

1.2A White LED Regulating Charge Pump for Camera Flashes and Movie Lights

General Description

The MAX1577Y/MAX1577Z charge pumps drive white LEDs, including camera strobes, with regulated current up to 1.2A (guaranteed to 800mA). The very low open-loop output resistance allows high flash brightness, even from a low battery input voltage. The adaptive 1x/2x regulating charge-pump operation provides high efficiency (up to 92%) while in movie mode or back-lighting. Fast (1MHz) switching allows the use of tiny external components.

The MAX1577Y/MAX1577Z use an external resistor to set the full-scale LED current. Two enable inputs (EN1 and EN2) provide simple on/off control and LED current of 20%, 33%, or 100% full scale. If there is less than 24mV across the external resistor, the output voltage is regulated. The MAX1577Z has fixed 5.1V output-voltage regulation, while the MAX1577Y has logic-controlled output voltage of 3.4V, 4.6V, or 5.1V for backlighting, keyboard, and RGB applications.

The MAX1577Y/MAX1577Z are available in an 8-pin, 3mm x 3mm TDFN package (0.8mm max height).

Applications

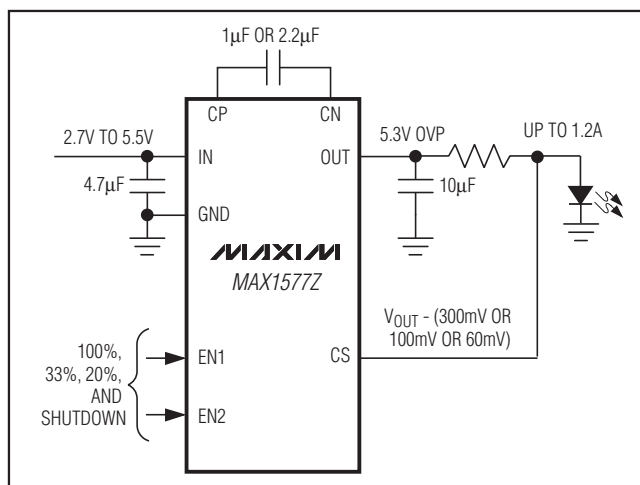
White LED Flashes, Strobes, and Movie Lights

LCD Backlighting

Camera Phones, Cell Phones, and Smart Phones

PDA's, Digital Cameras, and Camcorders

Typical Operating Circuit



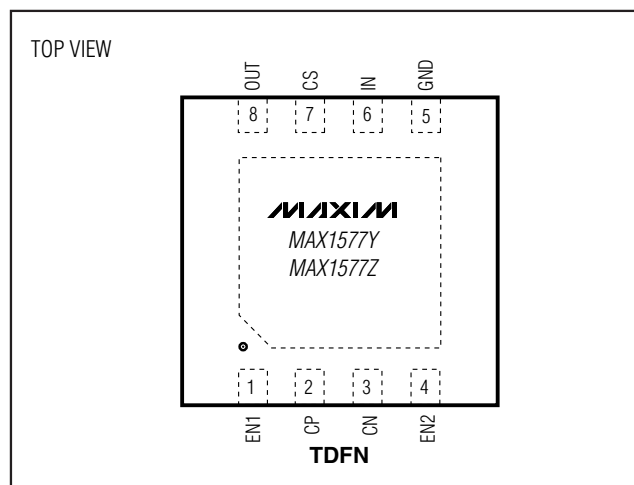
Features

- ◆ Up to 1.2A Output Drive Capability (800mA Guaranteed)
- ◆ Up to 92% PLED / PBATT Efficiency for Movie Mode
- ◆ Flexible Brightness Control
 - Two-Bit Logic for 100%, 33%, 20%, and Off
 - PWM for 20% to 100%
- ◆ 3% Current Regulation Over Line and Temperature
- ◆ Current or Voltage Regulation for Flash and Backlighting (MAX1577Y)
- ◆ Current Regulation for Flash (MAX1577Z)
- ◆ Low Ripple and EMI
- ◆ 2.7V to 5.5V Supply Voltage Range
- ◆ Soft-Start Limits Inrush Current
- ◆ Output-Voltage Regulation Mode
- ◆ Thermal-Shutdown Protection
- ◆ 8-Pin 3mm x 3mm TDFN Package

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
MAX1577YETA	-40°C to +85°C	8 TDFN (T833-2)	AMG
MAX1577ZETA	-40°C to +85°C	8 TDFN (T833-2)	AMQ

Pin Configuration



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ABSOLUTE MAXIMUM RATINGS

IN, OUT, EN1, EN2 to GND-0.3V to +6.0V
 OUT to GND During Shutdown.....-0.3V to ($V_{IN} + 0.3V$)
 OUT to CS-0.6V to +0.6V
 CS to GND.....-0.3V to ($V_{OUT} + 0.3V$)
 CN to GND.....-0.3V to ($V_{IN} + 0.3V$)
 CP to GND-0.3V to the Greater of ($V_{OUT} + 1V$) or ($V_{IN} + 1V$)
 OUT Short Circuit to GNDContinuous

Continuous Power Dissipation ($T_A = +70^\circ\text{C}$)
 8-Pin TDFN (derate 18.2mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)1455mW
 Operating Temperature Range-40 $^\circ\text{C}$ to +85 $^\circ\text{C}$
 Junction Temperature+150 $^\circ\text{C}$
 Storage Temperature Range-65 $^\circ\text{C}$ to +150 $^\circ\text{C}$
 Lead Temperature (soldering, 10s)+300 $^\circ\text{C}$

