MP4600

High-Voltage WLED Driver For Large Panel TV Backlighting

DESCRIPTION

The MP4600 is an integrated white LED driver. It can be applied with MPS patent pending technology to drive up to 55 inch LCD TV backlighting, in which the LED string voltage can be up to 300V. The novel technology can leverage the LED drive power by regulating only a small part of the LED drive voltage. As a result, working together with a fixed high voltage source, a low voltage LED driver can be used to drive the high voltage LED strings with super high power density, high efficiency and low cost due to the low voltage stress, high switching frequency, and smaller size of passive components.

MP4600 is a current mode controlled buck-boost regulator. With a 12V input V_{INL} and a high voltage source V_{INH}, it can deliver a regulated voltage (V_{INH} to V_{INH}+43V) to drive a LED string with up to 85 LEDs. It incorporates both DC and PWM dimming onto a single control pin. Fault protection includes LED open strings protection, output short circuit protection, input over voltage protection, cycle-by-cycle peak current limiting, and thermal shutdown.

The MP4600 is available in 10-pin 3x3mm QFN packages.

FEATURES

- Novel Power Leverage Control Technology
- Unique Step-up/down Operation
- 0.28Ω Internal Power MOSFET Switch
- Adjustable Switching Frequency
- Analog and PWM Dimming
- 0.198V Reference Voltage
- 5µA Shutdown Mode
- Stable with Low ESR Output Ceramic Capacitors
- Cycle-by-Cycle Over Current Protection
- Thermal Shutdown Protection
- Open Strings Protection
- Input Over Voltage Protection
- Output Short Circuit Protection
- Available in 10-Pin 3x3mm QFN Packages

APPLICATIONS

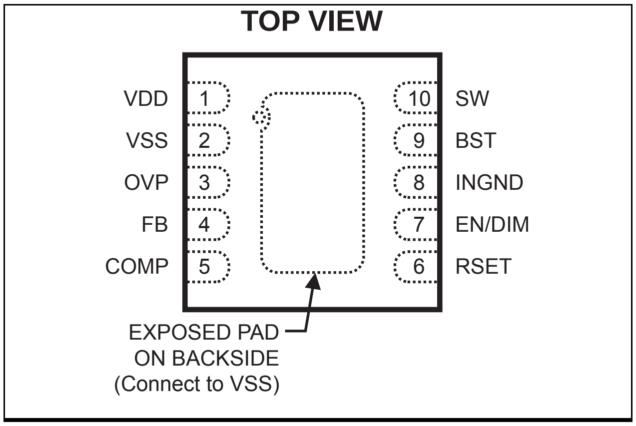
- TV Backlighting
- Large LCD Panels Backlighting

ORDERING INFORMATION

Part Number*	Package	Top Marking	Free Air Temperature (T_A)
MP4600DQ	QFN10 (3x 3mm)	9M	-40°C to +85°C

For Tape & Reel, add suffix –Z (e.g. MP4600DQ–Z);
For RoHS Compliant Packaging, add suffix –LF (e.g. 4600DQ–LF–Z)

PACKAGE REFERENCE



ABSOLUTE MAXIMUM RATINGS (1)

Supply Voltage V_{DD} – V_{SS} 60V
V_{SW} – V_{SS} .... -0.3V to V_{IN} + 0.3V
V_{BST} .... V_{SW} + 6V
V_{OVP} – V_{SS} .... -0.3V to +6V
V_{EN} – V_{INGND} .... -0.3V to +6V
V_{DIM} – V_{INGND} .... -0.3V to +6V
V_{INGND} – V_{SS} .... -0.3V to 60V
Continuous Power Dissipation (T_A = +25°C)(2)
.... 2.5W
Junction Temperature .... 150°C
Lead Temperature .... 260°C
Storage Temperature .... -65°C to +150°C

Recommended Operating Conditions (3)

Supply Voltage V_{DD} – V_{SS} .... 4.5V to 55V
Ambient Junct. Temp (T_J) .... -40°C to +125°C

Thermal Resistance (4) θ_{JA} θ_{JC}

3x3 QFN10 .... 50 ...... 12... °C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX)-T_A)/θ_{JA}. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device function is not guaranteed outside of the recommended operating conditions.
4) Measured on JESD5 1-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

