LM3464A 4 Channel LED Driver Evaluation Board

National Semiconductor
Application Note 2071
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June 3, 2011

Introduction

This evaluation board demonstrates the high power efficiency and outstanding output current accuracy of the LM3464A typical application circuit. With four LED strings connected, the total output power is about 50W. The schematic, bill of material and PCB layout drawing of the LM3464A evaluation board are provided in this document. This evaluation board can be adapted to different types of power supply with changes of a few components. The PCB of this evaluation board is pin to pin compatible to both LM3464 and LM3464A with 80V and 95V maximum input voltage respectively. The information being presented in this document are also applicable to both the LM3464 and LM3464A.

The LM3464A is a 4 channel linear LED driver which combined the advantages of high power efficiency of switching regulators and low current ripple of linear current regulators. With the incorporation of the proprietary Dynamic Headroom Control (DHC) technology, the LM3464A optimizes system efficiency automatically while providing outstanding output stability and accuracy. Each LED current regulators of this board consists of an external MOSFET and a control circuit inside the LM3464A to provide the best flexibility to fulfill the needs of different applications. The LM3464A includes a built-in Low Drop-Out (LDO) voltage regulator which accepts an input voltage up to 95V (LM3464A) to provide power and voltage references to internal circuits, allowing the LM3464A to adapt to difference source voltages easily. The integrated thermal foldback control circuit protects the LED Strings from damages due to over-temperature. This eventually secures the lifetime of the entire lighting system. The LM3464A includes a fault handling mechanism which latches off output channels upon open or short circuit of the LED strings, preventing substantial damages due to failures of the LEDs. The number of output channel can be expanded by cascading several LM3464A evaluation boards to achieve high luminous output.

Standard Settings of the Evaluation Board

- Vin range 12V to 95V (LM3464A)
- 48V LED turn ON voltage
- 350mA LED current per channel
- 2kHz thermal foldback dimming frequency

Because the LM3464A evaluation board is designed to turn on the LED strings at 48V rail voltage, applying excessive input voltage to this board will increase power dissipation on the MOSFETs and could eventually damage the circuit. In order to avoid permanent damages, it is not recommended not to apply higher than 60V input voltage to this evaluation board. This board is generally designed to drive 4 LED strings at 350mA which each sting contains 12 serial LEDs. For driving LED strings of different configuration, the value of a few components should be adjusted following the descriptions in this document.

Highlight Features

- Dynamic Headroom Control (DHC)
- Thermal foldback control
- High speed PWM dimming
- Minimum brightness limit for thermal foldback control
- Cascade operation for output channel expansion
- Vin Under-Voltage-Lockout
- Fault protection and indication
- Programmable startup voltage
- Thermal Shutdown

