# CAT4237EVAL2EVB

# CAT4237 High Voltage White LED Driver Evaluation Board User's Manual

**ON Semiconductor®**

## EVAL BOARD USER'S MANUAL

### Introduction

This document describes the CAT4237EVAL2 Evaluation Board for the Catalyst Semiconductor CAT4237 white LED driver. The functionality and major parameters of the CAT4237 can be evaluated with the CAT4237EVAL2 board.

The CAT4237 is a high voltage CMOS constant−current DC/DC converter that has been designed to drive with high efficiency white or other high brightness LEDs. The high−voltage output stage allows driving up to 8 white LEDs in series. A single external resistor sets the LED current between 5 mA and 30 mA. LED current can be adjusted using either a pulse width modulated (PWM) signal or a DC voltage. Detailed descriptions and electrical characteristics are in the CAT4237 data sheet.

### CAT4237EVAL2 Board Hardware

The evaluation board contains a CAT4237 DC−DC boost converter and an array of white LEDs. As configured, the board circuit is set to drive up to 8 white LEDs in series. The user can chose to connect the CAT4237 output to the LEDs string available on board or to an external LEDs string from an application.

The board provides also the option to connect a different number of LEDs available on board, 6, 7 or 8, using a jumper shunt for one of the J2 to J4 connectors. The board schematic is shown in Figure 1.

The board is powered from an external voltage applied to the VIN (T1) pad. The circuit is delivered with the jumper shunt on the J4 connector, which connects the 8 LEDs string available on board to the CAT4237 output. The user can move the jumper to other connector, J2 or J3, if they desire to connect a different number of LEDs (6 or 7 LEDs).

The user can connect their own white LEDs between VOUT (T7) and LED (T10) test points, with no jumper shunt set to any of J2 to J4 connectors.

The LED current is set through the external resistors connected to the FB pin (R1, R2). Using the variable resistor R2, the LED current can be set from 3 mA to 30 mA. Most white LEDs are driven at a nominal current between 15 mA and 20 mA to ensure a pure "white" light.
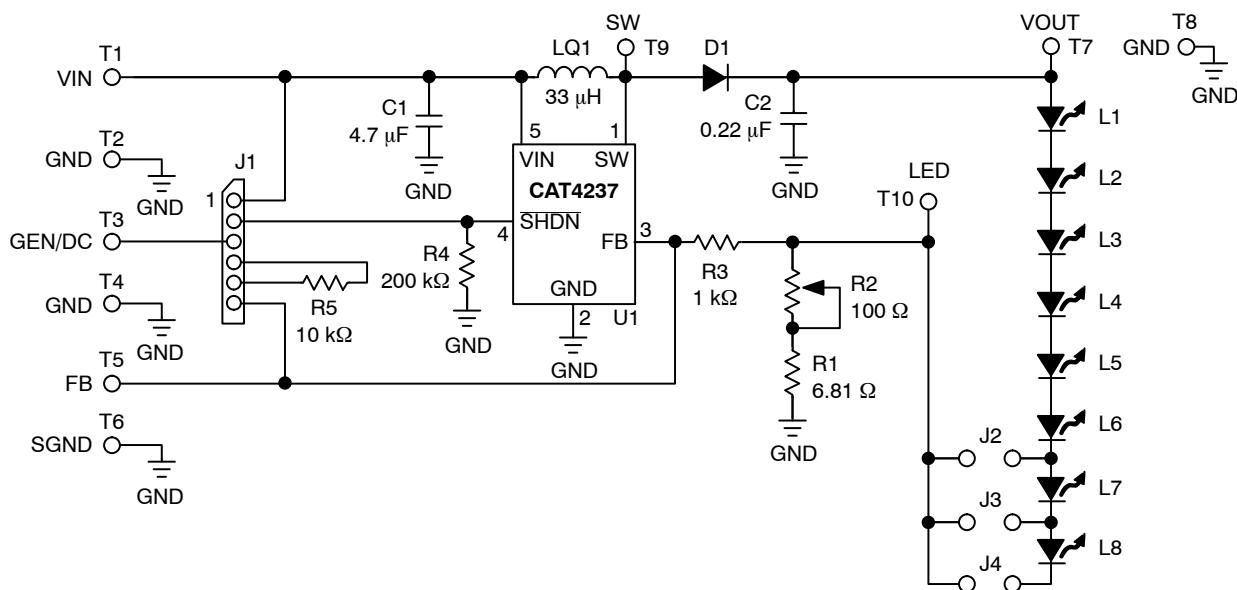


