DESCRIPTION

The Microsemi LX1995-x is a miniature LED driver with integrated drivers. It is designed to drive white or color LEDs in portable display applications. The LX1995-x is an adjustable step-up boost converter. The LX1995-x can switch up to 2MHz allowing designers to use a low cost, small inductor and filter capacitor.

The driver supports a wide input voltage range (1.6V to 5.5V) with efficiency greater than 85% and can start up at 1.6V input. The LX1995-x is a low cost, high efficiency LED driver. The design is based on a pseudo-hysteretic pulse frequency modulation topology. In portable battery applications the LX1995-x offers high system efficiency with low quiescent current: in operation I_Q is < 70µA and in standby I_Q is < 1µA.

The LX1995-x output current is programmable using an external current sense resistor in series with LEDs. This configuration provides a feedback to the FB pin which maintains constant output current independent of input voltage and LED forward voltage (VF). LED dimming is accomplished using a PWM signal or varying DC voltage methods.

The LX1995-x is available in the 5-Pin TSOT and SOT-23 package. The LX1995-1 can drive up to 6 LEDs (switching current is 325mA). The LX1995-2 can drive up to 10 LEDs (switching current is 500mA).

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

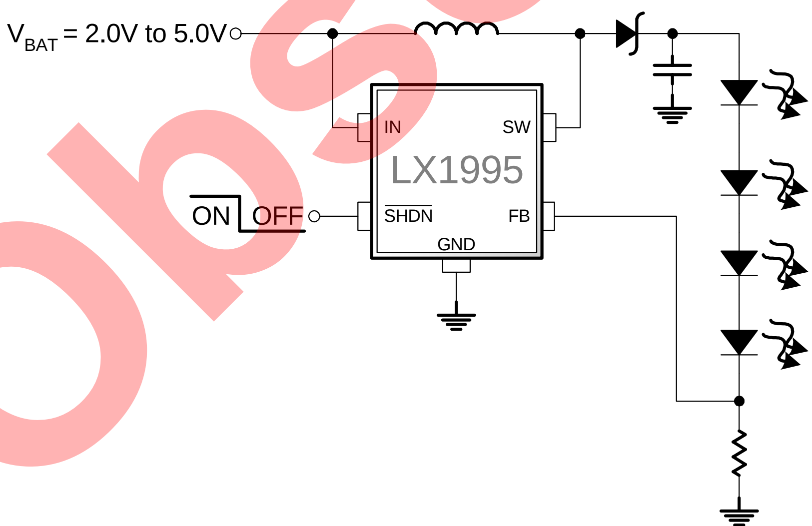
KEY FEATURES

- < 1µA Shutdown Current
- > 85% Maximum Efficiency
- Efficient at Low Current Levels
- < 70µA Quiescent Supply Current in Operating Mode
- V_{IN} Range 1.6V to 5.5V
- Logic Controlled Shutdown
- Dimming Options: PWM or Varying DC Voltage
- Tiny 5-Pin TSOT Package
- Smallest External Components

APPLICATIONS

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

PRODUCT HIGHLIGHT



PACKAGE ORDER INFO

T_A (°C)	Switch Current	SG Plastic TSOT 5-Pin RoHS Compliant / Pb-free	SE Plastic SOT-23 5-Pin RoHS Compliant / Pb-free Transition DC: 0503
-40 to 85	325mA	**LX1995-1CSG**	**LX1995-1CSE**
-40 to 85	500mA	**LX1995-2CSG**	**LX1995-2CSE**

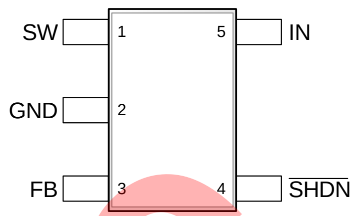
Note: Available in Tape & Reel. Append the letters "TR" to the part number. (i.e. LX1995-1CSG-TR)

ABSOLUTE MAXIMUM RATINGS

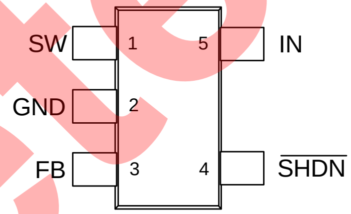
Supply Input Voltage .... -0.3V to 7.0V
Feedback Peak Pulse Input Voltage (V_{FB}) .... -0.3V to V_{IN} + 0.3V
Shutdown Input Voltage ($V_{\overline{SHDN}}$) .... -0.3V to V_{IN} + 0.3V
Switch Voltage (V_{SW}) .... -0.3V to 30V
Switch Current (I_{SW}) 500mA
Operating Temperature Range .... -40°C to 85°C
Maximum Operating Junction Temperature .... 125°C
Storage Temperature Range .... -65°C to 150°C
Peak Package Solder Reflow Temp. (40 second max. exposure) ... 260°C (+0, -5)