Evaluation Board Schematic

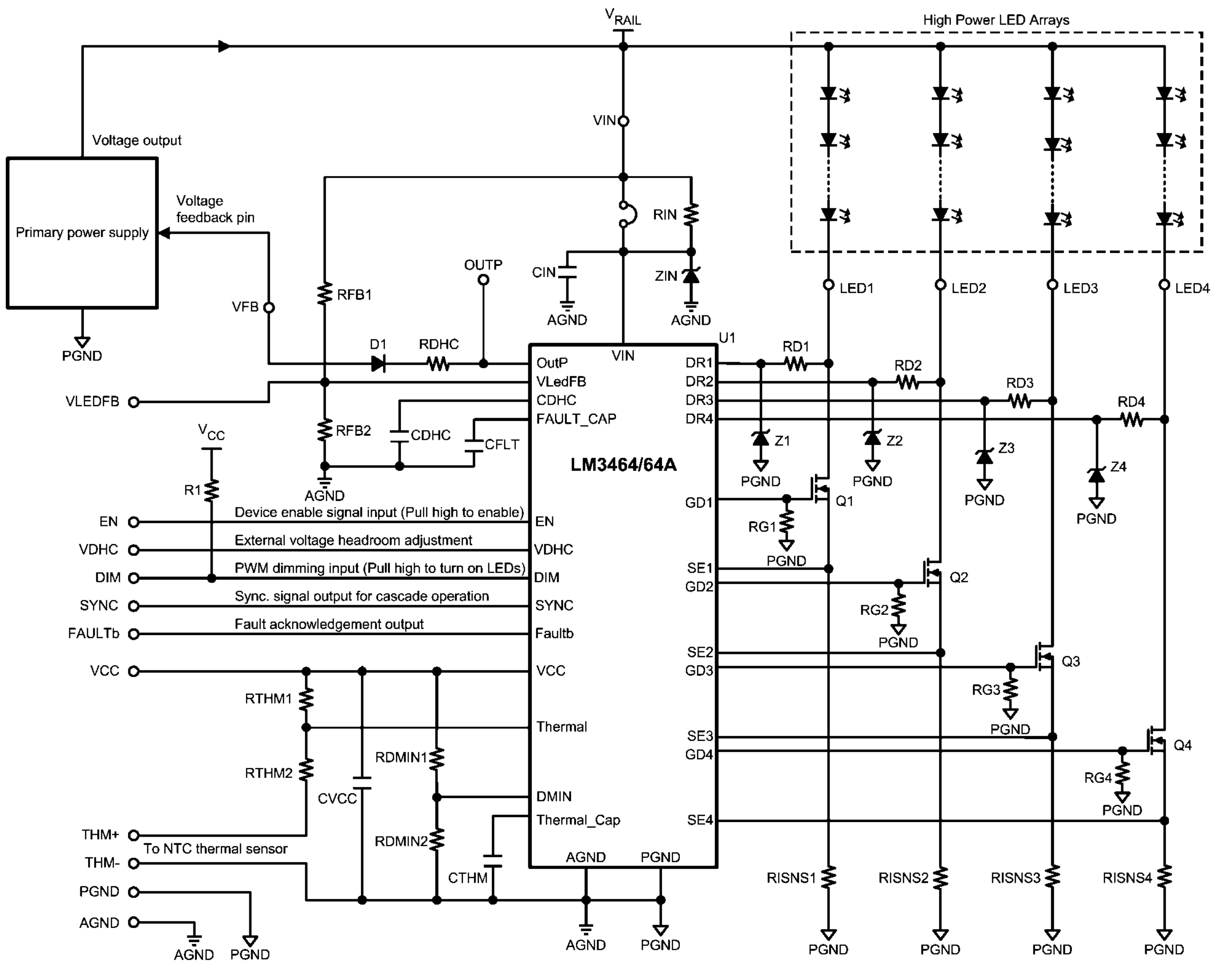


FIGURE 1. LM3464A Evaluation Board Schematic

Bill of Materials

Designation	Description	Package	Manufacturer Part #	Vendor
U1	LED Driver IC, LM3464A eTSSOP-28	eTSSOP-28	LM3464AMH	NSC
D1	Schottky Diode 40V 1.1A DO219AB	DO219AB	SL04-GS08	Vishay
Q1,Q2,Q3,Q4	MOSFET N-CH 150V 29A D-PAK	D-PAK	FDD2572	Fairchild
	MOSFET N-CH 150V 50A TO252–3	TO252–3	IPD200N15N3	Infineon
CIN	Cap MLCC 100V 2.2uF X7R 1210	1210	GRM32ER72A225KA35L	Murata
CVCC	Cap MLCC 10V 1uF X5R 0603	0603	GRM185R61A105KE36D	Murata
CDHC	Cap MLCC 50V 0.22uF X5R 0603	0603	GCM188R71H224KA64D	Murata
CFLT	Cap MLCC 50V 2.2nF X7R 0603	0603	GRM188R71H222KA01D	Murata
CTHM	Cap MLCC 50V 68nF X7R 0603	0603	GRM188R71H683KA01D	Murata
R1	Chip Resistor 8.06Kohm 1% 0603	0603	CRCW06038K06FKEA	Vishay
RTHM1	Chip Resistor 4.87Kohm 1% 0603	0603	CRCW06034K87FKEA	Vishay
RTHM2	Chip Resistor 232ohm 1% 0603	0603	CRCW0603232RFKEA	Vishay
RDMIN1	Chip Resistor 15.4Kohm 1% 0603	0603	CRCW060315K4FKEA	Vishay
RDMIN2	Chip Resistor 1.05Kohm 1% 0603	0603	CRCW06031K05FKEA	Vishay
RDHC	Chip Resistor 2.67Kohm 1% 0603	0603	CRCW06032K67FKEA	Vishay
RFB1	Chip Resistor 48.7Kohm 1% 0603	0603	CRCW060348K7FKEA	Vishay
RFB2	Chip Resistor 2.67Kohm 1% 0603	0603	CRCW06032K67FKEA	Vishay
RISNS1, RISNS2, RISNS3, RISNS4	Chip Resistor 1.13ohm 1% 0603	0603	CRCW06031R13FKEA	Vishay
RIN, RD1, RD2, RD3, RD4	Chip Resistor 0ohm 1% 0603	0603	CRCW06030000Z0EA	Vishay
VIN,PGND	Banana Jack 5.3(mm) Dia	5.3 (mm) Dia.	575-8	Keystone
FAULTb,DIM, SYNC, THM+, THM-,	Turret 2.35(mm) Dia	2.35 (mm) Dia.	1502-2	Keystone
AGND, VFB, VIN, PGND, EN	Turret 2.35(mm) Dia	2.35 (mm) Dia.	1502-2	Keystone
LED1, LED2, LED3, LED4	Turret 2.35(mm) Dia	2.35 (mm) Dia.	1502-2	Keystone
PCB	LM3464EVAL PCB 82.5 X 60 (mm)	82.5 x 60 (mm)	N/A	NSC
RG1, R2, RG3, RG4	No Connection	0603		
ZIN, Z1, Z2, Z3, Z4	No Connection	SMA		

Connectors and Test Pins

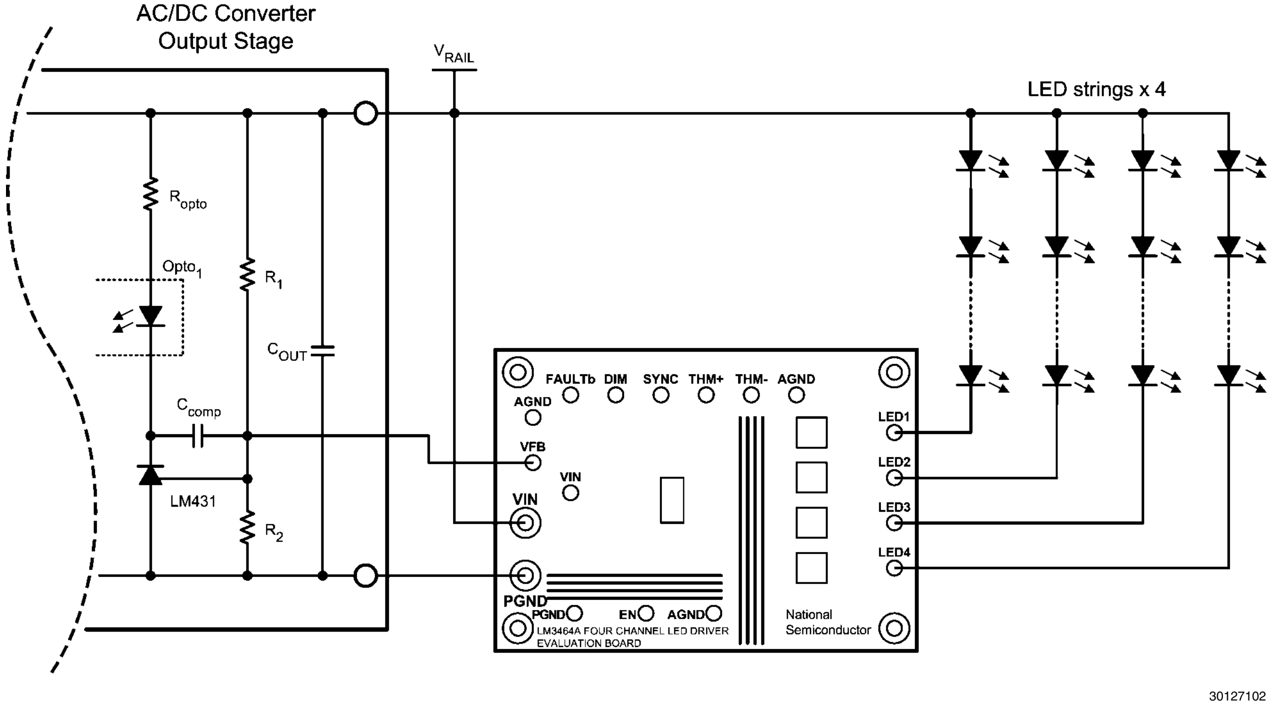


FIGURE 2. Typical Connection Diagram

Evaluation Board Quick Setup Procedures

Terminal Designation	Description
VIN	Power supply positive (+ve) connection
PGND	Power supply negative (-ve) connection
AGND	LM3464A analog signal ground
LED1	Output Channel 1 (Connect to cathode of LED string 1)
LED2	Output Channel 2 (Connect to cathode of LED string 2)
LED3	Output Channel 3 (Connect to cathode of LED string 3)
LED4	Output Channel 4 (Connect to cathode of LED string 4)
EN	LM3464A enable pin (pull down to disable)
VFB	Connect to voltage feedback node of primary power supply for DHC
FAULTb	Acknowledgement signal for arising of ‘FAULT’
DIM	PWM dimming signal input (TTL signal compatible)
SYNC	Synchronization signal for cascade operation
THM+	Connect to NTC thermal sensor for thermal foldback control
THM-	Connect to NTC thermal sensor for thermal foldback control
VLEDFB	Connected to LM3464A VLedFB pin
OUTP	Connected to LM3464A OutP pin
VCC	LM3464A internal voltage regulator output
VDHC	Connected to LM3464A VDHC pin

Structure of the System

A LM3464A LED lighting system is basically consist of three main parts, the LM3464A evaluation board, an AC/DC power supply and an LED array containing four LED strings. In general, the LM3464A evaluation board can be regarded as four independent current sources that the dropout voltages on the current sources are being monitored by an internal circuit that generates the DHC signal. The LM3464A evaluation board is designed to drive 4 LED strings of 12 LEDs in series. With 350mA driving current for every LED string, the default total output power of the LM3464A evaluation board is around 60W. In order to ensure proper operation, the AC/DC power supply and LED array should be selected following the steps presented in this document.

Selection of AC/DC Power Supply

The LM3464A evaluation board can be powered by an AC/DC power supply through the banana-plug type connectors on the board as shown in figure 2. Assuming the nominal forward voltage of one LED is 3.5V, the total forward voltage of a LED string containing 12 LED is about 42V. In order to reserve extra voltage headroom to compensate the variations of the LED forward voltages due to changes of operation temperature, the LED turn ON voltage of this evaluation board is set to 48V. As this evaluation board is designed to deliver 350mA for each output channel, which is about 60W output power at 48V rail voltage, the AC/DC power supply must be able to supply no less than 60W continuous output power at 48V. Therefore, a 60W AC/DC power supply with 48V output voltage is needed.

In order to facilitate Dynamic Headroom Control (DHC), the output voltage of the AC/DC power supply is adjusted by the LM3464A. The LM3464A adjusts the output voltage of the AC/DC power supply by sinking current from the output voltage feedback node of the AC/DC converter through a resistor RDHC into the OutP pin according to the dropout voltage of the linear current regulators. The OutP pin of the LM3464A is a open drain pin that can only sink current from the voltage feedback node of the AC/DC power supply, thus the LM3464A evaluation board is only able to increase the output voltage of the AC/DC power supply to acquire wider voltage headroom.