**Figure 1. CAT4237EVAL2 Board Schematic**

# CAT4237EVAL2EVB

The board also demonstrates the CAT4237 shutdown mode and LED brightness control by using an external PWM signal or DC voltage. Resistors R3 and R5 (R5 – soldered on board by the user) are used to adjust the LED current using the dimming control with an external applied DC voltage on the FB pin. The ON/OFF operation and dimming control can be selected using the jumper options for the J1 connector.

Test points T1 to T10 are available to apply the external voltages/signal generator or to measure the output voltages/signals provided by CAT4237.

The component placement and the board picture are shown in Figure 2. Table 1 presents the component list for this evaluation board.
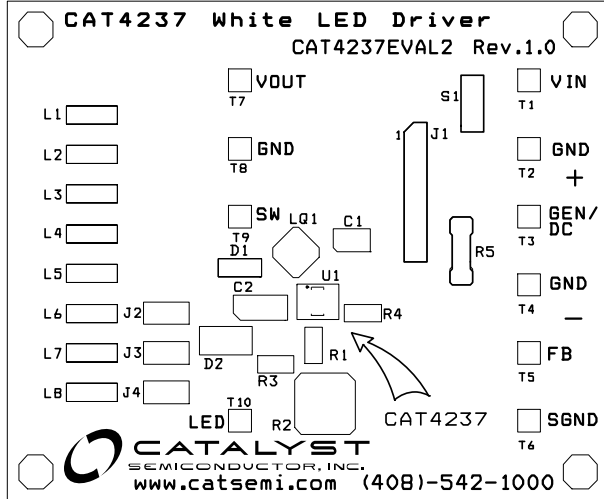


**Figure 2. CAT4237EVAL2 Board**

### Table 1. CAT4237EVAL2 EVAL BOARD LIST OF COMPONENTS

| Name | Manufacturer | Description Part | Number | Units |
|------|-------------|------------------|--------|-------|
| U1 | Catalyst | CMOS White LED Driver, TSOT23 – 5–pin | CAT4237TSI | 1 |
| C1 | Taiyo Yuden (or Panasonic) | Ceramic Capacitor 4.7 μF/6.3 V, X5R, Size 0805 | JMK212BJ475 (or Digi–Key PCC2315CT–ND) | 1 |
| C2 | Taiyo Yuden (or Kemet) | Ceramic Capacitor 0.22 μF/50 V, X5R(X7R) | (C1206C224K5RACTU) | 1 |
| L1 | Sumida (or TDK) | Inductor 33 μH, Low DCR, High Current | CDRH3D16–330 or VLCF4018T–330MR42–2 | 1 |
| D1 | Central | Schottky Diode, Low VF, High Current, SOD–323 | CMDSH05–4 | 1 |
| R1 | Yageo | SMT Resistor 1/16 W, 6.81 Ω, 0603 | Digi–Key 311–6.81HCT–ND | 1 |
| R2 | Bourns | Trimmer Pot, 1/4", 100 Ω | 3329W–101–ND (or equiv) | 1 |
| R3 | Yageo | SMT Resistor 1/16 W, 1.0 kΩ, 0603 | Digi–Key 311–1.0KHCT–ND | 1 |
| R4 | Yageo | SMT Resistor 1/16 W, 200 Ω, 0603 | Digi–Key 311–200KHCT–ND | 1 |
| R5 | Yageo | Metal Film Resistor 1/16 W, 10 kΩ (Not Soldered on Board) | Digi–Key 10.0KXBK–ND | 1 |
| L1 to L8 | Nichia | White LED, SMT | NSCW100 or NSCW335 | 8 |
| J1 | | 6–pin Header Connector, 0.1", Single Strip" | Digi–Key S1012–06–ND (or equiv) | 1 |
| J2 to J4 | | 2–pin Header Connector, 0.1", Single Strip" | Digi–Key S1012–02–ND (or equiv) | 3 |
| T1 to T10 | | Pin Receptacle (Test Points) | #0149–0–15–01–30–14–04–0 (or equiv) | 10 |

