

LX1996

Multi-string LED Back-light Controller

Evaluation Board



Microsemi[®]

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obsolete

Introduction to Product

LX1996 is a compact white LED driver for notebook size displays. It is designed to drive up to six strings of LEDs with a variable DC current. The LX1996 consists of a boost converter and six precision current sources. The evaluation board (EB) contains a LX1996 white LED back light controller, a LX1972 light sensor interface and provides a DC input for analog or internal digital dimming. Customer can select manual DC dimming adjustment or automatic light sensor dimming adjustment for both analog and internal digital dimming modes. In addition, external PWM dimming, combination external PWM with analog dimming, and internal digital dimming with external clock synchronization are also provided.

Features:

Analog input can be selected from either LX1972 or DC input (J4 Input select)

V-Boost out can be used for either internal LED assembly or external LED assembly (J7 LED select)

Jumpers DSEL1 and DSEL2 for all 6 dimming mode options.

All jumpers accessible to perform protection tests: LED open/short, V-boost output open.

Thermistor is included for LED current thermal profile testing or jumpers to select an external thermistor.

Internal 42 or 60 white LED assembly

Operation

The EB has 2 inputs for power and 4 inputs for enable, PWM, and dimming mode selections.

The EB requires an input supply voltage from 6 to 28V between the Vin and GND pins. It can operate in either stand alone mode, or with external PWM input. The dimming modes can be selected by changing the input of DSEL1 and DSEL2 jumpers as shown table1.

Table1

DSEL1	DSEL2	FUNCTIONS
Low	Low	Direct digital dimming mode. The LED current will be turned on/off directly by PWM input signal up to 25kHz. The minimum on time = 4usec.
Low	High	Combination of direct analog input and direct digital input. This option will yield dimming ratios up to 1000:1.
High	Low	Direct analog dimming mode. The amplitude of LED current will be changed proportional with DC input voltage provided by on-board Pot (R10), or LX1972.
High	High	Direct analog dimming mode with Ultra Sonic Noise Reduction (USPS) on. This option will ensure the boost frequency will be out of audio range (> 25kHz).
Open	Low	Analog to digital dimming mode. The internal circuit will convert DC input into PWM output to control the LED current. The internal frequency will be set by an external Rt and Ct
Open	High	Analog to digital dimming mode synchronized with external clock at the PWM signal input. The frequency capture range = 230Hz ± 25%

An external voltage signal or open collector logic can be applied to 4 control inputs:

- Enable signal input at "EN" terminal. If an external enable signal is not available, then the Enable input can be tied to Vin by inserting a jumper on J3 "EN".
- An external PWM signal, with frequency in the range of 100Hz to 25 kHz (minimum pulse width is 4usec) input at "PWM" terminal .
- DSEL1 can be selected by an external 3-level input or through jumper selection at J2.
- DSEL2 can be selected by an external logic input or through jumper selection at J3.

On the LX1996 Evaluation Board, resistor R4 sets the LED current. The relationship of R4 to LED current is:

$$I_{LED} = (V_{PRG}/R_{PRG}) * 50 = (2V/4.99k) * 50 = 20.04mA$$

Where $R_{PRG} = R4 = 4.99K$

In analog dimming mode, the DC signal at TP4 "DI" will drive V_{PRG} from 0.2V to 2V. For "DI" inputs above 2V, V_{PRG} is clamped at 2V. Therefore, the maximum LED current will be 20.04mA in analog dimming mode with $R4 = 4.99K$.

In analog to digital dimming mode, the EB presets the internal dimming frequency to 15 kHz. If desired, the customer can change the internal frequency using the following formula:

$$\text{Frequency} = i/(2*CT*V) \text{ or } F=5e-6/CT$$

Where $i=20\mu A$; CT is the external capacitor value in farad.

