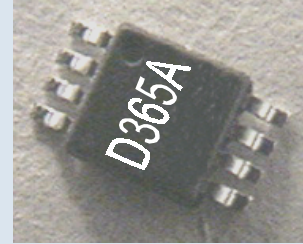


## General Description

The Durel® D365 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. The D365 IC and three components make a complete EL lamp driving circuit. Equipped with a patented discharge circuitry, the D365 device offers low-noise performance in applications that are sensitive to audible and electrical noise.

## Data Sheet D365A Electroluminescent Lamp Driver IC



**MSOP-8**

## Features

- Integrated Low Noise Circuitry
- High AC Voltage Output
- Circuit Topology Shields EMI
- Drives up to 20 in<sup>2</sup> EL Lamps
- Small Package Size

## Applications

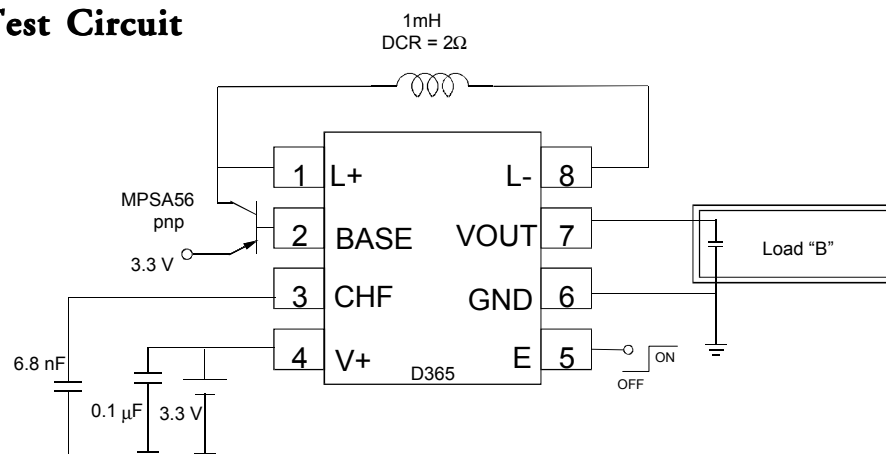
- Cellular Phones and Handsets
- Data Organizers/PDAs
- LCD Backlighting

## Lamp Driver Specifications

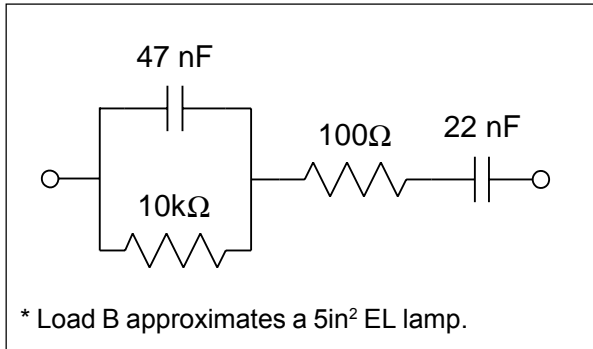
(Using Standard Test Circuit at Ta=25°C, unless otherwise specified)

Parameter	Symbol	Minimum	Typical	Maximum	Unit	Conditions
Standby Current			40	1000	nA	E = GND
Supply Current	I		44	60	mA	E = V+
Enable Current						
ON			15	50	μA	E = V+
OFF			20	20	nA	E = GND
Output Voltage	Vout	160	175	280	Vpp	E = V+
Lamp Frequency	LF	236	267	330	Hz	E = V+
Inductor Oscillator frequency	HF	17	19.2	24	kHz	E = V+

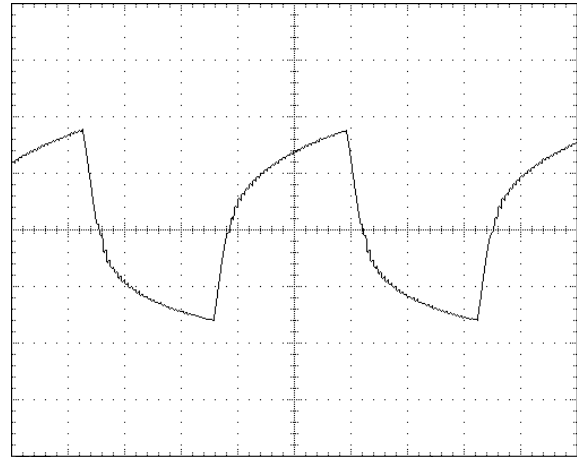
## Standard Test Circuit



## Load B\*



## Typical Output Waveform

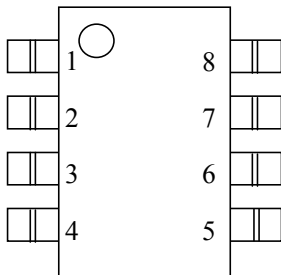


## Absolute Maximum Ratings

Parameter	Symbol	Minimum	Maximum	Unit	Comments
Supply Voltage					
Operating Range	V+	2.5	6.5	V	E=V+
Withstand Range		-0.5	7.0		E=GND
Enable Voltage	E	-0.5	(V+) +0.5	V	
Lamp Output	V <sub>peak</sub>		140	V	Positive peak voltage
Power Dissipation	P <sub>d</sub>		250	mW	
Operating Temperature	T <sub>a</sub>	-20	85	°C	
Storage Temperature	T <sub>s</sub>	-40	150	°C	

