

AN-1969 LM3424 Boost Evaluation Board

1 Introduction

This evaluation board showcases the LM3424 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 many of the LM3424 features including thermal foldback, analog dimming, external switching frequency synchronization, and high frequency PWM dimming, among others. There are many external connection points to facilitate the full evaluation of the LM3424 device including inputs, outputs and test points. Refer to [Table 1](#) for a summary of the connectors and test points.

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.

This application note is designed to be used in conjunction with the *LM3424 Constant Current N-Channel Controller with Thermal Foldback for Driving LEDs* ([SNVS603](#)) data sheet as a reference for the LM3424 boost evaluation board and for a comprehensive explanation of the device, design procedures, and application information.

2 Key Features

- Input: 10V to 26V
- Output: 9 to 12 LEDs at 1A
- Thermal Foldback / Analog Dimming
- PWM Dimming up to 30 kHz
- External Synchronization > 360 kHz
- Input Under-voltage and Output Over-voltage Protection

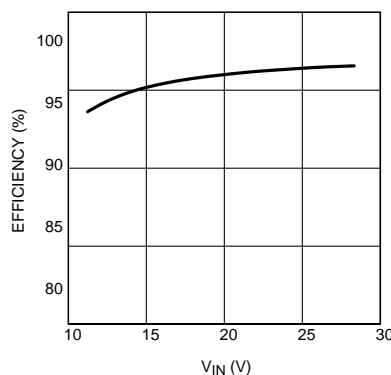


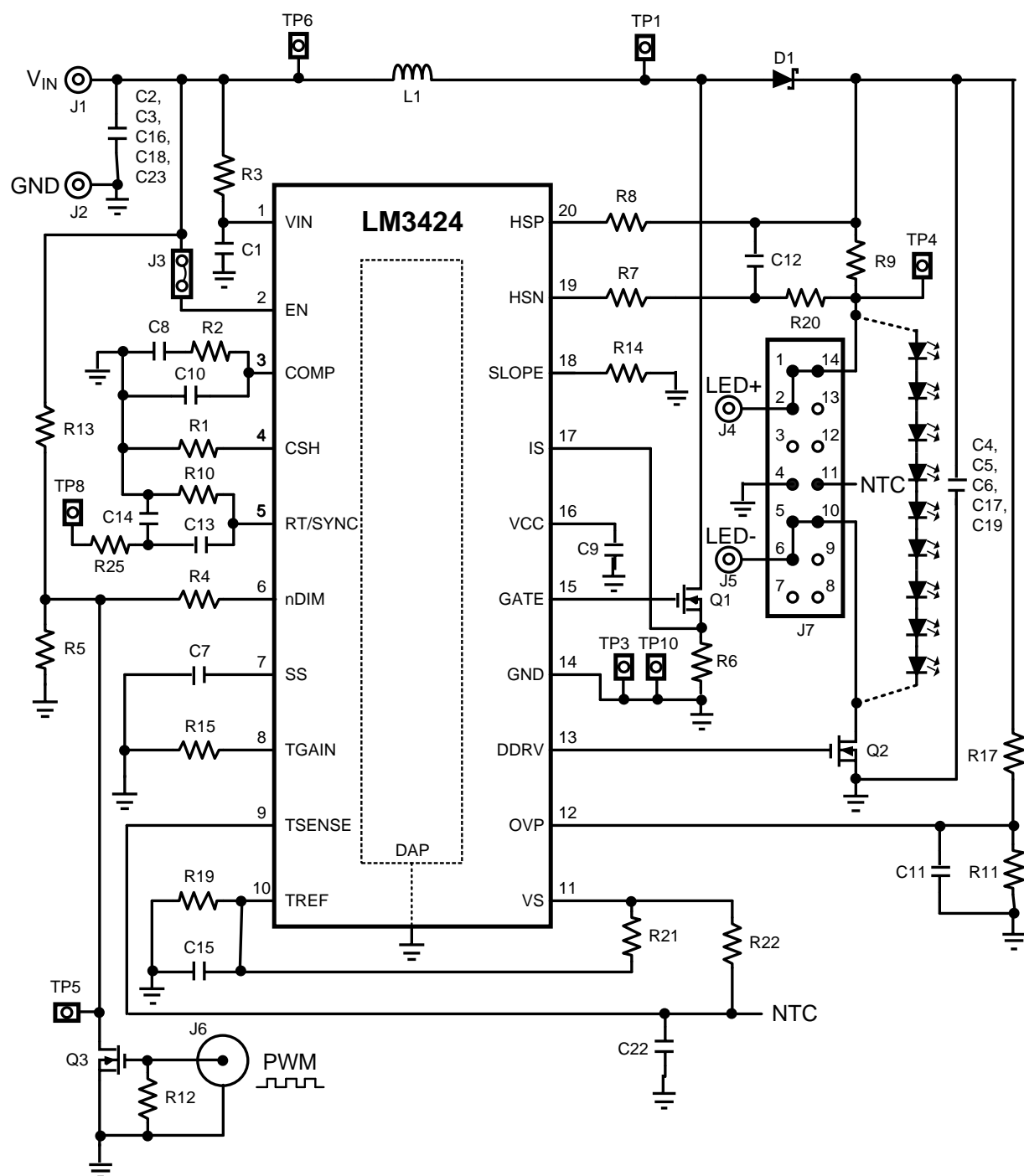
Figure 1. Efficiency with 6 Series LEDs AT 1A

