A large, light blue decorative graphic consisting of a thick, curved line that forms a partial circle, with a small circle at its top end, is positioned behind the main title text.

# Electronic Transformer Compatible Step-down Converter for 3W MR16 Lamp with **ILD4035**

Application Note AN214

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**Application Note AN214**

**Revision History: 2011-09-02**

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**Previous Revision: Previous\_Revision\_Number**

| <b>Page</b> | <b>Subjects (major changes since last revision)</b> |
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## 1 Introduction

### 1.1 Features

- Driver number of LED, 3 in series
- Output Power, 3 Watt
- 12 Volt AC operation
- Stable LED current vs. input voltage
- Temperature protection

### 1.2 Brief Description

The ILD4035 provides a low-cost solution for driving 1W LEDs with a LED current up to 400mA. The supply voltage of this LED driver IC is up to 22V; hence this IC is suitable for MR16 application at 12VAC operation.

## 2 LED Driver PCB Design

The 3W MR16 control board has 2 input pins, it connect to 12 VAC input power supply. There are 2 LED terminal pins, it allow use connect to 3 LED in series. The demo board is configured with 350mA LED current.

### 2.1 Calculation of Rsense resistance

The internal voltage reference for the  $R_{sense}$  resistors is typically  $(V_s - V_{sense}) = 0.114V$

To set the LED current to near 0.35 A, the effective resistance between  $V_s$  and  $V_{sense}$  pin is calculated as:

$$R_{sense} = 0.114V / 0.35A = 0.33 \Omega$$

This  $R_{sense}$  can be achieved by paralleling three physical resistor,  $R_1=R_2=R_3=1.0 \Omega$  (Or one piece of 0.33  $\Omega$  resistor).

### 2.2 Calculation of the L1 inductance

Given the following data:

Buck-switching frequency  $f = 200 \text{ kHz}$ ,

Duty-on-cycle of  $V_{switch}$  of ILD4035,  $D = 90\%$ ,

Voltage drop of LEDs,  $V_{fLEDs} = 3.3V \times 3 \text{ pcs in series} = 9.9V$ ,

Voltage drop of schottky diode,  $V_{fD} = 0.3V$ ,

Voltage drop of  $V_{switch}$  to ground when internal switch is on,  $V_{drop} = 1.1V$ ,

Average LED current,  $I_{LED} = 0.35A$ ,

Inductance of L1 can be calculated approximately as:

$$L_1 = \frac{10 \cdot (1 - D) \cdot (V_{fLED} + V_{fD} + V_{drop})}{2 \cdot f \cdot I_{LED}} = 80.7 \mu H$$

