

Data Sheet
D355B
Electroluminescent
Lamp Driver IC



General Description

The Durel®D355B is part of a family of highly integrated EL drivers based on Durel's patented three-port (3P) topology, which offers built-in EMI shielding. This high efficiency device is well suited for backlighting most timepieces and liquid crystal displays for portable electronic applications.

Features

- High Efficiency
- Low Voltage Operation
- Small System Footprint
- Controlled Current Discharge for Low EMI
- Capacitor or External Clock LF Control

Applications

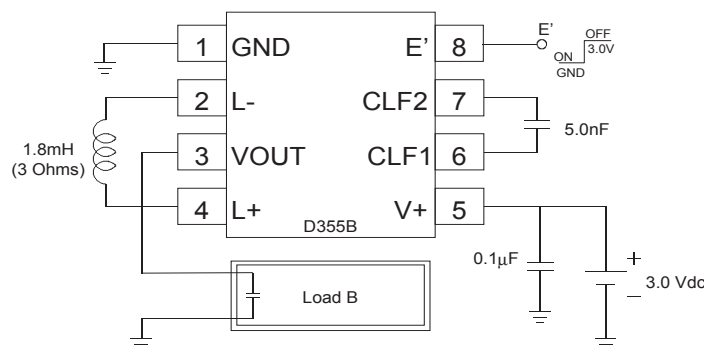
- Watches
- Data Organizers/PDAs
- Pagers
- LCD and Keypad Backlighting

Lamp Driver Specifications

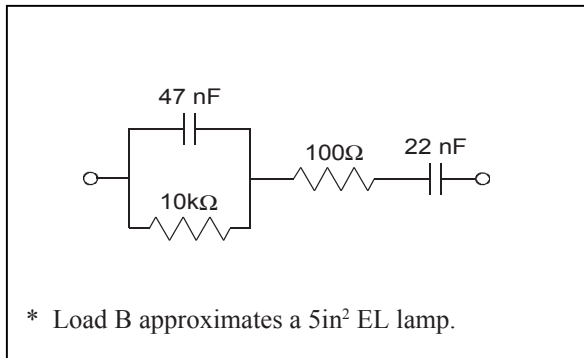
(Using Standard Test Circuit at Ta=25 °C unless otherwise specified.)

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Conditions
Standby Current			10	1000	nA	E' = 3.0V
Supply Current	I		23	30	mA	E' = GND
Enable Current			-10	-35	μA	E' = GND
Output Voltage	Vout	110	145	220	V _{pp}	E' = GND
Lamp Frequency	LF	230	310	390	Hz	CLF = 5.0nF
Inductor Frequency	HF		23		kHz	

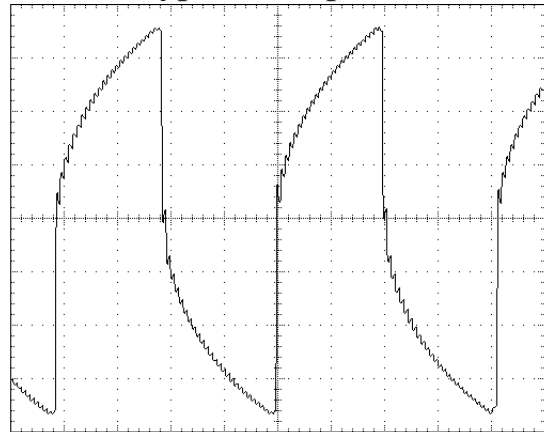
Standard Test Circuit



Load B*



Typical Output Waveform

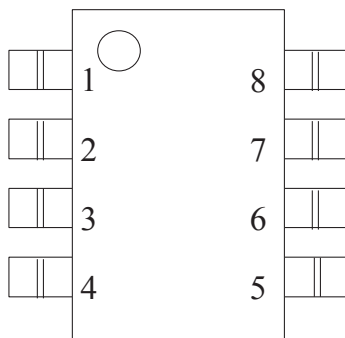


Absolute Maximum Ratings

Parameter	Symbol	Minimum	Maximum	Unit	Comments
Supply voltage					
Operating range	V+	1.0	7.0	V	E' = GND
Withstand range		-0.5	10.0		E' = V+
Enable Voltage	E'	-0.5	(V+)+0.5	V	
Output Voltage	V _{out}		220	V _{pp}	Peak to peak voltage
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 are 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.

