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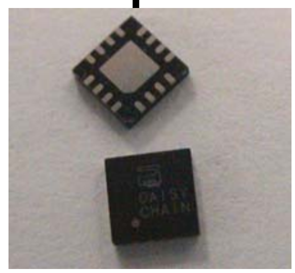
Data Sheet

D307A Electroluminescent Lamp Driver IC

Features

- 9.0 – 16.0 V_{DC} Battery Operation
- High AC Voltage Output Up To 400Vpp
- Flexible Wave-shaping Capability
- QFN-16 Square Body with Heat Slug
- Over Voltage Protection Circuitry
- PWM Signal Control for Lamp Brightness on Low or High Frequency Logic



QFN–16 with Heat Slug

Applications

- Automotive Interior Lighting
- Automotive Cluster Lighting

Rogers DUREL® D307A IC is a high-power IC inverter intended for driving EL lamps as large as 35 in^2 (225.8 cm^2). The D307A offers a variety of functionality, including: flexible wave shaping capability for minimizing audible noise, precision control of frequencies, accurate lamp luminance variability using a PWM on the CHF and/ or CLF inputs, and stable power dissipation.

Lamp Driver Specifications for Circuit A:

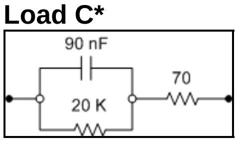
(Using Standard Test Circuit at Ta=25^{0}C unless otherwise specified)

Parameter	Symbol	Minimum	Typical*	Maximum	Units	Conditions
DC Standby Current	$I_{(V+)}$	0	450	900	uA	E = GND
DC Supply Current	$I_{(Vbat + Vcc)}$	240	275	310	mA	E = 5.0 Vdc+
DC Enable Current	I_{ena}	15	18	21	uA	E = 5.0 Vdc+
Output Voltage	V_{out}	330	375	420	Vpp	E = 5.0 Vdc+
Lamp Frequency	LF	350	365	380	Hz	CLF = 47 nF

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

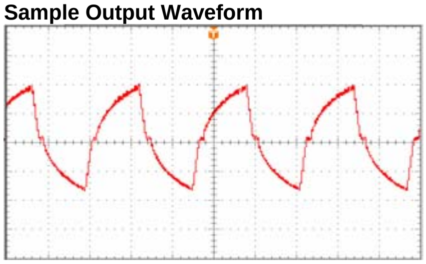
Sample Application Circuit A

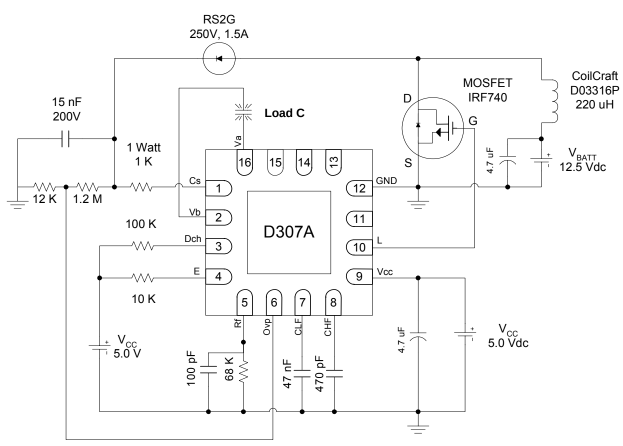
Load C*



*Load C approximates a 30 in^2 (193.5 cm^2) EL lamp.

Sample Output Waveform





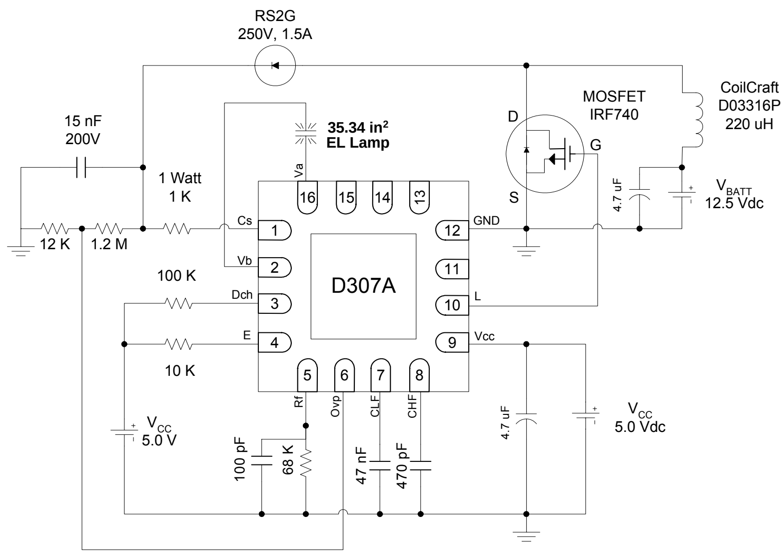
Lamp Driver Specifications for Circuit B:

(Using Standard Test Circuit at Ta=25^{0}C unless otherwise specified)

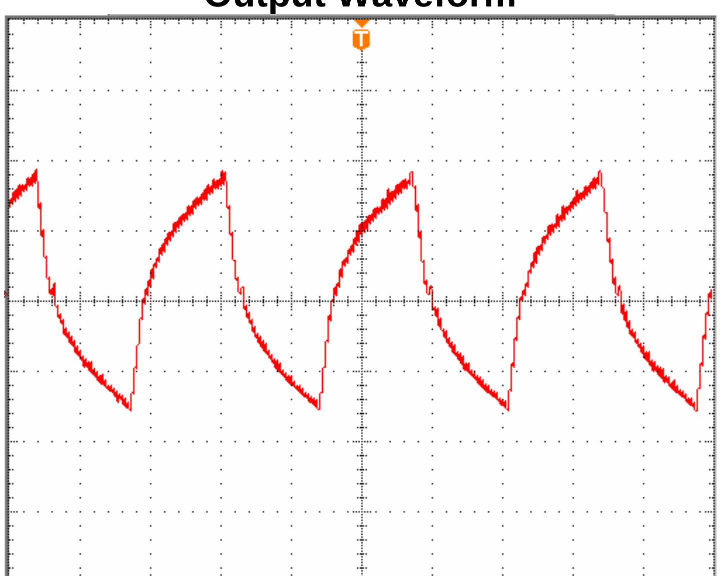
Parameter	Symbol	Minimum	Typical*	Maximum	Units	Conditions
DC Standby Current	$I_{(V+)}$	0	450	900	uA	E = GND
DC Supply Current	$I_{(Vbat + Vcc)}$	250	280	305	mA	E = 5.0 Vdc+
DC Enable Current	I_{ena}	15	18	21	uA	E = 5.0 Vdc+
Output Voltage	V_{out}	320	355	400	Vpp	E = 5.0 Vdc+
Lamp Frequency	LF	350	365	380	Hz	CLF = 47.0 nF

