Miniature LED Driver

PRODUCTION DATA SHEET

DESCRIPTION

The LX1995 is a small sized step-up boost converter available in a Tiny TSOT-5 package suitable for driving adjustable boost topologies, which include drivers for white or color LEDs in portable devices. The LX1995 switches at rates up to 2 MHz to allow the use of extremely small inductor and filter capacitor. The LX1995 is available in two versions, 1 and 2, capable of driving 6 or 10 white LEDs, respectively.

Designed for maximum efficiency over a wide output power range, the LX1995 is ideal for displays with day and night usage. The LX1995 features a pseudo-hysteretic pulse frequency modulation that promotes improved performance in battery-operated systems by operating with a quiescent supply current <70µA (typical) and a shutdown current of less than 1µA.

The input voltage range is from 1.6V to 5.5V thus allowing for a broad selection of battery voltage applications and start-up is guaranteed at 1.6V input.

The output current is readily programmed using one external current sense resistor in series with the LEDs. This configuration provides a feedback signal to the FB pin thus maintaining constant output current regardless of varying input voltage and LED forward voltage (VF). Dimming may be accomplished by PWM modulating the shutdown input; the fast response time and stability of the PFM modulation circuit allows PWM dimming to low duty cycles.

The LX1995 is available in the 5-Pin TSOT and thus requires a very small PCB area.

IMPORTANT: For the most current data, consult *MICROSEMI*'s website: http://www.microsemi.com

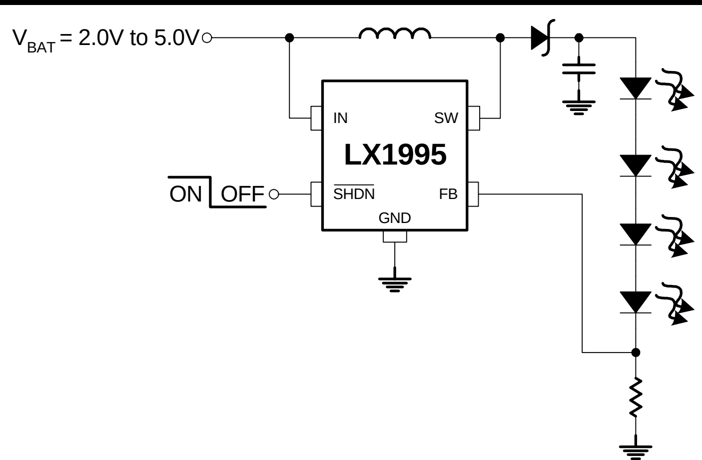
KEY FEATURES

- Tiny 5-Pin TSOT Package
- Smallest External Components
- Efficient even at low current levels
- Logic Controlled Shutdown
- < 1µA Shutdown Current
- > 85% Maximum Efficiency
- 70µA Typical Quiescent Supply Current

APPLICATIONS

- Pagers
- Wireless Phones
- PDAs
- Handheld Computers
- LED Driver
- Digital Camera Displays
- GPS Receivers

PRODUCT HIGHLIGHT



PACKAGE ORDER INFO

T_A (°C)	Switch Current	SG Plastic TSOT 5-Pin	SE Plastic SOT-23 5-Pin
-40 to 85	325mA	LX1995-1-CSG	LX1995-1-CSE
-40 to 85	500mA	LX1995-2-CSG	LX1995-2-CSE

Note: Available in Tape & Reel.
Append the letter "T" to the part number. (i.e. LX1995-CSGT)

WWW.Microsemi.COM

LX1995

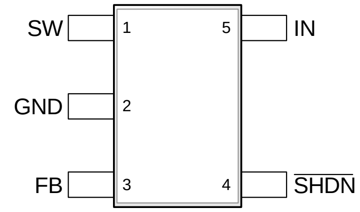
Microsemi
Integrated Products Division
11861 Western Avenue, Garden Grove, CA. 92841, 714-898-8121, Fax: 714-893-2570

ABSOLUTE MAXIMUM RATINGS

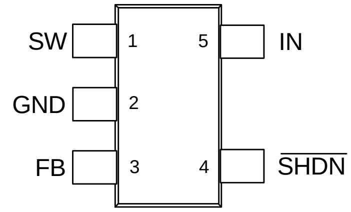
Supply Input Voltage .... -0.3V to 7.0V
Feedback Peak Pulse Input Voltage (V_{FB}) .... -0.3V to 16V
Shutdown Input Voltage ($V_{\overline{SHDN}}$) .... -0.3V to V_{IN} + 0.3V
Switch Voltage (V_{SW}) .... -0.3V to 30V
Switch Current (I_{SW}) 500mA
Operating Temperature Range .... -40°C to 85°C
Maximum Operating Junction Temperature .... 125°C
Storage Temperature Range .... -65°C to 150°C
Lead Temperature (Soldering 10 seconds) .... 235°C

Note: Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of specified terminal.

