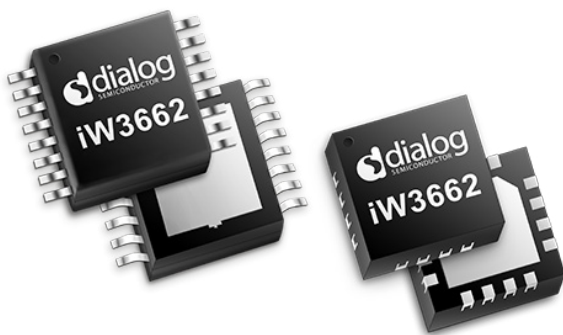


Low Voltage (12V_{AC}) Digital Control Dimmable LED Driver With Integrated FET

1.0 Features

- 10 to 24V_{DC} input voltage or 12V_{AC} input voltage
- Output power up to 8W
- Supports magnetic or electronic transformers
- Two operational modes:
 - Boost-Buck - low voltage LED arrays
 - Boost-Linear - high voltage COB LEDs
- Flickerless™ technology for flicker-free LED dimming
- Wide dimmer compatibility (leading edge, trailing edge, and digital)
- Deep dimming to 10% (depends on dimmers)
- Power factor > 0.7
- Integrated boost FET with 0.2Ω R_{DS(ON)}
- Tight LED current regulation (+/- 5%) in both modes
- Optimized dimming curve for maximizing dimmer and electronic transformer compatibility
- Over-temperature protection derating
- OVP, OCP, and open load protection
- 16-lead QFN (4x4mm) or 16-lead TSSOP



2.0 Description

The iW3662 advanced digital LED driver, designed for low voltage AC and DC input voltages, combines support for both low voltage LEDs and high voltage Chip-On-Board (COB) LED modules at power levels up to 8W.



The iW3662 features two selectable operating modes to accommodate both low voltage LEDs and high voltage COB LEDs in one part. The Boost-Buck mode provides a boost converter to step-up the input voltage to an intermediate voltage, which a second buck regulator stage steps down to create a highly efficient, constant current LED controller. The Boost-Linear mode, designed to work with high voltage COB LEDs, steps up the input voltage to a higher voltage than in the Boost-Buck mode, then, with the buck converter now disabled and reconfigured into a linear current regulator, provides a highly accurate constant current sink to drive the LEDs.

By integrating a low RDS(ON) power N-channel MOSFET for the boost converter, the iW3662 reduces external component count while the highly configurable digital control circuitry allows the end user to specify one part for multiple applications, covering the bulk of low voltage LED replacement bulb applications. Using Dialog's Flickerless™ technology allows the iW3662 to operate without visible flicker and operate with a broad range of input dimmer types (leading edge, trailing edge and digital) while effectively detecting and managing both electronic and magnetic transformers automatically. When the iW3662 detects a magnetic transformer, an additional output drives an external switch that can add extra input capacitance needed to ensure proper operation, easing the design of replacement bulbs compatible with both transformer types.

The iW3662 also integrates an internal bleeder FET to add a dynamic load to the input to guarantee proper electronic transformer performance during low dimming ranges. Also, full protection features including over-temperature protection derating, which lowers the output current drive to the LEDs when an over-temperature event occurs to guarantee light output even during a fault condition, provides robust and functional solutions for low voltage LED replacement lighting.

3.0 Applications

- V_{AC} or V_{DC} input dimmable LED lighting
- Lighting systems using electronic transformers

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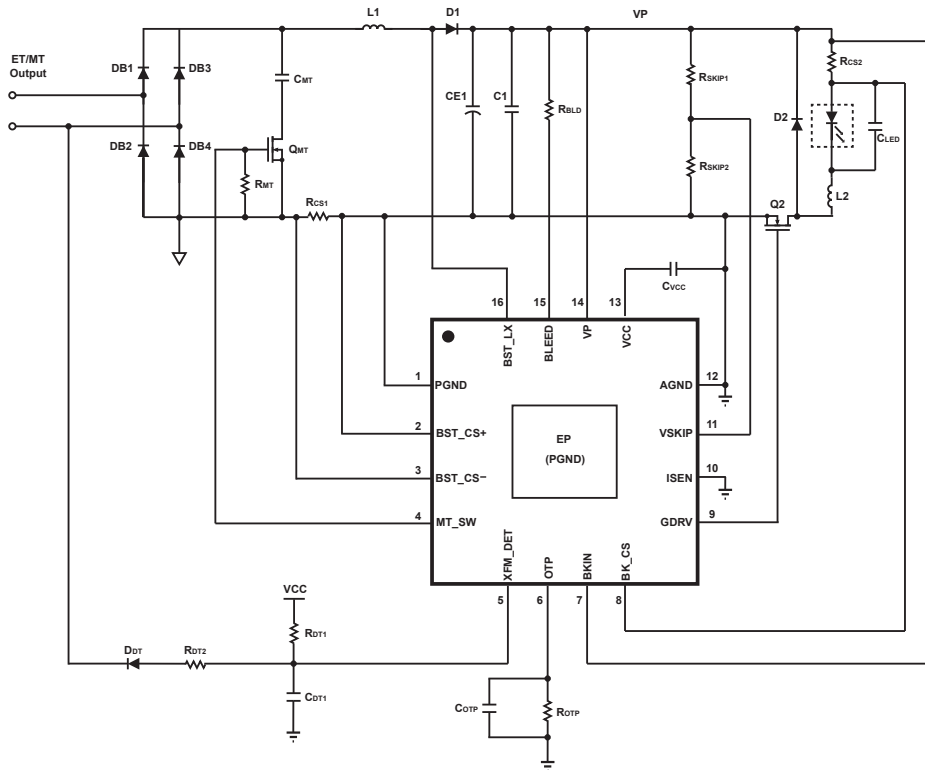