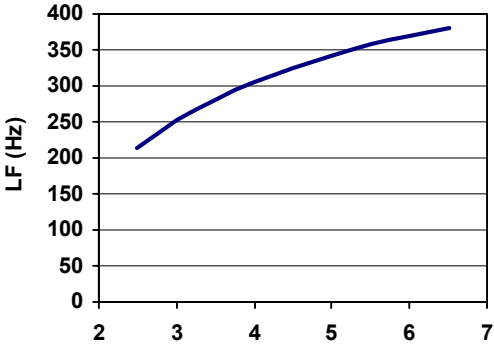
Note: The above are stress ratings only. Functional operation of the device at these ratings or any other above those indicated in the specification is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

## Physical Data

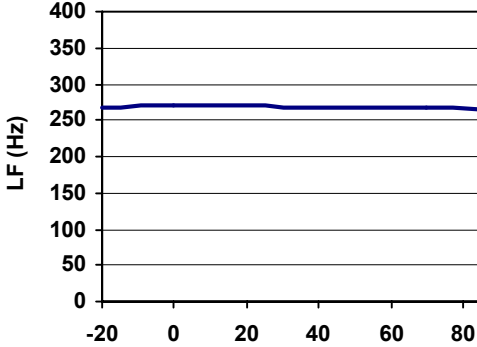


Pin #	Name	Function
1	L+	Positive input to inductor
2	Base	PNP transistor base connection
3	CHF	High frequency oscillator capacitor/clock input
4	V+	DC power supply input
5	E	System enable; HI=On
6	GND	System ground connection
7	V <sub>out</sub>	AC output to lamp
8	L-	Negative input to inductor

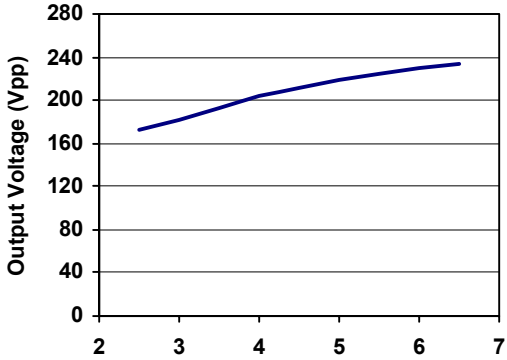
# Typical Performance Characteristics Using Standard Test Circuit



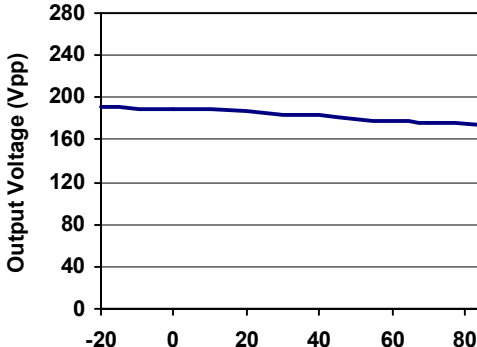
Output Frequency vs. DC Supply Voltage



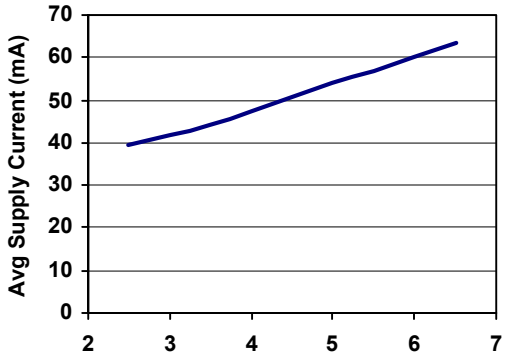
Output Frequency vs. Ambient Temperature