PACKAGE PIN OUT



SG PACKAGE
(Top View)



SE PACKAGE
(Top View)

THERMAL DATA

SG **Plastic TSOT 5-Pin**

THERMAL RESISTANCE-JUNCTION TO AMBIENT, θ_{JA}	**207°C/W**

SE **Plastic SOT-23 5-Pin**

THERMAL RESISTANCE-JUNCTION TO AMBIENT, θ_{JA}	**191°C/W**

Junction Temperature Calculation: $T_J = T_A + (P_D \times \theta_{JA})$.
The θ_{JA} numbers are guidelines for the thermal performance of the device/pc-board system. All of the above assume no ambient airflow.

FUNCTIONAL PIN DESCRIPTION

Name	Description
SW	Inductor Switching Connection – Internally connected to the drain of a 28V N-channel MOSFET. SW is high impedance in shutdown.
GND	Common terminal for ground reference.
FB	Feedback Input – Connect to a current sense resistor between the load and GND to set the maximum output current. FB pin is regulated to 320mV.
$\overline{SHDN}$	Active-Low Shutdown Input – A logic low shuts down the device and reduces the supply current to <1µA. Connect $\overline{SHDN}$ to V_{CC} for normal operation.
IN	Unregulated IC Supply Voltage Input – Input range from +2.0V to +5.5V. Bypass with a 1µF or greater capacitor for low voltage operation.

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PACKAGE DATA

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ELECTRICAL CHARACTERISTICS

Unless otherwise specified, the following specifications apply over the operating ambient[1] temperature 0°C ≤ T_A ≤ 70°C except where otherwise noted and the following test conditions: V_{IN} = 3V, $V_{\overline{SHDN}}$ = V_{IN}. Unless where indicated, these parameters apply to both the LX1995-1 and LX1995-2 part versions.

Parameter	Symbol	Test Conditions	LX1995 Min	LX1995 Typ	LX1995 Max	Units
Operating Voltage	V_{IN}		1.6		5.5	V
Minimum Start-up Voltage	V_{SU}	T_A = +25°C			1.6	V
Start-up Voltage Temperature Coefficient	k_{VST}	Guaranteed; not tested		-2		mV/°C
Quiescent Current	I_Q	Not switching		70	100	µA
		$V_{\overline{SHDN}}$ < 0.4V		0.2	0.5	
FB Threshold Voltage	$V_{FB(TH)}$		288	320	352	mV
FB Input Bias Current	I_{FB}	Not Switching, V_{FB} = 400mV	-10		10	nA
Shutdown Input Bias Current	$I_{\overline{SHDN}}$	$V_{\overline{SHDN}}$ = 0V	-100		100	nA
Shutdown Low Input Voltage	$V_{\overline{SHDN}}$				0.6	V
Shutdown High Input Voltage			1.4			
Switch Peak Current	I_{PEAK}	L= 47µH; LX1995-1	250	325	400	mA
Switch Peak Current	I_{PEAK}	L= 47µH; LX1995-2	400	500	600	mA
Minimum Switch Off-Time	t_{OFF}	T_A = +25°C; V_{FB} < $V_{FB(TH)}$		300		ns
Switch Pin Leakage Current	I_{LEAK}	V_{SW} = 28V		0.23		µA

Note:
1. Low duty cycle pulse testing techniques are used which maintains junction and case temperatures equal to the ambient temperature.
2. Functionality over the -40°C to +85°C operating temperature range is assured by design, characterization, and correlation.

