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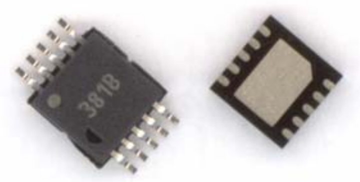
Data Sheet

D381B 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) and Green MSOP Package
- PB-Free DFN Package



MSOP-8 / MSOP-10 / DFN-10

Applications

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

Rogers DUREL® D381B EL 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.

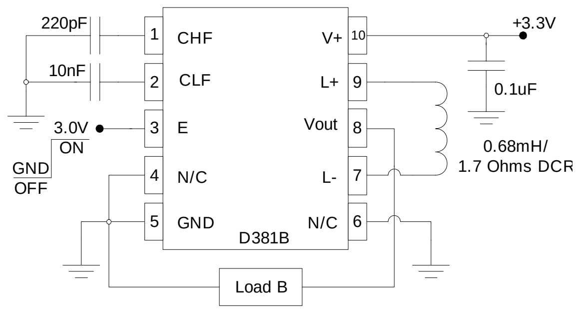
Lamp Driver Specifications:

(Using **Standard Test Circuit** at Ta=25^{0}C unless otherwise specified. Specified values and ranges represent allowable product variability at standard test but overall functionality is not limited.)

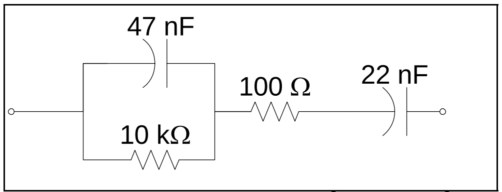
Parameter	Symbol	Minimum	Typical*	Maximum	Units	Conditions
Standby Current	I_{V+}	0	10	1000	nA	E = GND
Supply Current	I	0	40	50	mA	E = 3.3V+
Enable Current	I_{ena}		50		uA	E = 3.3V+
Output Voltage	Vout	150	182	220	Vpp	E = 3.3V+
Lamp Frequency	LF	230	270	310	Hz	CLF = 10nF
Inductor Frequency	HF	14	20	27	kHz	CHF = 220pF

***Typical values should not be used for specification limits**

Standard Test Circuit

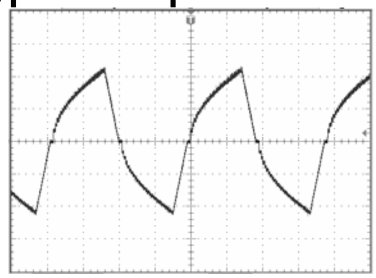


Load B*



***Load B approximates a 5in^2 (32.3cm^2) EL lamp.**

Typical Output Waveform

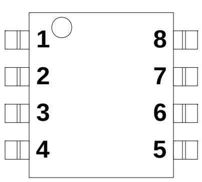


Absolute Maximum Ratings:

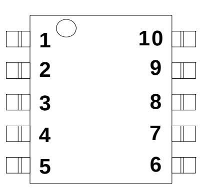
Parameter	Symbol	Minimum	Maximum	Unit	Comments
Supply Voltage Operating Range Withstand Range	V+	2.0 -0.4	7.0 7.0	V	E=V+ E=GND
Enable Voltage	E	-0.4	V+	V	
Enable Current	I_{ena}	10	50	uA	E>0
Output Voltage	V_{out}		220	Vpp	Peak-to-Peak voltage
CHF Voltage	V_{chf}	0	V_++0.3	V	External Clock input
CLF Voltage	V_{clf}	0	V_++0.3	V	External Clock input
Operating Temperature	T_a	-40	85	°C	
Storage temperature	T_s	-55	150	°C	
Lamp series resistance	R_{lamp}	100		Ohm	

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

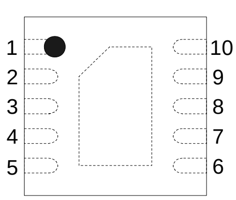
Physical Data:



MSOP8



MSOP10



DFN10

MSOP8 Pin Description

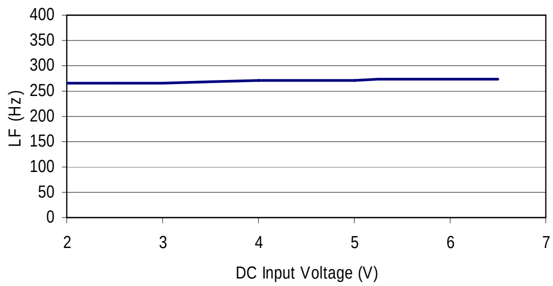
PIN #	NAME	FUNCTION
1	CHF	High frequency oscillator capacitor/clock input
2	CLF	Lamp frequency capacitor/clock input
3	E	System enable; Wave-shaping resistor control
4	GND	System ground connection
5	L-	Negative input to inductor
6	VOUT	High voltage AC output to lamp
7	L+	Positive input to inductor
8	V+	DC power supply input

MSOP10 and DFN10 Pin Description

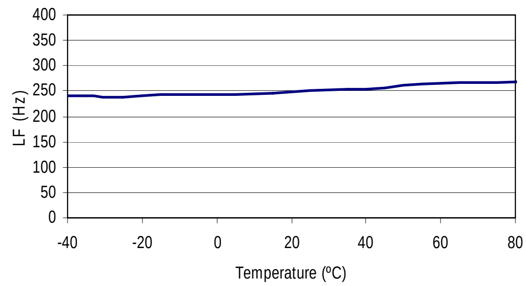
PIN #	NAME	FUNCTION
1	CHF	High frequency oscillator capacitor/clock input
2	CLF	Lamp frequency capacitor/clock input
3	E	System enable; Wave-shaping resistor control
4	N/C*	No Connect
5	GND	System ground connection
6	N/C*	No Connect
7	L-	Negative input to inductor
8	VOUT	High voltage AC output to lamp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

*Grounding pin 4 and pin 6 enhances ESD protection

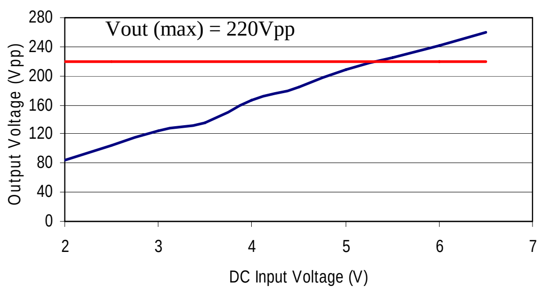
Typical Performance Characteristics



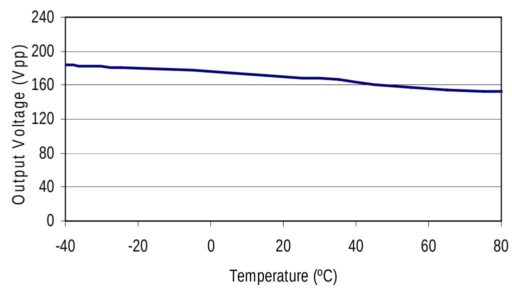
Output Frequency vs. DC Supply Voltage



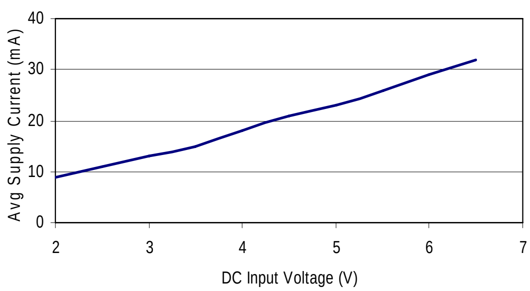
Output Frequency vs. Ambient Temperature