V_{DD} = 12V, T_A = +25°C, all voltages with respect to V_{SS}, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
Feedback Voltage	V_{FB}	V_{DD}=4.5V to 55V	0.188	0.198	0.208	V
Feedback Current	I_{FB}	V_{FB} = 0.22V	-50		50	nA
Switch-On Resistance	$R_{DS(ON)}$			0.28		Ω
Switch Leakage	I_{SW-LK}	V_{EN} = 0V, V_{SW} = 0V			1	μA
Current Limit	I_{LIMIT}			3.0		A
Oscillator Frequency	f_S	V_{FB} = 0.1V, RST=100kΩ		0.5		MHz
Default Oscillator Frequency	$f_{S-Default}$	V_{FB} = 0.1V, RST open		1.35		MHz
Fold-back Frequency	f_{S-FB}	V_{FB} = 0V, V_{OVP}=0V		250		kHz
Maximum Duty Cycle	D_{MAX}	V_{FB} = 0.1V		90		%
Minimum On-Time	t_{ON}			100		ns
Under Voltage Lockout Threshold Rising	V_{DD-TH}		3.0	3.3	3.6	V
Under Voltage Lockout Threshold Hysteresis	V_{DD-HYS}			100		mV
EN Input Current	I_{EN}	V_{EN} = 2V		2.1		μA
		V_{EN} = 0V		0.1		
EN OFF Threshold (w/Respect to INGND)	V_{ENL}	V_{EN} Falling	0.4			V
EN ON Threshold (w/Respect to INGND)	V_{ENH}	V_{EN} Rising			0.6	V
Minimum EN Dimming Threshold	V_{DIML}		0.6	0.7	0.8	V
Maximum EN Dimming Threshold	V_{DIMH}		1.25	1.4	1.5	V
PWM Dimming Frequency (5)	f_{PWM}		100		20k	Hz
Supply Current (Quiescent)	I_Q	V_{EN} = 2V, V_{FB} = 1V		0.8	1.0	mA
Supply Shut Down Current	I_{OFF}	V_{EN} = 0V		3.4	15	μA
Thermal Shutdown	T_{TH}			150		°C
Thermal Shutdown Hysteresis	T_{HYS}			20		°C
Open LED OV Threshold	V_{OVP-TH}		1.1	1.2	1.3	V
Open LED OV Hysteresis	$V_{OVP-HYS}$			60		mV

Note:

5) Guaranteed by design.

PIN FUNCTIONS

Pin #	Name	Description
1	VDD	Positive Voltage Input Pin. A decoupling cap is needed to prevent large voltage spikes from appearing at the input.
2	VSS	Negative Voltage Output Pin. This pin is the voltage reference for OVP, FB, COMP and RSET pins. This node should be placed away from switching noise sources. The exposed pad is connected to this pin.
3	OVP	Over Voltage Protection Pin. Use one external resistor voltage divider across INGND and VSS to program OVP threshold. Its voltage is referred to VSS. When the OVP pin voltage reaches the shutdown threshold 1.2V, the switch will be turned off and will recover when OVP voltage decreases sufficiently. When the OVP pin voltage is lower than 0.4V and FB pin voltage is lower than 0.1V, the chip frequency will be folded back. Program the OVP pin voltage from 0.4V to 1.2V for normal operation.
4	FB	LED Current Feedback Input. MP4600 regulates the voltage across the current sensing resistor between FB and VSS. Connect the current sensing resistor from the bottom of the LED strings to VSS. The FB pin is connected to the bottom of the LED strings. The regulation voltage is 0.198V.
5	COMP	Output of error amplifier. Connect a 1nF or larger capacitor on COMP to improve the stability and to provide a soft on at start up or PWM dimming.
6	RSET	Connect to a resistor to VSS to set the switching frequency.
7	EN/DIM	On/Off Control Input and Dimming Command Input. Its voltage is referred to INGND. A voltage greater than 0.7V will turn on the chip. When the EN/DIM pin voltage rises from 0.7V to 1.4V, the LED current will change from 0% to 100% of the maximum LED current. To use PWM dimming, apply a 100Hz to 20kHz square wave signal with amplitude greater than 1.5V to this pin.
8	INGND	Input Ground Reference. This pin is the reference for the EN/DIM signal.
9	BST	Bootstrap. A capacitor is connected between SW and BST pins to form a floating supply across the power switch driver.
10	SW	Switch Output. SW is the source of the internal MOSFET switch. Connect to the power inductor and cathode of the Schottky rectifier.
		Exposed pad should be connected to VSS.