Since the output voltage of the AC/DC converter will be increased by the LM3464A to allow dynamic head room control (DHC), the nominal output voltage of the AC/DC power supply must be reduced prior to connecting to the LM3464A evaluation board to reserve voltage headroom for DHC to take place. This is achieved by modifying the resistance of the output voltage sensing resistors of the AC/DC power supply. To adapt the AC/DC power supply to the LM3464A evaluation board, the nominal output voltage of the AC/DC power supply is recommended to be reduced from 48V to 36V. Usually, the nominal output voltage of the AC/DC power supply can be reduced by changing the resistance of the resistor divider for output voltage feedback. Figure 2 shows the voltage feedback circuit using LM431 which has been widely used in typical AC/DC power supplies as an example.

To reduce the output voltage of the AC/DC power supply from 48V to 36V, the resistance of R_2 is increased without changing the value of R_1. The output voltage and value of R_2 are related by the following equations:

$$R_2 = R_1 \times \frac{V_{REF(AC/DC)}}{V_{REF(AC/DC)} - V_{REF(AC/DC)}}\ \Omega \quad (1)$$

For $V_{REF(AC/DC)} = 2.5V$
And $V_{RAIL(nom)} = 36V$:

$$R_2 = R_1 \times \frac{2.5V}{36V - 3.5V}\ \Omega \quad (2)$$

In the above equations, $V_{REF(AC/DC)}$ is the reference voltage of the AC/DC converter for output voltage feedback. $V_{RAIL(nom)}$ is the objective rail voltage level being adjusted to. In this example, reducing of the rail voltage is achieved by increasing the value of R_2. With the rail voltage is reduced to 36V, the LED strings are unable to be driven at 350mA due to insufficient voltage headroom until the DHC loop functions. In order to ensure the LED strings an regulated driving current at the time that the LED stings being turned on, the LM3464A increases the output voltage of the AC/DC power supply (V_{RAIL}) from 36V to 48V (V_{DHC_READY}) prior to turning on the LED strings. The level of V_{DHC_READY} is defined by the value of the resistors, RFB1 and RFB2. Figure 3 shows the changes of V_{RAIL} upon the AC/DC power supply is powered until the system enters steady state operation.

As the output voltage of the AC/DC power supply is depending on the current being sunk from the output voltage feedback node of the AC/DC power supply, the output voltage could increase to exceed the rated output voltage of the AC/DC power supply and damage the system if the resistance of the RDHC is too low and the OutP pin of the LM3464A is accidentally shortened to GND ($V_{OutP} = 0V$). To avoid this, the value of the RDHC must be selected appropriately following the equations below. In the equations, $V_{RAIL(peak)}$ is the maximum voltage that V_{RAIL} can reach if the OutP pin is shortened to GND. R_1 and R_2 are the resistors of the output voltage feedback resistor divider of the AC/DC power supply. When designing the values of the RDHC, it is essential to ensure that the $V_{RAIL(peak)}$ does not exceed the rated output voltage of the AC/DC power supply, otherwise the AC/DC power supply could be damaged.

$$V_{RAIL(peak)} = \left[(R_1 \times I_{R1}) + V_{REF(AC/DC)}\right] V \quad (3)$$

where

$$I_{R1} = \left[\frac{V_{REF(AC/DC)}}{R_2} + \frac{V_{REF(AC/DC)} - 0.8V}{R_{DHC}}\right] A \quad (4)$$

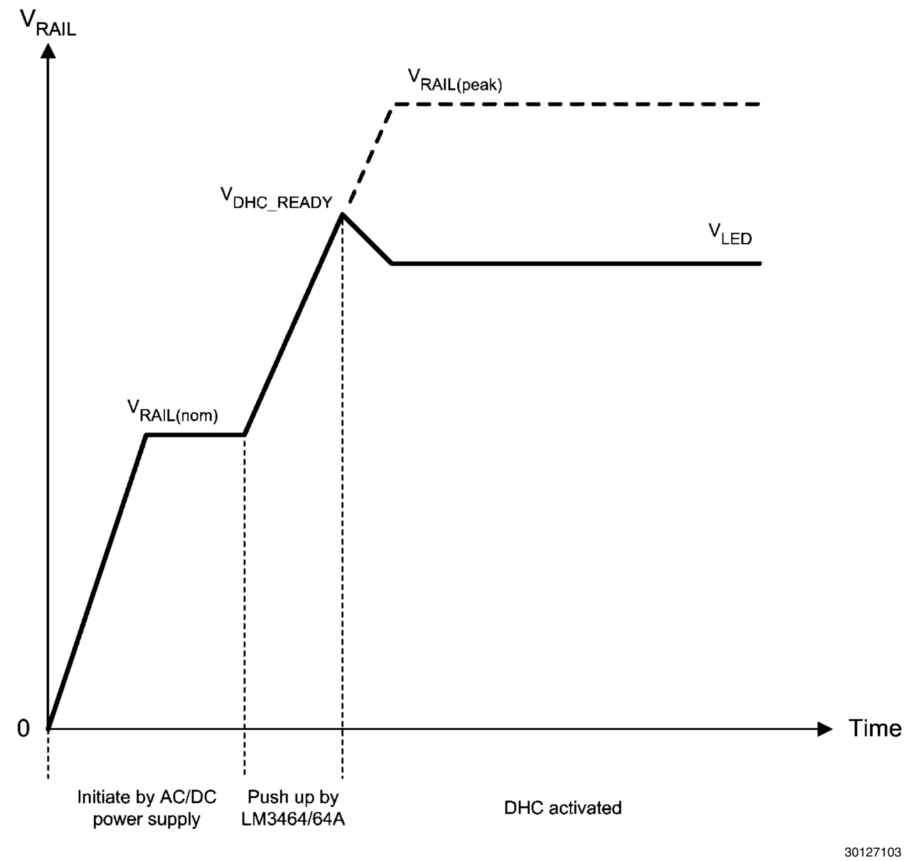


FIGURE 3. Changes of Rail Voltage Upon Power Up

Setting of V_{DHC_READY}

When V_{RAIL} reaches V_{DHC_READY}, the voltage at the VLedFB pin of the LM3464A equals 2.5V. As the voltage at the VLedFB pin reaches 2.5V, the LM3464A performs a test for no long than 400uS to identify and exclude the idle (no LED connected) or failed (shorten / open circuit of LED string) output channels from the DHC loop. When a LED string is open circuit, the voltage drop on the current sensing resistors (V_{SE1} — V_{SE4}) is below 30mV. If the voltage of the SEx pin maintains below 30mV longer than the fault detection time defined by CFLT, an 'open fault' is recognized. When a LED string is short circuit, causing the drain voltage of an external MOSFET 8.4V higher than the drain voltage of any other channel and maintains longer than the fault detection time defined by CFLT, an short fault is recognized. Either a short or open fault will cause the Faultb pin to pull low. When a LED string experiences an open or short circuit, the corresponding output channel will be disabled and excluded from the DHC loop to sustain normal operation of the remaining LED strings. The LM3464A will maintain the failed channels in disable state until the EN pin is pulled low or the entire system is re-powered. When the test is completed, the LM3464A enables the output channels and provides constant current to the LED strings.

The level of V_{DHC_READY} is defined by the values of RFB1 and RFB2 on the evaluation board and can be adjusted to any level below 80V / 95V (LM3464/LM3464A) as desired. By default, the V_{DHC_READY} is set at 48V. The V_{DHC_READY} must set no more than 20V higher than the forward voltages of any LED string connected to the system under possible temperatures, otherwise a 'short fault' may arise and results in immediate output channel latch-off to protect the MOSFETs from over-heat. The V_{DHC_READY} is can be adjusted following equation (5):

$$V_{DHC\_READY} = 2.5 \times \frac{R_{FB1} + R_{FB2}}{R_{FB2}} V \quad (5)$$

Adjusting Voltage Headroom

The voltage headroom of the LM3464A evaluation board can be altered by adjusting the voltage at the VDHC pin (V_{VDHC}) in the range of 0.8V to 2V. For the applications with high rail voltage ripple, the voltage headroom should be increased to secure accurate output current regulation. By default, the VD-HC pin is biased internally to 0.9V as shown in figure 4.

