CAT37EVAL1 EVALUATION BOARD FOR THE CAT37 WHITE LED DRIVER

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1. INTRODUCTION

This document describes the CAT37EVAL1 Evaluation Board for the Catalyst Semiconductor CAT37 white LED driver. The functionality and major parameters of the CAT37 can be evaluated with the CAT37EVAL1 board.

The CAT37 is a CMOS constant-current DC/DC converter that has been designed to drive with high efficiency white or other high brightness LEDs. A single external resistor sets the LED current between 5mA and 40 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 CAT37 data sheet.

2. CAT37EVAL1 BOARD HARDWARE

The evaluation board contains a CAT37 boost converter and an array of white LEDs. As configured, the board circuit is set to drive up to 4 white LEDs in series. However, the user can chose a wide variety of other LED configurations using different jumper options available on board. The board schematic is shown in Figure 1.

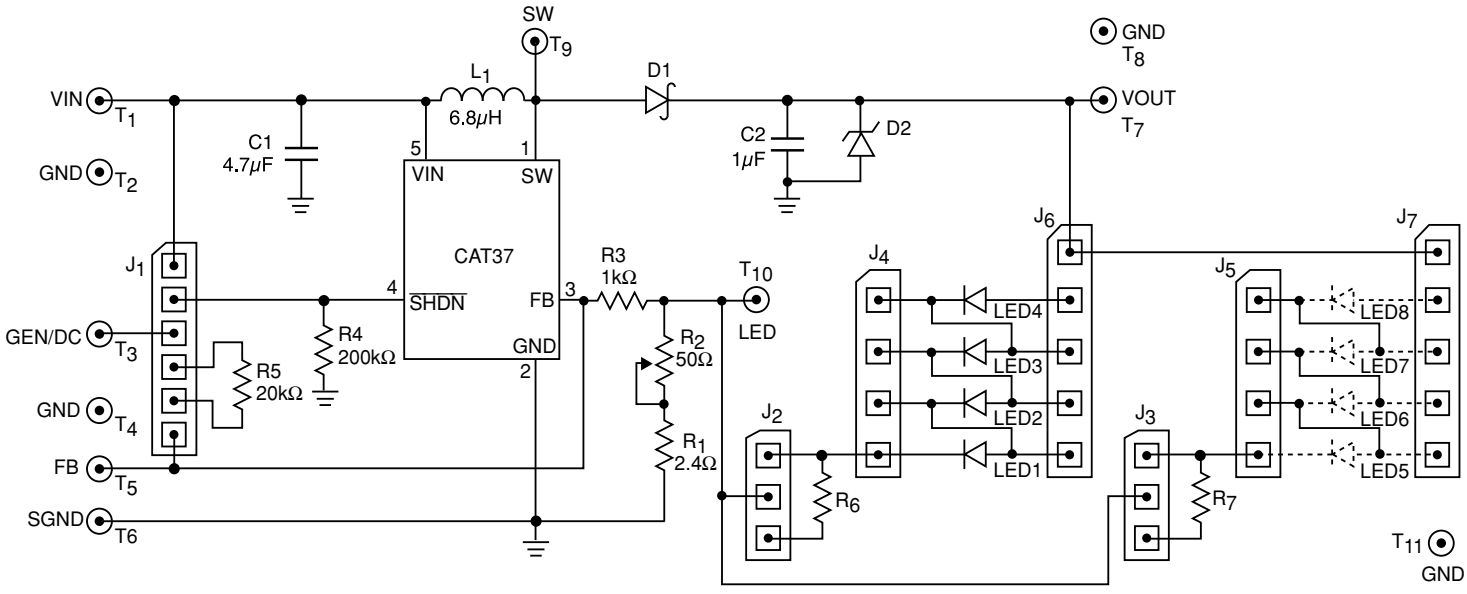


Figure 1. CAT37EVAL1 Evaluation Board Schematic

The board is powered from an external voltage applied to the VIN (T1) pad. The circuit is delivered with the LEDs disconnected to the CAT37 output. The Zener diode, D2, clamps the output voltage VOUT at +18V for the output-open circuit configuration. The zener provides added protection when the LEDs are not connected to the CAT37 output. The CAT37 is internally protected.

