MBP8700TR

LED DRIVER BOOST CONVERTER

DESCRIPTION

The MBP8700TR isavoltagemodeboostconverterintheSOT23-6package.Itslow feedback voltage allows the current in a chain of LEDs to be set and accurately monitored with a single resistor giving minimal losses. Its excellent load and line regulation means that for the full supply range from lithium-ion cells, the LED currentwilltypicallychangebylessthan1%.Usinghighefficiency ASIC switching transistors with ratings of 20V and higher allow many LEDs to be chained in series for the best LED current matching possible.

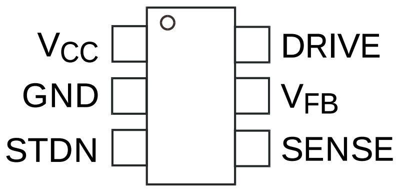
FEATURES

- 1.8V to 8V supply range
- Typical output regulation of ±1%
- Over 80% typical efficiency
- 4.5μA typical shutdown current
- Series connection for ultimate LED current matching

APPLICATIONS

- White LED backlighting for colour LCD panels
- General LED backlighting
- High performance white LED flashlights
- General LED driving from batteries

PINOUT



Top View

ORDERING INFORMATION

DEVICE	REEL SIZE	TAPE WIDTH	QUANTITY PER REEL
MBP8700TR	7"	8mm	3000 units

DEVICE MARKING

- C400

MBP8700TR

ABSOLUTE MAXIMUM RATINGS

V_{CC}	-0.3V	to	+10V
DRIVE	-0.3V	to	V_{CC} + 0.3V
EOR	-0.3V	to	V_{CC} + 0.3V
STDN	-0.3V	to	The lower of (+5.0V) or (V_{CC} + 0.3V)
SENSE	-0.3V	to	The lower of (+5.0V) or (V_{CC} + 0.3V)
Operating Temp.	-40°C	to	+85°C
Storage Temp.	-55°C	to	+125°C
Power Dissipation	450mW		

ELECTRICAL CHARACTERISTICS

Test Conditions V_{CC}= 3V, T= -40°C to 85°C unless otherwise stated.

Symbol	Parameter	Conditions	Limits			Units
			Min	Typ	Max	
Supply parameters						
V_{IN}	V_{CC} Range		1.8		8	V
Iq[1]	Quiescent Current	V_{CC} = 8V			220	µA
I_{STDN}	Shutdown Current			4.5		µA
Eff[1]	Efficiency	30mA > I_{LED} > 10mA		80		%
Acc_{REF}	Reference tolerance	1.8V < V_{CC} < 8V	-3.0		3.0	%
TCO_{REF}	Reference Temp Co			0.005		%/°C
T_{DRIVE}	Discharge pulse width	1.8V < V_{CC} < 8V		1.7		µs
F_{OSC}	Operating Frequency				200	kHz
Input parameters						
V_{SENSE}	Sense voltage		22	28	34	mV
I_{SENSE}	Sense input current	V_{FB} = 0V, V_{SENSE} = 0V	-1	-7	-15	µA
V_{FB}	Feedback voltage		291	300	309	mV
I_{FB}[2]	Feedback input current	V_{FB} = 0V, V_{SENSE} = 0V	-1.2		-4.5	µA
V_{IH}	Shutdown high voltage		1.5		V_{cc}	V
V_{IL}	Shutdown low voltage		0		0.55	V
dV_{LN}	Line voltage regulation			0.5		%/V
Output parameters						
I_{OUT}[3]	Output current	Vin > 2V, Vout = 10.5V	50			mA
I_{DRIVE}	Transistor drive current	Vdrive = 0.7V	2	3.5	5	mA
V_{DRIVE}	Transistor voltage drive	1.8V < V_{CC} < 8V	0		V_{cc}-0.4	V
C_{DRIVE}	Mosfet gate drive cpbty			300		pF
dILD[4]	Load current regulation				0.1	mA/V

Note

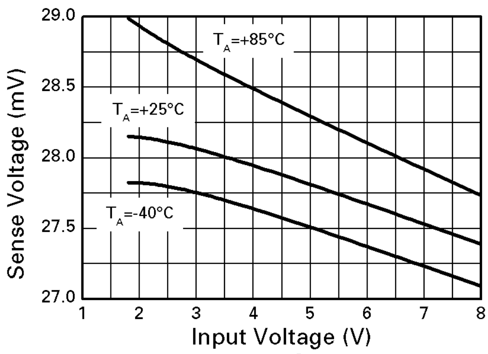
[1] Excluding gate/base drive current.