3 External Connection Descriptions

Table 1. Connectors and Test Points

| Qty | Name | Description | Application Information |
|------|-----------------|-----------------------|--|
| J1 | V _{IN} | Input Voltage | Connect to positive terminal of supply voltage. |
| J2 | GND | Input Ground | Connect to negative terminal of supply voltage (GND). |
| J3 | EN | Enable On/Off | Jumper connected enables device. |
| J4 | LED+ | LED Positive | Connect to anode (top) of LED string. |
| J5 | LED- | LED Negative | Connect to cathode (bottom) of LED string. |
| J6 | BNC | Dimming Input | Connect a 3V to 10V PWM input signal up to 10 kHz for PWM dimming the LED load. |
| J7 | OUT | Output with NTC | Alternative connector for LED+ and LED-. Pins 4 and 11 are used for connecting an external NTC thermistor. Refer to schematic for detailed connectivity. |
| TP1 | SW | Switch Node Voltage | Test point for switch node (where Q1, D1, and L1 connect). |
| TP3 | SGND | Signal Ground | Connection for GND when applying signals to TP5, TP8, and TP9. |
| TP4 | LED+ | LED Positive Voltage | Test point for anode (top) of LED string. |
| TP5 | nDIM | Inverted Dim Signal | Test point for dimming input (inverted from input signal). |
| TP6 | V _{IN} | Input Voltage | Test point for input voltage. |
| TP8 | SYNC | Synchronization Input | Connect a 3V to 6V PWM clock signal > 500 kHz (pulse width of 100ns) to synchronize the LM3424 switching frequency to the external clock. |
| TP9 | NTC | Temp Sense Input | Connect a 0V to 1.24V DC voltage to analog dim the LED current. |
| TP10 | PGND | Power Ground | Test point for GND when monitoring TP1, TP4, or TP6. |

4 Schematic



5 LM3424 Pin Descriptions

| Pin | Name | Description | Application Information |
|----------|-----------------|--------------------------------------|---|
| 1 | V _{IN} | Input Voltage | Bypass with 100 nF capacitor to GND as close to the device as possible in the circuit board layout. |
| 2 | EN | Enable | Connect to > 2.4V to enable the device or to < 0.8V for low power shutdown. |
| 3 | COMP | Compensation | Connect a capacitor to GND to compensate control loop. |
| 4 | CSH | Current Sense High | Connect a resistor to GND to set the signal current. Can also be used to analog dim as explained in the <i>Thermal Foldback / Analog Dimming</i> section of the datasheet. |
| 5 | RT | Resistor Timing | Connect a resistor to GND to set the switching frequency. Can also be used to synchronize external clock as explained in the <i>Switching Frequency</i> section of the datasheet. |
| 6 | nDIM | Not DIM input | Connect a PWM signal for dimming as detailed in the <i>PWM Dimming</i> section of the datasheet and/or a resistor divider from V _{IN} to program input under-voltage lockout (UVLO). Turn-on threshold is 1.24V and hysteresis for turn-off is provided by 20 µA current source. |
| 7 | SS | Soft-start | Connect a capacitor to GND to extend start-up time. |
| 8 | TGAIN | Temperature Foldback Gain | Connect a resistor to GND to set the foldback slope. |
| 9 | TSENSE | Temperature Sense Input | Connect a resistor/ thermistor divider from V _S to sense the temperature as explained in the <i>Thermal Foldback / Analog Dimming</i> section of the datasheet. |
| 10 | TREF | Temperature Foldback Reference | Connect a resistor divider from V _S to set the temperature foldback reference voltage. |
| 11 | V _S | Voltage Reference | 2.45V reference for temperature foldback circuit and other external circuitry. |
| 12 | OVP | Over-Voltage Protection | Connect to a resistor divider from V _O to program output over-voltage lockout (OVLO). Turn-off threshold is 1.24V and hysteresis for turn-on is provided by 20 µA current source. |
| 13 | DDRV | Dimming Gate Drive Output | Connect to gate of dimming MosFET. |
| 14 | GND | Ground | Connect to DAP to provide proper system GND |
| 15 | GATE | Gate Drive Output | Connect to gate of main switching MosFET. |
| 16 | V _{CC} | Internal Regulator Output | Bypass with a 2.2 µF–3.3 µF, ceramic capacitor to GND. |
| 17 | IS | Main Switch Current Sense | Connect to the drain of the main N-channel MosFET switch for R _{DS-ON} sensing or to a sense resistor installed in the source of the same device. |
| 18 | SLOPE | Slope Compensation | Connect a resistor to GND to set slope of additional ramp. |
| 19 | HSN | High-Side LED Current Sense Negative | Connect through a series resistor to the negative side of the LED current sense resistor. |
| 20 | HSP | High-Side LED Current Sense Positive | Connect through a series resistor to the positive side of the LED current sense resistor. |
| DAP (21) | DAP | Thermal pad on bottom of IC | Connect to GND and place 6 - 9 vias to bottom layer ground pour. |