Figure 3.1: Typical Schematic for 12V/350mA (4W) Boost-Buck Configuration

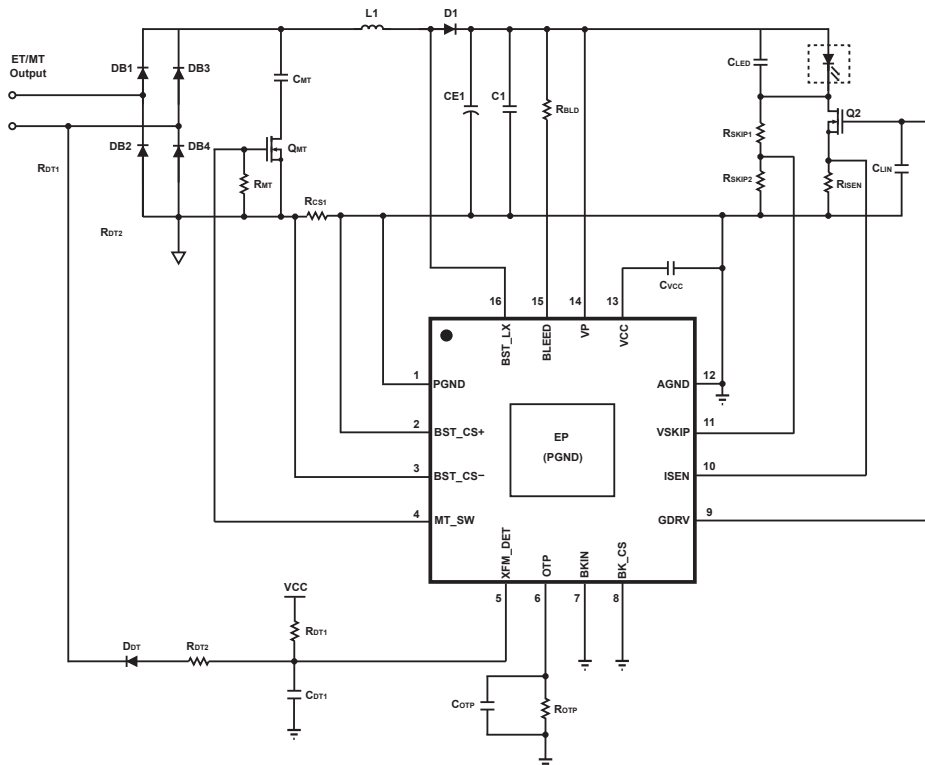


Figure 3.2: Typical Schematic for 38V/105mA (4W) Boost Configuration

Low Voltage (12V_{AC}) Digital Control
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4.0 Pinout Description

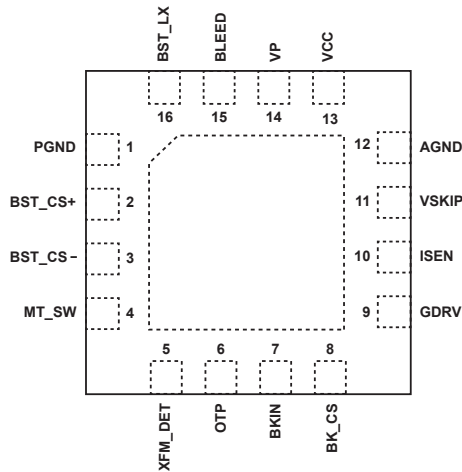


Figure 4.1: 16-Lead QFN Package

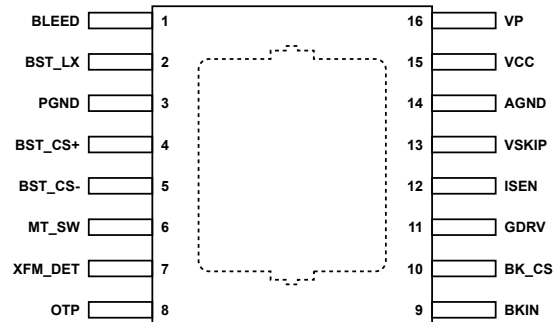


Figure 4.2: 16-Lead TSSOP Package

Pin #		Name	Type	Pin Description
QFN	TSSOP			
1	3	PGND	Ground	Power ground for internal boost FET and bleeder FET.
2	4	BST_CS+	Input	Boost current sense positive input.
3	5	BST_CS-	Input	Boost current sense negative input.
4	6	MT_SW	Output	Indicator of MT/ET detection within PMOS open drain output. MT: MT_SW = V _{CC} ; ET: MT_SW = OD
5	7	XFM_DET	Input	MT/ET detection input.
6	8	OTP	Input	OTP threshold program pin. Used to set the power derating temperature that is determined by an external resistor tied to AGND.
7	9	BKIN	Input	Buck power supply input. It is also used to configure the operation mode. V _{BKIN} > 2V: Boost-Buck mode; V _{BKIN} < 2V: Boost-Linear mode
8	10	BK_CS	Input	Buck current sense input. Connect resistor RCS2 from this pin to BKIN to define nominal average output current. It is also used to configure the skip function when in boost-linear mode. V _{BK_CS} > 2V: Disable skip function in boost-linear mode. V _{BK_CS} < 2V: Enable skip function in boost-linear mode.
9	11	GDRV	Output	Dual function: Boost-Buck mode: Gate driver for Buck FET. Boost-Linear mode: Gate driver for linear current regulator.
10	12	ISEN	Input	Current sense input for the linear current regulator.