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)

RoHS / Pb-free 100% Matte Tin Lead Finish

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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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-x			Units
			Min	Typ	Max	
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

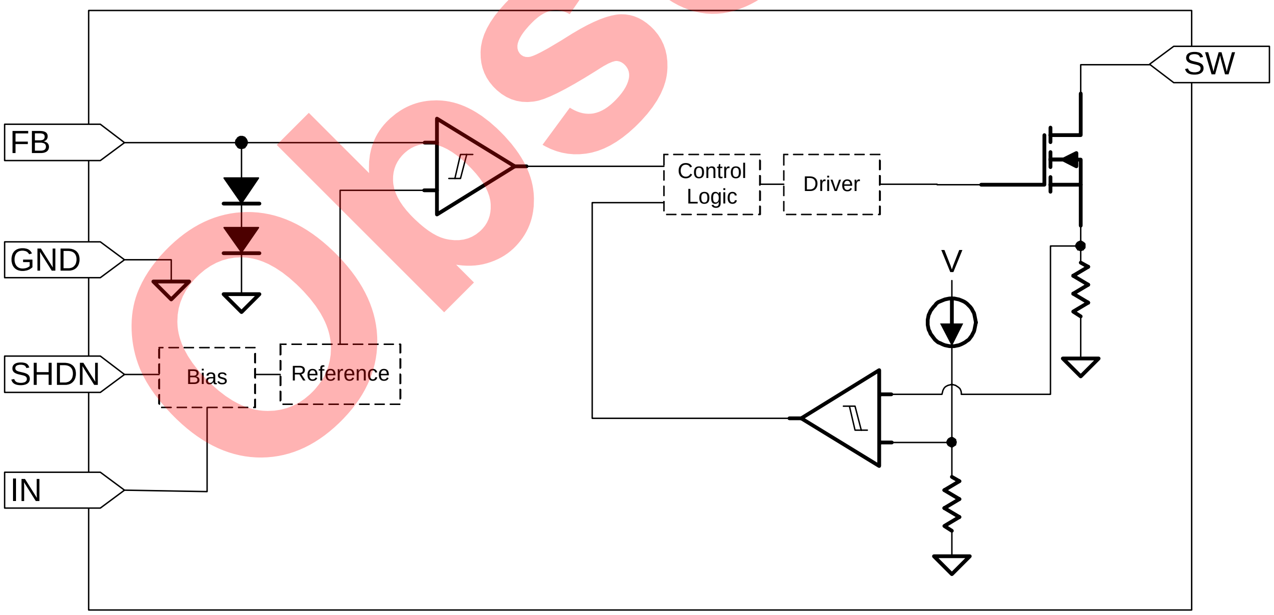


Figure 1 – Simplified Block Diagram

APPLICATION CIRCUITS

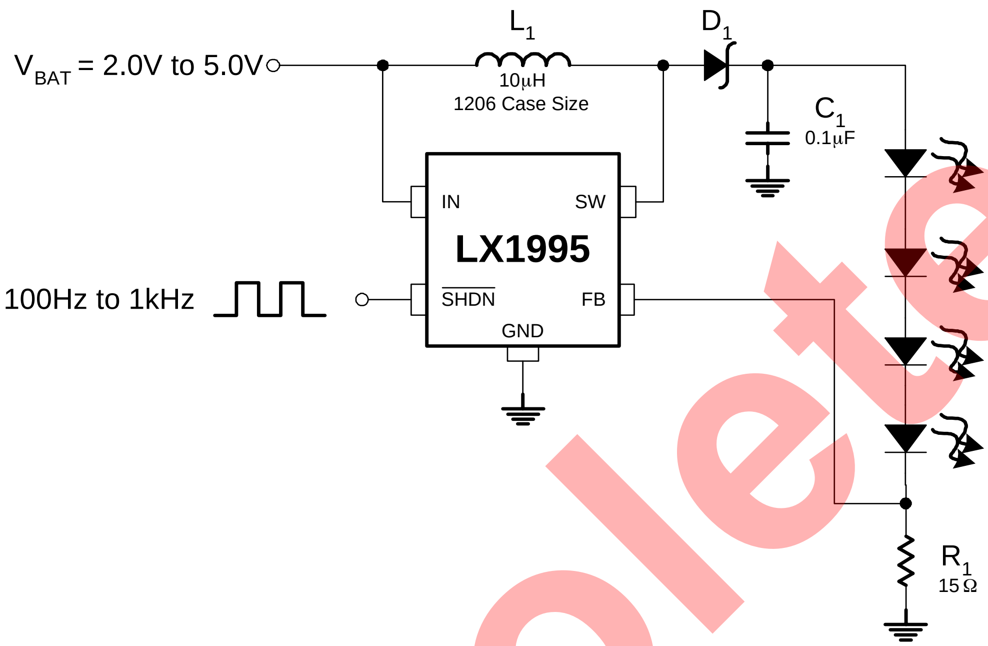


Figure 2 – Typical Bust Mode Dimming LED Driver Application

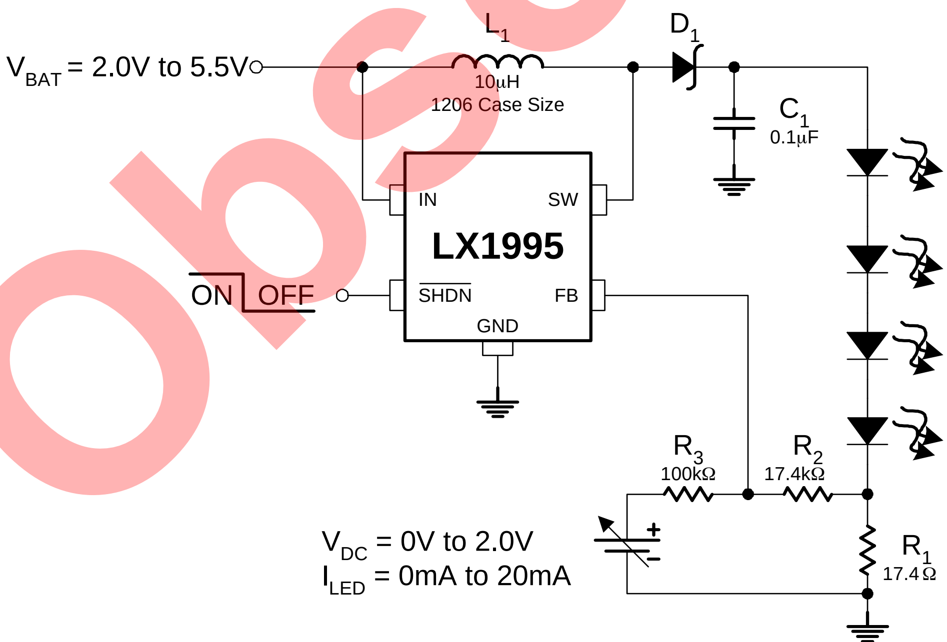


Figure 3 – Analog Voltage Dimming LED Driver Application

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

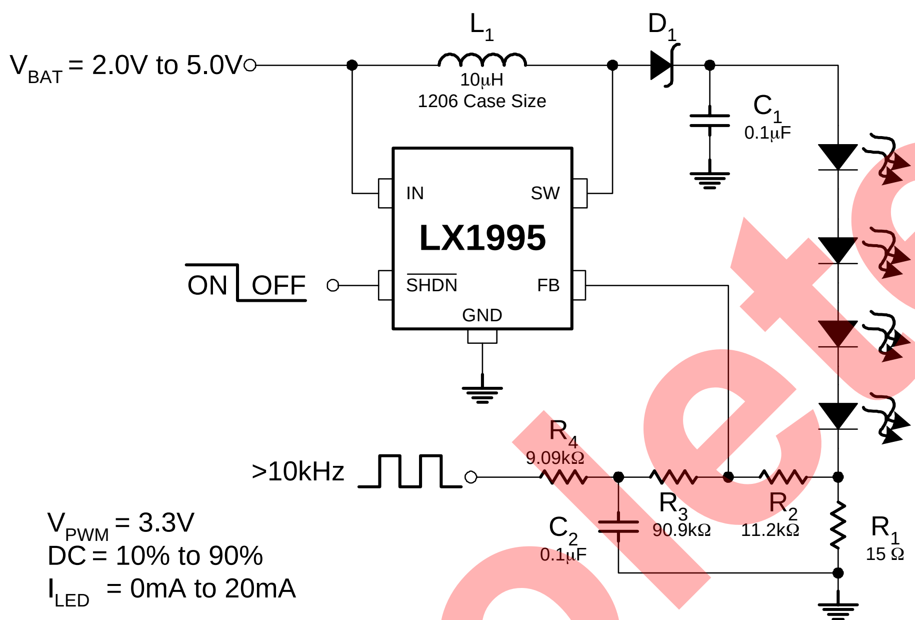
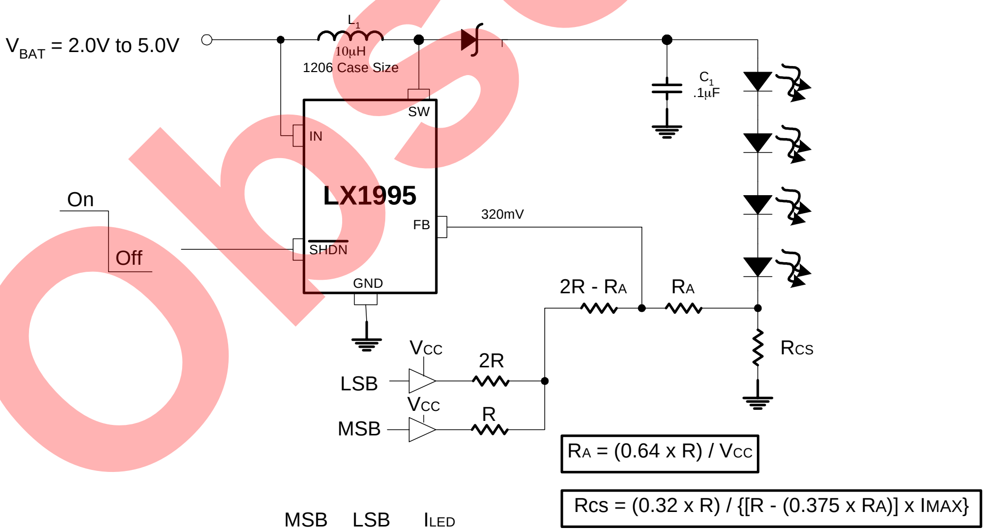


Figure 4 – PWM to Analog Voltage Dimming LED Driver Application



MSB	LSB	ILED
1	1	0.25 x IMAX
1	0	0.50 x IMAX
0	1	0.75 x IMAX
0	0	IMAX

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-x is a PFM boost converter optimized for driving a series of white or color LEDs. It operates in a pseudo-hysteretic mode