AND8156/D

NUD4001 and NUD4011 Low Cost Integrated Current Sources for LEDS Lighting Applications of Low and High Voltage (6.0 V - 120 V)

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APPLICATION NOTE

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ABSTRACT

The increasing usage of Light Emitting Diodes (LEDs) to address different lighting applications such as traffic signals, exit signs, backlighting and general illumination have made them very popular to the point where they are now an attractive choice for all those lighting applications that were once the domain of incandescent lamps. LEDs have several advantages when compared with incandescent lamps. They offer fast turn−on, lower heat generation, lower power consumption, higher operating life, and high resistance to shock/vibration. Nevertheless, LEDs need to be driven properly to ensure optimal performance and long life. Designing and implementing an effective driver is key to obtain all the benefits of LEDs. The driver's implementation must be cost effective, which is not usually achieved with discrete components but with integrated solutions.

INTRODUCTION

LEDs are created from various doped semiconductor materials in the form of a P−N diode junction. When electrical current flows through the junction in the forward direction, the electrical carriers deliver energy proportional to the forward voltage drop across the diode junction, which is emitted in the form of light. The amount of energy is relatively low for low current (< 30 mA) infrared or red LEDs. However, for green and blue LEDs which are manufactured from higher forward voltage materials, the amount of energy is greater.

The conversion efficiency of electrical energy into light energy is very important. Today's LEDs vary between 10 and 20 percent efficiency. The rest of the energy is converted to heat. This heat must be effectively dissipated, as the operating junction temperature of the LED die must be maintained no higher than +125°C.

Since the device is being used in the forward biased mode, once the voltage applied exceeds the diode forward voltage; the current through the device can rise exponentially. Very high currents would damage the LEDs, so this is why electronic drivers must be added when LEDs are driven from any voltage source. The amount of light emitted by an LED is proportional to the amount of average current flowing through the device in the forward bias direction. As the current is varied, the output of the light will vary in a similar way. Therefore, a Light−Emitting Diode (LED) is essentially a PN junction semiconductor diode that emits light when current is applied.

By definition, it is a solid−state device that controls current without heated filaments and is therefore very reliable. LEDs have special characteristics that assure high reliability and compatibility with electronic drive circuits.

LEDs have advantages and disadvantages when compared with other light sources such as incandescent or fluorescent lamps. The most significant advantages are fast turn−on, lower heat generation, lower power consumption, longer operating life, and high resistance to shock/vibration. Some of the disadvantages are the narrow viewing angle, near monochromatic light, limited wavelength selection, and they require electronic drive circuits for operation.

LEDs, regardless of color, have an extremely long lifetime, whenever their current and temperature limits are not exceeded.

Lumileds™ Lighting LLC [1, 2] has published lifetime data stating that after 50,000 hours the LEDs will have 70 percent or greater of the original light output. Using an engineering rule of thumb with data already collected and plotted on a semi−log graph paper, LEDs are projected to have 50 percent or greater of the original light output after 100,000 hours. This is approximately 11 years and 5 months of continuous service with light greater than 50 percent of the initial output. Remember, in order to obtain maximum life, the LEDs must be operated within the manufacturers specified limits of both current and diode junction temperature. LEDs should be used where extremely long life is desired and the cost of lamp replacement is very high.

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Figure 1 shows a typical LED V – I curve. This graph in particular makes reference to the high current LED technology recently introduced. The maximum forward current varies with the different type, style, and manufacturer of LEDs. LED manufacturers have specified the maximum forward currents at 30 mA, 75 mA, 150 mA, 350 mA, and 700 mA for differently constructed LEDs. The higher current devices have special thermally designed packages to transfer the heat to a heat sink. The same rules can apply to devices having other current ratings by simply scaling down the current and power designs.

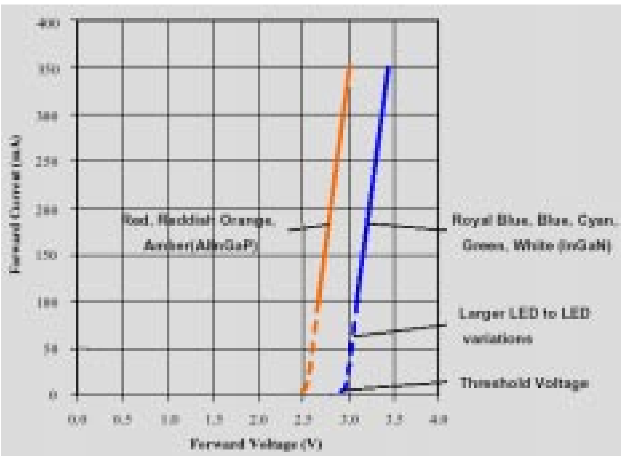

Figure 1. Typical V– I Curve for Different LED's Colors (Courtesy: Lumileds)

TRADITIONAL METHODS FOR DRIVING LEDS USING DISCRETE COMPONENTS

There are several methods to drive LEDs with discrete components. Figure 2 illustrates one of the simplest using a resistor in series with the supply voltage to limit the current.