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Pin #		Name	Type	Pin Description
QFN	TSSOP			
11	13	VSKIP	Input	Skip voltage threshold set pin.
12	14	AGND	Ground	Chip ground.
13	15	V _{CC}	Output	LDO 5V output. Connect a 4.7uF capacitor typically to AGND.
14	16	VP	Power	Chip power supply input.
15	1	BLEED	Input	Input for the internal bleeder FET. It ties a resistor to VP.
16	2	BST_LX	Input	Boost switch node.
		EP	Ground	Exposed PAD. It is internally tied to PGND.

5.0 Absolute Maximum Ratings

Absolute maximum ratings are the parameter values or ranges which can cause permanent damage if exceeded.

Parameter	Symbol	Value	Unit	
BST_LX, VP to AGND		-0.3 to 60	V	
BLEED, VSKIP to AGND		-0.3 to 60	V	
BKIN, BK_CS to AGND		-0.3 to 60	V	
BST_CS- to AGND		-5 to 0.3	V	
XFM_DET, MT_SW to AGND		-0.3 to 6.5	V	
Other pins to AGND		-0.3 to 6.5	V	
Maximum junction temperature	T _{JMAX}	150	°C	
Operating junction temperature	T _{JOPT}	-40 to 150	°C	
Storage temperature	T _{STG}	-65 to 150	°C	
Thermal Resistance Junction-to-Ambient [Still Air]	θ_{JA}	QFN4x4	TBD	°C/W
		TSSOP16	TBD	
ESD rating per JEDEC JESD22-A114		±2,000	V	

Parameter	Symbol	Value	Unit
Supply voltage (VP)		7 to 60	V
Boost output voltage range (boost-buck mode)		22 to 28	V
Boost output voltage range (boost-linear mode)		25 to 45	V

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6.0 Electrical Characteristics

V_{CC} = 12V, -40°C ≤ T_A ≤ 85°C, unless otherwise specified (Note 1)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Xxxxxx						
Xxxxx xxx xxxxx xxxxx	Xxxxx xxxx	Xxxxx xxx xxxx				
Xxxxxx xx xx xxxxxx xx	Xxxxxx	Xxxxxx				
Xxxxxx xx xx xxxxxx xx	Xxxxxx	Xxxxxx				
Xxxxxx xx xx xxxxxx xx	Xxxxxx	Xxxxxx				
Xxxxxx xx xx xxxxxx xx	Xxxxxx	Xxxxxx				
Xxxxxx xx xx xxxxxx xx	Xxxxxx	Xxxxxx				
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Xxxxxx xx xx xxxxx xx	Xxxxx	Xxxxxx				
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Xxxxxx xx xx xxxxxx xx	Xxxxxx	Xxxxxx				
Xxxxxx xx xx xxxxxx xx	Xxxxxx	Xxxxxx				

Low Voltage (12V_{AC}) Digital Control Dimmable LED Driver With Integrated FET

6.0 Electrical Characteristics (cont.)

V_{CC} = 12V, -40°C ≤ T_A ≤ 85°C, unless otherwise specified (Note 1)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Xxxxxxx						
Xxxxx xx xx xxxxx	Xxxxxx					
Xxxxx xx xx xxxxx	Xxxxxx					
Xxxxx xx xx xxxxx	Xxxxxx					
Xxxxx xx xx xxxxx	Xxxxxx					
Xxxxxx						
Xxxxxx xx xx xxx	Xxxxxx					

Notes:

Note 1. Xxxxx xxx xx xxxxx xxx xxxxx xxxxx.

Note 2. Xxxxx xxx xx xxxxx xxx xxxxx xxxxx.

Note 3. Xxxxx xxx xx xxxxx xxx xxxxx xxxxx.

Note 4. Xxxxx xxx xx xxxxx xxx xxxxx xxxxx.

Low Voltage (12V_{AC}) Digital Control Dimmable LED Driver With Integrated FET

7.0 Typical Performance Characteristics

Figure 7.1 : XxxX XxxXxx XxxXxx XxxXxx

Figure 7.2 : XxxX XxxXxx XxxXxx XxxXxx

Figure 7.3 : XxxX XxxXxx XxxXxx XxxXxx

Figure 7.4 : XxxX XxxXxx XxxXxx XxxXxx

Low Voltage (12V_{AC}) Digital Control Dimmable LED Driver With Integrated FET

8.0 Functional Block Diagram

The iW3662 integrates a buck controller and a boost-buck controller in a dual-mode device designed to drive LEDs from a low voltage AC or DC input voltage. In Boost-Buck mode, the initial boost stage steps up the input voltage to a configurable intermediate voltage and provides the input voltage for the second, buck (step-down) stage. The second stage is a constant-current step-down current regulator that provides the regulated output current to the low voltage LED array. A second operational mode, the Boost-Linear mode, works by disabling the buck stage, the boost stage steps up the voltage and the LED current is regulated by a linear current regulator.

The iW3662 integrates an internal N-channel MOSFET for the first boost stage to reduce the external component count. The second stage is a control circuit that drives an

external MOSFET for either a buck converter (Boost-Buck mode) or a linear current regulator (Boost-Linear mode), making a highly configurable IC for driving discrete LEDs or high-voltage Chip-On-Board (COB) LED modules.

