

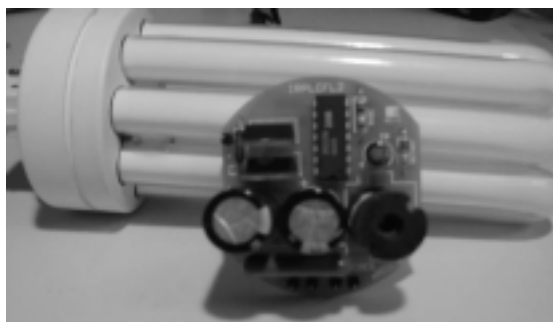
# REFERENCE DESIGN IRPLCFL2a

International Rectifier • 233 Kansas Street, El Segundo, CA 90245 USA

## IRPLCFL2 42 Watt Compact Fluorescent Ballast Reference Design

### Overview

The CFL-2 is an electronic ballast design for driving a 42 watt compact fluorescent lamp from a 120 or 230 volt AC line. The circuit was designed using the IR2156 Ballast Driver IC. The main features of the circuit are programmable frequency, preheat time, over-current threshold and dead time. A circuit board was designed and tested to verify reliable functionality under actual operating conditions.



LAMP TYPE: GE BIAx Q/E 42W (F42QBX)

### Features

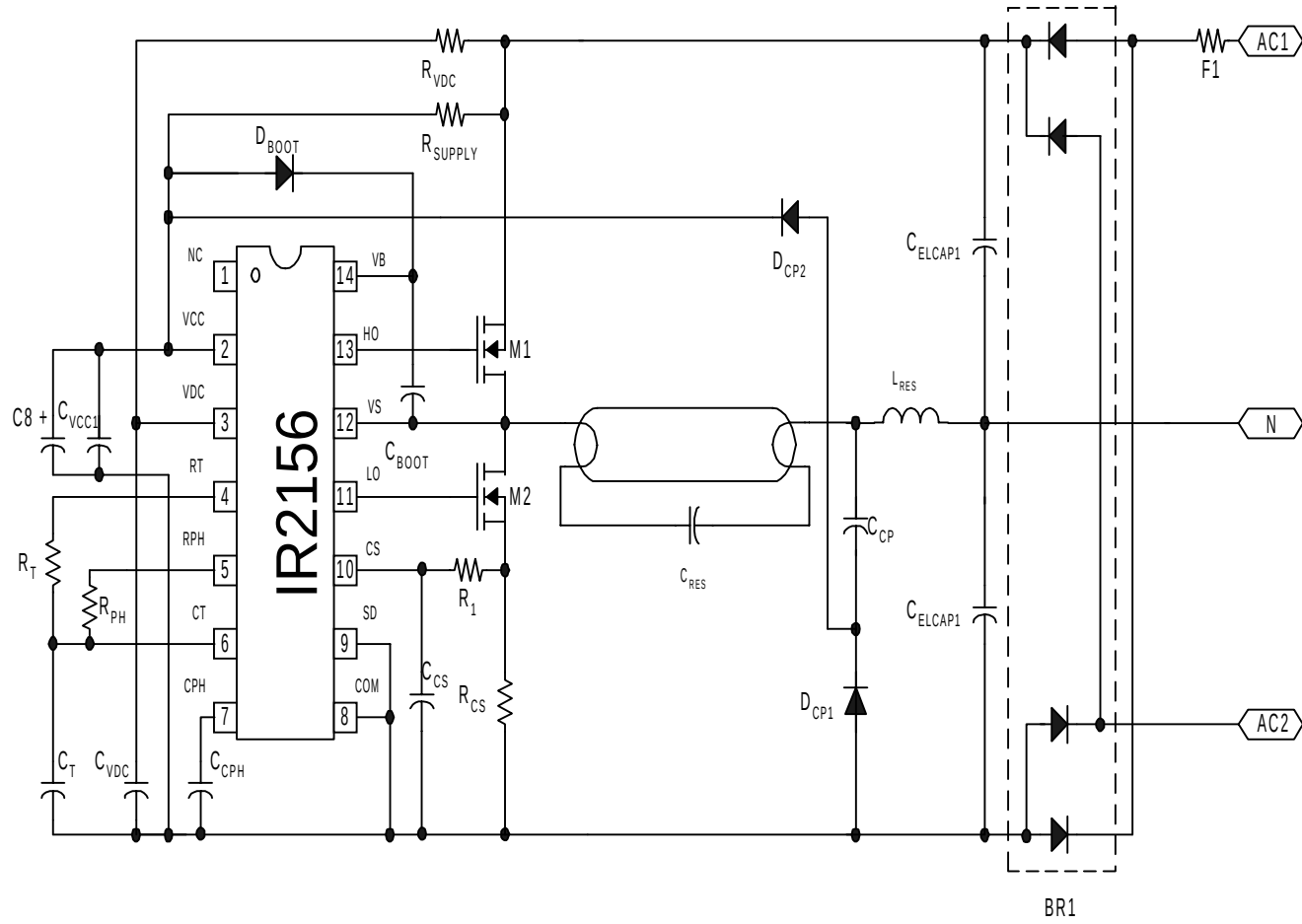
- \* Programmable preheat frequency
- \* Programmable preheat time
- \* Programmable over-current threshold
- \* Programmable run frequency
- \* Programmable dead time