[2] I_{FB} is typically half these values at 300mV.

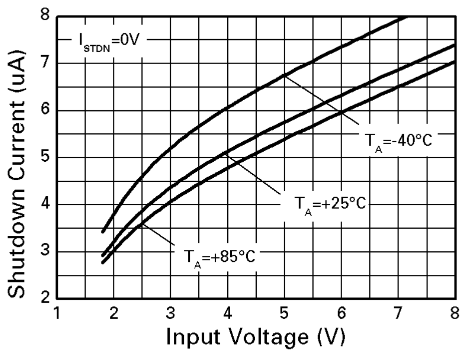
[3] System not device spec, including recommended transistors. 10.5V represents 3 white LEDs.

[4] Change in LED current with changing supply voltage (LED V_F x number of series LEDs).

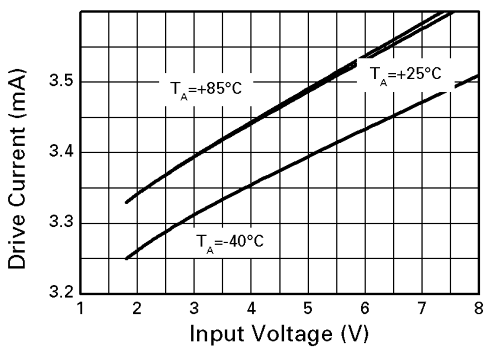
TYPICAL CHARACTERISTICS



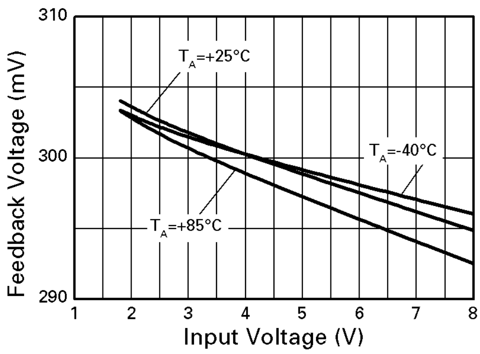
Input Voltage vs Sense Voltage



Input Voltage vs Shutdown Current



Input Voltage vs Drive Current



Input Voltage vs Feedback Voltage

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DESIGN INFORMATION

IC operation description

Bandgap Reference

All threshold voltages and internal currents are derived from a temperature compensated bandgap reference circuit with a reference voltage of 1.22V nominal.

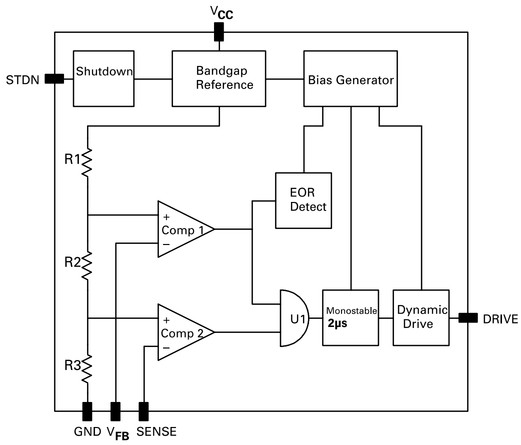
Dynamic Drive Output

Depending on the input signal, the output is either “LOW” or “HIGH”. In the high state a 2.5mA current source (max drive voltage = V_{CC}-0.4V) drives the base or gate of the external transistor. In order to operate the external switching transistor at optimum efficiency, both output states are initiated with a short transient current in order to quickly discharge the base or the gate of the switching transistor.

Switching Circuit

The switching circuit consists of two comparators, Comp1 and Comp2, a gate U1, a monostable and the drive output. Normally the DRIVE output is “HIGH”; the external switching transistor is turned on. Current ramps up in the inductor, the switching transistor and external current sensing resistor. This voltage is sensed by comparator, Comp2, at input I_{SENSE}. Once the current sense voltage across the sensing resistor exceeds 30mV, comparator Comp2 through gate U1 triggers a re-triggerable monostable and turns off the output drive stage for 2μs. The inductor discharges to the load of the application. After 2μs a new charge cycle begins, thus ramping the output voltage. When the output voltage reaches the nominal value and FB gets an input voltage of more than 300mV, the monostable is forced “on” from Comp1 through gate U1, until the feedback voltage falls below 300mV. The above action continues to maintain regulation.

