



**THE DATASHEET OF  
A8530EESTR-T**

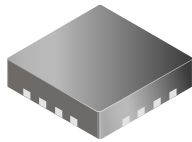


## Ultracompact 6-Channel Backlight and Flash/Torch White LED Driver

### Features and Benefits

- Proprietary adaptive control scheme (1×, 1.5×, 2×)
- 0.5% typical LED current matching
- 2 separate serial interfaces for dimming control
- Drives up to 6 white LEDs (4 display backlight, 2 flash/torch)
- 30 mA per LED channel for display backlight
- 100 mA per LED channel for flash/torch backlight
- 320 mA total output current capability
- Low EMI design and soft-start function
- Short circuit, overvoltage, thermal shutdown protection
- 0.75 mm very thin profile, 3 mm × 3 mm package

### Package: 16 pin QFN/MLP (suffix ES)



Approximate Scale 1:1



### Description

The A8530 high efficiency charge pump ICs offer a simple, low-cost white LED driver solution for driving four display backlight and two flash/torch/video mode white LEDs. Using a proprietary control scheme (1×, 1.5×, and 2×), the A8530 can deliver well-matched LED current while maintaining the highest efficiency and low EMI. The LED current is regulated over the entire range of Li+ battery voltage to provide uniform intensity.

LED brightness and on/off can be controlled for 4 display backlight LEDs and 2 flash/torch LEDs through 2 single-wire serial interface pins.

The A8530 is available in a very thin profile (0.75 mm nominal height) 3 mm×3 mm QFN/MLP 16 pin package. Applications include:

- White LED backlights for cellular phones, PDAs
- Digital cameras, camcorders
- Other portable device white LED backlighting
- 320 mA WLED flash/torch