6 Bill of Materials

| Qty | Part ID | Part Value | Manufacturer | Part Number |
|-----|---|-----------------------------|--------------|--------------------|
| 3 | C1, C5, C23 | 0.1 μ F X7R 10% 100V | TDK | C2012X7R2A104K |
| 4 | C2, C3, C16, C18 | 6.8 μ F X7R 10% 50V | TDK | C5750X7R1H685K |
| 4 | C4, C6, C17, C19 | 10 μ F X7R 10% 50V | TDK | C5750X7R1H106K |
| 2 | C7, C22 | 0.47 μ F X7R 10% 16V | MURATA | GRM21BR71C474KA01L |
| 0 | C8 | DNP | | |
| 1 | C9 | 2.2 μ F X7R 10% 16V | MURATA | GRM21BR71C225KA12L |
| 1 | C10 | 1 μ F X7R 10% 16V | MURATA | GRM21BR71C105KA01L |
| 1 | C11 | 47 pF COG/NPO 5% 50V | AVX | 08055A470JAT2A |
| 1 | C12 | 0.22 μ F X7R 10% 16V | MURATA | GRM219R71C224KA01D |
| 2 | C13, C14 | 100 pF COG/NPO 5% 50V | MURATA | GRM2165C1H101JA01D |
| 1 | C15 | 1 μ F X7R 10% 16V | MURATA | GRM21BR71C105MA01L |
| 1 | D1 | Schottky 100V 12A | VISHAY | 12CWQ10FNPBF |
| 4 | J1, J2, J4, J5 | Banana Jack | KEYSTONE | 575-8 |
| 1 | J3 | 1x2 Header Male | SAMTEC | TSW-102-07-T-S |
| 1 | J6 | BNC connector | AMPHENOL | 112536 |
| 1 | J7 | 2x7 Header Male Shrouded RA | SAMTEC | TSSH-107-01-SDRA |
| 1 | L1 | 33 μ H 20% 6.3A | COILCRAFT | MSS1278-333MLB |
| 2 | Q1, Q2 | NMOS 100V 32A | FAIRCHILD | FDD3682 |
| 1 | Q3 | NMOS 60V 260mA | ON-SEMI | 2N7002ET1G |
| 2 | R1, R11 | 12.4 k Ω 1% | VISHAY | CRCW080512K4FKEA |
| 0 | R2 | DNP | | |
| 2 | R3, R20 | 10 Ω 1% | VISHAY | CRCW080510R0FKEA |
| 1 | R4 | 17.4 k Ω 1% | VISHAY | CRCW080517K4FKEA |
| 1 | R5 | 1.43 k Ω 1% | VISHAY | CRCW08051K43FKEA |
| 1 | R6 | 0.04 Ω 1% 1W | VISHAY | WSL2512R0400FEA |
| 2 | R7, R8 | 1.0 k Ω 1% | VISHAY | CRCW08051K00FKEA |
| 1 | R9 | 0.1 Ω 1% 1W | VISHAY | WSL2512R1000FEA |
| 1 | R10 | 20.0 k Ω 1% | VISHAY | CRCW080520K0FKEA |
| 4 | R12, R13, R14, R15 | 10.0 k Ω 1% | VISHAY | CRCW080510K0FKEA |
| 1 | R17 | 499 k Ω 1% | VISHAY | CRCW0805499KFKEA |
| 3 | R19, R21, R22 | 49.9 k Ω 1% | VISHAY | CRCW080549K9FKEA |
| 1 | R25 | 150 Ω 1% | VISHAY | CRCW0805150RFKEA |
| 8 | TP1, TP3, TP4, TP5, TP6, TP8, TP9, TP10 | Turret | Keystone | 1502-2 |
| 1 | U1 | Boost controller | NSC | LM3424MH |

