MIC2843A

High Efficiency 6 Channel Linear WLED Driver with DAM™ and Ultra Fast PWM™ Control

General Description

The MIC2843A is a high efficiency linear White LED (WLED) driver designed to drive up to six WLEDs, greatly extending battery life for portable display backlighting keypad backlighting, and camera flash in mobile devices. The MIC2843A provides the highest possible efficiency as this architecture has no switching losses present in traditional charge pumps or inductive boost circuits. The MIC2843A provides six linear drivers which maintain constant current for up to six WLEDs. It features a typical dropout of 40mV at 20mA. This allows the WLEDs to be driven directly from the battery eliminating switching noise/losses present with the use of boost circuitry.

The MIC2843A features Dynamic Average Matching™ (DAM™) which is specifically designed to provide optimum matching across all WLEDs. The six channels are matched better than ±1.5% typical, ensuring uniform display illumination under all conditions. The brightness is controlled through an Ultra Fast PWM™ interface operating down to less than 1% duty cycle.

The MIC2843A is available in the 10-pin 2mm x 2mm Thin MLF® leadless package with a junction temperature range of -40°C to +125°C.

Datasheets and support documentation can be found on Micrel's web site at: www.micrel.com.

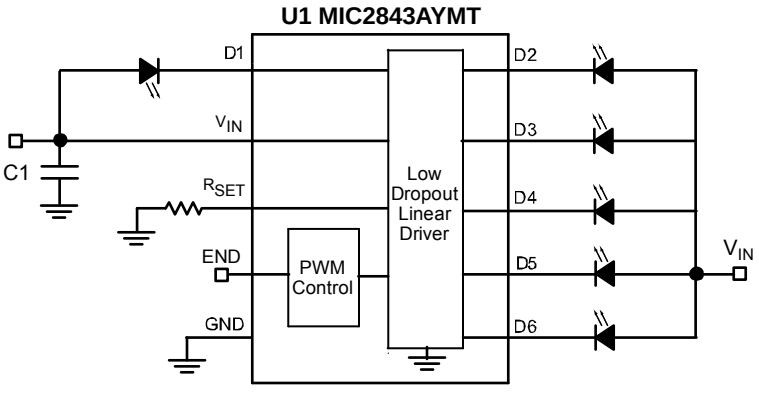
Features

- **High Efficiency (no Voltage Boost losses)**
- Dynamic Average Matching (DAM™)
- Ultra Fast PWM™ control (200Hz to 500kHz)
- Input voltage range: 3.0V to 5.5V
- Dropout of 40mV at 20mA
- Matching better than ±1.5% (typical)
- Current Accuracy better than ±1.5% (typical)
- Maintains proper regulation regardless of how many channels are utilized
- Available in a 10-pin 2mm x 2mm Thin MLF® package

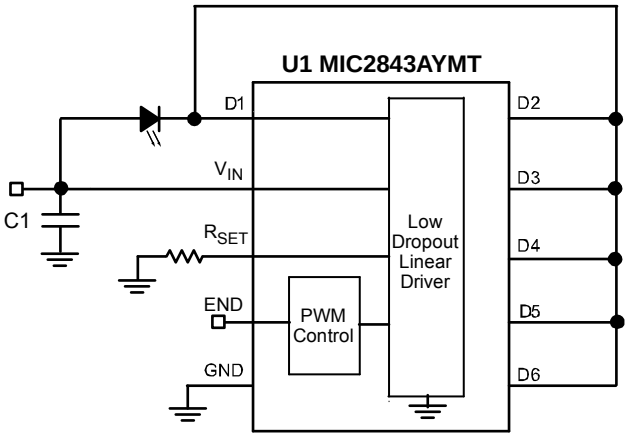
Applications

- Mobile handsets
- LCD Handset backlighting
- Handset keypad backlighting
- Digital cameras
- Portable media/MP3 players
- Portable navigation devices (GPS)
- Portable applications

Typical Application



LCD Display Backlight with Six WLEDs



High Current Flash Driver

Ultra Fast PWM, DAM and Dynamic Average Matching are trademark of Micrel, Inc.
MLF and *Micro*LeadFrame are registered trademark Amkor Technology Inc.

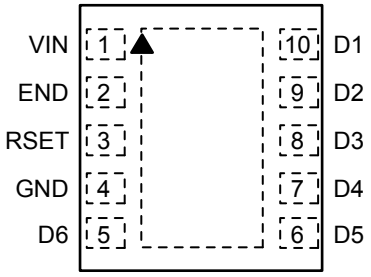
Ordering Information

Part Number	Mark Code[1]	Temperature Range	Package[2]
MIC2843AYMT	S3Y	–40°C to +125°C	10-Pin 2mm x 2mm Thin MLF®

Note:

1. Thin MLF® ▲ = Pin 1 identifier.
2. Thin MLF® is a GREEN RoHS compliant package. Lead finish is NiPdAu. Mold compound is halogen free.