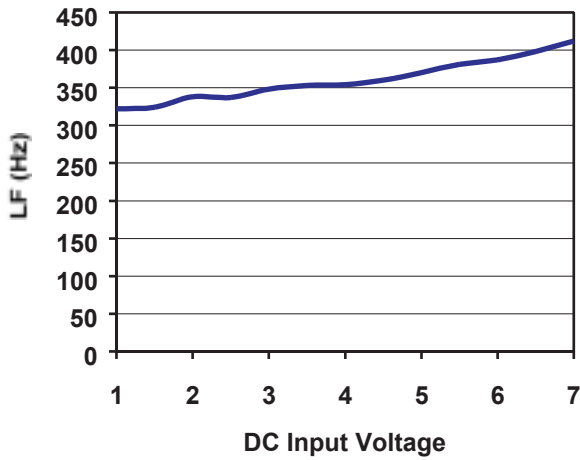
Physical Data



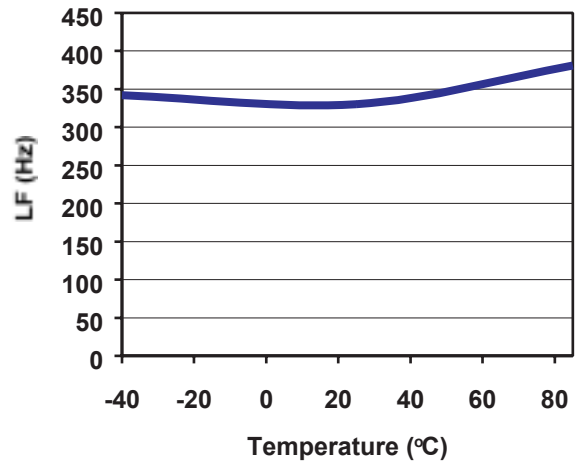
PIN #	NAME	FUNCTION
1	GND	System ground connection
2	L-	Negative input to inductor
3	Vout	High voltage AC output to lamp
4	L+	Positive input to inductor
5	V+	DC power supply input
6	CLF1	Lamp frequency capacitor/clock input
7	CLF2	Lamp frequency capacitor/clock input
8	E'	System enable; Power Down Control

Note: Please consult factory for bare die physical data and bond pad locations

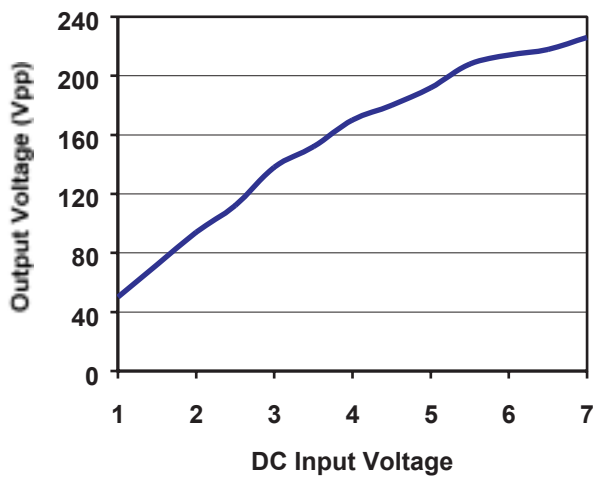
Typical Performance Characteristics Using Standard Test Circuit



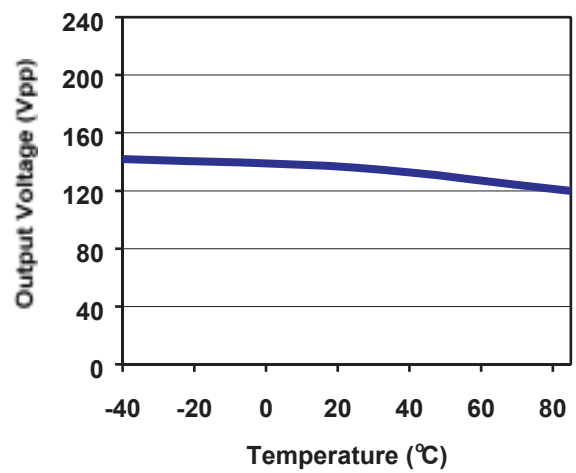
Output Frequency vs. DC Supply Voltage



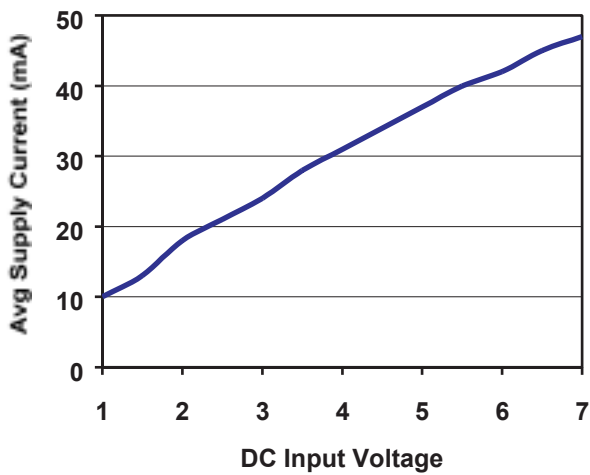
Output Frequency vs. Ambient Temperature



