HT7L4661
Active PFC Non-isolation Buck LED Lighting Driver With Dimming Function

Feature

- Non-isolation buck topology
- Wide AC input range − from $85V_{AC}$ to $265V_{AC}$
- High Power Factor of >0.9 without additional circuitry
- Internal 650V high voltage JFET for quick startup
- Provides 5V LDO output
- Accurate constant current (< ±3%)
- Includes linear dimming function
- Low operating current to maximise conversion efficiency
- Under-voltage lockout with hysteresis
- Full protection functions for enhanced safety
  - Maximum gate drive output clamp
  - VCC over voltage protection − VCC OVP
  - VCC under-voltage lockout with hysteresis − VCC UVLO
  - Output LED string over current protection
  - Output LED string short protection
  - Output LED string open protection
  - CS, ZCD pins open protection
  - On-chip Vver temperature protection − OTP
- Small 10-pin MSOP package

Applications

- General illumination
- E26/27, T5/T8 LED Lamp
- Other LED Lighting Applications

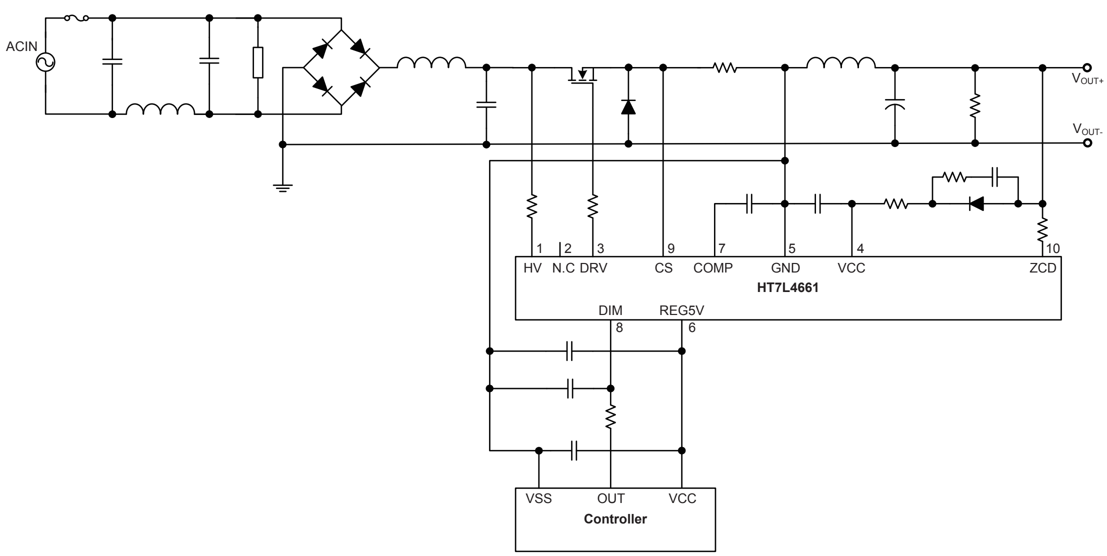
General Description

The HT7L4661 is a Buck converter controller using quasi-resonant conversion technology. It can be used for driving high-brightness LEDs with power factor correction in off-line applications. The controller is implemented by driving an external power MOSFET and measuring and regulating a constant LED current.

