

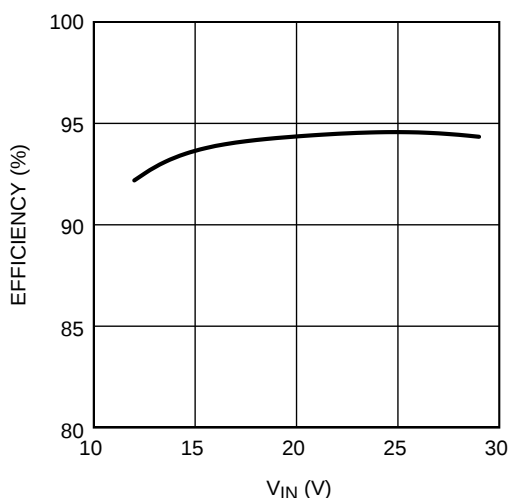
## **AN-1986 LM3429 Boost Evaluation Board**

### **1 Introduction**

This evaluation board showcases the LM3429 NFET controller used with a boost current regulator. It is designed to drive 9 to 12 LEDs at a maximum average LED current of 1A from a DC input voltage of 10 to 26V.

The evaluation board showcases most features of the LM3429 including PWM dimming, overvoltage protection and input under-voltage lockout. It also has a right angle connector (J7) which can mate with an external LED load board allowing for the LEDs to be mounted close to the driver. Alternatively, the LED+ and LED- banana jacks can be used to connect the LED load.

The boost circuit can be easily redesigned for different specifications by changing only a few components (see [Alternate Designs](#)). Note that design modifications can change the system efficiency for better or worse. See the *LM3429 LM3429Q1 N-Channel Controller for Constant Current LED Drivers* ([SNVS616](#)) data sheet for a comprehensive explanation of the device and application information.