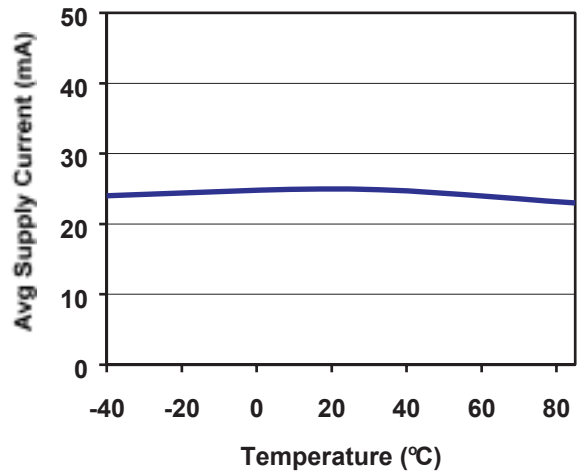
Output Voltage vs. DC Supply Voltage



Output Voltage vs. Ambient Temperature

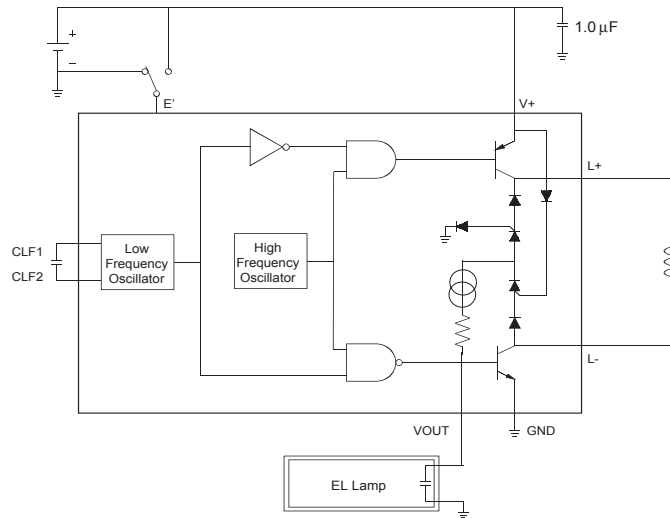


Supply Current vs. DC Supply Voltage



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. When a strong AC voltage is applied across the EL lamp electrodes, the phosphor glows. The required AC voltage is typically not present in most systems and must be generated from a low voltage DC source. Thus, Durel 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. The Durel 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 D355B 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 on 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 output 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 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 were kept to a minimum.

Durel provides a D355B Designer's Kit, which includes a printed circuit evaluation board intended to aid you in developing an EL lamp driver configuration using the D355B that meets your requirements. A section on designing with the D355B is included in this datasheet to serve as a guide to help you select the appropriate external components to complete your D355B EL driver system.

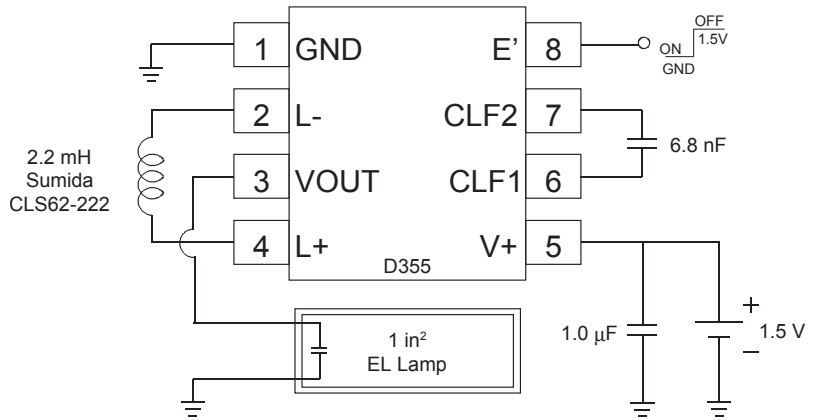
Typical D355B configurations for driving EL lamps in various applications are shown on the following page. The expected system outputs, such as lamp luminance, lamp output frequency and voltage and average supply current draw, for the various sample configurations are also shown with each respective figure.

Typical D355B EL Driver Configurations

1.5V Analog Watch

Typical Output

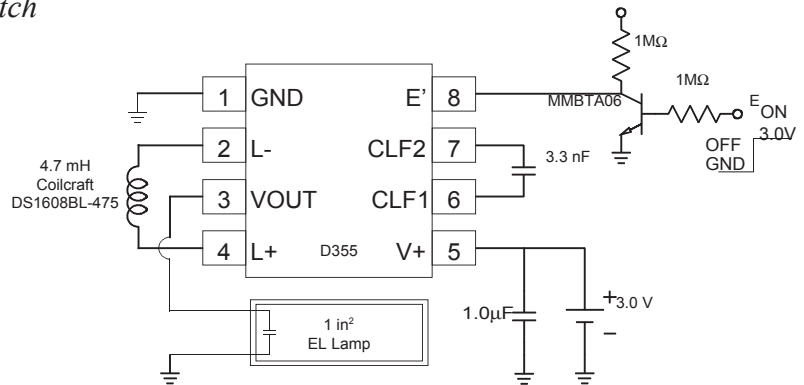
Luminance = 3.5 fL (12 cd/m²)
 Lamp Frequency = 220 Hz
 Supply Current = 10 mA
 Vout = 178 Vpp
 Load = 1 in² Durel ®3 Green EL



3.0V Handset LCD or Digital Watch

Typical Output

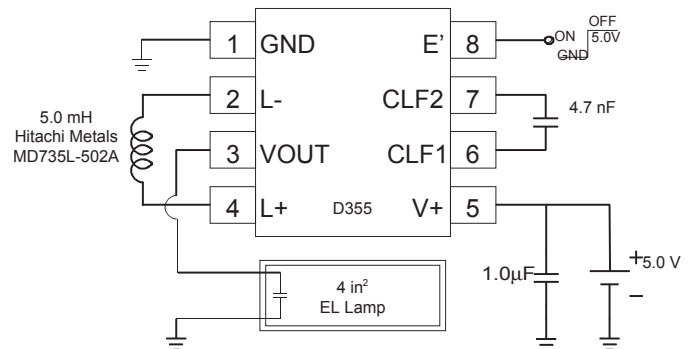
Luminance = 8.6 fL (29.5 cd/m²)
 Lamp Frequency = 475 Hz
 Supply Current = 14 mA
 Vout = 208 Vpp
 Load = 1 in² Durel ®3 Green EL



5.0V PDA

Typical Output

Luminance = 7.7 fL (26.4 cd/m²)
 Lamp Frequency = 360 Hz
 Supply Current = 19 mA
 Vout = 220 Vpp
 Load = 4 in² Durel ®3 Green EL



Designing With D355B

I. Lamp Frequency Capacitor (CLF) Selection

Selecting the appropriate value of capacitor for the low frequency oscillator (CLF) will set the output frequency of the D355 inverter. Figure 1 graphically represents the inversely proportional relationship between the CLF capacitor value and the oscillator frequency. In this example at $V^+=3.0V$, $LF = 1600 \text{ nF-Hz/CLF}$.

