

CAT4237EVAL2EVB

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



ON Semiconductor®

<http://onsemi.com>

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 choose 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.

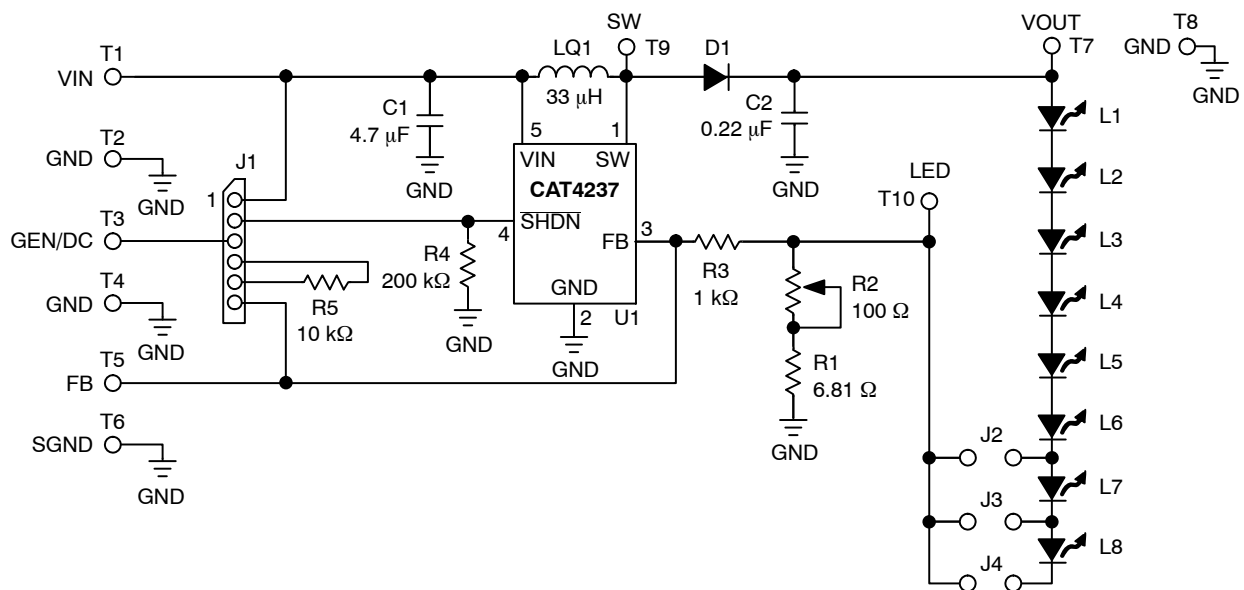


Figure 1. CAT4237EVAL2 Board Schematic

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.

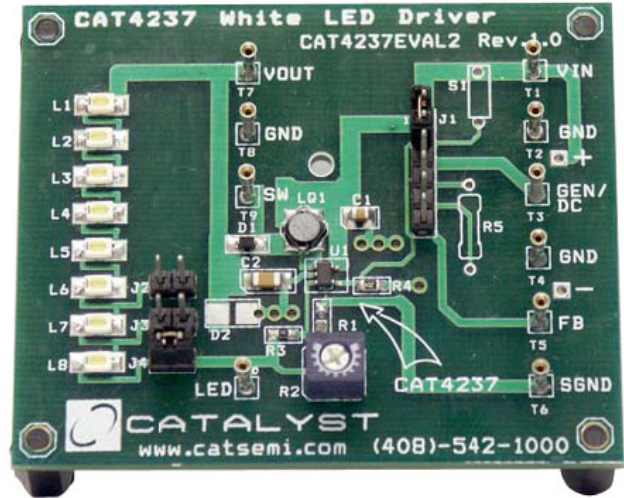
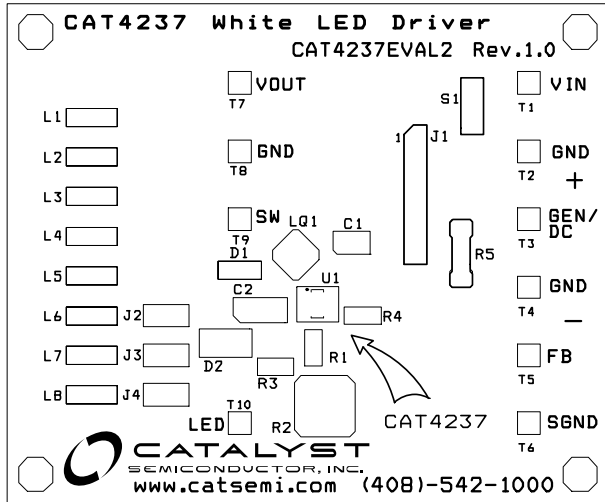