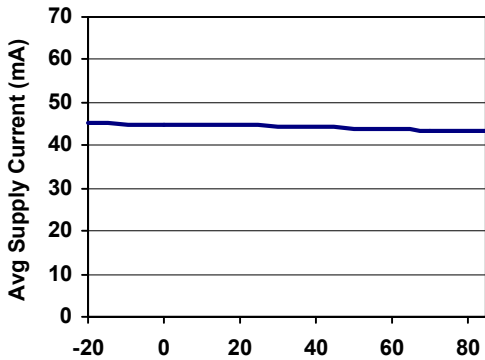
Output Voltage vs. DC Supply Voltage



Output Voltage vs. Ambient Temperature

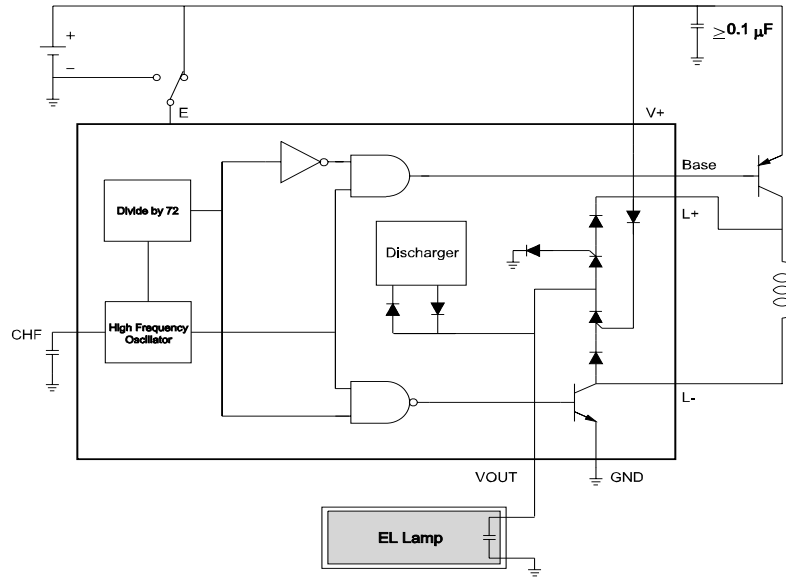


Supply Current vs. DC Supply Voltage



Supply Current vs. Ambient Temperature

## Block Diagram of the Inverter 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. Durel developed its patented 3-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 D365 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) charging cycle the voltage on the lamp is increased. After 32 HF charging cycles, the lamp voltage is discharged to ground in the period of 4 HF cycles. Then, the polarity of the inductive charging is reversed, and the charging and discharging cycles are repeated. By this means, a low frequency alternating positive and negative voltage is developed at the single output lead of the device to one of the electrodes of the EL lamp. Commonly connected to ground, the other lamp electrode 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 the HF and LF duty cycles. These signals are combined and buffered to drive 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. 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 of EL driver systems is to save space and cost, required off-chip components were kept to a minimum.

Durel provides a D365 Designer's Kit, which includes a PC board intended to aid you in developing an EL lamp driver configuration using the D365 that meets your requirements. A section on designing with the D365 is included in this datasheet to serve as a guide to help you select the appropriate external components to complete your D365 EL driver system.

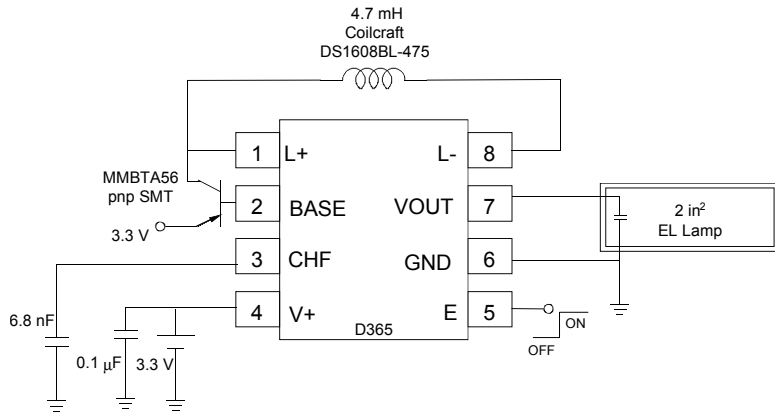
Typical D365 configurations for driving EL lamps in various applications are shown on the following page. The expected system outputs, such as lamp luminance, lamp output frequency and voltage, and average supply current draw, for the various circuit configurations are also shown with each respective figure.

# Typical D365A EL Driver Configurations

## 3.3V Handset LCD

### Typical Output

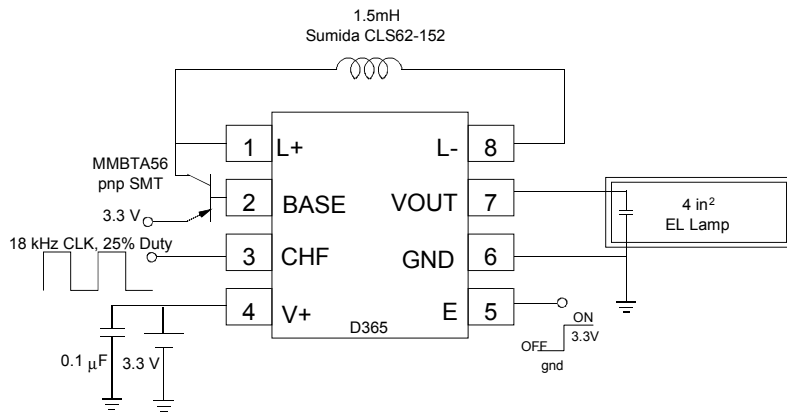
Luminance = 6.1 fL (21 Cd/m<sup>2</sup>)  
 Lamp Frequency = 278Hz  
 Supply Current = 13mA  
 Vout = 190 Vpp  
 Load = 2in<sup>2</sup> Durel® 3 Green EL