Block diagram



Pin functions

Pin No.	Name	Description
1	V_{CC}	Supply voltage, 1.8V to 8V.
2	GND	Ground
3	STDN	Shutdown
4	SENSE	Inductor current sense input. Internal threshold voltage set to 30mV. Connect external sense resistor
5	V_{FB}	Reference voltage. Internal threshold set to 300mV. Connect external resistor to program LED current
6	DRIVE	Drive output for external switching transistor. Connect to base or gate of external switching transistor.

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Peak current definition

In general, the I_{PK} value must be chosen to ensure that the switching transistor, Q1, is in full saturation with maximum output power conditions, assuming worse-case input voltage and transistor gain under all operating temperature extremes.

Once I_{PK} is decided the value of R_{SENSE} can be determined by:

$$R_{SENSE} = \frac{V_{SENSE}}{I_{PK}}$$

Sense Resistor

A low value sense resistor is required to set the peak current. Power in this resistor is negligible due to the low sense voltage threshold, V_{ISENSE}. At the bottom of the page there is a table of recommended sense resistors.

Output power calculation

By making the above assumptions for inductance and peak current the output power can be determined by:

$$P_{OUT} = I_{AV} \times V_{IN} \times \eta \text{ (Watts)}$$

where

$$I_{AV} = \frac{I_{PK}}{2} \times \frac{(T_{ON} + T_{DIS})}{(T_{ON} + T_{OFF})}$$

and

$$T_{ON} = \frac{I_{PK} \times L}{V_{IN}}$$

and

$$T_{DIS} = \frac{I_{PK} \times L}{(V_{LED} - V_{IN})}$$

and

$$T_{OFF} \cong 1.7\mu s \text{ (internally set by MBP8700TR)}$$

and

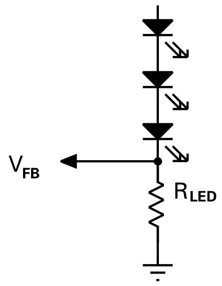
$$\eta = \text{efficiency e.g. } 100\% = 1$$

Operating frequency can be derived by:

$$F = \frac{1}{T_{ON} + T_{OFF}}$$

Programming LED current

Once the required output power is determined, the LED current can be programmed by adding a single resistor in the LED chain. The resistor value is determined by the following:



$$I_{LED} = \frac{V_{FB}}{R_{LED}}$$

Where V_{FB} = 300mV

R_{LED} selection table

I_{LED}	R_{LED}
40mA	7.5Ω
30mA	10Ω
20mA	15Ω
15mA	20Ω
10mA	30Ω

Shutdown Control

The MBP8700TR offersashutdownmodethatconsumes a standby current of less than 5µA. When the voltage at the S_{TDN} pin between 1V and 8V (and also open circuit), the MBP8700TR isenabledandthedriverisinnormal operation. When the voltage at the STDN pin is 0.7V or lower,the MBP8700TR isdisabledandthedriverisin shutdown mode. The SHDN input is a high impedance current source of 1µA typ. The driving device can be an open collector or an open drain or a logic output with a “High“ voltage of 5V max. The device shutdown current depends of the supply voltage, see typical characteristics graph

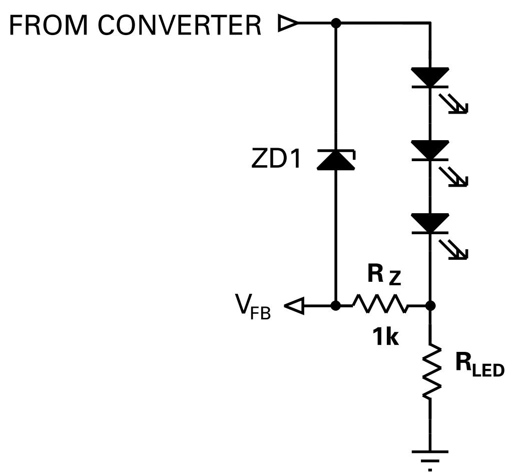
Manufacture	Series	R_{DC}(Ω) Range	Size	Tolerance	URL
Cyntec	RL1220	0.022 - 10	0805	±5%	
IRC	LR1206	0.010 - 1.0	1206	±5%	

Open-circuit protection

For applications where the LED chain might go open-circuit a Zener diode can be connected across the LED chain preventing over-voltage and possible damage to the main switching transistor. The Zener diodes should be selected by ensuring its voltage rating is higher than the combined forward voltage of the LED chain. Under open circuit conditions the curren in the Zener diode defines the output current as:

$$I_Z = \frac{V_{FB}}{R_Z}$$

The circuit example below give an open circuit output current of 300μA.