### Electrical Characteristics

| <u>Parameter</u>     | <u>Value</u> |
|----------------------|--------------|
| Input Power          | 42W          |
| Input Current (120V) | 530mA        |
| Preheat Frequency    | 75kHz        |
| Run Frequency        | 45kHz        |

### Circuit Description

The schematic for CFL-2 is shown in Figure 1. With a 120 volt AC line input (AC1-N), the voltage is rectified and doubled to provide a bus voltage of approximately 300 volts. With a 220 volt AC line input (AC1-AC2), the voltage is rectified but not doubled and again provides a bus voltage of approximately 300 volts. The start up resistor,  $R_{SUPPLY}$ , is sized such that it can supply the micro-power current during under-voltage lockout (UVLO). When  $V_{CC}$  exceeds the UVLO+ threshold, the IR2156 begins to oscillate and the charge pump circuit ( $C_{CP}$ ,  $D_{CP1}$ , and  $D_{CP2}$ ) supplies the current to  $V_{CC}$  which causes the internal 15.6V shunt clamp to regulate.



At initial startup, the output frequency is determined by timing capacitor  $C_T$  and the parallel combination of  $R_T$ ,  $R_{PH}$  and an internal resistor,  $R_{SOFTSTART}$ .  $C_T$  is selected depending on the desired deadtime and is given as:

$$t_{DT} = C_T \cdot 1475 \text{ [Seconds]} \quad (1)$$

After a few hundred micro-seconds,  $R_{SOFTSTART}$  is slowly switched away (See Figure 4). This provides a soft-start of the resonant output stage which eliminates large voltage transients which can cause a small start-up flash across the lamp. Once  $R_{SOFTSTART}$  is disconnected, the parallel combination of  $R_T$  and  $R_{PH}$  determine the output frequency during preheat and is given as:

$$f_{PH} = \frac{1}{2 \cdot C_T \cdot \left( \frac{0.51 \cdot R_T \cdot R_{PH}}{R_T + R_{PH}} + 1475 \right)} \quad (2)$$

The IC remains in preheat mode until the voltage on CPH exceeds  $V_{CC}-2V$ . The preheat time is determined by an internal current source charging external capacitor  $C_{PH}$  and is given as:

$$t_{PH} = C_{PH} \cdot 2.6e6 \quad (3)$$

When CPH exceeds  $V_{CC}-2V$ ,  $R_{PH}$  is slowly disconnected from  $R_T$ , which causes the frequency to ramp smoothly from the preheat frequency, through the ignition frequency to the final run frequency.

The voltage across the lamp at ignition should be sufficient to ignite the lamp under all operating conditions. The ignition current should never saturate the inductor, and is given as:

$$I_{IGN} = \frac{1.3}{R_{CS}} \text{ [Amps Peak]} \quad (4)$$

The run frequency is programmed using only external components  $R_T$  and  $C_T$  and is given as:

$$f_{RUN} = \frac{1}{2 \cdot C_T (0.51 \cdot R_T + 1475)} \text{ [Hertz]} \quad (5)$$

If  $V_{CS}$  exceeds the over-current threshold of 1.3V, the IC will enter fault mode, and the half-bridge is disabled (See Figure 6). At this point,  $V_{CC}$  requires only micro-power current and remains at the shunt clamp voltage. The IC can only be reset with a re-cycling of  $V_{CC}$  below and back above the UVLO thresholds, or, pin SD, (shown grounded in the schematic) can be recycled above and back below the internal 5.1V threshold.