This type of methodology is simple and cheap but has several disadvantages. The most significant one is that since there is not any current control device, the variations in the input voltage will change the average current to the LEDs, which results in poor illumination quality and sometimes even in the degradation or total damage of the LEDs for high line voltage conditions. To better illustrate the problem, calculations of the current supplied to the LEDs will be made based on the circuit shown in Figure 2. The normal ac line can fluctuate by 10 percent and therefore the transformer output can vary between 10.8 Vac and 13.2 Vac whenever the normal secondary voltage is 12.0 Vac. Based on this, the LED's current calculation for low, normal, and high voltage ac line is made through the Formula 1:

Formula 1:

$$I_{LEDs} = \frac{\left[\left(V_{in} \cdot \sqrt{2}\right) - \left(3 \cdot V_{LED}\right)\right]}{R1}$$

Assuming that the characteristics of the LEDs used are: If = 350 mA and Vf = 3.5 V, then the resulting current calculation for each of the voltage line conditions is as follows:

Low line: I_{LEDs} = 238 mA
Normal line: I_{LEDs} = 323 mA
High line: I_{LEDs} = 408 mA

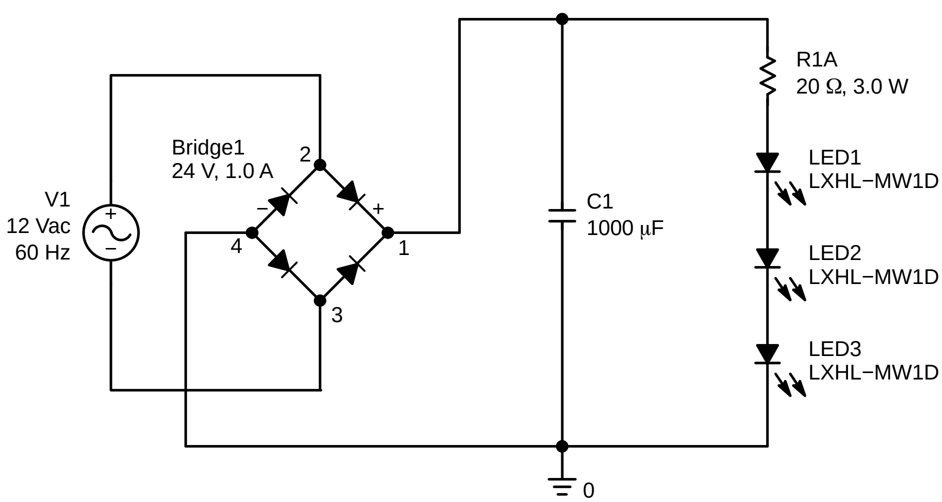

Figure 2. Discrete LED driver circuit using a resistor in series with the supply voltage. Application circuit for 12 Vac landscape lighting.

As it can be seen, the change of the LED's current is higher than $\pm$25% for a $\pm$10% variation in the ac line. For the low line case, it causes the LEDs to dim while for the high line case it may potentially damage them due to the overheating caused by the high current. This is why, these type of drive circuits are not recommended nor often used because they basically eliminate the valuable features of the LEDs.

Another common LED driver method using discrete components is made through a linear regulator (MC7805, MC7809 or similar), and a series medium power resistor (usually 1.0 W or bigger). Figure 3 shows this concept.

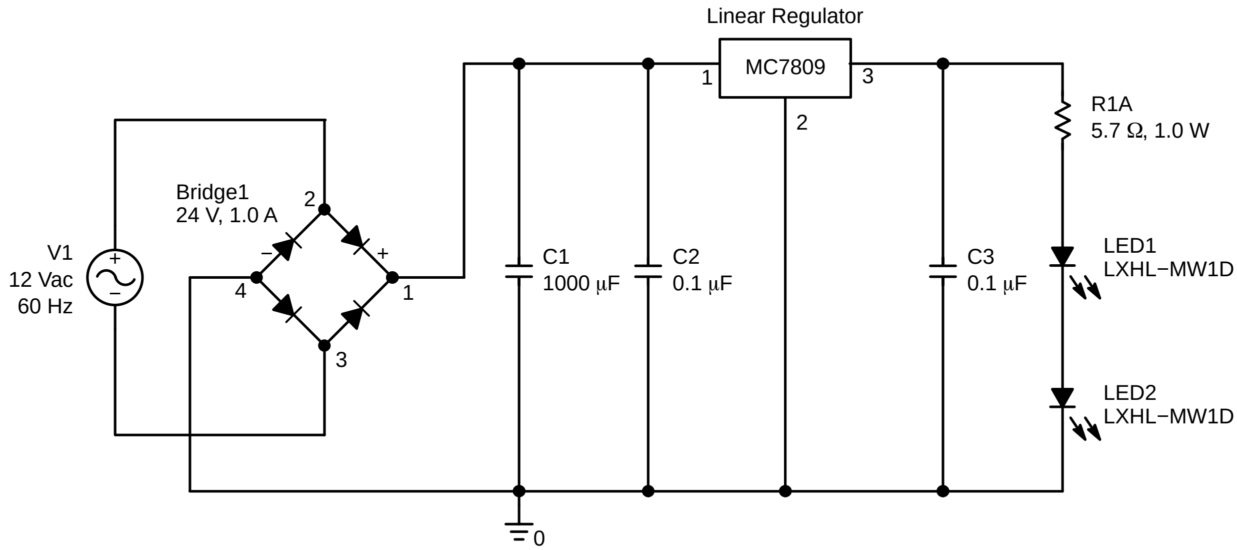

Figure 3. Discrete LED driver circuit using a linear regulator and a series resistor. Application circuit for 12 Vac landscape lighting.

The LED's current is set by the regulated output voltage of the linear regulator and the value of the resistor R1. The resistor value is easily calculated through Formula 2:

Formula 2:

$$R1 = \frac{(V_{out} - V_{LEDs})}{I_{LEDs}}$$

Assuming that the characteristics of the LEDs used are: If = 350 mA and Vf = 3.5 V, then the resulting resistor calculation is as follows:

$$R1 = \frac{(9.0\ V - 7.0\ V)}{0.350\ A} = 5.7\ \Omega$$

The power dissipation in R1 is given by:

$$P = I^2 \cdot R = (0.350)^2 \cdot 5.7 = 0.7\ W$$

The current regulation is mostly dependent on the regulator's performance and should be expected to be good since most voltage regulators provide good percentage of line and load regulation, usually lower than $\pm$5%.

Although this type of concept provides good current regulation to the LEDs, it may not be optimum for applications where cost is critical, and either for those requiring enable or electronic dimming functions.