Integrated in the iW3662 is a detection circuit allowing the device to work with either Electronic Transformers (ET) or Magnetic Transformers (MT). When a magnetic transformer is detected, the device enables an external switch that allows for additional input capacitance to be added to the input line. As a device with Dialog's Flickerless™ technology integrated, the iW3662 works with a wide range of dimmers and provides flicker-free operation over the full dimming range. The dimming algorithm is optimized for operation with electronic transformers to ensure compatibility.

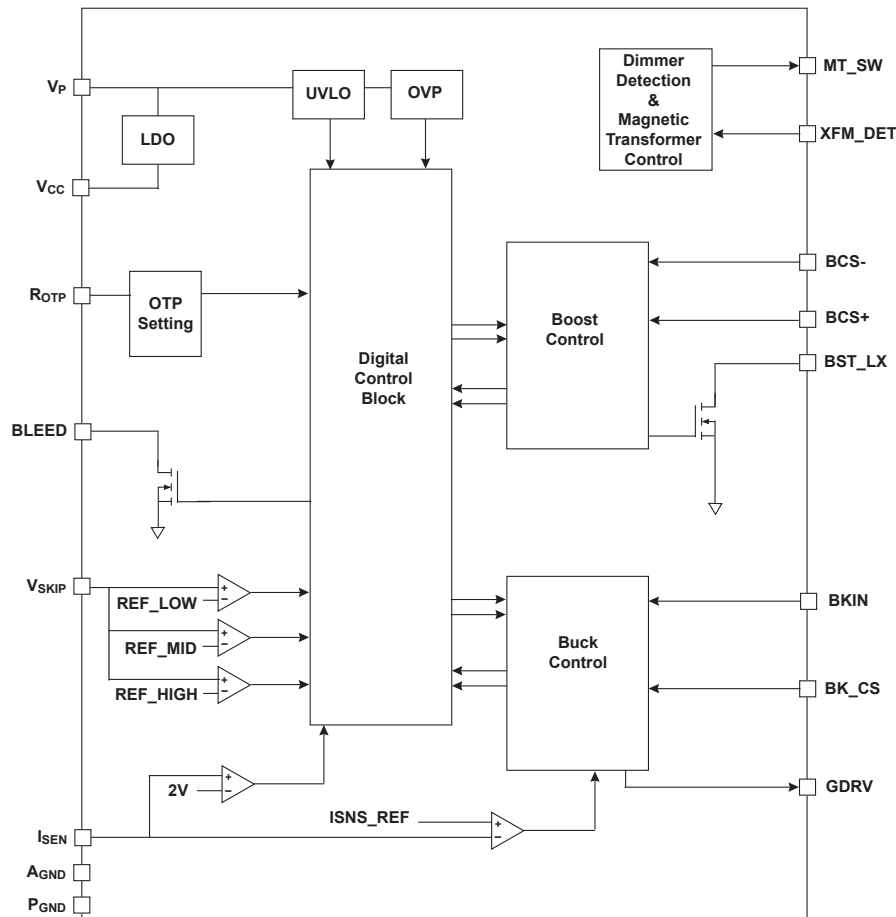


Figure 8.1 : iW3662 Functional Block Diagram

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9.0 Theory of Operation

9.1 Input Voltage (V_P)

The V_P pin on the iW3662 is the main input power supply and has an operating range of 7V to 60V. An under voltage lock out (UVLO) circuit protects the circuit from an undervoltage condition by holding the main gate driver output low (MOSFET off) until the input voltage reaches a minimum of 6.0V. The UVLO circuit also incorporates 300mV of hysteresis to prevent chattering.

The input is also protected from overvoltage events by two different levels of protection. If the input exceeds the overvoltage protection (OVP) threshold, the iW3662 will stop switching the internal MOSFET until the input voltage drops below the OVP threshold plus 1% of hysteresis. In the event that the overvoltage event continues for more than 50ms, or if a secondary higher threshold (OVP_SD) is tripped, the device shuts down and will not re-start until the system power is cycled. When in Boost-Buck Mode, the OVP threshold is set at 56V with the OVP_SD threshold at 59V. In the Boost-Linear mode, OVP is 51V and OVP_SD is 54V.

9.2 V_{CC} Regulator

An internal LDO regulator provides a stable 5V power supply to the MOSFET driver and bias circuits inside the iW3662. A low-ESR, 4.7uF ceramic capacitor should be placed between V_{CC} and the AGND pin for stability. A UVLO circuit prevents the internal circuitry from enabling until the output of the LDO is at least 4V. Once the voltage on the V_{CC} pin goes above the 4V level, the iW3662 will be enabled.

9.3 Transformer Type Detection

Both Magnetic Transformers and Electronic Transformers each have a distinct waveform which contains frequency information that can be used by the iW3662 to detect which type of transformer is being used. Figure 9.1 shows the waveforms for both Magnetic and Electronic Transformers.

INSERT ELECTRONIC AND MAGNETIC TRANSFORMER WAVEFORMS FROM SOURCE DOCUMENT (FIGURE 9.1 in source document)

Figure 9.1 : Electronic and Magnetic Transformer Waveforms

The iW3662 detects the transformer type by extracting the information from the waveform and, using a digital detection circuit, determines which type is connected. The iW3662 starts in a default state that assumes an Electronic Transformer will be used. This default state assures that

users of ET devices will not have to populate any external components and those who use MT devices will also be ensured proper start-up, detection and operation. The MT_SW output defaults in a low state (V_{OL}) and if a magnetic transformer is detected, the output of MT_SW then goes high (V_{OH}). The MT_SW pin drives an external MOSFET that allows additional input capacitance to be added to the circuit when a magnetic transformer is detected. The output of the MT_SW pin is an open-drain PMOS device and requires a pull-down resistor to make sure that the output is in a known (Low) state until the internal circuitry powers up correctly.