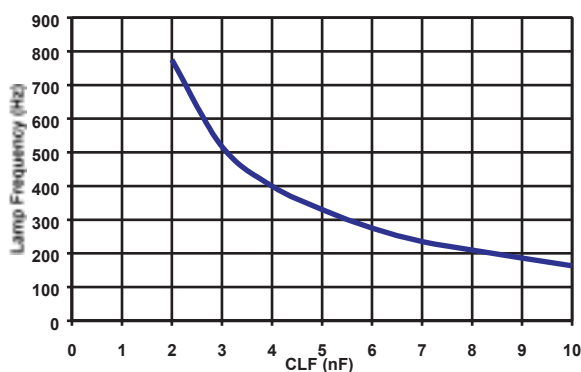


Figure 1: Typical Lamp Frequency vs. CLF Capacitor

Alternatively, the lamp frequency may also be controlled with an external clock signal with a 50% duty cycle. The output lamp frequency will be the same frequency as the input clock signal. For example, if a 250Hz 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. The luminance of various sizes of Durel 3 Blue-green EL lamp driven by a D355B at $V^+ = 3.0V$ using the same inductor value is shown in Figure 2 with respect to lamp frequency.

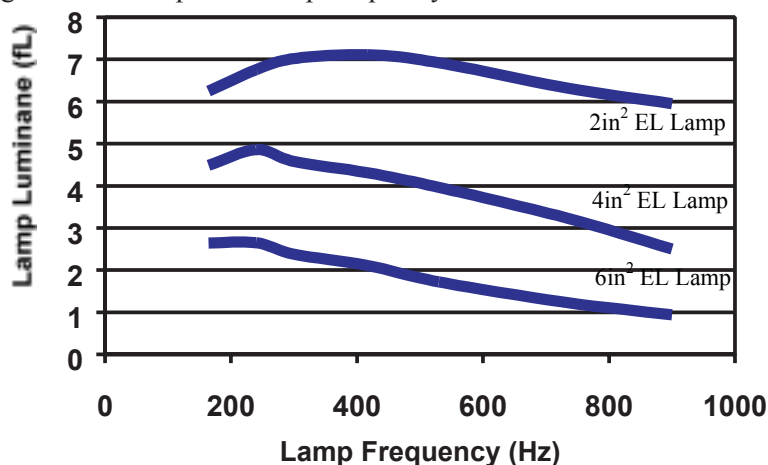


Figure 2: Typical Lamp Luminance vs. Lamp Frequency

II. Inductor (L) Selection

The external inductor (L) selection for a D355B circuit greatly affects the output capability and current draw of the driver. A careful designer will balance current draw considerations with output performance in the choice of an ideal inductor for a particular application. Figures 3, 4, and 5 show typical brightness and current draw of a D355B circuit with different inductor values, lamp sizes, and supply voltages while keeping the LF constant. Please note that the DC resistance (DCR) of inductors with the same nominal inductance value may vary with manufacturer and inductor type. Thus, inductors made by a different manufacturer may yield different outputs, but the trend of the different curves should be similar. Lamp luminance is also a function of lamp size. In each example, a larger lamp will have less luminance with approximately the same current draw.