There are several jumpers to allow users to perform full functional test without interrupting the input power to verify performance features. The following tables describe Test Point and Jumper functions:

Test points

Test point	Functions
Vin, TP2	Input voltage from 6V to 28V
EN	Enable signal input. Signal low puts system into sleep mode.
DSEL1	Tri-level signal input. See table 1 for more detail.
DSEL2	Signal input. See table1 for more detail
PWM	Multi function PWM input. Input for PWM signal for LED dimming, or external clock input for synchronization of internal digital dimming clock.
TP1	Boost output
TP4	Voltage monitor for on-board adjustable DC used for analog dimming. DC is adjusted by Pot R10
TP5	5V output.
TP7	Triangle waveform signal used to generate internal digital dimming clock.
TP3, TP6, TP8, TP9, TP10	Ground test points to facilitate testing.
CS1A – CS6A	Test points for connecting external LED strings, or for connection of (-) side of DC current meter for measuring LED string current. Also used to measure voltage at LED string's respective current source input.
CS1B – CS6B	Test points for connecting (+) side of DC current meter for measuring LED string current. LED string's associated jumper (J15 – J20) must be removed to make current measurements. Note: remove jumper after connecting DC current meter between CS _x A and CS _x B test points.

Jumpers

Jumper	Functions
J2-DSEL1	Used to select dimming mode when external DSEL1 signal is not used
J1-DSEL2	Used to select dimming mode when external DSEL2 signal is not used
J3-EN	Used to enable system when external enable signal is not used.
J4-DC/ALS	Selects analog input source for analog dimming modes. Selects on-board adjustable DC or LX1972 light sensor as source.
J7-LED select	Used to select either internal or external LED assembly
J8	Selects on-board thermistor for LED temperature compensation. Remove jumper if external or no thermistor used.
J9	External thermistor input. Connect an external thermistor between J9-1 and J9-2. Leave open if not used. Note: Remove jumper J8 if external thermistor is connected to J9.

J10 – J14	Used to short individual LEDs on string #1.
J15 – J20	Used to test open LED string failure and to provide a method of inserting a current meter in series with the individual LED strings for measuring LED string current.
J21	Used for inserting a current probe in series with the boost converter inductor for measuring inductor current.

Jumpers default

(This set up is for analog dimming mode with DC input adjustment provided by POT R10)

Jumper	Position
J2-DSEL1	High
J1-DSEL2	Low
J3-EN	Closed
J4-DC/ALS	DC
J7-LED select	Int.
J8	Closed. The on-board evaluation board thermistor is selected
J9	Open – used for external thermistor connection and should be left open when not used .
J10 – J14	Open
J15 – J20	Closed
J21	Closed

7 LEDs per String Configuration Vs. 10 LEDs per String Configuration

The EB provides an on-board LED assembly, designed to accommodate 42 LEDs (6 strings of 7 LEDs), or 60 LEDs (6 strings of 10 LEDs). Component values for the output filter capacitor, OVP setting resistor, and LED shorting resistors will differ, depending on the configuration. The following table shows the differences:

Component Differences for 7 LEDs per String and 10 LEDs per String Configurations			
Reference Designator	Value for 7 LEDs per String Configuration	Value for 10 Leds per String Configuration	Component Function
R3	78.7k	56.2k	Sets OVP level (based on total V_F of LEDs used). R3 = 78.7k; OVP = 27.4V R3 = 56.2k; OVP = 37.6V
C13	Not Used	4.7uF 50V	Increases total output filter capacitance
R12 – R17	0 Ohm Jumpers	Not Used	Used to bypass 3 LEDs per string
D45 – D62	Not Used	LEDs Installed	Additional LEDs for 10 per string configuration