7 PCB Layout

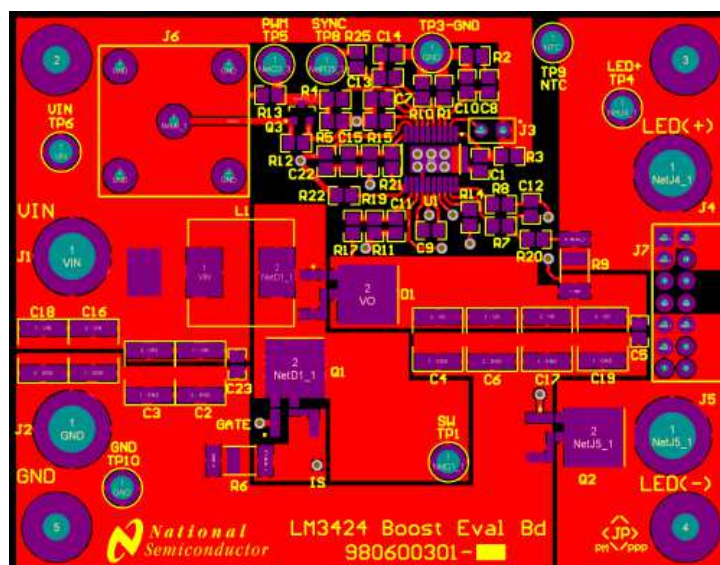


Figure 2. Top Layer

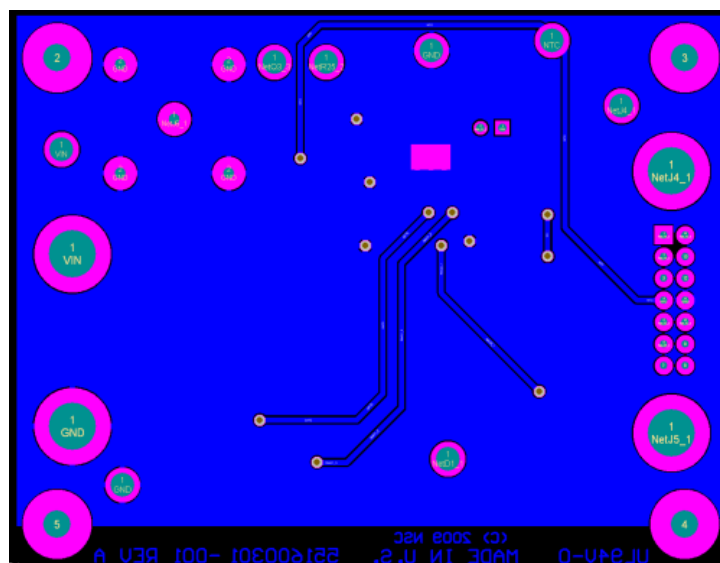


Figure 3. Bottom Layer

8 Design Procedure

8.1 Specifications

$$N = 6$$

$$V_{LED} = 3.5V$$

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

$$V_{IN} = 24V$$

$$V_{IN-MIN} = 10V$$

$$V_{IN-MAX} = 70V$$

$$f_{SW} = 500 \text{ kHz}$$

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

$$I_{LED} = 1A$$

$$\Delta i_{L-PP} = 700 \text{ mA}$$

$$\Delta i_{LED-PP} = 12 \text{ mA}$$

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

$$I_{LIM} = 6A$$

$$V_{TURN-ON} = 10V$$

$$V_{HYS} = 3V$$

$$V_{TURN-OFF} = 40V$$

$$V_{HYSO} = 10V$$

$$T_{BK} = 70^{\circ}C$$

$$T_{END} = 120^{\circ}C$$

$$t_{TSU} = 30 \text{ ms}$$

8.2 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} :