INTEGRATED LED DRIVERS NUD4001 DEVICES' DESCRIPTION

NUD4001 Device Description

This integrated current source is designed to replace discrete solutions for driving LEDs in low and high ac or dc voltage applications (6.0 V − 30 V). Its integrated design technology eliminates individual components by combining them into a single small surface mount package (SOIC−8), which results in a significant reduction of both system cost and board space. Figure 4 illustrates the pin−out of the NUD4001 LED driver device.

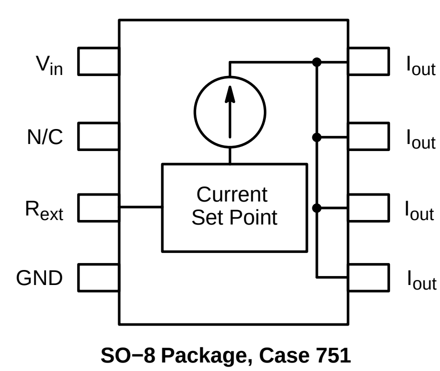

Figure 4. NUD4001 Integrated LED Driver Pin−out Description

This device provides a regulated dc current to a LED array, from an ac or dc input. It can drive arrays of series or parallel−series LEDs for a wide range of applications. It has a low voltage overhead (1.4 V) to facilitate its usage in low voltage applications. Its current regulating principle is made through the generation of a constant voltage drop (0.7 V) across an external low power sense resistor (R_{ext}), which sets the current independently of the input voltage supplied. This operating principle makes it very simple to design LED's circuits around the NUD4001 device. Nevertheless, there are certain design considerations such as the maximum device's power dissipation (1.13 W), operating ambient temperature range, device's voltage overhead and LED's array configuration that have to be taken into account before implementing this integrated driver. A general design guide is explained in the next section and illustrated in Figure 5. In this case the device is utilized to drive three high intensity white LEDs (If = 0.350 A, Vf = 3.5 V).

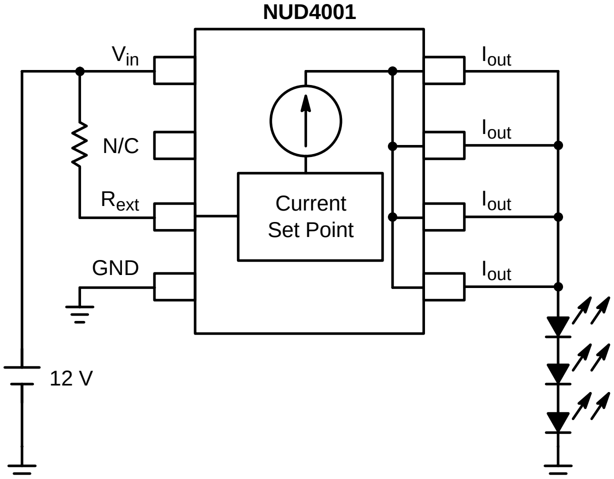

Figure 5. NUD4001 Device Driving Three White High Current LEDs

The steps to calculate the value of the external sense resistor (R_{ext}), and to validate the operation of the device within its power dissipation capability are explained in the following design guide:

NUD4001 Device's Design Guide:

1. Determine I_{out} – LED's current:
   a. I_{LED} = 330 mA
2. Calculate Resistor Value for R_{ext}:
   a. $R_{ext} = \frac{0.7\text{ V}}{I_{out}}$
   b. $R_{ext} = \frac{0.7\text{ V}}{0.330} = 2.2\ \Omega$
3. Define V_{in}:
   a. Per Figure 5, V_{in} = 12 V
4. Define V_{LED} @ I_{LED} per LED supplier's data sheet:
   a. Per Example in Figure 5,
   V_{LED} = 3.5 V + 3.5 V + 3.5 V = 10.5 V
5. Calculate V_{drop} across NUD4001:
   a. $V_{drop} = V_{in} – V_{LED}$
   b. V_{drop} = 12.0 V – 10.5 V
   c. V_{drop} = 1.5 V (V_{drop} must be higher than device's overhead, 1.4 V)
6. Calculate Power Dissipation (P_D):
   a. $P_D = V_{drop} \times I_{out}$
   b. P_D = 1.5 V x 0.330 A
   c. P_D = 0.495 W
7. If P_D > 1.13 W (or derated value based on ambient temperature. Refer to Figure 3 of NUD4001 device's data sheet), then select the most appropriate recourse and repeat steps 1−6:
   a. Reduce V_{in}
   b. Reconfigure LED array to reduce V_{drop}
   c. Reduce I_{out} by increasing R_{ext}
   d. Use parallel configuration of two or more NUD4001 devices.

The typical current regulation performance of the NUD4001 device for the circuit of Figure 5 using R_{ext} = 2.2 Ω is shown in Figure 6:

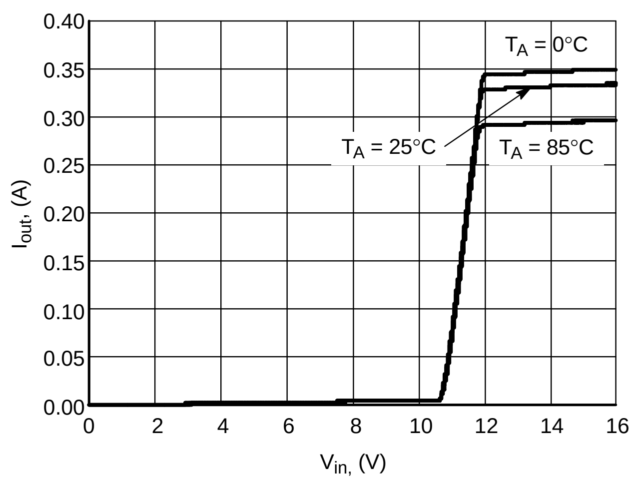

Figure 6. NUD4001 Device Regulation Performance at Three Different Ambient Temperatures (0°C, 25°C and 85°C)