SIMPLIFIED BLOCK DIAGRAM

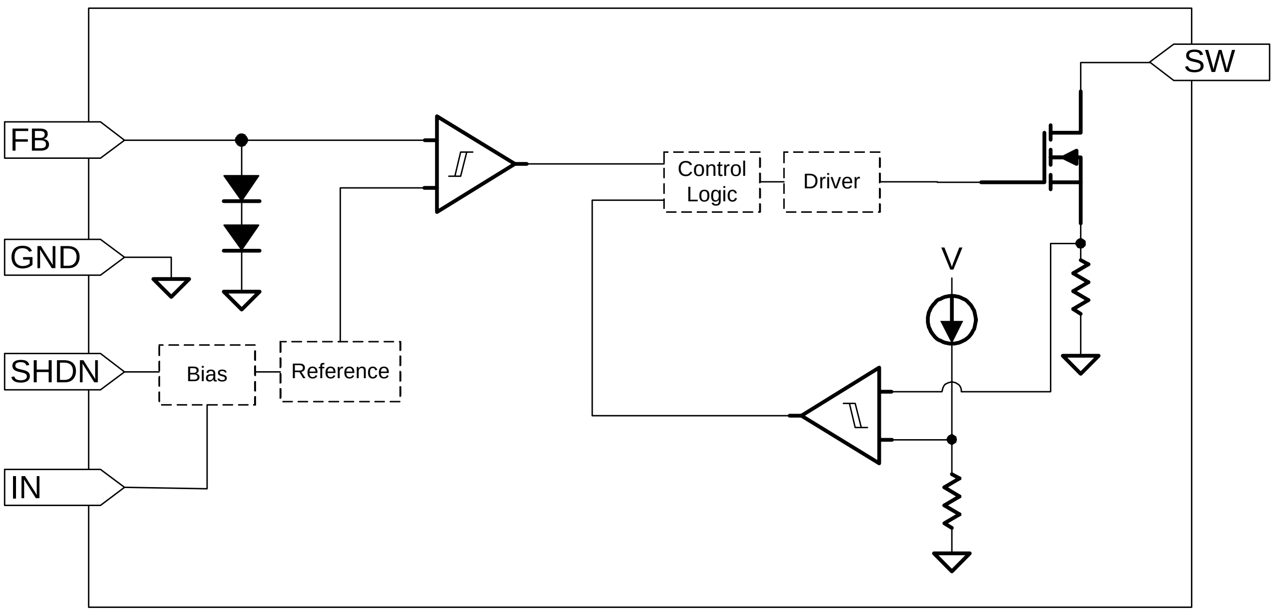


Figure 1 – Simplified Block Diagram

APPLICATION CIRCUITS

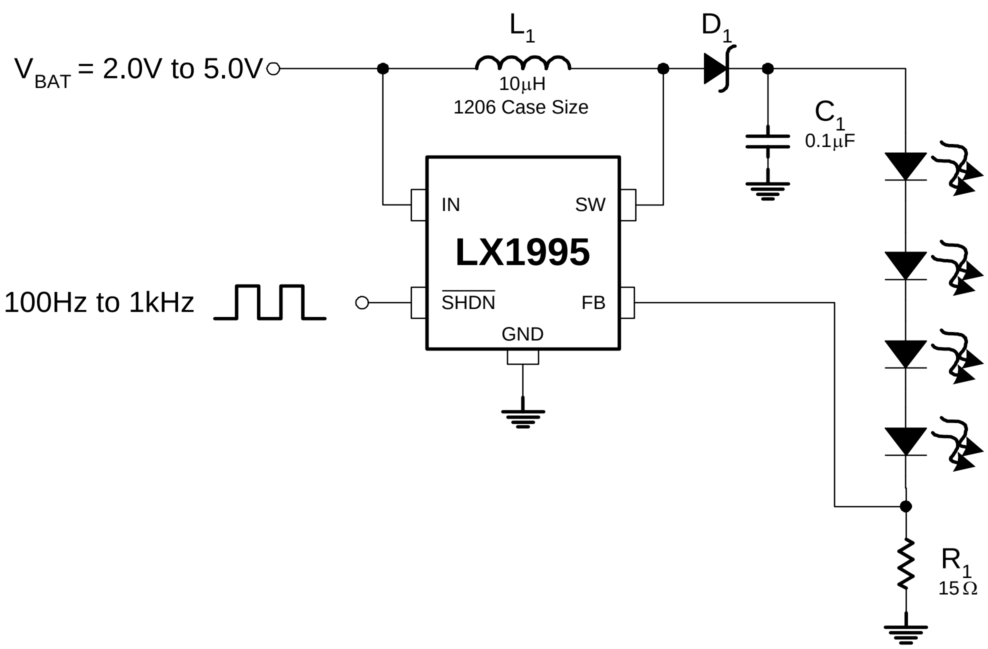


Figure 2 – Typical Bust Mode Dimming LED Driver Application