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

Sample Application Circuit B



Output Waveform



Load: 35.34 in^2 (228.0 cm^2) DUREL® Automotive EL

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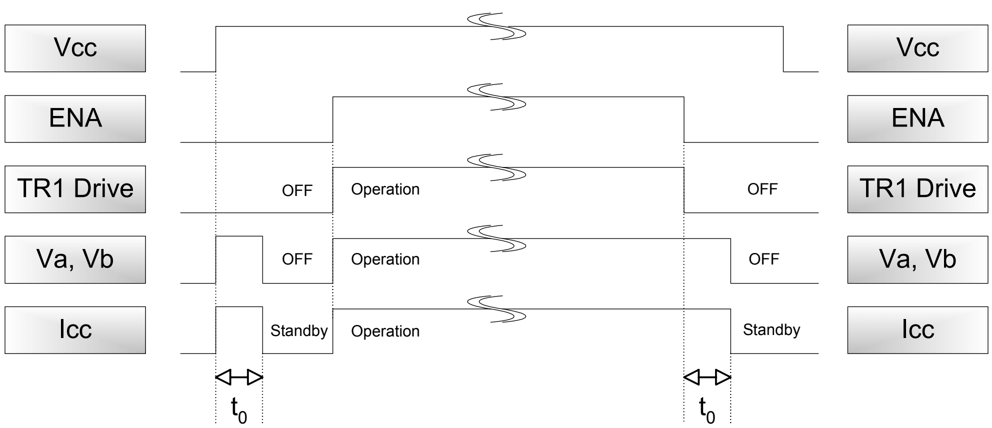
Absolute Maximum Ratings

Parameter	Symbol	Minimum	Maximum	Unit	Comments
DC Supply Voltage Operating Range	Vbat	9	16	V	E = Vcc E = GND
DC Logic Drive Voltage Operating Range Withstand Range	Vcc	4.5 -0.5	5.5 7.0	V	E = Vcc E = GND
DC Enable Voltage	E	-0.5	V_{cc} + 0.5	V	
Vout	Va-Vb	360	440	Vpp	E = Vcc
Operating Temperature	T_a T_j	-40	85 125	°C °C	Ambient Junction
Average Thermal Resistance	Θ_{ja} Θ_{jc}		40 5.3	°C/W °C/W	Junction to Ambient Junction to case
Storage Temperature	T_s	-55	150	°C	

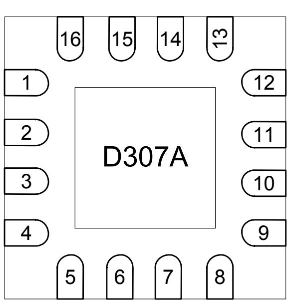
*At a given ambient temperature, the maximum power rating can be calculated with the following equation: $T_j = P (\Theta_{ja}) + T_a$.
Note: The above are stress ratings only. Functional operation of the device at these ratings or any other above those indicated in the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

Power ON and OFF Sequence of D307A IC



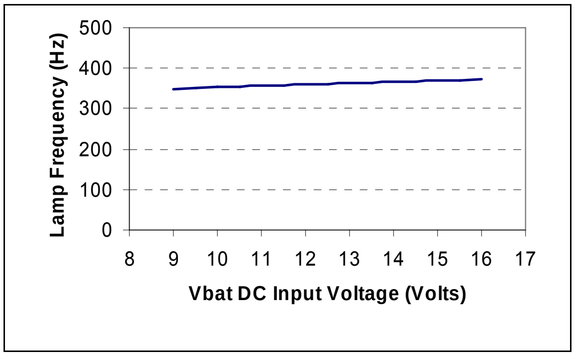
t_0 = 2/ LF   LF (Lamp Frequency)

Physical Data:

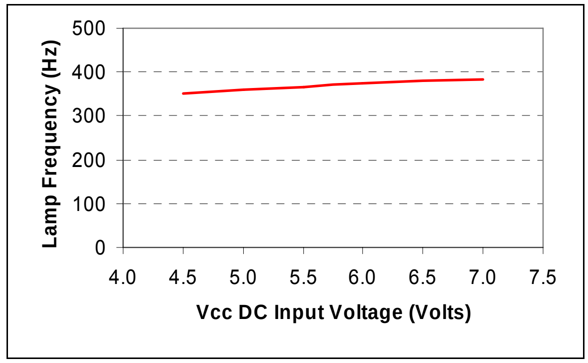


PIN #	NAME	FUNCTION
1	Cs	High voltage storage capacitor to input
2	Vb	AC voltage output to EL lamp
3	Dch	Resistor input for discharge control
4	E	System enable; Wave-shaping resistor control
5	Rf	Resistor input for frequency control
6	Ovp	Voltage divider input to overprotection circuitry
7	CLF	Capacitor input to low frequency oscillator
8	CHF	Capacitor input to high frequency oscillator
9	Vcc	DC Logic drive voltage
10	L	Inductor input
11	NC	No connect
12	GND	Power ground
13	NC	No connect
14	NC	No connect
15	NC	No connect
16	Va	AC voltage output to EL lamp

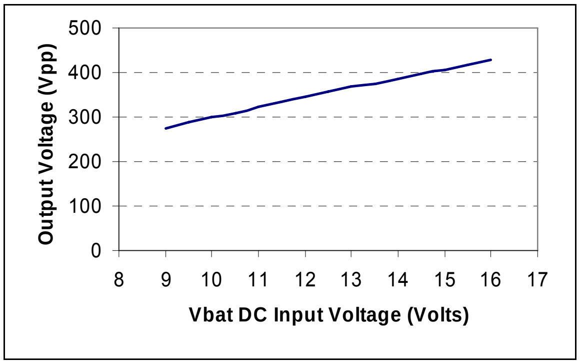
Typical Performance Characteristics Using Standard Test Circuit



