



Evaluation Board for Charge Pump Driver for LCD White LED Backlights

Preliminary Technical Data

EVAL-ADM8843

FEATURES

ADM8843 drives 4 white LEDs from a 2.6V to 5.5V (li-ion) input supply
1x/1.5x/2x Fractional Charge Pump to maximize power efficiency
0.3% Typ LED Current Matching
Power Sub and main Display LEDs
Low Power Shutdown Mode
Package footprint only 9mm² (3mm x 3mm)
Package height only 0.9mm
Shutdown Function
Soft-start limiting inrush current

APPLICATIONS

White LED Backlighting
Micro TFT Color displays
Mobile Phones with Main and Sub Displays
DSC
PDA's

INTRODUCTION

The ADM8843 Evaluation Board allows the ADM8843 Charge Pump Driver for LCD white LED backlights to be quickly and easily evaluated.

The evaluation board allows all of the input and output functions to be exercised without the need for external components.

ADM8843 GENERAL DESCRIPTION

The following gives a brief description of the ADM8843 and the evaluation board hardware overview. Further information can be found in the data sheet for the device.

The ADM8843 provides the power required to drive up to 4 white LEDs, using charge pump technology. The LEDs are used for backlighting a color LCD display. To maximize power efficiency, a charge pump that can operate in either a 1x, 1.5x or 2x mode is used. The charge pump automatically switches between 1x/1.5x/2x modes based on the input voltage, to maintain correct output levels at a high power efficiency.

Improved brightness matching of the LEDs is achieved by the use of a feedback pin to sense individual LED current with a typical I_{LED} to I_{LED} matching accuracy of 0.3%.

The ADM8843 provides two digital input control pins, CTRL1 and CTRL2, which control the operation and the brightness of the LEDs. The ADM8843 is configured with a sub and main display, the main display refers to 3 of the 6 LEDs (FB1 – FB3) and the sub display refers to the remaining LED (FB54).

The ADM8843 provides the option to control the brightness of the LEDs with a digital PWM signal. The duty cycle of the PWM signal determines the brightness of the backlight LEDs. Brightness control of the LEDs can also be controlled by a DC voltage. The ADM8843 has soft-start circuitry to limit inrush current flow at power up.

The ADM8843 is fabricated using CMOS technology for minimal power consumption. The part is packaged in a 16-lead LFCSP (Lead Frame Chip Scale Package).

EVALUATION SYSTEM PACKAGE CONTENTS

The evaluation system contains the following items:

- ADM8843 Evaluation Board
- PC Parallel to Serial Cable
- CD containing evaluation board software

EVALUATION BOARD HARDWARE

The ADM8843 evaluation board contains the following main components, which can be identified from the block diagram, the schematic diagram and the printed circuit board silkscreen of figures 1,3 and 4 overleaf.

- 13 jumper points to facilitate the connection of external inputs and internal circuitry.
- 21 test points for signal connection and measurement
- A patchwork area to facilitate the connection up the ADM8843 Eval Board to external components.

Rev. PrC

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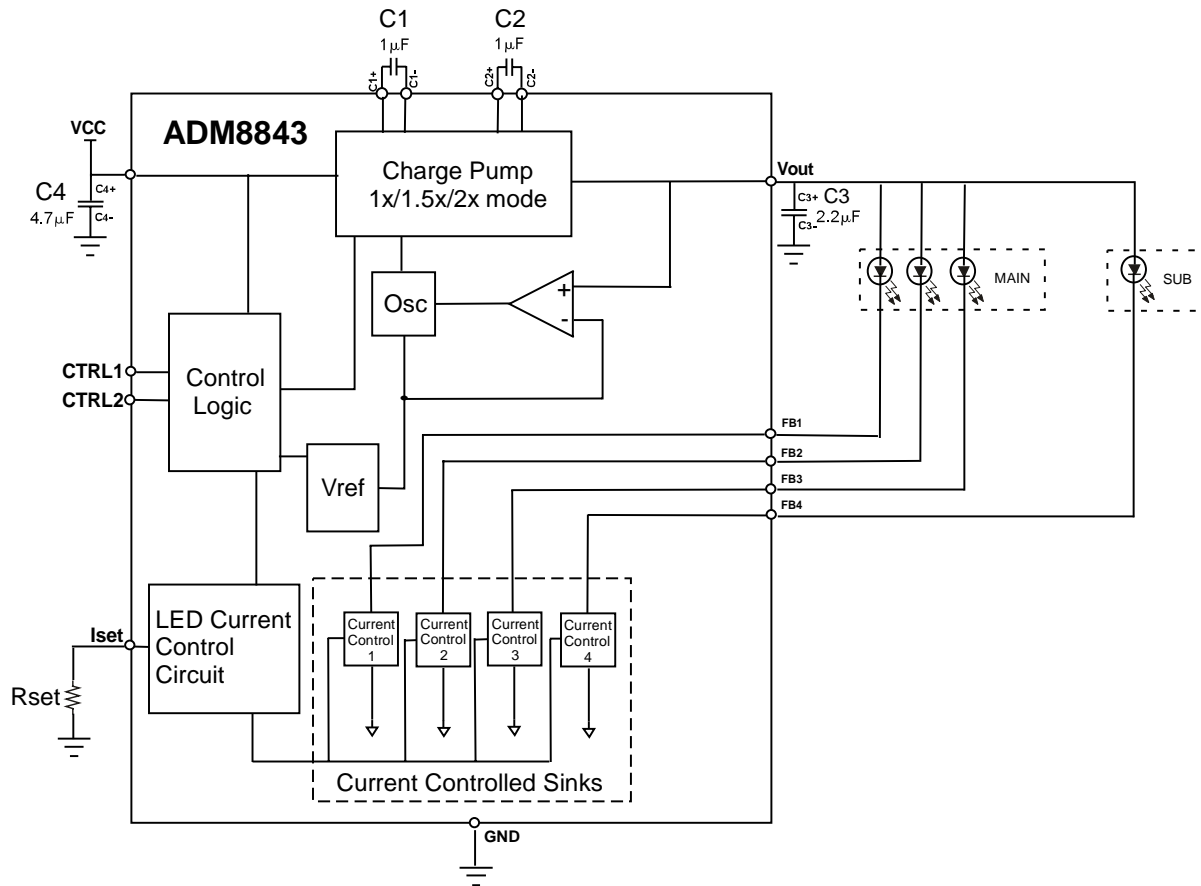