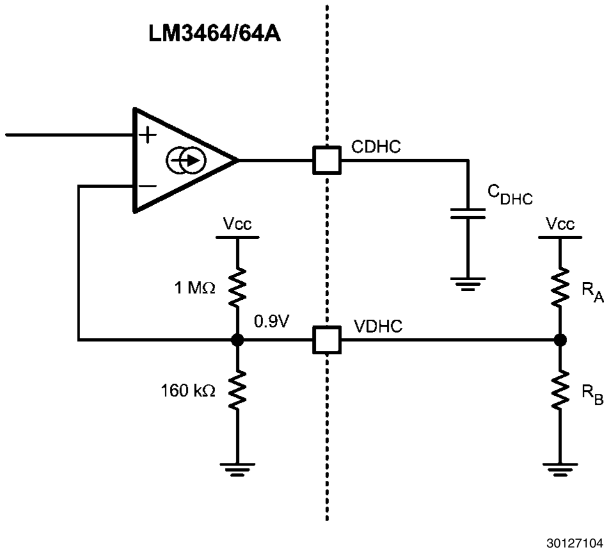


FIGURE 4. Adjusting the VDHC Pin Voltage

To adjust V_{VDHC} on the evaluation board, an additional resistor divider (R_A and R_B) can be added across the VDHC test pad and VCC or AGND terminals on the board. The values of of R_A and R_B should be below 100kΩ and 16kΩ respectively to ensure the accuracy of the headroom voltage under steady state. The V_{VDHC} is governed by the following equation:

$$V_{VDHC} = \frac{160\ k\Omega\ //\ R_B}{160\ k\Omega\ //\ R_B + 1\ M\Omega\ //\ R_A} \times V_{CC} \quad (6)$$

where

$$0.8V < V_{VDHC} < 2V \quad (7)$$

Connecting the LED Strings

The LM3464A evaluation board is designed to drive 4 common anode LEDs strings of 12 serial LEDs per string. The board includes four turret connectors, LED1, LED2, LED3 and LED4 for cathode connections of the LED strings. The anode of the LED strings should connect to the positive power output terminal of the AC/DC power supply. By default, the output current for each output channel is set at 350mA. The output currents of the LM3464A evaluation board can be programmed individually by changing the value of the resistors RISNS1, RISNS2, RISNS3 and RISNS4 accordingly. The LED driving current is governed by the following equation:

$$I_{LED} = \frac{200}{RISNSx}\ \text{mA (per ch.)} \quad (8)$$

Adjusting Frequency Response of the LM3464A Circuit

The frequency response of the LM3464A evaluation board can be adjusted by changing the value of the capacitor, C_{DHC}. Higher capacitance of C_{DHC} results in slower frequency response of the LM3464A driver stage. In order to ensure stable system operation, it is recommended to set the dominant pole of the LM3464A one decade lower than the dominant pole of the AC/DC converter. The default value of the C_{DHC} on the evaluation board is 0.22uF. For applications with slow response AC/DC power supply (e.g. converters with active PFC), the value of CDHC should be increased to make the frequency response of the board slower than the response of the AC/DC power supply. The cut-off frequency of the LM3464A driver stage is governed by the following equation:

$$f_{LM3464(-3\ dB)} = \frac{1}{2\pi(1.2 \times 10^6) \times C_{DHC}} \quad (9)$$

Thermal Foldback Control

The LM3464A evaluation board features an interface that enables thermal foldback control by connecting a NTC thermal sensor to the THM+ and THM- terminals. With the NTC sensor attached to the chassis of the LEDs, the integrated thermal foldback control circuit reduces the average LED current and effectively reduces the LED temperature to prevent thermal breakdown of the LEDs. The thermal foldback control circuit reduces the LED currents by means of PWM dimming which the dimming frequency is set by the capacitor, CTHM following the equation shows below:

$$f_{Thermal\_foldback} = \frac{50 \times 10^{-6}}{(3.25 - 0.4) \times CTHM} \text{ Hz} \quad (10)$$

The default value of the CTHM on the LM3464A evaluation board is 68nF, which set the thermal foldback dimming frequency at 258Hz.

Thermal foldback control is activated when the voltage at the Thermal pin, $V_{Thermal}$ is in between 3.25V and 0.4V as shown in figure 5. Thermal foldback control begins when $V_{Thermal}$ is below 3.25V. The LED current will be reduced to zero as $V_{Thermal}$ falls below 0.4V. The average LED current varies according to the Thermal pin voltage following the equation:

$$I_{LED(Avg)} = (V_{Thermal} - 0.4) \times 0.35 \times \frac{200}{R_{ISNSx}} \text{ mA (per ch.)} \quad (11)$$

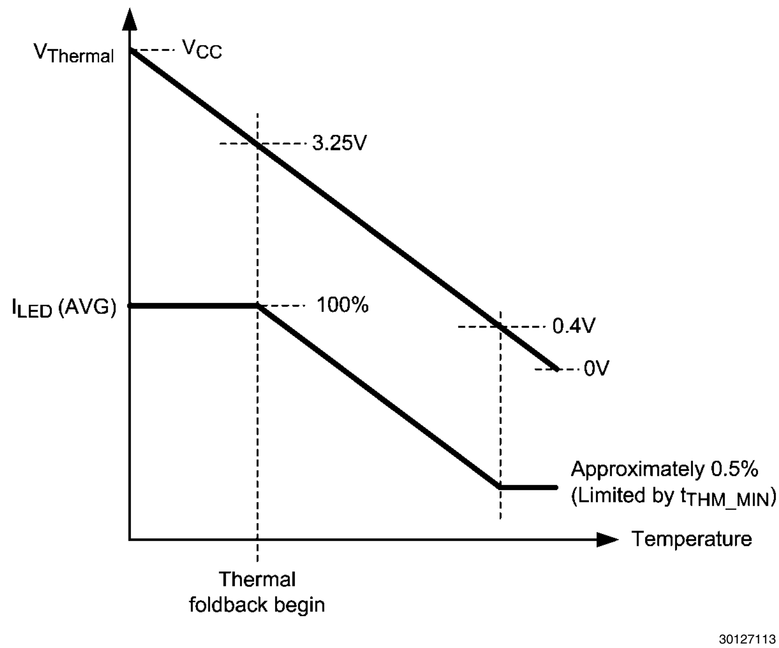


FIGURE 5. Changes of Average LED Current with Thermal Foldback Control

When the voltage at the DMIN pin is below 0.4V, the minimum on time for thermal foldback control is restricted by the value of C_{THM}. As the voltage of the Thermal pin is set below 0.4V, the on time for all output channels equals the discharge time of the C_{THM} following the equation:

$$t_{THM\_MIN} = 262 \times C_{THM} \text{ in second} \quad (12)$$

Thus the minimum dimming duty cycle for thermal foldback is calculated approximately equal to 0.5%:

$$D_{THM\_MIN} = (t_{THM\_MIN} \times f_{Thermal\_foldback}) \times 100\% \text{ Approximately equal to 0.5\%} \quad (13)$$