APPLICATION CIRCUITS

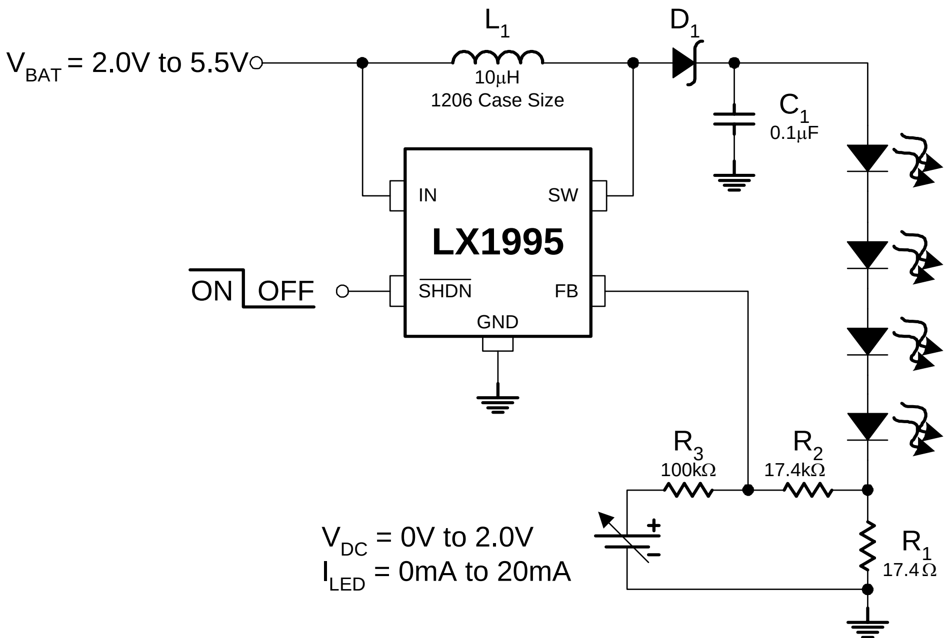


Figure 3 – Analog Voltage Dimming LED Driver Application

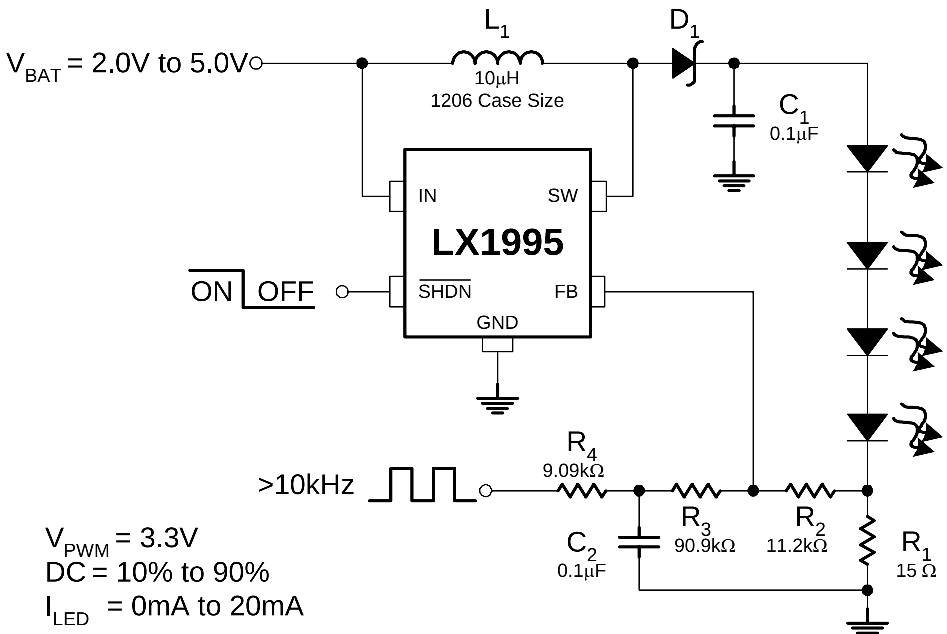
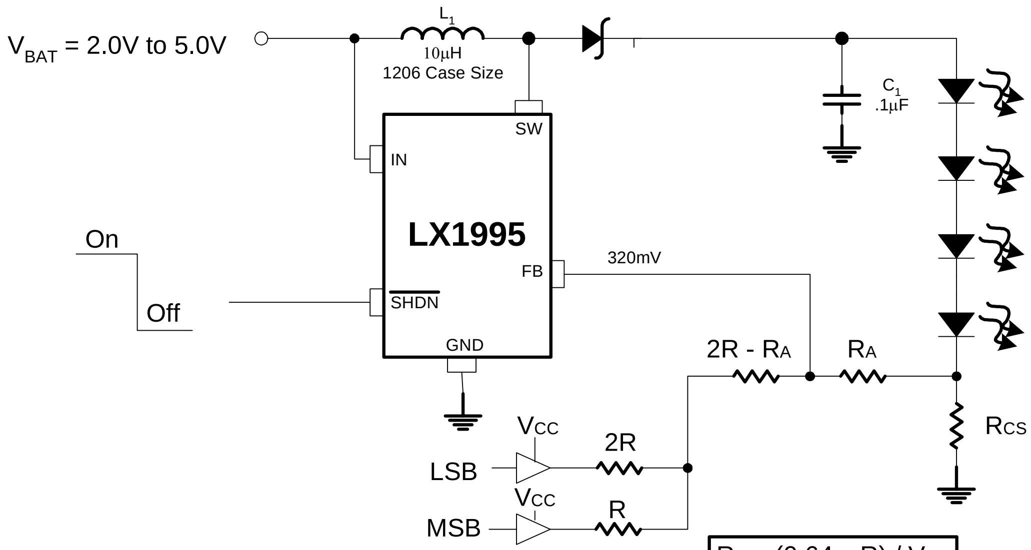