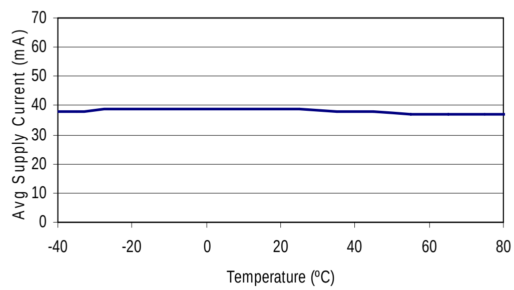
Output Voltage vs. DC Supply Voltage



Output Voltage vs. Ambient Temperature

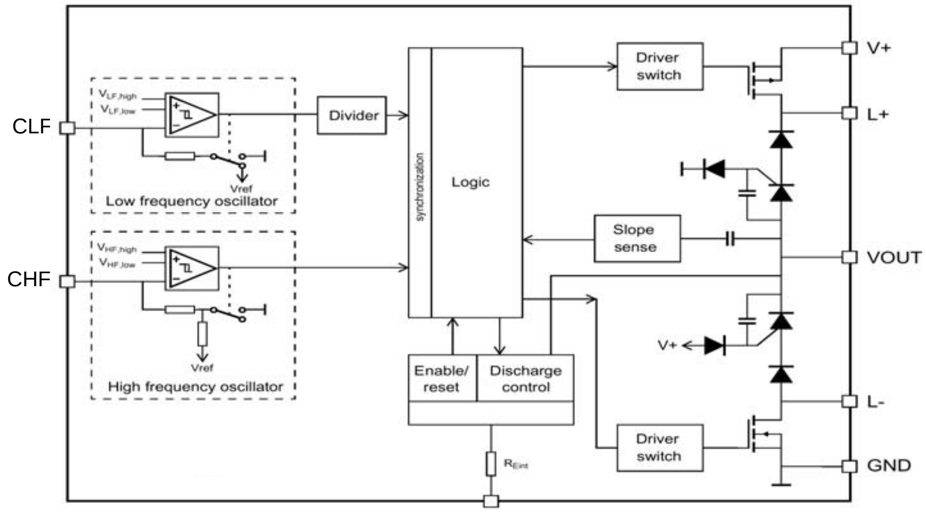


Supply Current vs. DC Supply Voltage



Supply Current vs. Ambient Temperature

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 D381B 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. As a key objective for EL driver systems is to save space and cost, required off-chip components are kept to a minimum.

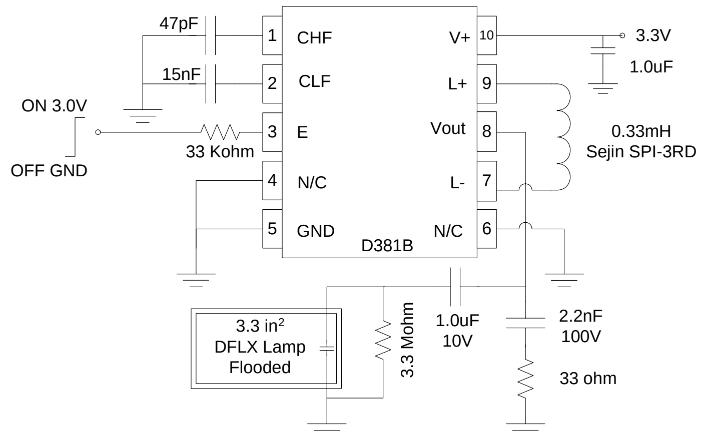
Rogers provides a D381B IC Designer's Kit, which includes a printed circuit evaluation board intended to aid you in developing an EL lamp driver configuration that meets your requirements using the D381B IC. A section on designing with the D381B IC is included in this datasheet to serve as a guide to help you select the appropriate external components to complete your D381B EL driver system.

Reference D381B EL Driver Configurations

Typical D381B 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.

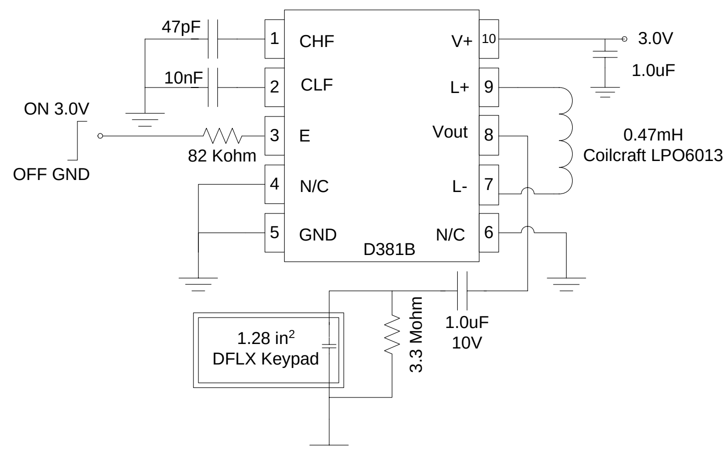
3.3V Handset DFLX Keypad

Typical Output
Luminance = 3.55 fL (12.16 cd/m^2)
Lamp Frequency = 203 Hz
Supply Current = 25 mA
Vout = 176 Vpp
Load: 3.3in^2 (2129 mm^2)
DUREL DFLX Full Lit Surface Blue EL



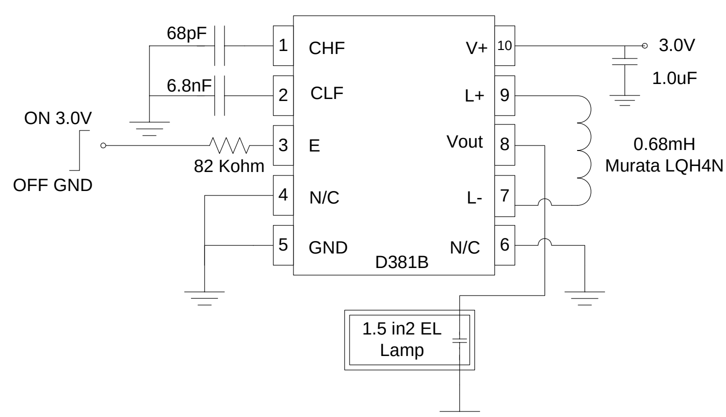
3.3V Handset DFLX Keypad

Typical Output
Luminance = 6.11 fL (20.9 cd/m^2)
Lamp Frequency = 276 Hz
Supply Current = 17 mA
Vout = 198 Vpp
Load: 1.28 in^2 (824 mm^2)
DUREL DFLX Selected Keys White EL



3.0V Handset LCD

Typical Output
Luminance = 9.7 fL (33.2 cd/m^2)
Lamp Frequency = 392 Hz
Supply Current = 15 mA
Vout = 210 Vpp
Load: 1.5in^2 (950 mm^2)
DUREL 3 Green EL



Designing With A D381B EL Driver IC

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 D381B 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.