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

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

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

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

8.3 Switching Frequency

Solve for R_T :

$$R_{10} = \frac{1 + 1.95e^{-8} \times f_{SW}}{1.40e^{-10} \times f_{SW}} = \frac{1 + 1.95e^{-8} \times 360 \text{ kHz}}{1.40e^{-10} \times 360 \text{ kHz}} = 19.99 \text{ k}\Omega \quad (7)$$

The closest standard resistor is 14.3 kΩ therefore f_{SW} is:

$$f_{SW} = \frac{1}{1.40e^{-10} \times R10 - 1.95e^{-8}}$$

$$f_{SW} = \frac{1}{1.40e^{-10} \times 20.0 \text{ k}\Omega - 1.95e^{-8}} = 360 \text{ kHz} \quad (8)$$

The chosen component from step 2 is:

$$R10 = 20 \text{ k}\Omega \quad (9)$$

8.4 Average LED Current

Solve for R_{SNS} :

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

Assume $R_{CSH} = 12.4 \text{ k}\Omega$ and solve for R_{HSP} :

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

The closest standard resistor for R_{SNS} is actually 0.1Ω and for R_{HSP} 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:

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

8.5 Thermal Foldback

Using a standard 100k NTC thermistor (connected to pins 4 and 11), find the resistances corresponding to T_{BK} and T_{END} ($R_{NTC-BK} = 243 \text{ k}\Omega$ and $R_{NTC-END} = 71.5 \text{ k}\Omega$) from the manufacturer's datasheet. Assuming $R_{REF1} = R_{REF2} = 49.9 \text{ k}\Omega$, then $R_{BIAS} = R_{NTC-BK} = 243 \text{ k}\Omega$.

Solve for R_{GAIN} :

$$R_{GAIN} = \frac{\left(\frac{R_{REF1}}{R_{REF1} + R_{REF2}} - \frac{R_{NTC-END}}{R_{NTC-END} + R_{BIAS}} \right) \times 2.45 \text{ V}}{I_{CSH}}$$

$$R_{GAIN} = \frac{\left(\frac{1}{2} - \frac{71.5 \text{ k}\Omega}{71.5 \text{ k}\Omega + 243 \text{ k}\Omega} \right) \times 2.45 \text{ V}}{100 \mu \text{ A}} = 6.68 \text{ k}\Omega \quad (14)$$

The chosen components from step 4 are:

$$\begin{aligned} R_{GAIN} &= 6.81 \text{ k}\Omega \\ R_{BIAS} &= 243 \text{ k}\Omega \\ R_{REF1} &= R_{REF2} = 49.9 \text{ k}\Omega \end{aligned} \quad (15)$$

8.6 Inductor Ripple Current

Solve for $L1$:

$$L1 = \frac{V_{IN} \times D}{\Delta I_{L-PP} \times f_{SW}} = \frac{24 \text{ V} \times 0.238}{500 \text{ mA} \times 360 \text{ kHz}} = 31.7 \mu \text{ H} \quad (16)$$

The closest standard inductor is 33 μH therefore ΔI_{L-PP} is:

$$\Delta i_{L-PP} = \frac{V_{IN} \times D}{L1 \times f_{SW}} = \frac{24V \times 0.238}{33 \mu H \times 360 \text{ kHz}} = 481 \text{ mA} \quad (17)$$

Determine minimum allowable RMS current rating:

$$I_{L-RMS} = \frac{I_{LED}}{D'} \times \sqrt{1 + \frac{1}{12} \times \left(\frac{\Delta i_{L-PP} \times D'}{I_{LED}} \right)^2}$$

$$I_{L-RMS} = \frac{1A}{0.762} \times \sqrt{1 + \frac{1}{12} \times \left(\frac{481 \text{ mA} \times 0.762}{1A} \right)^2} = 1.32A \quad (18)$$

The chosen component from step 5 is:

$$L1 = 33 \mu H \quad (19)$$

8.7 Output Capacitance

Solve for C_O :

$$C_O = \frac{I_{LED} \times D}{r_D \times \Delta i_{LED-PP} \times f_{SW}}$$

$$C_O = \frac{1A \times 0.238}{2.925 \Omega \times 6 \text{ mA} \times 360 \text{ kHz}} = 38 \mu F \quad (20)$$

The closest capacitance totals 40 μF therefore Δi_{LED-PP} is:

$$\Delta i_{LED-PP} = \frac{I_{LED} \times D}{r_D \times C_O \times f_{SW}}$$

$$\Delta i_{LED-PP} = \frac{1A \times 0.238}{2.925 \Omega \times 40 \mu F \times 360 \text{ kHz}} = 5.7 \text{ mA} \quad (21)$$