Figure 4 – PWM to Analog Voltage Dimming LED Driver Application

The component values shown are only examples for a working system. Actual values will vary greatly depending on desired parameters, efficiency, and layout constraints.

APPLICATION CIRCUITS



$R_A = (0.64 \times R) / V_{CC}$

$R_{CS} = (0.32 \times R) / \{[R - (0.375 \times R_A)] \times I_{MAX}\}$

MSB	LSB	I_{LED}
1	1	$0.25 \times I_{MAX}$
1	0	$0.50 \times I_{MAX}$
0	1	$0.75 \times I_{MAX}$
0	0	I_{MAX}

Figure 5 – Binary Dimming LED Driver Application

The component values shown are only examples for a working system. Actual values will vary greatly depending on desired parameters, efficiency, and layout constraints

THEORY OF OPERATION

OPERATING THEORY

The LX1995 is a PFM boost converter that is optimized for driving a string of series connected LEDs. It operates in a pseudo-hysteretic mode with a fixed switch "off time" of 300ns. Converter switching is enabled as LED current decreases causing the voltage at the FB pin to decrease to a value less than 320mV; this causes the feedback comparator (See Simplified Block Diagram) to activate the control logic. The control logic activates the DRV output circuit that connects to the gate of the internal N-Channel MOSFET. The switch output (SW) is switched "on" (and remains "on") until the inductor current ramps up to the peak current level (typically 325mA for LX1995-1).

The LED load is powered from energy stored in the output capacitor during the inductor charging cycle. Once the peak inductor current value is achieved, the output is turned off (off-time is typically 300ns) allowing a portion of the energy stored in the inductor to be delivered to the load. This causes the voltage to rise across the current setting resistor (R_1) at the input to the feedback circuit. The LX1995 continues to switch until the voltage at the FB pin exceeds 320mV. The value of R_1 is established by dividing 320mV by the maximum series LED current. A minimum value of 3.3Ω is recommended for R_{SET}. The voltage at the FB pin is the product of the LED current (I_{LED}) and R_1.

$$R_1 = \frac{320mV}{I_{LED(MAX)}} \qquad \text{eq. 1}$$

DIMMING METHODS

The designer can select one of two possible dimming methods. The first option is to connect a PWM logic signal to the SHDN pin (See Figure 1). This turns the LX1995 on and off which pulses the LED current between zero and the setting determined by R_1; the human eye averages the pulsed current if the PWM frequency is greater than 60Hz. This option may not be ideal as short wavelength LEDs become less efficient when the forward current is pulsed.