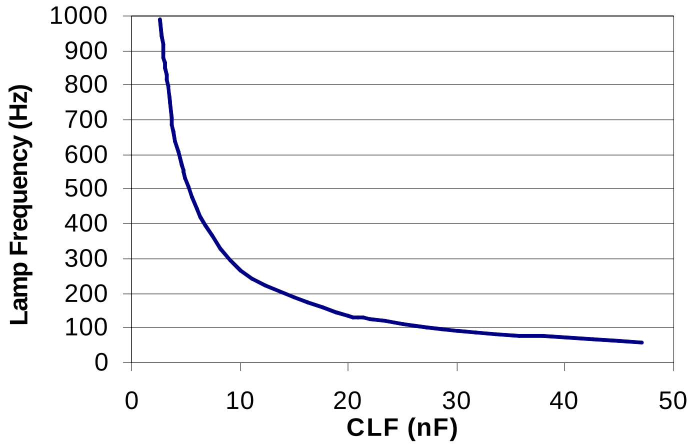


Figure 1—Typical lamp frequency vs. CLF capacitor

Alternatively, the lamp frequency may also be controlled with an external clock signal. 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 D381B IC circuit with respect to lamp frequency. In this example, the inductor and CHF values were kept constant while varying LF.

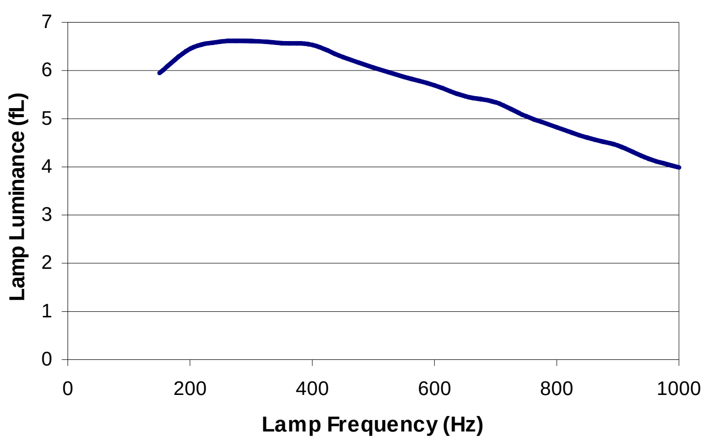


Figure 2—Luminance vs. lamp frequency
(V+ = 3.0V, 2.4 in^2 DUREL 3 Green EL Lamp Load)

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 D381B 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.

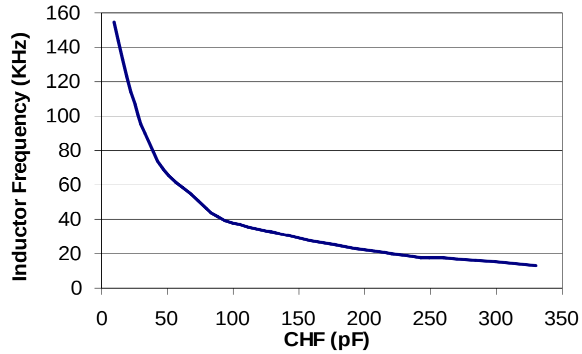


Figure 3—Typical inductor frequency vs. CHF capacitor

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+.

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. Figure 4 and Figure 5 shows the dependence of brightness and current draw of a D381B IC circuit on coil values and CHF values for two sample EL lamp sizes and input voltages. The CLF value was chosen such that the output voltage did not exceed 220Vpp. 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.

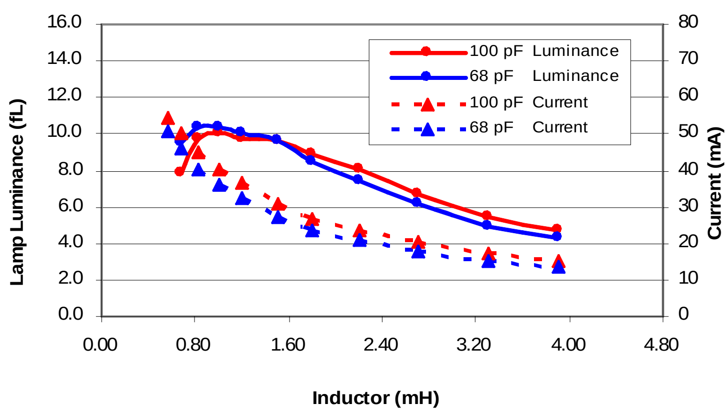


Figure 4—Luminance and current vs. inductor and CHF Value
(Conditions: V+=3.0V, 2in^2 EL Lamp)

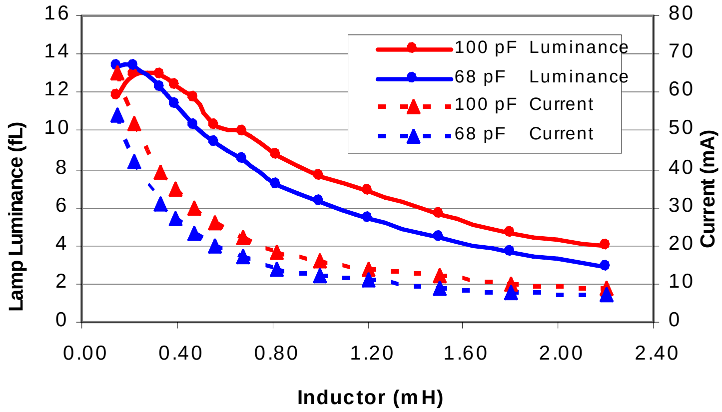


Figure 5—Luminance and current vs. inductor and CHF value
(Conditions: V+=5.0V, 4in^2 EL Lamp)

IV. Wave-shape Selection

The D381B IC driver uses a patented Wave-Shaping technique to control the discharge slope of the output waveform for reducing audible noise from an EL lamp system. The discharge current [Idischarge = Cload x Vmax / (discharge period)] may be adjusted by placing a wave-shaping resistor (Rena) between the Enable pin and Enable control voltage (E). Rena must be selected such that the current into the Enable pin (Iena) during operation is between 10 uA (slow discharge level) and 50 uA (high discharge level) to avoid unstable operation. Figure 6 shows measured discharge current dependence on Rena value for a given enable voltage and output load capacitance.