At 25°C, the change of the LED's current is only 1% for an increment of 15% in the input voltage. This regulation ratings are obtained from the data shown in Figure 6:

For V_{in} = 12 Vdc, I_{out} = 328 mA,
For V_{in} = 13.8 Vdc, I_{out} = 331 mA

Similar regulation values are obtained at low and elevated temperatures. However, it is important to note that at low temperature, the LED's current is shifted by a factor of 5% while at elevated temperature it is lowered by a factor of 11%. These values are also obtained from the data shown in Figure 6:

For T_A = 25°C and V_{in} = 12.5 Vdc, I_{out} = 329 mA
For T_A = 0°C and V_{in} = 12.5 Vdc, I_{out} = 344 mA
For T_A = 85°C and V_{in} = 12.5 Vdc, I_{out} = 291 mA

Even if it seems strange, this type of behavior is ideal and usually desired by the LED manufacturers. It is because at high ambient temperatures the junction temperature in the LEDs would increase but the reduction in current cancels this effect. At low temperatures the current may be increased by a small percentage (usually no higher than 10%) since the LED's junction temperature is colder.

NUD4001 Power Dissipation

Although the basic design considerations of the NUD4001 device are explained in the design guide, it is necessary to emphasize and put special attention in the power dissipation (P_D) and thermal parameters ($R_{\theta JA}$) of the device as these are the main things to consider for designing around it.

The power dissipation of the SO−8 package is a function of the pad size. This can vary from the minimum pad size for soldering to a pad size given for maximum power dissipation. Power dissipation for a surface mount device is determined by the maximum rated junction temperature of the die (T_J), the thermal resistance from the device junction to ambient ($R_{\theta JA}$), and the operating ambient temperature (T_A). Using the values provided in the NUD4001 device's data sheet, P_D can be calculated through the Formula 3:

Formula 3:

$$P_D = \frac{(T_J - T_A)}{R_{\theta JA}}$$

The NUD4001 device is rated for 1.13 W at T_A = 25°C whenever it is mounted onto FR−4, 2 sq inches pad, 1 oz coverage double side board. Its thermal resistance junction−to−ambient is 110°C/W under the same board conditions. From Formula 3, it is possible to calculate the power dissipation of the device for different ambient temperatures, which is reduced as the ambient temperature rises. Figure 7 shows the power derating graph at different ambient temperatures for the NUD4001 device (mounted onto FR−4, 2 sq inches copper pad, 1 oz coverage double sided board):

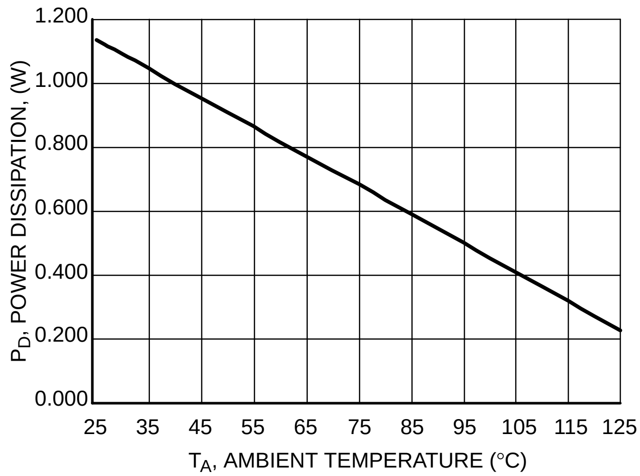

Figure 7. NUD4001 Power Dissipation (P_D) vs. Ambient Temperature (T_A)

Based on this information, it is possible to conclude that in order to optimize the LED's driver circuit design using the NUD4001 device, it is necessary to keep the ratio between V_{in} and V_{LEDs} as low as possible but also higher than the device's overhead value of 1.4 V. A good design window for this ratio should be between 1.5 V and 2.5 V for a 350 mA application.

NUD4001 DESIGN CONSIDERATIONS FOR 12 VAC APPLICATION CIRCUITS

Currently, most of the 12 Vac landscape lighting applications are being designed with the new technology of high intensity white LEDs. This LED technology needs to be supplied with currents between 100 mA and 700 mA, which makes the driver's power dissipation the main design consideration. Figure 8 illustrates a typical 12 Vac landscape lighting application circuit using the NUD4001 device as the LED's driver.

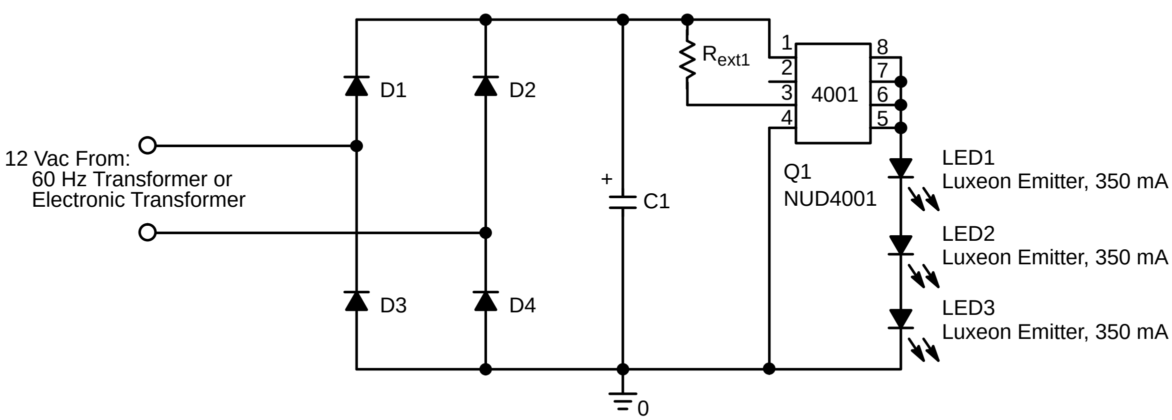

Figure 8. 12 Vac landscape lighting application circuit using the NUD4001 device to drive three 350 mA LEDs.