**The next higher practical value for SMD inductance is 100  $\mu H$ .**

### 2.3 PCB schematic and layout

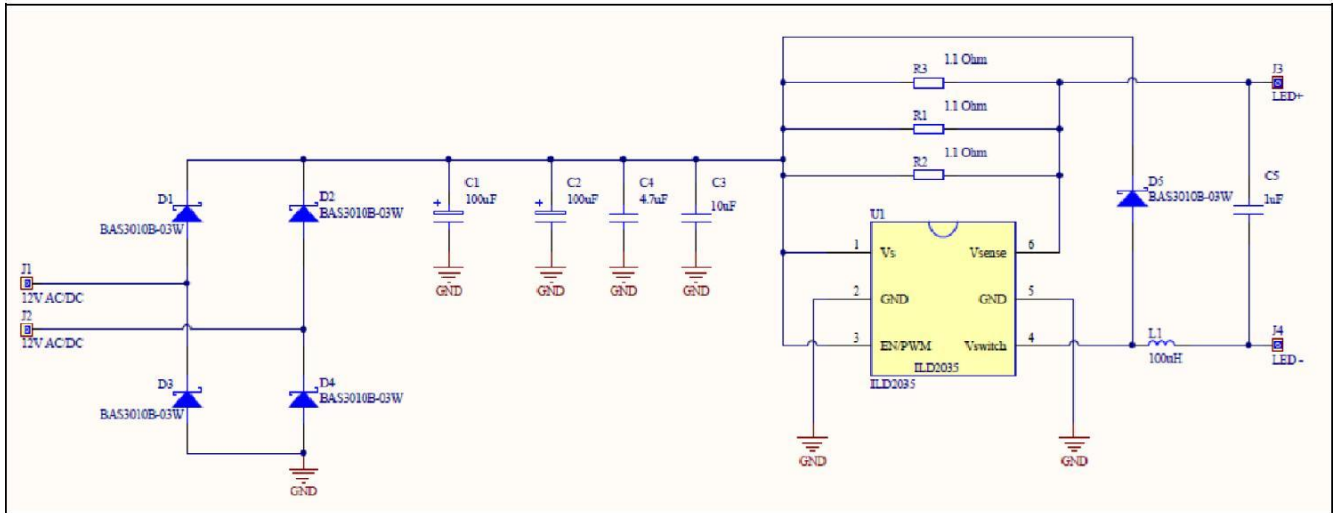


Figure 1 Schematic LED Driver Design

Table 1 Bill-of-Materials

| Symbol     | Value        | Size   | Manufacturer | Comment                                |
|------------|--------------|--------|--------------|--|
| J1, J2     | Solder pad   |        |              | 12 VAC input connector                 |
| R1, R2, R3 | 1.0 Ohm      | 0603   |              | For setting 0.35A of LED current       |
| C3         | 4.7µF        | 0805   |              | 35V SMD ceramic capacitor              |
| C4         | 10µF         | 0805   |              | optional                               |
| D1 – D5    | BAS3010B-03W | SOD323 | INFINEON     | Schottky Diode                         |
| C1, C2     | 100µF        |        |              | 25V, Electrolytic Capacitor            |
| U1         | ILD4035      | SC74   | INFINEON     | Buck Hysteretic LED current controller |
| L1         | 100µH        |        | Wuerth       | SMD Inductor                           |
| J3         | Hole         |        |              | LED+ terminal (Red)                    |
| J4         | Hole         |        |              | LED- terminal (Black)                  |

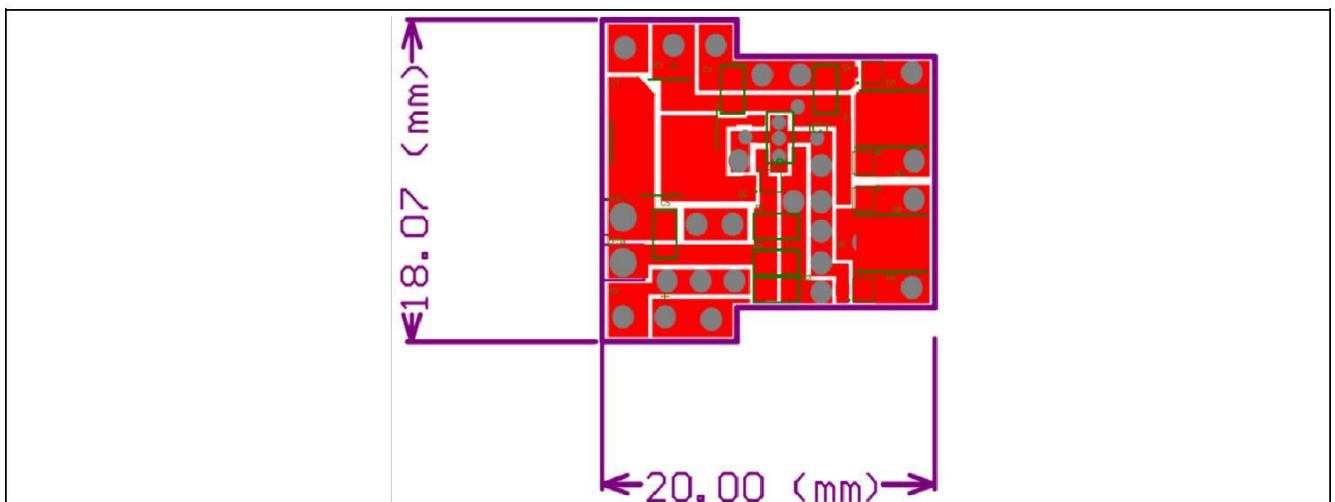


Figure 2 PCB Layout Top View of Driver Board.