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

($V_{IN} = 3.6V$, circuit of Figure 2, EN1 = EN2 = IN, $R_{CS} = 60\Omega$, $C_{IN} = 4.7\mu F$, $C_1 = 2.2\mu F$, $C_{OUT} = 10\mu F$, $T_A = -40^\circ\text{C}$ to +85 $^\circ\text{C}$, unless otherwise noted. Typical values are at $T_A = +25^\circ\text{C}$.) (Note 1)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
IN Operating Voltage			2.7		5.5	V
Undervoltage-Lockout Threshold	V_{IN} rising		2.3	2.45	2.6	V
Undervoltage-Lockout Hysteresis				35		mV
Supply Current	1MHz switching, no load			5		mA
	1x LDO mode, no switching			0.225	0.3	
Shutdown Supply Current	EN1 = EN2 = GND	$T_A = +25^\circ\text{C}$		0.01	1	μA
		$T_A = +85^\circ\text{C}$		0.2		
Soft-Start Time				0.5		ms
OUT Overvoltage Protection				5.3		V
OUT Voltage Regulation Mode	MAX1577Z, $T_A = +25^\circ\text{C}$, $I_{OUT} = 100\text{mA}$	EN1 or EN2 = IN	4.95	5.10	5.25	V
	MAX1577Y, $T_A = +25^\circ\text{C}$, $I_{OUT} = 100\text{mA}$	EN1 = GND, EN2 = IN	3.17	3.40	3.60	
		EN1 = IN, EN2 = GND	4.40	4.60	4.80	
		EN1 = EN2 = IN	4.95	5.10	5.25	
CS Voltage-Mode Threshold ($V_{OUT} - V_{CS}$)				24		mV
CS Regulation Voltage ($V_{OUT} - V_{CS}$)	EN1 = GND, EN2 = IN			60		mV
	EN1 = IN, EN2 = GND			100		
	EN1 = EN2 = IN			300		
CS Threshold Accuracy	$T_A = +25^\circ\text{C}$		-2	± 0.5	+2	%
	$V_{IN} = 2.7V$ to $5.5V$, $T_A = -40^\circ\text{C}$ to +85 $^\circ\text{C}$		-3		+3	
Maximum OUT Current	$V_{LED} = 4.1V$, EN1 = EN2 = IN	$V_{IN} = 3.1V$	600	900		mA
		$V_{IN} = 3.4V$	800	1200		
Open-Loop OUT Resistance	1x LDO mode			0.6		Ω
	2x mode, $V_{IN} = 3.4V$			2	3	
OUT Internal Pulldown in Shutdown	EN1 = EN2 = GND			5		k Ω
Switching Frequency			0.80	1.0	1.25	MHz

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ELECTRICAL CHARACTERISTICS (continued)

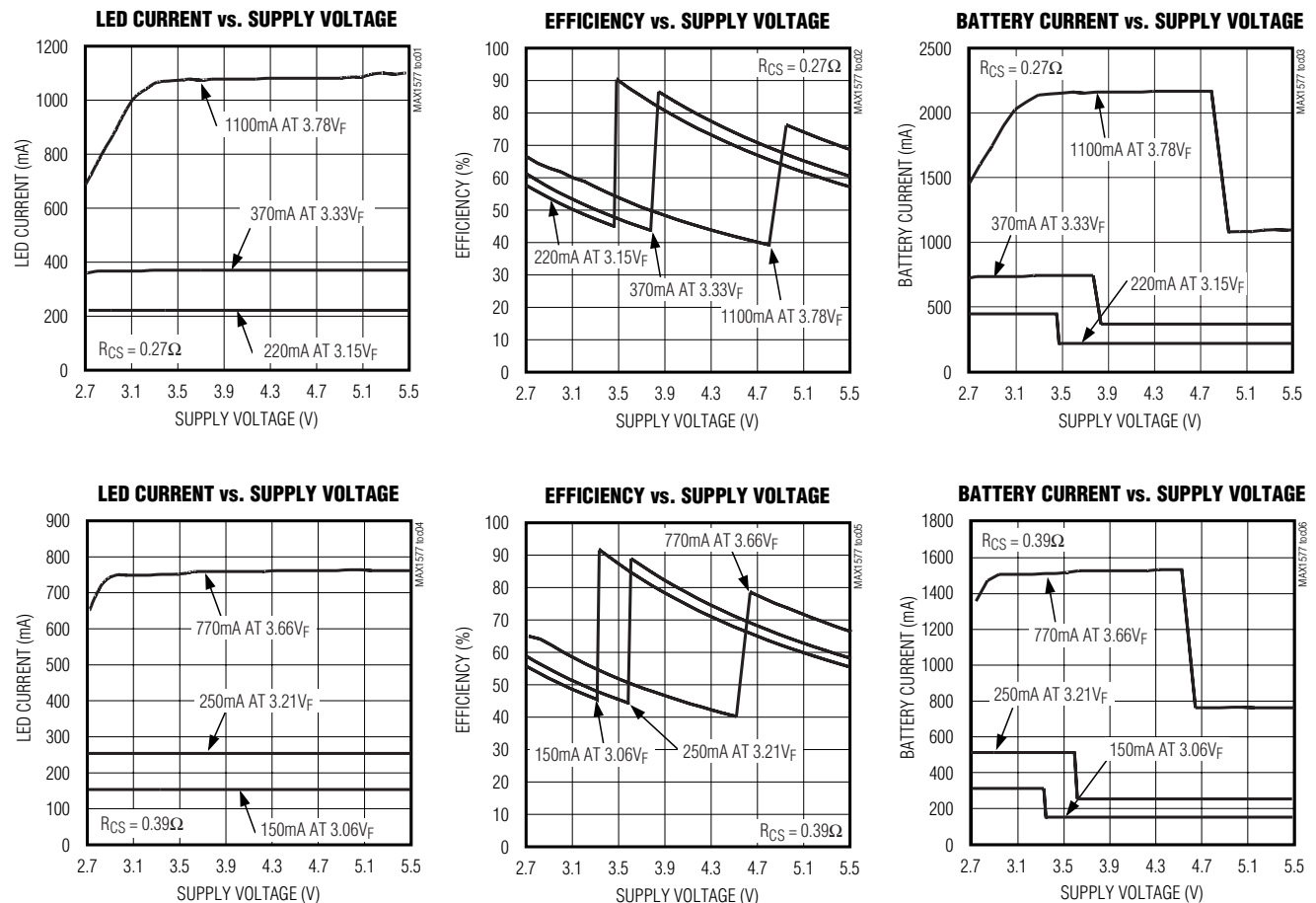
($V_{IN} = 3.6V$, circuit of Figure 2, $EN1 = EN2 = IN$, $R_{CS} = 60\Omega$, $C_{IN} = 4.7\mu F$, $C_1 = 2.2\mu F$, $C_{OUT} = 10\mu F$, $T_A = -40^{\circ}C$ to $+85^{\circ}C$, unless otherwise noted. Typical values are at $T_A = +25^{\circ}C$.) (Note 1)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
EN_ Logic-High Voltage	$V_{IN} = 4.2V$ to $5.5V$	1.6			V
	$V_{IN} = 2.7V$ to $4.2V$	1.4			
EN_ Logic-Low Voltage	$V_{IN} = 2.7V$ to $5.5V$			0.4	V
Logic Input Current	$V_{EN_} = 0V$ or $5.5V$	$T_A = +25^{\circ}C$		0.02	μA
		$T_A = +85^{\circ}C$		0.02	
Thermal-Shutdown Threshold	T_J rising		+160		$^{\circ}C$
Thermal-Shutdown Hysteresis			20		$^{\circ}C$