### Typical Applications

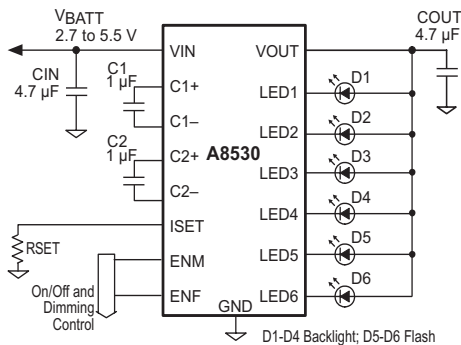


Figure 1. 4 × 30 mA backlight with 2 × 100 mA flash

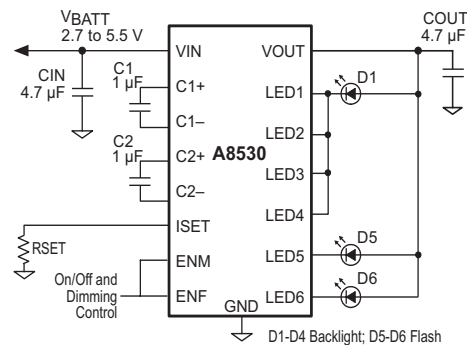


Figure 2. 3 × 100 mA flash

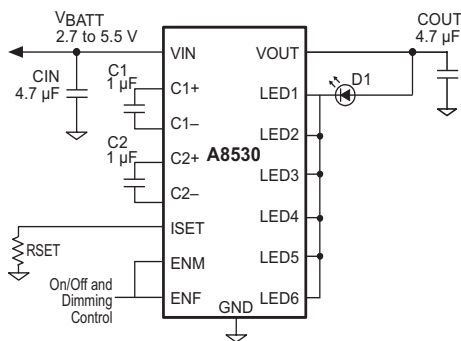


Figure 3. 320 mA flash

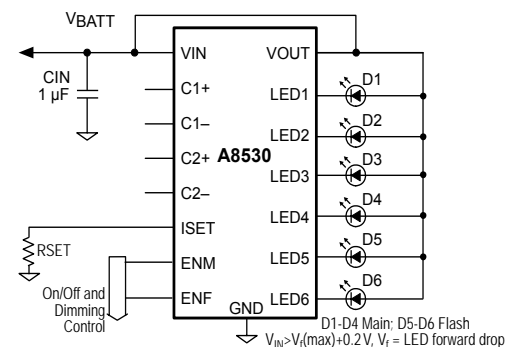
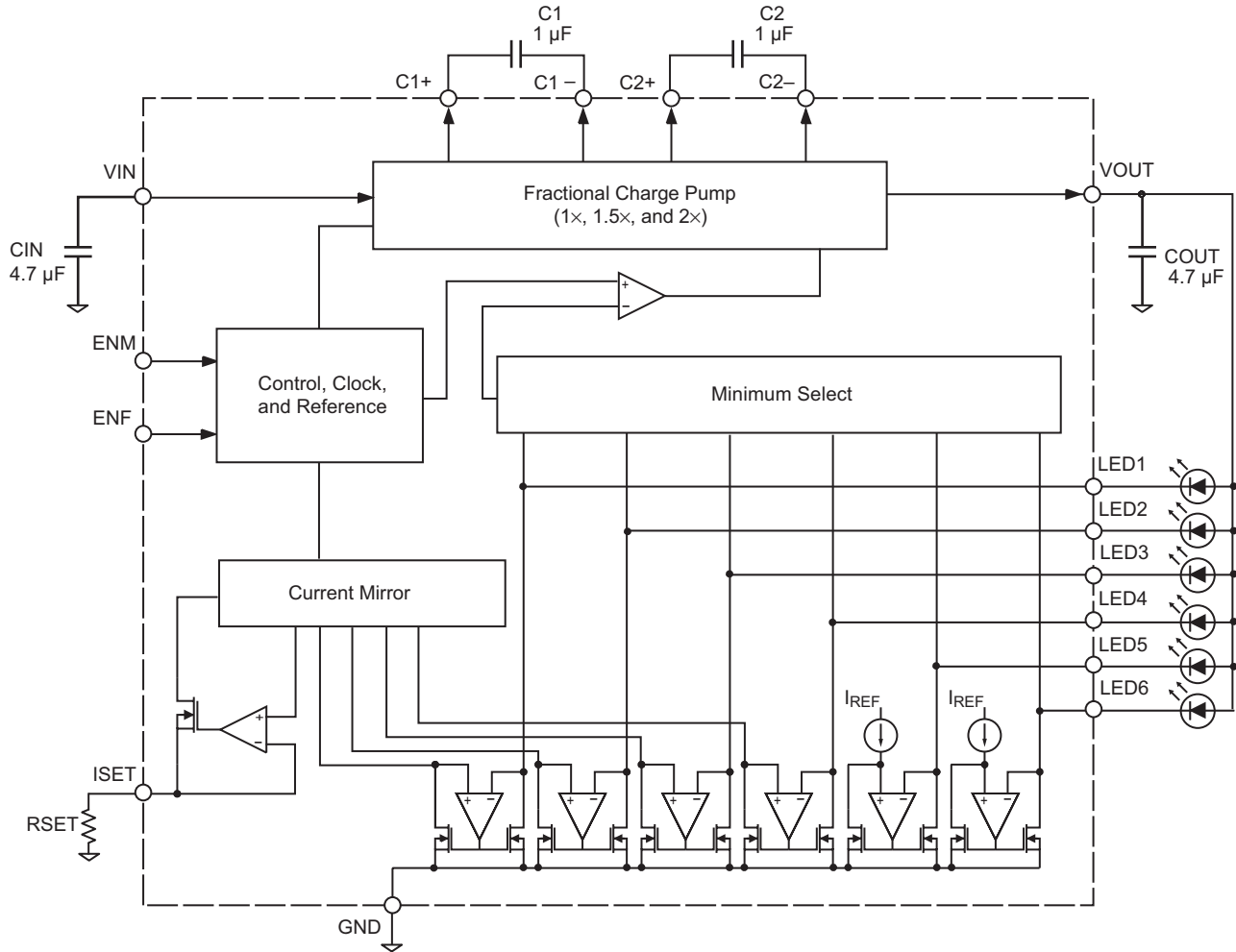


Figure 4. High efficiency current sink

## Functional Block Diagram



### Absolute Maximum Ratings

#### Input or Output Voltage

VIN, VOUT, C1+, C1-, C2+, C2- to GND ..... **-0.3 to 6 V**  
 All other pins ..... **-0.3 to VIN + 0.3 V**

VOUT Short Circuit to GND ..... **Continuous**

Operating Ambient Temperature, TA ..... **-40°C to 85°C**

Junction Temperature, TJ(max) ..... **150°C**

Storage Temperature, TS ..... **-55°C to 150°C**

### Package Thermal Characteristics

RθJA = 47 °C/W, on a 4-layer board based on JEDEC spec  
 Additional information is available on the Allegro Web site.

Device package is lead (Pb) free, with 100% matte tin leadframe plating.



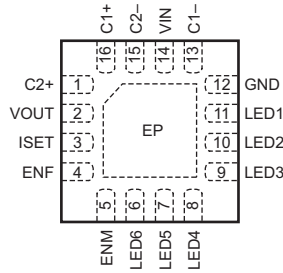
Use the following complete part number when ordering:

Part Number	Packaging*	Package Type
A8530EESTR-T	7-in. reel, 1500 pieces/reel	ES, 3 × 3 mm MLP-16

\*Contact Allegro for additional packing options.

### Pin-out Diagram

ES Package



(Top View)

### Terminal List Table

Name	Number	Function
C1–	13	Negative terminal of capacitor C1. Connect capacitor C1 between C1+ and C1–.
C1+	16	Positive terminal of capacitor C1.
C2–	15	Negative terminal of capacitor C2
C2+	1	Positive terminal of capacitor C2. Connect capacitor C2 between C2+ and C2–.
ENF	4	Enable and dimming control input for flash/torch.
ENM	5	Enable and dimming control input for display backlight.
EP	–	Exposed metal pad on bottom side. Connect this to ground plane for better thermal performance.
GND	12	Ground.
ISET	3	Connect RSET resistor to ground to set desired constant current through backlight LEDs. $I_{LED(max)} = 220 \times 0.6 \text{ V} / R_{SET}$
LED1, LED2, LED3, and LED4	8, 9, 10, and 11	Current sink for display backlight LEDs. If not used, connect to VOUT, but do not leave open. If left open, the IC works in 2 × mode.
LED5 and LED6	6 and 7	Current sink for flash/torch LEDs. If not used, connect to VOUT, but do not leave open. If left open, the IC works in 2 × mode.
VIN	14	Power supply voltage input.
VOUT	2	Charge pump output voltage source for display backlight and flash/torch LED anodes. Connect a 4.7 μF capacitor, COUT, between VOUT and GND (see figures 1 through 4).