Determine minimum allowable RMS current rating:

$$I_{CO-RMS} = I_{LED} \times \sqrt{\frac{D_{MAX}}{1 - D_{MAX}}} = 1A \times \sqrt{\frac{0.683}{1 - 0.683}} = 1.47A \quad (22)$$

The chosen components from step 6 are:

$$C4 = C6 = C17 = C19 = 10 \mu F \quad (23)$$

8.8 Peak Current Limit

Solve for R_{LIM} :

$$R6 = \frac{245 \text{ mV}}{I_{LIM}} = \frac{245 \text{ mV}}{6A} = 0.041 \Omega \quad (24)$$

The closest standard resistor is 0.04 Ω therefore I_{LIM} is:

$$I_{LIM} = \frac{245 \text{ mV}}{R6} = \frac{245 \text{ mV}}{0.04 \Omega} = 6.13A \quad (25)$$

The chosen component from step 7 is:

$$R6 = 0.04 \Omega \quad (26)$$

8.9 Slope Compensation

Solve for R_{SLP} :

$$R_{SLP} = \frac{1.5e^{13} \times L1}{V_O \times R_T \times R_{SNS}}$$

$$R_{SLP} = \frac{1.5e^{13} \times 33 \mu H}{21V \times 14.3 k\Omega \times 0.1\Omega} = 16.5 k\Omega \quad (27)$$

The chosen component from step 8 is:

$$R_{SLP} = 16.5 k\Omega \quad (28)$$

8.10 Loop Compensation

ω_{P1} is approximated:

$$\omega_{P1} = \frac{2}{r_D \times C_O} = \frac{2}{2.925\Omega \times 40 \mu F} = 17 k \frac{rad}{sec} \quad (29)$$

ω_{Z1} is approximated:

$$\omega_{Z1} = \frac{r_D \times D^2}{L1} = \frac{2.925\Omega \times 0.762^2}{33 \mu H} = 52 k \frac{rad}{sec} \quad (30)$$

T_{U0} is approximated:

$$T_{U0} = \frac{D' \times 310V}{I_{LED} \times R6} = \frac{0.762 \times 310V}{1A \times 0.04\Omega} = 5900 \quad (31)$$

To ensure stability, calculate ω_{P2} :

$$\omega_{P2} = \frac{\min(\omega_{P1}, \omega_{Z1})}{5 \times T_{U0}} = \frac{\omega_{P1}}{5 \times 5900} = \frac{17k \frac{rad}{sec}}{5 \times 5900} = 0.58 \frac{rad}{sec} \quad (32)$$

Solve for C_{CMP} :

$$C10 = \frac{1}{\omega_{P2} \times 5e^6\Omega} = \frac{1}{0.58 \frac{rad}{sec} \times 5e^6\Omega} = 0.35 \mu F \quad (33)$$

To attenuate switching noise, calculate ω_{P3} :

$$\omega_{P3} = (\max(\omega_{P1}, \omega_{Z1}) \times 10 = \omega_{Z1} \times 10$$

$$\omega_{P3} = 52k \frac{rad}{sec} \times 10 = 520k \frac{rad}{sec} \quad (34)$$

Assume $R_{FS} = 10\Omega$ and solve for C_{FS} :

$$C12 = \frac{1}{10\Omega \times \omega_{P3}} = \frac{1}{10\Omega \times 520k \frac{rad}{sec}} = 0.19 \mu F \quad (35)$$

The chosen components from step 9 are:

$$\begin{array}{l} C10 = 1 \mu F \\ R20 = 10\Omega \\ C12 = 0.22 \mu F \end{array} \quad (36)$$

8.11 Input Capacitance

Solve for the minimum C_{IN} :

$$C_{IN} = \frac{\Delta i_{L-PP}}{8 \times \Delta V_{IN-PP} \times f_{SW}} = \frac{481 mA}{8 \times 50 mV \times 360 kHz} = 3.4 \mu F \quad (37)$$

To minimize power supply interaction a 200% larger capacitance of approximately 20 μF is used, therefore the actual ΔV_{IN-PP} is much lower. Since high voltage ceramic capacitor selection is limited, four 4.7 μF X7R capacitors are chosen.