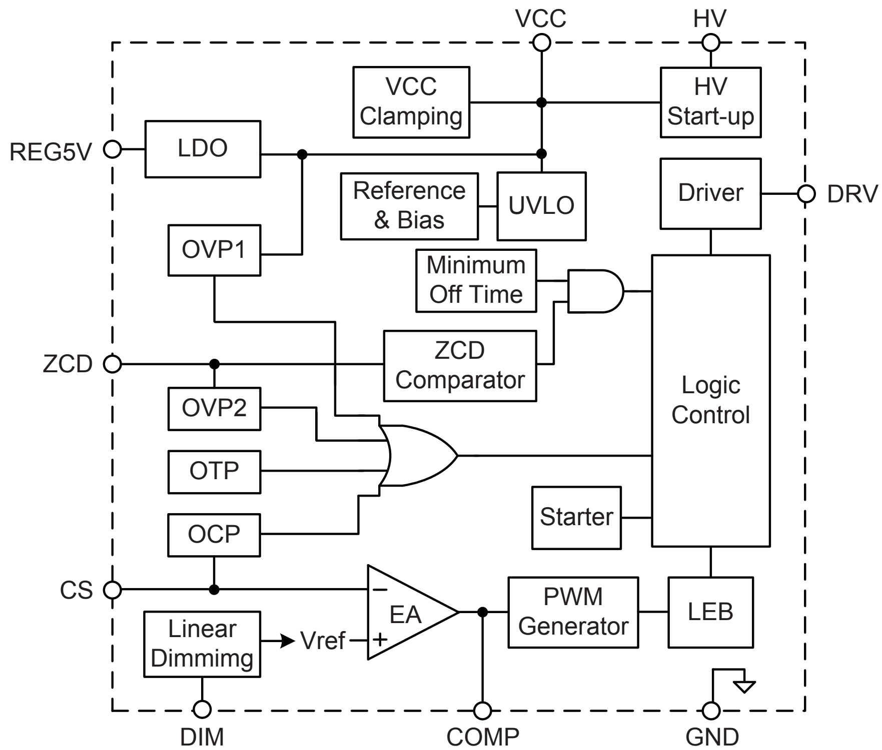
Additional features in the device include a rapid high voltage startup function and a 5V LDO output with a 1mA drive capability for external loads. There is also a linear dimming function to adjust the LED illumination level.

The device also includes multiple protection features to protect it from fault conditions. These include under-voltage lockout, over-current protection, Vcc pin over-voltage protection and a ZCD pin over-voltage protection for the output voltage. Additionally, to ensure device reliability, there is also a fully integrated thermal protection function.

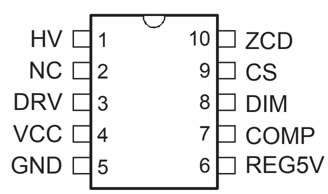
Application Circuits



Block Diagram



Pin Assignment



HT7L4661
10 MSOP-A

Pin Description

Pin No.	Pin Name	Description
1	HV	High-Voltage startup pin. The HV pin is connected to the AC line voltage to provide the charging current to the VCC capacitor.
2	NC	No Connection
3	DRV	Output to drive the external power MOSFET
4	VCC	Internal circuitry power supply pin. Must be bypassed with a capacitor to GND with value of at least 10μF.
5	GND	Ground
6	REG5V	5V LDO output. Must be bypassed with capacitor to GND with value of at least 1uF.
7	COMP	Error amplifier output. A capacitor is placed between COMP and GND to provide a stable frequency response.
8	DIM	Linear dimming input. Sets the current sense threshold as long as the voltage at this pin is less than 3V.
9	CS	Current sense pin. A resistor is connected here for MOSFET current sensing.
10	ZCD	Zero-current detect pin. Input from auxiliary winding for zero-current detection and output over-voltage sensing.

Absolute Maximum Ratings

VCC Supply Voltage .... -0.3V~33V
HV Voltage .... -0.3V~650V
DIM, CS,COMP, LDO Pins .... -0.3V~6V
ZCD pin Maximum current .... 3mA (source), 3mA (sink)
Maximum Junction Temperature .... 150°C
Storage Temperature Range .... -55°C~150°C