BOM – 7 LED String Board

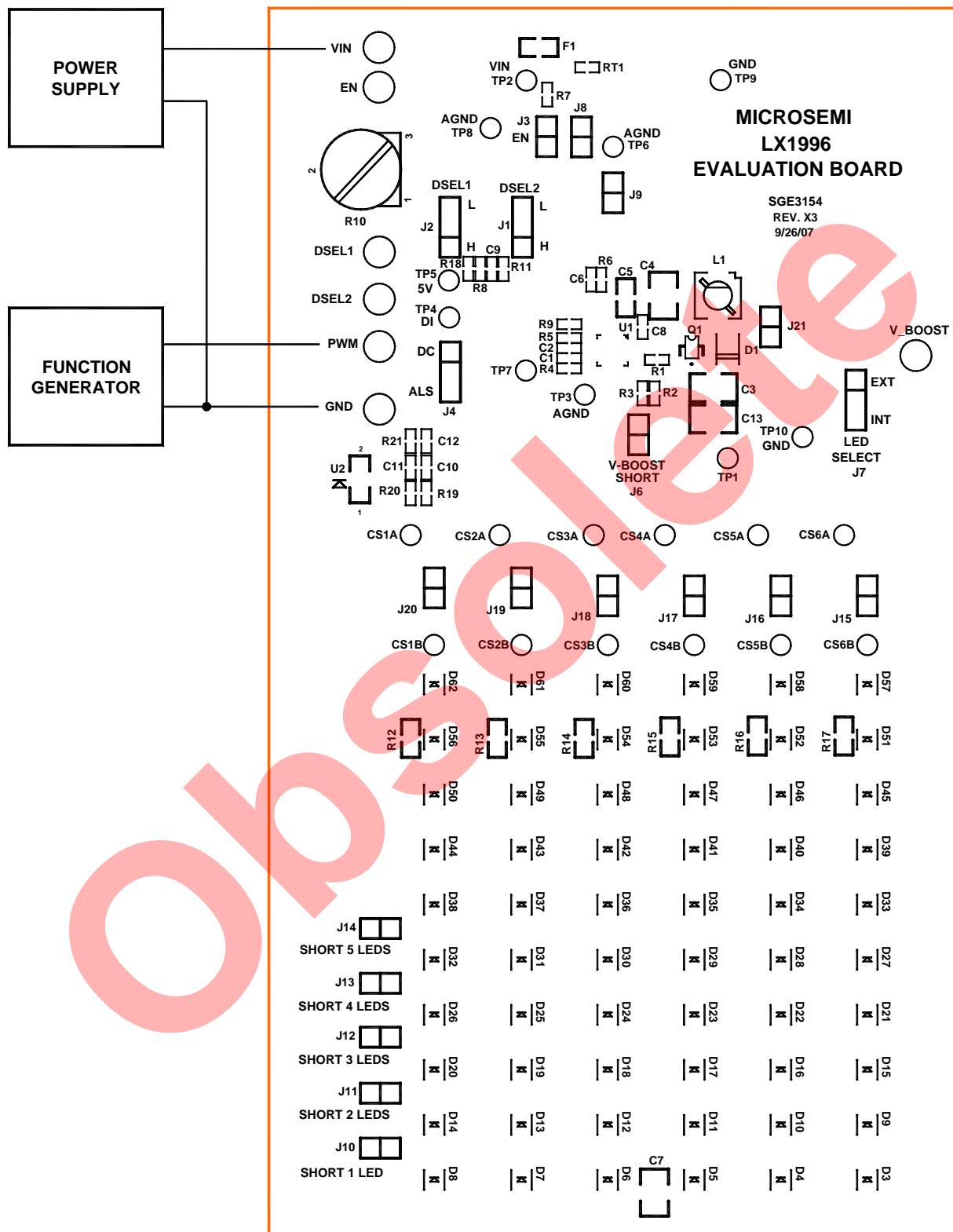
Item Number	Quantity	Part Reference	Description	Manufacturer	Manufacturer Part Number
1	REF		Schematic, LX1996EVAL Evaluation Board	Microsemi	24337 Rev X4
2	1	PCB	Printed Circuit Board, LX1996EVAL Evaluation Board	Microsemi	SGE3154 Rev X3
3	1	U1	LED back light controller, 24 MLPQ, 4 x4 mm ²	Microsemi	LX1996
4	1	U2	Light sensor	Microsemi	LX1972
5	2	C3, C4	Cap ceramic, 4.7uF, 50V, X5R, 1210	Murata	GRM32ER71H475KA88B
6	2	C11, C12	Cap ceramic, 1uF, 6.3V, X7R, 0603	TDK	C1608JB1H105K
7	3	C8, C10, C6	Cap ceramic, 0.1uF, 50V, X7R, 0603	TDK	C1608JB1H104K
8	1	C2	Cap ceramic, 0.022uF, 16V, X7R, 0603	Panasonic	ECJ-1VB1C223K
9	1	C5	Cap ceramic, 4.7uF, 6.3V, X7R, 0603	TDK	C1608JB1E475K
10	1	C1	Cap ceramic, 0.1uF, 16V, X7R, 0603	Panasonic	ECJ-1VB1C104K
11	1	D1	Diode, Schottky, 60V/1A, SMA, 30A<8.3mS	Vishay	B160
12	1	L1	Inductor, power, 6.8uH, >1.5A, DCR=26 - 50mΩ	Toko	A916CY-6R2
12 ALT				TDK	SLF6028-6R8M1R5-PF
13	1	Q1	NFET, 60V/2.8A ,TSOP-6, 130mΩ/Vgs=4.5V	Vishay	Si3458DS
14	1	R1	Resistor, .075 OHM 1/8W 1% 0603, Panasonic	Panasonic	ERJ-2BWJR075X
15	1	R2	Resistor, 1Mohm,1%, 0603, SMD	Panasonic	ERJ-3EKF1004V
16	1	R3	Resistor, 78.7k, 1%, 0603, SMD – Used for 7 LED String Evaluation	Panasonic	ERJ-3EKF7872V
17	1	R4	Resistor, 4.99k, 1%, 0603, SMD	Panasonic	ERJ-3EKF4991V
18	3	R5, R8, R9	Resistor, 100k,1%, 0603, SMD	Panasonic	ERJ-3EKF1003V
19	1	R19	Resistor, 750k, 1%, 0603, SMD	Panasonic	ERJ-3EKF7503V
20	1	R20	Resistor, 40.2k,1%, 0603, SMD	Panasonic	ERJ-3EKF4022V
21	1	R21	Resistor, 499k, 1%, 0603, SMD	Panasonic	ERJ-3EKF4993V