One string of 4 LEDs, LED1 to LED4 is available on board. To connect these LEDs to the CAT37 output, connect the VOUT and LED pins to the LEDs string. These connections can be done using the jumper shunts in the appropriate positions of J6 and J2 header-pin connectors. The user can chose to connect to the CAT37 output a variable number (1 to 4) of series LEDs, using the jumper options for J6 and J4 connectors.

The designer can also choose to connect the CAT37 output to the white LEDs available on the CAT37EVAL1 board or to his own LEDs. The board offers the possibility to connect the second string of maximum 4 LEDs in series with the associate header-pin connectors, J3, J5 and J7. This way, the user can use his own white LEDs, soldered in the positions LED5 to LED8 on this board, or to connect CAT37 output to the LEDs in his application.

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 2mA to 30mA. Most white LEDs are driven at a maximum current between 15mA and 20mA to ensure a pure “white” light. When the circuit is configured to drive two parallel strings of LEDs, the total current flowing into the LED pin should be set to 30mA (two strings of 15mA). Resistors R5 and R6 must be used to match the brightness of the two parallel connected LED strings.

The board also demonstrates the CAT37 shutdown mode and LED brightness control by using an external PWM signal or DC voltage. Resistor R3 is used to adjust the LED current using the dimming control with an external applied DC voltage or filtered PWM signal on FB pin. The ON/OFF operation and dimming control can be selected using the jumper options for the J1 connector.

Test points T1 to T11 are available to apply the external voltages/signal generator or to measure the output voltages/ signals provided by CAT37.

