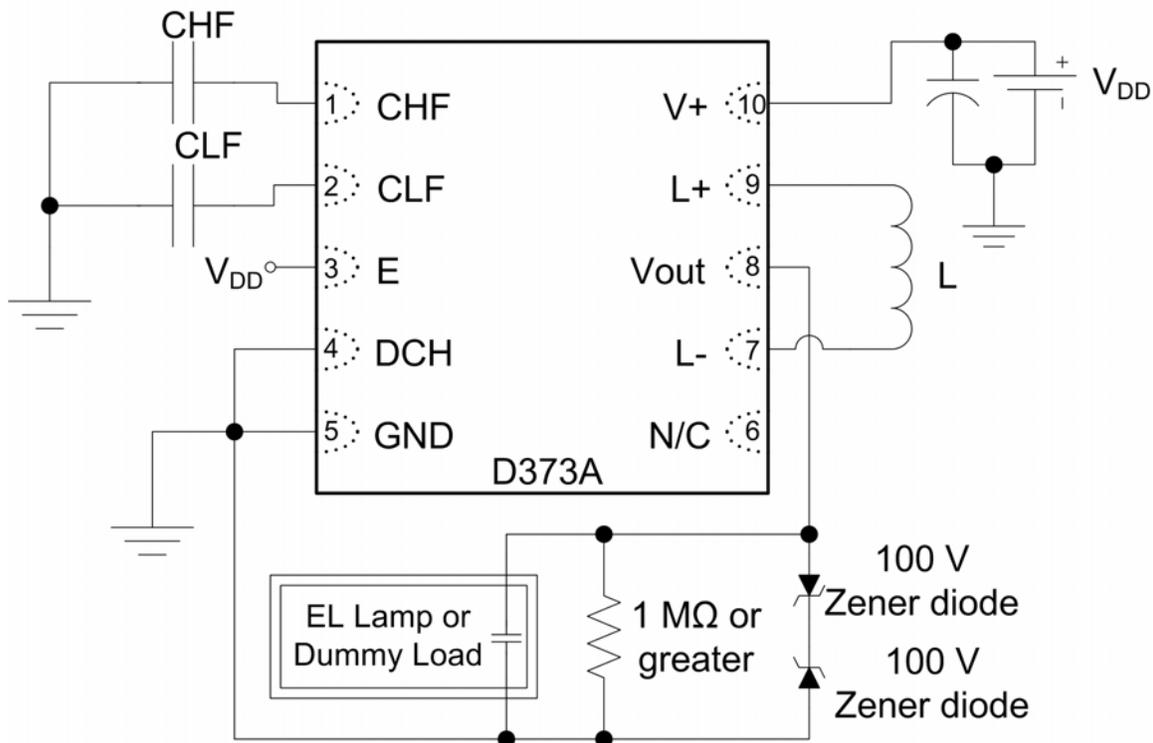
Figure 5-1 Classification Reflow Profile

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D373A IC Application Testing Recommendations

The following recommendations should be considered when testing the D373A devices to ensure that the devices are not damaged.