The second option is to apply a varying DC voltage to a voltage divider at the FB pin such that as the DC voltage increases, the LED current decreases. The equation (see Figure 3) is:

$$I_{LED} = \frac{1}{R_1}\left[320mV\cdot\left(\frac{R_2+R_3}{R_3}\right) - V_{ADJ}\cdot\left(\frac{R_2}{R_3}\right)\right] \qquad \text{eq. 2}$$

INDUCTOR SELECTION AND OUTPUT CURRENT LIMIT PROGRAMMING

The designer is encouraged to use inductors (for LX1995-1) that will not saturate at the peak inductor current level of 400mA. Larger inductor values will extend the power range of the converter slightly by increasing the average inductor current. Smaller inductor values will reduce output voltage ripple and are smaller in size. A range of 10uH to 47uH is recommended.

OUTPUT RIPPLE AND CAPACITOR SELECTION

Output voltage ripple is a function of the inductor value (L), output capacitor value (C_{OUT}), peak switch current (I_{PEAK}), load current (I_{OUT}), input voltage (V_{IN}) and the output voltage (V_{OUT}). When the switch is first turned on, the peak-to-peak voltage ripple is a function of the output droop (as the inductor current charges to I_{PEAK}), the feedback transition error (i.e., typically 10mV), and the output overshoot (when the stored energy in the inductor is delivered to the load at the end of the charging cycle). Therefore the total ripple voltage is:

$$V_{RIPPLE} = \Delta V_{DROOP} + \Delta V_{OVERSHOOT} + 10mV \qquad \text{eq. 3}$$

The initial droop can be estimated as follows where the 0.5V value in the denominator is an estimate of the voltage drop across the inductor and the FET RDS_ON:

$$\Delta V_{DROOP} = \frac{\left(\frac{L}{C_{OUT}}\right)\cdot\left(I_{PK}\times I_{LED}\right)}{V_{IN}-0.5} \qquad \text{eq. 4}$$

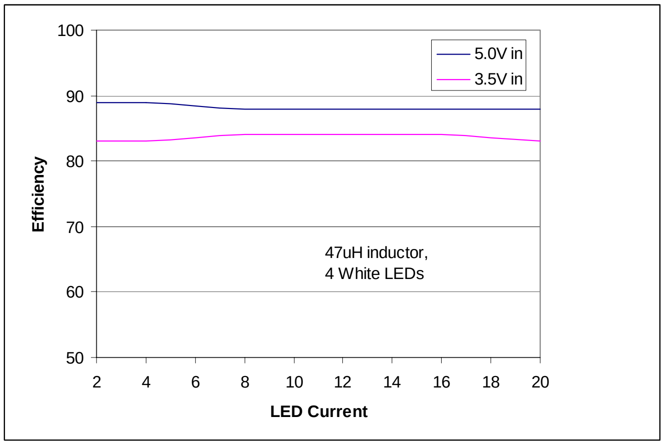
The output overshoot can be estimated as follows where the 0.5 value in the denominator is an estimate of the voltage drop across the diode:

$$\Delta V_{OVERSHOOT} = \frac{\frac{1}{2}\cdot\left(\frac{L}{C_{OUT}}\right)\cdot\left(I_{PK}-I_{LED}\right)^2}{V_{OUT}-V_{IN}+0.5} \qquad \text{eq. 5}$$

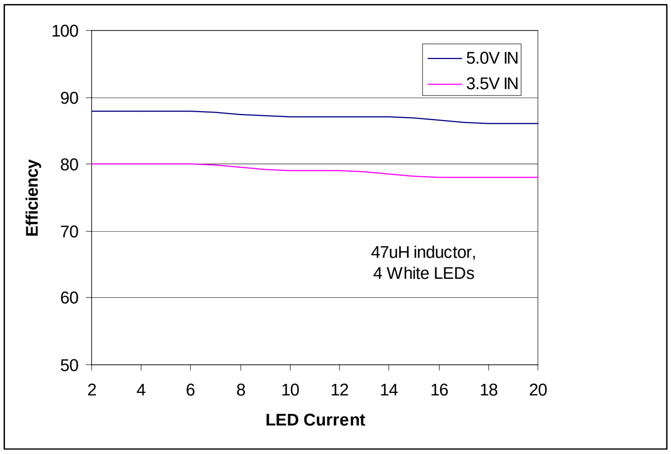
Once the output voltage ripple is determined for the selected components, the output capacitor can then be adjusted to meet the target ripple voltage requirements.

Since the LX1995 is targeted for LED driver applications, output voltage ripple is not a critical application requirement.