## 3.3V Handset LCD and Keypad

### Typical Output

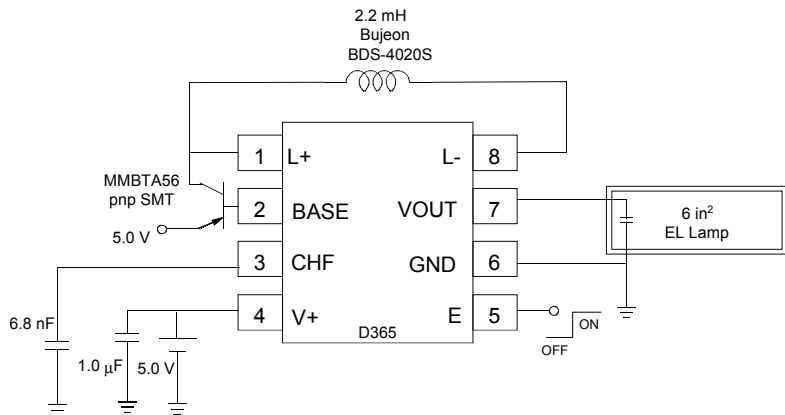
Luminance = 6.2 fL (21.2 Cd/m<sup>2</sup>)  
 Lamp Frequency = 246 Hz  
 Supply Current = 34 mA  
 Vout = 204 Vpp  
 Load = 4in<sup>2</sup> Durel® 3 Green EL



## 5.0V LCD Backlight

### Typical Output

Luminance = 7.1 fL (24.3 Cd/m<sup>2</sup>)  
 Lamp Frequency = 353 Hz  
 Supply Current = 34 mA  
 Vout = 190 Vpp  
 Load = 6in<sup>2</sup> Durel® 3 Green EL



# I. Lamp Frequency Capacitor (CHF) Selection

Selecting the appropriate value of CHF capacitor will specify the inductor switching frequency (HF) and the lamp frequency (LF) of the D365 EL driver. A divider circuit in the internal oscillator circuitry of the D365A divides the inductor switching frequency by 72 to get the lamp frequency ( $LF = HF/72$ ). Lamp frequencies of 200 – 500 Hz are typically used for longer EL lamp life. Figure 1 graphically represents the effect of CHF capacitor value on the lamp frequency oscillator at  $V_+ = 3.3V$ . In this example at  $V_+ = 3.3V$ ,  $LF = 2000 \text{ nF-Hz}/CHF$ .

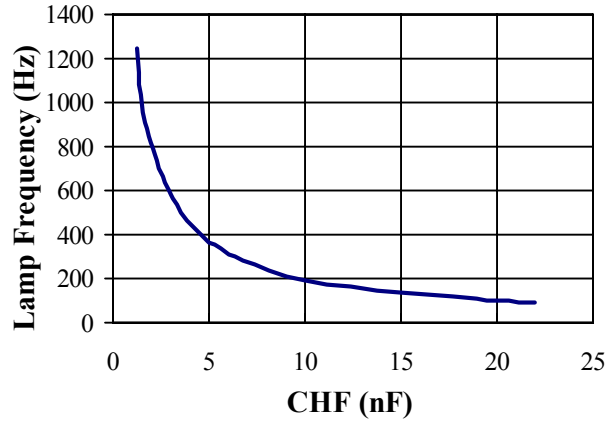


Figure 1: Typical Lamp Frequency vs. CLF Capacitor

Alternatively, a high frequency clock input may be connected to the CHF pin of the D365A to specify the output driver frequency. The internal oscillator circuitry in the D365A divides the input clock frequency by 72 to get the output frequency. Thus, for example, to get a 250Hz lamp frequency from a D365A, the input clock signal must be 18kHz.

The selection of the capacitor value can also affect the brightness of the EL lamp because of its control of LF and HF. Although input voltage and lamp size can change EL lamp frequency as well, LF mainly depends on the CHF value selected or the frequency of the input clock signal to CHF. Figure 2 shows typical brightness of a D365 circuit with respect to lamp frequency on different EL lamp sizes. In this example, the supply voltage and inductor values were kept constant while only varying frequency.

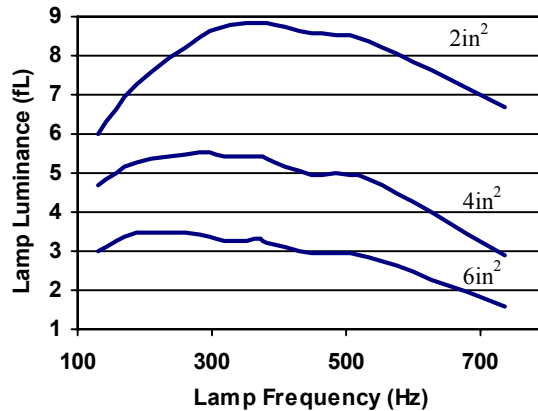


Figure 2: Luminance vs. Lamp Frequency  
( $V_+ = 3.3V$ , Durel 3 Green EL Lamp)

## II. Inductor (L) Selection

The external inductor (L) selection for a D365A 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 and 4 show typical brightness and current draw of a D365A circuit with different inductor values, lamp sizes, and supply voltages while keeping HF and 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.