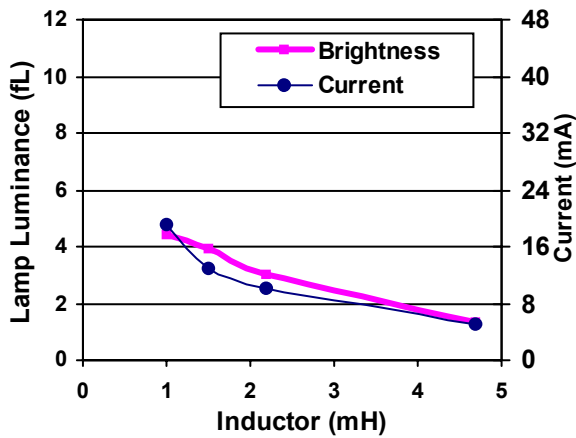


Figure 3: V+ = 1.5V, 1 in² EL Lamp

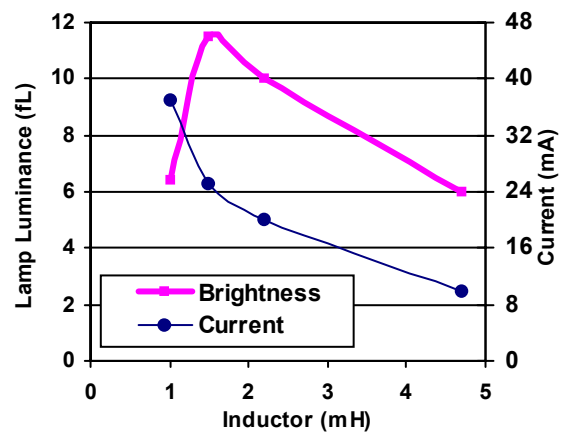


Figure 4: V+ = 3.0V, 1 in² EL Lamp

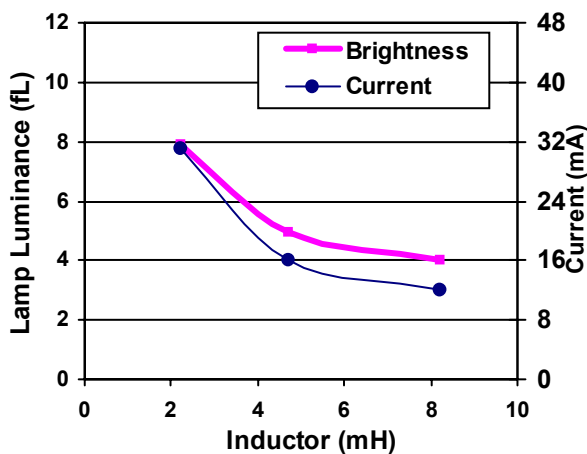
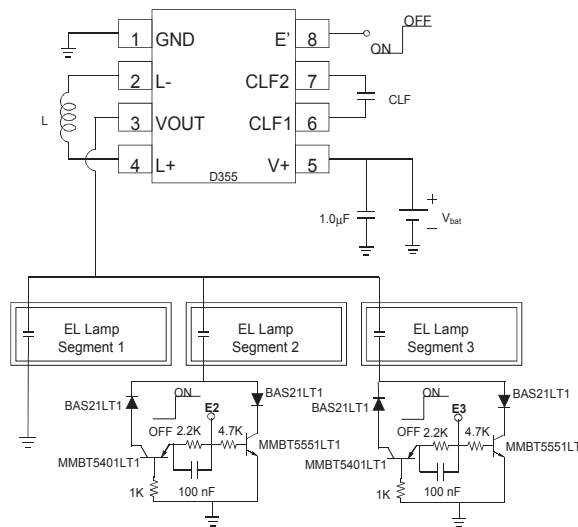


Figure 5: V+ = 5.0V, 4 in² EL Lamp

D355B Design Ideas

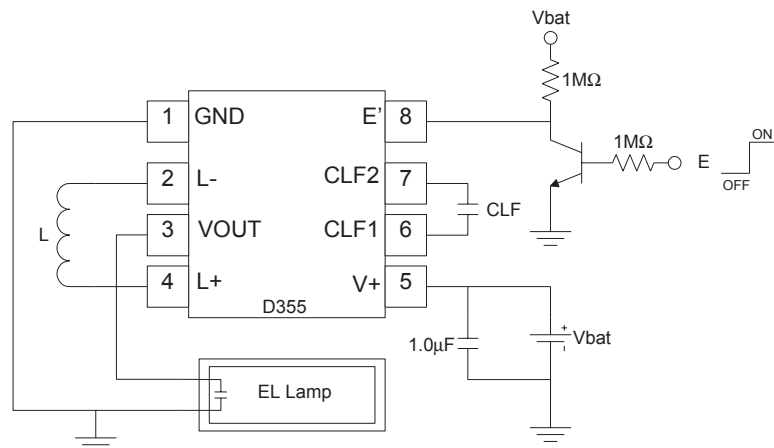
I. Driving Multi-Segment Lamps

The D355B may be used to drive two or more EL lamps or EL lamp areas independently. An external switching circuit can be used to turn each lamp segment on or off. A high signal at the E input for the corresponding EL lamp will power the segment when the IC is enabled. In this example, Segment 1 is always on when the Durel D355B is enabled. Otherwise, always make sure that at least one segment is switched on when the driver IC is activated.



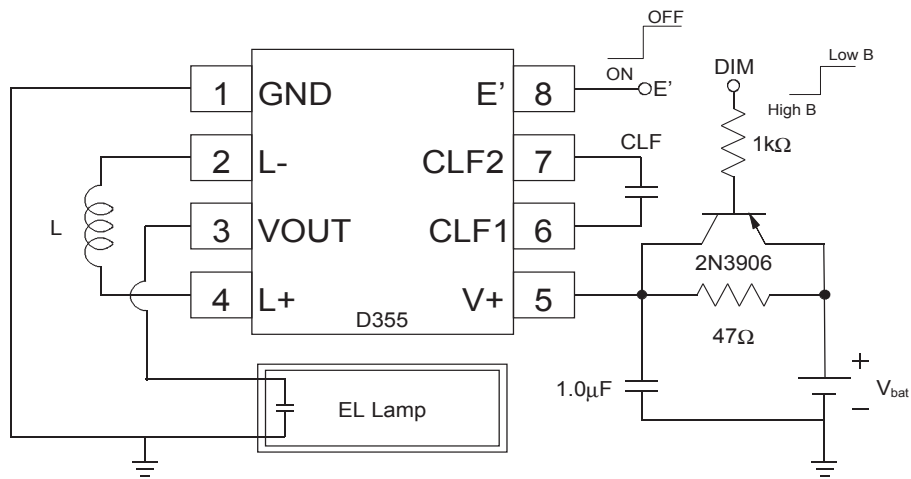
II. Enabling the D355B with a High Logic Signal

A low logic signal at the E' pin will enable the D355B. Adding a transistor and two resistors will allow the D355B to be enabled with a high voltage signal.



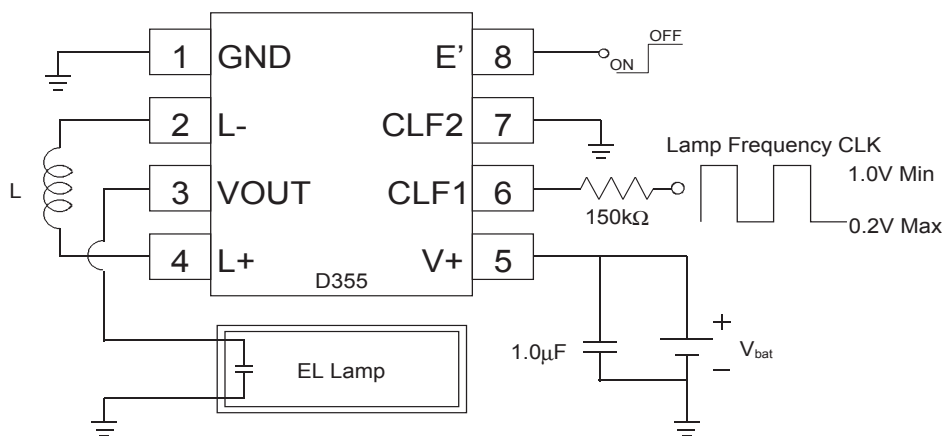
III. Two-Level Dimming

Toggle switching between two different EL lamp brightness levels may be achieved with the following circuit. 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.