OPERATION

The MP4600 is a current mode controlled Buck-Boost regulator. The sensing resistor senses the LED current and feeds it back to an error amplifier, which regulates it to 198mV with an inside compensation network. The COMP pin is the output of the error amplifier. The inductor peak current is proportional to the COMP pin voltage. An increase of the COMP voltage increases the current delivered to the output.

Open LED Protection

If the LED is open, there is no voltage on the FB pin. The duty cycle will increase until V_{DD}- V_{SS} reaches to 55V or V_{OVP}-V_{SS} reaches the shutdown threshold set by the external resistor. The top switch will turn off until the voltage V_{DD}-V_{SS} and V_{OVP}-V_{SS} decreases sufficiently.

Dimming Control

The MP4600 allows both DC and PWM dimming. When the voltage on EN is <0.6V, the chip is turned off. For analog dimming, when the voltage on EN is from 0.7V to 1.4V, the LED current will change from 0% to 100% of the maximum LED current. If the voltage on EN pin is higher than 1.4, maximum LED current will be generated. For PWM dimming, its amplitude (V_{DIM} – V_{INGND}) must exceed 1.5V. The PWM waveform is internally clamped to 0.198V.

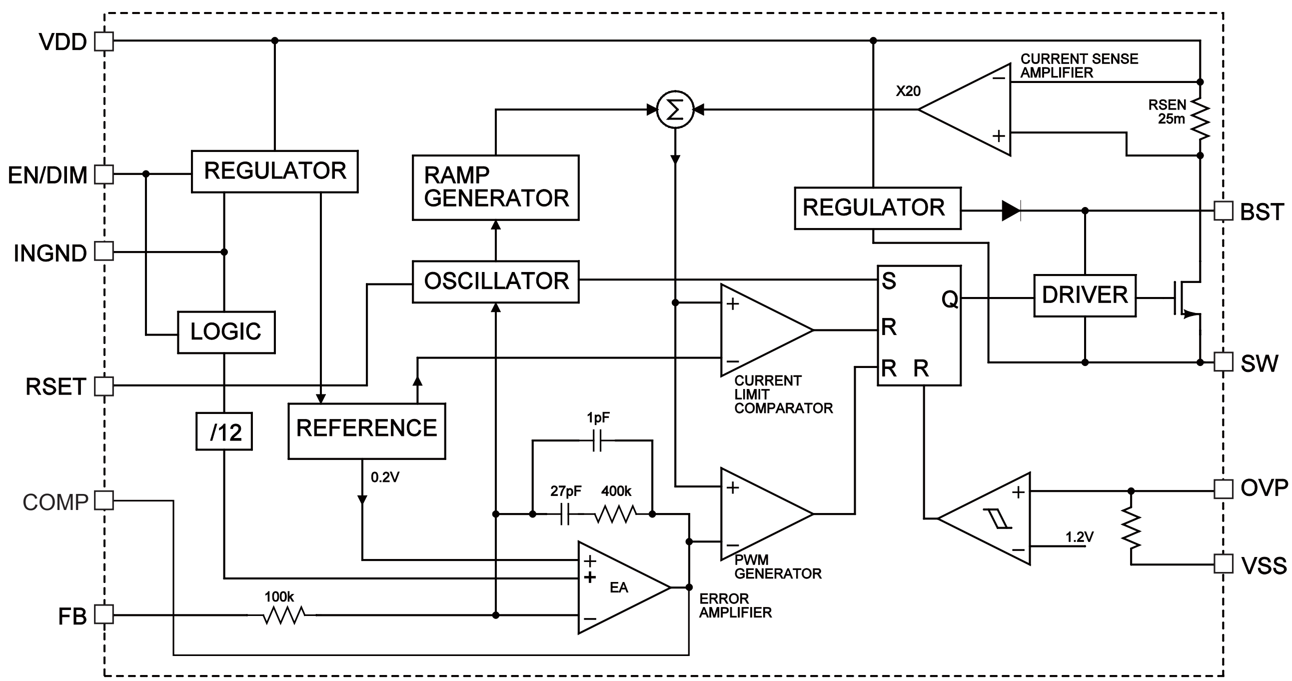


Figure 1—Functional Block Diagram

APPLICATION INFORMATION

Setting the LED Current

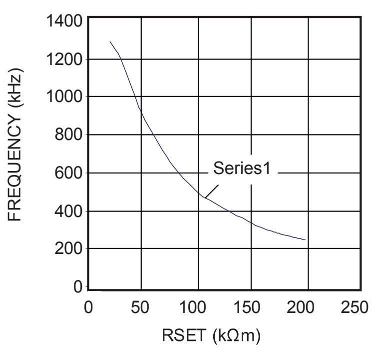
An external resistor R_{SENSE} is used to set the maximum LED current through the use of the equation:

$$R_{SENSE} = \frac{0.198V}{I_{LED}}$$

Setting the Switching Frequency

An external resistor R_{SET} is used to set the switching frequency f_S according to the following curve:

Frequency vs. RSET



If RSET pin is floating, the setting frequency is the default value 1.35MHz.