Design Example

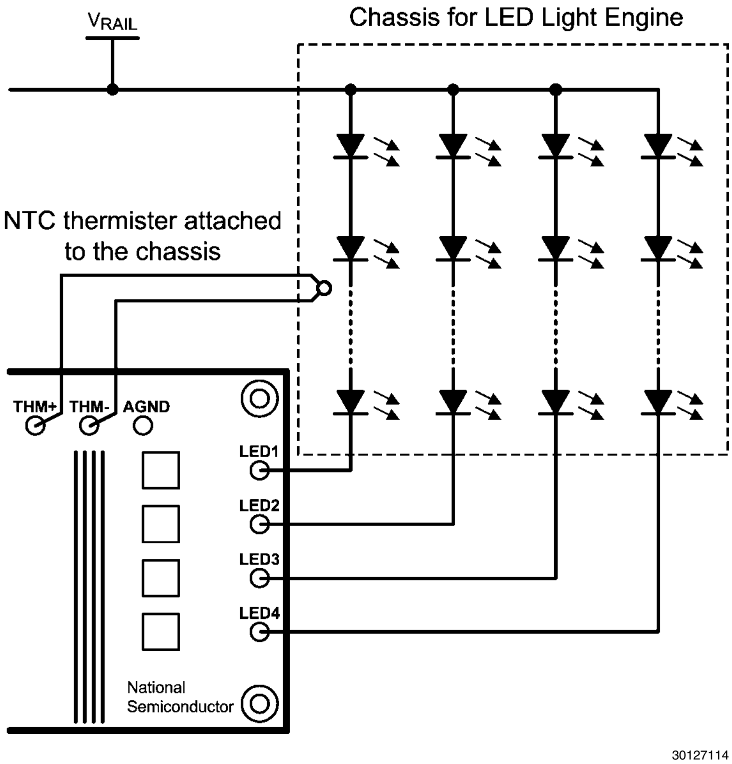


FIGURE 6. Attaching NTC Thermistor to the LEDs

A NTC thermistor is connected to the THM+ and THM- terminals of the LM3464A evaluation board as shown in figure 6 to activate the thermal foldback control function.

Assuming that thermal foldback control is required to begin at 70°C LED chassis temperature and reduce 55% average LED current (45% dimming duty cycle) when the chassis temperature reaches 125°C. Using the NTC thermister NXFT15W-B473FA1B from MURATA, which has 4.704kΩ resistance at 70°C ($R_{NTC(70°C)}$) and 1.436kΩ at 125°C ($R_{NTC(125°C)}$).

$V_{Thermal}$ at 125°C (45% dimming duty cycle):

$$V_{Thermal} = \left[(3.25V - 0.4V) \times D_{THMFB}\right] + 0.4V \quad (14)$$

$$= \left[(3.25V - 0.4V) \times 0.45\right] + 0.4V \quad (15)$$

$$= 1.68V \quad (16)$$

In the above equation, $V_{Thermal}$ is the voltage at the Thermal pin and D_{THMFB} is the dimming duty cycle under thermal foldback control. When thermal foldback begins:

$$3.25V = V_{CC} \times \frac{RTHM2 + R_{NTC(70°C)}}{RTHM1 + RTHM2 + R_{NTC(70°C)}} \quad (17)$$

$$= 6.5V \times \frac{RTHM2 + 4.704\ k\Omega}{RTHM1 + RTHM2 + 4.704\ k\Omega} \quad (18)$$

$$RTHM1 = RTHM2 + 4.704\ k\Omega \quad (19)$$

When the temperature goes up to 125°C

$$1.68V = V_{CC} \times \frac{RTHM2 + R_{NTC(125°C)}}{RTHM1 + RTHM2 + R_{NTC(125°C)}}$$

$$= 6.5V \times \frac{RTHM2 + 1.436\ k\Omega}{RTHM1 + RTHM2 + 1.436\ k\Omega}$$

$$RTHM1 = 2.87 \times RTHM2 + 4.121\ k\Omega \quad (20)$$

By combining the equations (17) and (18), the values of RTHM1 and RTHM2 can be obtained:

$$RTHM1 = 230\Omega$$

$$RTHM2 = 4.9\ k\Omega \quad (21)$$

The default values of RTHM1 and RTHM2 on the LM3464A evaluation board are 4.87kΩ and 232Ω respectively.

Minimum Dimming Duty Cycle for Thermal Foldback Control

The minimum dimming duty cycle for thermal foldback control (D_{THMFB_MIN}) can be limited by setting the voltage at the DMIN pin of the LM3464A. The minimum dimming duty cycle limit overrides the minimum dimming level defined by RTHM1, RTHM2 and the NTC thermistor. This function is especially useful for the applications that require to maintain certain brightness level under high operation temperature. The level of minimum duty cycle limit is governed by the following equation:

$$D_{MIN} = \left[\frac{1}{3.25 - 0.4} \times (V_{DMIN} - 0.4) \right] \times 100\% \qquad (22)$$

PWM Dimming

PWM dimming control can be realized by applying PWM dimming signal to the DIM terminal of the board directly. When the DIM pin is pulled to logic high, all output channles are enabled. When the DIM pin is pulled to logic low (GND), all output channels are turned OFF. In cascade operation, the DIM signal should only be applied to the MASTER unit. The LM3464A on the MASTER unit propagates the PWM dimming signal on its DIM pin to the slave units one by one through the SYNC pin. PWM dimming control is allowed when thermal foldback control is activated. When PWM dimming and thermal foldback controls are required simultaneously, the PWM dimming frequency should be set at least ten times below the thermal foldback dimming frequency. The thermal foldback dimming signal reduces the LED currents according to the voltage at the Thermal pin when the signal at the DIM pin is being pulled 'high' as shown in figure 7.