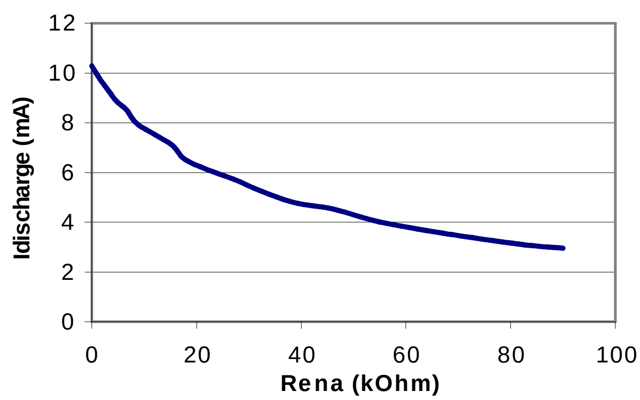


Figure 6—Discharge current vs. R_{ena} selection
(C_{LOAD}=15nF, E=3V)

The optimal discharge current for an application depends on the lamp size, lamp brightness, and operating conditions. To ensure that the D381B IC is configured optimally, various discharge current levels should be evaluated. In many cases the level with the smoothest transition slope in the discharge portion of the waveform yields the lowest audible noise from the EL lamp system. Typical wave-shapes corresponding to choice of Rena values for a 4in^2 lamp are shown in Figure 7 and Figure 8 respectively.

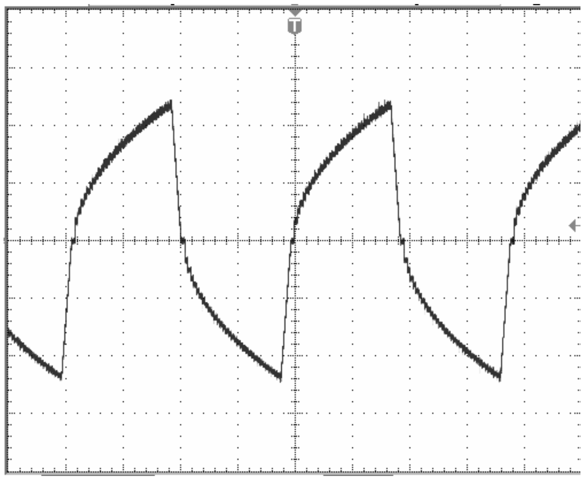


Figure 7—Rena=0Ω

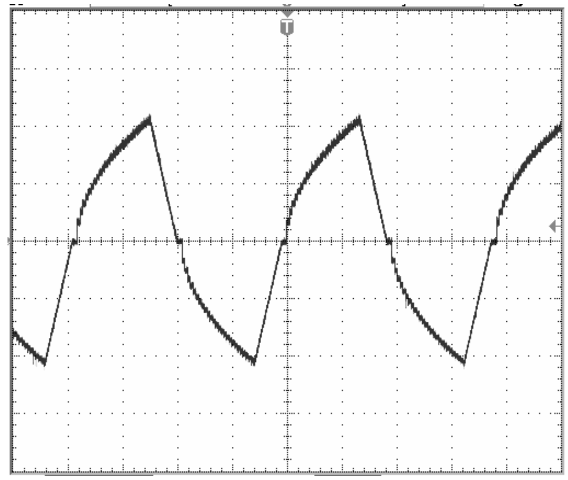


Figure 8—Rena=82kΩ

V. D381B IC Operating Considerations

The following recommendations should be considered when testing the D381B IC device to ensure that the devices are not damaged.

1) An EL driver system using the D381B IC driver should be designed such that the output voltage does not exceed the maximum rated value of 220Vpp. Vout voltage should always be between +100V and -100V. This should also be the case during the short moments where the inductor current flows to the lamp.

2) The DC input supply voltage (V+) should be applied to the V+ pin of the D381B IC prior to the application of the enable signal high to pin 3. Conversely, when powering off the device, the enable signal must be low prior to the removal of V+ signal.

3) The enable signal must have a fast rising and falling edge, less than a few HF cycles, with no mechanical contact bounce.

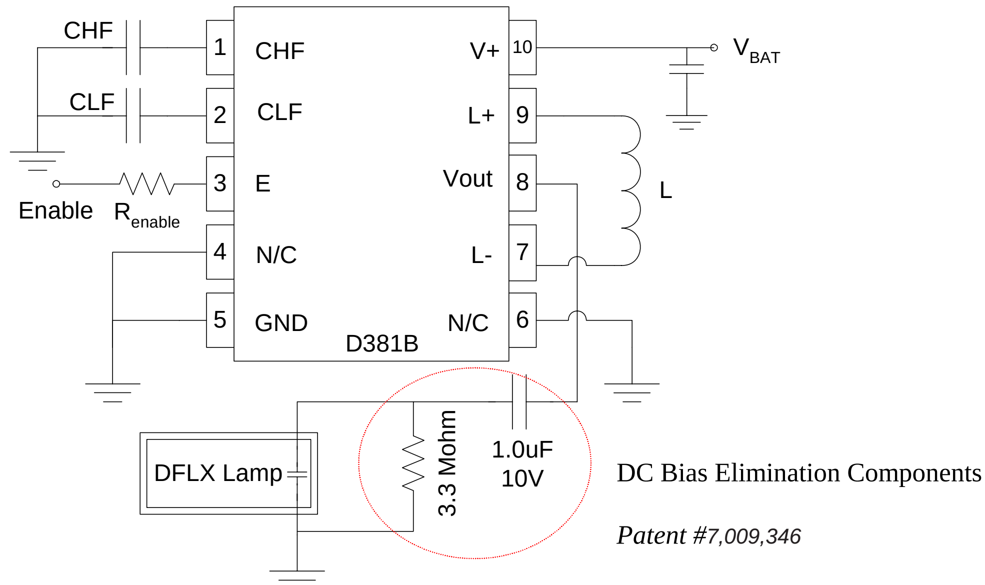
4) R_{enable} must be selected such that I_{enable} is between 10uA (slow discharge) and approximately 50uA (fast discharge). When driving larger lamps, a faster discharge rate (smaller value R_{enable}) is recommended to ensure lamp is fully discharged prior to next charging cycle. Refer to Figure 6 for selecting a proper R_{enable} value.