Selecting the Inductor

Inductor selection is related to the input voltage, output voltage, and LED current. Select the inductor to make the circuit always operate in continuous current mode (CCM). The inductance is designed as:

$$L = \frac{V_{IN} \cdot V_{OUT}}{f_S (V_{IN} + V_{OUT}) \cdot \Delta I_L},$$

where ΔI_L is the inductor peak-to-peak current ripple. Design ΔI_L as about 40% to 60% of the inductor average current, which is:

$$I_{L\_AVG} = I_{LED}\left(1 + \frac{V_{OUT}}{V_{IN}}\right).$$

Make sure the inductor is not saturated at the maximum peak current, which is:

$$I_{L\_PK} = I_{L\_AVG} + 0.5 \cdot \Delta I_L.$$

Selecting the Input Capacitor

The input capacitor reduces the surge current drawn from the input supply and the switching noise from the device. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. Enough capacitance is required for limited input voltage ripple ΔV_{IN}, which should be normally less than 5~10% of the DC value.

$$C_{IN} > \frac{I_{L\_AVG} \cdot V_{OUT}}{f_s \cdot \Delta V_{IN} (V_{IN} + V_{OUT})}$$

Selecting the Output Capacitor

The output capacitor keeps the output voltage ripple ΔV_{OUT} small (normally less than 1~5% of the DC value) and ensures feedback loop stable. The output capacitor impedance should be low at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended for their low ESR characteristics.

$$C_{OUT} > \frac{I_{LED} \cdot V_{OUT}}{f_s \cdot \Delta V_{OUT} (V_{IN} + V_{OUT})}$$

PC Board Layout

The high current paths (VSS, VDD and SW) should be aced very close to the device with short, direct and wide traces. The input capacitor needs to be as close as possible to the VDD and VSS pins. The external feedback resistors should be placed next to the FB pin. Keep the switch node traces short and away from the feedback network.

TYPICAL APPLICATION CIRCUITS

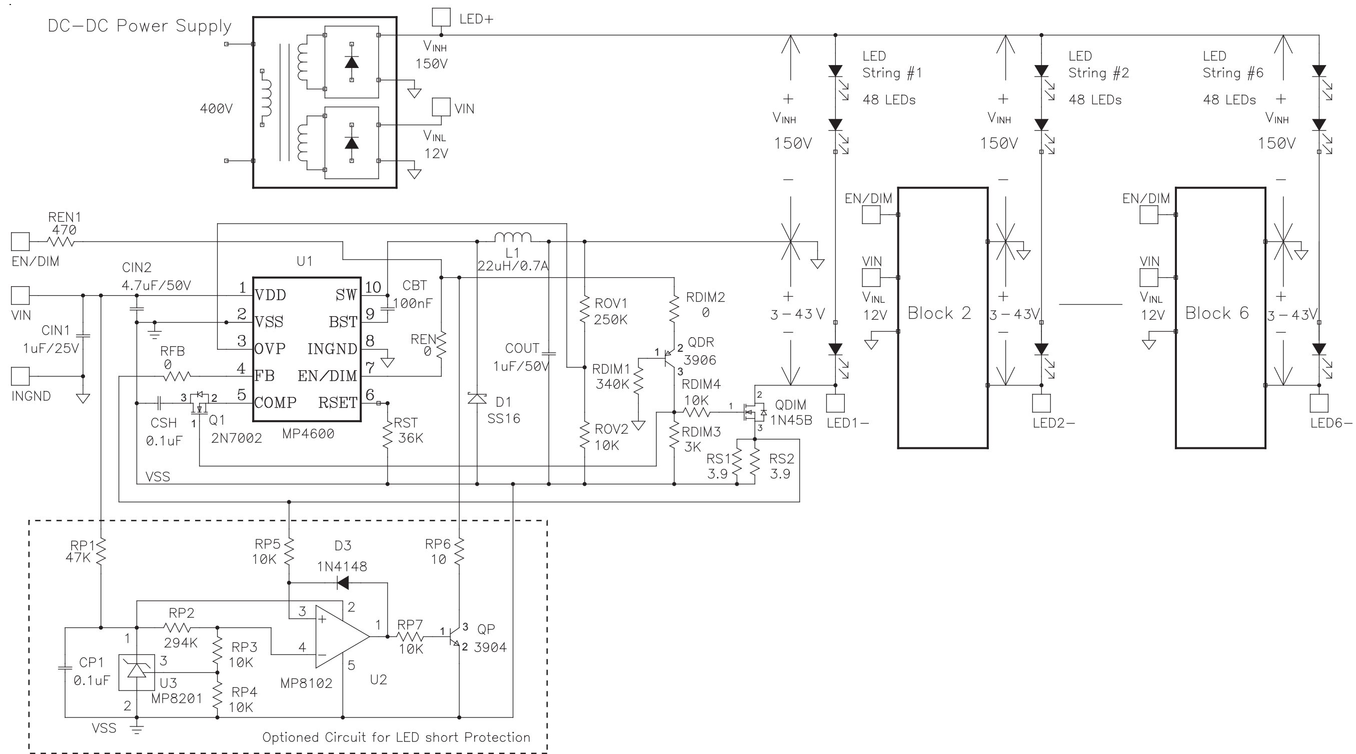
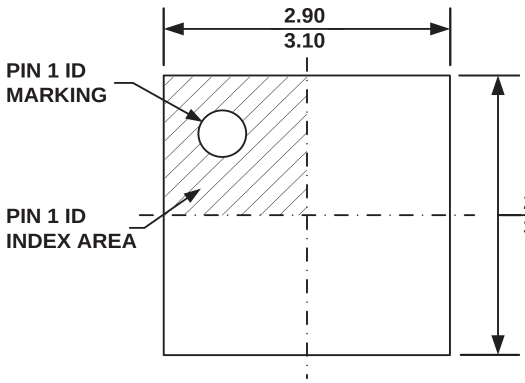