**ELECTRICAL CHARACTERISTICS**<sup>a</sup> VIN = ENM = 3.6 V, ENF = GND, C1 = C2 = 1 μF, CIN = COUT = 4.7 μF, RSET = 6.49 kΩ, TA = -40°C to +85°C; typical values are at TA = 25°C; unless otherwise noted

Characteristics	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Input Voltage Range	V <sub>IN</sub>		2.7	-	5.5	V
Undervoltage Lockout Threshold	V <sub>UVLO</sub>	V <sub>IN</sub> falling	2.25	2.45	2.60	V
UVLO Hysteresis Window	V <sub>UVLOHYS</sub>		-	60	-	mV
Quiescent Current	I <sub>Q</sub>	Switching in 1.5× or 2.0× mode; T <sub>A</sub> = 25°C	-	6	-	mA
		ENF = ENM = GND; T <sub>A</sub> = 25°C	-	0.1	2	μA
Soft-start Completion Time	t <sub>ss</sub>		-	2.0	-	ms
ISET Bias Voltage	V <sub>ISETBIAS</sub>		-	0.6	-	V
ISET Leakage in Shutdown	V <sub>ISETLKG</sub>		-	0.01	1	μA
ISET Current Range	I <sub>SET</sub>		40	-	140	μA
ISET to LEDx Current Ratio for LED1 through LED4	I <sub>LEDx</sub> /I <sub>SET</sub>	100% setting, I <sub>SET</sub> = 60 μA	-	220	-	A/A
100% Output Current for LED5 and LED6	I <sub>LED56MAX</sub>	Default 100% setting when ENF is enabled	92	100	108	mA
I <sub>LED</sub> Accuracy for LED1 through LED4 <sup>b</sup>	E <sub>ILED14ERR</sub>	ENF = GND, ENM = VIN	-	±1.6	-	%
LED Current Matching for LED1 through LED4 <sup>c</sup>	ΔI <sub>LED14</sub>	ENF = GND, ENM = VIN	-	±0.5	-	%
LED Current Matching for LED5 and LED6 <sup>c</sup>	ΔI <sub>LED56</sub>	ENF = VIN, ENM = GND, 100%	-	±0.5	-	%
Regulation Voltage at LEDx (1.5× and 2× modes)	V <sub>REG</sub>	ENF = ENM = VIN	-	250	-	mV
1x mode to 1.5x or 1.5x to 2x mode transition voltage at LEDx	V <sub>trans</sub>	V <sub>LEDx</sub> falling	-	150	-	mV
Transition-Dropout Delta <sup>d</sup>	ΔV <sub>dr</sub>	Measured as V <sub>trans</sub> - V <sub>dropout</sub>	-	40	-	mV
Open Loop Output Resistance <sup>e</sup>	R <sub>OUT</sub>	1× mode (V <sub>IN</sub> - V <sub>OUT</sub> )/I <sub>OUT</sub>	-	1	-	Ω
		1.5× mode (1.5 × V <sub>IN</sub> - V <sub>OUT</sub> )/I <sub>OUT</sub>	-	2.5	-	Ω
		2× mode (2 × V <sub>IN</sub> - V <sub>OUT</sub> )/I <sub>OUT</sub>	-	5	-	Ω
LED Leakage in Shutdown	V <sub>LEDLKG</sub>	ENF = ENM = GND, V <sub>IN</sub> = 5.5 V	-	0.01	1	μA
Oscillator Frequency	f <sub>osc</sub>		-	1	-	MHz
Output Overvoltage Protection (guaranteed by design)	V <sub>ovp</sub>	Open circuit at any LED that is programmed to be in the ON state	-	-	6.0	V
ENF and ENM Input High Threshold	V <sub>IH</sub>	Input high logic threshold	1.4	-	-	V
ENF and ENM Input Low Threshold	V <sub>IL</sub>	Input low logic threshold	-	-	0.4	V
Input High Current	I <sub>IH</sub>	V <sub>IH</sub> = VIN	-	-	1	μA
Input Low Current	I <sub>IL</sub>	V <sub>IL</sub> = GND	-	-	1	μA
ENM and ENF Pulse Low Time (figure 6)	t <sub>LO</sub>		0.5	-	250	μs
ENM and ENF Pulse High Time (figure 6)	t <sub>HI</sub>		0.5	-	-	μs
ENM and ENF Initial Pulse High Time (figure 6)	t <sub>INIHI</sub>	First ENM or ENF pulse after shutdown	50	-	-	μs
Shutdown or Dimming Reset Delay	t <sub>SHDN</sub>	Falling edge of ENF and/or ENM	-	0.5	-	ms
Thermal Shutdown Threshold	T <sub>TSD</sub>	20°C hysteresis	-	165	-	°C

<sup>a</sup>Specifications for the range T<sub>A</sub> = -40°C to 85°C are guaranteed by design.

<sup>b</sup>I<sub>LED</sub> accuracy is defined as (I<sub>SET</sub> × 220 - I<sub>LEDAVG</sub>)/I<sub>SET</sub> × 220.

<sup>c</sup>LED current matching is defined as (I<sub>LEDx</sub> - I<sub>LEDAVG</sub>)/I<sub>LEDAVG</sub>.

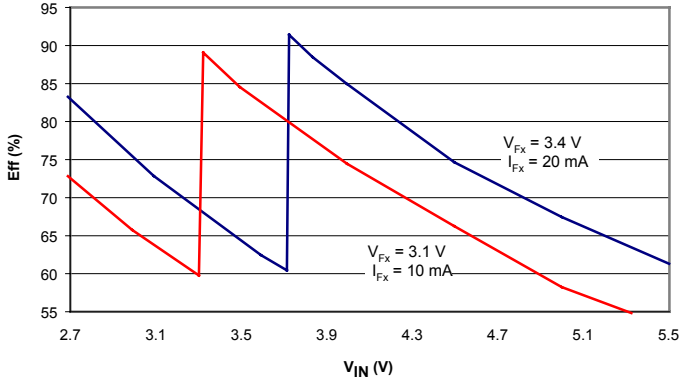
<sup>d</sup>Dropout voltage V<sub>dropout</sub> is defined as LEDx-to-GND voltage at which I<sub>LEDx</sub> drops 10% below the value of I<sub>LEDx</sub> when V<sub>LEDx</sub> = 300 mV.