5) Prevent voltage spikes at V+. Place the V+ decoupling capacitor close to the IC. Avoid long wires from the V+ power supply to the IC in the test environment.

D381B IC Design Ideas

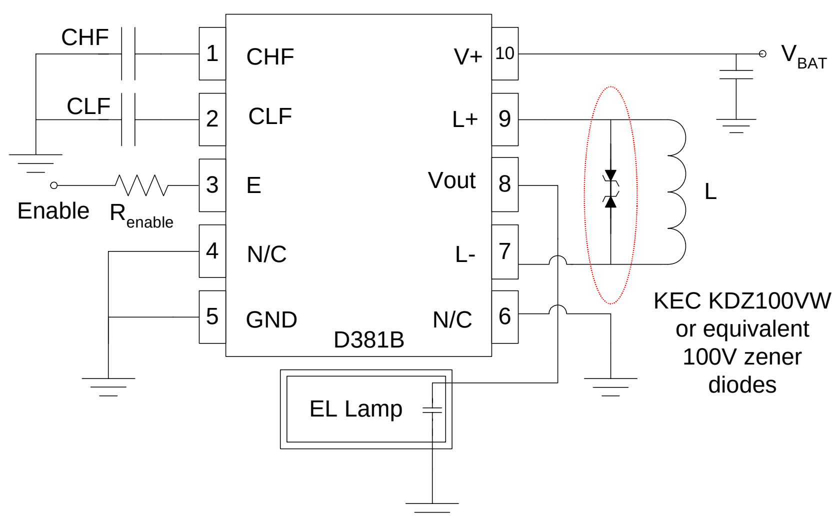
I. DC Bias Elimination Circuit

Semiconductor inverters will inherently induce a small DC bias across the electrodes 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.



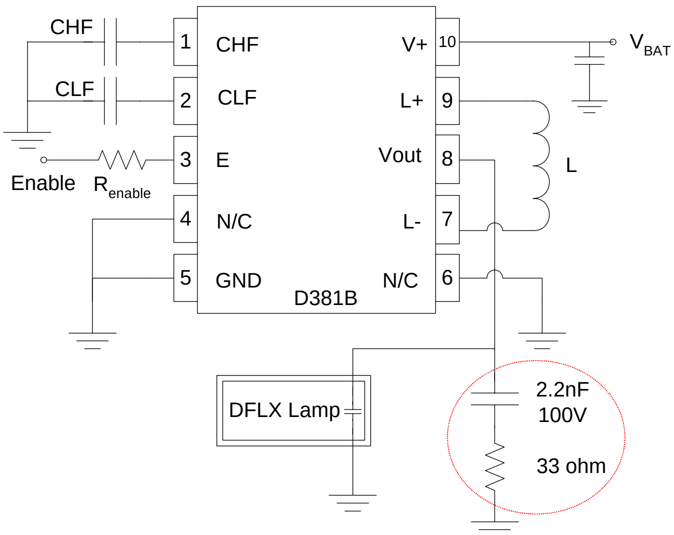
II. Output Voltage Limit Control

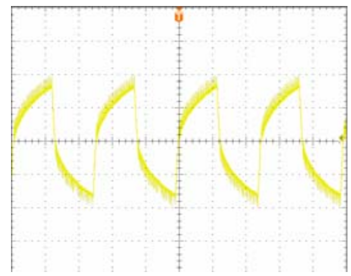
An EL driver system using the D381B IC should be designed such that the output voltage does not exceed the maximum rated value of 220Vpp. Using a pair of zener diodes connected in parallel to the inductor as shown below is an example of clamping the output voltage to within 200Vpp or less. This circuit protects the device from over-voltage when typical performance is near the maximum limit for the D381B IC.



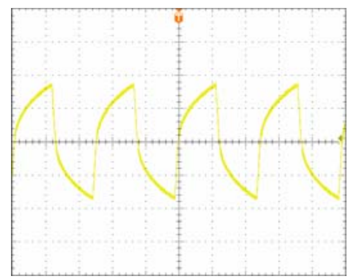
III. Output Impedance Reduction Circuit

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 a 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.





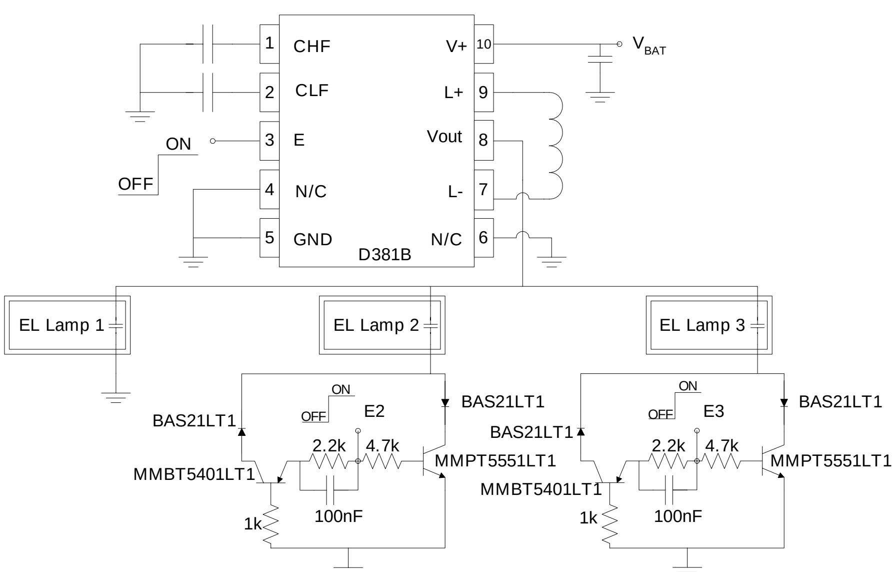
Vout with High Frequency Spikes



Vout with Output Impedance Reduction Circuit

IV. Driving Multiple EL Lamps

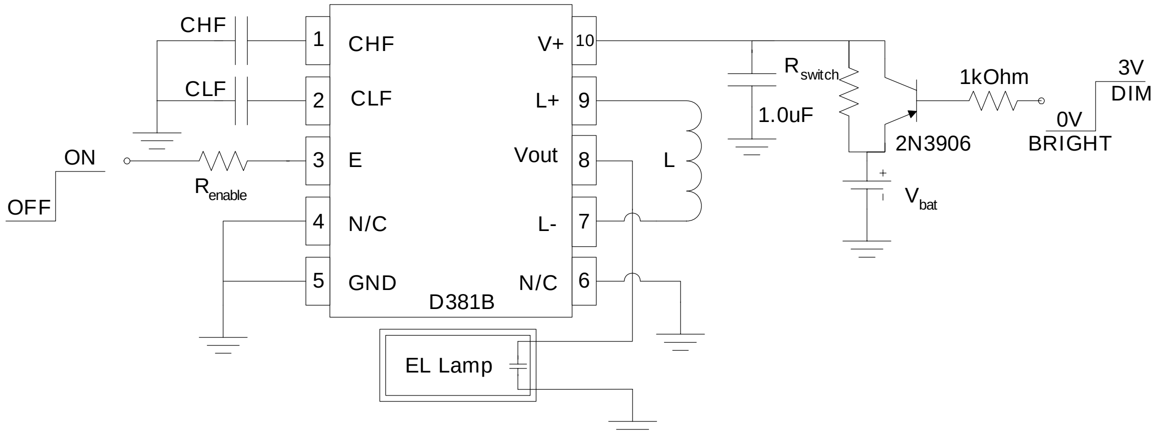
The D381B IC may be used to drive multiple EL lamp segments. An external transistor switching circuit is used to turn each lamp segment on or off independently or simultaneously. A high signal at the corresponding E input will enable the corresponding lamp segment. In this configuration, EL Lamp 1 is 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 D381B IC is enabled.