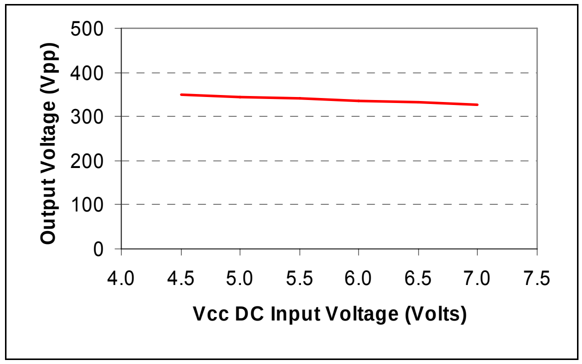
Output Frequency vs. Vbat DC Voltage



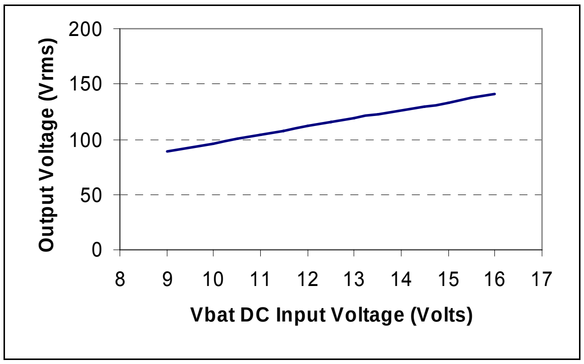
Output Frequency vs. Vcc DC Supply Voltage



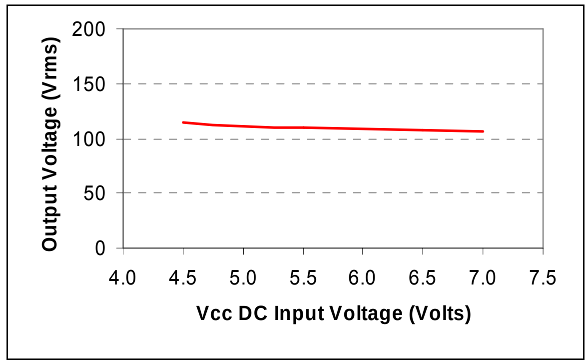
Output Voltage (Vpp) vs. Vbat DC Voltage



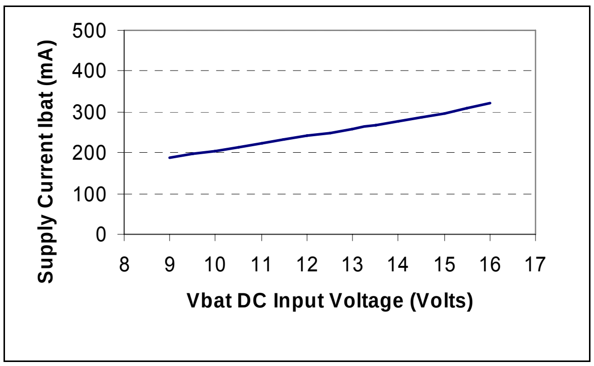
Output Voltage (Vpp) vs. Vcc DC Supply Voltage



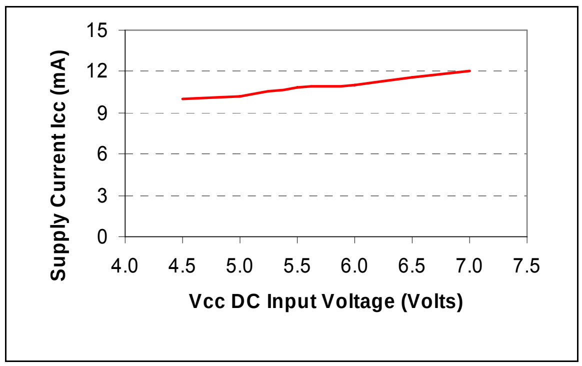
Output Voltage (Vrms) vs. Vbat DC Voltage



Output Voltage (Vrms) vs. Vcc DC Supply Voltage

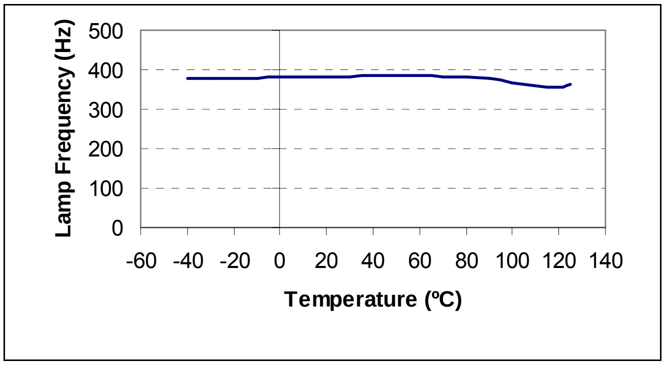


Supply Current (Ibat) vs. Vbat DC Voltage

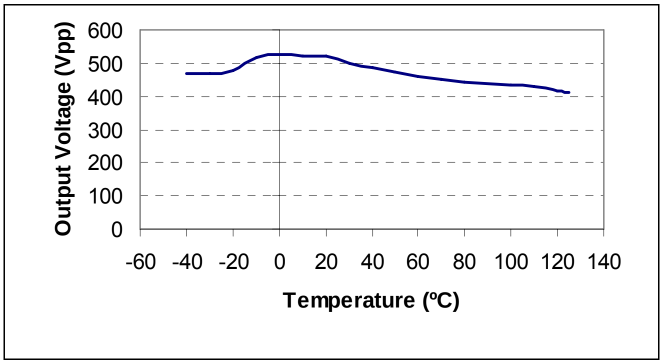


Supply Current (Icc) vs. Vcc DC Supply Voltage

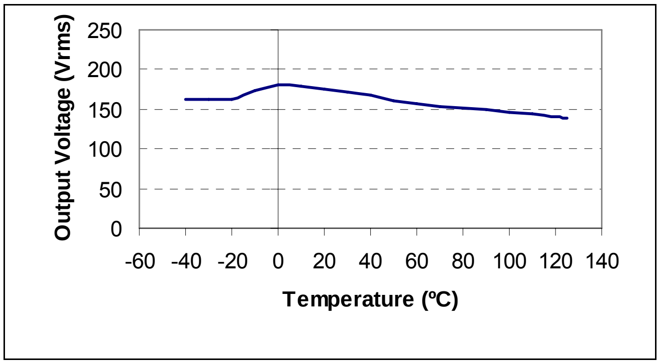
Typical Performance Characteristics Using Standard Test Circuit (Cont)