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

Recommended Operating Ranges

VCC Supply Voltage .... 9.5V~25V
Operating Junction Temperature .... -40°C~125°C

Electrical Characteristics

V_{CC}=18V, Ta=25°C

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Unit
Power Supply (VCC Pin)						
VCC_{ON}	Turn-on Threshold	—	—	16	—	V
VCC_{OFF}	Turn-off Threshold	—	—	8.4	—	V
Hys	Hysteresis	—	6.8	—	—	V
V_{OVP}	OVP level on VCC pin	—	26	29	32	V
I_{START}	Start-up Current	Before turn-on, V_{CC}=11V	—	45	60	μA
I_Q	Quiescent Current	No switching	—	—	700	μA
I_{CC}	Operating Current	70kHz, C_O=1nF	—	—	2.5	mA
High Voltage Start-up						
$VCC_{ST(ON)}$	High V section Turn-on Threshold	—	—	17	—	V
$VCC_{ST(OFF)}$	High V section Turn-off Threshold	—	—	10	—	V
Hys	Hysteresis	—	—	7	—	V
Linear Regulator						
V_{CC}	LDO Input Voltage	—	8	—	30	V
Reg5V	Regulated Output Voltage	—	4.5	5	5.5	V
$I_{OUT(STD)}$	Output Current at Standby Mode	V_{DIM} < 0.4V	1	—	—	mA
$I_{OUT(OP)}$	Output Current at Operating Mode	V_{DIM} > 0.4V	5	—	—	mA
Error Amplifier						
V_{FB}	Voltage Feedback Input Threshold	Tj=25°C	194	200	206	mV
Current Sense Comparator						
t_{LEB}	Leading Edge Blanking Time	—	—	400	—	ns
V_{OCP}	Over Current Protection Threshold	—	—	0.9	—	V
	Over Current Release Threshold	—	—	0.2	—	V
V_{CL}	Current Limit Threshold	—	—	1.3	—	V
Zero Current Detector						
V_{ZCDH}	Upper Clamp Voltage	I_{ZCD}=300μA	—	3	—	V
V_{ZCDL}	Lower Clamp Voltage	I_{ZCD}=-2.5mA	—	-0.2	—	V
V_{ZCDA}	Positive-Going Edge	—	—	1.5	—	V
V_{ZCDT}	Negative-Going Edge	—	—	1	—	V
I_{OVP}	ZCD pin OVP current level	—	285	300	315	μA
t_{B_OVP}	OVP Detection Blanking Time	—		1		μs
Starter						
t_{START}	Start Timer Period	—	—	40	—	μs
t_{OFF}	Minimum Off Time	—	—	4	—	μs
Over Temperature Protection						
OTP	Over Temperature Lockout	—	—	150	—	°C
	Over Temperature Resume	—	—	110	—	°C
Gater Driver						
t_R	Rise Time	Co=1nF, 10%~90%	—	100	—	ns
t_F	Fall Time	Co=1nF, 10%~90%	—	70	—	ns
V_{CLAMP}	Gate Clamp Voltage	V_{CC}=25V	—	—	19.5	V
Dimming						
V_{DIM}	Linear Dimming Range	—	0.4	—	3	V
V_{sat}	Saturation Threshold Voltage	—	—	3	—	V
$V_{led(off)}$	LED Current off Threshold Voltage	—	—	0.4	—	V

Note: These Parameters, although guaranteed, are not 100% tested in production.