<sup>e</sup>The open loop output resistance, R<sub>OUT</sub>, for 1.5× mode is measured when one of the LEDx pins is tied to ground or open (thus its voltage is always less than 80 mV).

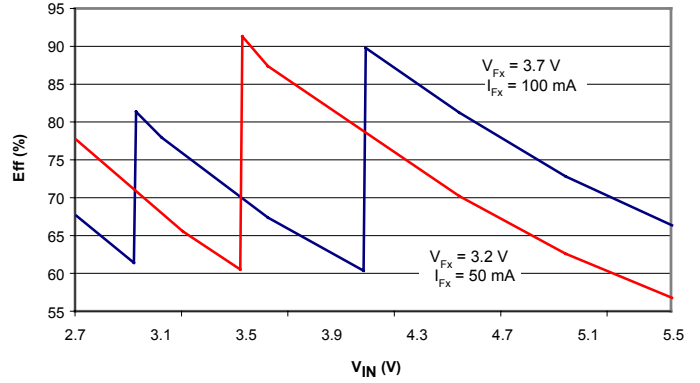
## Performance Characteristics

Tests performed using application circuit shown in figure 1  
 $T_A = 25^\circ\text{C}$ ,  $V_{IN} = 3.6\text{ V}$  (unless otherwise noted)

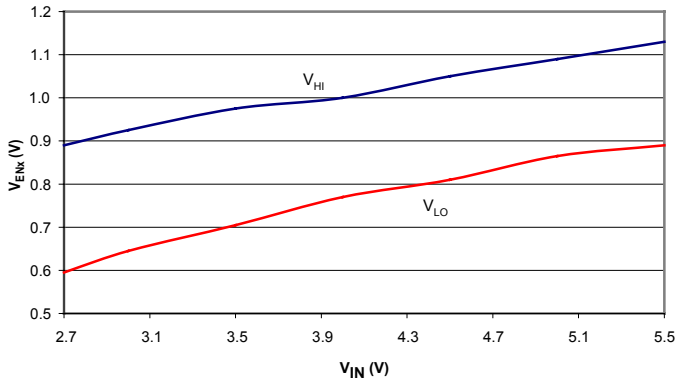
Efficiency versus Supply Voltage for LED1 through LED4, in parallel



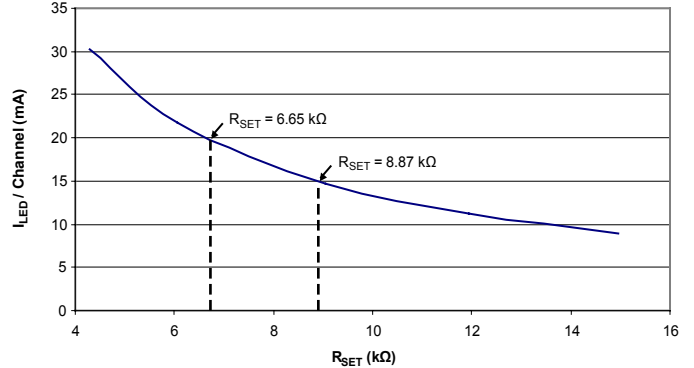
Efficiency versus Supply Voltage for LED5 and LED6, in parallel



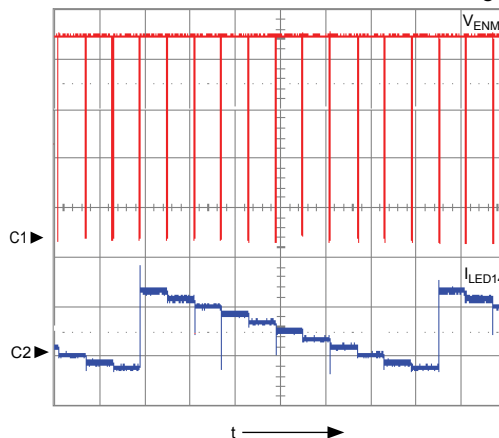
Logic Level



$R_{SET}$  versus  $I_{LED}$



Dimming on ENM  
 Enable Pulses versus Total Current, LED1 through LED4



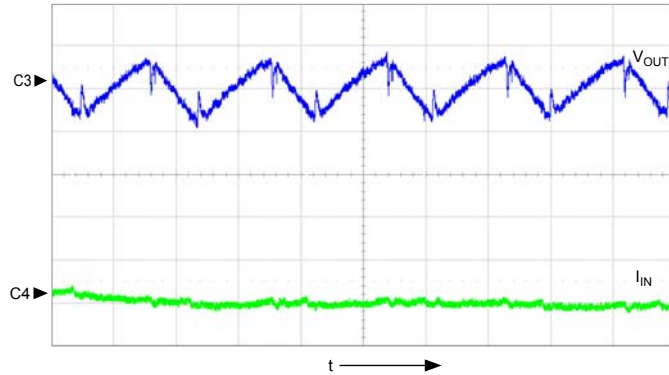
Symbol	Parameter	Units/Division
C1	$V_{ENM}$	0.5 V
C2	$I_{LED14}$	50 mA
t	time	50 ms