Pin Configuration



10-Pin 2mm x 2mm Thin MLF® (MT)
(Top View)

Pin Description

Pin Number	Pin Name	Pin Function
1	VIN	Voltage Input. Connect at least 1µF ceramic capacitor between VIN and GND.
2	END	Enable LED drivers. This pin can be used as a PWM input for dimming of WLEDs. Do not leave floating.
3	RSET	An internal 1.27V reference sets the nominal maximum WLED current. Example, apply a 20.5kΩ resistor between RSET and GND to set LED current to 20mA at 100% duty cycle.
4	GND	Ground.
5	D6	LED6 driver. Connect LED anode to VIN and cathode to this pin.
6	D5	LED5 driver. Connect LED anode to VIN and cathode to this pin.
7	D4	LED4 driver. Connect LED anode to VIN and cathode to this pin.
8	D3	LED3 driver. Connect LED anode to VIN and cathode to this pin.
9	D2	LED2 driver. Connect LED anode to VIN and cathode to this pin.
10	D1	LED1 driver. Connect LED anode to VIN and cathode to this pin.
EPAD	HS PAD	Heat sink pad. Not internally connected. Connect to ground.

Absolute Maximum Ratings[1]

Main Input Voltage (V_{IN}) ..... –0.3V to +6V
Enable Input Voltage (V_{END}) ..... –0.3V to +6V
LED Driver Voltage (V_{D1-D6}) ..... –0.3V to +6V
Power Dissipation ..... Internally Limited
Lead Temperature (soldering, 10sec.) ..... 260°C
Storage Temperature (T_s) ..... –65°C to +150°C
ESD Rating[3] ..... ESD Sensitive

Operating Ratings[2]

Supply Voltage (V_{IN}) ..... +3.0V to +5.5V
Enable Input Voltage (V_{END}) ..... 0V to V_{IN}
LED Driver Voltage (V_{D1-D6}) ..... 0V to V_{IN}
Junction Temperature (T_J) ..... –40°C to +125°C
Junction Thermal Resistance
2mm x 2mm Thin MLF-10L (θ_{JA}) ..... 90°C/W

Electrical Characteristics

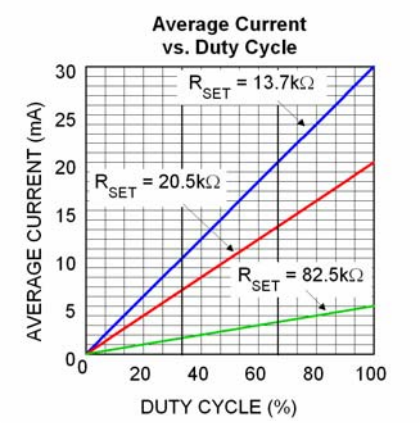
$V_{IN} = V_{END} = 3.8V$, $R_{SET} = 20.5k\Omega$; $V_{D1-D6} = 0.6V$; $T_J = 25°C$, **bold** values indicate $–40°C \le T_J \le 125°C$; unless noted.

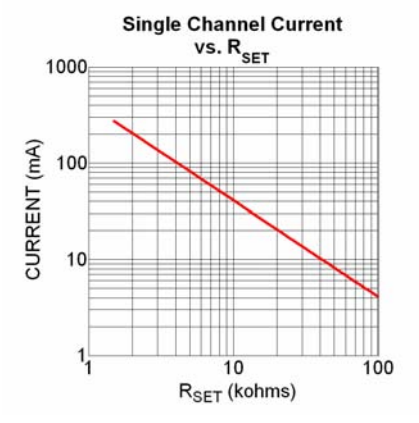
Parameter	Conditions	Min	Typ	Max	Units
Current Accuracy[4]			1.5		%
Matching[5]			1.5	3.6	%
Drop-out	Where I_{LED} = 90% of LED current seen at $V_{DROPNOM}$ = 0.6V, 100% brightness level		40	**80**	mV
Ground/Supply Bias Current	I_{OUT} = 20mA		1.4	1.8	mA
Shutdown Current	V_{END} = 0V		0.01	1	µA
PWM Dimming					
Enable Input Voltage (V_{END})	Logic Low			**0.2**	V
	Logic High	**1.2**			V
Enable Input Current	$V_{IH} \ge 1.2V$		0.01	1	µA
Current Source Delay (50% levels)	Shutdown to on Standby to on On to Standby		40 2 0.3	80	µs µs µs
Current Source Transient Time (10%-90%)	T_{RISE} T_{FALL}		1 0.3		µs µs
Stand-by to Shutdown Time	V_{END} = 0V	10	24	40	ms

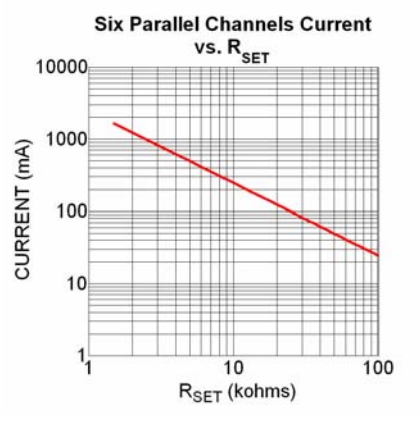
Notes:

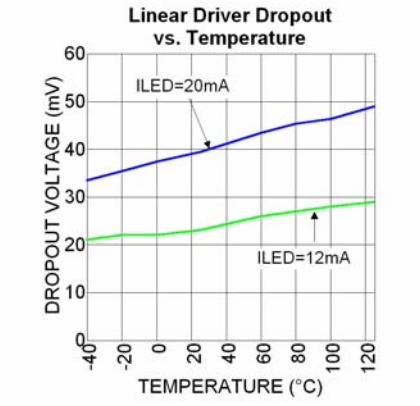
1. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. Devices are ESD sensitive. Handling precautions recommended. Human body model, 1.5kΩ in series with 100pF.
4. As determined by average current of all channels in use and all channels loaded.
5. The current through each LED meets the stated limits from the average current of all LEDs.