Note 1: Limits are 100% production tested at $T_A = +25^{\circ}C$. Limits over the operating temperature range are guaranteed by design.

Typical Operating Characteristics

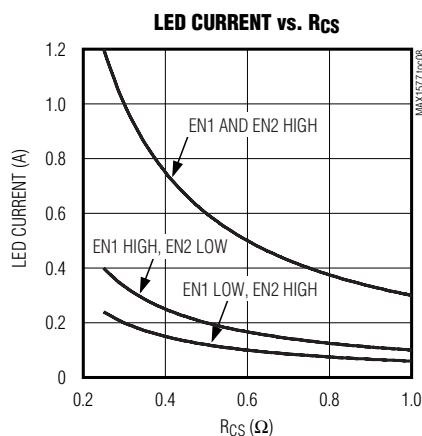
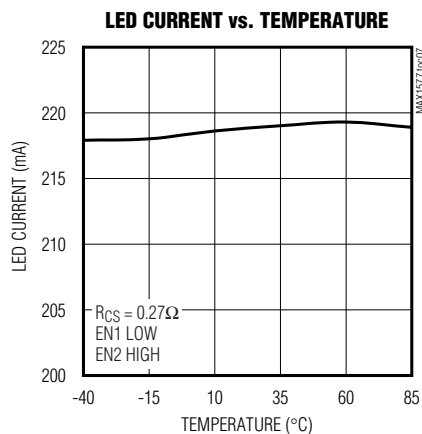
($V_{IN} = 3.6V$, circuit of Figure 2, $R_{CS} = 0.27\Omega$, Luxeon LXCL-PWF1 LED, $T_A = +25^{\circ}C$, unless otherwise noted.)



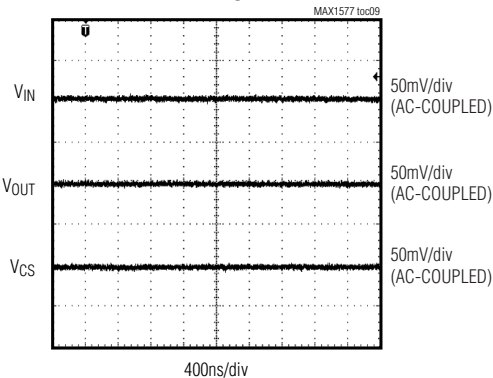
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Typical Operating Characteristics (continued)

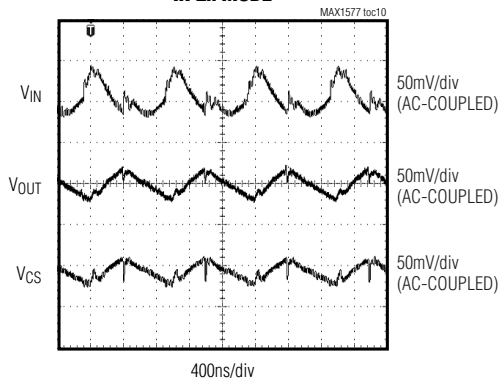
($V_{IN} = 3.6V$, circuit of Figure 2, $R_{CS} = 0.27\Omega$, Luxeon LXCL-PWF1 LED, $T_A = +25^\circ C$, unless otherwise noted.)