Determine minimum allowable RMS current rating:

$$I_{IN-RMS} = \frac{\Delta i_{L-PP}}{\sqrt{12}} = \frac{481 \text{ mA}}{\sqrt{12}} = 139 \text{ mA} \quad (38)$$

The chosen components from step 10 are:

$$C2 = C3 = C16 = C18 = 6.8 \mu F \quad (39)$$

8.12 NFET

Determine minimum Q1 voltage rating and current rating:

$$V_{T-MAX} = V_O = 31.5V \quad (40)$$

$$I_{T-MAX} = \frac{0.683}{1 - 0.683} \times 1A = 2.2A \quad (41)$$

A 100V NFET is chosen with a current rating of 32A due to the low $R_{DS-ON} = 50 \text{ m}\Omega$. Determine I_{T-RMS} and P_T :

$$I_{T-RMS} = \frac{I_{LED}}{D'} \times \sqrt{D} = \frac{1A}{0.762} \times \sqrt{0.238} = 640 \text{ mA} \quad (42)$$

$$P_T = I_{T-RMS}^2 \times R_{DS-ON} = 640 \text{ mA}^2 \times 50 \text{ m}\Omega = 20 \text{ mW} \quad (43)$$

The chosen component from step 11 is:

$$Q1 \rightarrow 32A, 100V, DPAK \quad (44)$$

8.13 Diode

Determine minimum D1 voltage rating and current rating:

$$V_{RD-MAX} = V_O = 31.5V \quad (45)$$

$$I_{D-MAX} = I_{LED} = 1A \quad (46)$$

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

$$P_D = I_D \times V_{FD} = 1A \times 600 \text{ mV} = 600 \text{ mW} \quad (47)$$

The chosen component from step 12 is:

$$D1 \rightarrow 12A, 100V, DPAK \quad (48)$$

8.14 Input UVLO

Solve for R_{UV2} :

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

$$R4 = \frac{1.43 \text{ k}\Omega \times (3V - 20 \mu A \times 10 \text{ k}\Omega)}{20 \mu A \times (1.43 \text{ k}\Omega + 10 \text{ k}\Omega)} = 17.5 \text{ k}\Omega \quad (49)$$

The closest standard resistor is 150 k Ω therefore V_{HYS} is:

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

$$V_{HYS} = \frac{20 \mu A \times 17.4 \text{ k}\Omega \times (1.43 \text{ k}\Omega + 10 \text{ k}\Omega)}{1.43 \text{ k}\Omega} + 20 \mu A \times 10 \text{ k}\Omega = 2.98V \quad (50)$$

Solve for R_{UV1} :

$$R5 = \frac{1.24V \times R13}{V_{\text{TURN-ON}} - 1.24V} = \frac{1.24V \times 10 \text{ k}\Omega}{10V - 1.24V} = 1.42 \text{ k}\Omega \quad (51)$$

The closest standard resistor is 21 k Ω making $V_{\text{TURN-ON}}$:

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

$$V_{\text{TURN-ON}} = \frac{1.24V \times (1.43 \text{ k}\Omega + 10 \text{ k}\Omega)}{1.43 \text{ k}\Omega} = 9.91V \quad (52)$$

The chosen components from step 13 are:

| |
|--|
| $R5 = 1.43 \text{ k}\Omega$ $R13 = 10 \text{ k}\Omega$ $R4 = 17.4 \text{ k}\Omega$ |
|--|

(53)

8.15 Output OVLO

Solve for R_{OV2} :

$$R17 = \frac{V_{\text{HYSO}}}{20 \mu\text{A}} = \frac{10V}{20 \mu\text{A}} = 500 \text{ k}\Omega \quad (54)$$

The closest standard resistor is 499 k Ω therefore V_{HYSO} is:

$$V_{\text{HYSO}} = R17 \times 20 \mu\text{A} = 499 \text{ k}\Omega \times 20 \mu\text{A} = 9.98V \quad (55)$$

Solve for R_{OV1} :

$$R11 = \frac{1.24V \times R17}{V_{\text{TURN-OFF}} - 1.24V} = \frac{1.24V \times 499 \text{ k}\Omega}{50V - 620 \text{ mV}} = 12.5 \text{ k}\Omega \quad (56)$$

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

$$V_{\text{TURN-OFF}} = \frac{1.24V \times (R11 + R17)}{R11}$$

$$V_{\text{TURN-OFF}} = \frac{1.24V \times (12.4 \text{ k}\Omega + 499 \text{ k}\Omega)}{12.4 \text{ k}\Omega} = 51.1V \quad (57)$$

The chosen components from step 14 are:

| |
|---|
| $R11 = 12.4 \text{ k}\Omega$ $R17 = 499 \text{ k}\Omega$ |
|---|

(58)