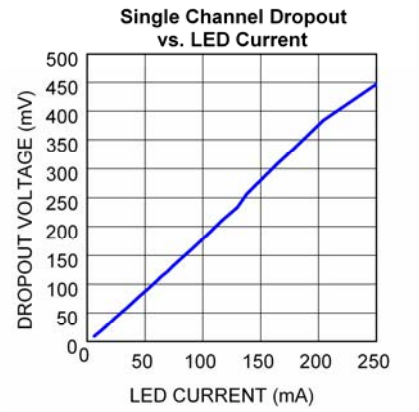
Typical Characteristics

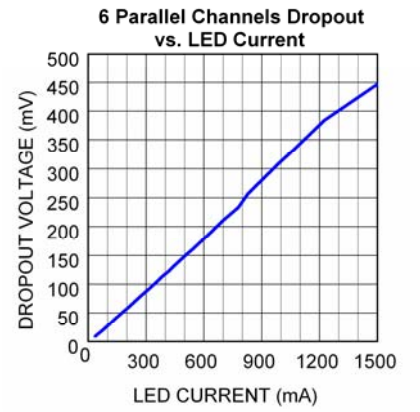


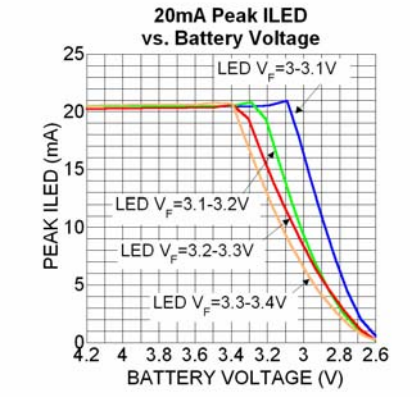


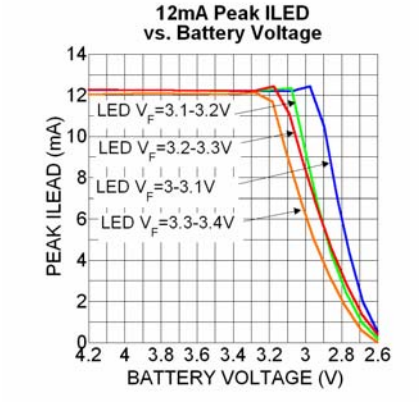


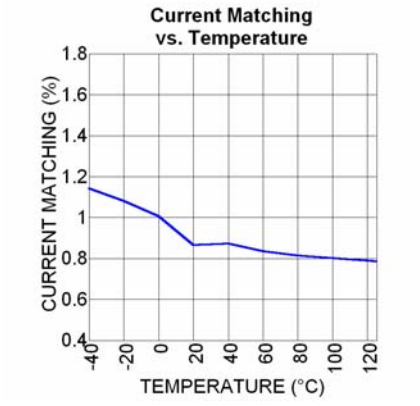


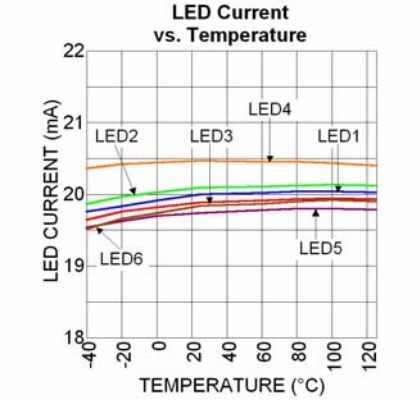






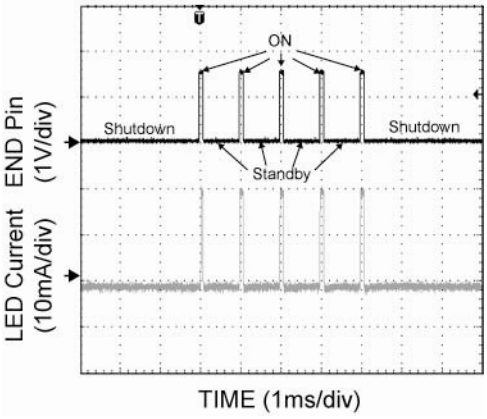




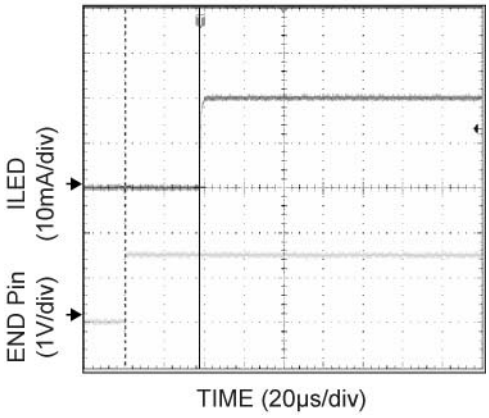


Functional Characteristics

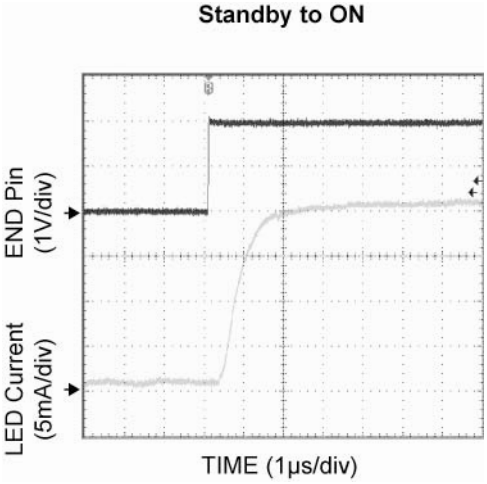
LED Startup into 10% Duty Cycle



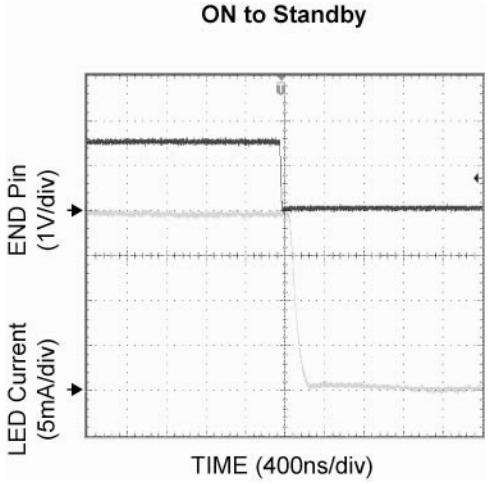
Shutdown to ON



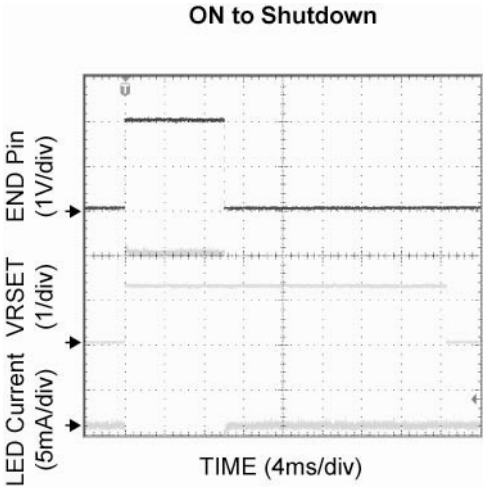
Standby to ON



ON to Standby



ON to Shutdown



Functional Diagram

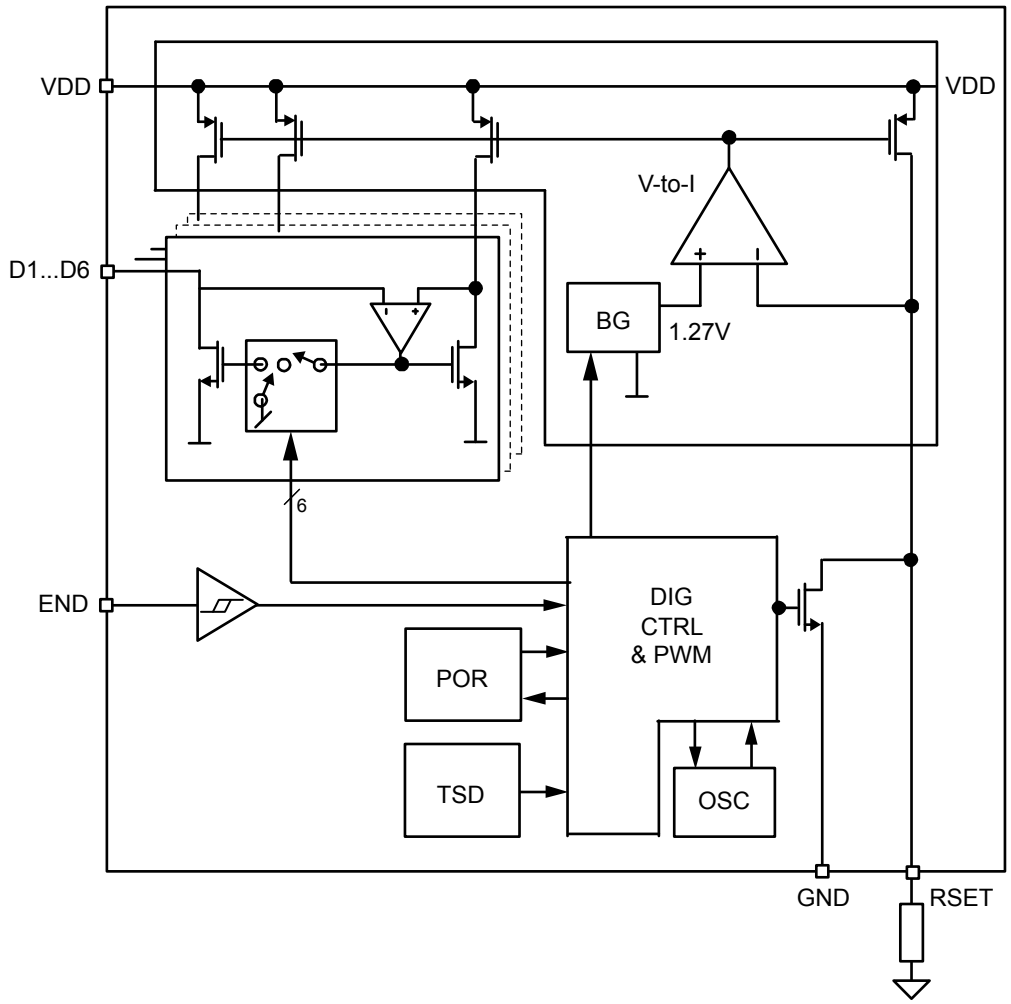


Figure 1. MIC2843A Functional Block Diagram

Functional Description

The MIC2843A is a six channel linear WLED driver. The WLED driver is designed to maintain proper current regulation with LED current accuracy of 1.5%, and typical matching of 1.5% across the six channels. The WLEDs are driven independently from the input supply and will maintain regulation with a dropout of 40mV at 20mA. The low dropout allows the WLEDs to be driven directly from the battery voltage and eliminates the need for large and inefficient charge pumps. The maximum WLED current for each channel is set by the external R_{SET} resistor. Dimming is controlled by applying a PWM signal to the END pin. The MIC2843A accommodates a wide PWM frequency range as outlined in the application information section.