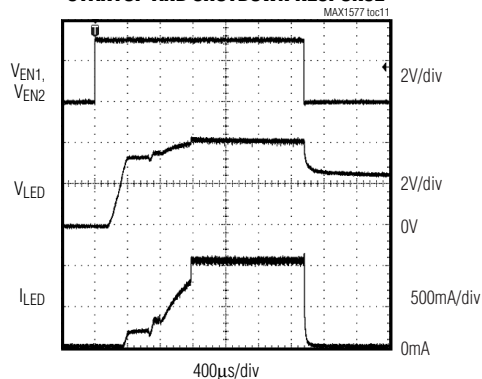
TYPICAL OPERATING WAVEFORMS IN 1x MODE



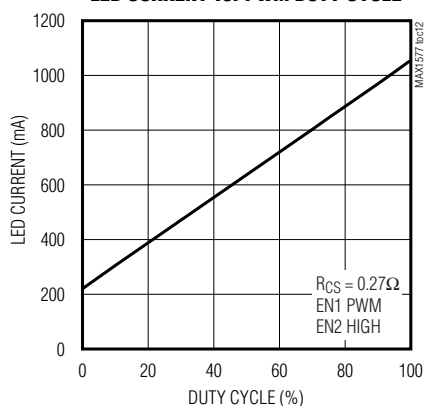
TYPICAL OPERATING WAVEFORMS IN 2x MODE



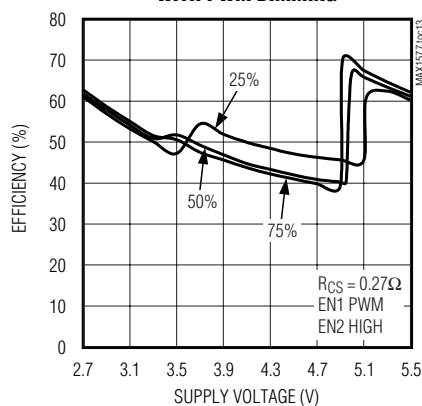
STARTUP AND SHUTDOWN RESPONSE



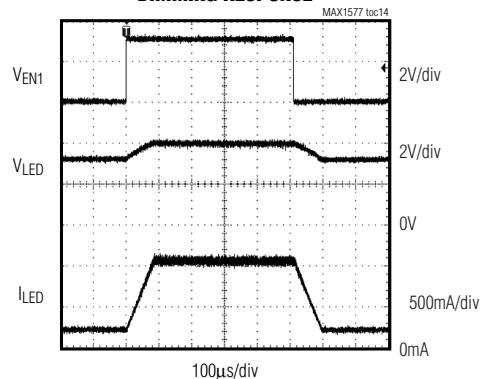
LED CURRENT vs. PWM DUTY CYCLE



EFFICIENCY vs. SUPPLY VOLTAGE WITH PWM DIMMING



DIMMING RESPONSE



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Pin Description

PIN	NAME	FUNCTION
1	EN1	Control Logic Input (see Table 1)
2	CP	Transfer Capacitor Positive Connection. Connect a 1 μ F capacitor (or 2.2 μ F for $I_{OUT} > 600\text{mA}$) from CP to CN.
3	CN	Transfer Capacitor Negative Connection. Connect a 1 μ F capacitor (or 2.2 μ F for $I_{OUT} > 600\text{mA}$) from CP to CN.
4	EN2	Control Logic Input (see Table 1)
5	GND	Ground
6	IN	Input Supply Voltage. Connect IN to a battery or supply voltage from 2.7V to 5.5V. Connect a 4.7 μ F ceramic capacitor from IN to GND.
7	CS	Current-Sense Input. Connect a current-sense resistor from OUT to CS to set the output current. Connect the anodes of the LEDs to CS and the cathodes to GND.
8	OUT	Output. Connect a 10 μ F ceramic capacitor from OUT to GND. In shutdown, OUT is pulled to GND with an internal 5k Ω resistor.
—	EP	Exposed Pad. Connect the exposed pad to GND directly under the IC.

Table 1. Enable, Dimming, Voltage Mode, and Overvoltage Protection

EN1	EN2	DIMMING LEVEL	CS THRESHOLD ($V_{OUT} - V_{CS}$)	VOLTAGE MODE		OVP	
				MAX1577Z	MAX1577Y	MAX1577Z	MAX1577Y
0	0	Shutdown	—	—	—	—	—
0	1	20% Current	60mV	5.10V	3.40V	5.30V	5.15V
1	0	33% Current	100mV	5.10V	4.60V	5.30V	5.17V
1	1	100% Current	300mV	5.10V	5.10V	5.30V	5.30V

Note: A “0” indicates $EN_{\text{—}}$ is logic low or connected to GND. A “1” indicates $EN_{\text{—}}$ is logic high or connected to IN.