# CAT4237EVAL2EVB

## CAT4237 EVALUATION

The CAT4237EVAL2 gives the user a way to evaluate the CAT4237 in a typical application of driving multiple LEDs. The user can connect 6 to 8 LEDs in series to the CAT4237 output, using the jumper options for J2, J3 or J4 header−pin connectors. The following steps are an example of how the user can evaluate the CAT4237 white LED driver:

### Driving 8 LEDs in Series and Shutdown Mode

1. Connect the 8−LEDs string to the CAT4237 output using a jumper shunt on J4 header−pin connector (J2 , J3 not jumpered)
2. Set the R2 potentiometer to the middle position
3. Apply the external voltage supply, $V_{EXT}$ (3.0 V < $V_{IN}$ < 5 V) between VIN (T1) and GND (T2)
4. The CAT4237 is in the shutdown mode (SHDN pin is connected to GND) if the J1 connector is not jumpered
   - Connect a current meter between VEXT and VIN pad to measure the shutdown current: $I_{SD}$ << 1 μA
   - In this mode of operation the LEDs are disconnected from the output: LEDs are OFF
5. Connect SHDN pin of the CAT4237 to VIN using a jumper shunt between Pin #1 and Pin #2 of J1 connector
   - Observe that LEDs are ON

### LED Current Evaluation

#### Programming LED Current
LED current is programmed using the external resistors, $R_{SET}$ = R1 + R2, connected to the FB pin. The voltage at the FB pin is internally regulated to the value $V_{FB}$ = 300 mV ±15 mV.
The current into the LED pin can be set according to the following equation:

$$I_{LED}(mA) \, = \, V_{FB}(mV)/R_{SET}(\Omega) \, = \, V_{FB}/(R1 \, + \, R2)$$

1. Set the input voltage: ex. $V_{IN}$ = 3.6 V
2. Disconnect the jumper from the J4 connector and insert a current meter between these pins to monitor the LED current, $I_{LED}$
3. Rotate the potentiometer R2 and observe the $I_{LED}$ value on the current meter. The current can be adjusted between 3 mA and 30 mA, approximately. Various LED current values and the associated RSET values are listed below:

| $I_{LED}$(mA) | 5 | 10 | 15 | 20 | 25 | 30 |
|---|---|---|---|---|---|---|
| $R_{SET}$(Ω) | 59 | 29.8 | 20 | 15 | 12 | 10 |

4. Monitor the voltage on FB (T5), VOUT (T7), and SW (T9)
5. Verify the internal switch frequency ($f_{SW}$ = 1.0 MHz – typically) using a scope probe connected on SW (T9) test point (GND = T8)

Figure 3 shows the internal switch output, $V_{SW}$ (DC coupled, 10 V/div) and the regulated voltage on FB pin, $V_{FB}$ (DC, 500 mV/div) for $V_{IN}$ = 3.6 V, $I_{LED}$ = 20 mA, 8 LEDs in series connected to the CAT4237 output.