Figure 1. ADM8843 Functional Block Diagram

| CTRL1 | CTRL2 | LED Operation |
|-------|-------|------------------------------------|
| 0 | 0 | Sub Display Off / Main Display Off |
| 0 | 1 | Sub Display Off / Main Display On |
| 1 | 0 | Sub Display On / Main Display Off |
| 1 | 1 | Sub Display On / Main Display On |

Figure 2. ADM8843 Digital Inputs Truth Table

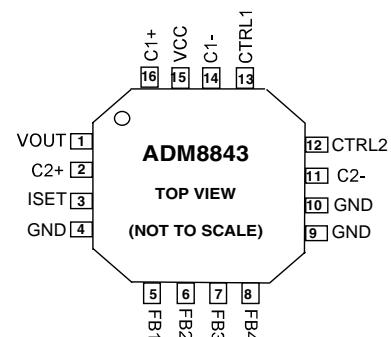


Figure 3. ADM8843 Pin Configuration

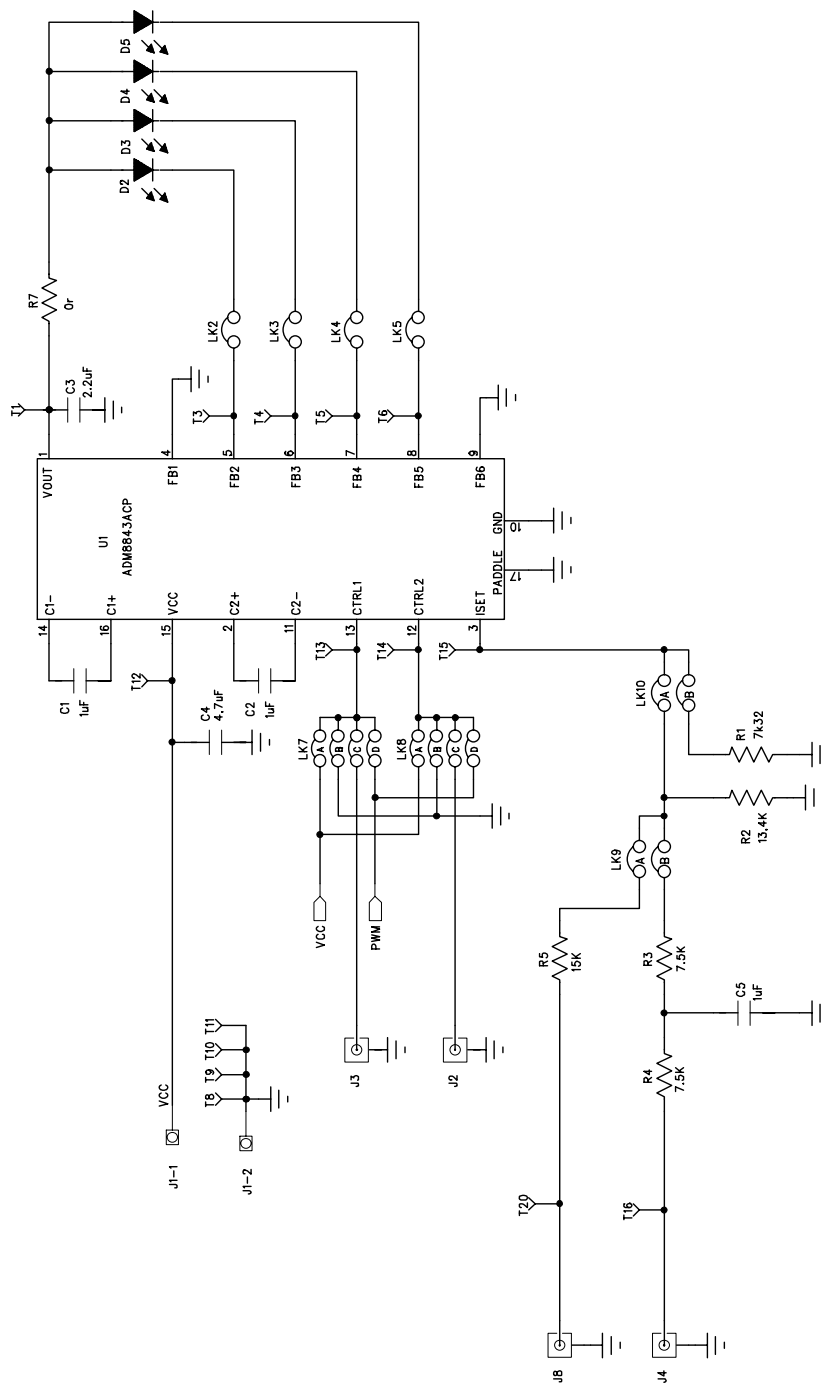
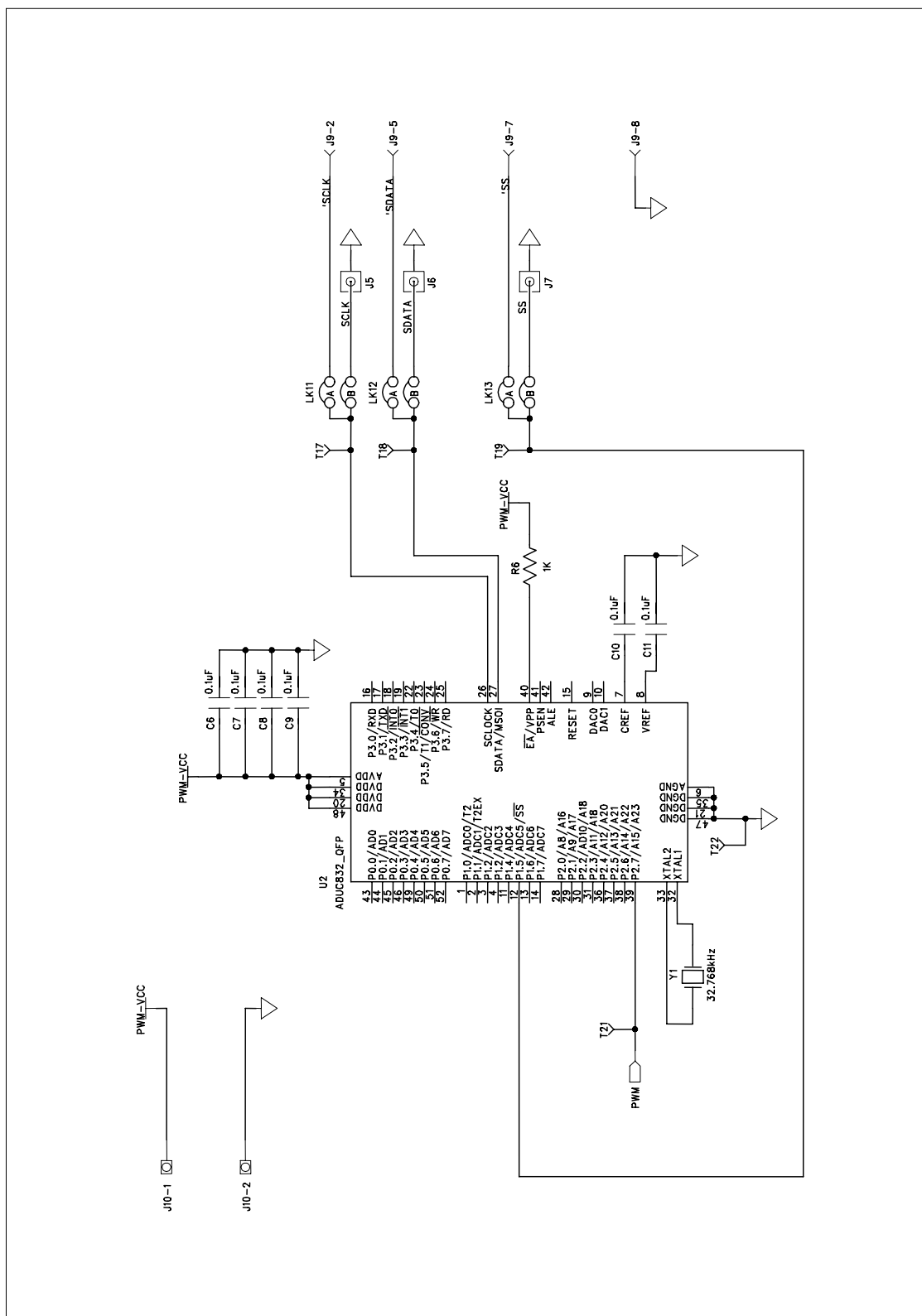