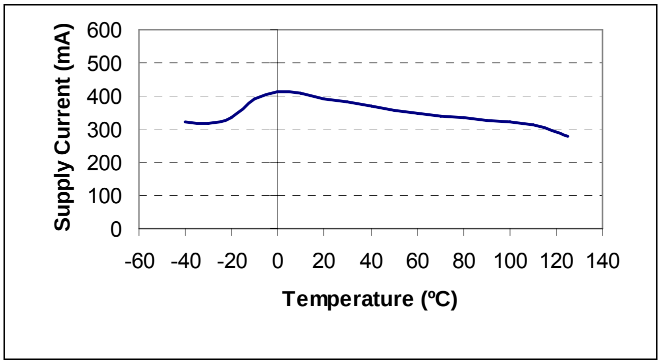
Output Frequency vs. Temperature



Output Voltage (Vpp) vs. Temperature

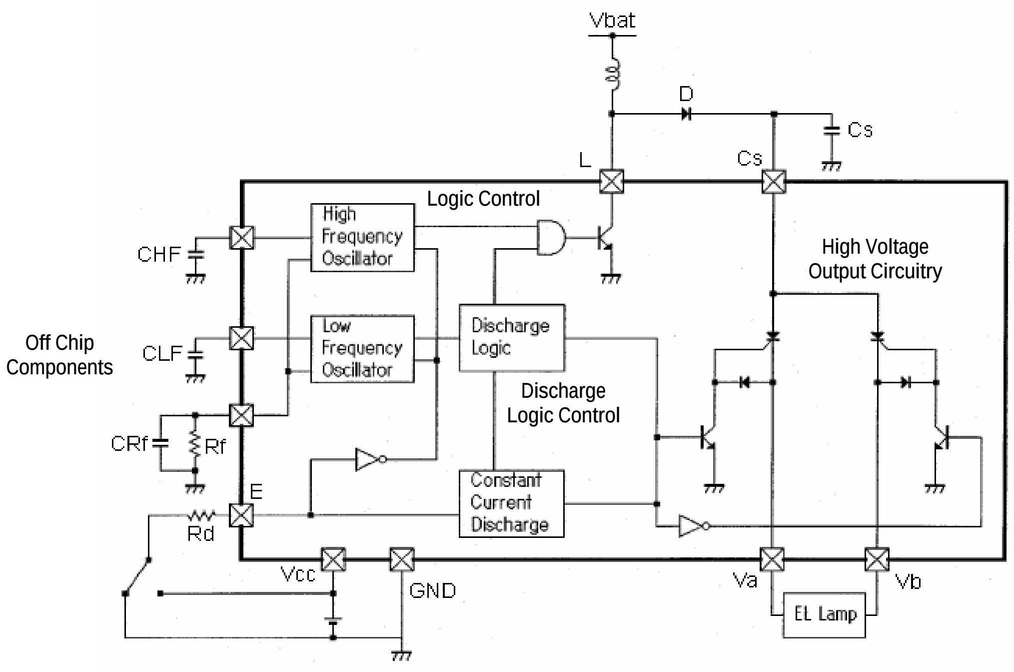


Output Voltage (Vrms) vs. Temperature



Supply Current vs. 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. 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.

The D307A IC inverter drives the EL lamp by using a switching transistor to repeatedly charge an external inductor and discharge it to the high voltage capacitor Cs. The discharging causes the voltage at Cs to continually increase. When the voltage at Cs reaches a nominal value, the switching transistor is turned off. The internal circuitry uses the H-bridge technology, using both electrodes to drive the EL lamp. One of the outputs, Va or Vb, is used to discharge Cs into the EL lamp during the first half of the low frequency (LF) cycle. By alternating the state of the H-bridge, the other output is used to charge the EL lamp during the second half of the LF cycle. The alternating states make it possible to achieve 400V peak-to-peak across the EL lamp.

The EL driving system is divided into several parts: on-chip logic control, on-chip high voltage output circuitry, on-chip discharge logic circuitry, and off-chip components. The on-chip logic controls the lamp operating frequency (LF) and the inductor switching frequency (HF). These signals are used to drive the high voltage output circuitry (H-bridge) by delivering the power from the inductor to the lamp. The integrated discharge logic circuitry uses a patented wave-shaping technique for reducing audible noise from an EL lamp. Changing the Rd value changes the slope of the linear discharge as well as the shape of the waveform. The off-chip component selection provides a degree of flexibility to accommodate various lamp sizes, system voltages, and brightness levels.

Designing with D307A IC

There are many variables which can be optimized to achieve the desired performance for specific applications. The luminance of the EL lamp is a function of the output voltage applied to the lamp by the IC, the frequency at which the voltage is applied, the lamp material properties, and the lamp size. Rogers offers the following component selection aids to help the designer select the optimum circuit configuration.

I. Lamp Frequency Capacitor (CLF) Selection

Selecting the appropriate value of capacitor (CLF) for the low frequency oscillator will set the output frequency of the D307A IC. Figure 1 graphically represents the effect of the CLF capacitor value on the oscillator frequency at Vbat = 12.5 V, Vcc = 5.0 V.

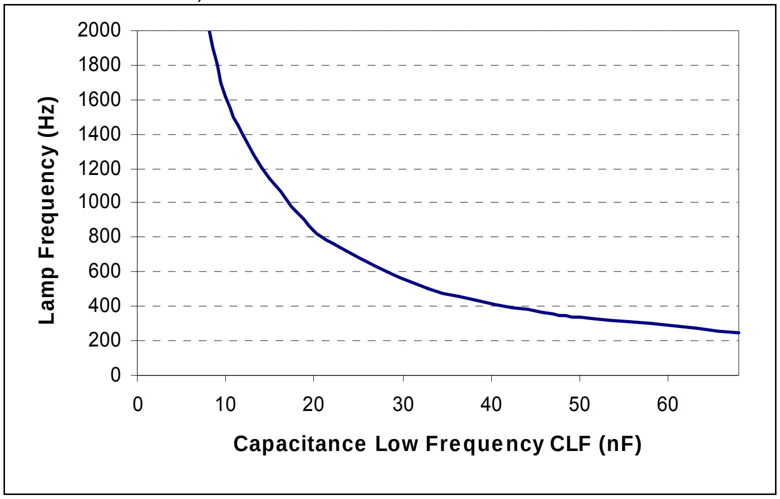


Figure 1: Graph of Lamp Frequency vs. CLF Capacitance

II. Inductor Switching Frequency (CHF) Selection

Selecting the appropriate value of capacitor (CHF) for the high frequency oscillator will set the inductor switching frequency of the D307A integrated circuit. Figure 2 graphically represents the effect of the CHF capacitor value on the oscillator frequency at Vbat = 12.5 V, Vcc = 5.0 V.