Item Number	Quantity	Part Reference	Description	Manufacturer	Manufacturer Part Number
22	1	R6	Resistor, 22.1k, 1%, 0603, SMD	Panasonic	ERJ-3EKF2212V
23	1	R11	Resistor, 0 ohm, 0603, SMD	ROHM	MCR03EZPJ000
24	6	R12-R17	Resistor, 0 ohm, 0805, SMD	ROHM	MCR10EZHJ000
25	1	RT1	Thermistor, 100k@25C, B= 4250, 0402, Murata		NCP18WF104J03RB
26	1	R10	Trim pot, 50K, 1/2W	Bourns	3352E-1-503
27	42	D3 - D44	White LED, SMD		NSSW008CT, Nichia
28		F1	Fuse, 3.15A Surface Mount, 0805	Matsuo	KAB 2402 322
29	22	TP1 - TP10, CS1A - CS6A, CS1B - CS6B	Test Point, Miniature Thru Hole, Yellow	Keystone	5004
30	7	VIN, EN, DSEL1, DSEL2, PWM, GND, VBOOST	Test Point, Compact Thru Hole, White	Keystone	5007
31	15	J3, J8 - J21	Header, 2 Position, Vertical	3M	929647-09-26
32	4	J1, J2, J4, J7	Header, 3 Position, Vertical	3M	929647-09-36
33	14	J1 - J4, J7, J8, J10, J15 - J21	Jumper Block	3M	929950-00

BOM – 10 LED String Board

Item Number	Quantity	Part Reference	Description	Manufacturer	Manufacturer Part Number
1	REF		Schematic, LX1996EVAL Evaluation Board	Microsemi	24337 Rev X4
2	1	PCB	Printed Circuit Board, LX1996EVAL Evaluation Board	Microsemi	SGE3154 Rev X3
3	1	U1	LED back light controller, 24 MLPQ, 4 x4 mm2	Microsemi	LX1996
4	1	U2	Light sensor	Microsemi	LX1972
5	3	C3, C4, C13	Cap ceramic, 4.7uF, 50V, X5R, 1210	Murata	GRM32ER71H475KA88B
6	2	C11, C12	Cap ceramic, 1uF, 6.3V, X7R, 0603	TDK	C1608JB1H105K
7	3	C8, C10, C6	Cap ceramic, 0.1uF, 50V, X7R, 0603	TDK	C1608JB1H104K
8	1	C2	Cap ceramic, 0.022uF, 16V, X7R, 0603	Panasonic	ECJ-1VB1C223K
9	1	C5	Cap ceramic, 4.7uF, 6.3V, X7R, 0603	TDK	C1608JB1E475K
10	1	C1	Cap ceramic, 0.1uF, 16V, X7R, 0603	Panasonic	ECJ-1VB1C104K
11	1	D1	Diode, Schottky, 60V/1A, SMA, 30A<8.3mS	Vishay	B160
12	1	L1	Inductor, power, 6.8uH, >1.5A, DCR=26 - 50mΩ	Toko	A916CY-6R2
12 ALT				TDK	SLF6028-6R8M1R5-PF
13	1	Q1	NFET, 60V/2.8A ,TSOP-6, 130mΩ/Vgs=4.5V	Vishay	Si3458DS
14	1	R1	Resistor, .075 OHM 1/8W 1% 0603, Panasonic	Panasonic	ERJ-2BWJR075X
15	1	R2	Resistor, 1Mohm,1%, 0603, SMD	Panasonic	ERJ-3EKF1004V
16	1	R3	Resistor, 56.2k, 1%, 0603, SMD – Used for 10 LED String Evaluation	Panasonic	ERJ-3EKF5622V
17	1	R4	Resistor, 4.99k, 1%, 0603, SMD	Panasonic	ERJ-3EKF4991V
18	3	R5, R8, R9	Resistor, 100k,1%, 0603, SMD	Panasonic	ERJ-3EKF1003V
19	1	R19	Resistor, 750k, 1%, 0603, SMD	Panasonic	ERJ-3EKF7503V