Figure 4. ADM8843 Evaluation Board Schematic Page 1



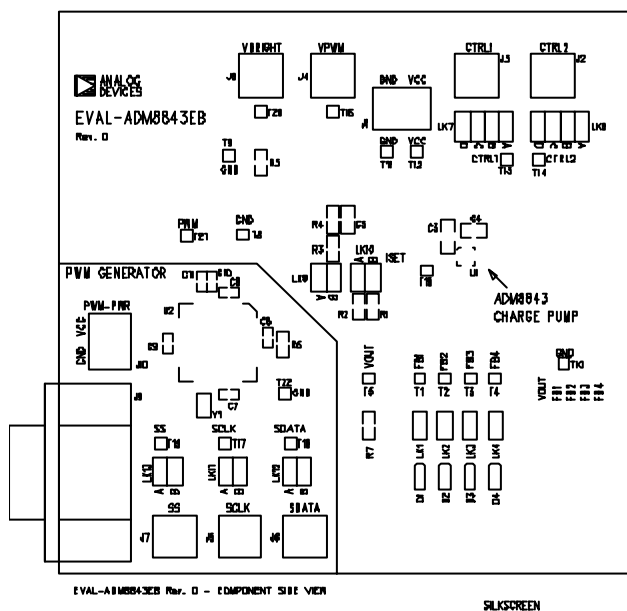


Figure 6. ADM8843 Evaluation Board Silkscreen

EVALUATION BOARD CONNECTORS AND JUMPERS

The function of the various connectors and jumpers on the evaluation board is explained below.

TABLE 1. EVALUATION BOARD POWER CONNECTORS

| Connector Number | Function |
|------------------|---|
| J1 | Supply to ADM8843 (3V Nominal) |
| J2 | External CTRL2 input signal |
| J3 | External CTRL1 input signal |
| J4 | External V_{PWM} node input signal |
| J5 | External SCLK input |
| J6 | External SDATA input |
| J7 | External \overline{SS} input |
| J8 | External V_{BRIGHT} node input signal |
| J9 | DB-9 Connector (Serial Interface Connector) |
| J10 | Supply to PWM Micro Converter (3V Nominal) |

TABLE 2. EVALUATION BOARD JUMPERS (LINKS)

| Jumper Name | Description | Default Status |
|-------------|--|-----------------|
| LK1 | LED 1 Connected | Inserted |
| LK2 | LED 2 Connected | Inserted |
| LK3 | LED 3 Connected | Inserted |
| LK4 | LED 4 Connected | Inserted |
| LK7 | A Connects CTRL1 (Pin 15) Digital Input to Vcc | Inserted |
| | B Connects CTRL1 (Pin 15) Digital Input to GND | Removed |
| | C Connects CTRL1 (Pin 15) Digital Input to SMB connector J3 | Removed |
| | D Connects CTRL1 (Pin 15) Digital Input to Micro Converter PWM | Removed |
| LK8 | A Connects CTRL2 (Pin 14) Digital Input to Vcc | Inserted |
| | B Connects CTRL2 (Pin 14) Digital Input to GND | Removed |
| | C Connects CTRL2 (Pin 14) Digital Input to SMB connector J2 | Removed |
| | D Connects CTRL2 (Pin 14) Digital Input to Micro Converter PWM | Removed |
| LK9 | A Connects I_{SET} (Pin 5) to V_{BRIGHT} node | Inserted |
| | B Connects I_{SET} (Pin 5) to V_{PWM} node | Removed |
| LK10 | A Connects I_{SET} (Pin 5) to V_{BRIGHT} node or V_{PWM} node | Removed |
| | B Connects I_{SET} (Pin 5) to I_{SET} resistor (7.2k Ohm) | Inserted |
| LK11 | A Connects SCLOCK to DBP Connector (SCLOCK controlled by Software GUI) | Inserted |
| | B Connects SCLOCK to SMB connector J5 | Removed |
| LK12 | A Connects SDATA to DBP Connector (SDATA controlled by Software GUI) | Inserted |
| | B Connects SDATA to SMB connector J6 | Removed |
| LK13 | A Connects SS to DBP Connector PWM (SS controlled by Software GUI) | Inserted |
| | B Connects SS to SMB connector J7 | Removed |

TABLE 3. EVALUATION BOARD COMPONENTS

| Item | Qty | Ref Des | Description |
|------|-----|------------|---------------------------|
| 1 | 1 | U1 | 16-Lead LFCSP Socket |
| 2 | 1 | U2 | ADuC832 Micro Converter |
| 3 | 2 | J1, J10 | Power Connector |
| 4 | 7 | J2- J8 | SMB Connectors |
| 5 | 1 | J9 | DB9 Connector |
| 6 | 21 | T1 - T21 | Test points |
| 7 | 3 | C1, C2, C5 | CAP, 1 μ F |
| 8 | 1 | C3 | CAP, 2.2 μ F |
| 9 | 1 | C4 | CAP, 4.7 μ F |
| 10 | 6 | C6 - C11 | CAP, 0.1 μ F |
| 11 | 1 | R1 | 7.32K Ohm |
| 12 | 1 | R2 | 13.4K Ohm |
| 13 | 2 | R3, R4 | 7.5K Ohm |
| 14 | 1 | R5 | 15K Ohm |
| 15 | 1 | R6 | 1K Ohm |
| 16 | 1 | R7 | 0 Ohm |
| 17 | 4 | D2 – D5 | White LEDs (FEC 335-7996) |
| 18 | 1 | Y1 | 32.768kHz Osc |

