6-String 400-mA WLED Driver with Independent PWM Dimming for Each String

Check for Samples: TPS61196

FEATURES

- **8V to 30V Input Voltage**
- **Up to 120V Output Voltage**
- **100KHz to 800kHz Programmable Switching Frequency**
- **Adaptive Boost Output for LED Voltages**
- **Six Current Sinks, 200mA Continuous Output / 400mA Pulse Output for Each String**
- **±1.5% Current Matching Between Strings**
- **High Precision PWM Dimming Resolution up to 5000:1**
- **Programmable Over-voltage Threshold at Output and Each Current Sink**
- **Programmable Under-voltage Threshold at Input with Adjustable Hysteresis**
- **Adjustable Soft Start Time Independent of Dimming Duty Cycle**
- **Built-in LED Open/Short Protection**
- **Built-in Schottky Diode Open/Short Protection**
- **Built-in ISET Short Protection**
- **Built-in IFB Short Protection**
- **Thermal Shutdown**
- **28L HTSSOP Package with PowerPAD**

APPLICATIONS

- **LCD TV Backlight**
- **Scan Mode LCD TV Backlight**

DESCRIPTION

The TPS61196 provides a highly integrated solution for LCD TV backlight with an independent PWM dimming function for each string. This device is a current mode boost controller driving up to six WLED strings with multiple LEDs in series. Each string has an independent current regulator providing a LED current adjustable from 50mA to 400mA within ±1.5% matching accuracy. The minimal voltage at the current sink is programmable in the range of 0.3V to 1.0V to fit with different LED current settings. The input voltage range for TPS61196 is from 8V to 30V.

The TPS61196 adjusts the boost controller's output voltage automatically to provide only the voltage required by the LED string with the largest forward voltage drop plus the minimum required voltage at that string's IFB pin, thereby optimizing the driver's efficiency. Its switching frequency is programmed by an external resistor from 100kHz to 800kHz.

The TPS61196 supports direct PWM brightness dimming. Each string has an independent PWM control input. During the PWM dimming, the LED current is turned on/off at the frequency and duty cycle which are determined by the external PWM signal. The PWM frequency ranges from 90Hz to 22kHz.

The TPS61196 integrates over current protection, output short circuit protection, ISET short to ground protection, diode open and short protection, LED open and short protection, and over temperature shutdown circuit. In addition, the TPS61196 can detect the IFB pin short to ground to protect the LED string. The device also provides programmable input under-voltage lockout threshold and output over-voltage protection threshold.

The TPS61196 has a built-in linear regulator which steps down the input voltage to the VDD voltage for powering the internal circuitry. An soft start circuit is implemented internally to work with an external capacitor to adjust the soft startup time to minimize the in-rush current during boost converter startup. The device is available in 28-pin HTSSOP package with powerPAD providing good thermal performance.

SIMPLIFIED SCHEMATIC CIRCUIT

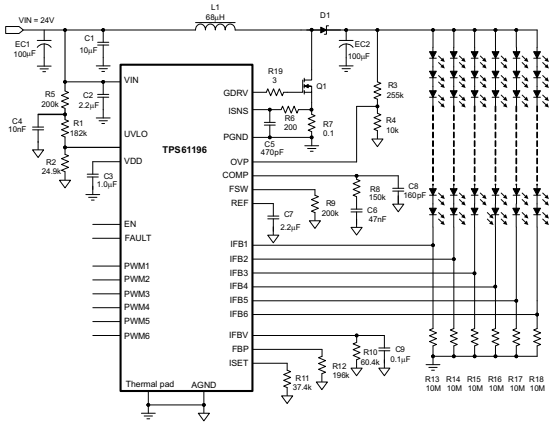


Figure 1. Typical Application of TPS61196

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ORDERING INFORMATION(1)

T_A	PACKAGE	ORDERING PART NUMBER	TOP MARK
-40°C to 85°C	28-Pin HTSSOP	TPS61196PWPR	TPS61196

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI website at www.ti.com.