Figure 2. CAT4237EVAL2 Board

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 μ F/6.3 V, X5R, Size 0805 | JMK212BJ475 (or Digi-Key PCC2315CT-ND) | 1 |
| C2 | Taiyo Yuden (or Kemet) | Ceramic Capacitor 0.22 μ F/50 V, X5R(X7R) | (C1206C224K5RACTU) | 1 |
| L1 | Sumida (or TDK) | Inductor 33 μ H, 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 k Ω , 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 k Ω (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} ($3.0\text{ V} < V_{IN} < 5\text{ V}$) 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: $I_{SD} \ll 1\ \mu\text{A}$
 - 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 $V_{FB} = 300\text{ mV} \pm 15\text{ mV}$.

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. $V_{IN} = 3.6\text{ V}$
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 |
| $R_{SET}(\Omega)$ | 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 ($f_{sw} = 1.0\text{ MHz}$ – 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 $V_{IN} = 3.6\text{ V}$, $I_{LED} = 20\text{ mA}$, 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).

CAT4237EVAL2EVB

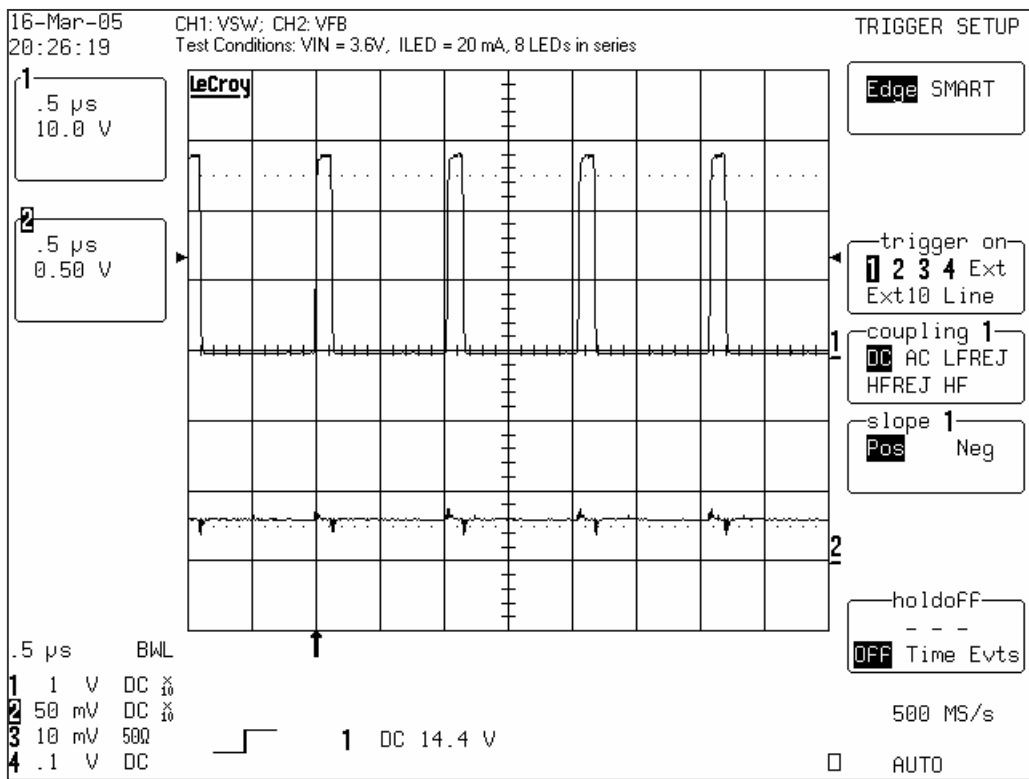


Figure 3. Internal Switch Output and Regulated V_{FB} Voltage Waveforms (I_{LED} = 20 mA, V_{IN} = 3.6 V)