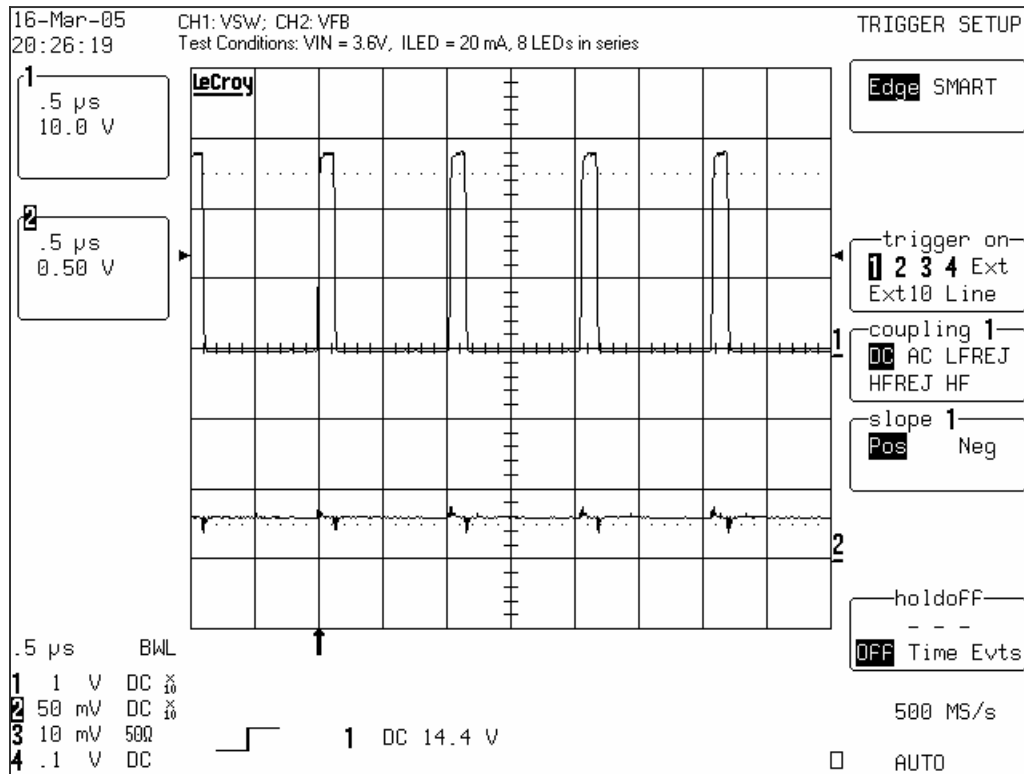Figure 4 shows the $V_{OUT}$ (CH2, AC coupled at 100 mV/div) against $V_{SW}$ (CH1).