The first design consideration for the circuit shown in Figure 8 is the type of diodes needed for rectification (D1, D2, D3 and D4), because the 12 Vac input can be supplied from a 60 Hz transformer or an electronic switching transformer. Therefore, for the case where an electronic transformer is used, it is necessary to use rectifier devices with fast reverse recovery time (t_{rr}), otherwise problems will be experienced. The ON Semiconductor's MURA105T3 device is the ideal choice for these purposes.

Another design consideration is the voltage drop (V_{drop}) across the NUD4001 device (Q1) as it directly impacts the power dissipation of the device. As explained previously, V_{drop} is dependent on the average voltage (V_{avg}) supplied to the device and the voltage drop of the LED's array ($V_{drop} = V_{avg} - V_{LEDS}$). For an optimum design, this V_{drop} should be kept between 1.5 and 2.5 V for a 350 mA application. The value of the capacitor (C1) is an important factor to consider as V_{avg} strongly depends on it. The value of the capacitor in farads can be determined by using the Formula 4 developed by Savant [3].

Formula 4:

$$C = \frac{V_{MAX}}{\Delta V f_R R_L}$$

C = Value of the capacitor is farad
V_{MAX} = Peak AC line voltage
ΔV = Peak−peak capacitor voltage normal 0.4 V_{peak}
f_R = Twice the ac line frequency (120 for a 60 Hz system)
R_L = Effective load resistance

The effective load resistance (elr) is a term used for converting the LEDs and the driver into an equivalent resistance. It is the value of this resistance that is used in selecting the electrolytic capacitor. The elr is the input average voltage to the driver for a given ac line voltage value divided by the LED current. Using Formula 4, it is possible to theoretically calculate the capacitor needed for the wanted V_{avg}. In the case of Figure 8, V_{avg} is selected so that V_{drop} is no higher than 2.5 V. If the Vf of each LED is 3.5 V and they all are in series, then the resulting V_{avg} is 13 V ($V_{drop} = V_{(avg)} - V_{LEDS}$). Based on this and using Formula 4, the capacitor is calculated as follows:

$$C = \frac{13}{\left[\left(0.4 \cdot \left(12 \cdot \sqrt{2}\right)\right) \cdot 120 \cdot 37.2\right]}$$

$$C = 428\ \mu F$$

The closest commercial capacitor value is 470 µF, which gives a first approximation of the capacitor (C1) needed. This value should not be taken as the final one as it is necessary to do additional lab analysis to validate it. It is important to notice that Formula 4 is only applicable for cases where the input voltage is supplied through a 60 Hz transformer. Therefore if an electronic transformer is used then the formula is not applicable and the selection of the capacitor is most likely to be made through entirely lab work.

The final design steps for the circuit of Figure 8 are to calculate the external sense resistor (R_{ext}), and the NUD4001 device's power dissipation (P_D), which is made by following steps two and six of the design guide previously explained. The resulting R_{ext} for a LED's current of 320 mA is 2.2 Ω, and the power dissipation for the same current value is 0.8 W. Based on these calculations, the resulting Bill of Materials (BOM) is as follows:

Part Code	Vendor	Part Number
D1 − D4	ON Semiconductor	MURA105T3
Q1	ON Semiconductor	NUD4001
C1	VISHAY	470 µF, 25 V
R1	VISHAY	2.2 Ω
LED1 − LED3	LUMILEDs	LXHL−MW1D

Figures 9 and 10 show two oscilloscope pictures of the waveforms generated across the circuit shown in Figure 8 once the previous BOM is implemented. Figure 9 refers to the case where the input voltage is taken from a 60 Hz transformer (Tamura 3FD−424 or similar), and Figure 10 for the case of a switching transformer (Cooper LZR−404 or similar).

The current regulation performance of the circuit shown in Figure 8 for different average voltages values resulting from variations in the ac line, is similar than the one shown in Figure 5. At 25°C, the change of the LED's current is expected to be of only 1% for an increment of 15% in the input voltage.

There are some cases where the application only requires to light up one LED instead of three, so for those cases it is necessary to add an external power resistor to reduce the voltage drop (V_{drop}) across the NUD4001 device to have it operating within its power dissipation (P_D) capabilities. Figure 11 illustrates this circuit concept and Figures 12, 13 and 14 show the circuit regulation performance, the NUD4001 device's power dissipation, and the power dissipation in the power external resistor (R_{ext2}) respectively.

The BOM for D1–D4, C1 and R_{ext1} is similar to the one defined for the circuit of Figure 8. The only addition to the circuit of the Figure 11 is the power resistor R_{ext2}.

Similar circuits can be made to drive different LED arrays for low input voltage applications (6.0 V to 24 V). The main important to consider is to not exceed the power dissipation of the NUD4001 device to assure reliable operation.

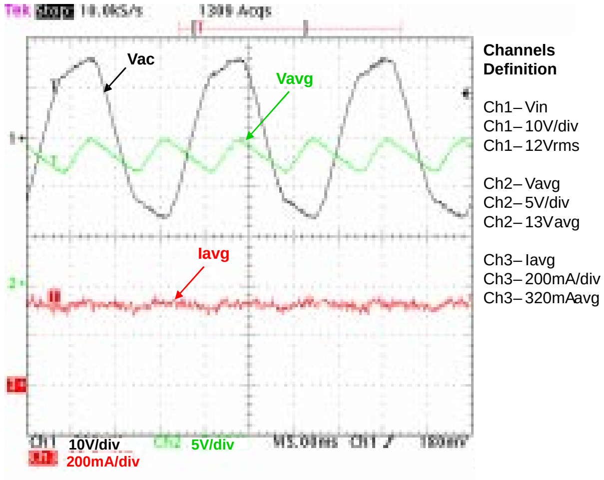

Figure 9. Waveforms generated across the circuit shown in Figure 8 when a 60 Hz transformer is used for the supply voltage.