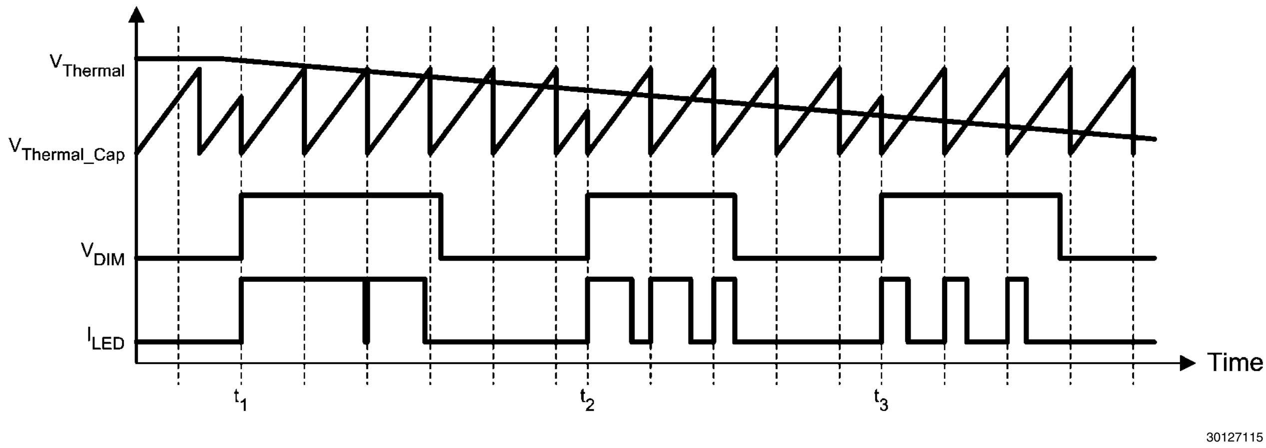


FIGURE 7. Thermal Foldback + PWM Dimming Control

Cascade Operation

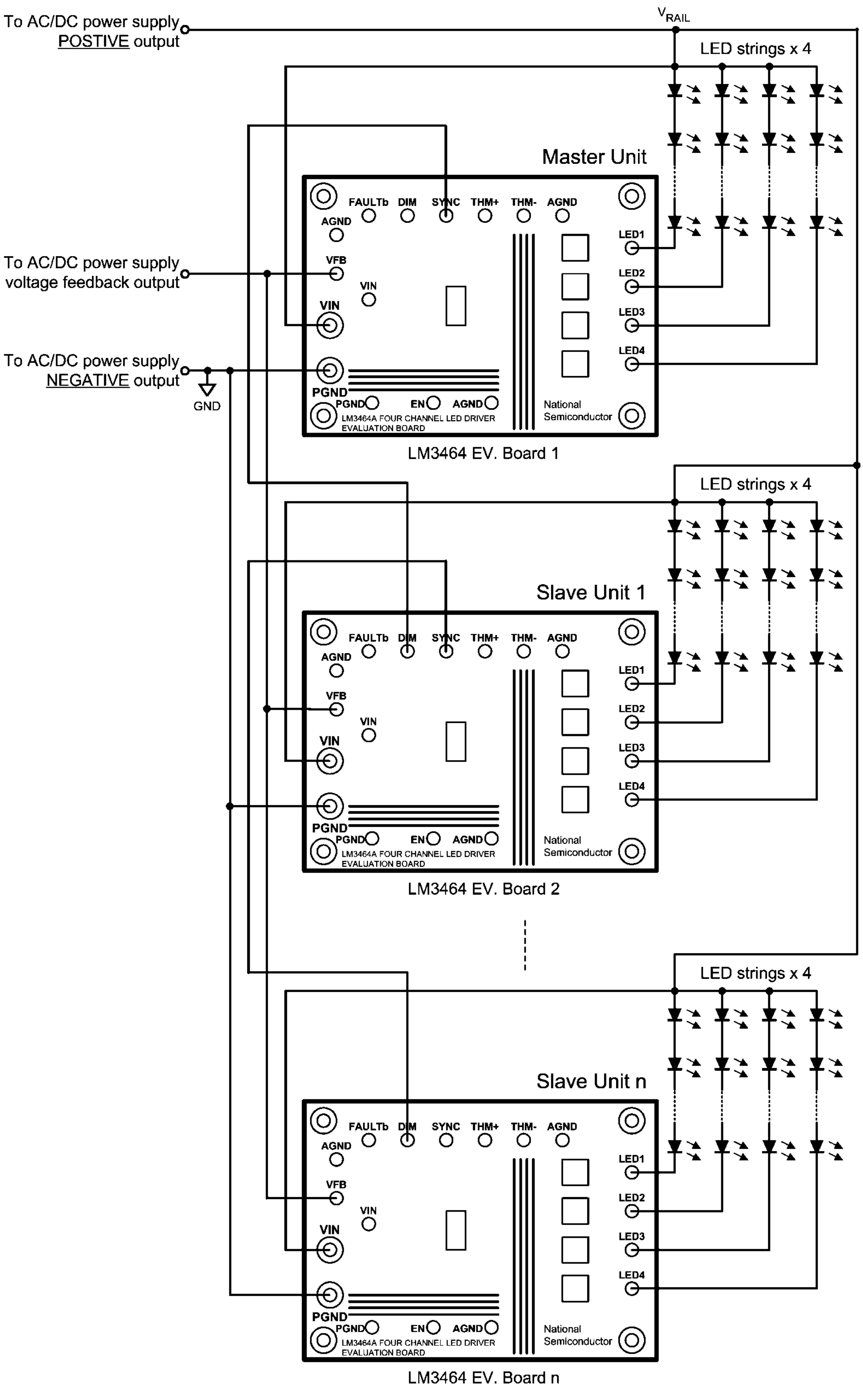


FIGURE 8. Cascading LM3464A Evaluation Boards for Output Channel Expansion

The total output power of the LED lighting system can be expanded by cascading the LM3464A evaluation boards. In cascade operation, the system involves one master unit and multiple slave units. Both master and slave units are LM3464A evaluation boards with minor modifications to program the LM3464A into master or slave modes. The connection diagram for cascade operation is shown in figure 8. The master unit is responsible to provide functions as listed in below:

1. Detect rail voltage upon system startup

2. Command slave units to turn on LEDs as its VLedFB voltage reaches 2.5V

3. Provide dimming signal to slave units according to the PWM dimming signal received at its DIM pin

4. Provide dimming signal to slave units according to the voltage of its Thermal pin

By default, the LM3464A evaluation board is set to master mode. To set the board to slave mode, the following changes to the board are required:

• Remove resistors RFB1 and RFB2

• Connect VLEDFB to VCC

When connecting the master and slaves, the following connections are required:

• Connect the VIN terminal of master and slave units together and then to the POSITIVE output of the AC/DC power supply

• Connect the PGND terminal of master and slave units together and then to the NEGATIVE output of the AC/DC power supply

• Connect the SYNC terminal of the master unit to DIM terminal of the next slave unit in the chain.

• Connect the VFB terminal of master and slave units together and then to the voltage feedback node of the AC/DC power supply.

If more than one slave unit is required, the SYNC pin of the first slave unit should connect to the DIM pin of the next slave unit to allow propagation of the control signal along the system chain.

Connection To Led Arrays

When LEDs are connected to the LM3464A driver stage through long cables, the parasitic components of the cable harness and external MOSFETs may resonant and eventually lead to unstable system operation. In applications that the cables between the LM3464A driver circuit and LED light engine are longer than 1 meter, a 4.7kΩ resistor should be added across the GDx pins to GND as shown in Figure 12.