If the lamp is removed during normal operation, or either of the lamp filaments fail, the resonant tank is interrupted and the charge pump becomes disconnected. The charge pump can no longer supply current to  $V_{CC}$  and  $V_{CC}$  drops below UVLO-.  $R_{SUPPLY}$  charges  $V_{CC}$  up to UVLO+ and the half-bridge begins to oscillate again, but only temporarily. Since  $R_{SUPPLY}$  cannot supply enough current to  $V_{CC}$  to sustain oscillations,  $V_{CC}$  once again drops below UVLO- and oscillations stop. This burst mode continues (See Figure 5) until a lamp is re-inserted, and the IR2156 starts again in the preheat mode. For a more detailed description of the IR2156, including a STATE diagram, TIMING diagram, and a complete functional description and electrical characteristics, please refer to the "IR2156 Ballast Control IC" data sheet.

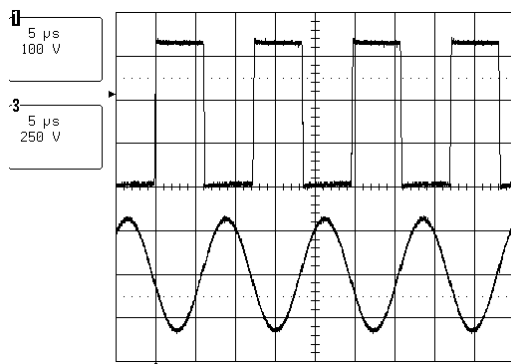


Fig. 2:  $V_S$  &  $V_{LAMP}$  during Preheat Mode

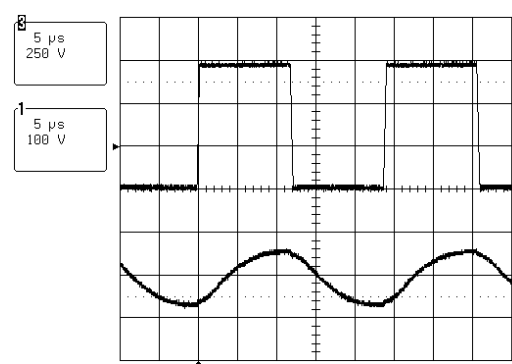


Fig 3:  $V_S$  &  $V_{LAMP}$  during Run Mode

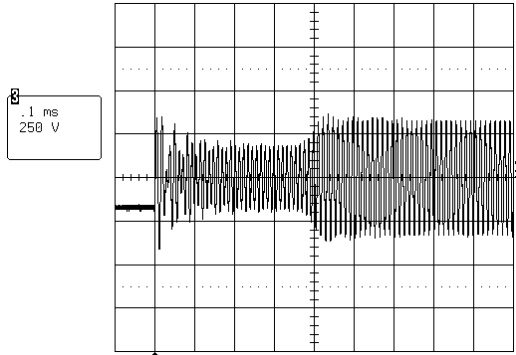


Fig 4:  $V_{LAMP}$  during Softstart Mode

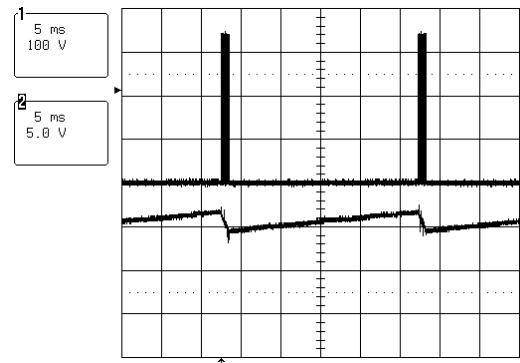


Fig 5:  $V_S$  &  $V_{CC}$  during lamp out or filament failure

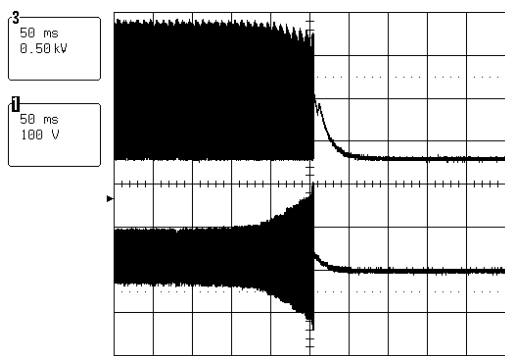


Fig 6:  $DCBUS$  &  $V_{LAMP}$  during a non-strike lamp fault condition

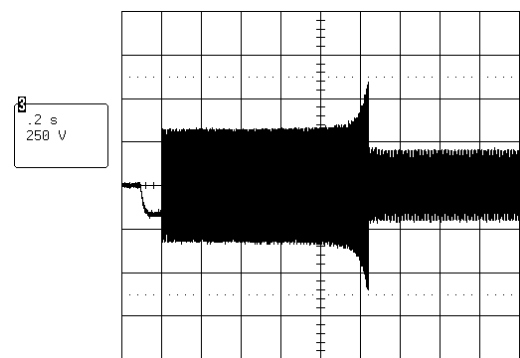


Fig 7:  $V_{LAMP}$  during Preheat, Ignition and Run Modes

**Bill Of Materials**

Schematic: IRPLCFL2, Figure 1

Lamp Type: 42W-Quad Biax

Line Input Voltage: 120VAC

| Item         | Qty       | Description            | Designator       | Value        | Manufacturer            | Part No.        |
|--------------|-----------|------------------------|------------------|--------------|-------------------------|-----------------|
| 1            | 1         | Fuse                   | F1               | 0.5Ω / 0.5Ω  | Dale                    | CW-1/2 0.5Ω 5%  |
| 2            | 1         | Bridge Rectifier       | BR1              |              | International Rectifier | DF10S           |
| 3            | 2         | Electrolytic Capacitor | CELCAP1, CELCAP2 | 47uF/250V    | Panasonic               | EEU-EB2E470     |
| 4            | 1         | Resonant Inductor      | LRES             | 1.25mH/1.5A  |                         |                 |