**Figure 1. Efficiency with 9 Series LEDs AT 1A**

## 2 Schematic

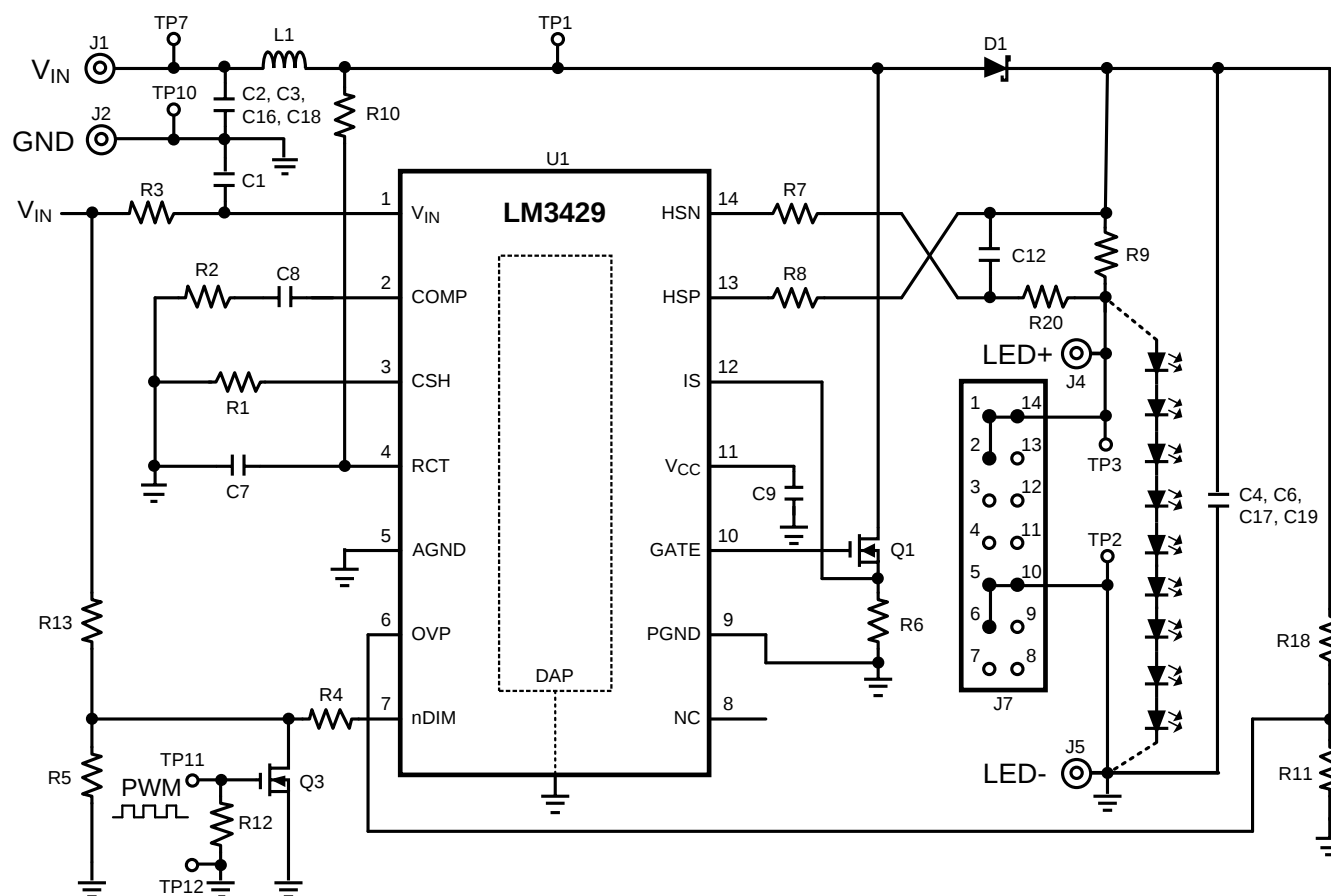


Figure 2. Board Schematic

### 3 Pin Descriptions

| Pin      | Name            | Description                          | Application Information                                                                                                                                                                                                                                                       |
|----------|-----------------|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | V <sub>IN</sub> | Input Voltage                        | Bypass with 100 nF capacitor to AGND as close to the device as possible in the circuit board layout.                                                                                                                                                                          |
| 2        | COMP            | Compensation                         | Connect a capacitor to AGND.                                                                                                                                                                                                                                                  |
| 3        | CSH             | Current Sense High                   | Connect a resistor to AGND to set the signal current. For analog dimming, connect a controlled current source or a potentiometer to AGND as detailed in the <i>Analog Dimming</i> section.                                                                                    |
| 4        | RCT             | Resistor Capacitor Timing            | Connect a resistor from the switch node and a capacitor to AGND to set the switching frequency.                                                                                                                                                                               |
| 5        | AGND            | Analog Ground                        | Connect to PGND through the DAP copper circuit board pad to provide proper ground return for CSH, COMP, and RCT.                                                                                                                                                              |
| 6        | OVP             | Over-Voltage Protection              | Connect to a resistor divider from V <sub>O</sub> to program output over-voltage lockout (OVLO). Turn-off threshold is 1.24V and hysteresis for turn-on is provided by 20 $\mu$ A current source.                                                                             |
| 7        | nDIM            | Not DIM input                        | Connect a PWM signal for dimming as detailed in the <i>PWM Dimming</i> section and/or a resistor divider from V <sub>IN</sub> to program input under-voltage lockout (UVLO). Turn-on threshold is 1.24V and hysteresis for turn-off is provided by 20 $\mu$ A current source. |
| 8        | NC              | No Connection                        | Leave open.                                                                                                                                                                                                                                                                   |
| 9        | PGND            | Power Ground                         | Connect to AGND through the DAP copper circuit board pad to provide proper ground return for GATE.                                                                                                                                                                            |
| 10       | GATE            | Gate Drive Output                    | Connect to the gate of the external NFET.                                                                                                                                                                                                                                     |
| 11       | V <sub>CC</sub> | Internal Regulator Output            | Bypass with a 2.2 $\mu$ F–3.3 $\mu$ F, ceramic capacitor to PGND.                                                                                                                                                                                                             |
| 12       | IS              | Main Switch Current Sense            | Connect to the drain of the main N-channel MosFET switch for R <sub>DS-ON</sub> sensing or to a sense resistor installed in the source of the same device.                                                                                                                    |
| 13       | HSP             | High-Side LED Current Sense Positive | Connect through a series resistor to the positive side of the LED current sense resistor.                                                                                                                                                                                     |
| 14       | HSN             | High-Side LED Current Sense Negative | Connect through a series resistor to the negative side of the LED current sense resistor.                                                                                                                                                                                     |
| DAP (15) | DAP             | Thermal pad on bottom of IC          | Star ground, connecting AGND and PGND.                                                                                                                                                                                                                                        |