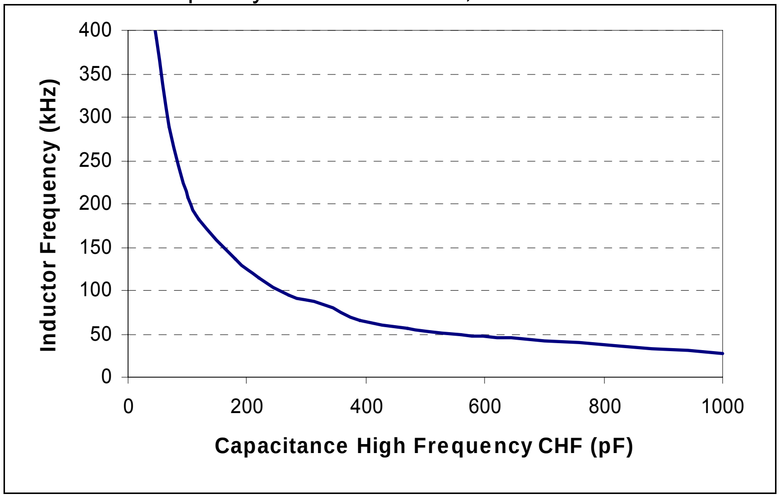


Figure 2: Graph of Inductor Frequency vs. CHF Capacitance

III. Inductor (L) Selection

The inductor value has a large impact on the output brightness and current consumption of the driver. Figure 3 shows typical brightness and current draw of a D307A IC with different inductor values. Please note that the DC resistance (DCR) and current rating of inductors with the same 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. This curve is intended to give the designer a relative scale from which to optimize specific applications. Absolute measurements may vary depending upon the type and brand of other external components selected.

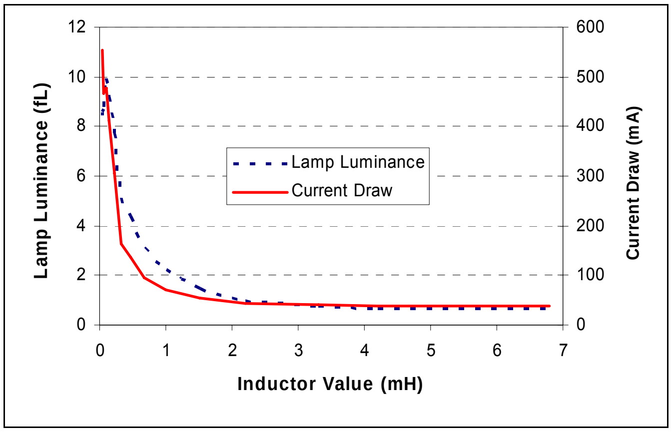


Figure 3: Luminance and Current vs. Inductor Value
Conditions: Vcc = 5.0Vdc, Vbat = 12.5Vdc, RBC White 35in^2 EL Lamp

IV. Wave-Shape Selection

The D307A EL driver IC uses a patented wave-shaping technique for reducing audible noise from an EL lamp. The slope of the discharge section of the output waveform may be adjusted by selecting a proper value for the wave-shape discharge resistor (Rd) in series with the E pin input. The optimal discharge level for an application depends on the lamp size, lamp brightness, and application conditions. To ensure that the D307A IC is configured optimally, various discharge levels should be evaluated. In many cases, lower discharge levels may result in lower audible noise from the EL lamp. The recommended typical value for Rd is 10 kΩ.

V. Storage Capacitor (Cs) Selection

The Cs capacitor is used to store the energy transferred from the inductor before discharging the energy to the EL lamp. Cs values can range from 5nF to 45nF for Load C as seen on page 1 of this datasheet, and must have minimum 200V rating. In general, the Cs value is recommended to range from 1/3 to 1/10 the load capacitance. The typical Cs capacitor recommendation is 15nF with 200V rating.

VI. Fast Recovery Diode

Energy stored by the coil is eventually forced through the external diode to power the switched H-bridge network. A fast recovery diode, such as RS2G (Rated: 250V, 1.5 Amp), is recommended for this function for optimum operation.

VII. External NMOS

The inductor is switched by an external NMOS transistor. A power MOSFET, such as IRF740 (Rated: $R_{DSS} \geq 250V$, $I_D \geq 1.5A$, $R_{DS(ON)} \leq 1\Omega$), is recommended for this function for optimum operation.

VIII. Rf and CRf Selection

The combination of Rf and the timing capacitors, CLF and CHF, determines the time constants for the low frequency oscillator and the high frequency oscillator, respectively. To simplify the tuning of the oscillator frequencies to the desired frequency range, a standard value is recommended for Rref = 68 kΩ.

The Cref capacitor is used as a stabilizing capacitor to filter noise on the Rf line. A small 100pF capacitor is typical and sufficient value for Cref.

IX. Printed Circuit Board Layout

The high frequency operation and very high voltage output of the D307A IC makes printed circuit board layout important for minimizing electrical noise. There are several basic design rules that will aid in the reduction of EMI/RFI and cross coupling in an electronic system. The following rules may not completely remove a specific problem but will assist in controlling electrical noise for general application of many unique printed circuit board layouts:

- Maintain IC connections to the inductor as short as possible.
- Keep the GND pin and the ground leads for the Cs, CLF, and CHF less than 5mm apart.
- Keep all leads as short as possible.
- Connect the GND of the device directly to the GND plane of the PCB.
- When using bypass capacitors to minimize ripple on the supply lines, keep the bypass caps as close as possible to the Vbat lead of the inductor and the Vcc pin.
- Apply a metallic separator between the EL lamp and PC board to prevent cross coupling.
- Use as wide as a trace as reasonable for the power lines on the PCBs to minimize noise development along the line.
- Locate the inverter away from signal chips and signal leads.
- Place a ground plane or bus between the inverter and signal chips and signal leads.
- Use separate returns for analog circuitry and digital circuitry.
- Avoid sharp bends or 90-degree turns in copper traces.
- Reduce peak current spikes by adding a resistor in series with the EL lamp.

The higher than normal operating temperature of the D307A IC also requires additional ground heat planes on the printed circuit board layout. The D307A IC has a heat slug attached to the bottom of the package to provide additional heat dissipation. It is recommended that the PCB incorporate a complimentary grounded heat plane to solder connect to the heat slug of the package. It is also recommended that no electrical traces, which can be adversely affected by the temperature transfer and the high voltage output, be laid out underneath the device. The temperature transfer as well as high voltage output may adversely affect these electrical traces. Recommended pad layout dimensions can be found on the last page of the datasheet.