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

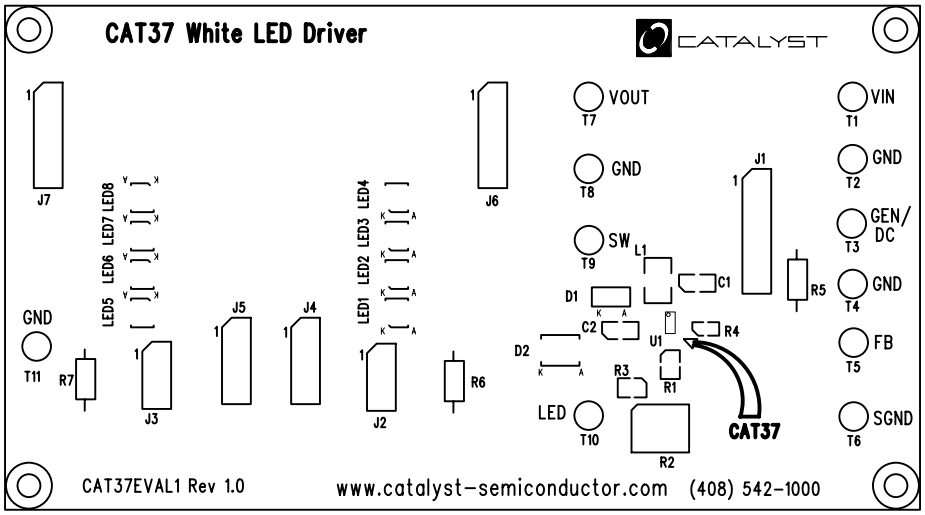


Figure 2. CAT37EVAL1 Board Component Placement

Table 1. CAT37EVAL1 Board List of Components

Name	Manufacturer	Description	Part Number	Units
U1	Catalyst	CMOS White LED Driver, SOT23 - 5pin	CAT37EKT	1
C1	Taiyo Yuden (or Panasonic)	Ceramic Capacitor 4.7µF, Size 0805	JMK212BJ475 (Digi-Key PCC2315CT-ND)	1
C2	Taiyo Yuden (or Kemet)	Ceramic Capacitor 1.0µF, low ESR, 0805	EMK212BJ105 (Digi-Key 399-1284-1-ND)	1
L1	Panasonic	Inductor 6.8µH, low DCR, 1210	ELJEA6R8 (PCD1422CT-ND) (or CLQ4D10-6R8)	1
D1	Zetex	Schottky Diode SOD-323	ZHCS400CT-ND	1
D2	Diodes	Zener Diode, 18V, 1W, SMT (SMA package)	SMAZ18DICT-ND	1
R1	Yageo	SMT Resistor 1/16W, 2.43ohm, 0603	Digi-Key 311-2.43HCT-ND	1
R2	Bourns	Trimmer Pot, 1/4", 50 ohm	3329W-500-ND (or equiv)	1
R3	Yageo	SMT Resistor 1/16W, 1.0 Kohm, 0603	Digi-Key 311-1.0KHCT-ND	
R4	Yageo	SMT Resistor 1/16W, 200 Kohm, 0603	Digi-Key 311-200KHCT-ND	1
R5	Yageo	Metal Film Resistor 1/16W, 20 Kohm	Digi-Key 20.0KXBK-ND	1
R6, R7	Yageo	Metal Film Resistor 1/16W, 50 ohm (NOT Soldered)	Digi-Key 49.9XBK-ND	
L1 to L8	Nichia	White LED, SMT (Four LEDs soldered))	NSCW100 (or NSCW335)	4
J1		6-pin Header Connector, 0.1", Single Strip	Digi_Key S1012-06-ND (or equiv)	1
J2, J3		3-pin Header Connector, 0.1", Single Strip	Digi_Key S1012-03-ND (or equiv)	2
J4, J5		4-pin Header Connector, 0.1", Single Strip	Digi_Key S1012-04-ND (or equiv)	2
J6, J7		5-pin Header Connector, 0.1", Single Strip	Digi_Key S1012-05-ND (or equiv)	2
T1 to T11	Mil-Max	Pin Receptacle (Test Points)	#0149-0-15-01-30-14-04-0 (or equiv)	11

3. CAT37 EVALUATION

The CAT37EVAL1 gives the user a way to evaluate the CAT37 in a typical application of driving multiple LEDs.

The board offers to the user the possibility to connect a different number of LEDs to the CAT37 output, using the jumper options for J4, J6 or J5, J7 header-pin connectors.

This document describes the evaluation of the CAT37 only in some of these configurations. The following steps are an example of how the user can evaluate the CAT37 white LED driver:

1) Driving 4 LEDs in series

a) Connect the LEDs to the CAT37 output.

- Connect VOUT to the LED string (anode terminal) using a jumper shunt between Pin #1 and Pin #2 of J6 header-pin connector.
- Connect LED output to the LED string (cathode terminal) using a jumper shunt between Pin #1 and Pin #2 of J2 header-pin connector.

b) Set the R2 potentiometer to the middle position.

c) Apply the external voltage supply, Vext (2.5V < VIN < 7V) between VIN (T1) and GND (T2).

d) The CAT37 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: IQSHDWN < 1μA.
- In this mode of operation the LEDs are disconnected from the output: LEDs are OFF.

e) Connect SHDN pin of CAT37 to VIN using a jumper shunt between Pin #1 and Pin #2 of J1 connector.

- Observe that LEDs are ON.

2) LED Current Evaluation

a) Programming LED current

LED current is programmed using the external resistors, RSET = R1 + R2, connected to the FB pin. The voltage at the FB pin is internally regulated to the value VFB = 95mV +/- 10 mV.

The current into the LED pin can be set according to the following equation:

ILED (mA) = VFB (mV) / RSET(ohm) = VFB / (R1 + R2).

- Set VIN = 3V.
- Disconnect the jumper between Pin #1 and Pin #2 of the J6 connector and insert a current meter between these pins to monitor the LED current, ILED.
- Rotate the potentiometer R2 and observe the ILED value on the current meter. The current can be adjusted between 2mA and 30mA.
- Monitor the voltage on FB (T5), VOUT (T7), and SW (T9).
- Verify the internal switch frequency (fSW = 1.2MHz - typically) using a scope probe connected on SW (T9) test point (GND = T8).

Figure 3 presents the internal switch output, VSW (DC coupled, 5V/div) and VOUT (AC coupled at 50 mV/div) for VIN = 3V, ILED = 15 mA, 4 LEDs in series connected to the CAT37 output.