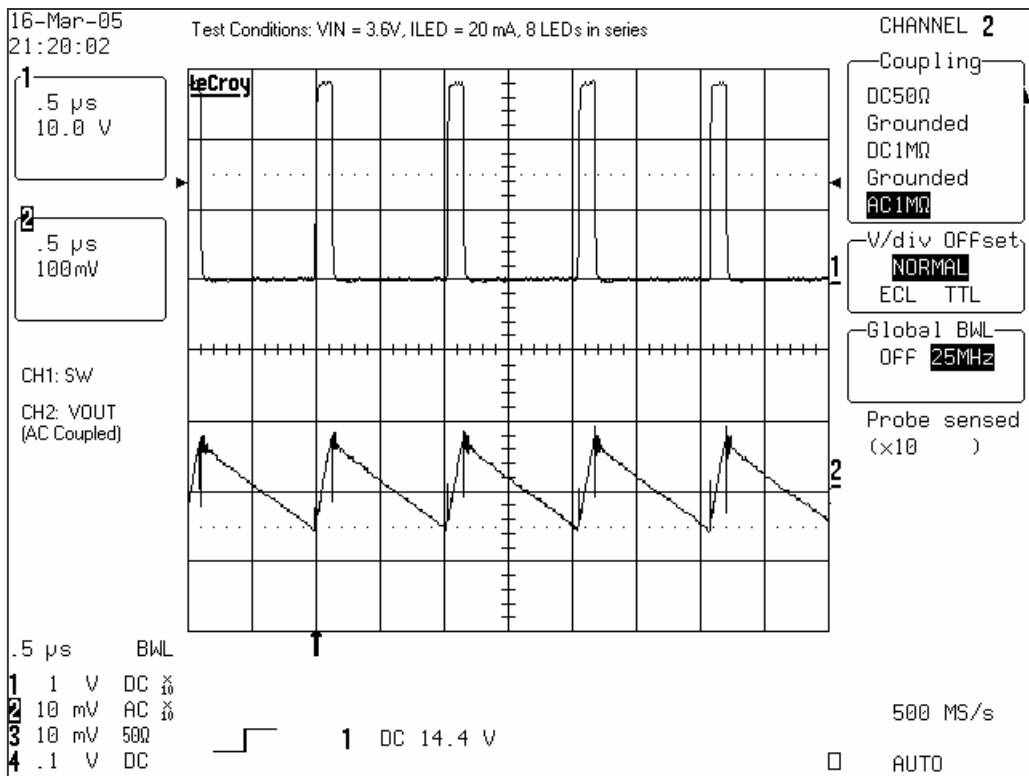
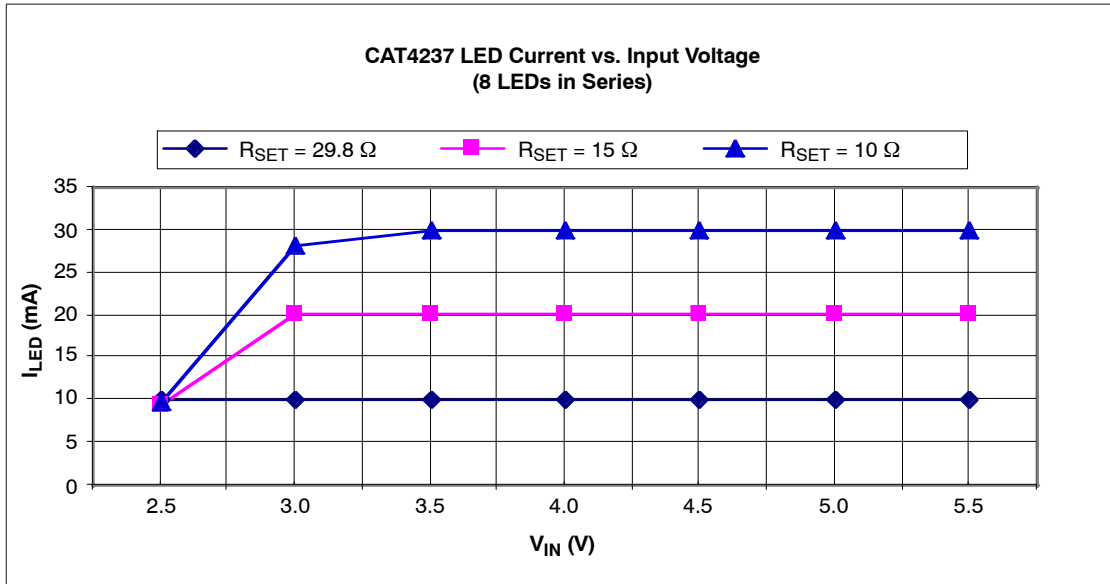