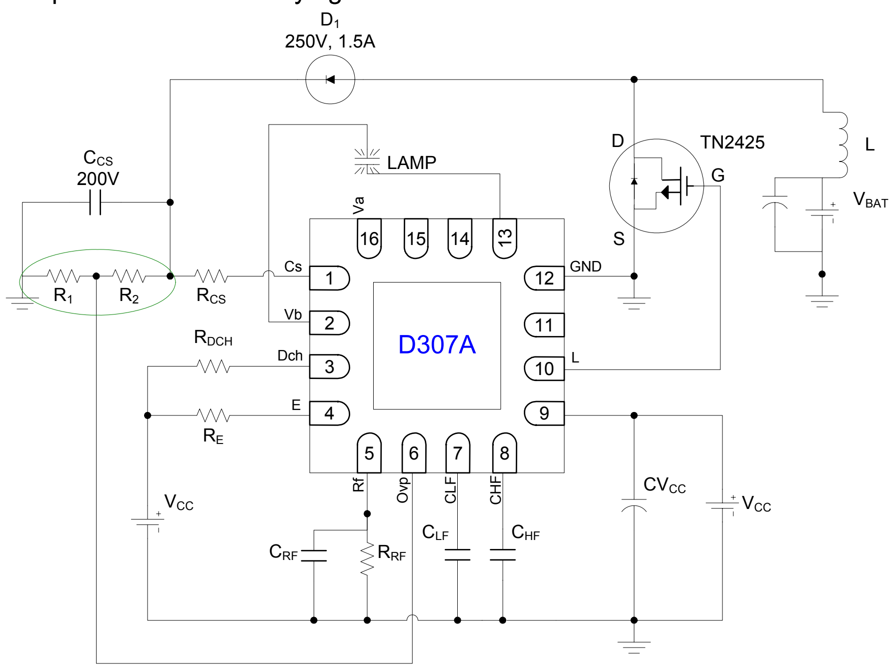
X. Split Voltage Supply

A split supply voltage is recommended to drive the D307A IC. To operate the on-chip logic, a regulated voltage supply (Vcc) ranging from 4.5V to 5.5V is applied. To supply the D307A IC with the necessary power to drive an EL lamp, another supply voltage (Vbat) with higher current capability is applied to the inductor. The voltage range of Vbat is determined by the following conditions: user application, lamp size, inductor selection, and power limitations of the battery.

An example of the split supply configuration is shown on page one. The example shows a regulated 5.0V applied to the Vcc pin, and a Vbat voltage that may range from 9.0V to 16.0V or regulated at 12.5V. This is a typical setup used in automotive.

XI. Over Voltage Protection

A new feature of the D307A is the ability to control the output voltage peak to peak with off chip components. This provides added protection to the inverter from over voltage conditions of the output caused through unexpected increases in input voltage or load changes. The over voltage protection is set by the voltage division of two resistors R1 and R2 as seen in schematic below. The setting is specific to each load and is recommended that the values of R1 and R2 be optimized to match the desired voltage limitation for each EL lamp. Figure 7 depicts graphically the effect on lamp luminance, current, and the voltage drop across R1 with varying values of R2 while R1 is held constant at 12KΩ.



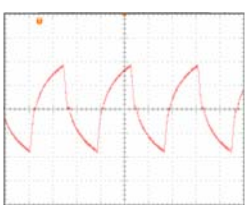


Figure 4: R2 = 1500kΩ

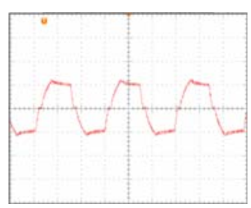


Figure 5: R2 = 680kΩ

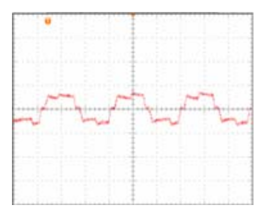


Figure 6: R2 = 470kΩ

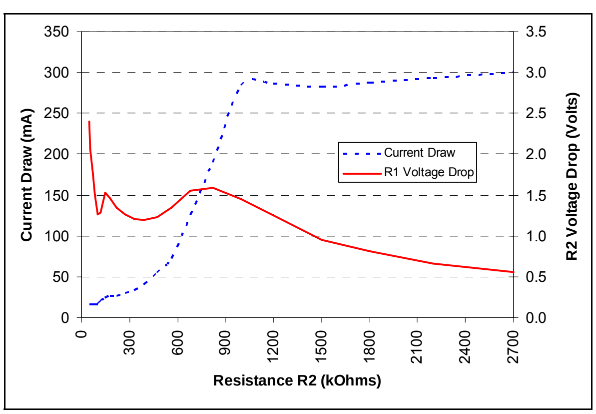


Figure 7: Total Current and R1 Voltage Drop vs. Resistance
Conditions: Vcc = 5.0Vdc, Vbat = 12.5Vdc, R1 = 12K,
RBC White 35in^2 EL Lamp

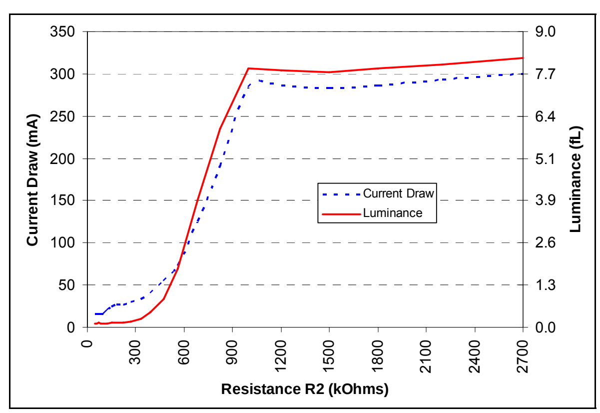
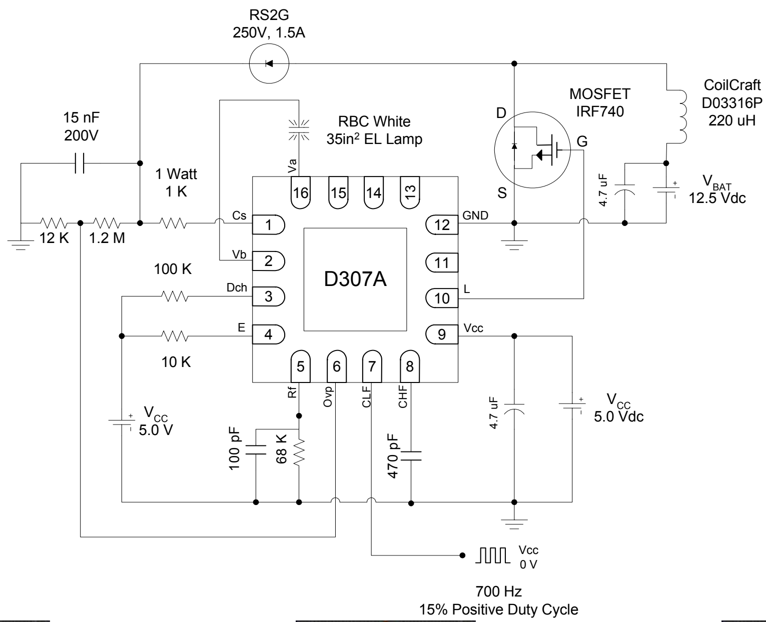


Figure 8: Luminance and Total Current vs. Resistance
Conditions: Vcc = 5.0Vdc, Vbat = 12.5Vdc, R1 = 12K,
RBC White 35in^2 EL Lamp

D307A IC Design Ideas

I. Controlling EL Brightness through LF Clock Pulse Width Modulation (Option 1)

Pulse-width modulation of the external LF input signal may be used to regulate the brightness of the EL lamp. Figures 9, 10, and 11 below demonstrate examples of the D307A IC output waveform with pulse width modulation of the LF input signal. As the positive duty cycle of the LF input signal is increased from 10% to 100%, the charging period of the output waveform decreases, and the peak voltage of the output waveform also decreases towards zero output. Therefore, incremental dimming occurs as a result of the wave-shaping changes. This scheme may also be used inversely to regulate lamp brightness over the life of the battery or to compensate for lamp aging. Figure 12 shows a typical dimming curve with this technique. Operation at duty cycles lower than 10% is not recommended. Clocking frequency can range from 200 Hz to 2000 Hz.