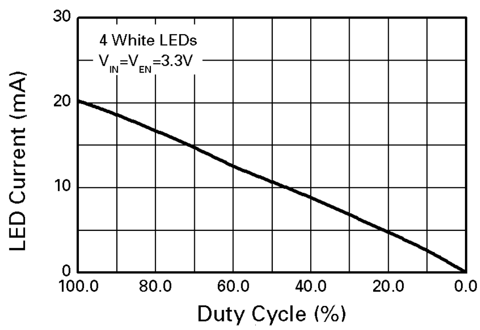
Dimming Control

There are four types of dimming control that can be implemented for the MBP8700TR

Dimming Control using the shutdown pin

The first method uses the shutdown pin. By injecting a PWM waveform on this pin and varying the duty cycle, LED current and hence LED brightness can be adjusted.

To implement this method of brightness control on the MBP8700TR,applyPWMsignalwithamplitudeof between 0.7V and Vcc at a frequency of 120Hz or above (to eliminate LED flicker). The LED current and hence LED brightness is linearly proportional to the duty cycle ratio, so for brightness control adjust duty cycle ratio as necessary. For example, a 10% duty cycle equates to 10% of full LED brightness.



LED Current v Duty Cycle

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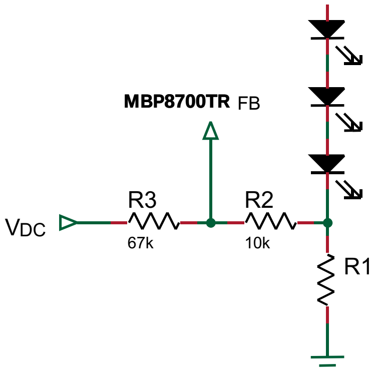
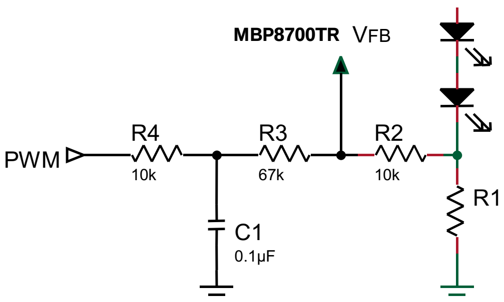
Dimming Control using a DC voltage

For applications where the shutdown pin is not available a DC voltage can be used to control dimming. By adding resistors R2 and R3 and applying a DC voltage, the LED current can be adjusted from 100% to 0%. As the DC voltage increases, the voltage drop across R2 increases and the voltage drop across R1 decreases, thus reducing the current through the LEDs. Selection of R2 and R3 should ensure that the current from the DC voltage is much less than the LED current and much larger than the feedback current. The component values in the diagram below represent 0% to 100% dimming control from a 0 to 2V DC voltage.



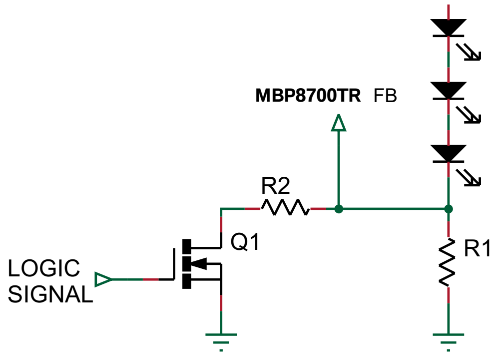
Dimming Control using a filtered PWM signal

The filtered PWM signal can be considered as an adjustable DC voltage by applying a RC filter. The values shown in the diagram below are configured to give 0% to 100% dimming for a 1kHz to 100kHz PWM signal with a 2V amplitude. e.g. a 50% duty cycle will give 50% dimming.



Dimming Control using a logic signal

For applications where the LED current needs to be adjusted in discrete steps a logic signal can be applied as shown in the diagram below. When Q1 os 'off', R1 sets the minimum LED current. When Q1 is 'on', R2 sets the LED current that will be added to the minimum LED current. The formula for selecting values for R1 and R2 are given below:



MOSFET 'off'

$$I_{LED(MIN)} = \frac{V_{FB}}{R_{LEB}}$$

MOSFET 'on'

$$I_{LED(MAX)} = \frac{V_{FLB}}{R_{LEB}} + I_{LED(MIN)}$$

Where $V_{FB} = 300mV$

Layout considerations

Layout is critical for the circuit to function in the most efficient manner in terms of electrical efficiency, thermal considerations and noise.