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 systems for each application.

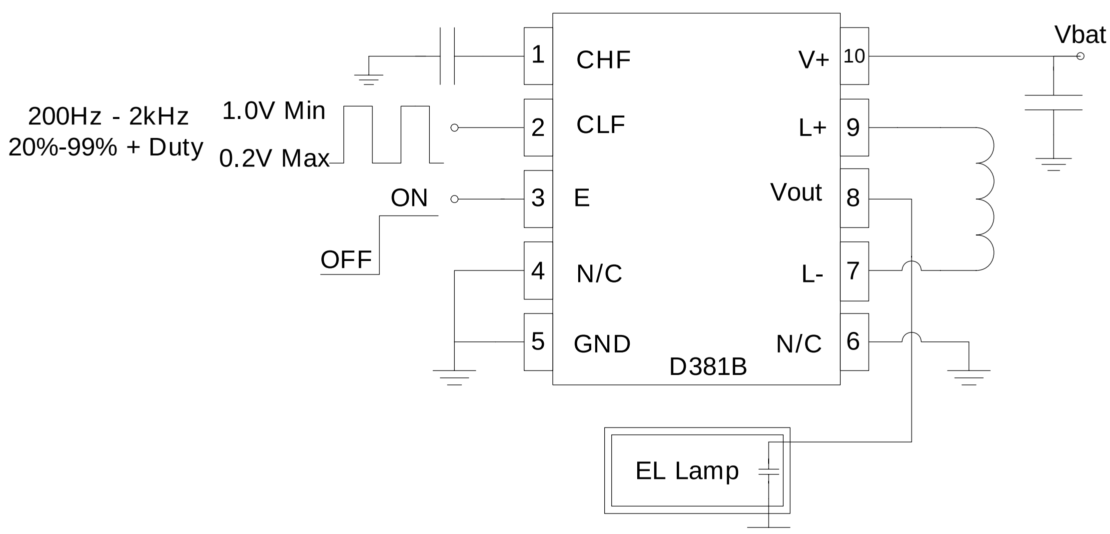
V. Two-level Dimming

Two level dimming may be achieved using the circuit configuration shown 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.



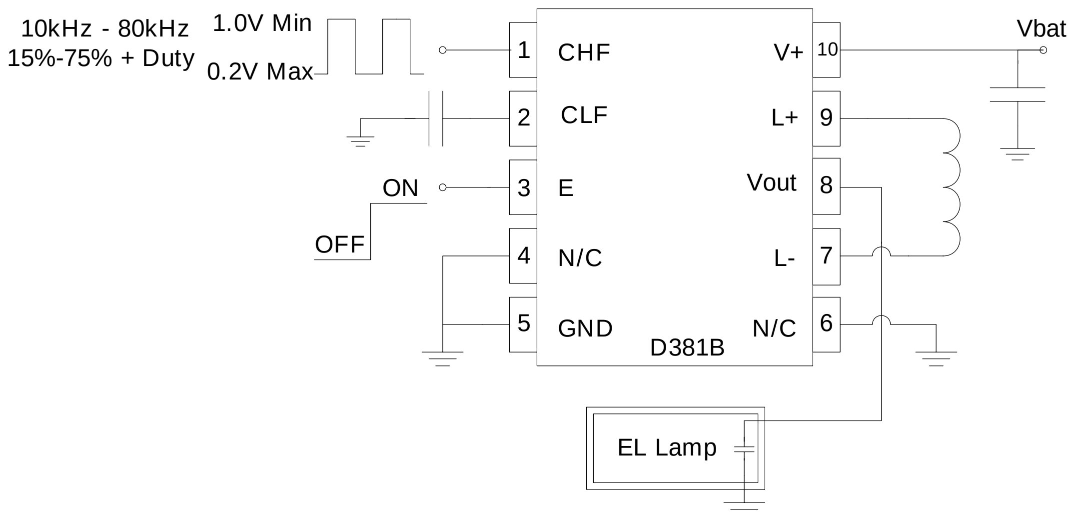
VI. Lamp Frequency Control with an External Clock Signal

An external clock signal may be used to control the EL lamp frequency (LF) of the D381B 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 +50%.



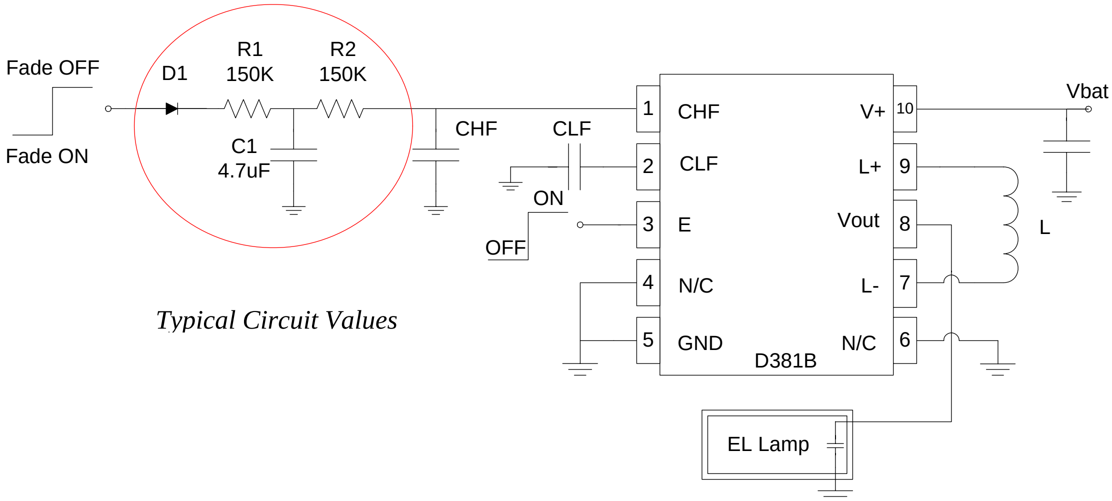
VII. EL Brightness Control through HF Clock Pulse Width Modulation

The inductor oscillating frequency may also be controlled on the D381B IC driver using an external clock input to CHF. In addition, pulse-width modulation of the external HF clock signal to the D381B IC 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.