with a fixed, 300ns, switch "off time". When the LX1995-x enables, the LED current decreases causing the FB voltage to decrease to a value less than 320mV. The feedback comparator (See Simplified Block Diagram) activates the control logic. The control logic turns on the DRV output circuit that connects to the internal N-Channel MOSFET gate. 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 and the energy stored in the inductor delivers 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-x continues to switch until the voltage at the FB pin exceeds 320mV. The value of R_1 is calculated 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.

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

DIMMING METHODS

LX1995-x supports two dimming methods: PWM or DC Voltage.

PWM mode: Connect system PWM logic signal to the SHDN pin (See Figure 1). This turns the LX1995-X on and off which pulses the LED current between zero and the setting determined by R_1.

DC Voltage mode: The designer can apply an adjustable DC voltage supply to the FB pin. As the DC voltage increases, the LED current decreases. The equation (see Figure 3) is:

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

INDUCTOR SELECTION AND OUTPUT CURRENT LIMIT PROGRAMMING

Microsemi recommends the use inductors (for the LX1995-1) in the range of 10µH to 47µH due to saturation of peak inductor current. By increasing the average inductor current, the LX1995-x will extend the power range. Smaller inductor values will reduce output voltage ripple and are smaller in size.

OUTPUT RIPPLE AND CAPACITOR SELECTION

Output voltage ripple is depended on the selection 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}). 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 (energy stored in the inductor). When the switch is first turn on, the total ripple voltage is:

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

The initial droop can be estimated with the assumption of 0.5V of voltage drop across the inductor and FET RDS_{ON}.

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

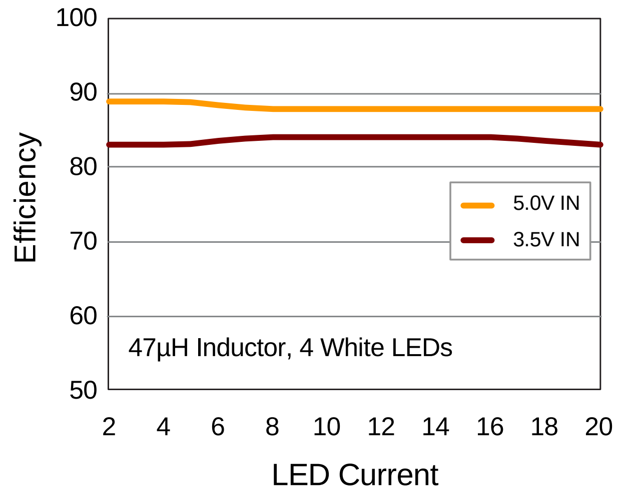
The output overshoot calculated with 0.5V as voltage drop across the diode.