### 4 Bill of Materials

| Qty | Part ID          | Part Value               | Manufacturer | Part Number        |
|-----|------------------|--------------------------|--------------|--------------------|
| 2   | C1, C4           | 0.1 $\mu$ F X7R 10% 100V | TDK          | C2012X7R2A104K     |
| 4   | C2, C3, C16, C18 | 4.7 $\mu$ F X7R 10% 100V | MURATA       | GRM55ER72A475KA01L |
| 3   | C6, C17, C19     | 2.2 $\mu$ F X7R 10% 100V | TDK          | C4532X7R2A225K     |
| 1   | C7               | 1000 pF COG/NPO 5% 50V   | MURATA       | GRM2165C1H102JA01D |
| 1   | C8               | 1 $\mu$ F X7R 10% 16V    | MURATA       | GRM21BR71C105KA01L |
| 1   | C9               | 2.2 $\mu$ F X7R 10% 16V  | MURATA       | GRM21BR71C225KA12L |
| 1   | C12              | 0.1 $\mu$ F X7R 10% 25V  | MURATA       | GRM21BR71E104KA01L |
| 1   | D1               | Schottky 100V 12A        | VISHAY       | 12CWQ10FNPBF       |
| 4   | J1, J2, J4, J5   | banana jack              | KEystone     | 575-8              |
| 1   | J7               | 2 x 7 shrouded header    | SAMTEC       | TSSH-107-01-SDRA   |
| 1   | L1               | 33 $\mu$ H 20% 6.3A      | COILCRAFT    | MSS1278-333MLB     |
| 1   | Q1               | NMOS 100V 40A            | VISHAY       | SUD40N10-25        |
| 1   | Q3               | NMOS 60V 260 mA          | ON-SEMI      | 2N7002ET1G         |
| 1   | R1               | 12.4 k $\Omega$ 1%       | VISHAY       | CRCW080512k4FKEA   |
| 1   | R2               | 0 $\Omega$ 1%            | VISHAY       | CRCW08050000Z0EA   |
| 2   | R3, R20          | 10 $\Omega$ 1%           | VISHAY       | CRCW080510R0FKEA   |

*Bill of Materials*
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|   |                                         |                       |          |                  |
|---|-----------------------------------------|-----------------------|----------|------------------|
| 1 | R4                                      | 16.9 k $\Omega$ 1%    | VISHAY   | CRCW080516k9FKEA |
| 1 | R5                                      | 1.43 k $\Omega$ 1%    | VISHAY   | CRCW08051k43FKEA |
| 1 | R6                                      | 0.04 $\Omega$ 1% 1W   | VISHAY   | WSL2512R0400FEA  |
| 2 | R7, R8                                  | 1.0 k $\Omega$ 1%     | VISHAY   | CRCW08051k00FKEA |
| 1 | R9                                      | 0.1 $\Omega$ 1% 1W    | VISHAY   | WSL2512R1000FEA  |
| 1 | R10                                     | 35.7 k $\Omega$ 1%    | VISHAY   | CRCW080535k7FKEA |
| 1 | R11                                     | 15.8 k $\Omega$ 1%    | VISHAY   | CRCW080515k8FKEA |
| 2 | R12, R13                                | 10.0 k $\Omega$ 1%    | VISHAY   | CRCW080510k0FKEA |
| 1 | R18                                     | 750 k $\Omega$ 1%     | VISHAY   | CRCW0805750kFKEA |
| 7 | TP1, TP2, TP3, TP7,<br>TP10, TP11, TP12 | turret                | KEYSTONE | 1502-2           |
| 1 | U1                                      | Buck-boost controller | TI       | LM3429           |