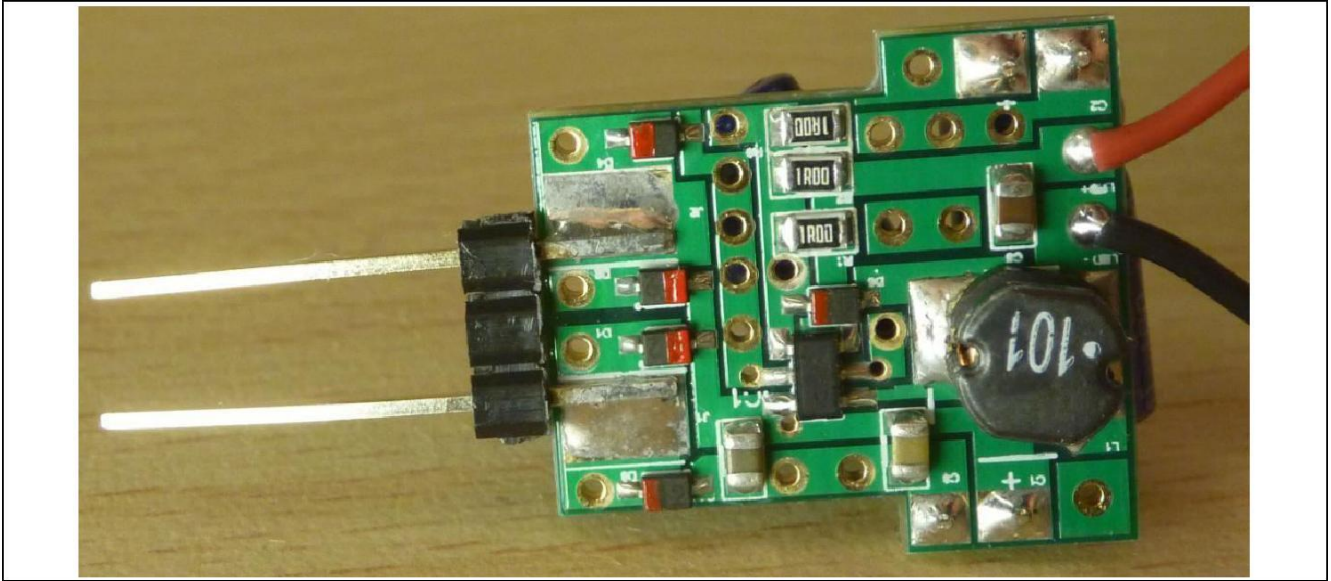
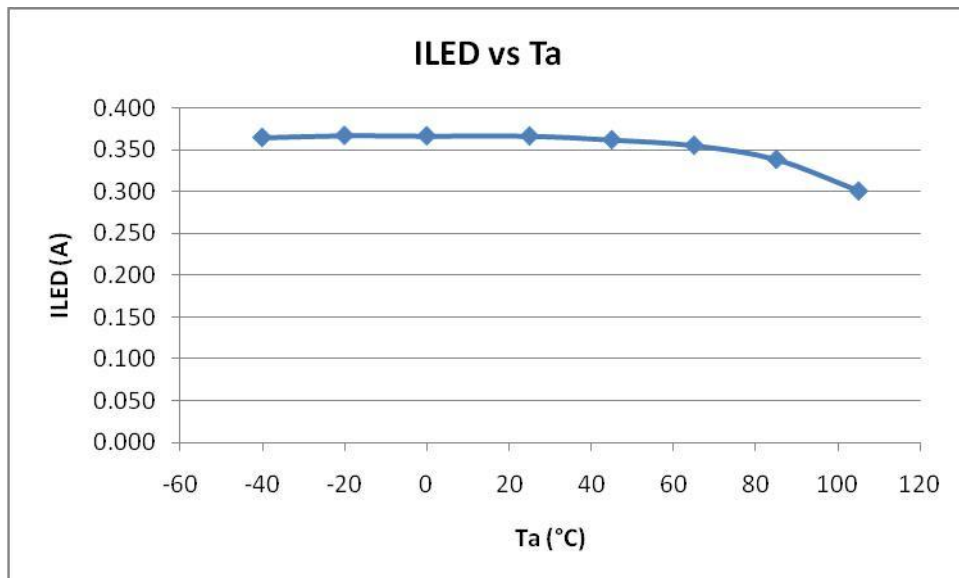