ABSOLUTE MAXIMUM RATINGS(1)

over operating free-air temperature range (unless otherwise noted)

		VALUE		UNIT
		MIN	MAX	
Voltage range(2)	Pin VIN	–0.3	33	V
	Pin FAULT	–0.3	VIN	
	Pin IFB1 to IFB6	–0.3	40	
	Pin FBP, ISET, ISNS, IFBV	–0.3	3.3	
	Pin EN, PWM1 to PWM6	–0.3	20	
	Pin GDRV	–0.3	7.0	
	Pin GDRV 10ns transient	–2.0	9.0	
	All other pins	–0.3	7.0	
ESD rating	HBM		2	kV
	MM		200	V
	CDM		1	kV
Continuous power dissipation		See Thermal Information Table		
Operating junction temperature range		–40	150	°C
Storage temperature range		–65	150	°C

(1) 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 under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to network ground terminal

THERMAL INFORMATION

THERMAL METRIC(1)		TPS61196	UNITS
		PWP (28 PINS)	
θ_{JA}	Junction-to-ambient thermal resistance	33.8	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance	18.8	
θ_{JB}	Junction-to-board thermal resistance	15.6	
ψ_{JT}	Junction-to-top characterization parameter	0.6	
ψ_{JB}	Junction-to-board characterization parameter	15.4	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance	2.5	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.

RECOMMENDED OPERATING CONDITIONS(1)

		MIN	NOM	MAX	UNIT
V_{IN}	Input voltage range	8		30	V
V_{OUT}	Output voltage range	V_{IN}		120	V
L_1	Inductor	10		100	µH
C_{IN}	Input capacitor	10			µF
C_{OUT}	Output capacitor	22		220	µF
f_{SW}	Boost regulator switching frequency	100		800	kHz
f_{DIM}	PWM dimming frequency	0.09		22	kHz
T_A	Operating ambient temperature	–40		85	°C
T_J	Operating junction temperature	–40		125	°C

(1) Customers need to verify the component value in their application if the values are different from the recommended values.

ELECTRICAL CHARACTERISTICS

V_{IN}= 24V, T_A = –40°C to 85°C, typical values are at T_A = 25°C, C1 = 10µF, C2 = 2.2µF, C3 = 1.0µF, EC1 = EC2 = 100µF (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY						
V_{IN}	Input voltage range		8		30	V
V_{VIN_UVLO}	Under voltage lockout threshold	V_{IN} falling		6.5	7.0	V
V_{VIN_HYS}	VIN UVLO hysteresis			300		mV
I_{q_VIN}	Operating quiescent current into VIN	Device enabled, no switching, V_{IN} = 30 V			2.0	mA
I_{SD}	Shutdown current	V_{IN} = 12 V, V_{IN} = 30 V			25 50	µA
V_{DD}	Regulation voltage for internal circuit	0 mA < I_{DD} < 15 mA	5.7	6.0	6.3	V
EN and PWMx						
V_H	Logic high input on EN,PWMx	V_{IN} = 8 V to 30 V	1.8			V
V_L	Logic Low input on EN, PWMx	V_{IN} = 8 V to 30 V			0.8	V
R_{PD}	Pull-down resistance on EN, PWMx		0.8	1.6	3.0	MΩ
UVLO						
V_{UVLOTH}	Threshold voltage at UVLO pin		1.204	1.229	1.253	V
I_{UVLO}	UVLO input bias current	V_{UVLO} = V_{UVLOTH} – 50 mV V_{UVLO} = V_{UVLOTH} + 50 mV	–0.1 –4.3	 -3.9	0.1 –3.3	µA
SOFT START						
I_{SS}	Soft start charging current	PWM ON, V_{REF}<2.0V PWM ON, V_{REF}>2.0V		200 10		µA
CURRENT REGULATION						
V_{ISET}	ISET pin voltage		1.217	1.229	1.240	V
I_{ISET_P}	ISET short to ground protection threshold		120	150	180	µA
K_{ISET}	Current multiple I_{IFB}/I_{ISET}	I_{ISET} = 32.56µA, V_{IFB} = 0.5V	3932	3992	4052	
$I_{IFB(AVG)}$	Current accuracy	I_{ISET} = 32.56µA, V_{IFB} = 0.5V	127.4	130	132.6	mA
$K_{IFB(M)}$	Current matching; ($I_{FB(MAX)}$-$I_{FB(MIN)}$)/2$I_{FB(AVG)}$	I_{ISET} = 32.56µA, V_{IFB} = 0.5V		0.5%	1.5%	
I_{IFB_LEAK}	IFB pin leakage current at dimming off	IFB voltage < 40 V			1	µA
I_{IFB_max}	Current sink max output current	V_{IFBV} = 350 mV	130			mA