Typical Performance Characteristics

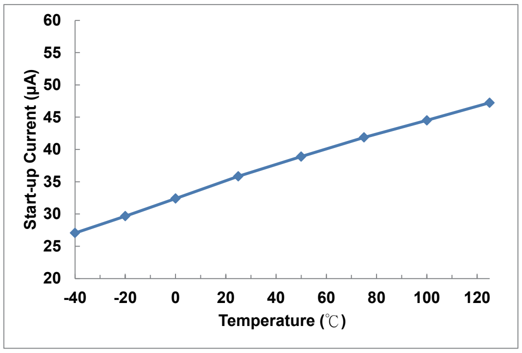


Figure 1. Start-Up current vs. temperature

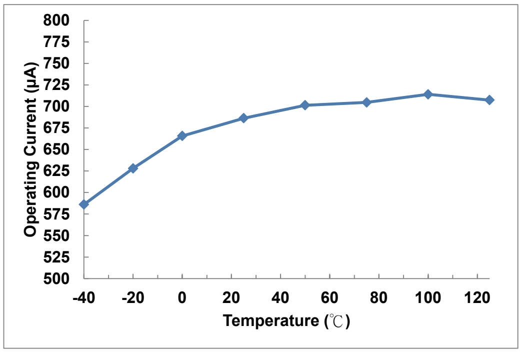


Figure 2. Operation current vs. temperature

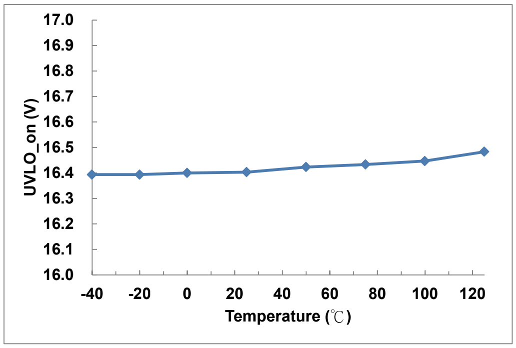


Figure 3. UVLO_on vs. temperature

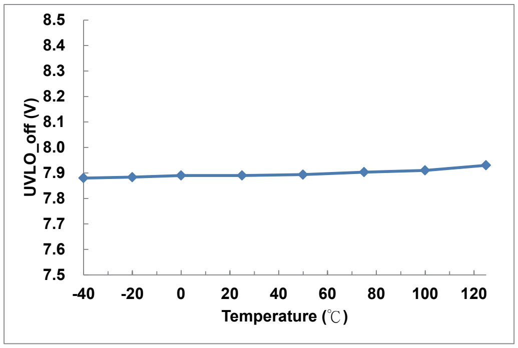


Figure 4. UVLO_off vs. temperature

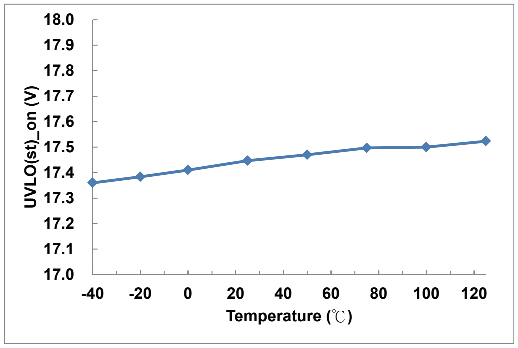


Figure 5. UVLO(st)_on vs. temperature

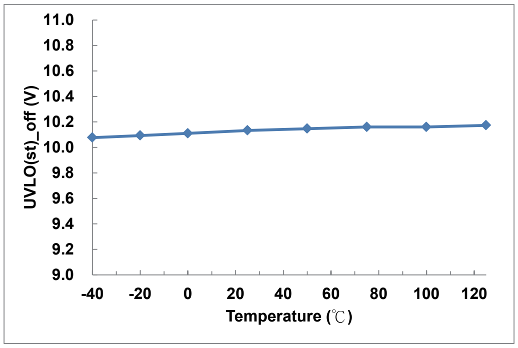


Figure 6. UVLO(st)_off vs. temperature

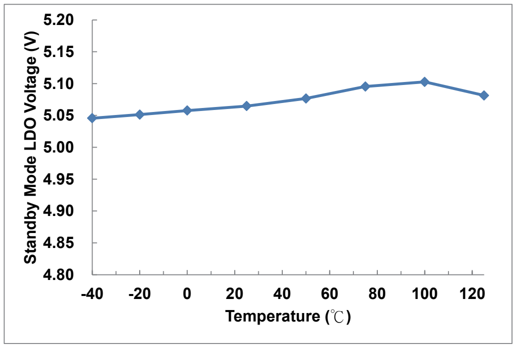


Figure 7. LDO Voltage (Standby Mode) vs. Temperature

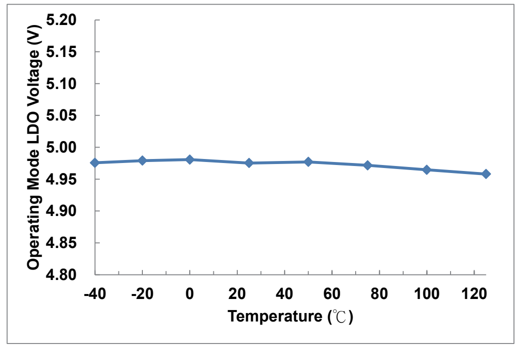


Figure 8. LDO Voltage (Operating Mode) vs. Temperature

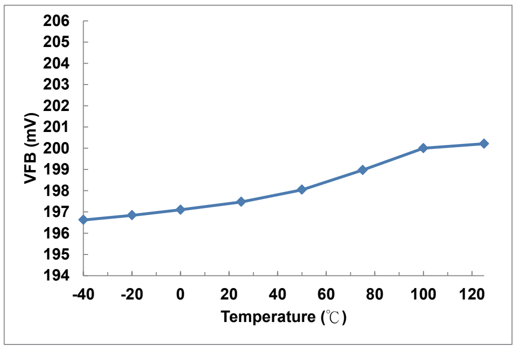


Figure 9. VFB vs. Temperature

Functional Description

The HT7L4661 is a universal AC/DC LED driver designed for LED lighting applications. The device can achieve high Power Factor values without resorting to additional external circuity and can also generate high accuracy LED drive currents with very few external components. Separate grounds are provided; one is a floating ground for the HT7L4661 while the other one is for ground. It is important to note that the two grounds cannot be directly connected together to avoid IC damage and system malfunction.

High Voltage Start-up

Due to its internal high-voltage startup circuit, when an AC voltage is applied to the power system, the device provides a high current to charge the external Vcc capacitor to speed up the system startup time. To save power consumption, after the Vcc voltage has exceeded the turn-on voltage and enters normal operation, the high-voltage startup circuit is shutdown.

VCC Under Voltage Lockout − UVLO

The device includes a UVLO feature which includes a 6.8V hysteresis value. The PWM controller turns on when VCC is higher than 16V and turns off when VCC is lower than 8.4V. The hysteresis characteristics guarantee that the device can be powered by an input capacitor during start-up. When the output voltage increases to a certain value after start-up, VCC will be charged by an output through an auxiliary winding or a Zener Diode. $V_Z=V_{LED}-V_{CC}$.

Low Dropout Regulator − LDO

A low dropout regulator (LDO) is included in the device and provides a stable 5V output voltage for other devices. When the dim voltage is lower than 0.4V, the LDO obtains its power from the high voltage start-up circuit and the drive current of LDO is 1mA. During normal operation, VCC will be charged by an output through an auxiliary winding or a Zener Diode. Thus, the driving current of LDO can increase to 5mA.