LX1995-1 EFFICIENCY

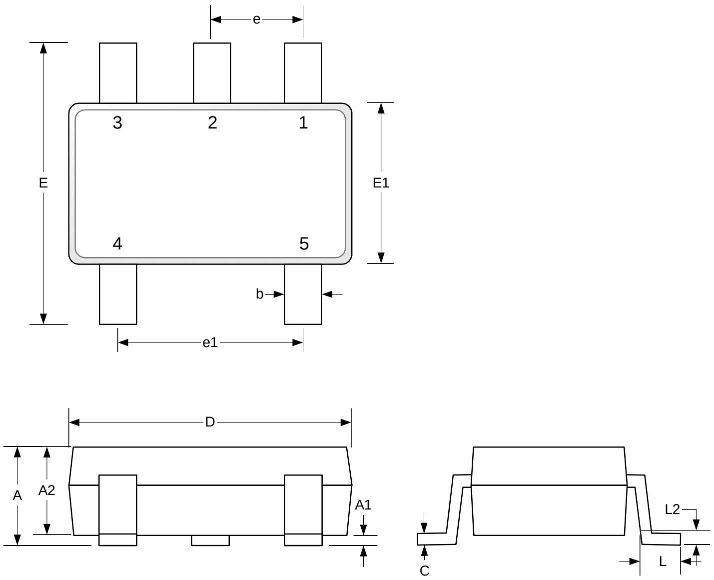


LX1995-2 EFFICIENCY



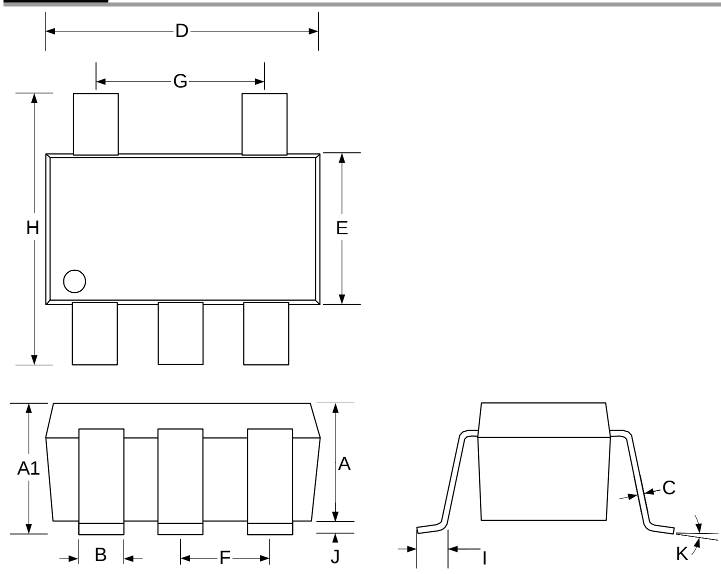
PACKAGE DIMENSIONS

SG 5-Pin Thin Shrink Small Outline Package (TSOT)



Dim	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	-	1.00	-	0.039
A1	0.01	0.10	0.0004	0.004
A2	0.84	0.90	0.033	0.035
b	0.30	0.45	0.012	0.018
C	0.12	0.20	0.005	0.008
D	2.90 BSC		0.114 BSC	
E	2.80 BSC		0.110 BSC	
E1	1.60 BSC		0.063 BSC	
e	0.95 BSC		0.037 BSC	
L	0.30	0.40	0.012	0.016
L2	0.25 BSC		0.010 BSC	

SE 5-Pin Small Outline Package (SOT-23)



Dim	MILLIMETERS MIN	MILLIMETERS MAX	INCHES MIN	INCHES MAX
A	0.90	1.30	0.035	0.051
A1	0.90	1.45	0.035	0.057
B	0.25	0.50	0.010	0.020
C	0.09	0.20	0.004	0.008
D	2.80	3.10	0.110	0.122
E	1.50	1.75	0.059	0.069
F	0.95 BSC		0.038 BSC	
G	1.90 BSC		0.075 BSC	
H	2.60	3.00	0.102	0.118
I	0.35	0.55	0.014	0.022
J	0.00	0.15	0.000	0.006
K	10° MAX		10° MAX	

Note: Dimensions do not include mold flash or protrusions; these shall not exceed 0.155mm(.006") on any side. Lead dimension shall not include solder coverage.

NOTES