### Performance Characteristics

Tests performed using application circuit shown in figure 1  
 $T_A = 25^\circ\text{C}$ ,  $V_{IN} = 3.6\text{ V}$  (unless otherwise noted)

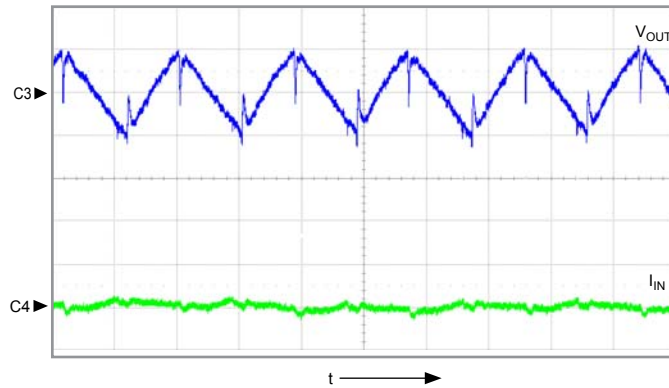
LED5-6 ON, 1.5 $\times$  mode  
 $V_{IN} = 3.2\text{ V}$ ,  $I_{OUT} = 200\text{ mA}$ ,  $V_F = 3.1\text{ V}$

Symbol	Parameter	Units/Division
C3	$V_{OUT}$ Ripple	20 mV
C4	$I_{IN}$ Ripple	50 mA
t	time	500 ns



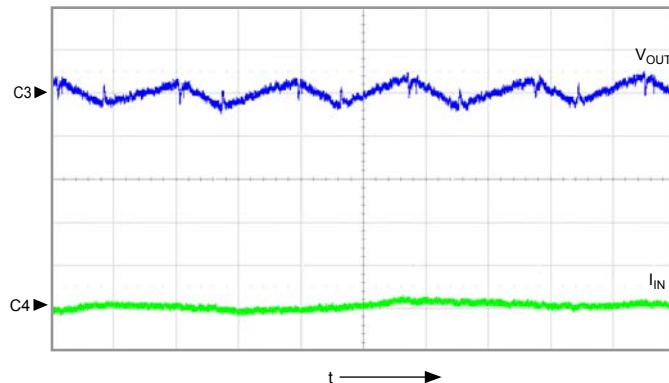
LED5-6 ON, 2 $\times$  mode  
 $V_{IN} = 2.7\text{ V}$ ,  $I_{OUT} = 200\text{ mA}$ ,  $V_F = 3.1\text{ V}$

Symbol	Parameter	Units/Division
C3	$V_{OUT}$ Ripple	20 mV
C4	$I_{IN}$ Ripple	50 mA
t	time	500 ns



LED1-4 ON, 1.5 $\times$  mode  
 $V_{IN} = 3.6\text{ V}$ ,  $I_{OUT} = 80\text{ mA}$ ,  $V_F = 3.4\text{ V}$

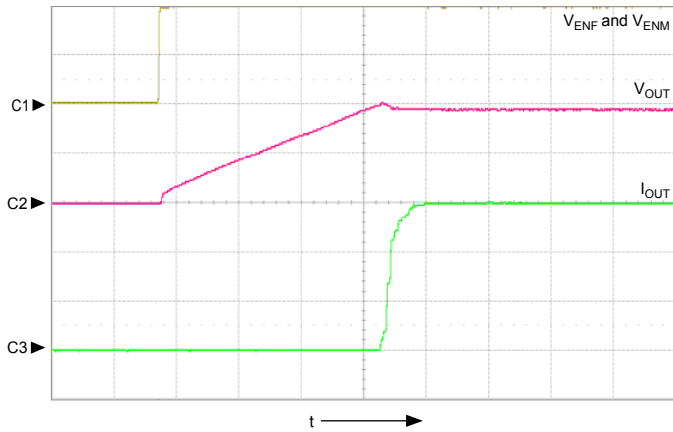
Symbol	Parameter	Units/Division
C3	$V_{OUT}$ Ripple	20 mV
C4	$I_{IN}$ Ripple	50 mA
t	time	500 ns



## Performance Characteristics

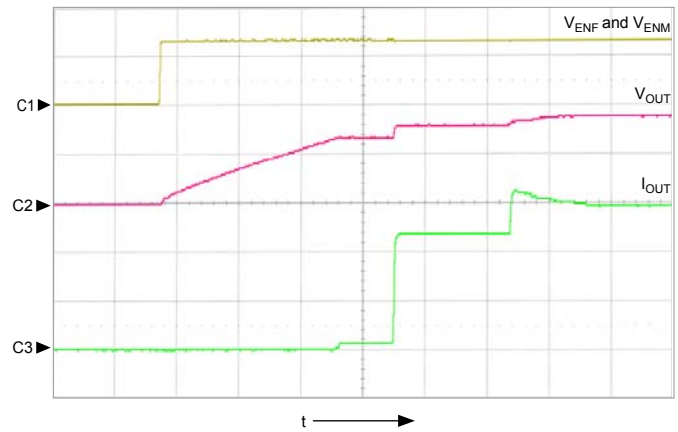
Tests performed using application circuit shown in figure 1  
 $T_A = 25^\circ\text{C}$

Turn ON LED1-6 in 1X Mode  
 $V_{IN} = 4.0\text{ V}$ ,  $I_{OUT} = 280\text{ mA}$