Boundary Conduction Mode − BCM

The power MOSFET is turned on by inductor current zero-crossing detector. The current zero-crossing can be detected by a ZCD voltage. When the inductor current is at the zero crossing point, the voltage on the ZCD pin will drop rapidly. The device then detects the falling edge and turns on the Power MOSFET. The boundary conduction mode provides low turn-on switching losses and high conversion efficiency.

Zero Current Detection − ZCD

The ZCD voltage is designed to operate between 0V and 3V for normal operation. If the voltage on the ZCD pin increases higher than 1.5V, the ZCD comparator waits until the voltage falls below 1V. When the inductor current is at the zero crossing point, the voltage on the ZCD pin will drop rapidly. The device will then detect the 1V falling edge and turn on the Power MOSFET. The 0.5V of hysteresis avoids any false triggering actions due to noise.

Constant Current Control

The device will sense the overall inductor current and form a closed-loop with an internal error amplifier to obtain high constant current accuracy. The CS voltage and the 0.2V reference voltage form the inputs to a Gm amplifier whose output is integrated using an external COMP capacitor. The ON time of the MOSFET is controlled by the COMP voltage to adjust the LED current.

Leading-Edge Blanking − LEB on CS

Each time the external power MOSFET is switched on, a turn-on spike will inevitably occur at the sense resistor. To avoid faulty triggering, a 400ns leading-edge blank time is generated. As this function is provided conventional RC filtering is therefore unnecessary. During this blanking period, the current-limit comparator is disabled and can therefore not switch off the gate driver.

Gate Driver Clamp

The DRV pin is connected to the gate of external MOSFET to control its ON/OFF function. To protect the external power MOSFET from being overstressed, the gate driver output is clamped to 17V.

Over Voltage Protection − OVP on VCC

In order to prevent PWM controller damage, the device includes an OVP function for VCC. Should the VCC voltage be higher than the OVP threshold voltage of 29V, the PWM controller will stop operation immediately. When the VCC voltage decreases below the UVLO off level, the controller will reset.

LED Open Protection – ZCD OVP

The LED voltage is reflected on the ZCD pin through a resistor RZCD. When the current through the RZCD resistor is higher than 300μA, then ZCD OVP protection will take place and the PWM controller will stop operation immediately. When the VCC voltage decreases below the UVLO off level, the controller will reset.