| 5            | 1         | Charge Pump Capacitor  | CCP              | 330pF/1kV    | Johanson                | 102S43N331JV4U  |
| 6            | 2         | Charge Pump Diodes     | DCP1, DCP2       | 1N4148       | Diodes                  | LL4148DICT      |
| 7            | 1         | Resonant Capacitor     | CRES             | 4.7nF/1.6kV  | Wima                    | MKP10           |
| 8            | 2         | Half-Bridge MOSFET     | M1, M2           | IRF730       | International Rectifier | IRF 730         |
| 9            | 1         | Current Sense Resistor | RCS              | 0.56Ω / 0.5W | Panasonic               | CW-1/2 0.56Ω 5% |
| 10           | 1         | Limit Resistor         | R1               | 1k / 1/8W    | Panasonic               | ERJ-8RQJ102Y    |
| 11           | 1         | Filter Capacitor       | CCS              | 1nF/25V      | Panasonic               | ECU-V1H102KBM   |
| 12           | 2         | Supply Capacitor       | CBOOT, CVCC1     | 0.1uF/25V    | Panasonic               | ECJ-3VB1E104K   |
| 13           | 1         | Supply Capacitor       | C8               | 2.2uF/25V    | Panasonic               | ECE-A1HFS2R2    |
| 14           | 1         | Bootstrap Diode        | DBOOT            | 600V, 1A     | Digi Key                | MURS160DICT-ND  |
| 15           | 1         | Ballast Control IC     | IC1              | IR2156       | International Rectifier | IR2156          |
| 16           | 2         | Resistor               | RSUPPLY, RVDC    | 1M/0.25W     | Yageo                   | 105QBK          |
| 17           | 1         | Timing Resistor        | RT               | 30k/1/8W1%   | Panasonic               | ERJ-8RQF303Y    |
| 18           | 1         | Timing Capacitor       | CT               | 560pF/25V,5% | Panasonic               | ECU-V1H561KBM   |
| 19           | 1         | Preheat Resistor       | RPH              | 33k/1/8W1%   | Panasonic               | ERJ-8RQF333Y    |
| 20           | 1         | Preheat Capacitor      | CPH              | 0.33uF/25V   | Panasonic               | ECJ-3VB1E224K   |
| 21           | 1         | Capacitor              | CVDC             | 0.01uF/25V   | Panasonic               | ECU-V1H103KBM   |
| <b>TOTAL</b> | <b>26</b> |                        |                  |              |                         |                 |

Table 1 CFL-2 Bill of Materials