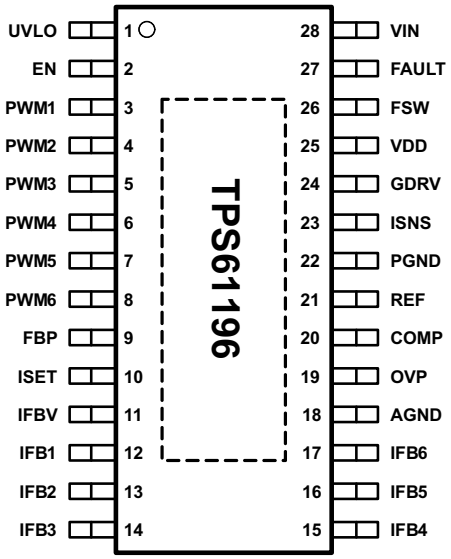
ELECTRICAL CHARACTERISTICS (continued)

V_{IN}= 24V, T_A = –40°C to 85°C, typical values are at T_A = 25°C, C1 = 10µF, C2 = 2.2µF, C3 = 1.0µF, EC1 = EC2 = 100µF (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
IFB REGULATION VOLTAGE						
V_{IFB}	Regulation voltage at IFB	Measured on V_{IFB}(min), other IFB voltages are 0.5V above V_{IFB}(min). I_{IFB} = 130 mA, V_{IFBV} = 0.5 V		508		mV
I_{IFBV}	IFB Regulation voltage setting sourcing current at IFBV	V_{IFBV} = 0.5 V	0.247	0.25	0.253	I_{ISET}
V_{IFBV}	IFBV voltage setting range		0.3		1.0	V
BOOST REFERENCE VOLTAGE						
V_{REF}	Reference voltage range for Boost Controller		0		3.1	V
I_{REF_LEAK}	Leakage current at REF pin		–25		25	nA
OSCILLATOR						
f_{SW}	Switching frequency	R_{FSW} = 200 kΩ	187	200	213	kHz
V_{FSW}	FSW pin reference voltage			1.8		V
D_{max}	Maximum duty cycle	f_{SW} = 200 kHz	90%	94%	98%	
$t_{on(min)}$	Minimum pulse width			200		ns
V_{FSW_H}	Logic high input voltage		3.5			V
V_{FSW_L}	Logic low input voltage				0.5	V
ERROR AMPLIFIER						
I_{SINK}	Comp pin sink current	V_{OVP} = V_{REF} + 200mV, V_{COMP} = 1V		20		µA
I_{SOURCE}	Comp pin source current	V_{OVP} = V_{REF} – 200mV, V_{COMP} = 1V		20		µA
Gm_{EA}	Error amplifier transconductance		90	120	150	µS
R_{EA}	Error amplifier output resistance			20		M Ω
f_{EA}	Error amplifier crossover frequency			1000		kHz
GATE DRIVER						
$R_{GDRV(SRC)}$	Gate driver impedance when sourcing	V_{DD} = 6 V, I_{GDRV} = –20 mA		2	3	Ω
$R_{GDRV(SNK)}$	Gate driver impedance when sinking	V_{DD} = 6 V, I_{GDRV} = 20 mA		1	1.5	Ω
$I_{GDRV(SRC)}$	Gate driver source current	V_{GDRV} = 5 V	200			mA
$I_{GDRV(SNK)}$	Gate driver sink current	V_{GDRV} = 1 V	400			mA
$V_{ISNS(OC)}$	Overcurrent detection threshold	V_{IN} = 8 V to 30 V, T_J = 25°C to 125°C	376	400	424	mV
OVER VOLTAGE PROTECTION (OVP)						
V_{OVPTH}	Output voltage OVP threshold		2.95	3.02	3.09	V
I_{OVP}	Leakage current		–100	0	100	nA
V_{IFB_OVP}	IFBx over voltage threshold	PWM ON		38		V
LED SHORT DETECTION						
I_{FBP}	LED short detection sourcing current	V_{FBP} = 1 V	0.247	0.25	0.253	I_{ISET}
FAULT INDICATOR						
I_{FLT_H}	Leakage current in high impedance	V_{FLT} = 24 V		1		nA
I_{FLT_L}	Sink current at low output	V_{FLT} = 1 V	1	2		mA
THERMAL SHUTDOWN						
$T_{shutdown}$	Thermal shutdown threshold			150		°C
T_{hys}	Thermal shutdown threshold hysteresis			15		°C