IV. Lamp Frequency Control with an External Clock Signal

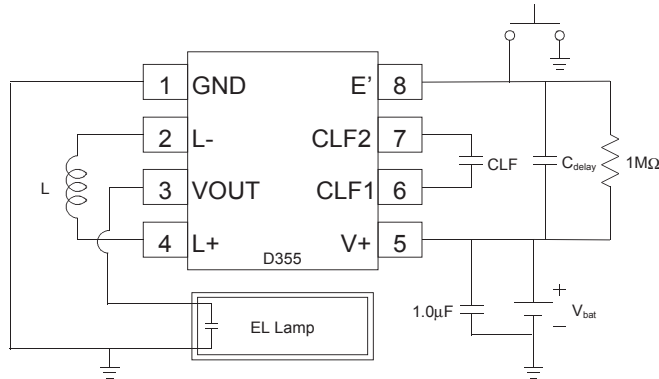
An external clock signal with a 50% duty cycle may be used to control the EL lamp frequency (LF). This technique allows the designer flexibility to synchronize the EI driver IC with other elements in the application. The output lamp frequency will be the same frequency as the input clock signal. For example, if a 250Hz input clock signal is used, the resulting lamp frequency will be 250Hz. The clock signal voltage should not exceed V+.



V. Automatic Turn-Off After Short Time Delay

It is sometimes desirable for the EL lamp to turn off automatically after a few seconds of operation. Typically, a mechanical switch pulls E' low to initially turn on the device. When the switch is released, C_{delay} keeps the D355B operating for a short period before turning off. The following table shows typical delay on-times.

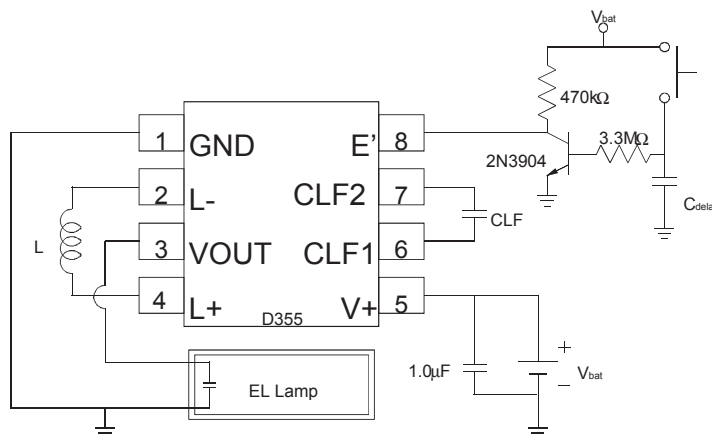
C _{delay} (μF)	V _{bat}		
	1.5V	3.0V	5.0V
5	2.4 s	4.0 s	6.0 s
7	3.3 s	5.5 s	7.8 s
10	5.1 s	8.6 s	12.5 s
15	7.2 s	12.7 s	19.3 s
20	9.9 s	17.2 s	27.0 s



VI. Automatic Turn-Off After Long Time Delay

Longer on-times can be achieved with the addition of an external transistor. Typically, a mechanical switch pulls E' low to initially turn on the device. When the switch is released, C_{delay} keeps the D355B operating for a period before turning off. The following table shows typical delay on-times using the following circuit with smaller capacitor values.

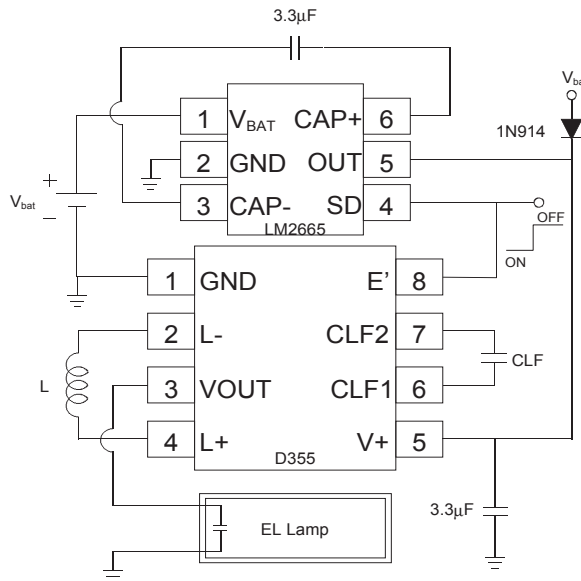
C _{delay} (μF)	V _{bat}		
	1.5V	3.0V	5.0V
1	9.5 s	13.0 s	15.6 s
2	17.8 s	24.0 s	29.0 s
3	26.5 s	36.0 s	42.0 s



VII. High EL Brightness Through Supply Voltage Doubling (Option 1)

Maximum brightness from a D355 is achieved at relatively high supply voltages (>3.0V). An external voltage boost circuit may be used to increase the voltage supplied to the D355. In the following circuit, the National Semiconductor LM2665 is used to double the voltage supplied to the D355. This can produce about twice the brightness of the D355 alone.