**Figure 3. Internal Switch Output and Regulated V$_{FB}$ Voltage Waveforms (I$_{LED}$ = 20 mA, V$_{IN}$ = 3.6 V)**



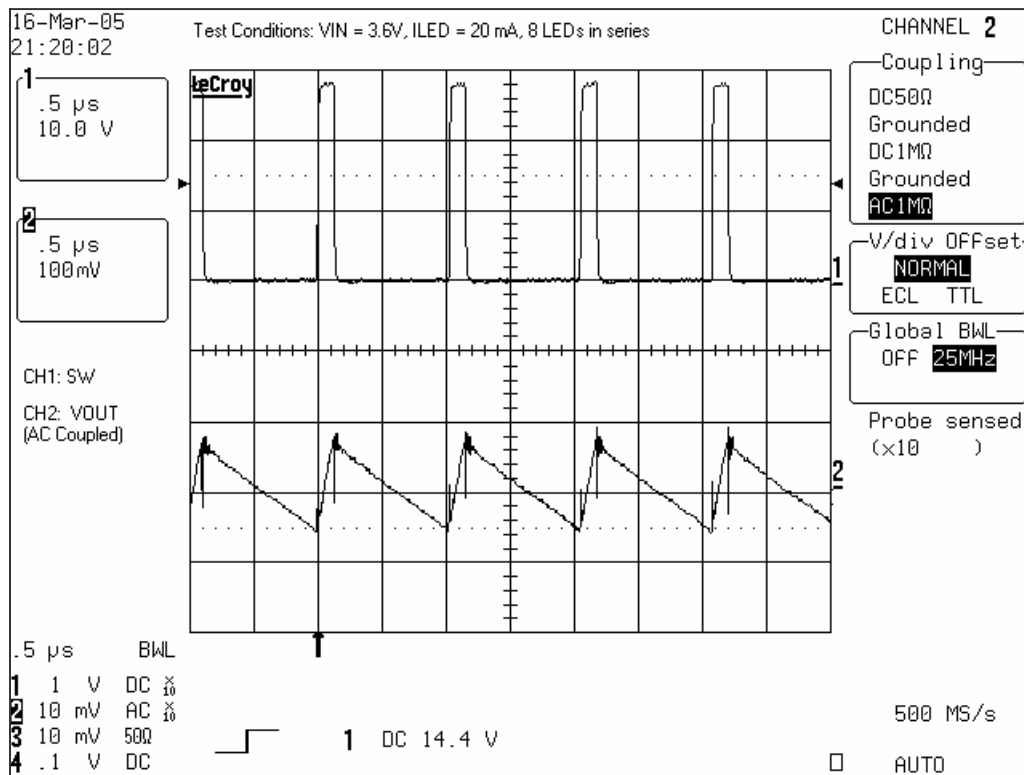**Figure 4. Internal Switch and Output Voltage Waveforms (I$_{LED}$ = 20 mA, V$_{IN}$ = 3.6 V)**

**Evaluating LED Current Regulation versus the Input Voltage, V$_{IN}$**

1. Set the I$_{LED}$ to a programmed value using the R2 potentiometer (i.e. 10 mA, 20 mA, 30 mA for V$_{IN}$ = 3.6 V)
2. For any I$_{LED}$ value vary the V$_{IN}$ voltage between 2.5 V and 5.5 V
3. Observe the value of I$_{LED}$ measured by the current meter and V$_{FB}$ using a voltmeter. Figure 5 presents the I$_{LED}$ current versus V$_{IN}$. Figure 6 shows the CAT4237 FB voltage versus input voltage
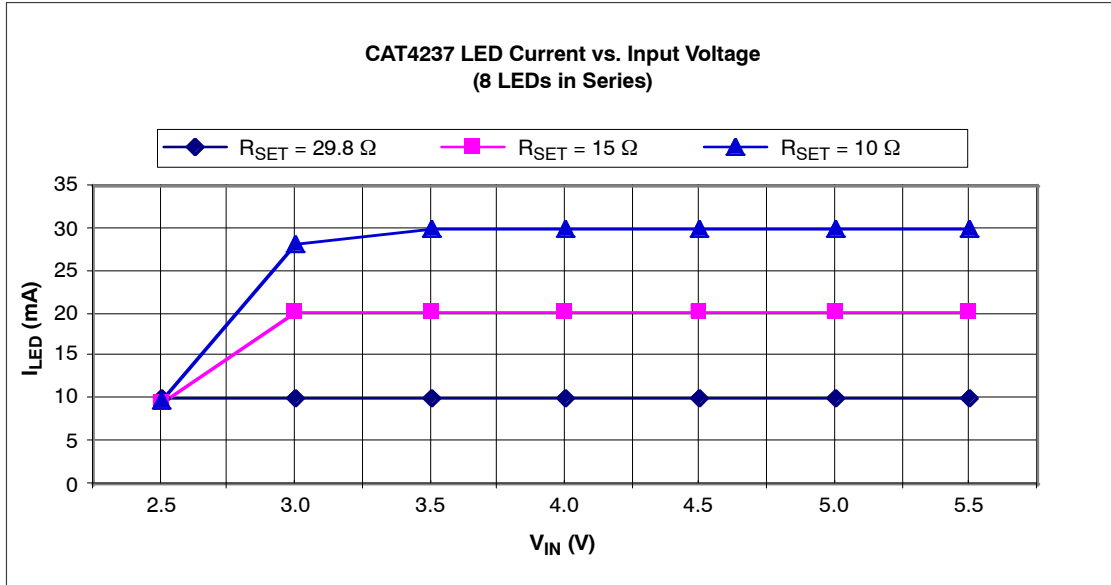