9.4 Operation Mode Selection

In order to program the iW3662 to operate either in the Boost-Buck mode or Boost-Linear mode, the BKIN pin serves the dual purpose to facilitate the programming process without adding additional pins. The BKIN pin, when used in the Boost-Buck mode will have a voltage higher than 2V on it and the device, when it detects this voltage, will automatically switch into Boost-Buck mode. If the BKIN pin is grounded, the device will detect a voltage lower than 2V and switch the iW3662 into Boost-Linear mode, disabling the buck controller mode and enabling the linear current regulator mode.

9.5 Bleeder

An internal bleeder switch is integrated in the iW3662 and provides various functions. An external resistor between V_P and BLEED helps to ensure flicker-free operation at low power and low dimming percentage. Also, the internal digital circuitry collects information from the Bleeder function and modulates the control circuit accordingly, depending upon which operating mode the device is in, Boost-Buck or Boost-Linear.

The Bleeder function only operates for a limited period of time so as to reduce power loss and maintain high efficiency. The on-time for the bleeder switch occurs during half of the line cycle and is internally limited as a function of the line frequency. In Boost-Buck mode, the on-time of the switch is limited to a maximum of 1.12ms. In Boost-Linear mode, the on-time is limited to a maximum of 0.45ms.

The maximum power loss of the bleed resistor can be calculated based on the input voltage, V_P, the on-time and the resistance value. The higher the power consumption in the bleeder resistor, the better the input power jitter can be filtered. In order to minimize size and optimize system

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efficiency, the max power loss in the bleeder resistor should be no more than 0.3W.

The maximum bleeder loss is calculated based on the maximum time limit, the voltage at V_P and the period of the line voltage. In the examples shown in figures 3.1 and 3.2, used for these calculations, the line frequency is assumed to be 50Hz.

$$P_{BLD} = \frac{V_P^2}{R_{BLD}} \times \frac{t_{lim}}{\frac{1}{2}T_{ac}} \quad (9.0)$$

For the Boost-Buck mode operation, the output voltage of the boost converter in figure 3.1 is 24V and for the Boost-Linear mode operation of figure 3.2, the boost voltage is 42V. Using equation 9.1, the R_{BLD} values calculate out to 215 Ω for the Boost-Buck mode and 264 Ω for the Boost-Linear mode.

9.6 Skip Function

The iW3662 integrates a skip function to aid in maintaining flicker-free operation and optimize efficiency when the bleeder resistor cannot. The skip function disables the boost circuit when the input power goes higher than necessary for the output power consumption at that time. This helps to reduce flicker and improve efficiency.

When the input power is higher than the output power, the boost voltage will increase. In the Boost-Buck mode, there are three skip mode thresholds, V_{REF_HIGH} , V_{REF_MID} and V_{REF_LOW} . The skip function monitors the output of the boost converter directly (V_P) via a resistor divider and when the voltage at the SKIP pin exceeds the V_{REF_HIGH} voltage (table xx), the boost converter stops functioning until the voltage begins to drop back down. When the voltage at the skip pin drops below V_{REF_MID} , the boost converter is enabled. V_{REF_LOW} acts to quickly start-up the output voltage of the boost in the event of a transient that occurs when the boost is disabled. In Boost-Linear mode, the voltage monitored is the voltage at the drain of the linear current regulator MOSFET, which helps to account for the variation of the forward voltage drop of the LEDs. There are two threshold voltages, V_{REF_HIGH} and V_{REF_LOW} . When the voltage at SKIP exceeds V_{REF_HIGH} , the boost converter stops switching. When the voltage decays below the V_{REF_LOW} threshold, the boost converter enables.

	Boost-Buck	Boost-Linear
VREF_HIGH	1.4V	1.6V
VREF_MID	1.2V	-

	Boost-Buck	Boost-Linear
VREF_LOW	1.0V	1.0V

Table 9.1 Skip Threshold Voltages

To calculate the Skip resistor values for Boost-Buck mode, the voltage at the output of the boost converter, 24V, is used as a starting point. The V_{REF_MID} voltage is the set point for the nominal output voltage. Using V_P and V_{REF_MID} , we can solve for R_{SKP1} and R_{SKP2} .

$$V_P \times \frac{R_{SKP2}}{R_{SKP1} + R_{SKP2}} = V_{REF_MID} = 1.2V \quad (9.1)$$

The ratio of R_{SKP1} to R_{SKP2} comes out to 19:1, which when using standard 1% resistor values, comes out to 190k Ω for R_{SKP1} and 10k Ω for R_{SKP2} for Boost-Buck mode.

For Boost-Linear mode, equation 9.1 can be re-used but, the V_{REF_MID} figure is replaced with V_{REF_LOW} , and V_P in the Boost-Linear circuit of Figure 3.2 is 42V. Therefore, the ratio of R_{SKP1} to R_{SKP2} is 2:1 and using standard 1% resistors, gives R_{SKP1} of 200k Ω and R_{SKP2} of 100k Ω .

9.7 Boost Controller

The boost controller is a hysteretic peak and valley mode control topology. The current is monitored via a current sense resistor connected between the BST_CS+ and BST_CS- pins. Internal circuitry removes any false readings due to current spikes, removing sensitivity to poor layout.

9.7.1 Boost Output Capacitor

On the output of the boost converter stage, two output capacitors are recommended for optimal operation. The main, bulk capacitance (CE1) and a second, high quality, low-ESR ceramic capacitor (C1) to help smooth out the ripple current. The main bulk capacitance provides energy to the output stage of the circuit during transients and when an electronic transformer has no output. For design purposes, a maximum dead-time of 4ms can be used for calculating the capacitance value.