Figure 4 shows the voltage on FB pin (CH4) against VSW (CH1).

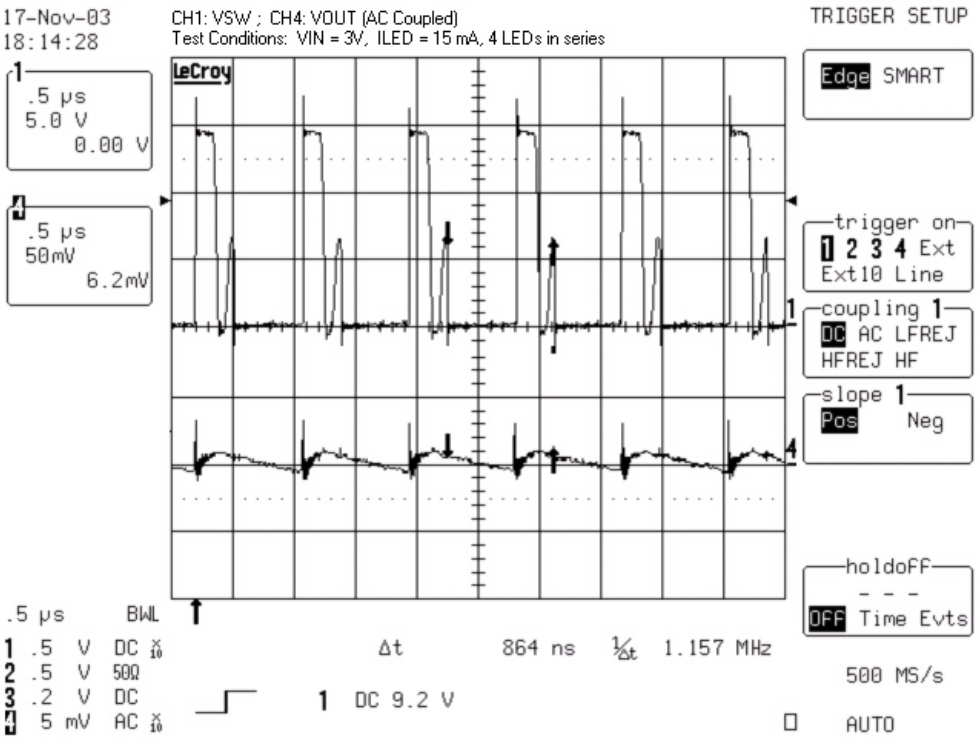


Figure 3. Internal Switch and Output Voltage Waveforms.