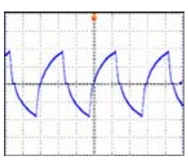


Figure 9: LF Input Duty Cycle = +15%

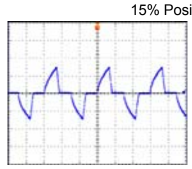


Figure 10: LF Input Duty Cycle = +50%

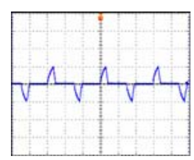


Figure 11: LF Input Duty Cycle = +75%

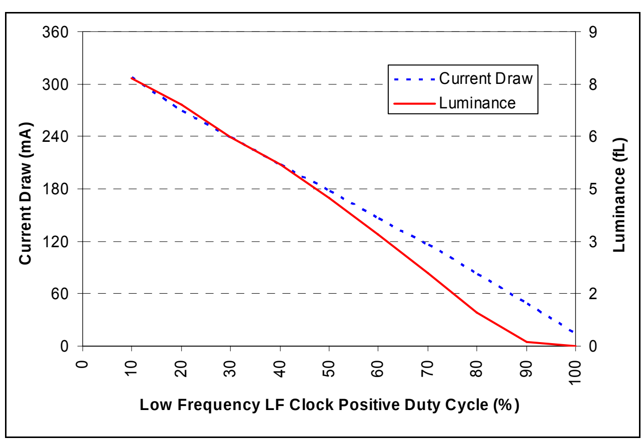


Figure 12: Dimming on LF Input with Square Wave Pulse Width Modulator Input

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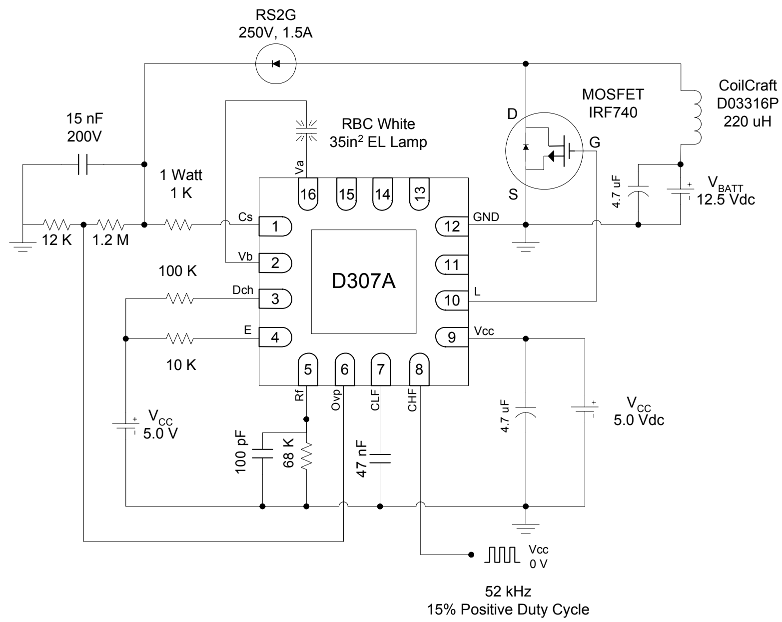
II. Controlling EL Brightness through HF Clock Pulse-Width Modulation (Option 2)

Pulse-width modulation of the external HF input signal also may be used to regulate the brightness of the EL lamp. As the positive duty cycle of the HF input signal is increased from 10% to 100%, the peak voltage of the output waveform decreases incrementally to zero output as the inductor charging period is affected by the HF duty cycle. Lamp dimming is thus achieved with pulse-width modulation of the HF input signal to the D307A IC. This scheme may also be used inversely to regulate lamp brightness over the life of the battery or to compensate for lamp aging. Figure 16 shows a typical dimming curve with this technique. The recommended HF duty cycle range is from 10% to 100%. Clocking frequency can range from 30 kHz to 500 kHz.



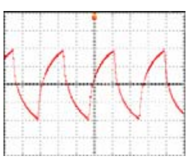


Figure 13: HF Input Duty Cycle = +15%

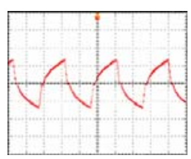


Figure 14: HF Input Duty Cycle = +50%

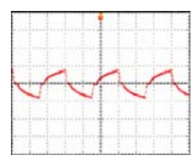


Figure 15: HF Input Duty Cycle = +75%

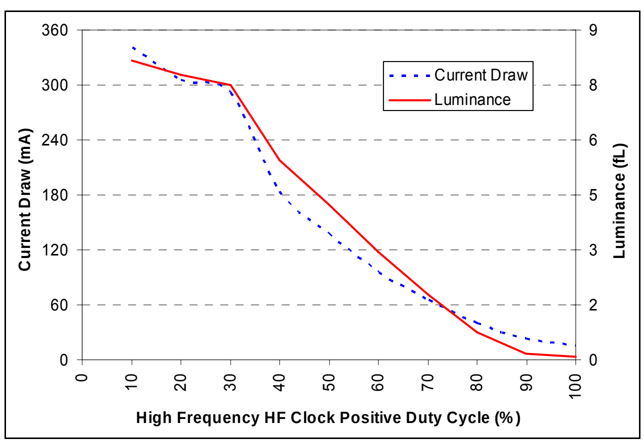


Figure 16: Dimming on HF Input with Square Wave Pulse Width Modulator Input

III. Solder Re-Flow Recommendations

Classification Reflow Profiles

Profile Feature	**Pb-Free Assembly** 1DDD307AA-P02 **Small Body**
Average ramp-up rate (T_L to T_P)	3°C/second max.
Preheat -Temperature Min (Ts_{min}) -Temperature Max (Ts_{max}) -Time (min to max) (ts)	 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)	 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 Time 25°C to Peak	6°C/second max.
Temperature	8 minutes max.