## 5 PCB Layout

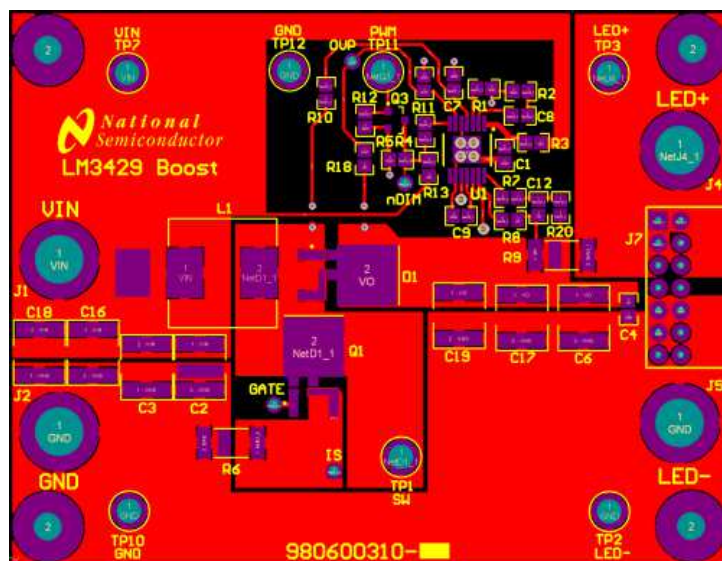


Figure 3. Top Layer

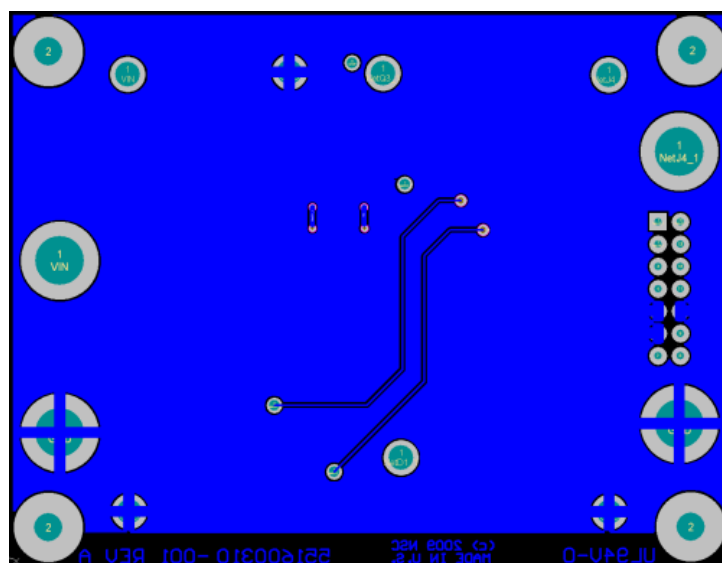


Figure 4. Bottom Layer

## 6 Design Procedure

Refer to *LM3429 LM3429Q1 N-Channel Controller for Constant Current LED Drivers* ([SNVS616](#)) data sheet for design considerations.

### 6.1 Specifications

$$N = 9$$

$$V_{LED} = 3.5V$$

$$r_{LED} = 325 \text{ m}\Omega$$

$$V_{IN} = 24V$$

$$V_{IN-MIN} = 10V; V_{IN-MAX} = 27V$$

$$f_{SW} = 700 \text{ kHz}$$

$$V_{SNS} = 100 \text{ mV}$$

$$I_{LED} = 1A$$

$$\Delta i_{L-PP} = 250 \text{ mA}$$

$$\Delta i_{LED-PP} = 17 \text{ mA}$$

$$\Delta v_{IN-PP} = 100 \text{ mV}$$

$$I_{LIM} = 6A$$

$$V_{TURN-ON} = 10V; V_{HYS} = 3V$$

$$V_{TURN-OFF} = 60V; V_{HYSO} = 15V$$

### 6.2 Operating Point

Solve for  $V_O$  and  $r_D$ :

$$V_O = N \times V_{LED} = 9 \times 3.5V = 31.5V \quad (1)$$

$$r_D = N \times r_{LED} = 9 \times 325 \text{ m}\Omega = 2.925\Omega \quad (2)$$

Solve for  $D$ ,  $D'$ ,  $D_{MAX}$ , and  $D_{MIN}$ :

$$D = \frac{V_O - V_{IN}}{V_O} = \frac{31.5V - 24V}{31.5V} = 0.238 \quad (3)$$

$$D' = 1 - D = 1 - 0.238 = 0.762 \quad (4)$$

$$D_{MIN} = \frac{V_O - V_{IN-MAX}}{V_O} = \frac{31.5V - 26V}{31.5V} = 0.175 \quad (5)$$

$$D_{MAX} = \frac{V_O - V_{IN-MIN}}{V_O} = \frac{31.5V - 10V}{31.5V} = 0.683 \quad (6)$$

### 6.3 Switching Frequency

Assume  $C7 = 1 \text{ nF}$  and solve for  $R10$ :

$$R10 = \frac{25}{f_{SW} \times C7} = \frac{25}{700 \text{ kHz} \times 1 \text{ nF}} = 35.7 \text{ k}\Omega \quad (7)$$