**Note:** R$_{SET}$ = R1 + R2

**Figure 5. LED Current Line Regulation**
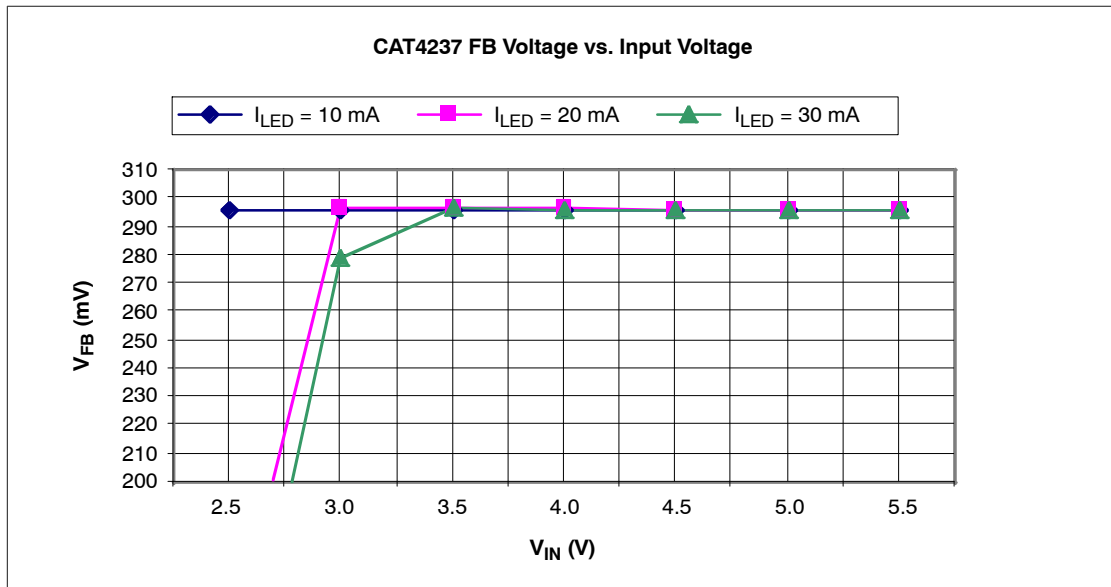


**Figure 6. V$_{FB}$ Voltage Line Regulation**

# CAT4237EVAL2EVB

**Efficiency Evaluation**

The efficiency is evaluated according to the following equation:

$$Efficiency(\%) \ = \ (I_{LED} \times \Sigma V_{Fi})/(I_{IN} \times V_{IN}) \times 100,$$

where $\Sigma V_{Fi} = V_{OUT} - V_{LED}$, $V_{LED}$ is the voltage measured at LED (T10) test point.

1. Insert a current meter, CM1, between input supply voltage, $V_{EXT}$, and $V_{IN}$ pad to monitor the input current, $I_{IN}$
2. Set the input voltage for $V_{IN}$ = 3.6 V
3. Adjust the R2 potentiometer for the $I_{LED}$ = 5 mA. Observe the $I_{LED}$ current on the meter, CM2, inserted between Pin #1 and Pin #2 of J4 connector
4. Measure the $I_{IN}$ current on CM1
5. Monitor the output voltage on $V_{OUT}$ (T7) and $V_{LED}$ voltage on LED (T10) test points
6. Repeat steps 3 to 5 for $I_{LED}$ = 10 mA, 15 mA, 20 mA, 25 mA and 30 mA