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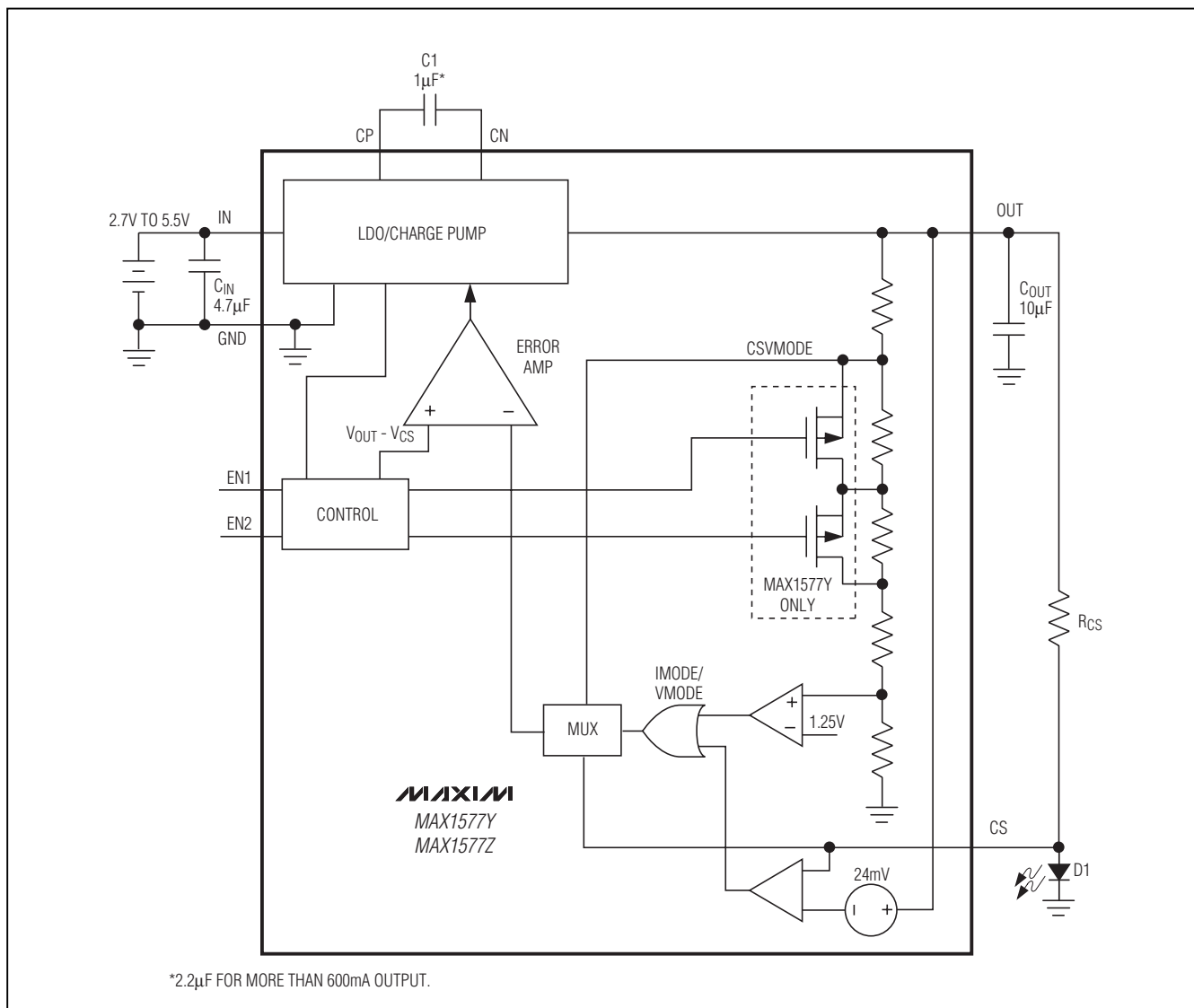


Figure 1. Functional Diagram

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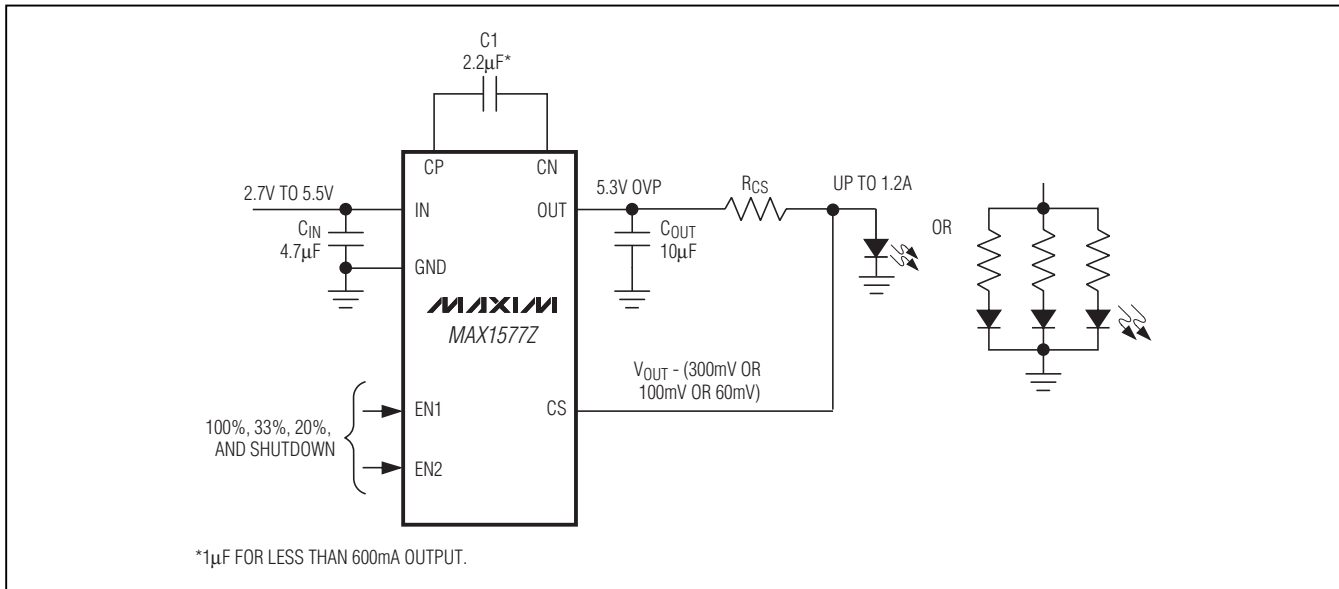