The closest standard resistor is actually  $35.7 \text{ k}\Omega$  therefore the  $f_{SW}$  is:

$$f_{SW} = \frac{25}{R10 \times C7} = \frac{25}{35.7 \text{ k}\Omega \times 1 \text{ nF}} = 700 \text{ kHz} \quad (8)$$

The chosen components from step 2 are:

|                                                     |
|-----------------------------------------------------|
| $C7 = 1 \text{ nF}$<br>$R10 = 35.7 \text{ k}\Omega$ |
|-----------------------------------------------------|

(9)

## 6.4 Average LED Current

Solve for R9:

$$R9 = \frac{V_{SNS}}{I_{LED}} = \frac{100 \text{ mV}}{1 \text{ A}} = 0.1 \Omega \quad (10)$$

Assume R1 = 12.4 kΩ and solve for R8:

$$R8 = \frac{I_{LED} \times R1 \times R9}{1.24 \text{ V}} = \frac{1 \text{ A} \times 12.4 \text{ k}\Omega \times 0.1 \Omega}{1.24 \text{ V}} = 1.0 \text{ k}\Omega \quad (11)$$

The closest standard resistor for R9 is 0.1Ω and the closest for R8 (and R7) is actually 1 kΩ therefore  $I_{LED}$  is:

$$I_{LED} = \frac{1.24 \text{ V} \times R8}{R9 \times R1} = \frac{1.24 \text{ V} \times 1.0 \text{ k}\Omega}{0.1 \Omega \times 12.4 \text{ k}\Omega} = 1.0 \text{ A} \quad (12)$$

The chosen components from step 3 are:

$$\begin{aligned} R9 &= 0.1 \Omega \\ R1 &= 12.4 \text{ k}\Omega \\ R8 &= R7 = 1 \text{ k}\Omega \end{aligned} \quad (13)$$

## 6.5 Inductor Ripple Current

Solve for L1:

$$L1 = \frac{V_{IN} \times D}{\Delta i_{L-PP} \times f_{SW}} = \frac{24 \text{ V} \times 0.238}{250 \text{ mA} \times 700 \text{ kHz}} = 32.6 \mu\text{H} \quad (14)$$

The closest standard inductor is 33 μH therefore the actual  $\Delta i_{L-PP}$  is:

$$\Delta i_{L-PP} = \frac{V_{IN} \times D}{L1 \times f_{SW}} = \frac{24 \text{ V} \times 0.238}{33 \mu\text{H} \times 700 \text{ kHz}} = 247 \text{ mA} \quad (15)$$

Determine minimum allowable RMS current rating:

$$\begin{aligned} I_{L-RMS} &= \frac{I_{LED}}{D'} \times \sqrt{1 + \frac{1}{12} \times \left( \frac{\Delta i_{L-PP} \times D'}{I_{LED}} \right)^2} \\ I_{L-RMS} &= \frac{1 \text{ A}}{0.762} \times \sqrt{1 + \frac{1}{12} \times \left( \frac{247 \text{ mA} \times 0.762}{1 \text{ A}} \right)^2} \\ I_{L-RMS} &= 1.31 \text{ A} \end{aligned} \quad (16)$$

The chosen component from step 4 is:

$$L1 = 33 \mu\text{H} \quad (17)$$

## 6.6 Output Capacitance

Solve for  $C_O$ :

$$\begin{aligned} C_O &= \frac{I_{LED} \times D}{r_D \times \Delta i_{LED-PP} \times f_{SW}} \\ C_O &= \frac{1 \text{ A} \times 0.238}{2.925 \Omega \times 17 \text{ mA} \times 700 \text{ kHz}} = 6.84 \mu\text{F} \end{aligned} \quad (18)$$

A total value of 6.6 μF (using 3 2.2 μF X7R ceramic capacitors) is chosen therefore the actual  $\Delta i_{LED-PP}$  is:

$$\begin{aligned} \Delta i_{LED-PP} &= \frac{I_{LED} \times D}{r_D \times C_O \times f_{SW}} \\ \Delta i_{LED-PP} &= \frac{1 \text{ A} \times 0.238}{2.925 \Omega \times 6.6 \mu\text{F} \times 700 \text{ kHz}} = 17.6 \text{ mA} \end{aligned} \quad (19)$$