Figure 7 presents the efficiency measured for 2 values of input voltage, $V_{IN}$ = 3.6 V and $V_{IN}$ = 4.2 V, with 8 LEDs in series connected to the CAT4237 output. The efficiency is over 80% for the recommended LED current levels of 15 mA to 20 mA that ensure a pure "white" light.
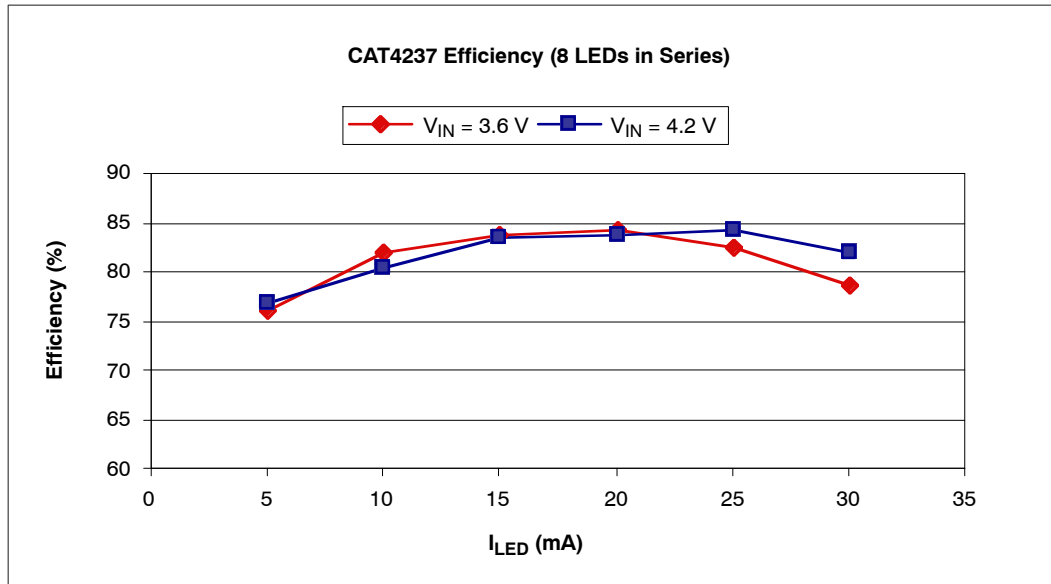


**Figure 7. CAT4237 Efficiency Driving 8 LEDs in Series**

**Dimming Control**

The LED brightness control can be accomplished by using a PWM signal applied to the SHDN pin or to the FB pin. The other method is to use a variable DC voltage applied through a resistor to FB pin.

1. Dimming using a **PWM signal on the SHDN pin**

    The LEDs are turned off and on at the PWM frequency. The average current changes with the duty cycle. Increasing the duty cycle will increase the LED brightness. The peak current value sets the light spectrum.

    - Connect the jumper shunt between Pin #2 and Pin #3 of the J1 connector
    - Apply a pulse signal generator to the GEN/DC (T3) pad: Frequency = 200 Hz to 2 kHz; Amplitude 0 V to 3 V; $V_{IN}$ = 3.6 V
    - Modify the duty cycle between 0% and 100%
    - Observe the average current through LEDs measured by a current meter inserted at J4 connector. For 0% duty cycle, the $I_{LED}$ will be off ($I_{LED}$ = 0 mA); At the maximum duty cycle, the LED will be driven at the maximum current set by the R2 potentiometer
    - Monitor the FB voltage compared with the PWM signal applied on SHDN input