For 'step-up converters' there are four main current loops, the input loop, power-switch loop, rectifier loop and output loop. The supply charging the input capacitor forms the input loop. The power-switch loop is defined when Q1 is 'on', current flows from the input through the inductor, Q1, R_{SENSE} and to ground. When Q1 is 'off', the energy stored in the inductor is transferred to the output capacitor and load via D1, forming the rectifier loop. The output loop is formed by the output capacitor supplying the load when Q1 is switched back off.

To optimise for best performance each of these loops kept separate from each other and interconnected with short, thick traces thus minimising parasitic inductance, capacitance and resistance. Also the R_{SENSE} resistor should be connected, with minimum trace length, between emitter lead of Q1 and ground, again minimising stray parasitics.

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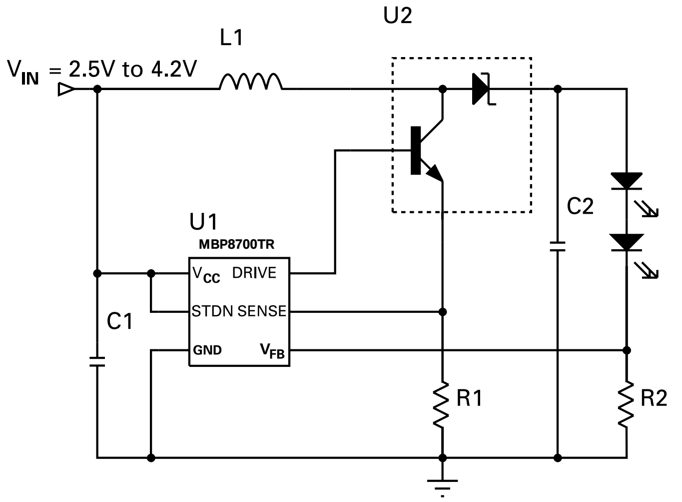
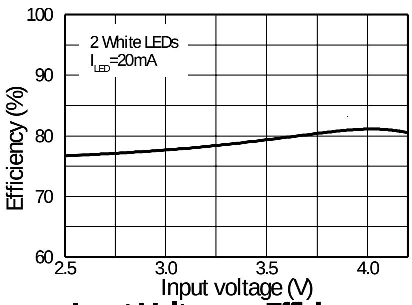
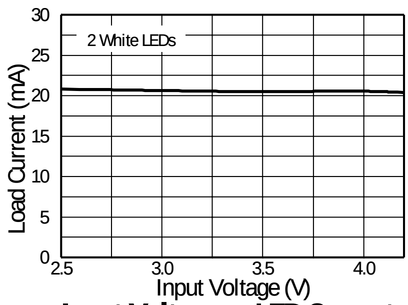
REFERENCE DESIGNS