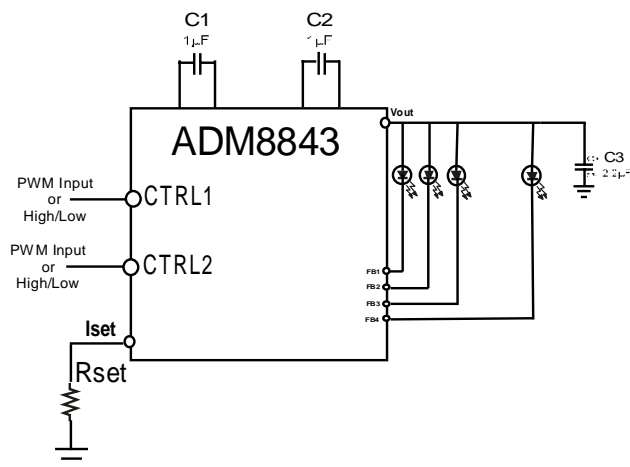
SETTING UP THE ADM8843 EVAL BOARD

Insert the following links to evaluate the ADM8843 with both the main and sub display on with approx. 20mA per LED:

1. Insert LK2 – LK5, this attaches all 4 LEDs to the Vout pin (Pin 3) of the ADM8843 chip. We are now going to operate the ADM8843 Eval Board with 4 LEDs in parallel.
2. Insert LK7 A and LK8 A. This turns on both the main and sub display.
3. Insert LK10 B. This connect a 7.32K Ohm resistor to the I_{SET} pin. This will give approx. 20mA per LED.
 $1.18V/7.32k\Omega = 161.20\mu A$. This is then scaled up by 120 to give $161.20\mu A * 120 = 19.344mA$ per LED
4. Remove all other Links
5. Apply power to Power Connector J1 (3V Nominal)

Insert the following links to evaluate the ADM8843 part with both the main and sub display on with approx. 20mA per LED, brightness controlled by a digital PWM signal applied to both CTRL1 and CTRL2:

1. Insert LK2 – LK5 this attaches all 4 LEDs to the Vout pin (Pin 3) of the ADM8843 chip. We are now going to operate the ADM8843 Eval Board with 4 LEDs in parallel.
2. Insert LK7 D and LK8 D. This turns on both the main and sub display for digital PWM brightness control.
3. Insert LK10 B. This connect a 7.32K Ohm resistor to the I_{SET} pin. This will give approx. 20mA per LED.
 $1.18V/7.32k\Omega = 161.20\mu A$. This is then scaled up by 120 to give $161.20\mu A * 120 = 19.344mA$ per LED
4. Insert LK11 A, LK12 A and LK13 A, this connect the ADuC832 to the software GUI to program the digital PWM frequency and duty cycle.
5. Remove all other Links
6. Apply power to Power Connector J1 (3V Nominal). This power up the ADM8843
7. Apply power to Power Connector J10 (3V Nominal). This powers up the ADuC832 which provides the digital PWM signal to CTRL1 and CTRL2.
8. Attach the PC cable provided to the parallel port of a PC and the Eval Board.
9. Open up the ADM8843/5 Software GUI and program the digital PWM frequency and duty cycle as required.



Insert the following links to evaluate the ADM8843 part with both the main and sub display on, brightness controlled by a DC voltage applied to the V_{BRIGHT} node, SMB J8.

1. Insert LK2 – LK5, this attaches all 4 LEDs to the Vout pin (Pin 3) of the ADM8843 chip. We are now going to operate the ADM8843 Eval Board with 4 LEDs in parallel.
2. Insert LK7 A and LK8 A. This turns on both the main and sub display.
3. Insert LK10 A and LK 9 A. This connects in the 13.4K Ohm resistor to ground and also the 15K Ohm resistor.
4. Apply a DC voltage from 0V to 2.5V to adjust the current flowing through the 4 LEDs, thereby adjusting their brightness.
5. The Following formula describes the relationship between I_{SET} and I_{LED}

$$I_{SET} = (1/R_{SET} + 1/R)(V_{SET}) - (1/R)(V_{BRIGHT})$$

$$I_{LED} = 120 * I_{SET}$$

Where $R = 15K$ Ohm, $V_{SET} = 1.18V$ (Voltage at I_{SET} pin)