Item Number	Quantity	Part Reference	Description	Manufacturer	Manufacturer Part Number
20	1	R20	Resistor, 40.2k, 1%, 0603, SMD	Panasonic	ERJ-3EKF4022V
21	1	R21	Resistor, 499k, 1%, 0603, SMD	Panasonic	ERJ-3EKF4993V
22	1	R6	Resistor, 22.1k, 1%, 0603, SMD	Panasonic	ERJ-3EKF2212V
23	1	R11	Resistor, 0 ohm, 0603, SMD	ROHM	MCR03EZPJ000
24	6	R12-R17	NOT USED	ROHM	MCR10EZHJ000
25	1	RT1	Thermistor, 100k@25C, B= 4250, 0402, Murata		NCP18WF104J03RB
26	1	R10	Trim pot, 50K, 1/2W	Bourns	3352E-1-503
27	60	D3 – D62	White LED, SMD		NSSW008CT, Nichia
28		F1	Fuse, 3.15A Surface Mount, 0805	Matsuo	KAB 2402 322
29	22	TP1 - TP10, CS1A - CS6A, CS1B - CS6B	Test Point, Miniature Thru Hole, Yellow	Keystone	5004
30	7	VIN, EN, DSEL1, DSEL2, PWM, GND, VBOOST	Test Point, Compact Thru Hole, White	Keystone	5007
31	15	J3, J8 - J21	Header, 2 Position, Vertical	3M	929647-09-26
32	4	J1, J2, J4, J7	Header, 3 Position, Vertical	3M	929647-09-36
33	14	J1 - J4, J7, J8, J10, J15 - J21	Jumper Block	3M	929950-00