Block Diagram

As shown in Figure 1, the MIC2843A consists of six current mirrors set to copy a master current determined by the R_{SET} resistor. The linear drivers have a designated control block for enabling and dimming the WLEDs.

V_{IN}

The input supply (V_{IN}) provides power to the linear drivers and the control circuitry. The V_{IN} operating range is 3V to 5.5V. A bypass capacitor of 1µF should be placed close to input (VIN) pin and the ground (GND) pin. Refer to the layout recommendations section for details on placing the input capacitor (C1).

END

The END pin is equivalent to the enable pin for the linear drivers on the MIC2843A. It can also be used for dimming using a PWM signal. See the PWM Dimming Interface in the Application Information section for details. Pulling the END low for more than 24ms puts the MIC2843A into a low Iq sleep mode. The END pin cannot be left floating; a floating enable pin may cause an indeterminate state on the outputs. A 200kΩ pull down resistor is recommended when using a high impedance control signal.

R_{SET}

The peak current of the linear drivers is set by connecting a resistor from the R_{SET} pin to ground. The average LED current can be calculated by equation (1) below:

$$I_{LED}\,(mA) = 410 * D / R_{SET}\,(k\Omega) \quad (1)$$

D is the duty cycle of the LED current during PWM dimming. When the device is fully on the duty cycle equals 100% (D = 1). A plot of I_{LED} versus R_{SET} is shown in Figure 2.

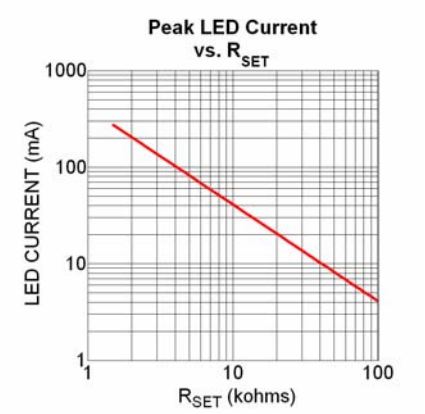


Figure 2. Peak LED Current vs. R_{SET}

D1-D6

The D1 through D6 pins are the linear driver inputs for WLED 1 through 6, respectively. Connect the anodes of the WLEDs to V_{IN} and each cathode of the WLEDs to D1 through D6. When operating with less than six WLEDs, leave the unused D pins unconnected. The linear drivers are extremely versatile in that they may be used in any combinations, for example D1 thru D6 leaving D5 unconnected or paralleled for higher current applications.

GND

The ground pin is the ground path for the linear drivers. The current loop for the ground should be as small as possible. The ground of the input capacitor should be routed with low impedance traces to the GND pin and made as short as possible. Refer to the layout recommendations for more details.

Application Information

Dynamic Average Matching (DAM™)

The Dynamic average matching architecture multiplexes four voltage references to provide highly accurate LED current and channel matching. The MIC2843A achieves industry leading LED channel matching of 1.5% across the entire dimming range.

Ultra Fast PWM™ Dimming Interface

The MIC2843A supports a wide range of PWM control signal frequencies from 200Hz to 500kHz. This extremely wide range of control provides ultimate flexibility for handheld applications using high frequency PWM control signals.

WLED dimming is achieved by pulse width modulating the linear drivers which are controlled by a PWM signal to the END pin. For PWM frequencies between 200Hz – 20kHz the MIC2843A supports a duty cycle range from 1% to 100%, see Figure3. The MIC2843A incorporates an internal shutdown delay to ensure that the internal control circuitry remains active during PWM dimming. This feature prevents the possibility of backlight flickering when using low frequency PWM control signals. The MIC2843A also supports Ultra Fast PWM™ frequencies from 20kHz to 500kHz. Due to input signal propagation delay, PWM frequencies above 20kHz have a non-linear relationship between the duty cycle and the average LED current, see Figures 4 and 5. Figures 6 through 10 show the WLED current response when a PWM signal is applied to the END pin [(1)].

[(1)] From the low Iq sleep mode PWM frequencies above 15kHz may require a logic high enable signal for 80µs to first enable the MIC2843A prior to PWM dimming.

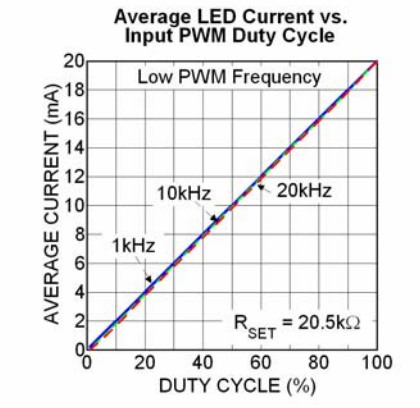


Figure 3. Average Current per LED Dimming by Changing PWM Duty Cycle for PWM Frequencies up to 20kHz