Li - Ion to 2 LED converter





Input Voltage vs Efficiency

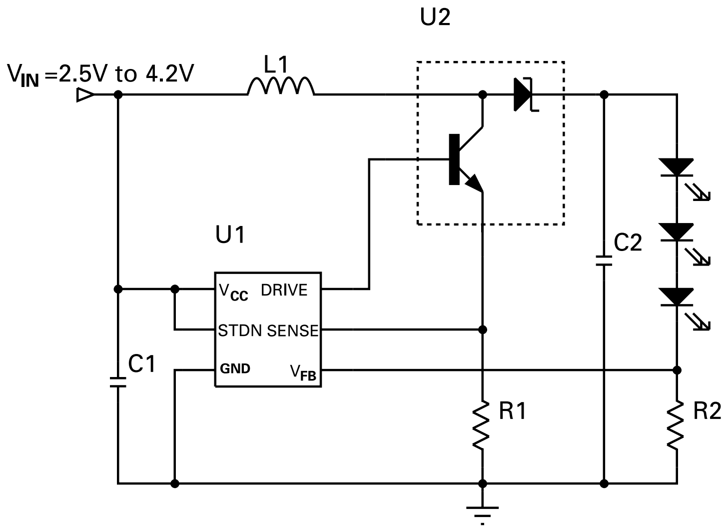


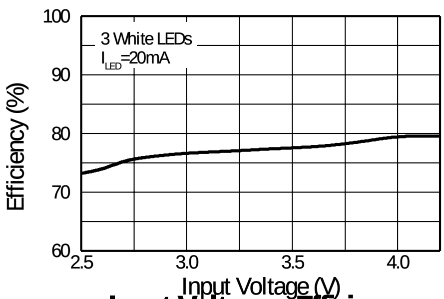
Input Voltage vs LED Current

Bill of Materials

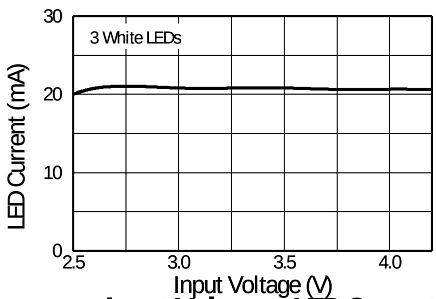
Ref	Value	Part Number	Manufacture	Comments
U1		MBP8700TR	ASIC	LEDdriverIC
U2		MBP8700TRM832	ASIC	NPN+Schottkydual
L1	10µH	CMD4D11-100MC	Sumida	1mm height profile
R1	100mΩ	LR1206 / RL1220	IRC / Cyntec	1206 / 0805 size
R2	15Ω	Generic	Generic	0603 size
C1	2.2µF/6V3	GRM Series	Murata	0805 size
C2	2.2µF/16V	GRM Series	Murata	1206 size
LED		NSCW215	Nichia	White SMT LED

Li - Ion to 3 LED converter





Input Voltage v Efficiency



Input Voltage v LED Current

Bill of Materials

Ref	Value	Part Number	Manufacture	Comments
U1		MBP8700TR	etexLEDdriverIC	
U2		MBP8700TRM832	ASIC	NPN+Schottkydual
L1	10µH	CMD4D11-100MC	Sumida	1mm height profile
R1	68mΩ	LR1206 / RL1220	IRC / Cyntec	1206 / 0805 size
R2	15Ω	Generic	Generic	0603 size
C1	2.2µF/6V3	GRM Series	Murata	0805 size
C2	2.2µF/16V	GRM Series	Murata	1206 size
LED		NSCW215	Nichia	White SMT LED

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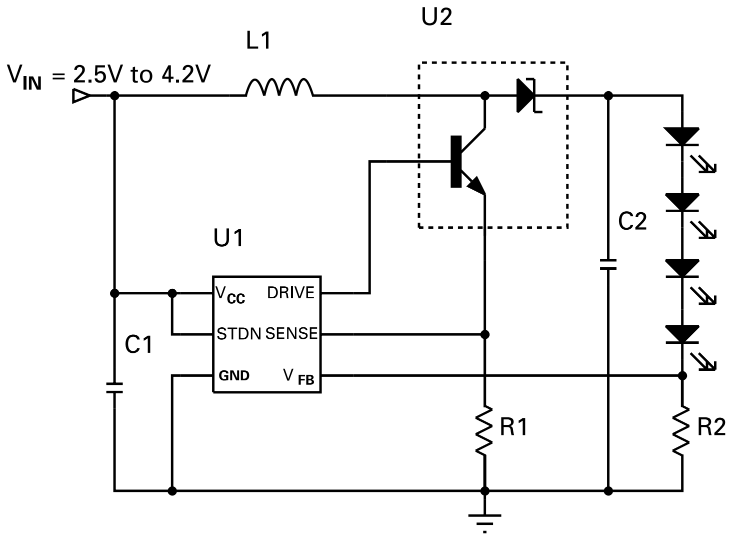
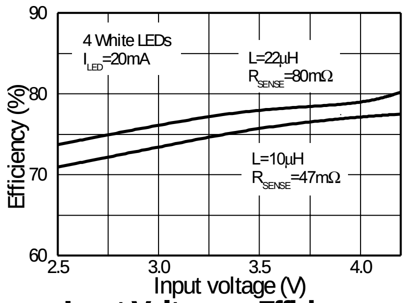
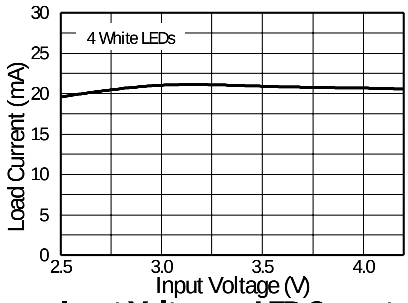
Li - Ion to 4 LED converter