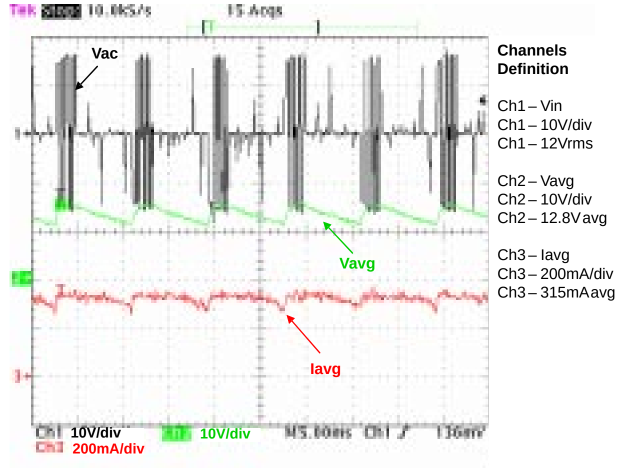

Figure 10. Waveforms generated across the circuit shown in Figure 7 when an electronic switching transformer is used for the supply voltage.

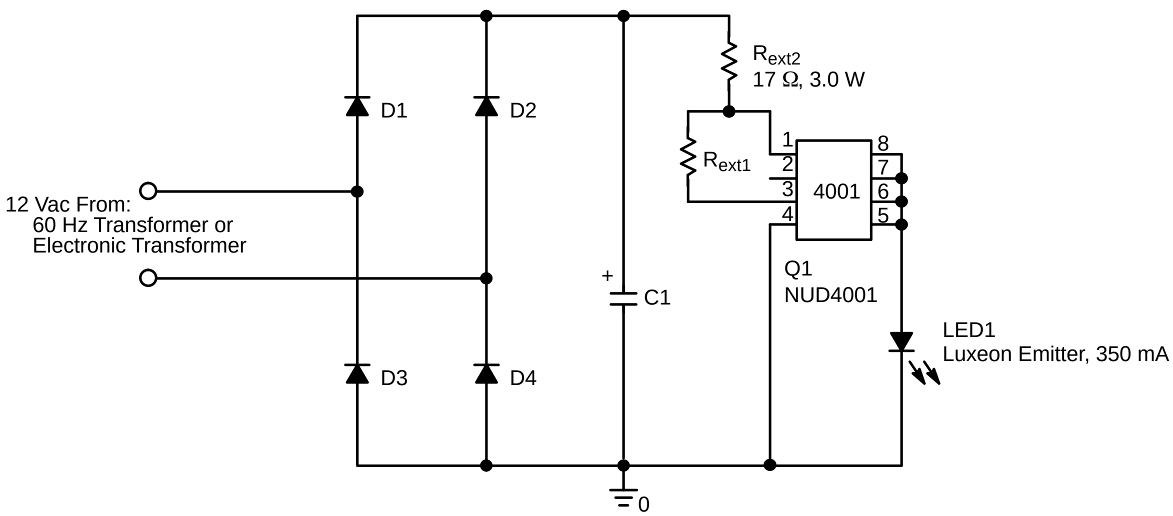

Figure 11. 12 Vac landscape lighting application circuit using the NUD4001 device to drive one 350 mA LED.

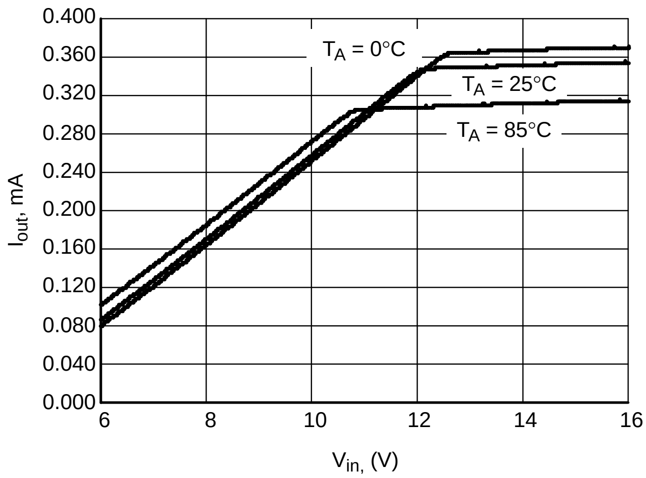

Figure 12. Current regulation performance of the circuit of Figure 11 for different V_{avg} values.

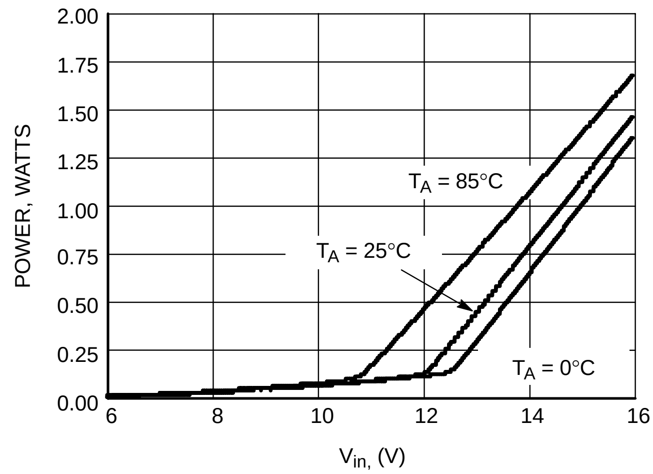

Figure 13. NUD4001 device's power dissipation when operating in the circuit of Figure 11 for different V_{avg} values.