Figure 4. Internal Switch and Output Voltage Waveforms (I_{LED} = 20 mA, V_{IN} = 3.6 V)

CAT4237EVAL2EVB

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: $R_{SET} = R_1 + R_2$

Figure 5. LED Current Line Regulation

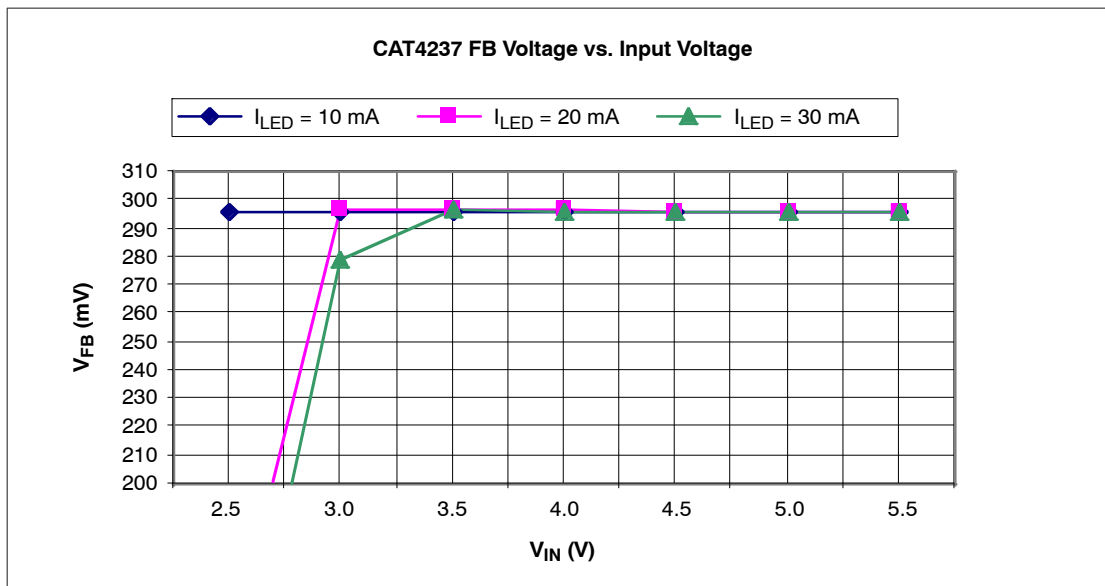


Figure 6. V_{FB} Voltage Line Regulation

CAT4237EVAL2EVB

Efficiency Evaluation

The efficiency is evaluated according to the following equation:

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

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 $V_{IN} = 3.6\text{ V}$
3. Adjust the R2 potentiometer for the $I_{LED} = 5\text{ mA}$. 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 $I_{LED} = 10\text{ mA}$, 15 mA , 20 mA , 25 mA and 30 mA

Figure 7 presents the efficiency measured for 2 values of input voltage, $V_{IN} = 3.6\text{ V}$ and $V_{IN} = 4.2\text{ V}$, 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.