Input Voltage vs Efficiency

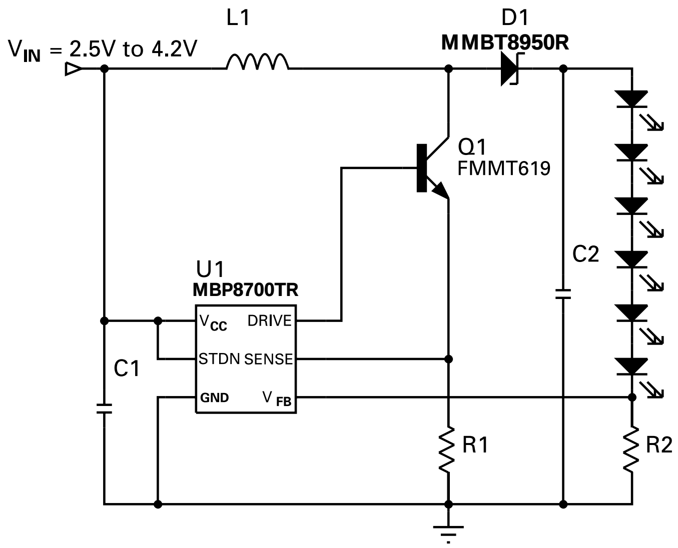


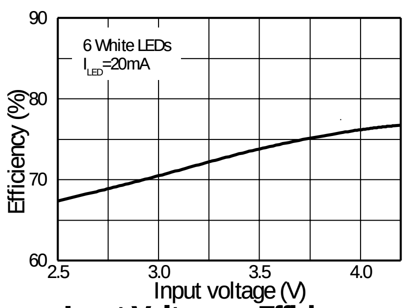
Input Voltage vs LED Current

Bill of Materials

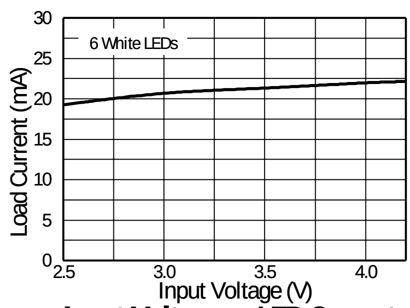
Ref	Value	Part Number	Manufacture	Comments
U1		MBP8700TR	ASIC	LEDdriverIC
U2		MBP8700TRM832	ASIC	NPN+Schottkydual
L1	10µH	CMD4D11-100MC	Sumida	1mm height profile
R1	47mΩ	LR1206 / RL1220	IRC / Cyntec	1206 / 0805 size
R2	15Ω	Generic	Generic	0603 size
C1	2.2µF/6V3	GRM Series	Murata	0805 size
C2	2.2µF/16V	GRM Series	Murata	1206 size
LED		NSCW215	Nichia	White SMT LED

Li - Ion to 6 LED converter





Input Voltage vs Efficiency



Input Voltage vs LED Current

Bill of Materials

Ref	Value	Part Number	Manufacture	Comments
U1		MBP8700	ASIC	LEDdriverIC
Q1		FSST619	ASIC	40VNPN
D1		MBP87001000	ASIC	1ASchottkydiode
L1	22µH	CMD4D11-220MC	Sumida	1mm height profile
R1	47mΩ	LR1206 / RL1220	IRC / Cyntec	1206 / 0805 size
R2	15Ω	Generic	Generic	0603 size
C1	2.2µF/6V3	GRM Series	Murata	0805 size
C2	2.2µF/25V	GRM Series	Murata	1206 size
LED		NSCW215	Nichia	White SMT LED

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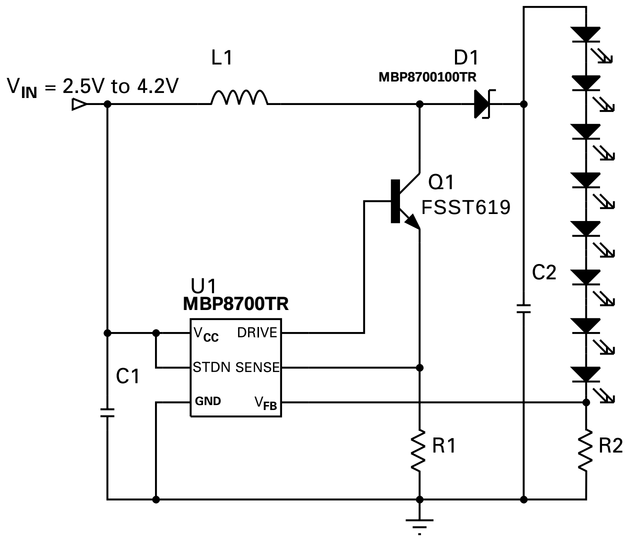
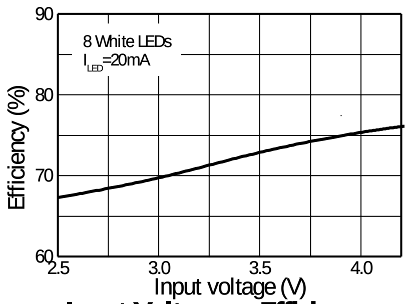
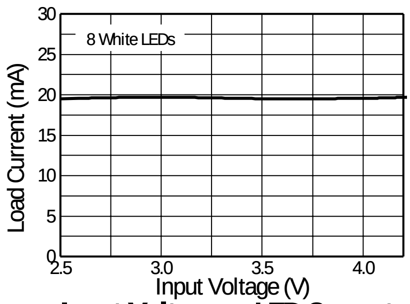
Li - Ion to 8 LED converter