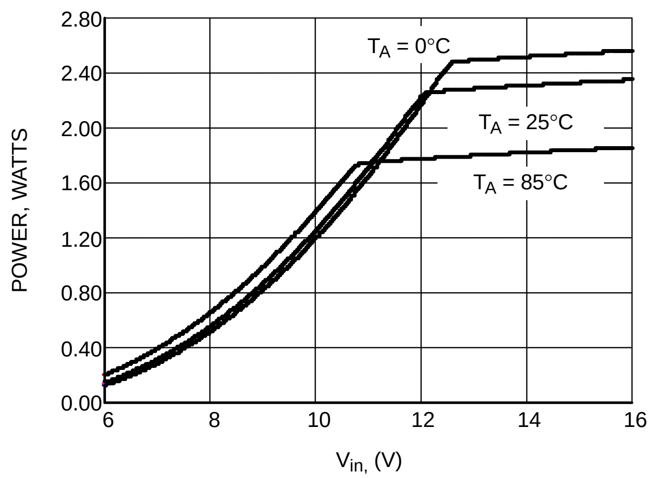

Figure 14. Power dissipation in R_{ext2} for the circuit of Figure 11 for different V_{avg} values.

NUD4011 DESIGN CONSIDERATIONS FOR 120 VAC APPLICATION CIRCUITS

In addition to the already explained design considerations for the NUD4001 device, it is necessary to consider power factor requirements and transient voltage protection when designing 120 Vac circuits around it. If there is no requirement for power factor, then the circuit becomes simpler as it does not need to have a full bridge rectifier nor a capacitor. Figure 15 shows a schematic diagram to drive a LED array of 30 white, low current units (30 mA) for a 120 Vac application using the NUD4011 device. This device is similar than the NUD4001 device but with higher breakdown voltage.

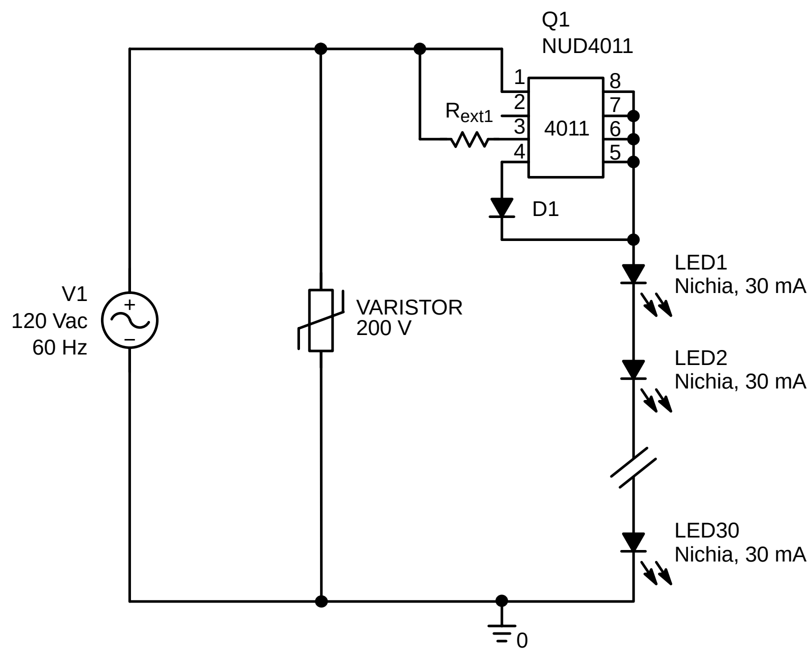

Figure 15. 120 Vac application circuit using the NUD4011 to drive 30 white low current LEDs (30 mA) in series. No requirement for power factor.

For Figure 15, current conduction occurs only after the peak voltage of the positive ac cycle exceeds the forward voltage of the LED array. The total forward voltage is given by the Vf voltage of a specific LED device multiplied by the number of LEDs connected in series. Assuming that Nichia white LEDs with characteristics of Vf = 3.6 V and If = 30 mA are used, then the resulting total forward voltage of the 30 series LEDs array is 108 V. This indicates that current conduction is only present during the time that the positive cycle of the ac input is higher than 108 V. This is something very important to consider for determining the value of the external resistor (R_{ext1}) to set the LED's current because it is now dependent on the peak current value and the conduction time. To better illustrate this, the current peak calculation is made for the circuit shown in Figure 15. Formula 5 shows the equation to calculate the instantaneous voltage over time for a sinusoidal waveform:

Formula 5:

$$V = V_{peak} \cdot \sin\theta$$

Using this formula and other analogies, it is possible to determine the time for current conduction during the positive cycle of the ac input.

As known, V_{peak} happens at θ = 90° of the ac cycle, which translates to 4.165 msec in time for a 60 Hz frequency.

Formula 5 is then used to find θ for 108 V:

$$108\ \text{V} = \left(120 \cdot \sqrt{2}\right) \cdot \sin\theta$$

$$\theta = 39.52^\circ$$

and then, since 90° is 4.165 msec, then 39.44° is 1.82 msec. Based on this, the current conduction time is calculated as follows:

$$(4.165\ \text{msec} - 1.82\ \text{msec}) \cdot 2 = 4.67\ \text{msec}$$

Assuming that the 60 Hz current waveform is square shaped, it is possible to say that since 16.66 msec is 100% duty cycle, and 4.67 msec is 28%, therefore:

$$I_{(avg)} = I_{peak} \cdot \text{duty cycle}$$

If the average LED current wanted is 25 mA:

$$I_{peak} = \frac{I_{(avg)}}{\text{duty cycle}}$$

$$I_{peak} = \frac{25\ \text{mA}}{0.28}$$

$$I_{peak} = 89.2\ \text{mA}$$

Upon the calculation of the I_{peak}, it is possible to calculate R_{ext}:

$$R_{ext} = \frac{0.7\ \text{V}}{I_{peak}}$$

$$R_{ext} = 7.84\ \Omega$$

This theoretical procedure provides a way to have a first approximation for the value of the R_{ext} needed. However it should not be taken as final until validated through lab analysis. Figure 11 shows the expected current waveforms in the LED's array for the circuit shown in Figure 10, with $R_{ext} = 7.8\ \Omega$.