Determine minimum allowable RMS current rating:

$$I_{CO-RMS} = I_{LED} \times \sqrt{\frac{D_{MAX}}{1 - D_{MAX}}} = 1A \times \sqrt{\frac{0.683}{1 - 0.683}} = 1.47A \quad (20)$$

The chosen components from step 5 are:

$$C6 = C17 = C19 = 2.2 \mu F \quad (21)$$

## 6.7 Peak Current Limit

Solve for R6:

$$R6 = \frac{245 \text{ mV}}{I_{LIM}} = \frac{245 \text{ mV}}{6A} = 0.041 \Omega \quad (22)$$

The closest standard resistor is 0.04  $\Omega$  therefore  $I_{LIM}$  is:

$$I_{LIM} = \frac{245 \text{ mV}}{R6} = \frac{245 \text{ mV}}{0.04 \Omega} = 6.1A \quad (23)$$

The chosen component from step 6 is:

$$R6 = 0.04 \Omega \quad (24)$$

## 6.8 Loop Compensation

$\omega_{P1}$  is approximated:

$$\omega_{P1} = \frac{2}{r_D \times C_O} = \frac{2}{2.925 \Omega \times 6.6 \mu F} = 104k \frac{\text{rad}}{\text{sec}} \quad (25)$$

$\omega_{Z1}$  is approximated:

$$\omega_{Z1} = \frac{r_D \times D'^2}{L1} = \frac{2.925 \Omega \times 0.762^2}{33 \mu H} = 52k \frac{\text{rad}}{\text{sec}} \quad (26)$$

$T_{U0}$  is approximated:

$$T_{U0} = \frac{D' \times 310V}{I_{LED} \times R_{LIM}} = \frac{0.762 \times 310V}{1A \times 0.04 \Omega} = 5900 \quad (27)$$

To ensure stability, calculate  $\omega_{P2}$ :

$$\omega_{P2} = \frac{\min(\omega_{P1}, \omega_{Z1})}{5 \times T_{U0}} = \frac{52k \frac{\text{rad}}{\text{sec}}}{5 \times 5900} = 1.76 \frac{\text{rad}}{\text{sec}} \quad (28)$$

Solve for C8:

$$C8 = \frac{1}{\omega_{P2} \times 5e^6 \Omega} = \frac{1}{1.76 \frac{\text{rad}}{\text{sec}} \times 5e^6 \Omega} = 0.11 \mu F \quad (29)$$

Since PWM dimming can be evaluated with this board, a much larger compensation capacitor  $C8 = 1.0 \mu F$  is chosen.

To attenuate switching noise, calculate  $\omega_{P3}$ :

$$\begin{aligned} \omega_{P3} &= \max(\omega_{P1}, \omega_{Z1}) \times 10 = \omega_{P1} \times 10 \\ \omega_{P3} &= 104k \frac{\text{rad}}{\text{sec}} \times 10 = 1.04M \frac{\text{rad}}{\text{sec}} \end{aligned} \quad (30)$$

Assume  $R20 = 10 \Omega$  and solve for C12:

$$C12 = \frac{1}{10 \Omega \times \omega_{P3}} = \frac{1}{10 \Omega \times 1.04M \frac{\text{rad}}{\text{sec}}} = 0.097 \mu F \quad (31)$$

The chosen components from step 7 are:

$$\begin{aligned} C8 &= 1.0 \mu\text{F} \\ R20 &= 10\Omega \\ C12 &= 0.1 \mu\text{F} \end{aligned}$$

(32)

## 6.9 Input Capacitance

Solve for the minimum  $C_{IN}$ :

$$C_{IN} = \frac{\Delta i_{L-PP}}{8 \times \Delta V_{IN-PP} \times f_{SW}} = \frac{250 \text{ mA}}{8 \times 100 \text{ mV} \times 700 \text{ kHz}} = 0.45 \mu\text{F} \quad (33)$$

To minimize power supply interaction a much larger capacitance of approximately 20  $\mu\text{F}$  is used, therefore the actual  $\Delta V_{IN-PP}$  is much lower. Since high voltage ceramic capacitor selection is limited, four 4.7  $\mu\text{F}$  X7R capacitors are chosen.