Figure 3 Picture of MR16 3W control board

### 3 Performance and measurement

#### 3.1 Temperature Protection

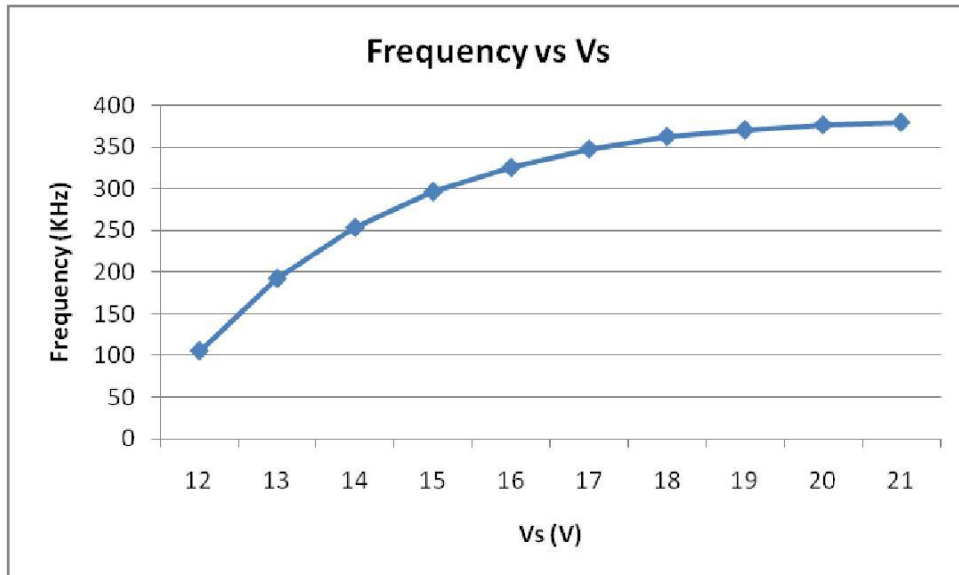
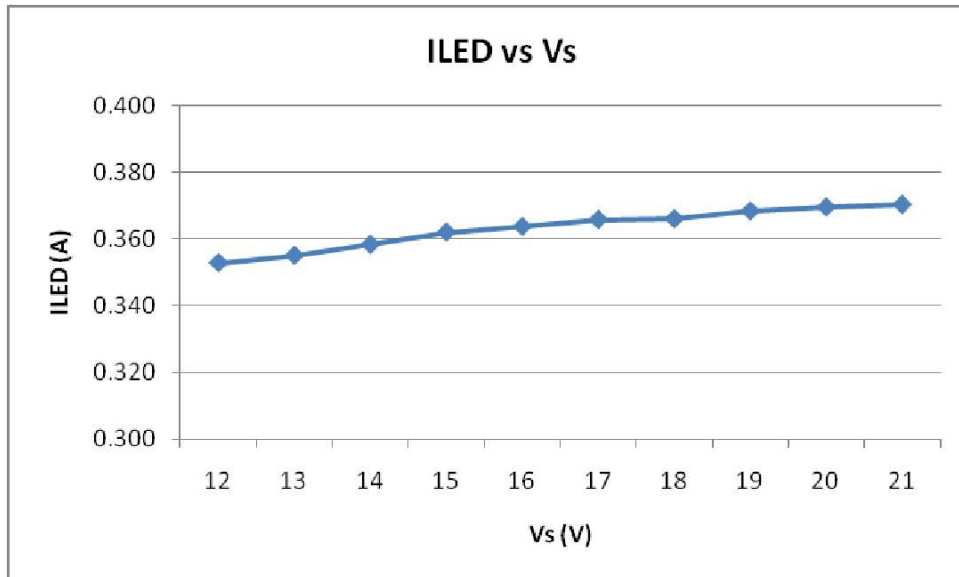
ILD4035 incorporates a temperature protection circuit referring to the junction temperature of the IC. The higher junction temperature the lower current of the LEDs. This feature helps to reduce the power dissipation of ILD4035 and the LEDs.