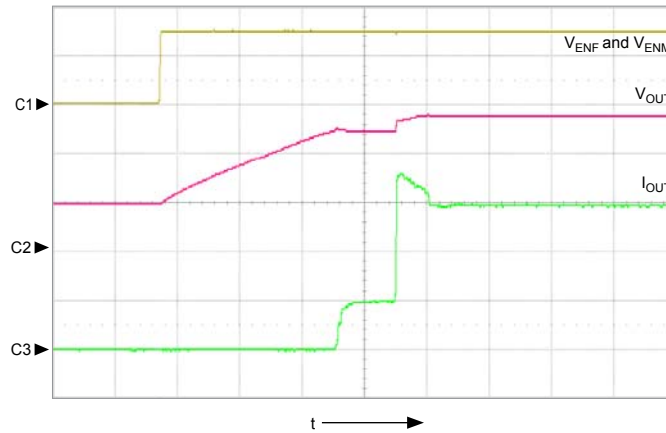
Symbol	Parameter	Units/Division
C1	$V_{ENF}$ and $V_{ENM}$	2.00 V
C2	$V_{OUT}$	2.00 V
C3	$I_{OUT}$	100 mA
t	time	0.5 ms

Turn ON LED1-6 in 2X mode  
 $V_{IN} = 2.7\text{ V}$ ,  $I_{OUT} = 280\text{ mA}$



Symbol	Parameter	Units/Division
C1	$V_{ENF}$ and $V_{ENM}$	2.00 V
C2	$V_{OUT}$	2.00 V
C3	$I_{OUT}$	100 mA
t	time	0.5 ms

Turn ON LED1-6 in 1.5X Mode  
 $V_{IN} = 3.0\text{ V}$ ,  $I_{OUT} = 280\text{ mA}$



Symbol	Parameter	Units/Division
C1	$V_{ENF}$ and $V_{ENM}$	2.00 V
C2	$V_{OUT}$	2.00 V
C3	$I_{OUT}$	100 mA
t	time	0.5 ms

## Application Information

### Setting LED Current

Use the following formula to set the display backlight LED full current (100%) using RSET on LED1 through LED4. The maximum current through one LED should not exceed 30 mA:

$$R_{SET} = 0.6 \text{ V} \times 220 / I_{LEDx}$$

where  $R_{SET}$  is in  $\Omega$  and  $I_{LEDx}$  in amperes.

The default flash/torch current on LED5 and LED6 is set internally to 100 mA per channel. When both the display backlight and the flash/torch LEDs are on, the maximum current output from LED1 through LED4 is 30 mA per channel. The output current of the flash/torch LEDs (LED5 and LED6) can be adjusted by serial dimming at the ENF pin within 1 ms after ENF is pulled high.

### Transitions Between 1× and 1.5× or 2× Modes

The A8530 adaptively selects operating mode. When  $V_{IN}$  is sufficiently high to maintain  $V_{LEDx} > 150 \text{ mV}$ , the A8530 operates

in 1× mode unless, as  $V_{IN}$  drops, the  $LEDx$  nodes fall below the 150 mV threshold. When  $V_{LEDx}$  falls below 150 mV, the IC enters 1.5× mode.

When the A8530 switches from 1× to 2× mode, it first switches to 1.5× mode for a typical duration of 1 ms before entering 2× mode.

When operating in 1.5× mode, if  $V_{OUT} < V_{IN}$ , then the IC switches back to 1× mode every 130 ms, and then reenters 1.5× mode again if necessary.

### Transitions Between 1.5× and 2× Modes

The transition from 1.5× to 2× mode depends upon dropout conditions.

When operating in 2× mode, the IC switches back to 1.5× mode every 130 ms, and then reenters 2× mode again if necessary. Furthermore, when in 2× mode, whenever a channel disabling is sensed (that is, whenever ENM is held low for > 0.5 ms with ENF high, or vice versa), the IC automatically reverts to 1.5× mode, and then reenters 2× mode again if necessary.

### Dimming

**Display Backlight LED1 through LED4 Dimming** The display backlight LEDs (LED1 through LED4) brightness and on/off can be controlled using digital input at the ENM pin. The ENM pin accepts one-wire serial pulse input to enable the A8530 and to set up to 11 dimming levels, from 100% down to 5%.

When ENM is initially pulled up from shutdown, after a soft-start, the current for the backlight LEDs is programmed to 100% of the setting current, which is determined by the current through the ISET pin. Each subsequent pulse reduces the LED current by 10%, and the 10th pulse reduces the current by 5%. The next pulse restores 100% (full) brightness. Figure 6 shows the timing diagram for ENM control.