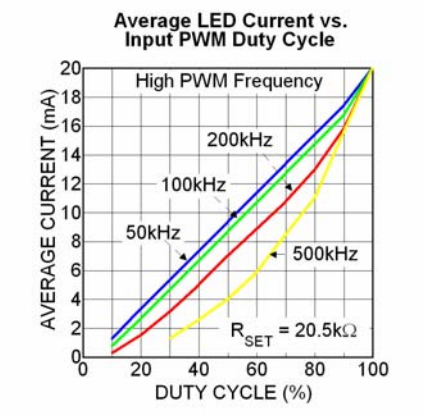


Figure 4. Channel Current Response to PWM Control Signal Frequencies from 50kHz to 500kHz

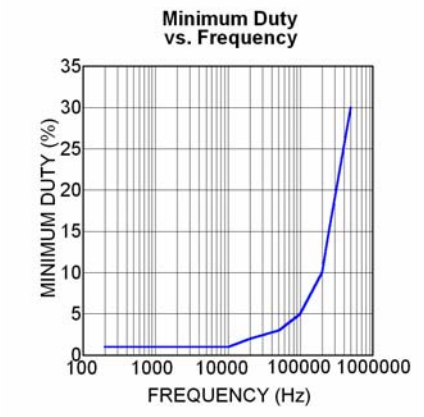


Figure 5. Minimum Duty Cycle for Varying PWM Frequency

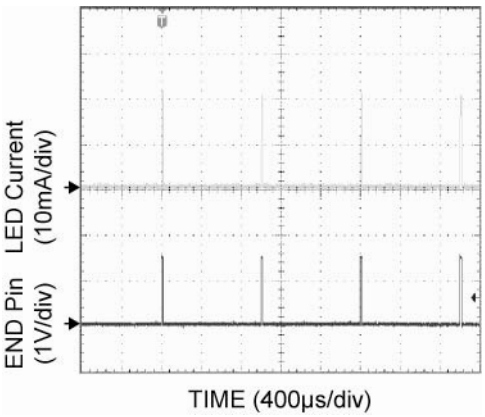


Figure 6. PWM Signal at 1% Duty Cycle (I_{avg} = 0.2mA)

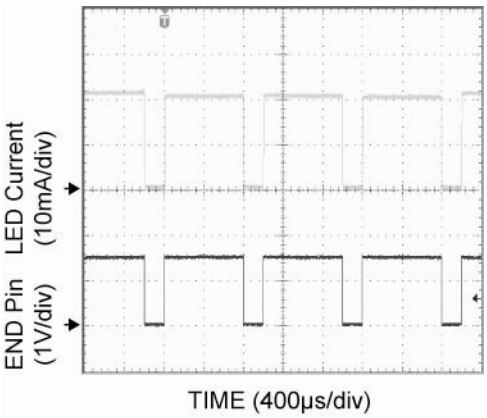


Figure 9. PWM Signal at 80% Duty Cycle (I_{avg} = 16mA)

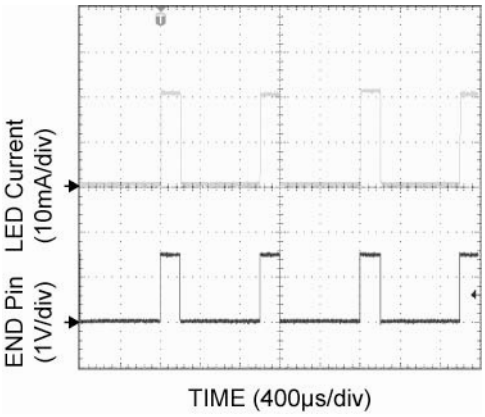


Figure 7. PWM Signal at 20% Duty Cycle (I_{avg} = 4mA)

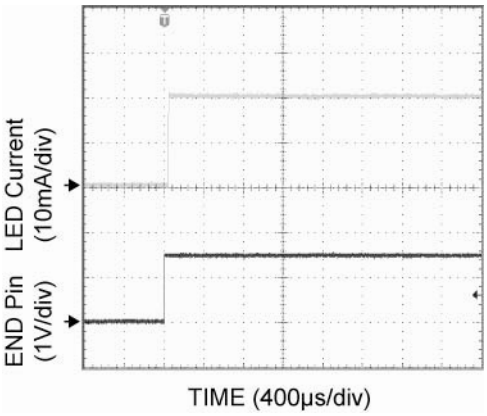


Figure 10. PWM Signal at 100% Duty Cycle (I_{avg} = 20mA)

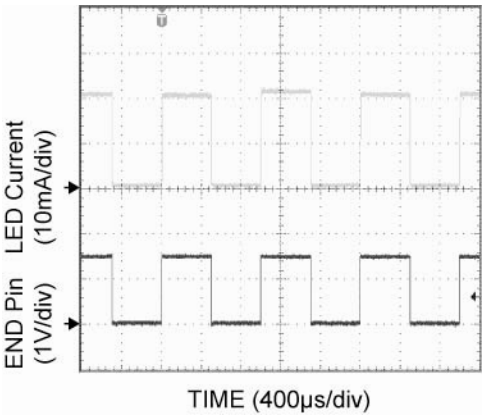


Figure 8. PWM Signal at 50% Duty Cycle (I_{avg} = 10mA)