DEVICE INFORMATION

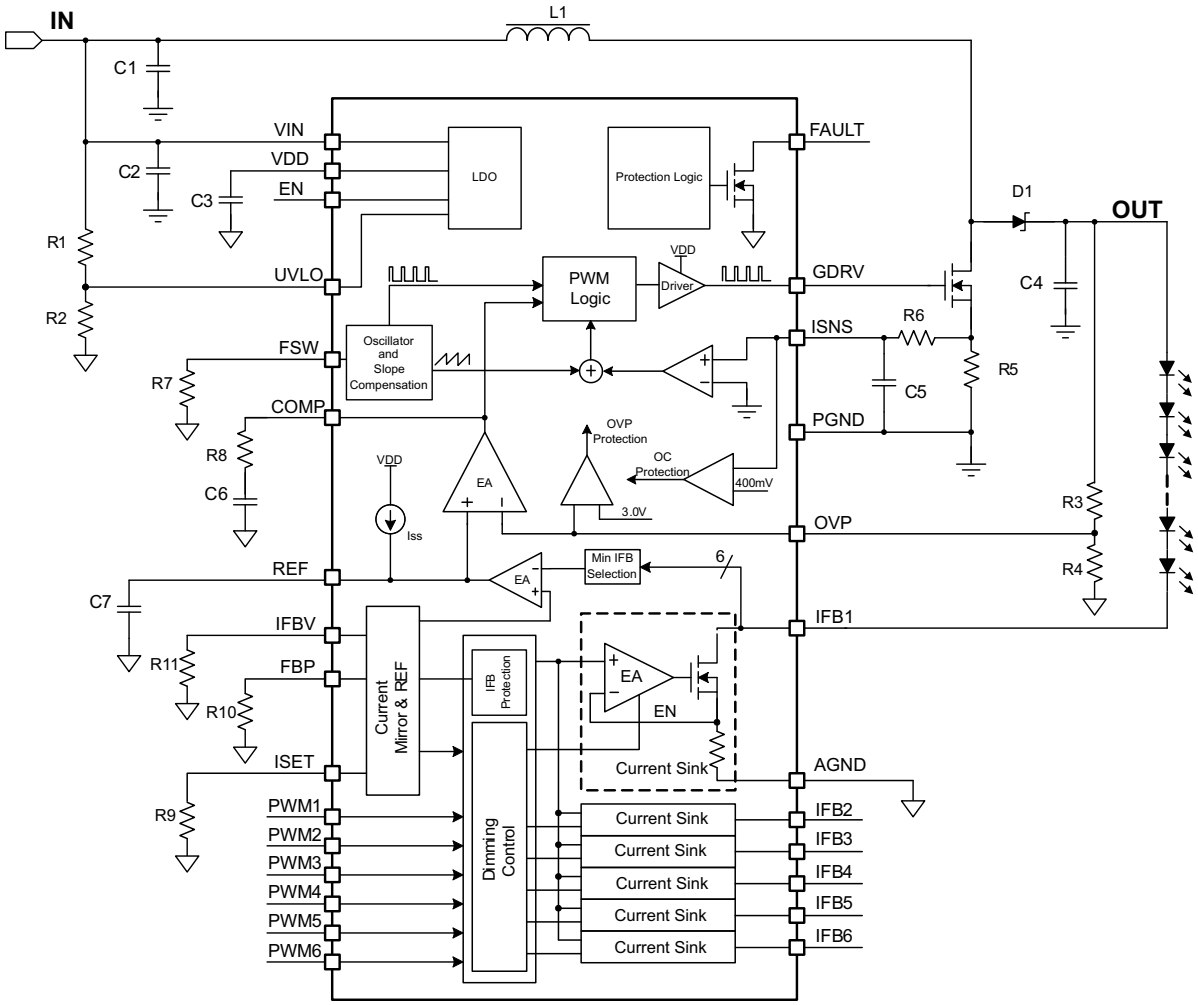
HTSSOP-28 (PWP)
(TOP VIEW)