Figure 2. Current Regulation with the MAX1577Z

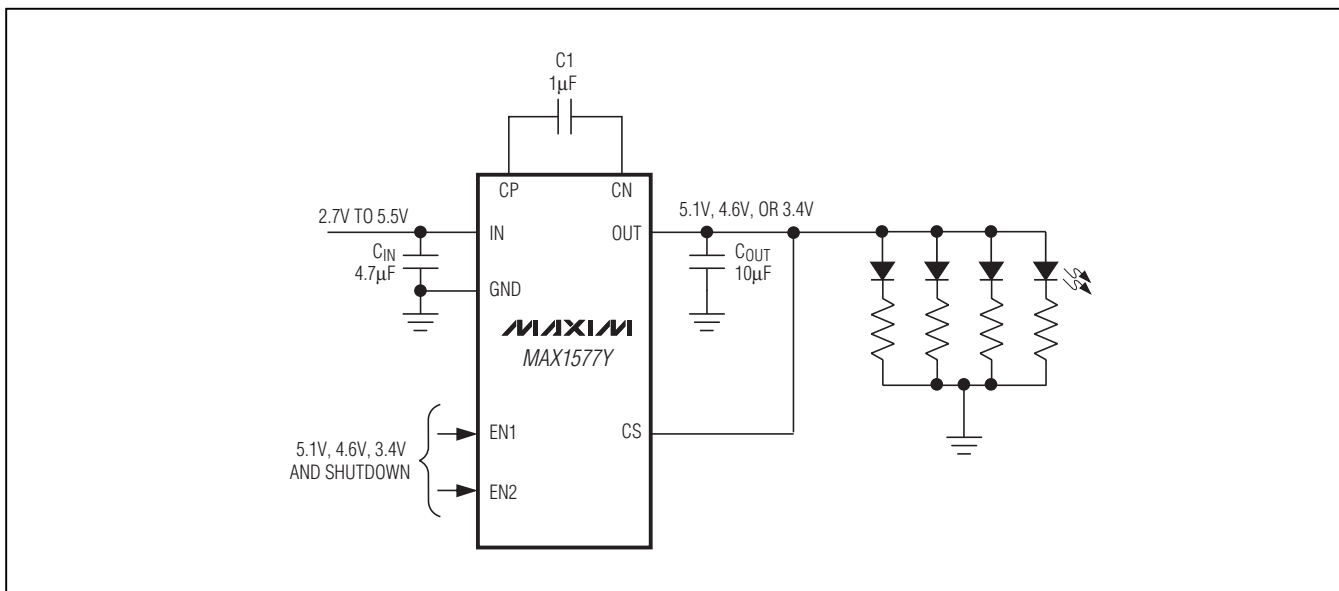


Figure 3. Voltage Regulation with the MAX1577Y

1.2A White LED Regulating Charge Pump for Camera Flashes and Movie Lights

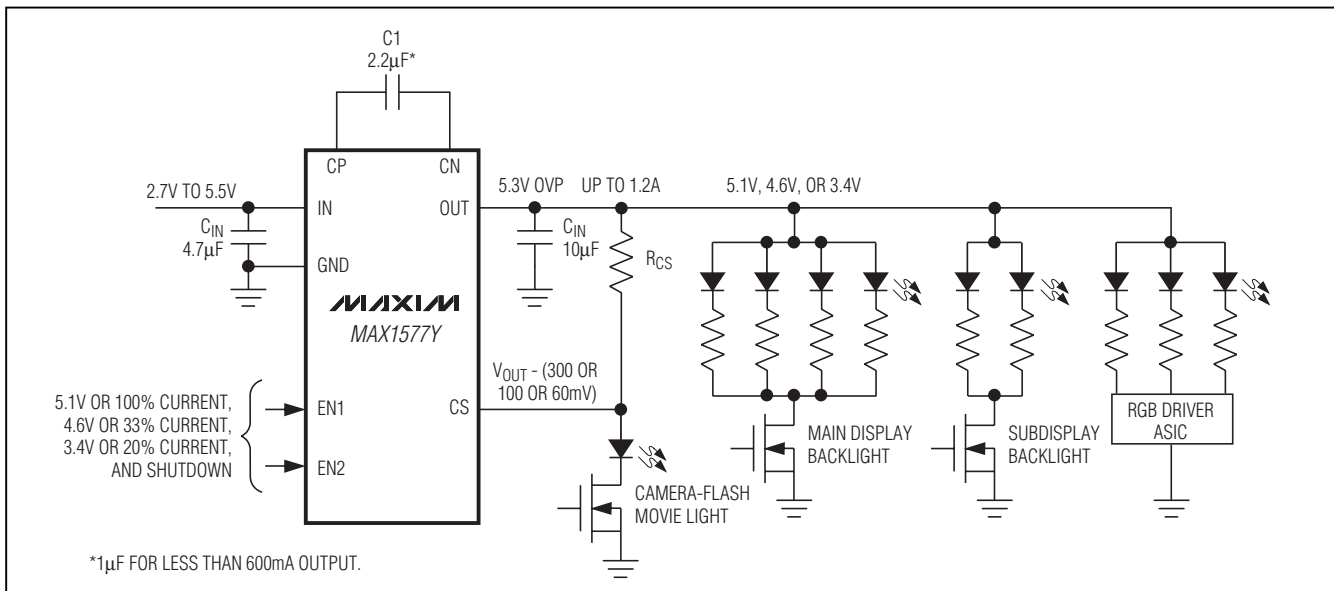


Figure 4. Flash and Backlighting with the MAX1577Y

Detailed Description

1x LDO to 2x Mode Switchover

When V_{IN} is greater than V_{OUT} , the MAX1577Y/MAX1577Z are in 1x LDO mode and regulate the current through R_{CS} . As V_{IN} decreases and the LDO approaches dropout, the 2x charge pump starts boosting the output to maintain the regulation current. When V_{IN} rises enough above V_{OUT} to maintain LDO regulation, the charge pump stops and the MAX1577Y/MAX1577Z switch back to the more efficient 1x LDO mode.