Figure 3.1 shows the schematic for a typical Boost-Buck application circuit and capacitor CE1 can be calculated by using the following assumptions. The iW3662 can tolerate a droop on the output of the boost converter up to 5V during the dead-time in Boost-Buck mode. Using this voltage droop and the known 4ms dead-time, the required output capacitance value can easily be calculated.

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$$C_{EI} = \frac{I_{LED1} \times T_{DEAD}}{\Delta V} \quad (9.2) \quad \Delta I_{LI} = I_{PEAK} - I_{VALLEY} = 0.8A \quad (9.8)$$

$$C_{EI} = \frac{350mA \times 4ms}{5V} = 280\mu F \quad (9.3)$$

For Boost-Linear mode, C_{E1} can be calculated using equation 9.1, but using a maximum droop voltage of 3V and 105mA of LED current, the current rating of figure 3.2

$$C_{EI} = \frac{105mA \times 4ms}{3V} = 140\mu F \quad (9.4)$$

9.7.2 Boost Current Sense Resistor

A current sense resistor, R_{CS1} , is used by the boost converter for its peak and valley mode control scheme. Equation 9.5 is used to calculate the current sense resistor value.

$$R_{CS1} = \frac{V_{REF_IPEAK} + V_{REF_IVALLEY}}{2 \times I_{L_AVG}} \quad (9.5)$$

Where V_{REF_IPEAK} is 0.22V and $V_{REF_IVALLEY}$ is 0.1V, and for better ET compatibility, the average inductor current is 1.1A. Using equation 9.5, the R_{CS1} value can be calculated for the example used in figures 3.1 and 3.2 to be 0.145Ω or 0.15Ω, a more standard value. Using these values, then the Peak and Valley currents can be calculated.

$$I_{PEAK} = \frac{V_{REF_IPEAK}}{R_{CS1}} \quad (9.6)$$

$$I_{VALLEY} = \frac{V_{REF_IVALLEY}}{R_{CS1}} \quad (9.7)$$

Using the variables above, I_{PEAK} calculates out to 1.467A and I_{VALLEY} calculates out to 0.667A. The difference between the peak current and valley current gives the full change in current in the boost inductor.

9.7.3 Boost Inductor

To calculate the boost inductor value required for the first stage, first the on-time and off-time must be determined. Then, using the currents determined in section 9.4.2 and the on and off times, the inductor value required can easily be determined. First, the equations for on time and off time.

$$t_{on} = \frac{L \times \Delta I}{V_{ET}} \quad (9.9)$$

$$t_{off} = \frac{L \times \Delta I}{V_P - V_{ET}} \quad (9.10)$$

The operating period of the boost converter, and therefore the frequency, can be determined using the on and off times.

$$f = \frac{1}{t_{on} + t_{off}} = \frac{1}{L \times \Delta I \times \left(\frac{1}{V_{ET}} + \frac{1}{V_P - V_{ET}} \right)} \quad (9.11)$$

$$= \frac{V_{ET} \times (V_P - V_{ET})}{L \times \Delta I \times V_P}$$

Solving for the inductance value using equation 9.11 gives the following.

$$L = \frac{1}{f \times \Delta I} \times \frac{V_{ET} \times (V_P - V_{ET})}{V_P} \quad (9.12)$$

In order to properly select the inductance value, the minimum boost frequency should be determined based on the minimum voltage out of the ET. In this case, the minimum voltage is 6V and the recommended minimum switching frequency for optimal size and efficiency is recommended to be 400kHz. Using these new variables and previous assumptions about the output voltage of the boost converter (24V for Boost-Buck mode and 42V for Boost-Linear mode), The inductance value for each operating mode can easily be calculated.

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For Boost-Buck mode:

$$L = \frac{I}{400 \times 10^3 \times 0.8} \times \frac{6 \times (24 - 6)}{24} = 14.06 \mu\text{H} \quad (9.13)$$

$$L = 15 \mu\text{H}$$

For Boost-Linear mode:

$$L = \frac{I}{400 \times 10^3 \times 0.8} \times \frac{6 \times (42 - 6)}{42} = 16.07 \mu\text{H} \quad (9.14)$$

$$L = 15 \mu\text{H}$$

In both operating modes, the inductance value selected comes out at 15uH in order to use standard inductor values. The switching frequency range for each mode is substantially different in that the Boost-Buck mode, with the lower output voltage, gives a tighter range of switching frequency. The Boost-Linear mode, with the much higher output voltage on the output voltage of the boost gives a switching frequency variation of almost 2:1.

9.7.4 Boost Output Rectifying Diode

A schottky diode in the output of the boost converter is needed to rectify the output voltage. The diode must have a reverse voltage rating minimum of the output voltage of the boost converter, while the forward conduction current rating must support the full output current of the boost converter at a low forward voltage drop.

9.8 Buck Controller

The buck controller integrated in the iW3662 provides the constant current control portion of the Boost-Buck mode. The controller operates in hysteretic mode with dynamic hysteresis to control the inductor current and guarantee flicker-free operation down to the minimum dimming percentage. The switching frequency of the buck converter is determined by the hysteresis, load current and output filter. At the lower end of the dimming range, the switching frequency increases in order to prevent dimming or jittering that can be caused by minimum pulse widths at low duty cycle operation.