PIN FUNCTIONS

PIN		DESCRIPTION
NUMBER (PWP)	NAME	
1	UVLO	Low input voltage lock out. Use a resister divider from VIN to this pin to set the UVLO threshold
2	EN	Enable and disable pin. EN high=Enable, EN low=Disable
3,4,5,6,7,8	PWM1 to PWM6	PWM signal input pins. The frequency of PWM signal is in the range of 90Hz to 22kHz
9	FBP	LED cross-short protection threshold program pin. Use a resistor to GND to set the threshold
10	ISET	Connecting a resistor to the pin programs the IFB pin current level for full brightness (i.e., 100% dimming)
11	IFBV	Minimum feedback voltage setting for LED strings
12,13,14,15,16, 17	IFB1 to IFB6	Regulated current sink input pins
18	AGND	Analog ground
19	OVP	Over-voltage protection detection input. Connect a resistor divider from output to this pin to program the OVP threshold.
20	COMP	Loop compensation for the boost converter. Connect a RC network to make loop stable
21	REF	Internal reference voltage for the boost converter. Use a capacitor at this pin to adjust the soft start time. When two chips operate in parallel, connect the master's REF pin to the slave's COMP pin.
22	PGND	External MOSFET current sense ground input
23	ISNS	External MOSFET current sense positive input
24	GDRV	External switch MOSFET gate driver output
25	VDD	Internal regulator output for IC internal power supply. Connect a 1.0µF ceramic capacitor to this pin.
26	FSW	Switching frequency setting pin. Use a resistor to set the frequency between 100kHz to 800kHz. An external input voltage above 3.5V or below 0.5V disables the internal clock and makes the device as slave device
27	FAULT	Fault indicator. Open-drain output. Output high impedance when fault conditions happen
28	VIN	Power supply input pin