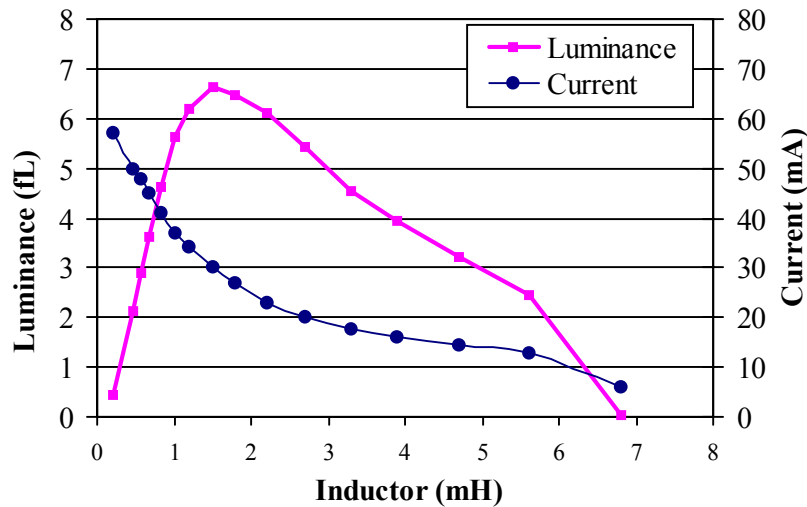


Figure 3: Brightness and current vs. inductor value.  
(Conditions:  $V_+ = 3.3V$ ,  $2 \text{ in}^2$  EL Lamp)

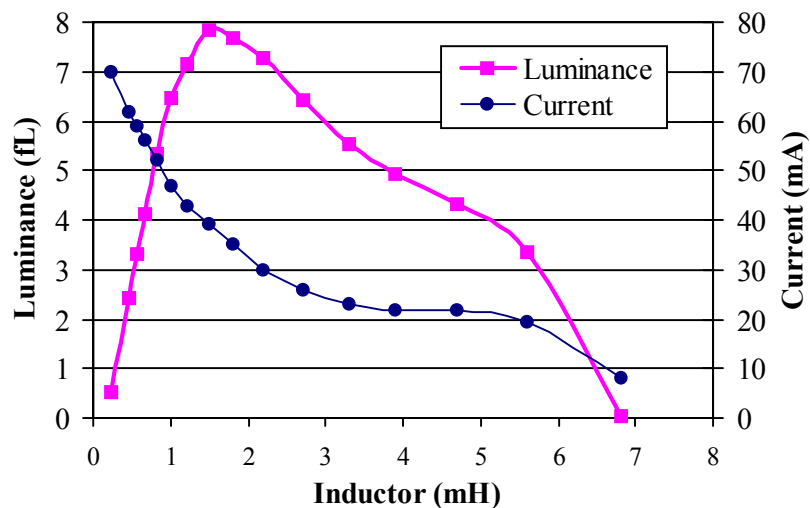


Figure 4: Brightness and current vs. inductor value.  
(Conditions:  $V_+ = 5.0V$ ,  $4 \text{ in}^2$  EL Lamp)

### III. PNP Transistor Selection

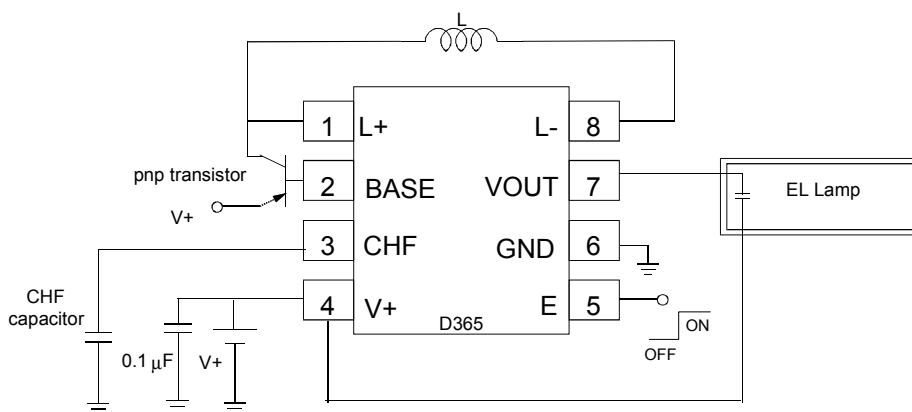
The D365A requires an external pnp transistor to complete the high voltage 3P circuitry. Ideally, this transistor should have a minimum collector-emitter breakdown voltage higher than the required peak voltage output of the EL driver. It should also have a high DC current gain (>50) and fast switching characteristics.

Durel typically recommends the MMBTA56 surface mount amplifier transistor for general purpose because it is a standard device part number supplied by several large manufacturers. The MMBTA56 has a breakdown voltage that is normally above 100V although it has a minimum rating of 80V only. The counterpart internal npn transistor in the D365 has a minimum 100V breakdown, with typical breakdown value above 120V. Under most nominal design considerations using the D365, the MMBTA56 is an appropriate selection. Nevertheless, caution is advised to limit designs well within the maximum output voltage ratings of all devices to avoid failure of the IC or any required external components.