Soft-Start

The MAX1577Y/MAX1577Z include soft-start circuitry to limit inrush current at turn-on. When starting up with an output voltage that is not near the input voltage, the output capacitor is charged directly from the input with a ramped current source (with no charge-pump action) until the output voltage approaches the input voltage. If current-mode or voltage-mode regulation is met, soft-

start is terminated and normal operation begins in 1x mode. Otherwise, after 500µs, the 2x charge-pump soft-start operates until the voltage across the sense resistor reaches the current regulation threshold, the output voltage is in regulation, or 500µs has elapsed, whichever occurs first. If the output is shorted to ground, soft-start is repeated until the output exceeds 2.3V.

Dimming and Shutdown

The MAX1577Y/MAX1577Z use two inputs (EN1 and EN2) to select between three brightness levels and low-power shutdown mode (see Table 1). By regulating the voltage across the current-sense resistor ($V_{OUT} - V_{CS}$) to one of three levels, the MAX1577Y/MAX1577Z control the output current, thus providing the three-level dimming. In shutdown mode, the IC is turned off, reducing the supply current to 0.01µA (typ). When the MAX1577Y/MAX1577Z are shut down, C1 is discharged and the output is pulled to GND through an internal 5kΩ resistor.

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Overvoltage Protection

Output overvoltage protection (OVP) protects the IC and other components in case the output is open circuit. The MAX1577Z always limits the output voltage to 5.3V. With the MAX1577Y, the output OVP voltage varies slightly depending on the state of the EN₋ inputs (see Table 1).

Output-Voltage Regulation Mode

When the voltage across the sense resistor ($V_{OUT} - V_{CS}$) is less than 24mV, the MAX1577Y/MAX1577Z regulate the output voltage. For applications requiring a fixed output voltage instead of current regulation, simply connect CS directly to OUT as shown in Figure 3. The MAX1577Z regulates to a fixed 5.1V. The adjustable regulation voltage (3.4V, 4.6V, or 5.1V) of the MAX1577Y depends on the state of the EN₋ inputs (see Table 1).

Thermal Protection

Thermal protection prevents damage to the IC during overload conditions. When the die temperature exceeds +160°C, the MAX1577Y/MAX1577Z turn off until the die cools by 20°C. Once the die has cooled, the MAX1577Y/MAX1577Z turn on and initiate soft-start. During a continuous overload, this produces a pulsed output. Continuous operation at high-output-current settings may induce thermal protection.

Capacitor Selection

Ceramic capacitors are recommended due to their low equivalent series resistance (ESR), small size, and low cost. Select capacitors that maintain their capacitance over temperature and DC bias. Typically X5R, X7R, or better ceramic capacitors perform well.

A 4.7μF input capacitor and 10μF output capacitor are recommended for most applications. Larger values can be used to reduce ripple.

For the transfer capacitor (C1), a 1μF capacitor is suitable for output currents up to 600mA. For output currents between 600mA and 1200mA, use a 2.2μF capacitor.

Input Ripple

In 1x LDO mode there is no charge-pump switching, and thus very little input ripple. The input ripple in 2x charge-pump mode depends on the input source impedance. Typical waveforms showing the ripple in 1x and 2x mode are in the *Typical Operating Characteristics*. In sensitive applications, increase the input capacitance to reduce input ripple.

Applications Information

Setting the Output Current

For applications requiring a regulated output current, see the circuit of Figure 2. The output regulation current is set by R_{CS} as follows:

$$R_{CS} = (V_{OUT} - V_{CS}) / I_{OUT}$$

where I_{OUT} is the output current (up to 1200mA) and ($V_{OUT} - V_{CS}$) is the current-sense threshold (see Table 1).

For camera-flash applications with a short pulse duration, a 0.25W resistor is recommended.

Setting the Output Voltage

To regulate the output voltage instead of the current, connect CS directly to the output as shown in Figure 3. In this configuration the MAX1577Z regulates the output to 5.1V. The output voltage of the MAX1577Y is set to 5.1V, 4.6V, or 3.4V using the EN1 and EN2 inputs as shown in Table 1.

Driving Camera Strobe/Flash

In applications that do not require dimming, such as a camera strobe/flash, connect EN1 and EN2 together and drive as a single on/off control input. Pulse this input high to generate a strobe output.

PWM Dimming

To vary the brightness from 20% to 100% using pulse-width modulation (PWM), hold EN2 high and apply the PWM signal (up to 5kHz) to EN1. Holding EN2 high keeps the part enabled and prevents repeated soft-starts. The duty cycle of the PWM signal applied to EN1 controls the brightness, where 0% duty cycle corresponds to 20% brightness and 100% duty cycle corresponds to 100% brightness. A PWM signal with a logic-high voltage between 1.6V and 5.5V can be safely used regardless of the input voltage. The voltage of the PWM signal does not affect the brightness level.

For highest movie-mode efficiency, it is best to choose R_{CS} so 0% PWM duty cycle provides the desired movie-mode current. Then, the flash current level is adjusted by the PWM duty cycle. When the movie-mode current is more than 33% of the flash current, it is more efficient to apply the PWM dimming signal to EN2 while holding EN1 high.