FUNCTIONAL BLOCK DIAGRAM



TYPICAL CHARACTERISTICS

Table 1. TABLE OF GRAPHS

Figure 1 as test circuit		
TITLE	**TEST CONDITIONS**	**FIGURE**
Efficiency (20LEDs)	20 LEDs(V_{OUT} = 60V), I_{OUT} = 0.78A, 200Hz Dimming Frequency	Figure 2
Efficiency (16LEDs)	16 LEDs(V_{OUT} = 50V), I_{OUT} = 0.78A, 200Hz Dimming Frequency	Figure 3
Dimming Linearity	20 LEDs(V_{OUT} = 60V), V_{IN} = 24V	Figure 4
Dimming Linearity at Low Dimming Duty Cycle	20 LEDs(V_{OUT} = 60V), V_{IN} = 24V	Figure 5
DC Load Efficiency	f_{SW} = 200 kHz	Figure 6
Switching Frequency Setting	V_{IN} = 24V	Figure 7
Recommended Minimum Headroom Voltage		Figure 8
Boost Switching Waveform	V_{IN} = 24V, V_{OUT} = 74V, I_{OUT} = 0.78A	Figure 9
Startup Waveform (1% Dimming)	200Hz Dimming Frequency, 1% Dimming Duty Cycle	Figure 10
Startup Waveform (100% Dimming)	200Hz Dimming Frequency, 100% Dimming Duty Cycle	Figure 11
Dimming Waveform (0.1% Dimming)	200Hz Dimming Frequency, 0.1% Dimming Duty Cycle	Figure 12
Dimming Waveform (2% Dimming)	200Hz Dimming Frequency, 2% Dimming Duty Cycle	Figure 13
Shutdown Waveform (1% Dimming)	200Hz Dimming Frequency, 1% Dimming Duty Cycle	Figure 14
Shutdown Waveform (100% Dimming)	200Hz Dimming Frequency, 100% Dimming Duty Cycle	Figure 15
LED Open Protection (1% Dimming)	200Hz Dimming Frequency, 1% Dimming Duty Cycle	Figure 16
LED Open Protection (100% Dimming)	200Hz Dimming Frequency, 100% Dimming Duty Cycle	Figure 17
LED Short Protection (1% Dimming)	200Hz Dimming Frequency, 1% Dimming Duty Cycle	Figure 18
LED Short Protection (100% Dimming)	200Hz Dimming Frequency, 100% Dimming Duty Cycle	Figure 19
IFB Short to Ground Protection (1% Dimming)	200Hz Dimming Frequency, 1% Dimming Duty Cycle	Figure 20
IFB Short to Ground Protection (100% Dimming)	200Hz Dimming Frequency, 100% Dimming Duty Cycle	Figure 21

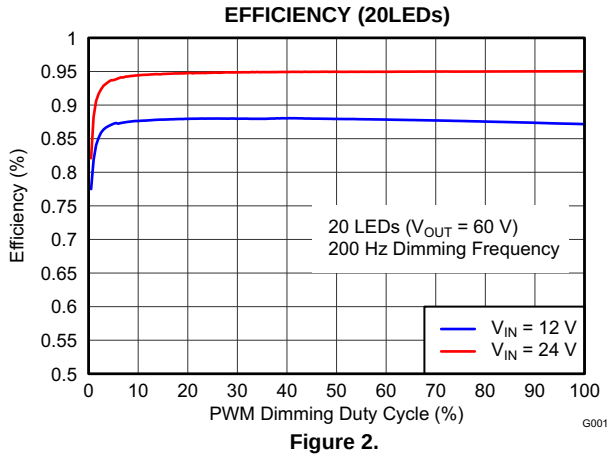


Figure 2.

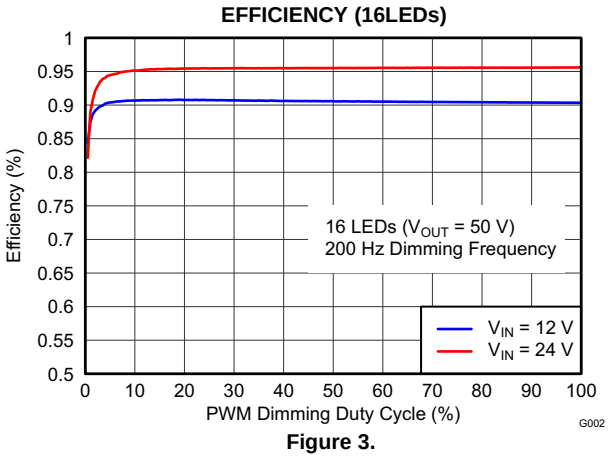


Figure 3.