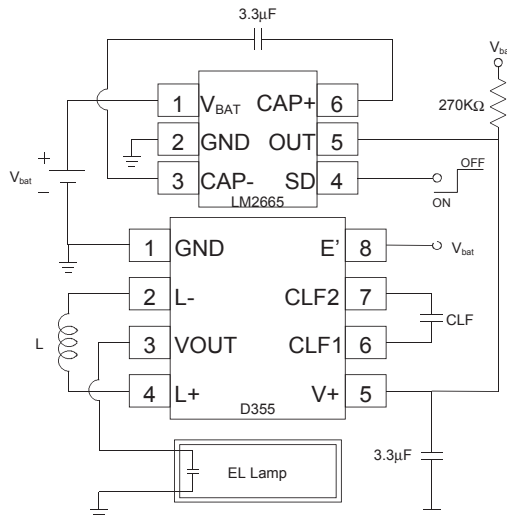
NOTE: It is important not to exceed the maximum ratings of either device in this circuit.



VIII. High EL Brightness Through Supply Voltage Doubling (Option 2)

In many cases, a resistor may replace the diode in the previous circuit. The diode is used by the LM2665 during startup (see LM2665 datasheet). The circuit below ensures that the LM2665 starts properly before the D355 is turned on.

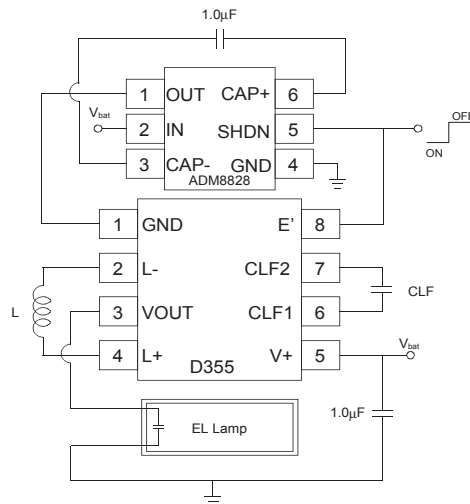
NOTE: It is important not to exceed the maximum ratings of either device in this circuit.



IX. High EL Brightness Through Supply Voltage Doubling (Option 3)

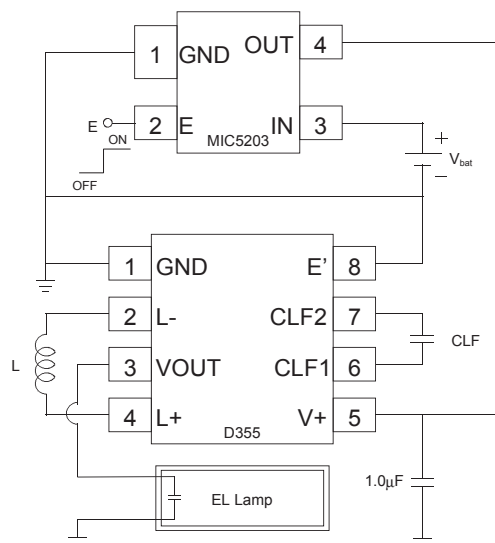
In the following circuit, the Analog Devices ADM8828 produces a negative V_{bat} voltage. This voltage may be connected to the GND pin on the D355 to double the differential voltage supplied to the D355. This can produce about twice the brightness of the D355 alone.

*NOTE: It is important not to exceed the maximum ratings of either device in this circuit.



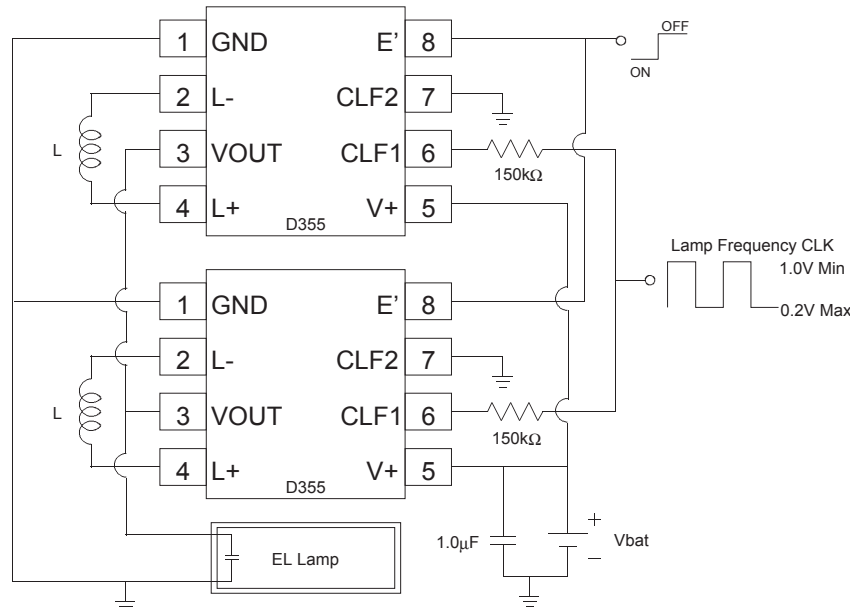
X. EL Lamp Brightness Regulation

Regulating the DC supply input voltage to the D355 will result in a constant brightness level from the EL lamp, regardless of battery voltage. In this example, a Micrel voltage regulator is used.