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

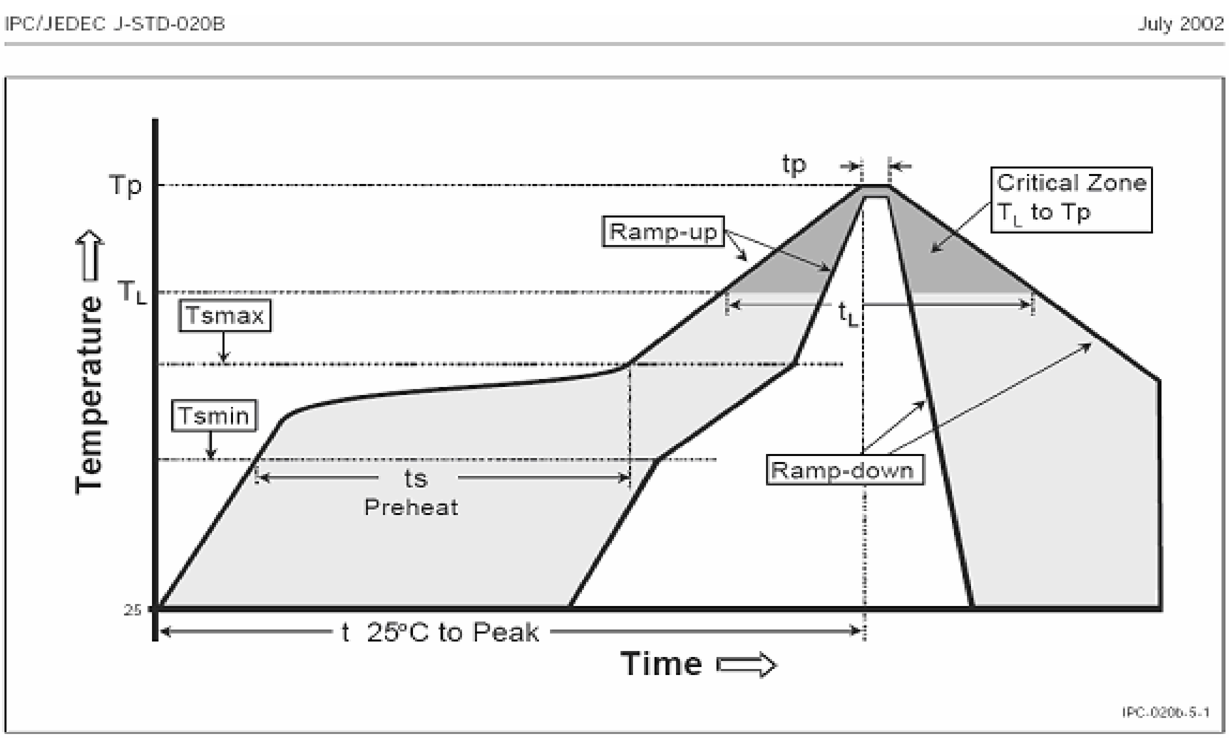
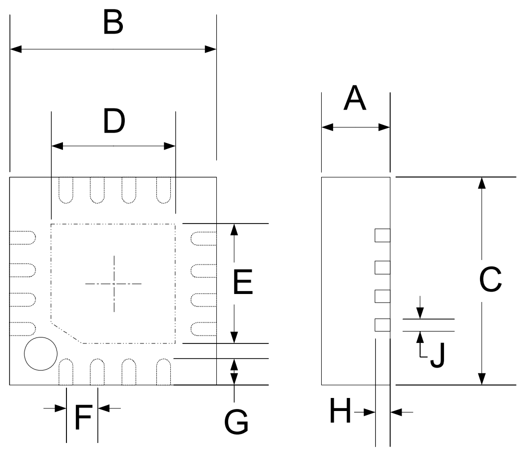


Figure 5-1 Classification Reflow Profile

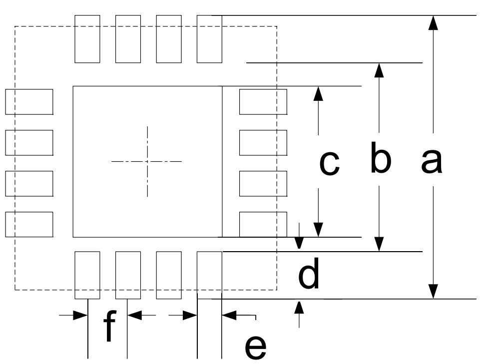
Ordering Information

The D307A IC is available in standard Lead-free (Pb-Free) QFN with heat slug plastic package per tape and reel. A Rogers' D307A IC Designer's Kit (1DDD307AA-K01) provides a vehicle for evaluating and identifying the optimum component values for any particular application using D307A IC. Rogers' engineers also provide full support to customers including specialized circuit optimization and application retrofits upon request.



	QFN-16 DIMENSIONS					
	Min		Nominal		Max	
	mm	in	mm	in	mm	in
A	0.70	0.027	0.75	0.029	0.8	0.031
B	3.925	0.155	4.00	0.157	4.075	0.160
C	3.925	0.155	4.00	0.157	4.075	0.160
D	0.75	0.029	1.70	0.067	2.25	0.088
E	0.75	0.029	1.70	0.067	2.25	0.088
F			0.65	0.026		
G	0.35	0.014	0.55	0.021	0.75	0.029
H			0.20	0.008		
J	0.25	0.010	0.30	0.012	0.35	0.014

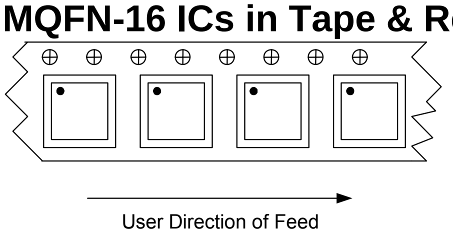
Recommended Pad Layout:



Devices are marked with Rogers' logo, part number, and a 4- digit code. Bottom of marking is on the Pin 1 side.

	QFN-16 PAD LAYOUT					
	Min		Typical		Max	
	mm	in	mm	in	mm	in
a	4.30	0.169	4.35	0.171	4.40	0.173
b	2.85	0.112	2.90	0.114	2.95	0.116
c	2.10	0.083	2.15	0.085	2.20	0.087
d	0.67	0.026	0.72	0.028	0.77	0.030
e	0.25	0.010	0.30	0.012	0.35	0.014
f			0.65	0.026		

MQFN-16 ICs in Tape & Reel:



Embossed tape on 360 mm diameter reel. 2500 units per reel. Quantity marked on reel label.

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

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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