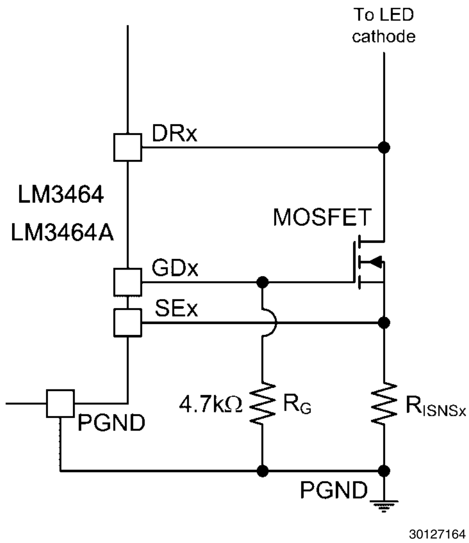


FIGURE 9. Additional Resistor Across GDx and SEx for Cable Harness Over 1m Long

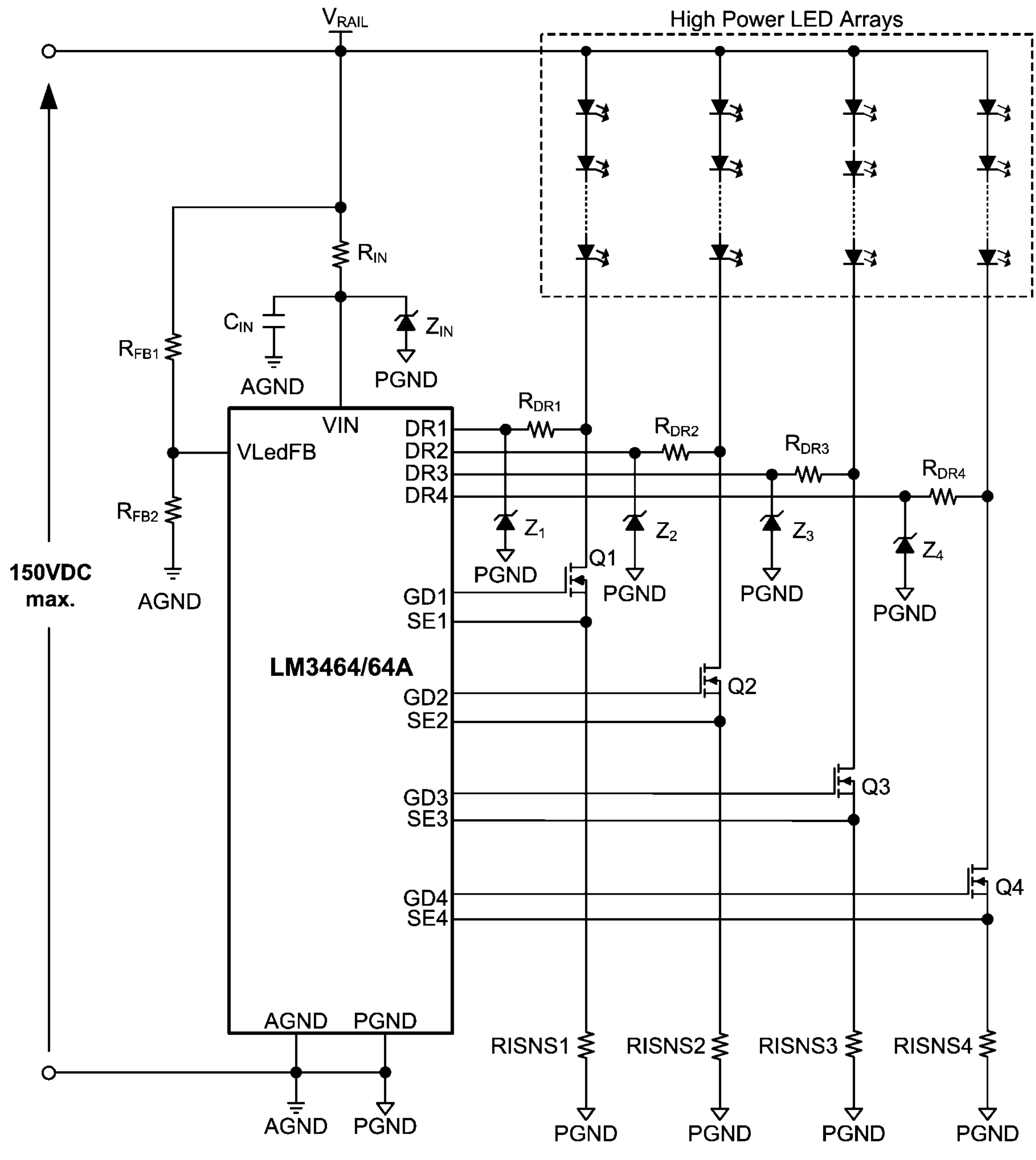


FIGURE 10. Additional Voltage Clamping Circuits for $V_{RAIL(peak)}$ > 80V/95V (LM3464A)

Applications With High Rail Voltage

Since the LM3464A is rated to 95V supply voltage, applying a voltage to any pin of the device exceeding the absolute rated voltage could damage the device permanently. For the applications that the rail voltage could increase to exceed 95V, external voltage clamping circuit must be added to the Vin and DRx pins to avoid system breakdown. Figure 13 shows a typical application circuit with 150V peak rail voltage.

In figure 13, Z_1, Z_2, Z_3, Z_4 and Z_{IN} are zener diodes for limiting voltages at the DRx and VIN pins of the LM3464A. The reverse voltage of the selected zener diodes must not exceed the rated voltage of the corresponding pin. For the LM3464A evaluation board, the reverse voltage of the additional zener diodes must not exceed 95V. The resistors R_{DR1}, R_{DR2}, R_{DR3}, R_{DR4} and R_{IN} are resistors for absorbing the voltage difference across the DRx pins and V_{RAIL}.

Calculating the Values of Z_x and R_{DRx}:

Since the current being passed through the zener diodes are derived by the resistance of R_{DRx}, the value of the R_{DRx} must be calculated properly according to the reverse current of the zener diode and input current of the DRx pins of the LM3464A avoid unnecessary power dissipations. For instant, a 500mW/75V zener diode CMHZ5267B (Central Semiconductor) is used to clamp the DRx pins at 75V. Because the reverse current of the CMHZ5267B is 1.7mA at 75V zener voltage, the maximum allowable reverse current is 6.67mA at 500mW power dissipation.

Given that the input current of the DRx pins of the LM3464A at 100V is 63uA maximum, if the DRx pin voltage is below 100V, the current flowing into the DRx pin (I_{DRx}) is below 63uA. In the following calculations, I_{DRx} is assumed to 63uA to reserve operation margin to compensate the characteristics variations of the components.

Because $V_{RAIL(peak)}$ is the possible highest voltage at the DRx pins, the maximum resistance of R_{DRx} can be calculated following this equation:

$$R_{DRX} = \frac{V_{RAIL(peak)} - V_Z}{I_{DRX} + I_Z}$$

Where V_Z and I_Z are the reverse voltage and current of the zener diode Zx respectively.

For $V_{RAIL(peak)}$ = 150V, the maximum value of R_{DRx} is:

$$R_{DRX(max)} = \frac{150V - 75V}{63\mu A + 1.7mA}$$

$$= 42.5k\Omega$$

And the minimum value of R_{DRx} is:

$$R_{DRX(min)} = \frac{150V - 75V}{63\mu A + 6.67mA}$$

$$= 11.14k\Omega$$

Thus, the value of R_{DRx} must be selected in the range:

$$11.14k\Omega \le R_{DRX} \le 42.5k\Omega$$

To minimize power dissipation on the zener diodes, a standard 42.2kΩ resistor can be used for the R_{DRx}. The maximum power dissipation on the R_{DRx} is then equals to:

$$P_{RDRX(max)} = \frac{(V_{RAIL(peak)} - V_Z)^2}{R_{DRX}}$$

$$= \frac{(150V - 75V)^2}{42.2k\Omega}$$

$$= 133mW$$

Thus, a standard 42.2kΩ resistor with 0.25W power rating (1206 package) and 1% tolerance can be used.

Calculating the Values of Z_{IN} and R_{IN}:

Assume the VIN pin of the LM3464A is about to be clamped to 75V, a 1.5W/75V zener diode CMZ5946B from Central Semiconductor is used to ensure adequate conduction current for Z_{IN}. Because the reverse current of the CMZ5946B is 5mA at 75V, the allowable current flows through Z_{IN} is in between 5mA to 20mA. Similar to the requirements of selecting the Zx and R_{DRx}, the voltage at the VIN pin of the LM3464A is clamped to 75V by a voltage clamping circuit consists of Z_{IN} and R_{IN}. Also since the maximum operating and shutdown current (V_{EN} < 2.1V) are 3mA and 700uA respectively, to ensure the voltage of the VIN pin is clamped close to 75V even when the LM3464A is disabled, the value of R_{IN} should be calculated following the equations below:

$$R_{IN} = \frac{V_{RAIL(peak)} - V_{ZIN}}{I_{IN} + I_{ZIN}}$$

Maximum value of R_{IN}:

$$R_{IN(max)} = \frac{150V - 75V}{3mA + 5mA} = 9.375k\Omega$$

Minimum value of R_{IN}:

$$R_{IN(min)} = \frac{150V - 75V}{3mA + 20mA} = 3.26k\Omega$$

So the value of R_{IN} must be in the range:

$$3.26k\Omega \le R_{DRX} \le 9.38k\Omega$$

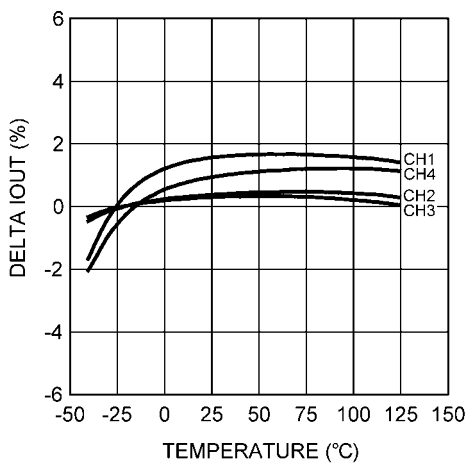
To minimize power dissipations on both the Z_{IN} and R_{IN}, a standard 9.31kΩ resistor can be selected for the R_{IN}. Then the maximum power dissipation on R_{IN} is:

Thus, a standard 9.38kΩ resistor with 2512 package (1W) and 1% tolerance can be used.

Typical Performance and Waveforms

All curves taken at V_{IN} = 48V with configuration in typical application for driving twelve power LEDs with four output channels active and output current per channel = 350mA. T_A = 25°C, unless otherwise specified.