8.16 Soft-Start

Solve for t_{SU} :

$$t_{\text{SU}} = 168\Omega \times C_{\text{BYP}} + 36 \text{ k}\Omega \times C_{\text{CMP}} + \frac{V_{\text{O}}}{I_{\text{LED}}} \times C_{\text{O}}$$

$$t_{\text{SU}} = 168\Omega \times 2.2 \mu\text{F} + 36 \text{ k}\Omega \times 0.33 \mu\text{F} + \frac{21V}{1A} \times 40 \mu\text{F}$$

$$t_{\text{SU}} = 13.1 \text{ ms} \quad (59)$$

If t_{SU} is less than t_{TSU} , solve for $t_{\text{SU-SS-BASE}}$:

$$t_{\text{SU-SS-BASE}} = 168\Omega \times C_{\text{BYP}} + 28 \text{ k}\Omega \times C_{\text{CMP}} + \frac{V_{\text{O}}}{I_{\text{LED}}} \times C_{\text{O}}$$

$$t_{\text{SU-SS-BASE}} = 168\Omega \times 2.2 \mu\text{F} + 28 \text{ k}\Omega \times 0.33 \mu\text{F} + \frac{21V}{1A} \times 40 \mu\text{F}$$

$$t_{\text{SU-SS-BASE}} = 10.5 \text{ ms} \quad (60)$$

Solve for C_{SS} :

$$C_{SS} = \frac{(t_{TSU} - t_{SU-SS-BASE})}{20 \text{ k}\Omega} = \frac{(30 \text{ ms} - 10.5 \text{ ms})}{20 \text{ k}\Omega} = 975 \text{ nF} \quad (61)$$

The chosen component from step 15 is:

$$\boxed{C_{SS} = 1 \mu\text{F}} \quad (62)$$

9 Typical Waveforms

$T_A = +25^\circ\text{C}$, $V_{IN} = 24\text{V}$ and $V_O = 32\text{V}$.

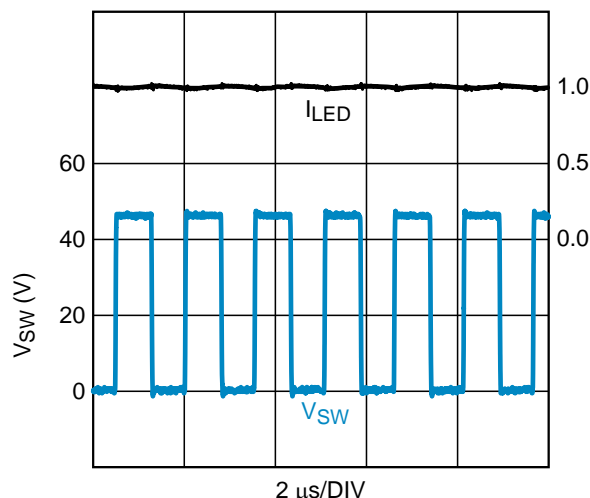


Figure 4. Standard Operation
TP1 Switch Node Voltage (V_{sw})
LED Current (I_{LED})

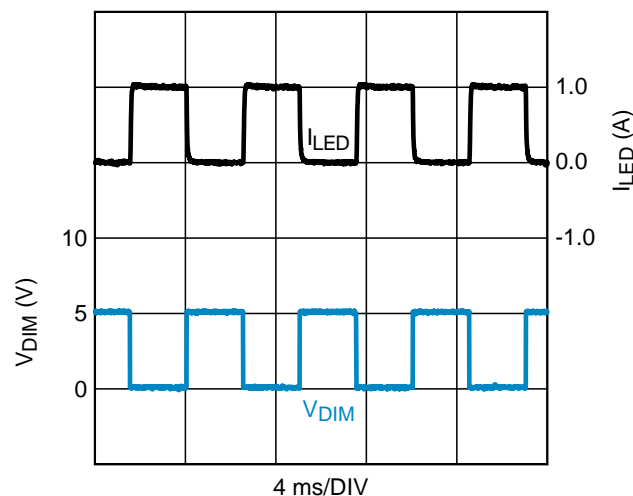


Figure 5. 200Hz 50% PWM Dimming
TP5 Dim Voltage (V_{DIM})
LED Current (I_{LED})

10 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 2 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 2. 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 | 12.1 kΩ | 10.2 kΩ | 14.3 kΩ | 10.2 kΩ |
| L1 | 22μH | 68μH | 15μH | 33μH |

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