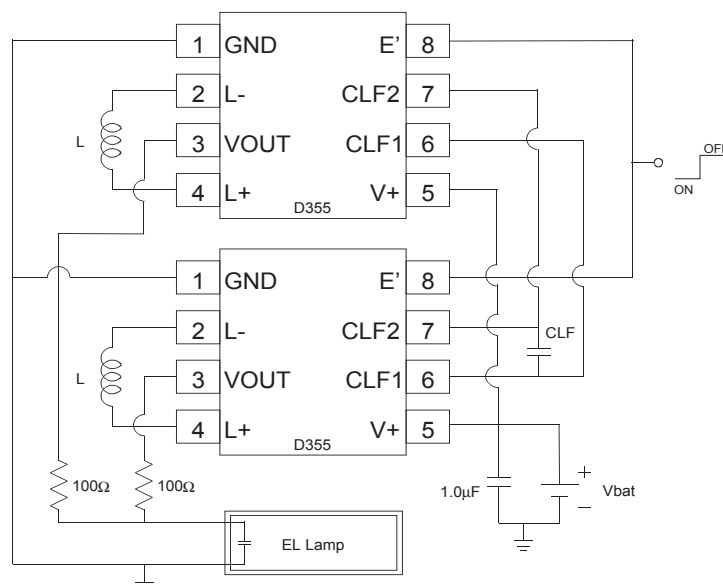
XI. High EL Brightness with Parallel D355 Drivers (Option 1)

Two or more D355 EL drivers may be operated in parallel to increase the brightness of the EL lamp by 50-100%. In this circuit, an external clock signal with a 50% duty cycle is needed to synchronously drive both D355 ICs. The clock signal voltage should not exceed $V+$.



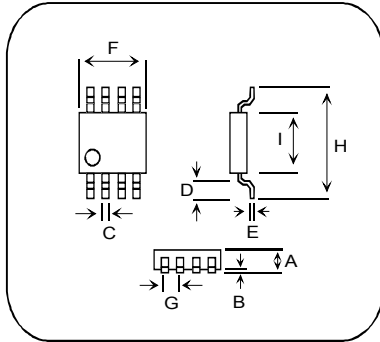
XII. High EL Brightness with Parallel D355 Drivers (Option 2)

Two or more D355 EL drivers may be operated in parallel to increase the brightness of the EL lamp by 50-100%. In this circuit, two D355 ICs are operating synchronously using their internal oscillators. The lamp frequency is controlled by a shared CLF capacitor.

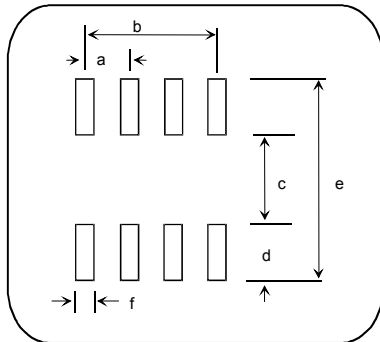


Ordering Information:

The D355B IC is available as bare die in probed wafer form or in die tray, and in standard MSOP-8 plastic package per tape and reel. A Durel D355B Designer's Kit (1DDD355BB-K01) provides a vehicle for evaluating and identifying the optimum component values for any particular application using D355B. Durel engineers also provide full support to customers, including specialized circuit optimization and application retrofits.



RECOMMENDED PAD LAYOUT

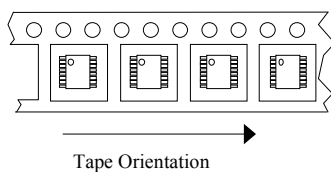


Description	MSOP-8					
	Min.		Typical		Max.	
	mm.	in.	mm.	in.	mm.	in.
A	0.94	0.037	1.02	0.040	1.09	0.043
B	0.05	0.002	0.10	0.004	0.15	0.006
C	0.20	0.008	0.33	0.013	0.46	0.018
D	0.41	0.016	0.53	0.021	0.65	0.026
E	0.13	0.005	0.18	0.007	0.23	0.009
F	2.84	0.112	3.00	0.118	3.15	0.124
G	0.43	0.017	0.65	0.026	0.83	0.033
H	4.70	0.185	4.90	0.193	5.11	0.201
I	2.84	0.112	3.00	0.118	3.25	0.128

MSOPs are marked with part number (355B) and 3-digit wafer lot code. Bottom of marking is on the Pin 1 side.

	MSOP-8 PAD LAYOUT					
	Min.		Typical		Max.	
	mm.	in.	mm.	in.	mm.	in.
a	0.60	0.0236	0.6	0.0256	0.70	0.0276
b	1.90	0.0748	1.9	0.0768	2.00	0.0788
c	3.3	0.130			3.45	0.136
d	0.89	0.035	0.9	0.038	1.05	0.041
e	5.26	0.207			5.41	0.213
f	0.41	0.016	0.4	0.018	0.51	0.020

MSOPs in Tape and Reel: 1DDD355BB-M02



Embossed tape on 360 mm diameter reel per EIA-481-2. 2500 units per reel. Quantity marked on reel label.

ISO 9001 Certified

DUREL Corporation

2225 W. Chandler Blvd.

Chandler, AZ 85224-6155

Tel: (480) 917-6000

FAX: (480) 917-6049

Website: <http://www.durel.com>

The DUREL name and logo are registered trademarks of DUREL CORPORATION.

This information is not intended to and does not create any warranties, express or implied, including any warranty of merchantability or fitness for a particular purpose. The relative merits of materials for a specific application should be determined by your evaluation.

The EL driver circuits herein are covered by one or more of the following U.S. patents: #5,313,141, #5,347,198, #6,043,610. Corresponding foreign patents are issued and pending.