Output Current Variation



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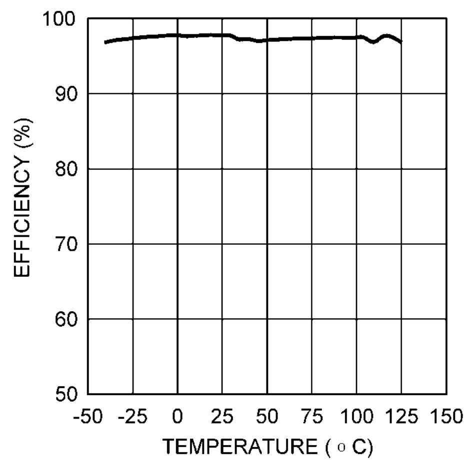
Efficiency (%)



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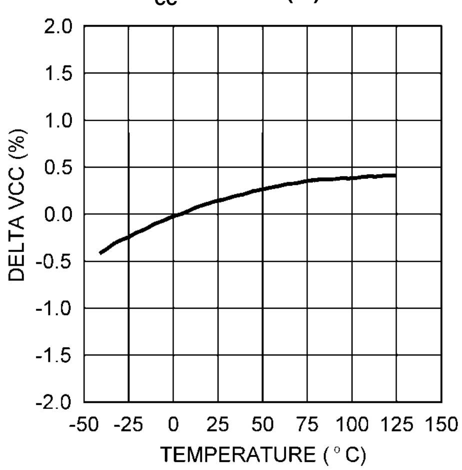
V_{CC} Variation (%)



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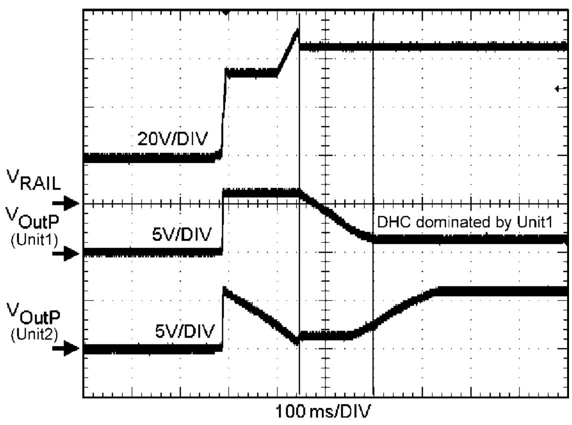
DHC in Cascade Operation



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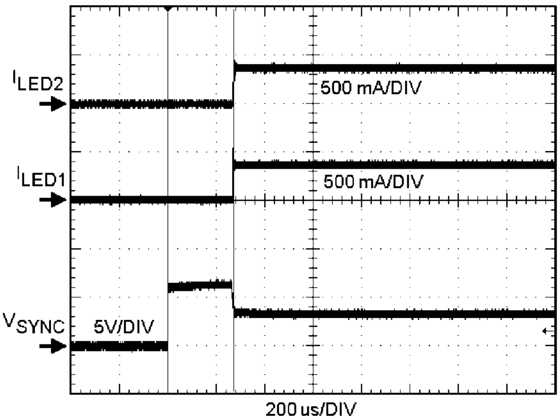
V_{SYNC} of Master Unit



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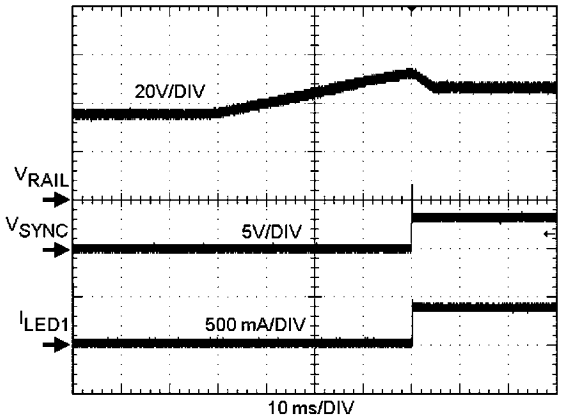
V_{SYNC} at System Startup



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Evaluation Board Layout

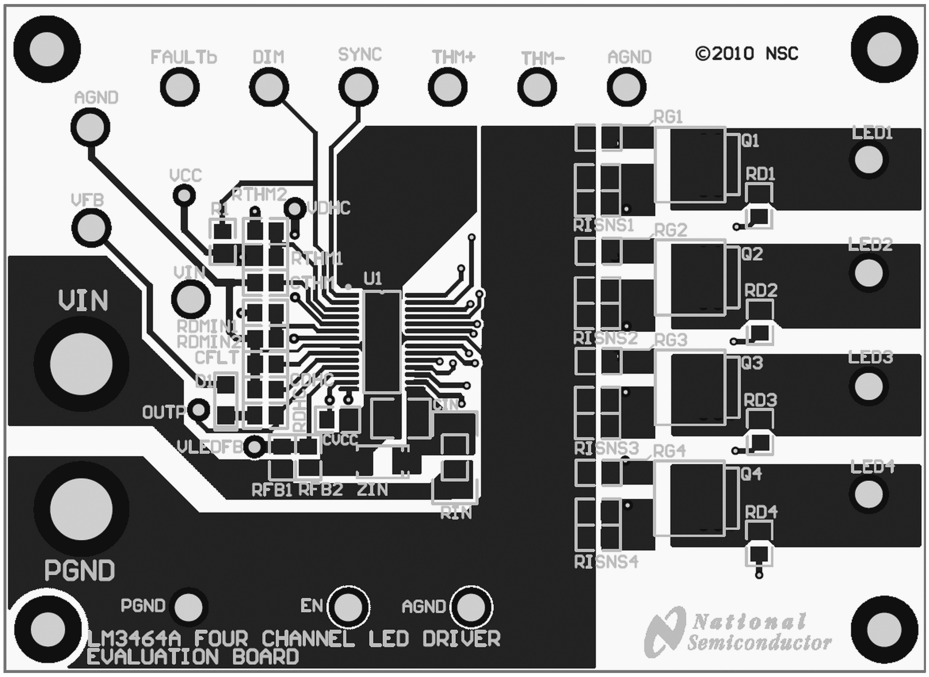

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FIGURE 11. Top Layer and Top Overlay

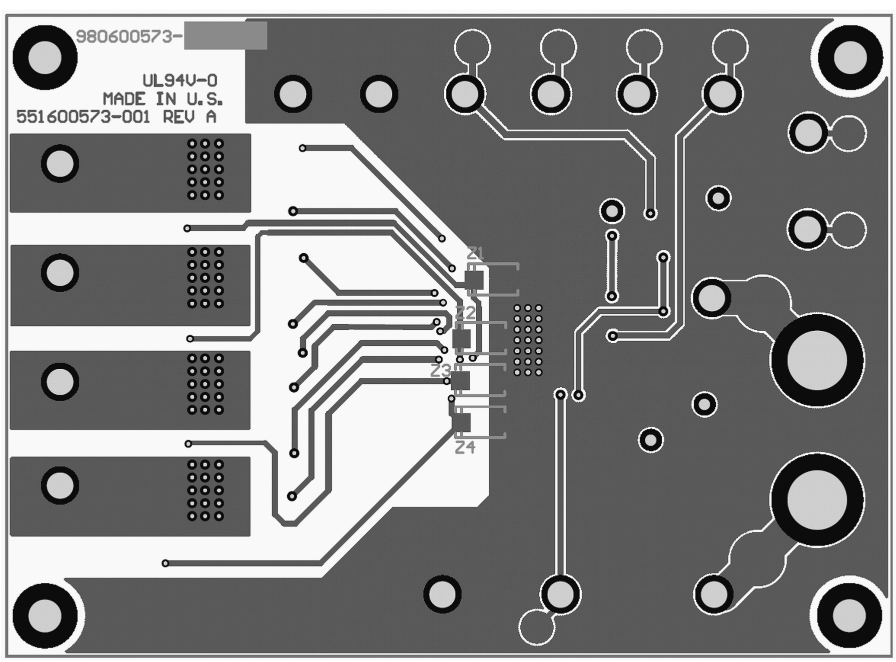

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FIGURE 12. Bottom Layer and Bottom Overlay

Notes

Notes

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