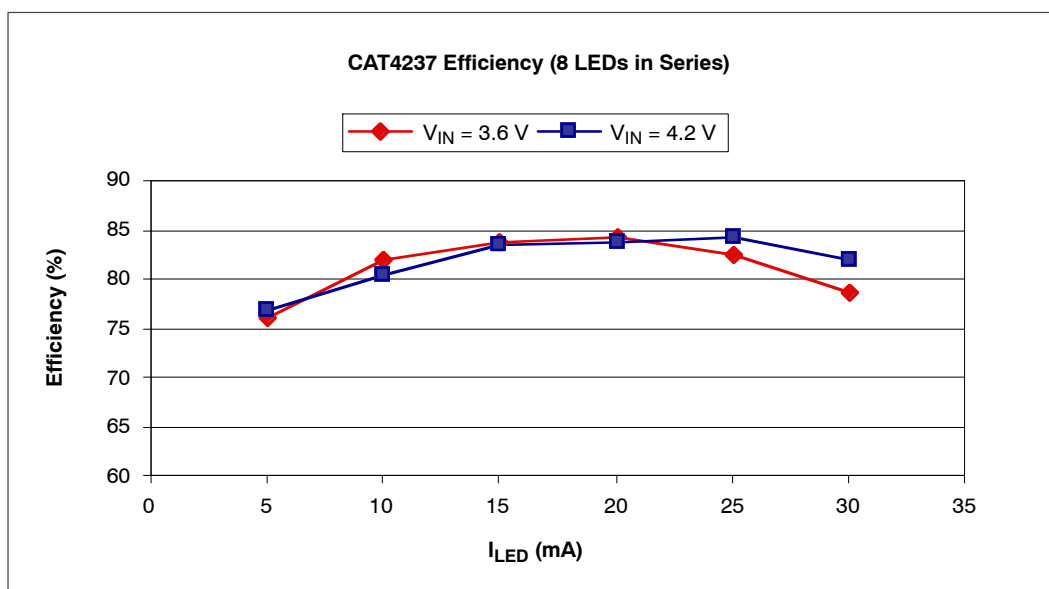


Figure 7. CAT4237 Efficiency Driving 8 LEDs in Series

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; $V_{IN} = 3.6\text{ V}$
- 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 ($I_{LED} = 0\text{ mA}$); 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

CAT4237EVAL2EVB

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.

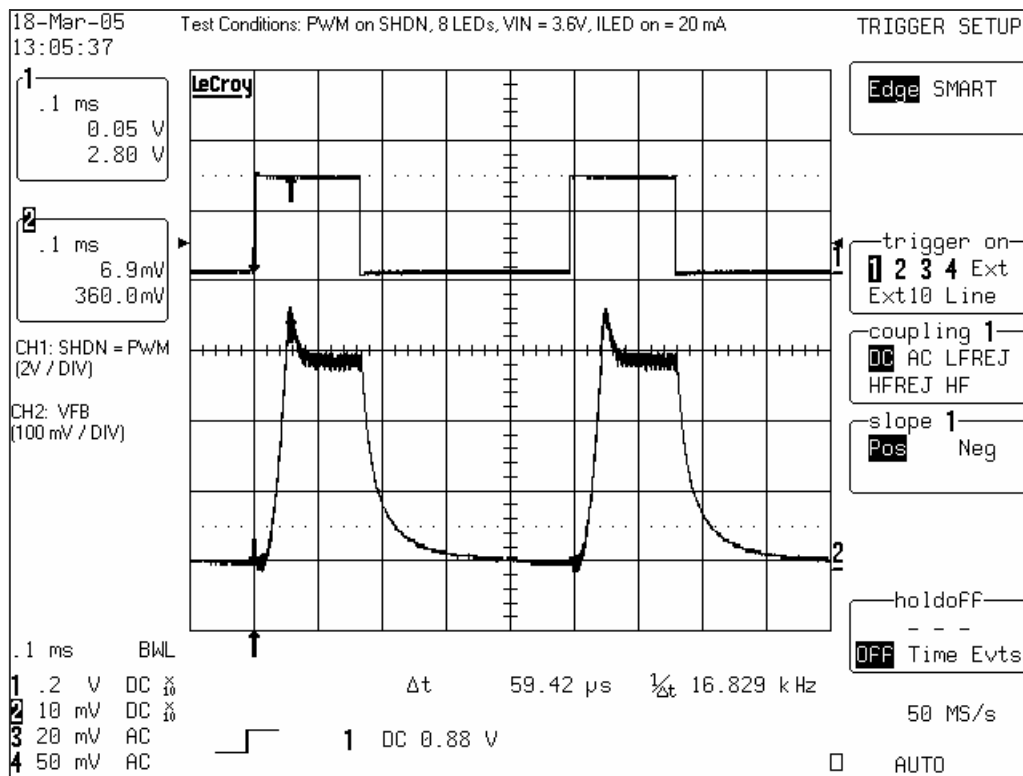


Figure 8. FB Voltage Waveform with PWM

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 ILED 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 ILED 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, $R3 = 1\ k\Omega$, $R5 = 10\ k\Omega$)

onsemi, **Onsemi**, and other names, marks, and brands are registered and/or common law trademarks of Semiconductor Components Industries, LLC dba "**onsemi**" or its affiliates and/or subsidiaries in the United States and/or other countries. **onsemi** owns the rights to a number of patents, trademarks, copyrights, trade secrets, and other intellectual property. A listing of **onsemi**'s product/patent coverage may be accessed at www.onsemi.com/site/pdf/Patent-Marking.pdf. **onsemi** is an Equal Opportunity/Affirmative Action Employer. This literature is subject to all applicable copyright laws and is not for resale in any manner.