6. Remove all other Links
7. Apply power to Power Connector J1 (3V Nominal). This power up the ADM8843

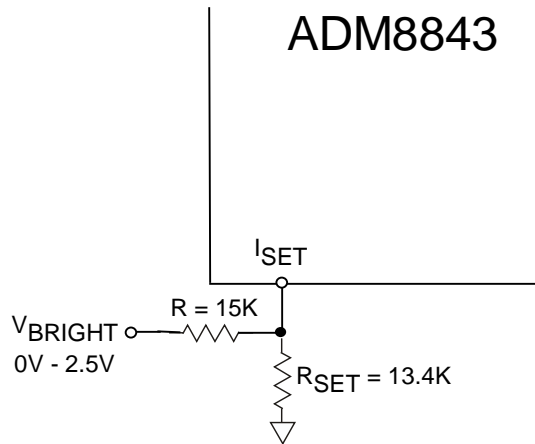


Figure 8. V_{BRIGHT} Node

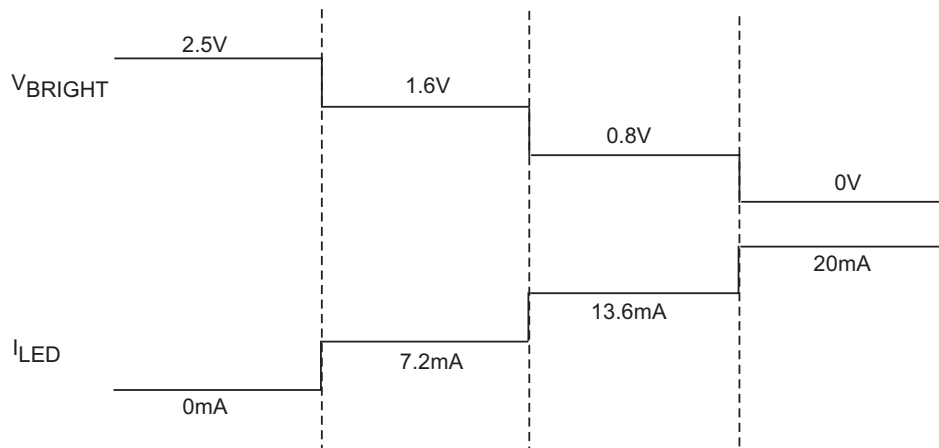


Figure 9. V_{BRIGHT} Node Operation

Insert the following links to evaluate the ADM8843 part with both the main and sub display on, brightness controlled by a PWM signal applied to the V_{PWM} node, SMB J4.

1. Insert LK2 – LK5, this attaches all 4 LEDs to the Vout pin (Pin 3) of the ADM8843 chip. We are now going to operate the ADM8843 Eval Board with 4 LEDs in parallel.
2. Insert LK7 A and LK8 A. This turns on both the main and sub display.
3. Insert LK10 A and LK 9 B. This connects in the 13.4K Ohm resistor to ground and also the two 7.5K Ohm resistors and the 1 μ F capacitor to ground between them.
4. Apply a PWM signal (Amplitude from 0V - 2.5V only) to adjust the current flowing through the 6 LEDs, thereby adjusting their brightness.
5. The Following formula describes the relationship between V_{PWM} and I_{LED}

$$I_{LED} = \frac{I_{SET_Voltage}}{\frac{R_{SET} * 2R}{R_{SET} + 2R}} * 120 * \frac{(1 - \text{Duty Cycle})}{100}$$

Where $R = 7.5K$ Ohm, $V_{SET} = 1.18V$ (Voltage at I_{SET} pin)