## D365 Design Ideas

### I. Alternate Lamp Connection

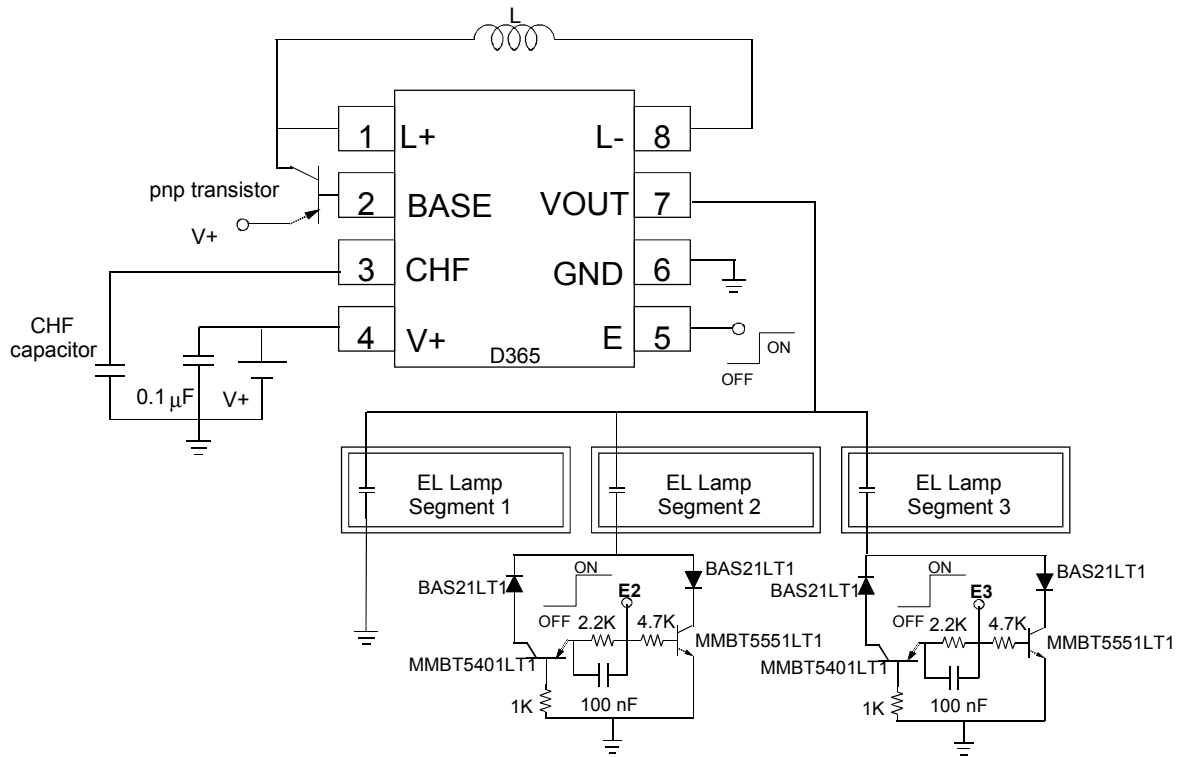
In some applications it may be more convenient to connect the EL lamp to the supply voltage rather than ground. This connection (shown below) provides design flexibility and does not degrade EL driver performance. This configuration may also be used to minimize any positive DC bias on the lamp.





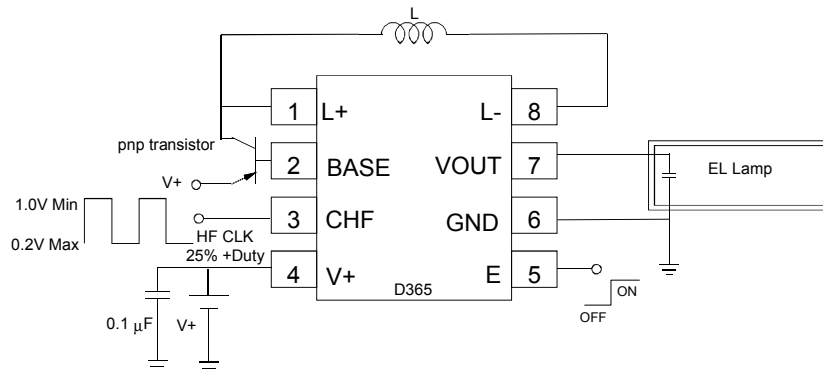
## II. Driving Multi-segment Lamps

The D365 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 D365 is enabled.