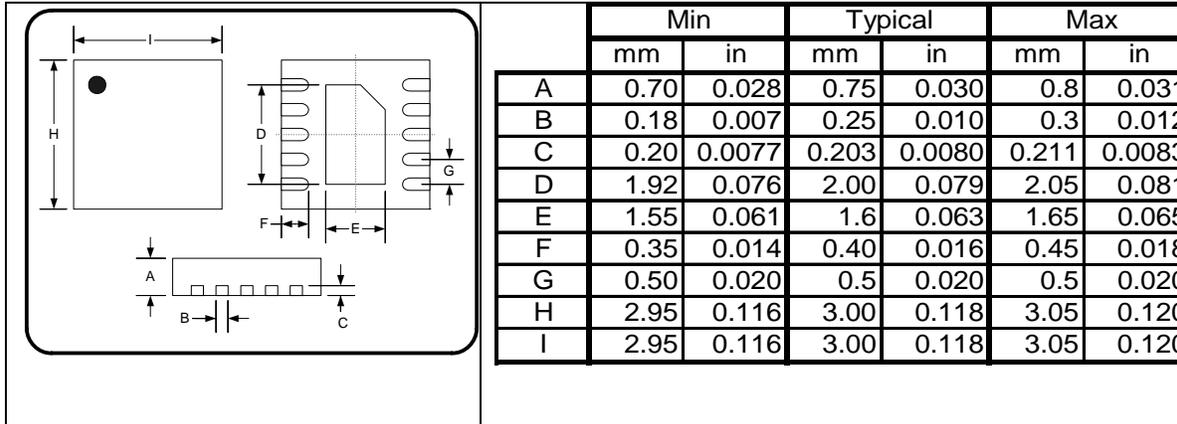
- 1) Do not perform any no load test. If no load test is required, please contact Rogers Corporation for proper test procedure.
- 2) Place 100V Zener diodes on the Vout pin to ground to prevent exceeding the maximum rated output (220Vpp). Zener diodes will clamp output voltage to 2200Vpp. See diagram below.
- 3) It has been found that DC transient voltage applied to the Vout pin of the D373A IC while in operation can cause internal damage. Built up charge can sometimes be found on an EL Lamp or dummy load test fixture. This built up charge can act as a DC transient. Place a high value resistor (value depending on RC time constant) in parallel with EL Lamp or dummy load to allow built up charge to discharge properly. See diagram below.



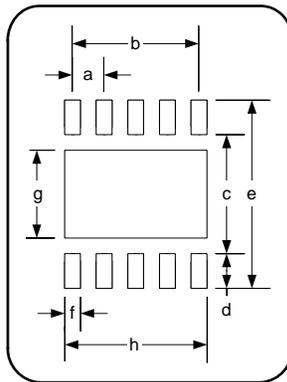
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Ordering Information

The D373A IC is available Pb-free green for the DFN-10 packages per tape and reel. A DUREL D373A IC Designer's Kit (1DDD373AA-K01) provides a vehicle for evaluating and identifying the optimum component values for any particular application using D373A IC. Rogers' engineers also provide full support to customers, including specialized circuit optimization and application retrofits.

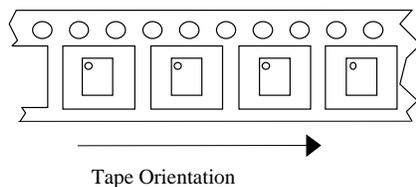


Recommended Pad Layout:

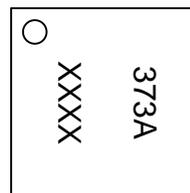


	DFN-10 PAD LAYOUT					
	Min		Typical		Max	
	mm	in	mm	in	mm	in
a			0.50	0.020		
b	1.90	0.075	2.00	0.079	2.10	0.0820
c			1.90	0.075		
d	0.45	0.017	0.55	0.022	0.65	0.026
e			3.00	0.118		
f	0.18	0.007	0.25	0.010	0.30	0.012
g	1.60	0.063	1.62	0.064	1.65	0.065
h	2.35	0.093	2.37	0.093	2.40	0.094

D373A ICs in Tape & Reel:



DFN-10 Lead Free
1DDD373AA-PO5



DFN: Embossed tape on 330mm diameter reel. 2500 units per reel.
PN: 1DDD373AA-P05

The information contained in this data sheet is intended to assist you in designing with Rogers EL systems. It is not intended to and does not create any warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose or that the results shown on the data sheet will be achieved by a user for a particular purpose. The user should determine the suitability of Rogers EL drivers for each application.

ISO 9001:2000, ISO/TS 16949:2002, and ISO14001:2004 Certified

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These EL drivers are covered by one or more of the following U.S. patents: #5,313,141; #5,347,198; #5,677,599; #5,789,870; #6,043,610. Corresponding foreign patents are issued and pending

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