Ballast Resistors for Multiple LEDs

When using multiple parallel LEDs, add a ballast resistor in series with each LED to help balance the current between the LEDs. When using current regulation

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(Figure 2), the ballast resistors must be small enough to prevent triggering the overvoltage protection:

$$R_{BALLAST} < (5.1V - V_F) / I_{LED}$$

where I_{LED} is the current through each LED and V_F is the forward voltage of the LED at I_{LED} . Within this limit, larger values of $R_{BALLAST}$ improve LED-to-LED matching but also increase the input voltage where the 2x charge pump makes the transition to the more efficient 1x LDO mode.

When using voltage regulation (Figure 3), select the ballast resistors based on the full brightness setting as follows:

With EN1 high and EN2 high:

$$R_{BALLAST} = (5.1V - V_F) / I_{LED}$$

The LED current at the dimmed settings are calculated as follows:

with EN1 high and EN2 low:

$$I_{LED} = (4.6V - V_F) / R_{BALLAST}$$

with EN1 low and EN2 high:

$$I_{LED} = (3.4V - V_F) / R_{BALLAST}$$

Note that V_F varies as a function of I_{LED} . Typically, LED manufacturers provide a plot of forward voltage (V_F) vs. forward current (I_{LED}) in the LED data sheet.

PC Board Layout and Routing

The MAX1577Y/MAX1577Z are high-frequency switched-capacitor regulators. For best circuit performance, use a solid ground plane and place C_{IN} , C_{OUT} , and C_1 as close to the IC as possible. Connect the exposed pad to GND directly under the IC and allow sufficient copper area for cooling. Refer to the MAX1577Z evaluation kit for an example PC board layout.

Chip Information

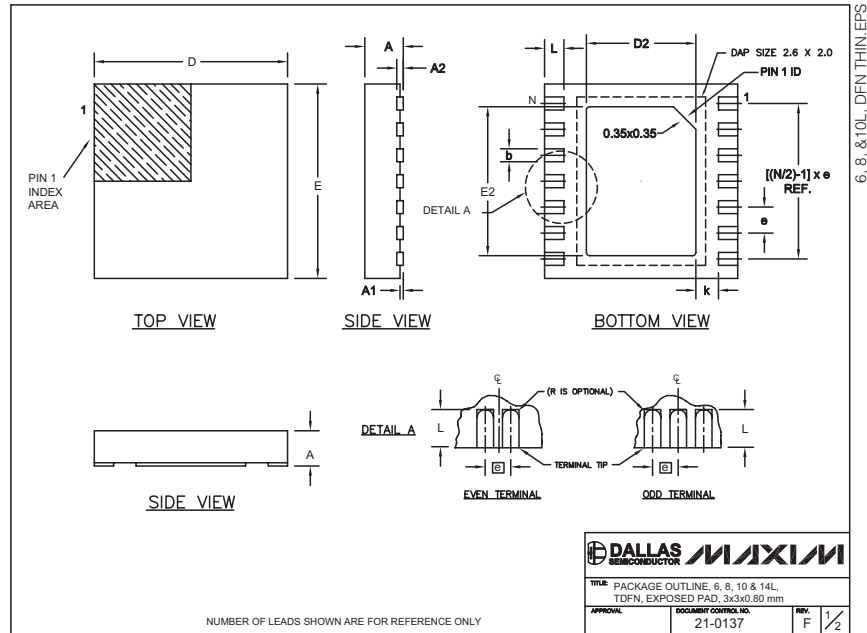
TRANSISTOR COUNT: 2482

PROCESS: BiCMOS

1.2A White LED Regulating Charge Pump for Camera Flashes and Movie Lights

Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information go to www.maxim-ic.com/packages.)



COMMON DIMENSIONS		
SYMBOL	MIN.	MAX.
A	0.70	0.80
D	2.90	3.10
E	2.90	3.10
A1	0.00	0.05
L	0.20	0.40
k	0.25 MIN.	
A2	0.20 REF.	

PACKAGE VARIATIONS							
PKG. CODE	N	D2	E2	e	JEDEC SPEC	b	[(N/2)-1] x e
T633-1	6	1.50±0.10	2.30±0.10	0.95 BSC	MO229 / WEEA	0.40±0.05	1.90 REF
T833-1	8	1.50±0.10	2.30±0.10	0.65 BSC	MO229 / WEEC	0.30±0.05	1.95 REF
T1033-1	10	1.50±0.10	2.30±0.10	0.50 BSC	MO229 / WEED-3	0.25±0.05	2.00 REF
T1433-1	14	1.70±0.10	2.30±0.10	0.40 BSC	----	0.20±0.03	2.40 REF
T1433-2	14	1.70±0.10	2.30±0.10	0.40 BSC	----	0.20±0.03	2.40 REF

NOTES:

- ALL DIMENSIONS ARE IN mm. ANGLES IN DEGREES.
- COPLANARITY SHALL NOT EXCEED 0.08 mm.
- WARPAGE SHALL NOT EXCEED 0.10 mm.
- PACKAGE LENGTH/PACKAGE WIDTH ARE CONSIDERED AS SPECIAL CHARACTERISTIC(S).
- DRAWING CONFORMS TO JEDEC MO229, EXCEPT DIMENSIONS "D2" AND "E2", AND T1433-1 & T1433-2.
- "N" IS THE TOTAL NUMBER OF LEADS.

DALLAS SEMICONDUCTOR		
MAXIM		
TITLE: PACKAGE OUTLINE, 6, 8, 10 & 14L, TDFN, EXPOSED PAD, 3x3x0.80 mm	APPROVAL: 21-0137	REV: F 2/2

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