Determine minimum allowable RMS current rating:

$$I_{IN-RMS} = \frac{\Delta i_{L-PP}}{\sqrt{12}} = \frac{250 \text{ mA}}{\sqrt{12}} = 72 \text{ mA} \quad (34)$$

The chosen components from step 8 are:

$$C2 = C3 = C16 = C18 = 4.7 \mu\text{F} \quad (35)$$

## 6.10 NFET

Determine minimum Q1 voltage rating and current rating:

$$V_{T-MAX} = V_O = 31.5\text{V} \quad (36)$$

$$I_{T-MAX} = \frac{0.683}{1 - 0.683} \times 1\text{A} = 2.2\text{A} \quad (37)$$

A 100V NFET is chosen with a current rating of 40A due to the low  $R_{DS-ON} = 50 \text{ m}\Omega$ . Determine  $I_{T-RMS}$  and  $P_T$ :

$$I_{T-RMS} = \frac{I_{LED}}{D'} \times \sqrt{D} = \frac{1\text{A}}{0.762} \times \sqrt{0.238} = 640 \text{ mA} \quad (38)$$

$$P_T = I_{T-RMS}^2 \times R_{DS-ON} = 640 \text{ mA}^2 \times 50 \text{ m}\Omega = 20 \text{ mW} \quad (39)$$

The chosen component from step 9 is:

$$Q1 \rightarrow 40\text{A}, 100\text{V}, \text{ DPAK} \quad (40)$$

## 6.11 Diode

Determine minimum D1 voltage rating and current rating:

$$V_{RD-MAX} = V_O = 31.5\text{V} \quad (41)$$

$$I_{D-MAX} = I_{LED} = 1\text{A} \quad (42)$$

A 100V diode is chosen with a current rating of 12A and  $V_D = 600 \text{ mV}$ . Determine  $P_D$ :

$$P_D = I_D \times V_{FD} = 1\text{A} \times 600 \text{ mV} = 600 \text{ mW} \quad (43)$$

The chosen component from step 10 is:

$$D1 \rightarrow 12\text{A}, 100\text{V}, \text{ DPAK} \quad (44)$$

## 6.12 Input UVLO

Since PWM dimming will be evaluated a three resistor network will be used. Assume  $R13 = 10 \text{ k}\Omega$  and solve for  $R5$ :

$$R5 = \frac{1.24V \times R13}{V_{\text{TURN-ON}} - 1.24V} = \frac{1.24V \times 10\text{ k}\Omega}{10V - 1.24V} = 1.43\text{ k}\Omega \quad (45)$$

The closest standard resistor is 1.43 kΩ therefore  $V_{\text{TURN-ON}}$  is:

$$V_{\text{TURN-ON}} = \frac{1.24V \times (R5 + R13)}{R5}$$

$$V_{\text{TURN-ON}} = \frac{1.24V \times (1.43\text{ k}\Omega + 10\text{ k}\Omega)}{1.43\text{ k}\Omega} = 9.91V \quad (46)$$

Solve for R4:

$$R4 = \frac{R5 \times (V_{\text{HYS}} - 20\text{ }\mu\text{A} \times R13)}{20\text{ }\mu\text{A} \times (R5 + R13)}$$

$$R4 = \frac{1.43\text{ k}\Omega \times (2.9V - 20\text{ }\mu\text{A} \times 10\text{ k}\Omega)}{20\text{ }\mu\text{A} \times (1.43\text{ k}\Omega + 10\text{ k}\Omega)} = 16.9\text{ k}\Omega \quad (47)$$

The closest standard resistor is 16.9 kΩ making  $V_{\text{HYS}}$ :

$$V_{\text{HYS}} = \frac{20\text{ }\mu\text{A} \times R4 \times (R5 + R13)}{R5} + 20\text{ }\mu\text{A} \times R_{\text{UV2}}$$

$$V_{\text{HYS}} = \frac{20\text{ }\mu\text{A} \times 16.9\text{ k}\Omega \times (1.43\text{ k}\Omega + 10\text{ k}\Omega)}{1.43\text{ k}\Omega} + 20\text{ }\mu\text{A} \times 10\text{ k}\Omega = 2.9V \quad (48)$$

The chosen components from step 11 are:

|                                                                                       |
|---------------------------------------------------------------------------------------|
| $R5 = 1.43\text{ k}\Omega$<br>$R13 = 10\text{ k}\Omega$<br>$R4 = 16.9\text{ k}\Omega$ |
|---------------------------------------------------------------------------------------|

(49)