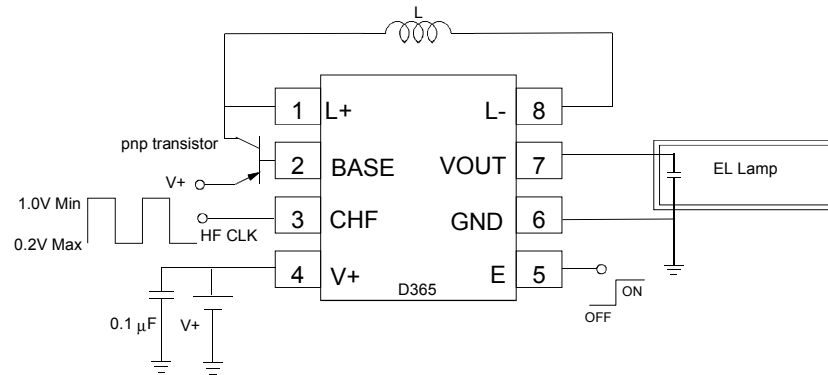
## III. Lamp Frequency Control with an External Clock Signal

An external clock signal may be used to control the inductor oscillating frequency (HF) and, consequently, the EL lamp frequency (LF) of the D365. HF and LF can be varied to synchronize the EL driver with other elements in the application. An internal divider network in the IC creates a ratio of  $HF/LF=72$ .



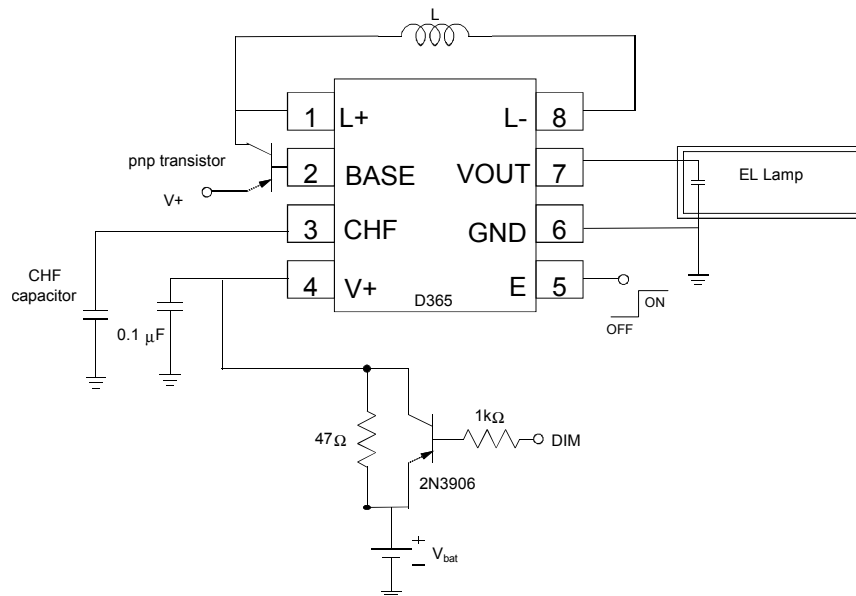
## IV. Controlling EL Brightness Through Clock Pulse Width Modulation

Pulse-width modulation of an external clock signal that controls the inductor oscillating frequency may also be used to regulate the brightness of an EL lamp. In this circuit, when the positive duty cycle of the external clock is at 25%, the lamp is at full brightness. Incremental dimming occurs as the positive duty cycle is increased to as high as 75%. This scheme may also be used inversely to regulate lamp brightness over the life of the battery or to compensate for lamp aging. In these cases, positive duty cycle may be incrementally increased as part of a feedback control in the application. (Note: Operation at duty cycles higher than 75% or lower than 25% is not recommended.)



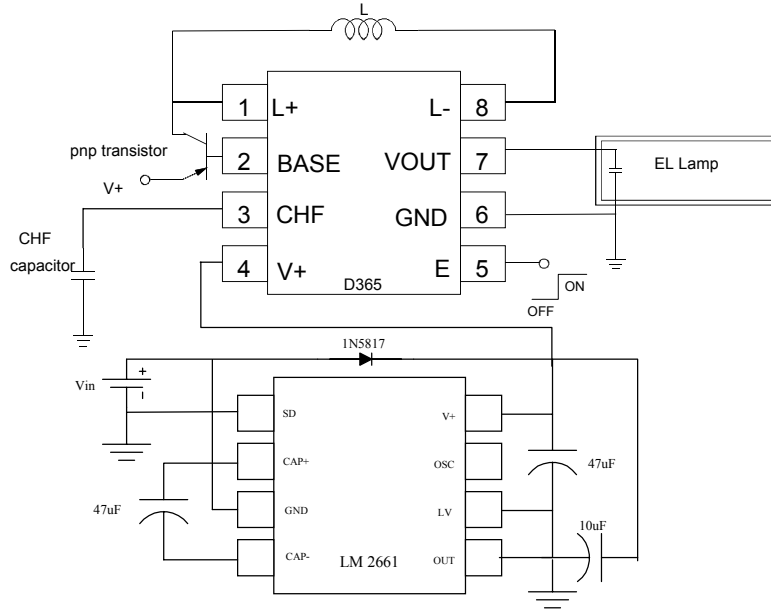
## V. Two-Level Dimming Control

Two level dimming may be achieved with the circuit 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.