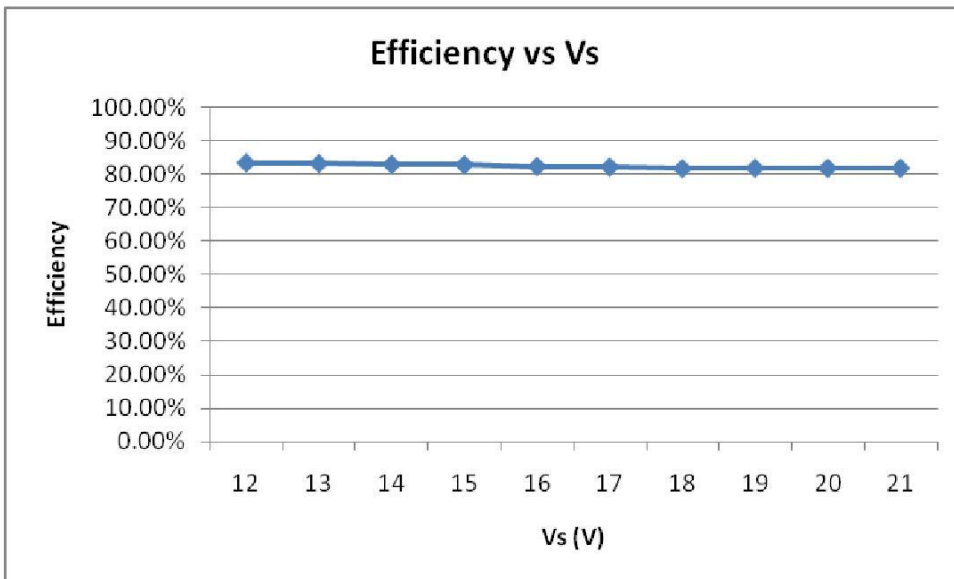
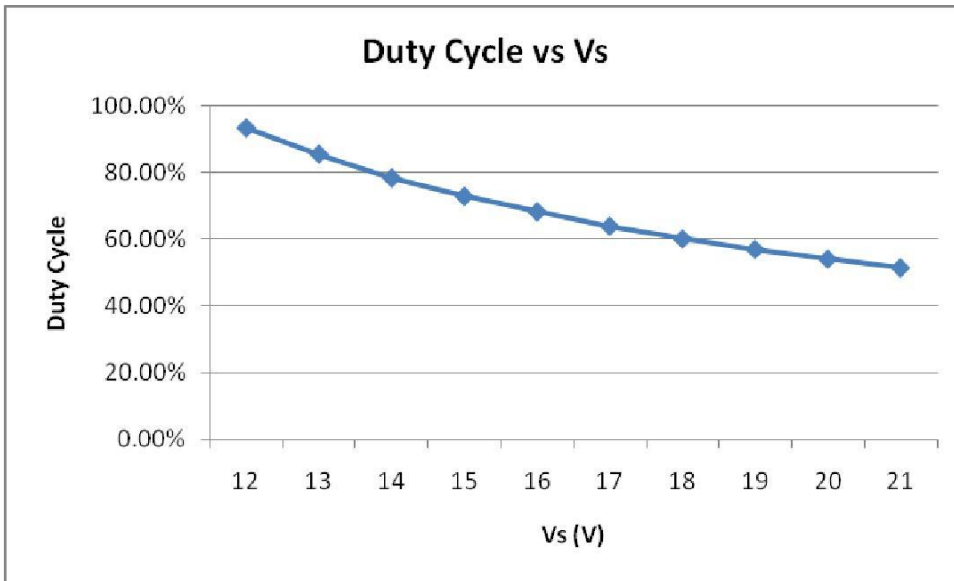


### 3.2 Stable LED current control with input voltage variations

ILD4035 provides less than 5% LED current variation in an input voltage range from 12V to 21V.