### 6.13 Output OVLO

Solve for R18:

$$R18 = \frac{V_{\text{HYSO}}}{20\text{ }\mu\text{A}} = \frac{15V}{20\text{ }\mu\text{A}} = 750\text{ k}\Omega \quad (50)$$

The closest standard resistor is 750 kΩ therefore  $V_{\text{HYSO}}$  is:

$$V_{\text{HYSO}} = R18 \times 20\text{ }\mu\text{A} = 750\text{ k}\Omega \times 20\text{ }\mu\text{A} = 15V \quad (51)$$

Solve for R11:

$$R11 = \frac{1.24V \times R18}{V_{\text{TURN-OFF}} - 1.24V} = \frac{1.24V \times 750\text{ k}\Omega}{60V - 1.24V} = 15.8\text{ k}\Omega \quad (52)$$

The closest standard resistor is 15.8 kΩ making  $V_{\text{TURN-OFF}}$ :

$$V_{\text{TURN-OFF}} = \frac{1.24V \times (R11 + R18)}{R11}$$

$$V_{\text{TURN-OFF}} = \frac{1.24V \times (15.8\text{ k}\Omega + 750\text{ k}\Omega)}{15.8\text{ k}\Omega} = 40V \quad (53)$$

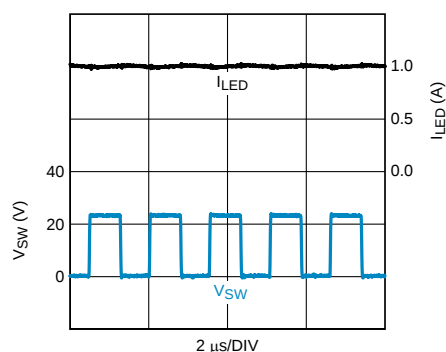
The chosen components from step 12 are:

|                                                           |
|-----------------------------------------------------------|
| $R11 = 15.8\text{ k}\Omega$<br>$R18 = 750\text{ k}\Omega$ |
|-----------------------------------------------------------|

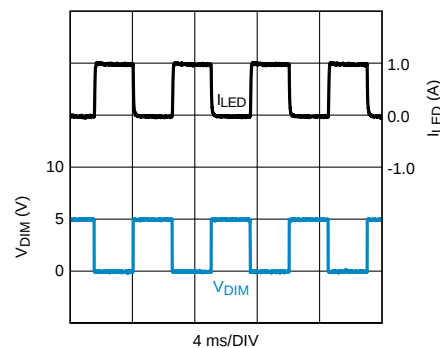
(54)

## 7 Typical Waveforms

$T_A = +25^\circ\text{C}$ ,  $V_{IN} = 24\text{V}$  and  $V_O = 31.5\text{V}$ .



**Figure 5. Standard Operation**  
TP1 Switch Node Voltage ( $V_{SW}$ )  
LED Current ( $I_{LED}$ )



**Figure 6. 200Hz 50% PWM Dimming**  
TP11 Dim Voltage ( $V_{DIM}$ )  
LED Current ( $I_{LED}$ )

## 8 Alternate Designs

Alternate designs with the LM3429 evaluation board are possible with very few changes to the existing hardware. The evaluation board FETs and diodes are already rated higher than necessary for design flexibility. The input UVLO, output OVP, input and output capacitance can remain the same for the designs shown below. These alternate designs can be evaluated by changing only R9, R10, and L1.

[Table 1](#) gives the main specifications for four different designs and the corresponding values for R9, R10, and L1. PWM dimming can be evaluated with any of these designs.

**Table 1. Alternate Design Specifications**

| Specification / Component | Design 1 | Design 2 | Design 3 | Design 4 |
|---------------------------|----------|----------|----------|----------|
| $V_{IN}$                  | 10V      | 15V      | 20V      | 25V      |
| $V_O$                     | 14V      | 21V      | 28V      | 35V      |
| $f_{SW}$                  | 600kHz   | 700kHz   | 500kHz   | 700kHz   |
| $I_{LED}$                 | 2A       | 500mA    | 2.5A     | 1.25A    |
| R9                        | 0.05Ω    | 0.2Ω     | 0.04Ω    | 0.08Ω    |
| R10                       | 41.2 kΩ  | 35.7 kΩ  | 49.9 kΩ  | 35.7 kΩ  |
| L1                        | 22μH     | 68μH     | 15μH     | 33μH     |

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|                               |                                                                                          |
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