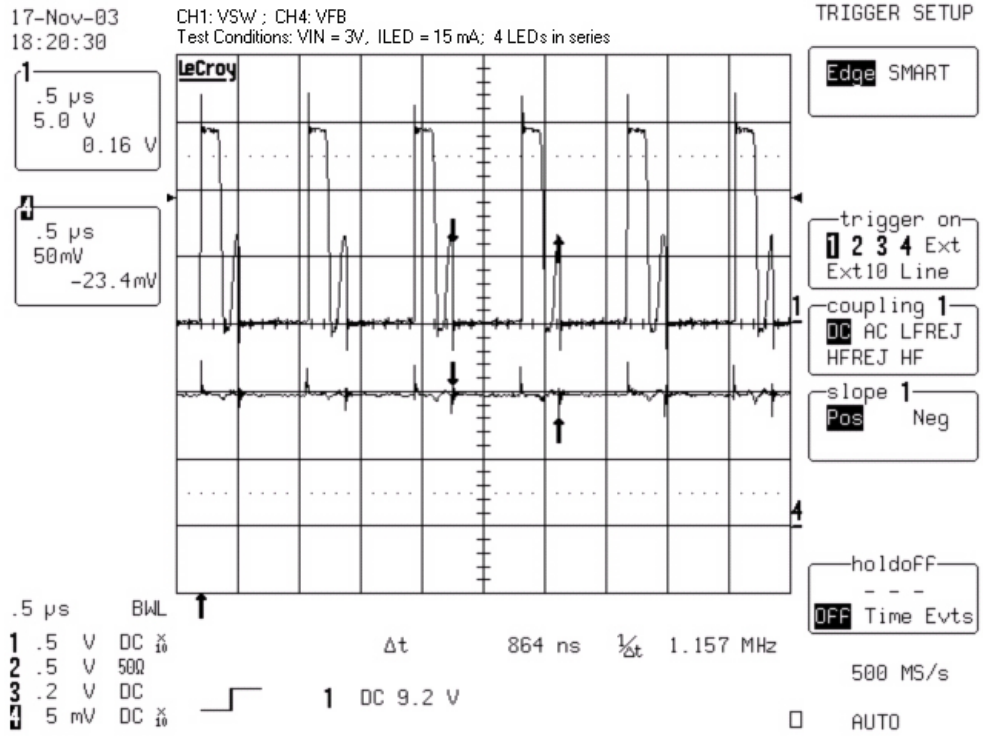
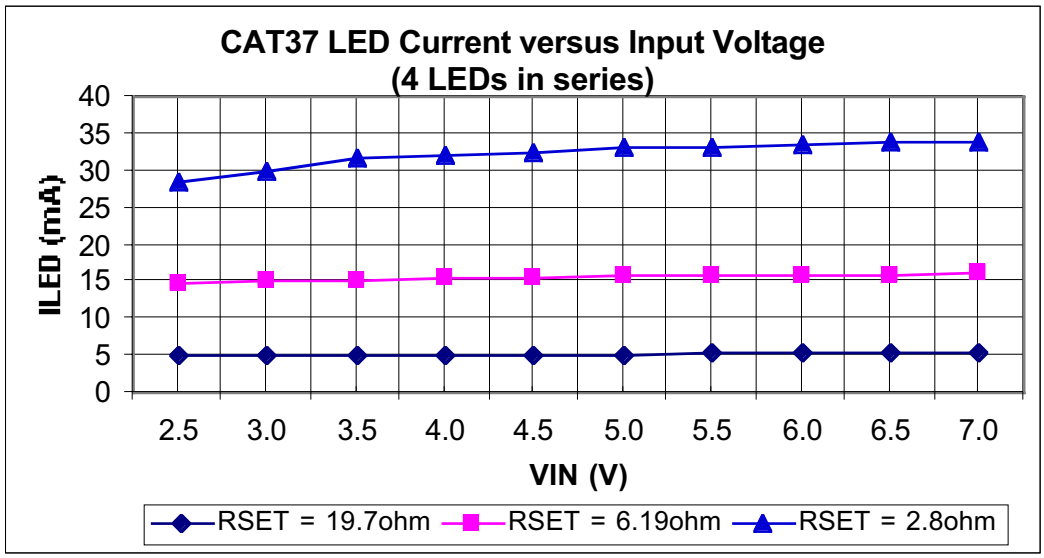


Figure 4. Internal Switch Output and Regulated VFB Voltage Waveforms (ILED = 15mA, VIN = 3.0V)

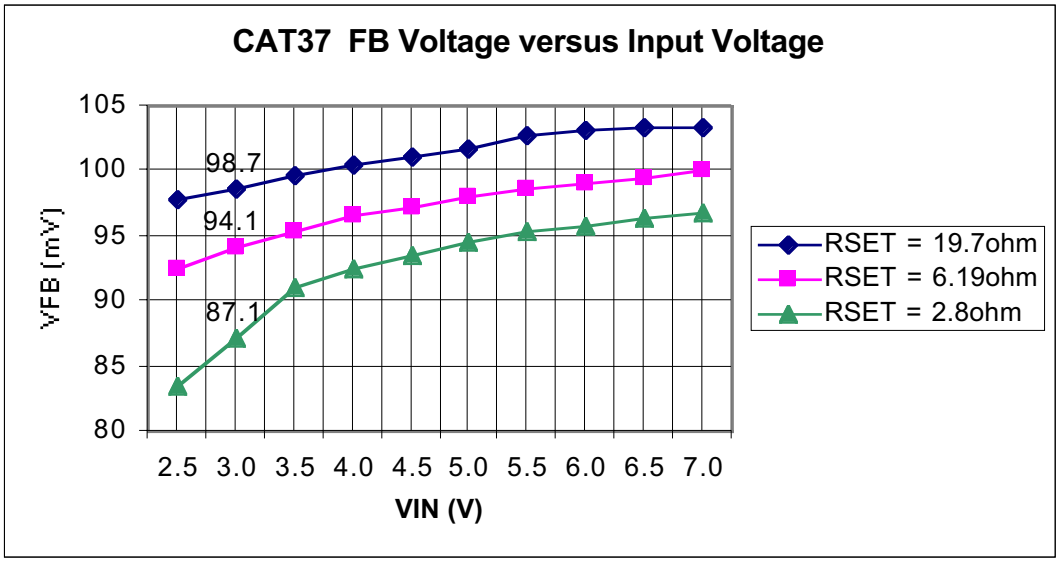
b) Evaluating LED current regulation versus the input voltage VIN.