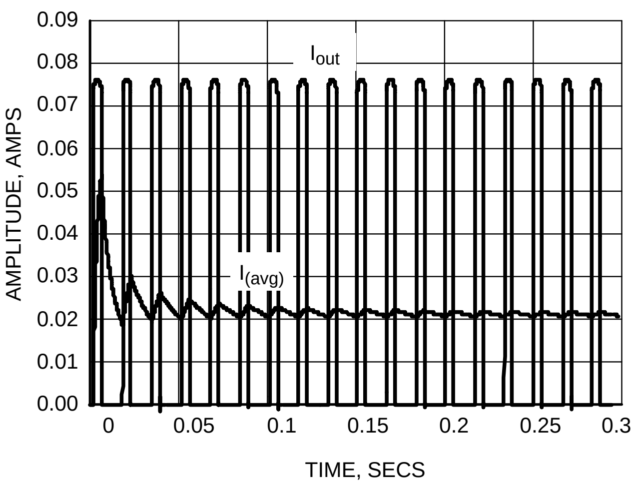

Figure 16. I_{peak} and $I_{(avg)}$ waveforms through the LED's array for the circuit shown in Figure 15, with $R_{ext} = 7.8\ \Omega$.

As it can be observed, the I_{peak} and $I_{(avg)}$ values do not exactly match with the calculated ones. So this is why, it is important to do lab analysis to achieve specific design targets.

The power dissipation of the NUD4011 device for the circuit shown in Figure 15 is calculated as follows:

$$P_D = [(V_{peak} - V_{LEDs}) \cdot I_{(avg)}] \cdot 0.28$$

$$P_D = 0.464\ \text{W}$$

In order to achieve lower power dissipation in the LED driver (NUD4011), it is necessary to configure the LED's array in a way so that the total Vf is close enough to the voltage applied to it.

If the application has power factor requirements, then it is necessary to use a full bridge rectifier across the ac input to keep in phase the current and voltage waveforms as much as possible. The R_{ext} calculation is made through the same procedure already explained. The only variation is the frequency which is increased to 120 Hz because of the usage of a full bridge rectifier. The frequency affects the duty cycle and therefore the I_{peak} calculation.

NUD4001 DEVICE'S PWM AND ENABLE FUNCTIONS

In addition to the current regulation function, the NUD4001 device offers the ability to PWM the LEDs for dimming applications by using an external small signal NPN transistor connected between pin 4 and ground. This is a very important feature specially for those applications where multicolor lighting is required (swimming pools, bars, etc.). The same small signal transistor can be used for an enable function for conditioning applications. Figure 17 illustrates the circuit for PWM function in a 12 Vdc application to drive three high current (350 mA) white LEDs.

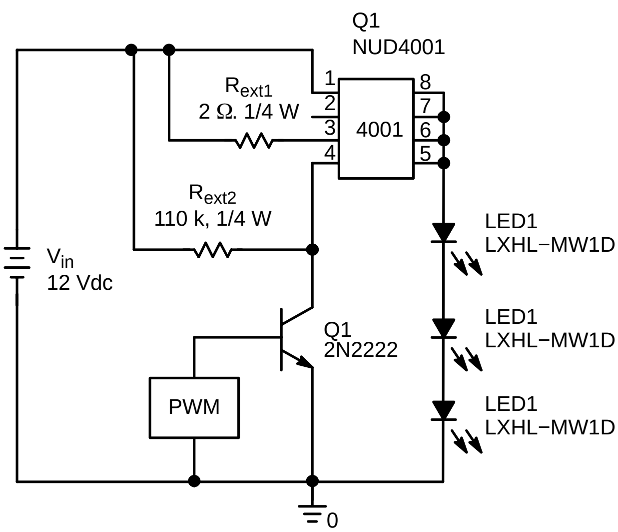

Figure 17. NUD4001 Device Configuration for PWM Function

The function of R_{ext2} is to pull up the pin 4 of the device when the PWM signal in the base of the NPN transistor is low. The average current applied to the LED is directly dependent on the duty cycle ($I_{avg} = I_{peak}$ x duty cycle). And the LED's light intensity is directly dependent on the average current $I_{(avg)}$ applied. In the case of Figure 17, the current is set to be 350 mA at 100% duty cycle and therefore, it proportionally decreases for narrower duty cycles. The PWM circuit is good for frequencies between 100 Hz and 1.0 kHz. Most dimming applications use frequencies within this range.

The same type of configuration is used for the enable function. The only difference is the way that the base of the NPN transistor is driven. The same concepts can be applied for high voltage applications, the only things to consider is to select a transistor with high enough breakdown voltage, and to add an external low power resistor (1/4 W) of 80 kΩ between pin 4 and the collector of the PWM transistor.

SUMMARY

Discrete Methods (resistors)

Discrete methods to drive LEDs are not recommended nor often used because they basically eliminate the valuable features of LEDs, and sometimes even cause total damage.

Linear Regulators

Although the concept of linear regulators provide good current regulation for LED's circuits, it may not still be optimum for applications where cost is critical, and either for those applications requiring enable or electronic dimming functions.

NUD4001 Device

The NUD4001 device offers a low cost current regulation integrated solution for different LED's circuits of high and low ac/dc voltage (6.0 V – 24 V).

Design considerations such as the device's power dissipation, breakdown voltage and maximum current capability have to be taken into account before implementation in application circuits.

Selection of the proper LED's configuration to drop as much as possible of the supply voltage in the LED array is key to achieve design optimization. If a low quantity of LEDs are driven from a high voltage supply, then it is necessary to add an external power resistor to reduce the voltage drop across the device (see Figure 11).

Selection of the proper copper area according to the application needs and device's specifications is key to achieving optimum device's operation.

The enable and PWM features as well as the low cost implementation is what distinguishes the NUD4001 and NUD4011 devices from linear regulators and discrete solutions (resistors) to drive LEDs.

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