High Current Parallel Operation

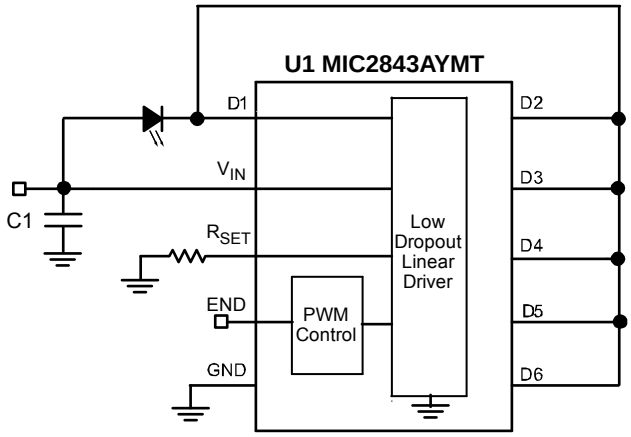


Figure 11. High Current LED Driver Circuit

The linear drivers are independent of each other and can be used individually or paralleled in any combination for higher current applications. A single WLED can be driven with all 6 linear drivers by connecting D1 through D6] in parallel to the cathode of the WLED as shown in Figure 11. This will generate a current 6 times the individual channel current and can be used for higher current WLEDs such as those used in flash or torch applications. The current is set by the R_{SET} resistor, and can be calculated by the following equation.

$$I_{LED}\,(mA) = 6 * 410 * D / R_{SET}\,(k\Omega).$$

D is the duty cycle of the LED current during PWM dimming. When the device is fully on the duty cycle equals 100% (D = 1). Figure 12 shows the response time of the six paralleled linear drivers configured for 800mA to the enable signal, while Figure 13 shows the turn off response. With a R_{SET} resistor of 1.65kΩ, each linear driver is set to 250mA, with all 6 linear drivers connected in parallel, the MIC2843A is capable of driving a total current of 1.5A.

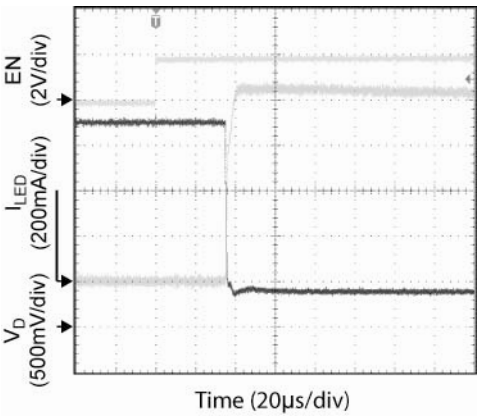


Figure 12. Current Response to a Rising Enable Signal (Six Paralleled Channels)

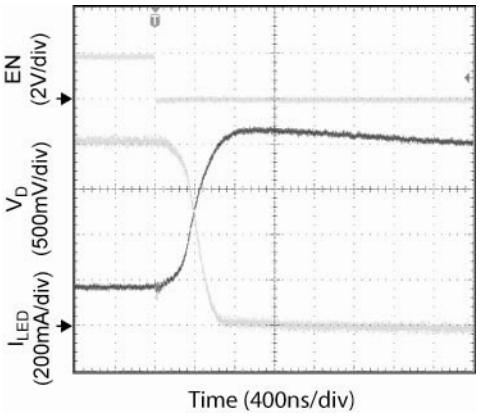
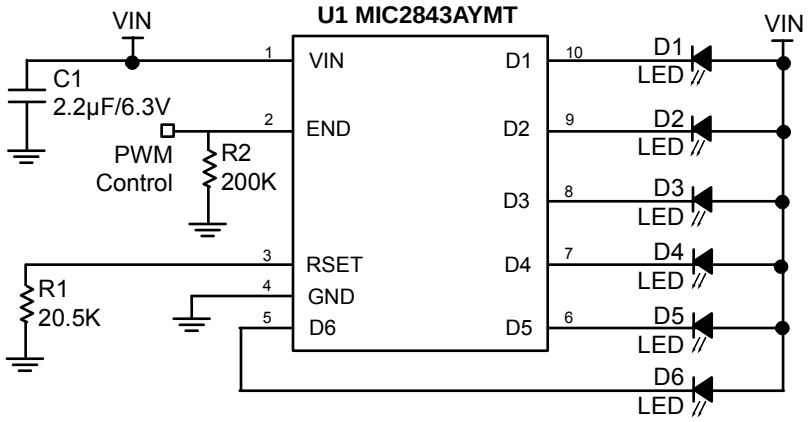


Figure 13. Current Response to a Falling Enable Signal (Six Paralleled Channels)

Input Capacitor

The MIC2843A is a high-performance, high bandwidth device. Stability can be maintained using a ceramic input capacitor of 1µF. Low-ESR ceramic capacitors provide optimal performance at a minimum amount of space. X5R or X7R dielectrics are recommended for the input capacitor. Y5V dielectrics lose most of their capacitance over temperature and are therefore, not recommended.