The evaluation board/kit (research and development board/kit) (hereinafter the "board") is not a finished product and is not available for sale to consumers. The board is only intended for research, development, demonstration and evaluation purposes and will only be used in laboratory/development areas by persons with an engineering/technical training and familiar with the risks associated with handling electrical/mechanical components, systems and subsystems. This person assumes full responsibility/liability for proper and safe handling. Any other use, resale or redistribution for any other purpose is strictly prohibited.

THE BOARD IS PROVIDED BY ONSEMI TO YOU "AS IS" AND WITHOUT ANY REPRESENTATIONS OR WARRANTIES WHATSOEVER. WITHOUT LIMITING THE FOREGOING, ONSEMI (AND ITS LICENSORS/SUPPLIERS) HEREBY DISCLAIMS ANY AND ALL REPRESENTATIONS AND WARRANTIES IN RELATION TO THE BOARD, ANY MODIFICATIONS, OR THIS AGREEMENT, WHETHER EXPRESS, IMPLIED, STATUTORY OR OTHERWISE, INCLUDING WITHOUT LIMITATION ANY AND ALL REPRESENTATIONS AND WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, TITLE, NON-INFRINGEMENT, AND THOSE ARISING FROM A COURSE OF DEALING, TRADE USAGE, TRADE CUSTOM OR TRADE PRACTICE.

onsemi reserves the right to make changes without further notice to any board.

You are responsible for determining whether the board will be suitable for your intended use or application or will achieve your intended results. Prior to using or distributing any systems that have been evaluated, designed or tested using the board, you agree to test and validate your design to confirm the functionality for your application. Any technical, applications or design information or advice, quality characterization, reliability data or other services provided by **onsemi** shall not constitute any representation or warranty by **onsemi**, and no additional obligations or liabilities shall arise from **onsemi** having provided such information or services.

onsemi products including the boards are not designed, intended, or authorized for use in life support systems, or any FDA Class 3 medical devices or medical devices with a similar or equivalent classification in a foreign jurisdiction, or any devices intended for implantation in the human body. You agree to indemnify, defend and hold harmless **onsemi**, its directors, officers, employees, representatives, agents, subsidiaries, affiliates, distributors, and assigns, against any and all liabilities, losses, costs, damages, judgments, and expenses, arising out of any claim, demand, investigation, lawsuit, regulatory action or cause of action arising out of or associated with any unauthorized use, even if such claim alleges that **onsemi** was negligent regarding the design or manufacture of any products and/or the board.

This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and may not meet the technical requirements of these or other related directives.

FCC WARNING – This evaluation board/kit is intended for use for engineering development, demonstration, or evaluation purposes only and is not considered by **onsemi** to be a finished end product fit for general consumer use. It may generate, use, or radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment may cause interference with radio communications, in which case the user shall be responsible, at its expense, to take whatever measures may be required to correct this interference.

onsemi does not convey any license under its patent rights nor the rights of others.

LIMITATIONS OF LIABILITY: **onsemi** shall not be liable for any special, consequential, incidental, indirect or punitive damages, including, but not limited to the costs of requalification, delay, loss of profits or goodwill, arising out of or in connection with the board, even if **onsemi** is advised of the possibility of such damages. In no event shall **onsemi**'s aggregate liability from any obligation arising out of or in connection with the board, under any theory of liability, exceed the purchase price paid for the board, if any.

The board is provided to you subject to the license and other terms per **onsemi**'s standard terms and conditions of sale. For more information and documentation, please visit www.onsemi.com.

PUBLICATION ORDERING INFORMATION

LITERATURE FULFILLMENT:

Email Requests to: orderlit@onsemi.com

onsemi Website: www.onsemi.com

TECHNICAL SUPPORT

North American Technical Support:

Voice Mail: 1 800-282-9855 Toll Free USA/Canada

Phone: 011 421 33 790 2910

Europe, Middle East and Africa Technical Support:

Phone: 00421 33 790 2910

For additional information, please contact your local Sales Representative