- Set the ILED to a programmed value using the R2 potentiometer (i.e. 5mA, 15mA, 30mA for VIN = 3.0V).
- For any ILED value vary the VIN voltage between 2.5V and 7V.
- Observe the value of ILED measured by the current meter and VFB using a voltmeter. Figure 5 presents the ILED current versus VIN. Figure 6 shows CAT37 FB voltage versus input voltage.



Note: RSET = R1 + R2

Figure 5. LED Current Line Regulation



Note: RSET = R1 + R2

Figure 6. VFB Voltage Line Regulation

3) EFFICIENCY EVALUATION

The efficiency is evaluated according to the following equation:

Efficiency % = (ILED x VOUT)/(IIN x VIN) x 100

a) Insert a current meter, CM1, between input supply voltage, Vext, and VIN pad to monitor the input current, IIN.

b) Set the input voltage for VIN = 3V.

c) Adjust the R2 potentiometer for the ILED = 5mA. Observe the ILED current on the meter, CM2, inserted between VOUT and Pin #2 of J6 connector.

d) Measure the IIN current on CM1.

e) Monitor the output voltage on VOUT (T7) and VIN voltage on VIN (T1) test points.

f) Repeat steps c) to e) for ILED = 10mA, 15mA, and 20mA.

Figure 7 presents the efficiency measured for 2 values of input voltage, VIN = 3V and VIN = 5V, with 4 LEDs in series connected to the CAT37 output. The efficiency is over 80% for the recommended LED current levels of 15mA to 20mA that ensure a pure “white” light.

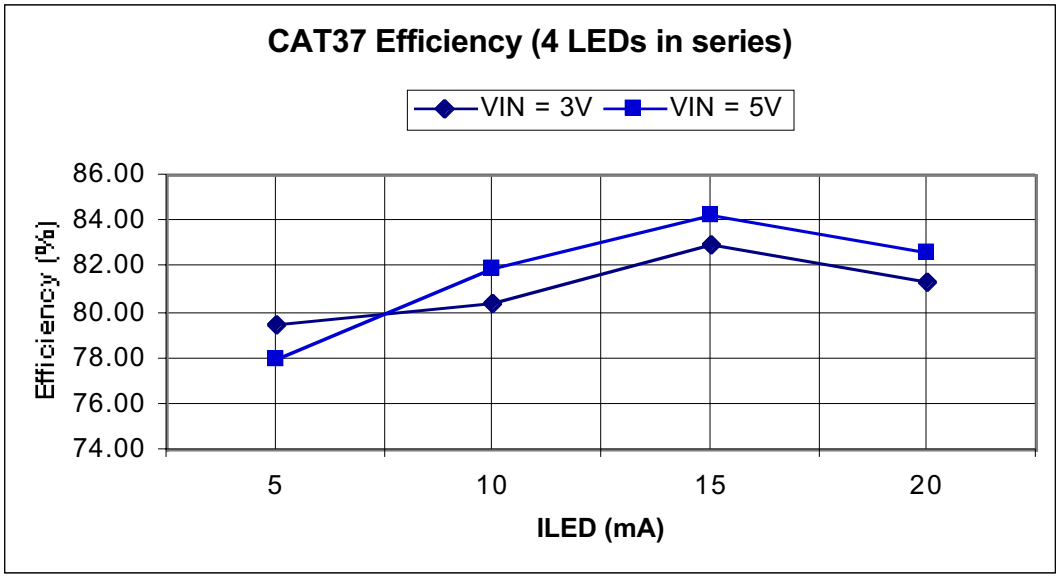


Figure 7. **CAT37 Efficiency Driving 4 LEDs in Series**

4) 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.