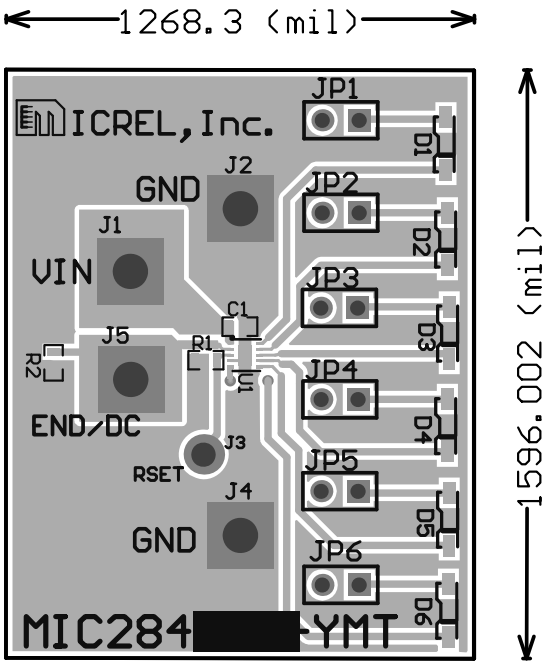
Bill of Materials

Item	Part Number	Manufacturer	Description	Qty.
C1	C1608X5R0J225K	TDK[1]	Ceramic Capacitor, 2.2µF, 6.3V, X5R, Size 0603	1
	06036D225KAT2A	AVX[2]		
	GRM188R60J225KE19D	Murata[3]		
	VJ0603G225KXYAT	Vishay[4]		
D1 – D6	SWTS1007	Seoul Semiconductor[5]	WLED	6
	99-116UNC	EverLight[6]		
R1	CRCW060320K5F5EA	Vishay[4]	Resistor, 20.5k, 1%, 1/16W, Size 0603	1
R2	CRCW06032003FKEA	Vishay[4]	Resistor, 200k, 1%, 1/16W, Size 0603	1
U1	**MIC2843AYMT**	**Micrel, Inc.[7]**	**High Efficiency 6 Channel Linear WLED Driver with DAM™ and Ultra Fast PWM™ Control**	**1**

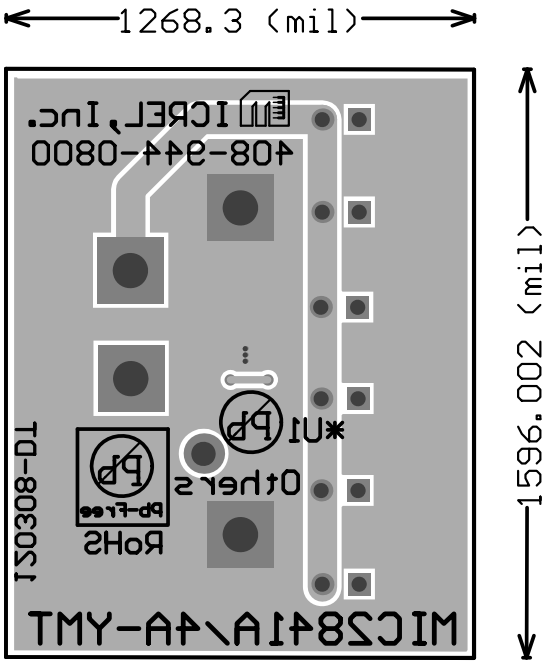
Notes:

1. TDK: www.tdk.com
2. AVX: www.avx.com
3. Murata: www.murata.com
4. Vishay: www.vishay.com
5. Seoul Semiconductor: www.seoulsemicon.com
6. EverLight: www.everlight.com
7. **Micrel, Inc.: www.micrel.com**

PCB Layout Recommendations

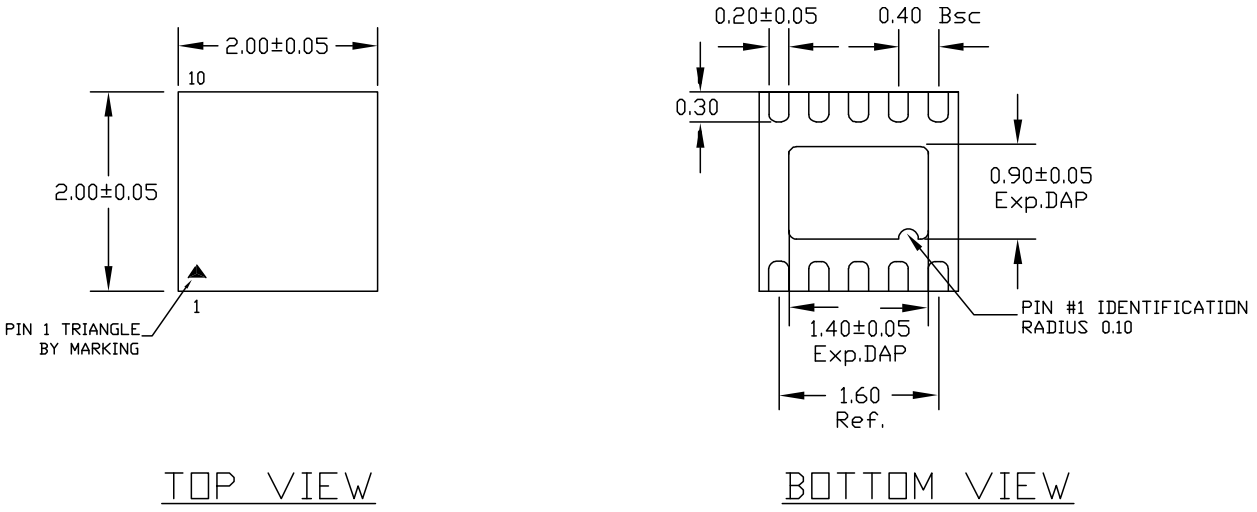


Top Layer



Bottom Layer

Package Information



NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. MAX. PACKAGE WARPAGE IS 0.08 mm.
3. MAXIMUM ALLOWABE BURRS IS 0.08 mm IN ALL DIRECTIONS.
4. PIN #1 ID WILL BE LASER MARKED.

10-Pin (2mm x 2mm) Thin MLF® (MT)

MICREL, INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA
TEL +1 (408) 944-0800 FAX +1 (408) 474-1000 WEB http://www.micrel.com

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