The pins that govern the buck controller functionality start with the BKIN and BKCS pins. The BKIN pin has two functions. It functions as a current sense input for the buck controller

along with BK_CS, and it also is an input pin to define the operating mode of the iW3662 as discussed in section 9.4. For designs using only the Boost-Linear mode, the BKIN pin should be grounded, disabling the buck controller circuitry.

9.8.1 Buck Current Sense Resistor

The current supplied to the LED in Boost-Buck mode is determined by the current sense resistor connected between BKIN and BK_CS and it is determined by the following equation.

$$I_{LED1} = \frac{0.1\text{V}}{R_{CS2}} \quad (9.15)$$

$$R_{CS2} = \frac{0.1\text{V}}{I_{LED1}} = \frac{0.1\text{V}}{350\text{mA}} = 0.285\Omega \quad (9.16)$$

9.8.2 Buck Inductor

The inductor for the buck converter can be determined very similarly to how the boost inductor was determined in section 9.7.3. First, the on and off times are calculated, then the switching frequency and finally the required inductance value.

$$t_{on} = \frac{L \times \Delta I}{V_P - V_{LED}} \quad (9.17)$$

$$t_{off} = \frac{L \times \Delta I}{V_{LED}} \quad (9.18)$$

$$f = \frac{I}{t_{on} + t_{off}} = \frac{I}{L \times \Delta I \times \left(\frac{1}{V_{LED}} + \frac{1}{V_P - V_{LED}} \right)} \quad (9.19)$$

$$= \frac{V_{LED} \times (V_P - V_{LED})}{L \times \Delta I \times V_P}$$

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$$L = \frac{I}{f \times \Delta I} \times \frac{V_{LED} \times (V_P - V_{LED})}{V_P} \quad (9.20)$$

$$R_{ISEN} = \frac{0.2V}{I_{LED2}} = \frac{0.2V}{105mA} = 1.9\Omega \quad (9.22)$$

The highest recommended buck converter switching frequency for optimal efficiency is 250kHz. Using this number and plugging in the rest of the variables, the inductance value can easily be calculated. For the example shown in figure 3.2, V_P is 24V, V_{LED} is 12V and I_{LED} is 350mA.

$$L = \frac{I}{250 \times 10^3 \times 0.35 \times 30\%} \times \frac{12 \times (24 - 12)}{24} = 229\mu H \quad (9.21)$$

$$L = 220\mu H$$

Care must be taken in specifying the inductor so that the saturation current rating is higher than the peak current and that the continuous current rating is above the mean output current.

9.8.4 Buck Rectifier Diode

A rectifier diode from V_P to the Drain of the power N-channel MOSFET must be used to ensure high efficiency. A schottky diode with current capability rated to be above the peak current rating in forward conduction mode and low leakage in reverse conduction mode at max input voltage is recommended to maximize efficiency.

9.9 Linear Current Regulator

When in Boost-Linear mode, the control circuits used in Boost-Buck mode to control the buck converter function become the control circuits for a linear current regulator. This provides stable current control for high voltage Chip-On-Board (COB) LEDs. When in Boost-Linear mode, the GDRV output controls an N-Channel MOSFET and current sense resistor via the ISEN pin (figure 3.2). The LED current is programmed by the voltage at ISEN and the current sense resistor. The voltage at ISEN is 0.2V and it is adjusted by an internal circuit in order to dim the LED current. The current regulation accuracy is better than +/-5%. A 1.5nF capacitor from GDRV to AGND is recommended to aid in stabilizing the output of the driver.

R_{ISEN} is calculated by a very simple Ohm's law calculation.

$$I_{LED2} = \frac{0.2V}{R_{ISEN}} \quad (9.21)$$

9.10 LED Shunt Capacitor

A capacitor can be placed across the LED load, whether in Boost-Buck mode or Boost-Linear mode to aid in reducing the ripple current. The capacitor does not affect stability nor efficiency, but it will reduce start-up time as the output has to charge the C_{LED} capacitor before the LEDs begin to emit light. A value of 1 μ F is recommended.

9.11 Protection Features - Over-Temperature Protection (OTP)

The iW3662 integrates Dialog's unique over-temperature protection derating circuit that reduces the output current to the LEDs in small steps when the internal temperature sensor reaches a pre-determined temperature threshold in order to reduce the power dissipation to protect the IC and the application while maintaining light output. Figure 9.2 shows the OTP characteristic of the iW3662. The iW3662 linearly reduces drive to the output LEDs when the internal over-temperature threshold is crossed. The device reduces drive from 100% of programmed output current to 80% output current and at that point, if the temperature keeps rising, it will trip a secondary thermal shutdown threshold which will shut down the output completely.

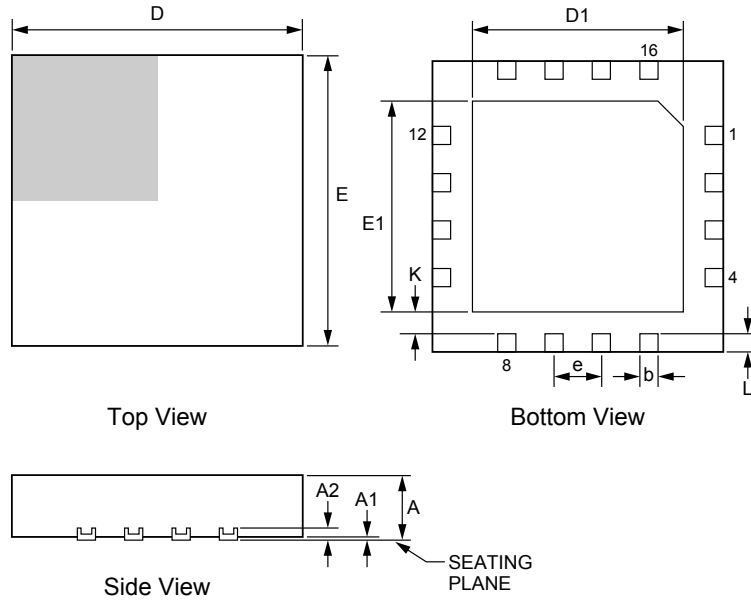
ADD FIGURE 9.4 FROM THE SOURCE DOCUMENT HERE and LABEL:

Figure 9.2 : Over-Temperature Protection Characteristic

Low Voltage (12V_{AC}) Digital Control
Dimmable LED Driver With Integrated FET

10.0 Physical Dimensions

Figure 10.1 : 16-Lead QFN4x4 Package



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.031	0.035	0.80	0.90
A1	0.0	0.002	0.00	0.05
A2	0.008 REF		0.20 REF	
b	0.010	0.014	0.25	0.35
D	0.157 BSC		4.00 BSC	
D1	0.110	0.118	2.80	3.00
E	0.157 BSC		4.00 BSC	
E1	0.110	0.118	2.80	3.00
e	0.026 BSC		0.65 BSC	
K	0.0098 REF		0.25 REF	
L	0.008	0.016	0.20	0.40

Compliant to JEDEC Standard MS12F

Controlling dimensions are in millimeters; inch dimensions are for reference only

This product is RoHS compliant and Halide free.

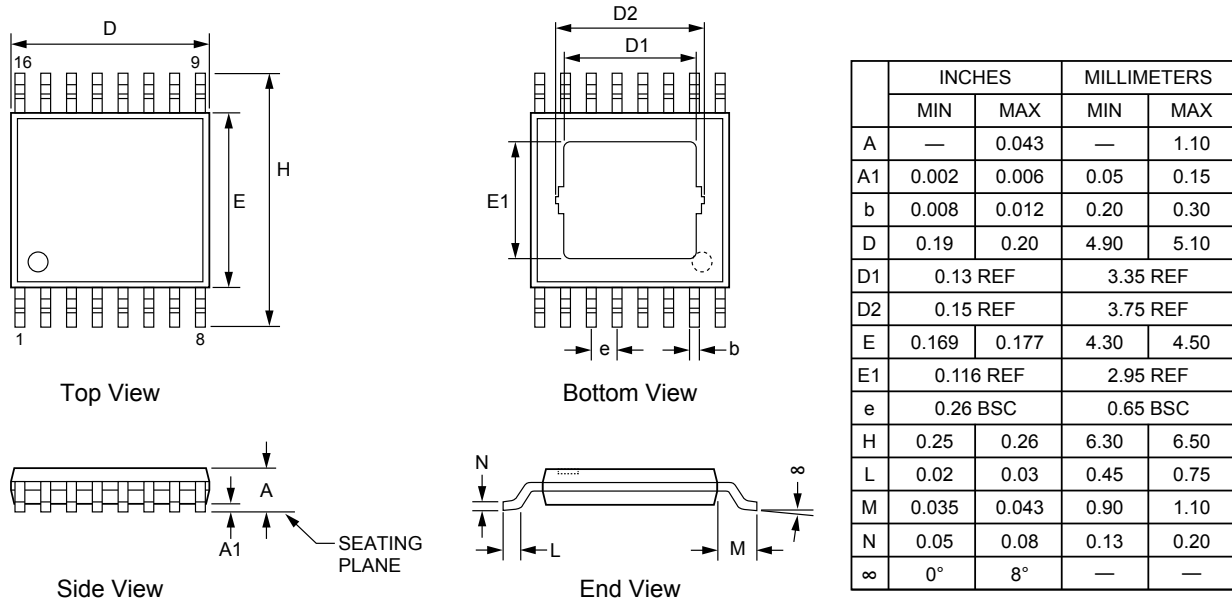
Soldering Temperature Resistance:

[a] Package is IPC/JEDEC Std 020D Moisture Sensitivity Level 1

[b] Package exceeds JEDEC Std No. 22-A111 for Solder Immersion Resistance; package can withstand 10 s immersion < 260°C

**Low Voltage (12V_{AC}) Digital Control
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Figure 10.2 : 16-Lead TSSOP Package



Compliant to JEDEC Standard MS12F

Controlling dimensions are in inches; millimeter dimensions are for reference only

This product is RoHS compliant and Halide free.

Soldering Temperature Resistance:

[a] Package is IPC/JEDEC Std 020D Moisture Sensitivity Level 1

[b] Package exceeds JEDEC Std No. 22-A111 for Solder Immersion Resistance; package can withstand immersion < 260°C

The package top may be smaller than the package bottom. Dimensions D and E are determined at the outermost extremes of the plastic body exclusive of mold flash, tie bar burrs, gate burrs and interlead flash, but including any mismatch between the top and bottom of the plastic body.

11.0 Ordering Information

Part Number	Options	Package	Description
iW3662-00	Low voltage SSL controller (12V _{AC} or 10-24V _{AC}) in QFN 16-lead, 4x4mm package	QFN16, 4x4	Tape & Reel ¹
iW3662-01	Low voltage SSL controller (12V _{AC} or 10-24V _{AC}) in TSSOP 16-lead package	TSSOP16	Tape & Reel ¹

Note 1: Tape & Reel packing quantity is 3,000/reel. Minimum ordering quantity is 3,000.

Low Voltage (12V_{AC}) Digital Control Dimmable LED Driver With Integrated FET

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