a) 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 = 5kHz to 40kHz; Amplitude 0V to 3V for VIN = 3V.
- Modify the duty cycle between 0% and 100%.
- Observe the average current through LEDs. For 0% duty cycle, the ILED will be off (ILED = 0mA); At the maximum duty cycle, the LED will be driven at the maximum current set by the R2 potentiometer.

Figure 8 shows the LED current measured with a current probe (CH2) using a PWM signal applied to the SHDN pin (CH1)

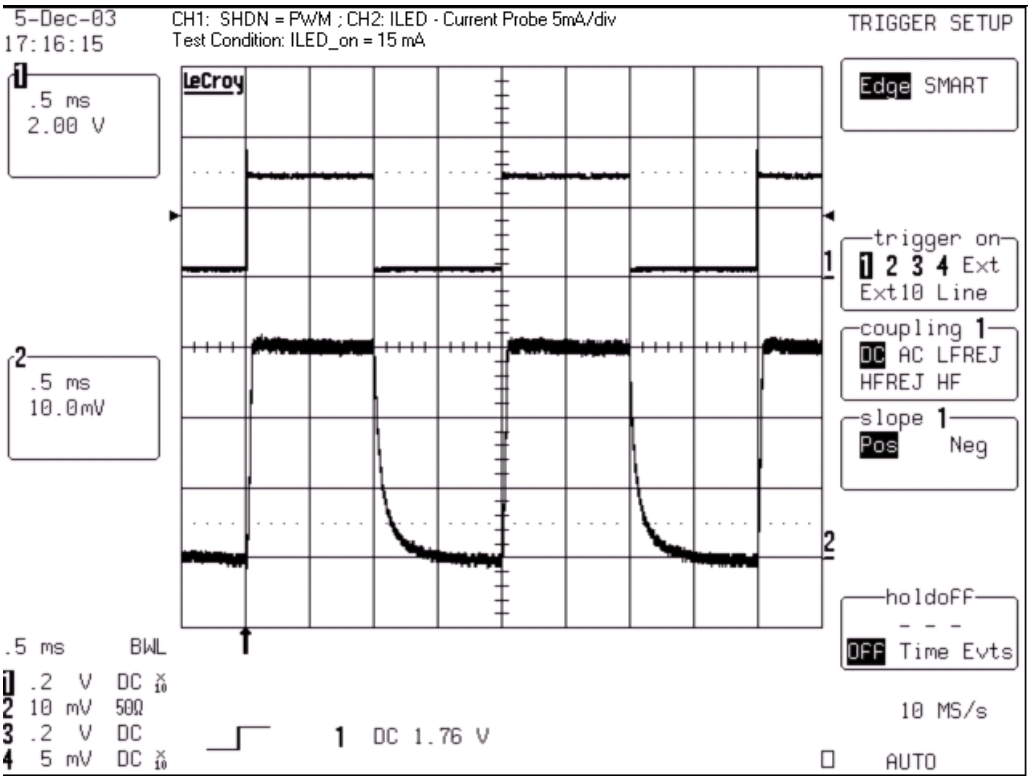


Figure 8. **LED Current Waveform with PWM**

a) Dimming using a **DC voltage or filtered PWM signal on 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 RSET = R1+R2 is decreased, thus the LED current decreases. The external DC voltage is applied to FB pin through a series resistor, R5.

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. ILED_MAX = 15 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 0V to VMAX = 2.2V).
- Observe the ILED current decreases from the ILED MAX (15mA – previous set) to ILED MIN (0 mA for VMAX = 2.2V with the existing resistors values, R3 = 1Kohm, R5 = 20Kohm).

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