Input Voltage vs Efficiency



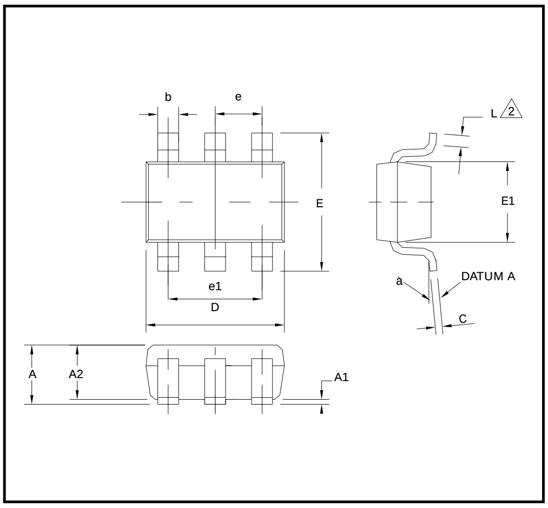
Input Voltage vs LED Current

Bill of Materials

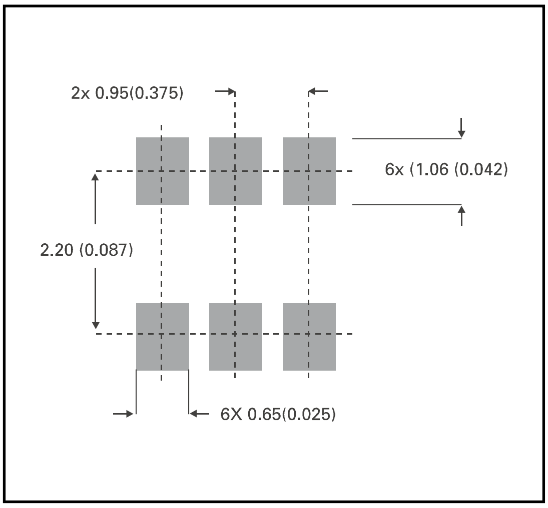
Ref	Value	Part Number	Manufacture	Comments
U1		MBP8700TR	ASIC	LEDdriverIC
Q1		FSST619	ASIC	40VNPN
D1		TFM000	ASIC	1ASchottkydiode
L1 or	22µH	CDRH4D28-220 D01608C-223	Sumida Coilcraft	0.7A, 0.235Ω 0.7A, 0.37Ω
R1	33mΩ	LR1206 / RL1220	IRC / Cyntec	1206 / 0805 size
R2	15Ω	Generic	Generic	0603 size
C1	2.2µF/6V3	GRM Series	Murata	0805 size
C2	2.2µF/35V	GRM Series	Murata	1206 size
LED		NSCW215	Nichia	White SMT LED

MBP8700TR

PACKAGE OUTLINE



PAD LAYOUT DETAILS



CONTROLLING DIMENSIONS IN MILLIMETRES APPROX CONVERSIONS INCHES.

PACKAGE DIMENSIONS

DIM	Millimetres		Inches		DIM	Millimetres		Inches	
	Min	Max	Min	Max		Min	Max	Min	Max
A	0.90	1.45	0.35	0.057	E	2.60	3.00	0.102	0.118
A1	0.00	0.15	0	0.006	E1	1.50	1.75	0.059	0.069
A2	0.90	1.30	0.035	0.051	L	0.10	0.60	0.004	0.002
b	0.35	0.50	0.014	0.019	e	0.95 REF		0.037 REF	
C	0.09	0.20	0.0035	0.008	e1	1.90 REF		0.074 REF	
D	2.80	3.00	0.110	0.118	L	0°	10°	0°	10°