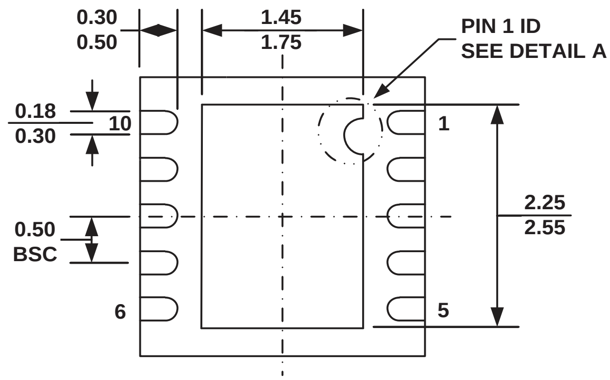
Figure 2—White LED Driver Application for TV Applications

PACKAGE INFORMATION

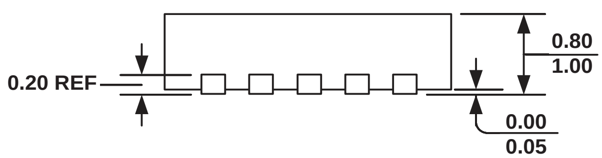
3mm x 3mm QFN10



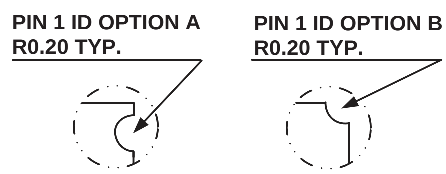
TOP VIEW



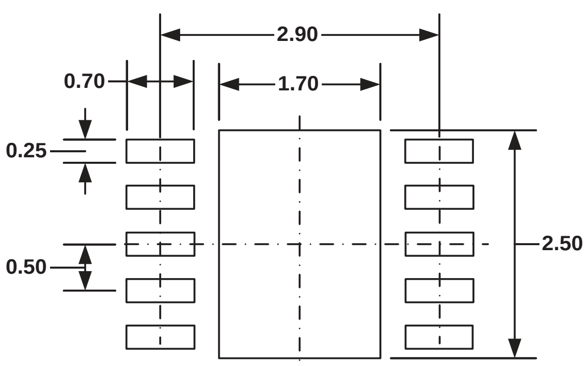
BOTTOM VIEW



SIDE VIEW



DETAIL A



RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETER MAX.
4) DRAWING CONFORMS TO JEDEC MO-229, VARIATION VEED-5.
5) DRAWING IS NOT TO SCALE.