6. Remove all other Links
7. Apply power to Power Connector J1 (3V Nominal). This power up the ADM8843.

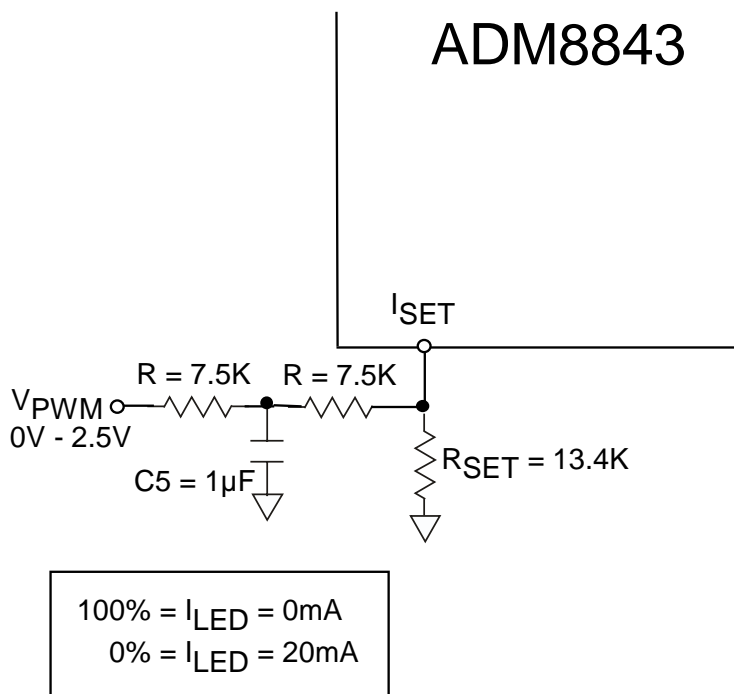
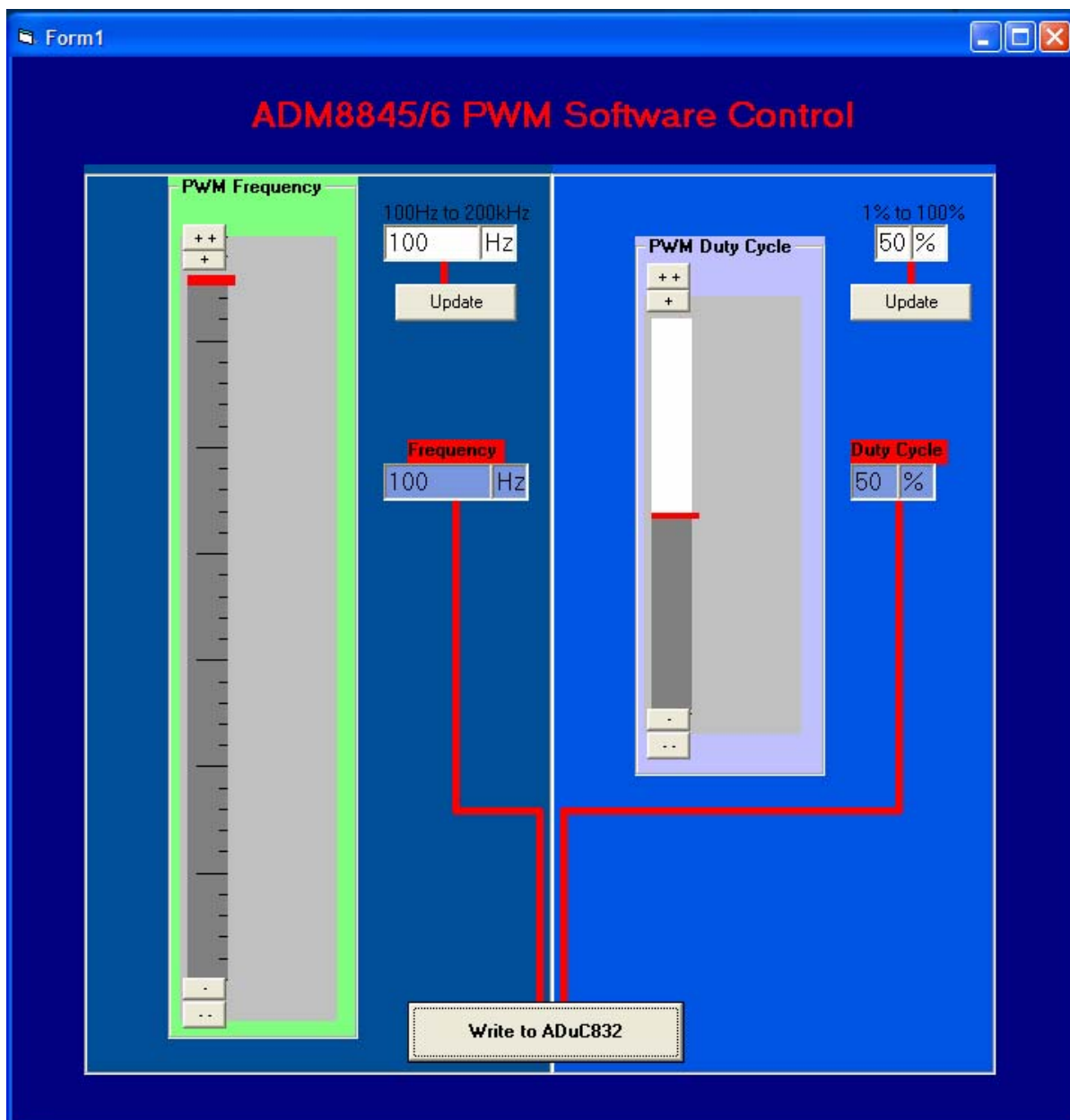


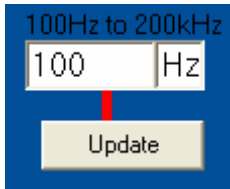
Figure 10. V_{PWM} Node Operation

USING THE ADM8843 SOFTWARE GUI TO PROGRAM THE ADUC832 PWM

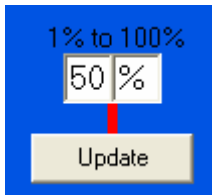
*Figure 11. ADM8843 Digital PWM Software GUI*

The ADM8843 software GUI allows the user to program the on-board ADuC832 to generate a PWM signal from 100Hz to 200 kHz with a duty cycle from 1% to 100%.

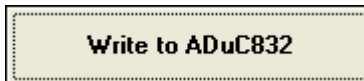
1. The user can enter the required frequency in Hz into the frequency text box and press the update button.



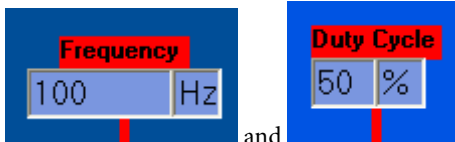
2. Also the user can enter the duty cycle required and press the update button.