Below figures show the measurement results for the ILED, switching frequency, duty cycle and efficiency versus  $V_s$ .

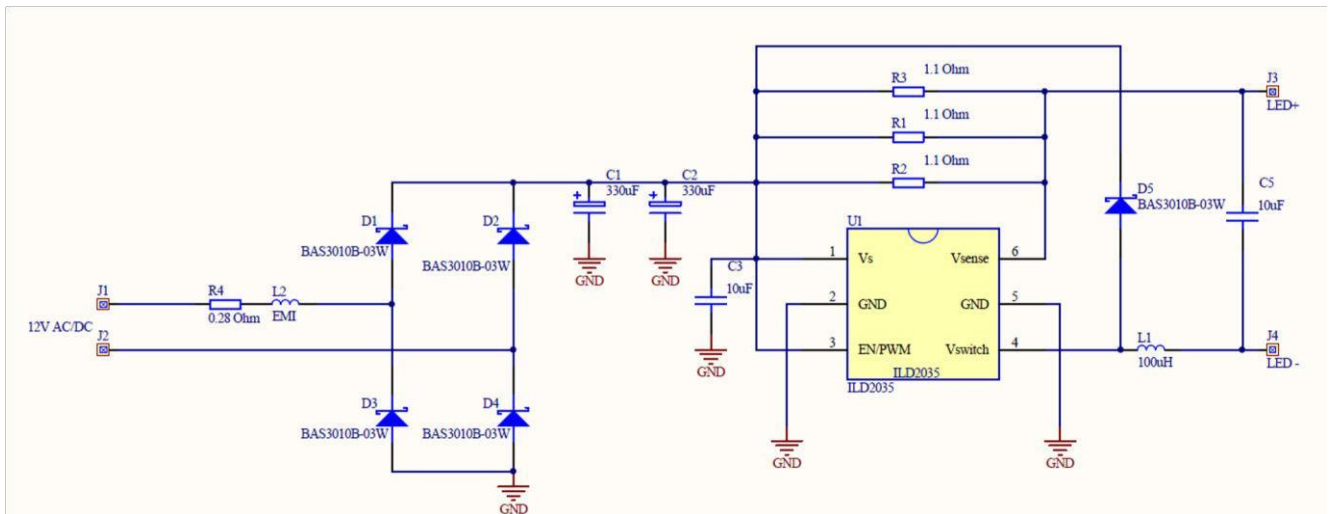




Note: This is demo board efficiency with DC input voltage



## 4 Flickering Free driving with Electronic Transformer



**Figure 4 Schematic LED Driver Design (Flickering free)**

**Table 2 Bill-of-Materials**

| Symbol     | Value        | Size     | Manufacturer | Comment                                |
|------------|--------------|----------|--------------|--|
| J1, J2     | Solder pad   |          |              | 12 VAC input connector                 |
| R1, R2, R3 | 1.0 Ohm      | 0603     |              | For setting 0.35A of LED current       |
| C3         | 4.7 $\mu$ F  | 0805     |              | 35V SMD ceramic capacitor              |
| C4         | 10 $\mu$ F   |          |              | optional                               |
| D1 – D5    | BAS3010B-03W | SOD323   | INFINEON     | Schottky Diode                         |
| C1, C2     | 100 $\mu$ F  |          |              | 25V, Electrolytic Capacitor            |
| U1         | ILD4035      | SC74     | INFINEON     | Buck Hysteretic LED current controller |
| L2         | 100 $\mu$ H  |          | Wuerth       | SMD Inductor                           |
| L1         | 27 $\mu$ H   |          | Wuerth       | SMD Inductor                           |
| R4         | 0.28 OHm     | SMD_2512 |              | Resistor                               |

This solution can be configured to be compatible with electronic transformer and there is not flickering and shimmering.

Below is electronic transformer:

- **OSRAM Halotronic® HTM 105/230-240**
- OSRAM ET-A 60/220-240
- Philips ET-E60 220-240
- GE SET110LVA
- GE SET60LS
- Tridonic TE-0060 BASIC 112

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