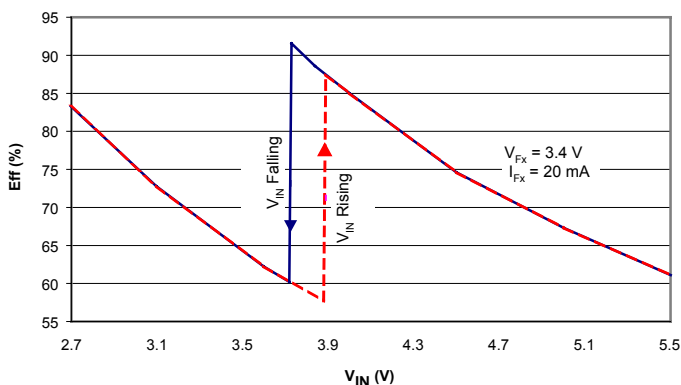


Figure 5. Mode change transitions

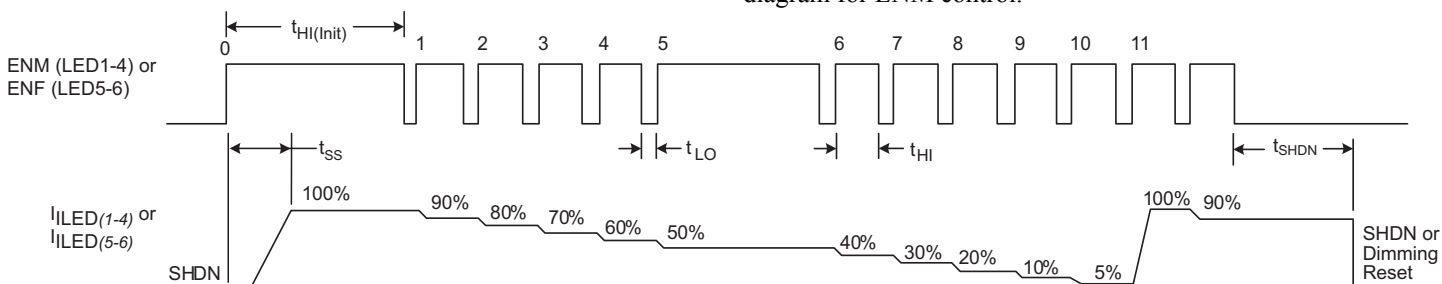


Figure 6. Single-Wire Serial Dimming Control; at pins ENF and ENM.

**Flash/Torch LED5 and LED6 Operation** The flash/torch LEDs (LED5 and LED6) brightness and on/off can be controlled using digital input at ENF pin. ENF accepts one-wire serial pulse input to enable the A8530 and to set up to 11 dimming levels, from 100 mA (the default 100% level) down to 5 mA.

When the ENF pin is initially pulled up from shutdown, after a soft-start (if the IC is not yet soft-started using the ENM pin), the current for LED5 and LED6 is, by default, programmed to 100 mA, corresponding to 100% of flash/torch brightness. Each subsequent pulse reduces the LED current by 10 mA, and the 10th pulse reduces the current by 5 mA. The next pulse then restores to 100 mA (full) output current per channel. Figure 6 shows the timing diagram for ENF.

**Absolute Level Operation** Some applications require dimming to a specific level, regardless of the present level of dimming. For example, if the IC should dim to 30%, this can be done with 7 steps, as shown in figure 6, irrespective of the dimming level in effect. This can be achieved by pulling corresponding ENx

pin low for time greater than  $t_{SHDN}$  and then applying pulses as shown in figure 6 (7 for 30% dimming). If the pulses are applied within 2 to 3 ms, the display flicker is not visible. The procedure is shown in figure 7.

### Shutdown

When the ENM pin is pulled low for 0.5 ms or longer, the display backlight channels are shut off and dimming is reset to 100% upon the next ENM going high edge. When the ENF pin is pulled low for 0.5 ms or longer, the brightness of the flash/torch channels is reset to 100 mA upon the next ENF going high edge. When both ENM and ENF are pulled low for 0.5 ms or longer, the A8530 enters the shutdown mode.

### Short Circuit Protection

The A8530 is protected against short circuits on the output. When  $V_{OUT}$  is externally pulled below 1.2 V, the IC enters Short Circuit mode. The A8530 resumes normal operation when the short circuit is removed.

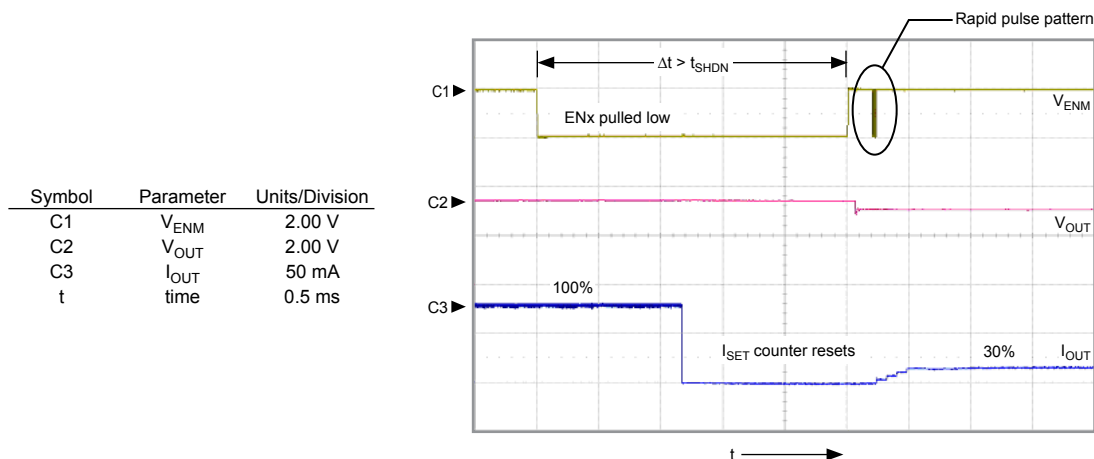


Figure 7. Absolute Dimming Level Setting. With ENM pulled low longer the  $t_{SHDN}$ , pulsing the corresponding ENx pin sets an absolute target level.

### Overvoltage Protection

The A8530 is protected up to 4.9 V supply voltage, against accidental overvoltage caused by an open LED. When any LED opens,  $V_{OUT}$  will increase till 6 V. Remaining LEDs will continue to function normally. Normal operation will be resumed when the fault is removed.