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

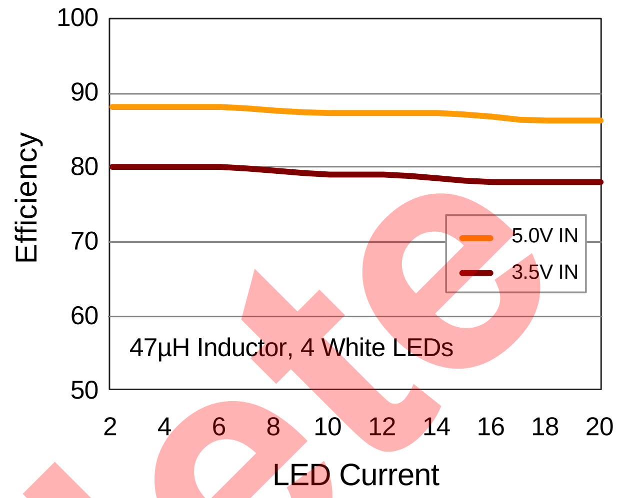
Once the output voltage ripple is determined for the selected components, the output capacitor can then be adjusted to meet the target ripple voltage requirements.

The LX1995-x is targeted for LED driver applications; output voltage ripple is not a critical application requirement.

LX1995-1 EFFICIENCY

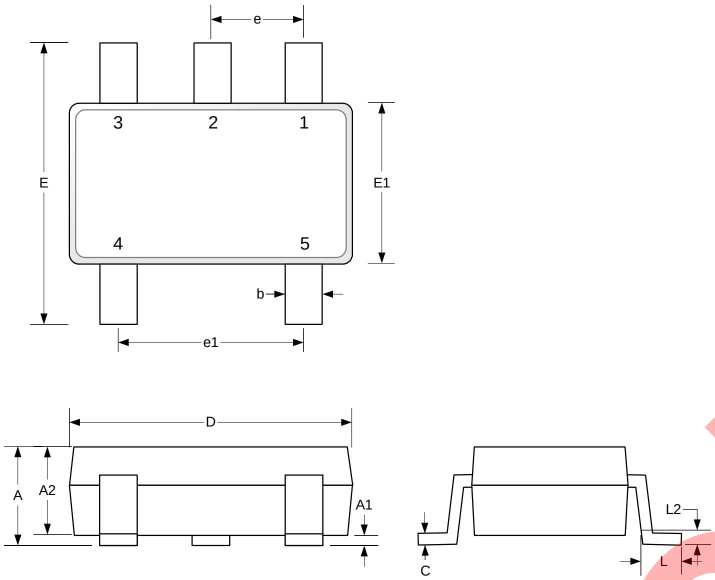


LX1995-2 EFFICIENCY



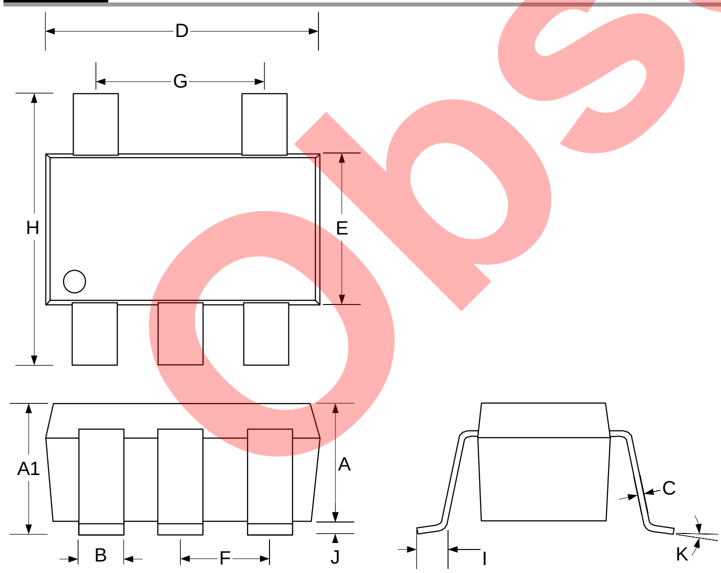
PACKAGE DIMENSIONS

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



Dim	MILLIMETERS		INCHES	
	MIN	MAX	MIN	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		INCHES	
	MIN	MAX	MIN	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