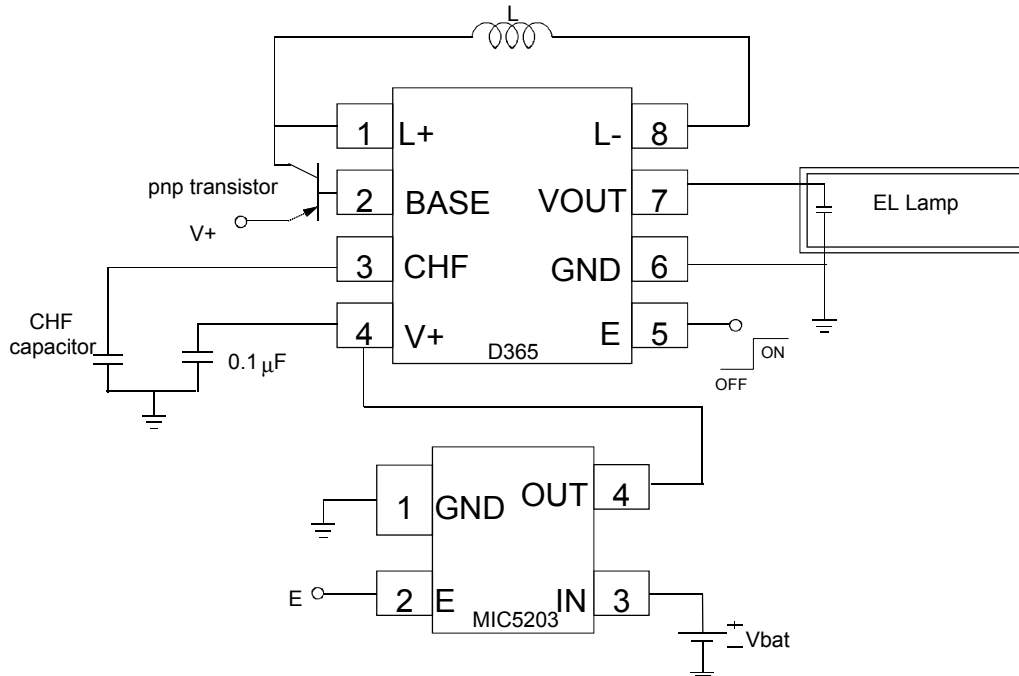
## VI. High EL Brightness Through Supply Voltage Doubling

An external voltage boost circuit may be used to increase the voltage supplied to the D365. In the following circuit, the National Semiconductor LM2661 is used as a positive voltage doubler.



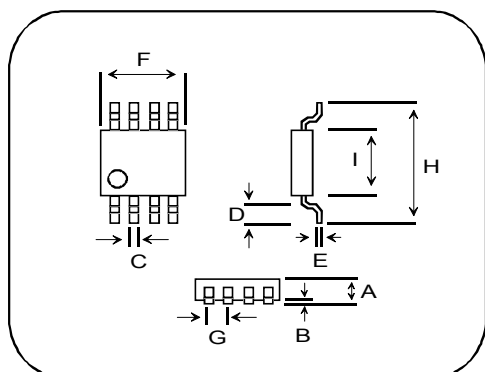
## VII. EL Lamp Brightness Regulation

Regulating the DC supply input voltage to the D365 will result in a constant brightness level from the EL lamp, regardless of battery voltage. In this example, a Micrel voltage regulator is used.



## Ordering Information:

The D365A IC is available as bare die in probed wafer form or in die tray, and in standard MSOP-8 plastic package per tube or per tape and reel. A Durel D365A Designer's Kit (1DDD365AA-K01) provides a vehicle for evaluating and identifying the optimum component values for any particular application using D365A. Durel engineers also provide full support to customers, including specialized circuit optimization and application retrofits.

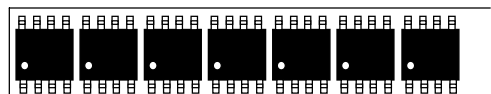


	<b>MSOP-8</b>					
	Min.		Typical		Max.	
	mm.	in.	mm.	in.	mm.	in.
A	0.94	0.037	1.02	0.040	1.09	0.043
B	0.05	0.002	0.10	0.004	0.15	0.006
C	0.20	0.008	0.33	0.013	0.46	0.018
D	0.41	0.016	0.53	0.021	0.65	0.026
E	0.13	0.005	0.18	0.007	0.23	0.009
F	2.84	0.112	3.00	0.118	3.15	0.124
G	0.43	0.017	0.65	0.026	0.83	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 (365A) and 3-digit wafer lot code. Bottom of marking is on the Pin 1 side.

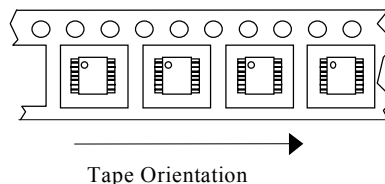
### MSOPs in Tubes: 1DDD365AA-M01

Tube-length = 320 mm (12.6 in). 100 units per tube.



### MSOPs in Tape & Reel: 1DDD365AA-M02

Embossed tape on 360 mm diameter reel per E1A-481-2. 2500 units per reel. Quantity marked on reel label.



## ISO 9001 Certified

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

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*The EL driver circuits herein are covered by one or more of the following U.S. patents: #5,313,141; #5,347,198; #5,789,870; #5,780,975; #6,043,610. Corresponding foreign patents are issued and pending.*