### LED Disconnection

Every LEDx pin has a disable subcircuit, as shown in figure 8. The A8530 compares the voltage on each LED pin, and if the voltage on the pin is greater than either  $V_{OUT} - 0.4$  V or  $V_{IN} - 0.4$  V, then the corresponding LED pin is disabled.

If any WLED is not used, connect the corresponding pin to VOUT. Never leave open any unused WLED pin. LED pins will sink 20  $\mu$ A typical when connected to VOUT and the correspond-

ing LED group (main or sub) is enabled.

Note: In shutdown mode ( $ENM = ENS = 0$  V for  $> 0.5$  ms), the total leakage current is  $< 1 \mu$ A.

### Thermal Shutdown

The IC is internally protected against overtemperature. The overtemperature limit is set to 165°C nominal. The IC shuts down when the junction temperature exceeds 165°C and automatically turns on again when the IC cools.

### Component Selection

Ceramic capacitors with X5R or X7R dielectric are recommended for the input capacitor, CIN, the output capacitor, COUT, and the charge pump capacitors, C1 and C2.

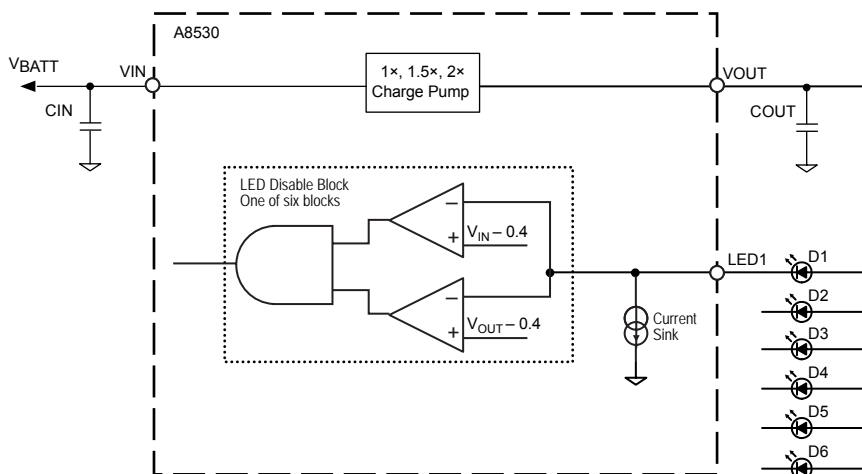
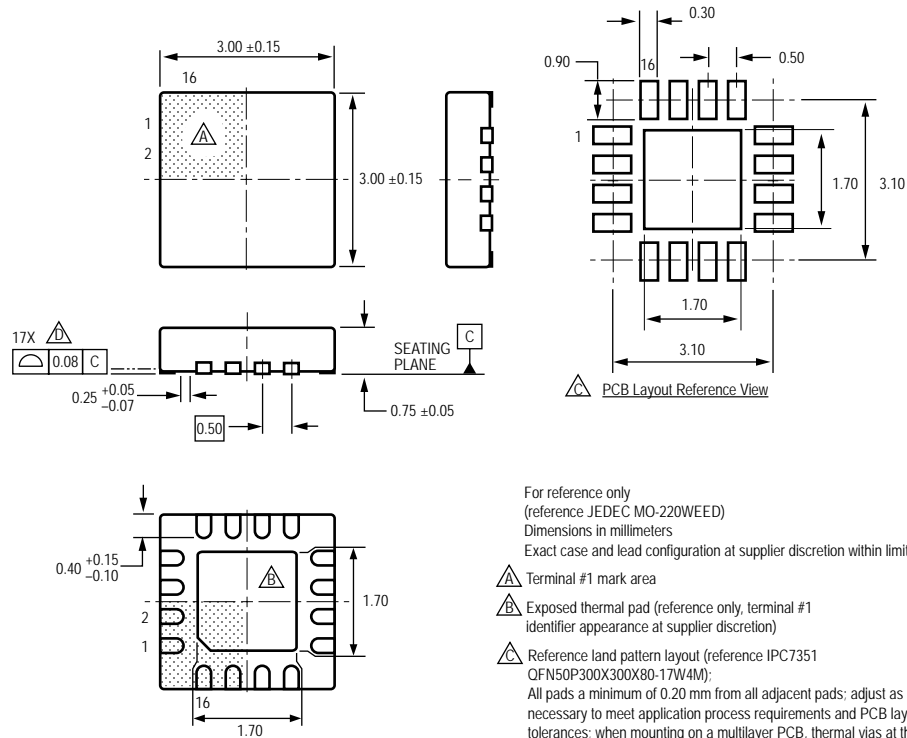


Figure 8. LED disable subcircuit. Subcircuit for one LEDx pin shown. A similar block is connected to each LEDx pin.

### Package ES, 3 × 3 mm 16-Pin QFN/MLP



For reference only  
 (reference JEDEC MO-220WEED)  
 Dimensions in millimeters  
 Exact case and lead configuration at supplier discretion within limits shown

- ⚠ Terminal #1 mark area
- ⚠ Exposed thermal pad (reference only, terminal #1 identifier appearance at supplier discretion)
- ⚠ Reference land pattern layout (reference IPC7351 QFN50P300X300X80-17W4M):  
 All pads a minimum of 0.20 mm from all adjacent pads; adjust as necessary to meet application process requirements and PCB layout tolerances; when mounting on a multilayer PCB, thermal vias at the exposed thermal pad land can improve thermal dissipation (reference EIA/JEDEC Standard JESD51-5)
- ⚠ Coplanarity includes exposed thermal pad and terminals

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