SILKSCREEN and test hook up

Schematic

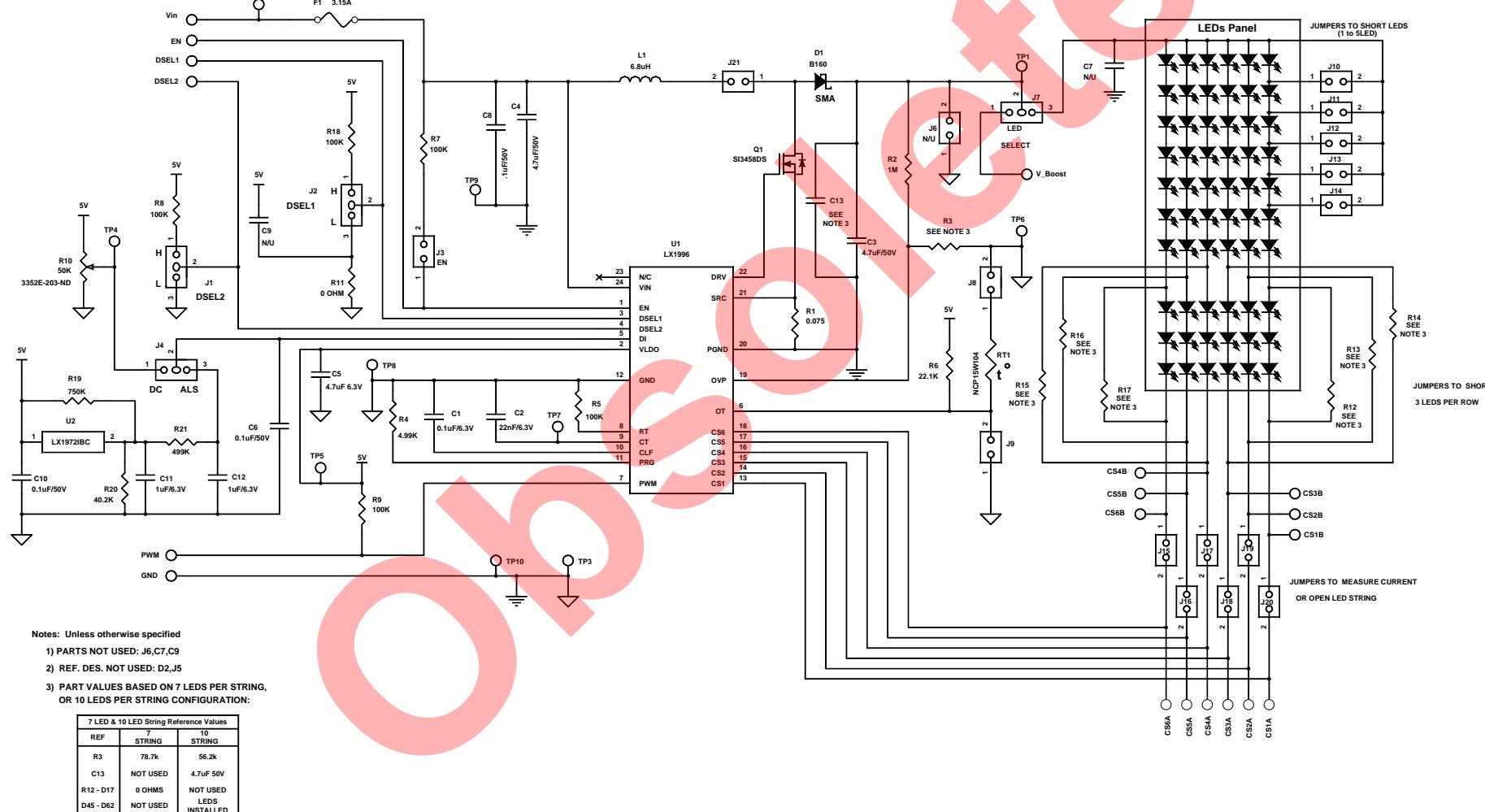


Figure 1 – LX1996 Evaluation Board Schematic

Printed Circuit Board Layout Recommendations

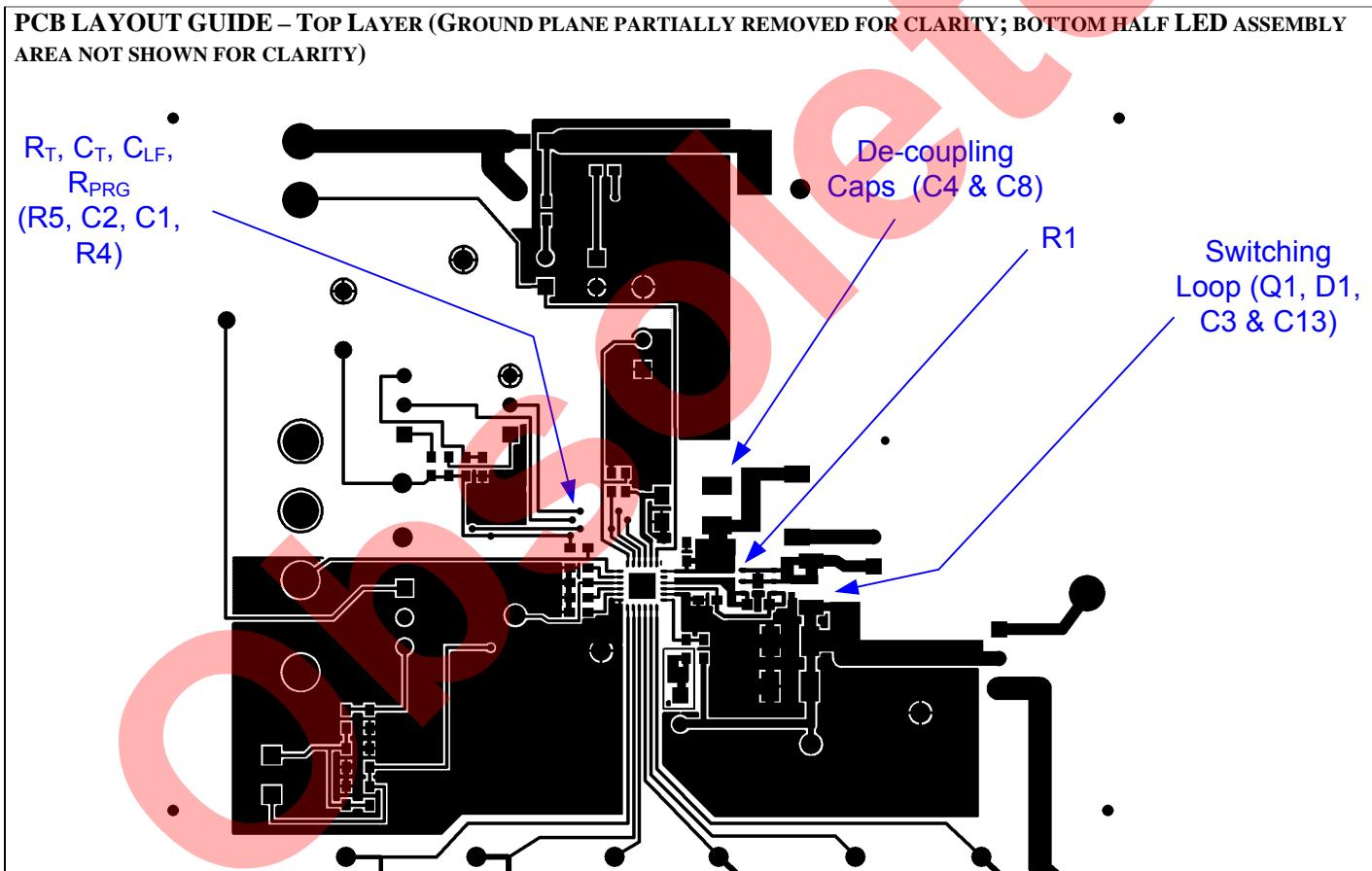
It is recommended that decoupling capacitors C8 and C4 be placed as close as possible to the LX1996. The Inductor current sense resistor R1 must tie directly to PGND pin, and then tie to the power ground plane at that pin.