Figure 8 shows the voltage monitored on the FB pin, $V_{FB}$ (CH2) using a PWM signal applied to the SHDN pin (CH1). The frequency of the PWM signal is 2 kHz approximately.
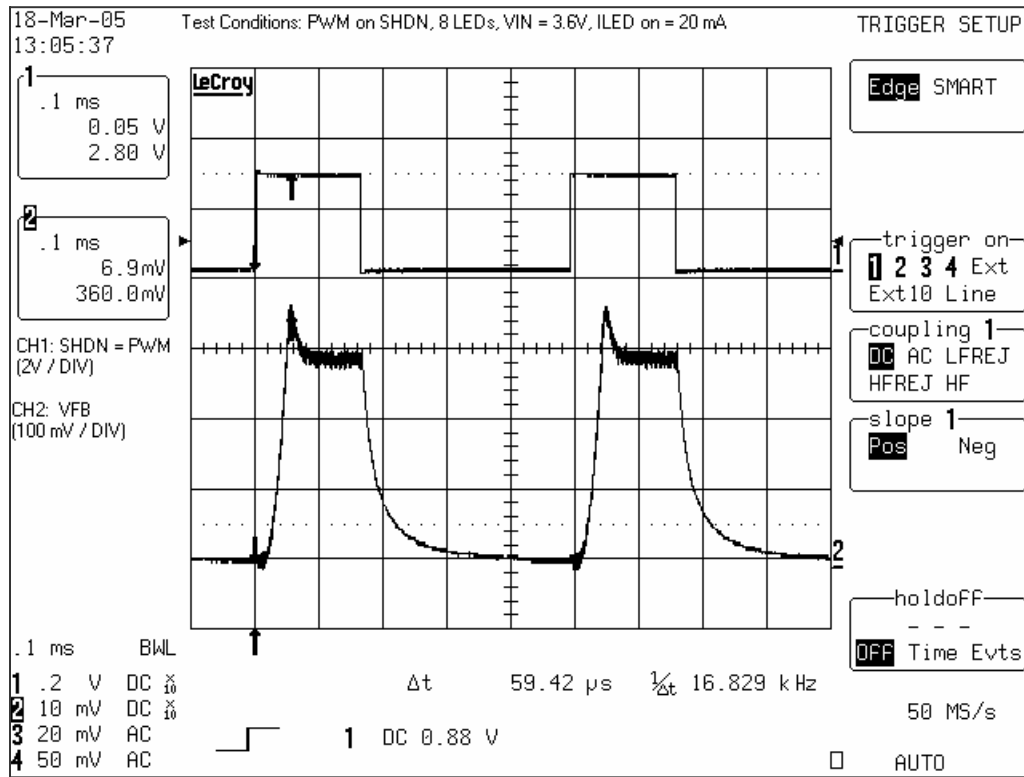


**Figure 8. FB Voltage Waveform with PWM**

2. Dimming using a **DC voltage applied to the FB pin**

A variable external DC voltage is applied on FB pin to adjust the LED current. As the DC voltage is increased, the voltage drop on resistor R3 is increased and the voltage drop on $R_{SET} = R1 + R2$ is decreased, thus the LED current decreases. The external DC voltage is applied to FB pin through a series resistor, R5, which sets the maximum DC voltage.

Also, a filtered PWM signal can be considered as a variable DC voltage.

- Connect the SHDN pin to VIN: jumper shunt between Pin #1 and Pin #2 of J1 connector
- Set the $I_{LED}$ current (i.e. $I_{LED\ MAX}$ = 20 mA)
- Connect the GEN/DC to FB pin through R5 resistor using one jumper between Pin #3 and Pin #4 and another jumper shunt between Pin #5 and Pin #6 of J1 connector
- Apply the variable DC voltage between GEN/DC (T3) and GND (T4)
- Increase the DC voltage value (from 0 V to $V_{MAX}$ = 3.2 V)
- Observe the $I_{LED}$ current decreases from the $I_{LED\ MAX}$ (20 mA – previous set) to $I_{LED\ MIN}$ (0 mA for $V_{MAX}$ = 3.2 V with the existing resistors values, R3 = 1 kΩ, R5 = 10 kΩ)

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105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: info@moschip.ru

Skype отдела продаж:
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