VIII. Fade ON Fade OFF Output Control

When the EL lamp is changing from on to off a fading option can be implemented using frequency control as an RC circuit on the CHF pin. The option of fading is separate from the enabling of the EL drive utilizing the E pin logic. The added circuitry shown below can be optimized to control the time interval of fading off (C1 and R1) as well as the interval of fading on (C1 and R2). The application of D1 is optional with respect to the control system applied for fading on and off. If the system does not have an internal diode other than D1, there may be an undesired current flow from the inverter driver to the control system during a low signal.



VII. Solder Re-Flow Recommendations

Classification Reflow Profiles

Profile Feature	**Sn-Pb Eutectic Assembly** 1DDD381BB-MO2 1DDD381BB-MO4	**Pb-Free Assembly** 1DDD381BB-NL2 1DDD381BB-NL4 1DDD381BB-PO5
Average ramp-up rate (T_L to T_P)	3°C/second max.	3°C/second max.
Preheat -Temperature Min (Ts_{min}) -Temperature Max (Ts_{max}) -Time (min to max) (ts)	100°C 150°C 60-120 seconds	150°C 200°C 60-180 seconds
Ts_{max} to T_L -Ramp-up Rate		3°C/second max.
Time maintained above: Temperature (T_L) -Time (T_L)	183°C 60-150 seconds	217°C 60-150 seconds
Peak Temperature (T_P)	240 +0/-5°C	250 +0/-5°C
Time within 5°C of actual Peak Temperature (T_P)	10-30 seconds	20-40 seconds
Ramp-down Rate	6°C/second max.	6°C/second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.

IPC/JEDEC J-STD-020B July 2002

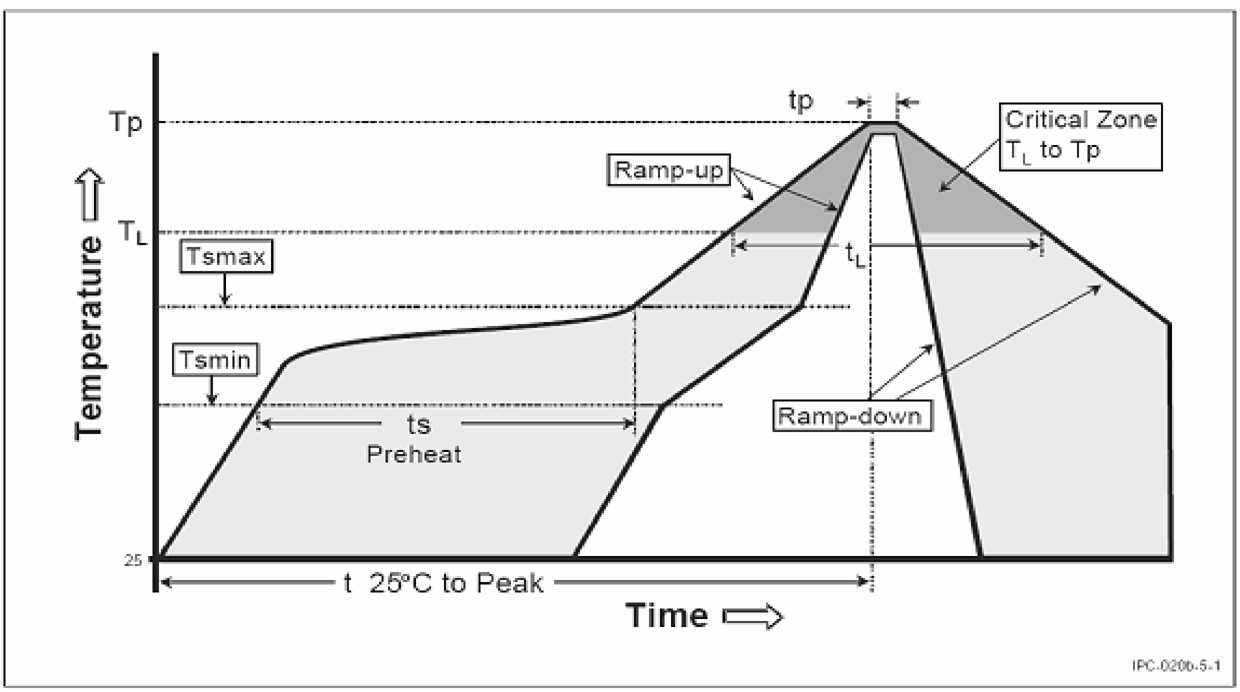
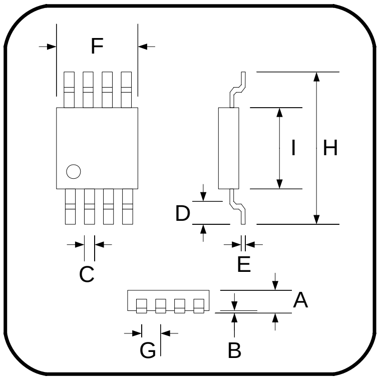


Figure 5-1 Classification Reflow Profile

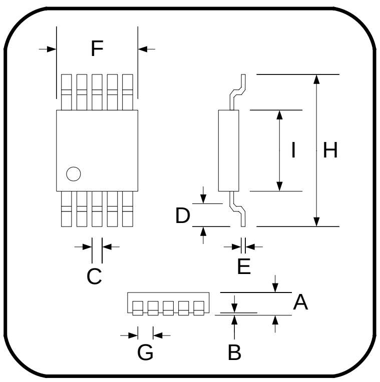
Note: All Temperatures refer to topside of the package, measured on the package body surface
Note: All Temperatures refer to IPC/JEDEC J-STD-020B

Ordering Information

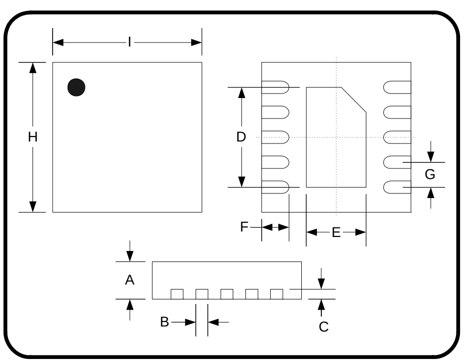
The D381B IC is available in standard or Pb-free green for the MSOP-8 and MSOP-10. The DFN-10 is only available in Pb-free green packages per tape and reel. A DUREL D381B IC Designer's Kit (1DDD381BB-K01) provides a vehicle for evaluating and identifying the optimum component values for any particular application using D381B IC. Rogers' engineers also provide full support to customers, including specialized circuit optimization and application retrofits.