For a good practical layout of switching boost circuit, keep loops as short as possible for the boost switching components (Q1, L1, D1,C3, & C13). Connect a separate signal ground plane to GND pin, a separate power ground plane to PGND pin, and then tie them together at GND pin.

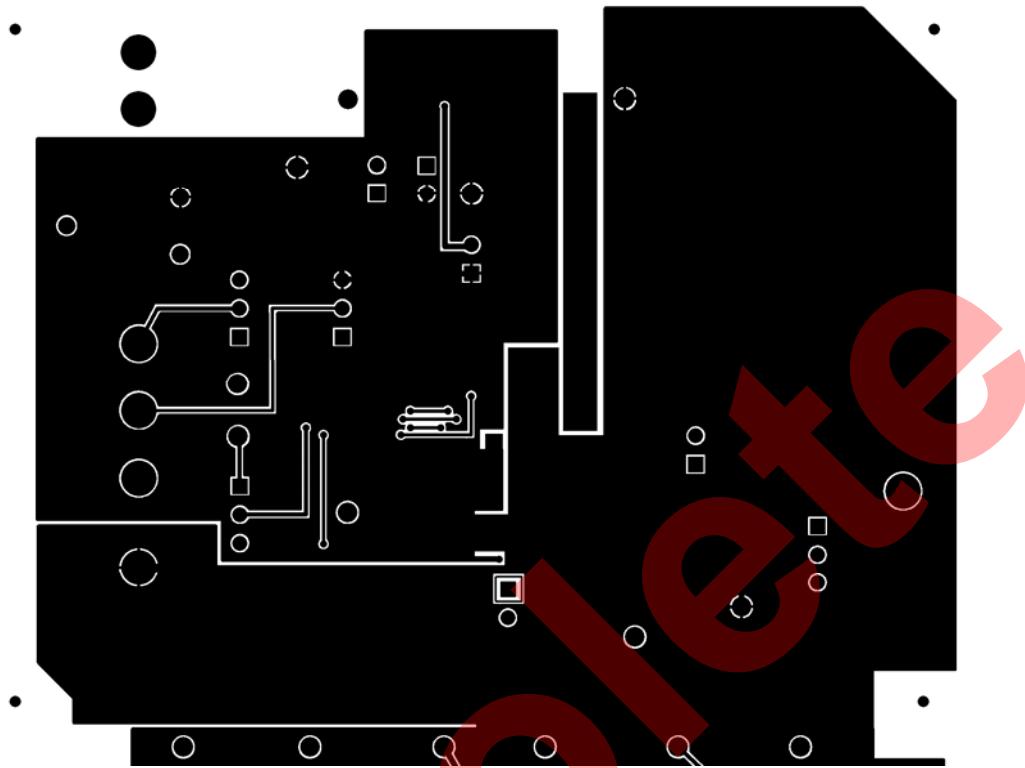
It is important that the LX1996 have a good thermal path to ambient to dissipate heat. The simplest way to do this is to heat sink the LX1996 bottom pad directly to the ground plane by placing 4 or more vias in the ground pad directly under the LX1996 footprint.