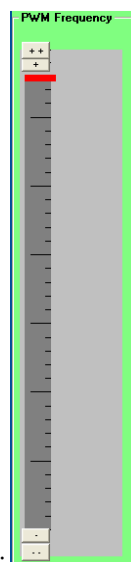
3. Then the corresponding values can be written to the ADuC832 over the parallel port to the eval board by pressing the Write to ADuC832 button.



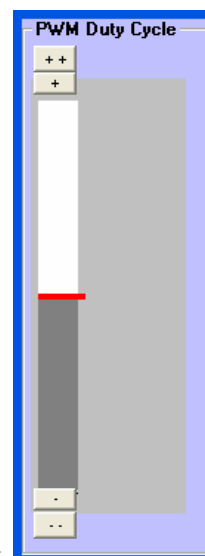
4. The values of frequency and duty cycle which are written to the ADuC832 are shown on the software GUI.



5. The user may also use the vertical sliding bars to select the frequency and duty cycle required.



6. Frequency vertical sliding bar :



- Duty Cycle vertical sliding bar :

ADuC832 PWM

The ADuC832 is operated in single variable resolution PWM (Mode 1), in this mode the pulse length and the cycle time (period) are programmable in user code, allowing the resolution of the PWM to be variable.

PWM1H/L sets the period of the output waveform. Reducing PWM1H/L reduces the resolution of the PWM output but increases the maximum output rate of the PWM. (e.g., setting PWM1H/L to 65536 gives a 16-bit PWM with a maximum output rate of 266Hz ($16.777\text{MHz}/65536$), because the maximum output rate is 266Hz and the ADM8843 PWM brightness control requires the output to go as low as 100Hz we have to use a lower frequency clock (32kHz) to generate the lower frequencies below 256Hz.

Setting PWM1H/L to 4096 gives a 12-bit PWM with a maximum output rate of 4096Hz ($16.777\text{MHz}/4096$).

PWM0H/L sets the duty cycle of the PWM output waveform, as shown on Figure 2.

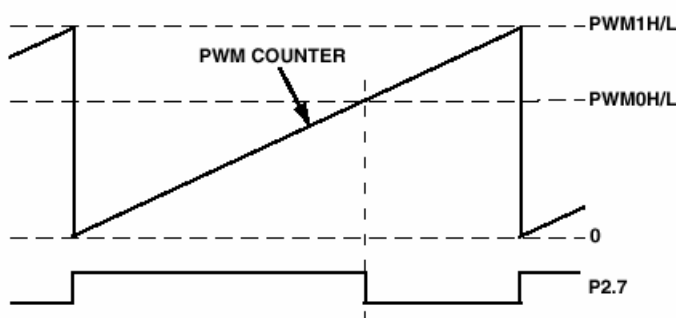


Figure 12. ADuC832 PWM in Mode 1

WRITING TO THE ADuC832

To program the ADuC832 PWM generator, five 8 bit words are written to the ADuC832 using the SPI interface.

- 1: PWM Frequency Low Bit
- 2: PWM Frequency High Bit
- 3: PWM Duty Low Bit
- 4: PWM Duty High Bit
- 5: PWM Mode

The ADuC832 takes a 16.777612MHz clock and divides this down by a 16 bit divisor

(PWM Frequency High Bit & PWM Frequency Low Bit)

This gives the PWM Frequency

The Duty Cycle 16 bit value is = (PWM Frequency High Bit & PWM Frequency Low Bit) * duty cycle

The PWM mode sets the PWMCON SFR

For example: 100 kHz and 80 % Duty Cycle

Frequency Divisor: $16.777612 \text{ MHz} / 100\text{kHz} = 167.77612 \Rightarrow 168$

Duty Cycle: $168 * 0.80 = 134.4 \Rightarrow 134$

- 1: PWM Frequency Low Bit = 10101000
- 2: PWM Frequency High Bit = 00000000
- 3: PWM Duty Low Bit = 10000110
- 4: PWM Duty High Bit = 00000000
- 5: PWM Mode = 10011

For example: 100Hz and 60 % Duty Cycle

Frequency Divisor: $32 \text{ kHz} / 100\text{Hz} = 320$

Duty Cycle: $320 * 0.60 = 192$

- 1: PWM Frequency Low Bit = 01000000
- 2: PWM Frequency High Bit = 00000001
- 3: PWM Duty Low Bit = 11000000
- 4: PWM Duty High Bit = 00000000
- 5: PWM Mode = 10001

The details of the ADuC832 can be found at: <http://products.analog.com/products/info.asp?product=ADuC832>

ADM8843 LAYOUT GUIDE

Layout considerations and noise

Because of the ADM8843 switching behavior, PCB trace layout is an important consideration. To ensure optimum performance a ground plane should be used, all capacitors (C1,C2,C3,C4) and the R_{SET} resistor particularly should be located with minimal track lengths to the pins of the ADM8843.