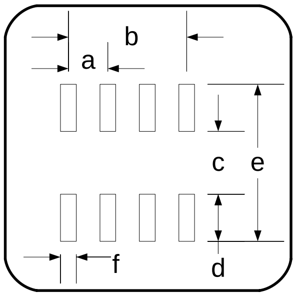
	MSOP-8					
	Min		Typical		Max	
	mm	in	mm	in	mm	in
A	0.94	0.037	1.02	0.040	1.09	0.043
B	0.05	0.002	0.10	0.004	0.15	0.006
C	0.20	0.008	0.33	0.013	0.46	0.018
D	0.41	0.016	0.53	0.021	0.65	0.026
E	0.13	0.005	0.18	0.007	0.23	0.009
F	2.84	0.112	3.00	0.118	3.15	0.124
G	0.43	0.017	0.65	0.026	0.83	0.033
H	4.75	0.187	4.90	0.193	5.11	0.201
I	2.90	0.114	3.00	0.118	3.25	0.128



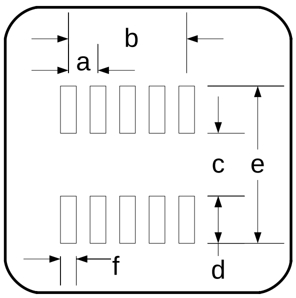
	MSOP-10					
	Min		Typical		Max	
	mm	in	mm	in	mm	in
A	0.92	0.036	1.00	0.039	1.08	0.043
B	0.05	0.002	0.10	0.004	0.15	0.006
C	0.15	0.006	0.23	0.009	0.31	0.012
D	0.40	0.016	0.55	0.022	0.70	0.028
E	0.13	0.005	0.18	0.007	0.23	0.009
F	2.90	0.114	3.00	0.118	3.10	0.122
G	0.35	0.014	0.50	0.020	0.65	0.026
H	4.75	0.187	4.90	0.193	5.05	0.199
I	2.90	0.114	3.00	0.118	3.10	0.122



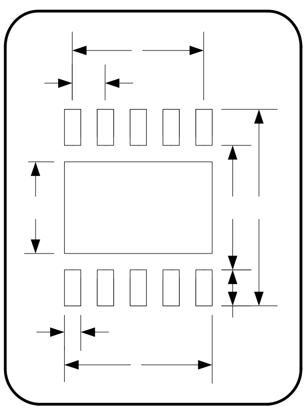
	DFN-10					
	Min		Typical		Max	
	mm	in	mm	in	mm	in
A	0.70	0.028	0.75	0.030	0.8	0.031
B	0.18	0.007	0.25	0.010	0.3	0.012
C	0.20	0.0077	0.203	0.0080	0.211	0.0083
D	1.92	0.076	2.00	0.079	2.05	0.081
E	1.55	0.061	1.6	0.063	1.65	0.065
F	0.35	0.014	0.40	0.016	0.45	0.018
G	0.50	0.020	0.5	0.020	0.5	0.020
H	2.95	0.116	3.00	0.118	3.05	0.120
I	2.95	0.116	3.00	0.118	3.05	0.120



	MSOP-8 PAD LAYOUT					
	Min		Typical		Max	
	mm	in	mm	in	mm	in
a	0.60	0.0236	0.65	0.0256	0.70	0.0276
b	1.90	0.0748	1.95	0.0768	2.00	0.0788
c	3.30	0.130			3.45	0.1360
d	0.89	0.035	0.97	0.0380	1.04	0.041
e	5.26	0.207			5.41	0.213
f	0.41	0.0160	0.46	0.0180	0.51	0.020

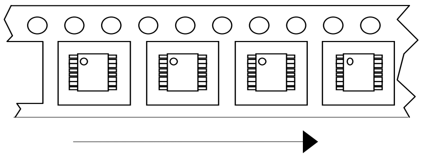


	MSOP-10 PAD LAYOUT					
	Min		Typical		Max	
	mm	in	mm	in	mm	in
a			0.50	0.0197		
b			2.00	0.0787		
c	3.3	0.130			3.45	0.136
d	0.89	0.035	0.97	0.038	1.05	0.041
e	5.26	0.207			5.41	0.213
f			0.30	0.012		



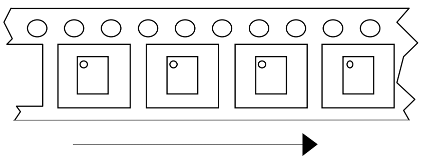
	DFN-10 PAD LAYOUT					
	Min		Typical		Max	
	mm	in	mm	in	mm	in
a			0.50	0.020		
b	1.90	0.075	2.00	0.079	2.10	0.083
c			1.90	0.075		
d	0.45	0.018	0.55	0.022	0.65	0.026
e			3.00	0.118		
f	0.18	0.007	0.25	0.010	0.30	0.012
g	1.60	0.063	1.62	0.064	1.65	0.065
h	2.35	0.093	2.37	0.093	2.40	0.094

D381B ICs in Tape & Reel:



Tape Orientation

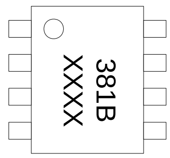
MSOP: Embossed tape on 330mm diameter reel per EIA-481-2. 2500 units per reel.
PN: 1DDD381BB-M02, 1DDD381BB-M04, 1DDD381BB-NL2, 1DDD381BB-NL4

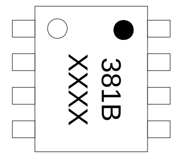


Tape Orientation

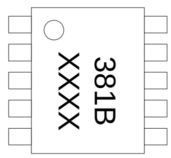
DFN: Embossed tape on 330mm diameter reel. 2500 units per reel.
PN: 1DDD381BB-P05

Standard Package	**Pb-free/ Green Package**
MSOP-8 Standard 1DDD381BB-M02	MSOP-8 Lead Free 1DDD381BB-NL2

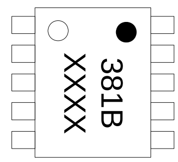




MSOP-10 Standard
1DDD381BB-M04

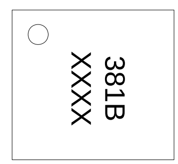


MSOP-10 Lead Free
1DDD381BB-NL4



DFN-10 Standard
Not Available

DFN-10 Lead Free
1DDD381BB-PO5



ISO 9001:2000, ISO/TS 16949:2002, and ISO 14001:1996 Certified

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Rogers EL drivers are covered by one or more of the following U.S. patents #5,313,141; #5,789,870; #5,677,599; #6,043,610, #7,009,346. Corresponding foreign patents are issued or pending.

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