Place R5 (R_T resistor), C2 (C_T capacitor), C1 (C_{LF} capacitor), and R4 (R_{PRG} resistor) as close to the IC as practical.

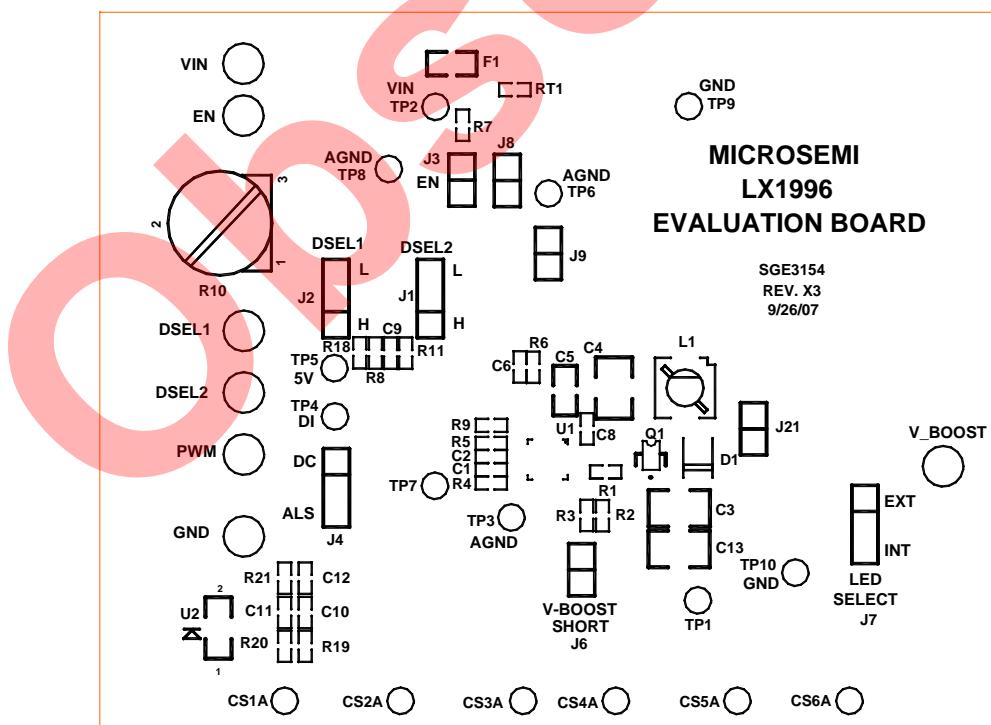
LX1996 Evaluation Board Printed Circuit Layout



PCB LAYOUT GUIDE – BOTTOM LAYER (BOTTOM HALF LED ASSEMBLY AREA NOT SHOWN FOR CLARITY)



PCB LAYOUT GUIDE – TOP SILKSCREEN (BOTTOM HALF LED ASSEMBLY AREA NOT SHOWN FOR CLARITY)



Test waveforms and measured data @ 25°C (untrimmed IC)