$V_{OVP-ZCD}$ can be set using the following equation:

$$V_{OVP-ZCD} = V_{ZCDH} + I_{OVP} \times R_{ZCD}$$

The V_{ZCDH} is the upper clamp voltage of 3V on the ZCD pin. The I_{OVP} represents the OVP current level on the ZCD pin which is 300μA. R_{ZCD} stands for the resistor connected between the ZCD pin and the LED positive terminal.

Over Current Protection – OCP

The device includes an over current protection function on the CS pin. An internal circuit detects the current level and when the current is larger than the over current protection threshold level, V_{OCP}/R_{CS}, the gate output will remain at a low level.

LED Short Protection – SCP

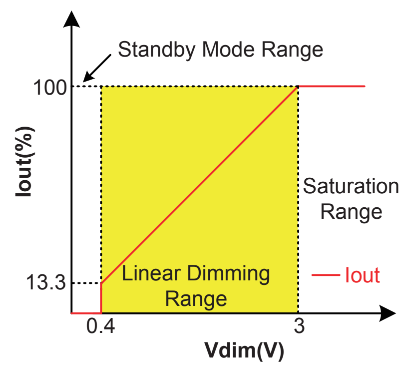
The output voltage drops when a number of LEDs in a string are shorted resulting in a voltage drop at VCC. Once the VCC drops below 8.4V, the device will stop operating. Under such situations, the start-up operation will recharge the VCC pin through the start-up resistor and the device will enter the UVLO hiccup mode.

Thermal Protection

A thermal protection feature is included to protect the device from excessive heat damage. When the junction temperature exceeds a threshold of 150°C, the thermal protection function will turn off the DRV terminal immediately. When the VCC decreases below the UVLO off level, the controller will reset.

Dimming Function

On the DIM pin, when the voltage on this pin is lower than 0.4V, the device output driving operation will be shut down and the LED current will reduce to zero for this condition. When the voltage is between 0.4V and 3V, the device will be operating in its linear dimming range and the LED current will be controlled according to the pin voltage. While the pin voltage is higher than 3V, the device will operate in its normal operating condition.



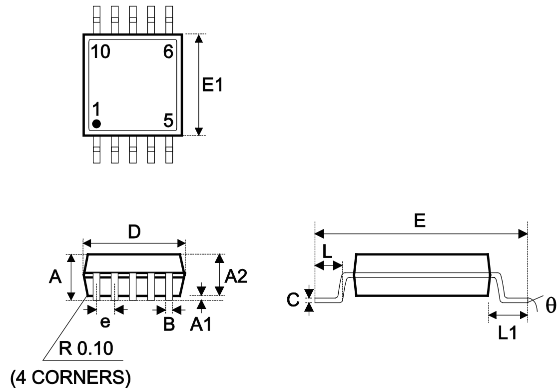
Package Information

Note that the package information provided here is for consultation purposes only. As this information may be updated at regular intervals users are reminded to consult the Holtek website for the latest version of the Package/Carton Information.

Additional supplementary information with regard to packaging is listed below. Click on the relevant section to be transferred to the relevant website page.

- Package Information (include Outline Dimensions, Product Tape and Reel Specifications)
- The Operation Instruction of Packing Materials
- Carton information

10-pin MSOP Outline Dimensions



Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	—	—	0.043
A1	0.000	—	0.006
A2	0.030	0.033	0.037
B	0.007	—	0.013
C	0.003	—	0.009
D	—	0.118 BSC	—
E	—	0.193 BSC	—
E1	—	0.118 BSC	—
e	—	0.020 BSC	—
L	0.016	0.024	0.031
L1	—	0.037 BSC	—
y	—	0.004	—
θ	0°	—	8°

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	—	—	1.10
A1	0.00	—	0.15
A2	0.75	0.85Q	0.95
B	0.17	—	0.33
C	0.08	—	0.23
D	—	3.00 BSC	—
E	—	4.90 BSC	—
E1	—	3.00 BSC	—
e	—	0.50 BSC	—
L	0.40	0.60	0.80
L1	—	0.95 BSC	—
y	—	0.10	—
θ	0°	—	8°