CR5608

AC/DC Digital Power Controller for Single-Stage High Power Factor Dimmable LED Drivers

iWatt®
Power Management Simplified Digitally™

1.0 Features

- Isolated/non-isolated offline 120V_{AC}/230V_{AC} LED driver up to 15W output power

- Wide line frequency range (from 45Hz to 66Hz)

- Meets IEC61000-3-2 current harmonic requirement

- Total harmonic distortion < 20% with PF > 0.92

- Wide dimmer compatibility
  - » Leading-edge dimmer
  - » Trailing-edge dimmer

- Dimming range from 10% to 100%

- Resonant control to achieve high efficiency (typical > 82% without dimmer)

- Over-temperature LED current foldback

- Small solution size
  - » Single-stage topology reduces part counts
  - » 90kHz maximum switching frequency enables small transformer use

- Primary-side sensing eliminates the need for opto-isolator feedback

- Tight LED current regulation (± 5%)

- Fast start-up (< 0.5s without dimmer)

- Compatible with NEMA SSL6 dimming curve standard

- Multiple protection features that include:
  - » LED open-circuit and short-circuit protection
  - » Over-current protection
  - » Over-temperature protection
  - » Current sense resistor short-circuit protection
  - » AC line over-voltage protection

2.0 Description

The CR5608 is a single-stage, high-performance AC/DC offline power supply controller for dimmable LED luminaires. It uses advanced digital control technology to detect the dimmer type, which provides dynamic impedance to interface with the dimmer and control the LED brightness at the same time.

With advanced dimmer detection technology, the CR5608 can operate with most wall dimmers including leading-edge dimmers (R-type or R-L type) and trailing-edge dimmers (R-C type). The CR5608's cycle-by-cycle waveform analysis technology allows for a fast dimmer setting response. When no dimmer is on the line, the CR5608 optimizes the power factor and minimizes the current harmonic distortion to the AC line. In no dimmer condition, output current is regulated at nominal output current value over a wide input voltage range.

The CR5608 operates the main power converter that delivers current to the LED load in quasi-resonant mode to provide high power efficiency and minimize electro-magnetic interference (EMI). The commonly used converter topologies for CR5608 are buck-boost and flyback. It uses iWatt's patented PrimAccurate™ primary-side sensing technology to achieve excellent LED current regulation under different AC line and LED load voltages, without using a secondary-side feedback circuit and thus eliminating the need for an opto-coupler.

The CR5608 minimizes the external component count by simplifying the EMI filter with iWatt's EZ-EMI® technology. The intelligent dimmer detection technology minimizes the bleeding power loss. Additionally, the CR5608 digital control loop maintains stable overall operating conditions without the need for loop compensation components.

3.0 Applications

- Dimmable LED retrofit lamps up to 15W
- Dimmable LED luminaries up to 15W
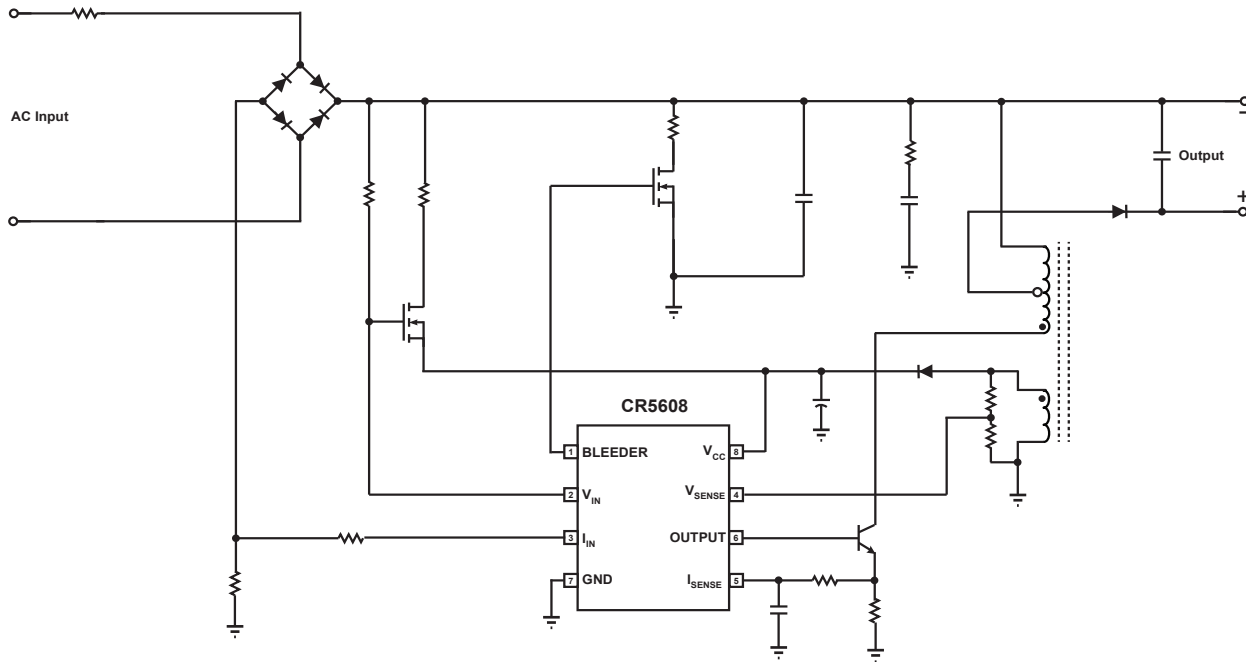
Figure 3.1 : CR5608 Simplified Application Circuit

4.0 Pinout Description
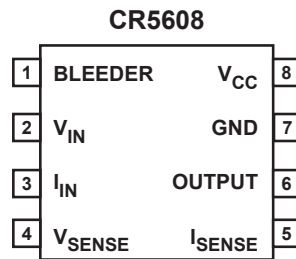
Pin #	Name	Type	Pin Description
1	BLEEDER	Output	Gate drive for bleeder switch.
2	V_{IN}	Analog Input	Rectified AC line voltage sense.
3	I_{IN}	Analog Input	Rectified AC line current sense.
4	V_{SENSE}	Analog Input	Auxiliary winding voltage sense.
5	I_{SENSE}	Analog Input	Primary side current sense.
6	OUTPUT	Output	Base drive for main BJT switch.
7	GND	Ground	Ground.
8	V_{CC}	Power	Power supply for control logic.

CR5608

AC/DC Digital Power Controller for Single-Stage High Power Factor Dimmable LED Drivers

iWatt
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5.0 Absolute Maximum Ratings

Absolute maximum ratings are the parameter values or ranges which can cause permanent damage if exceeded. For maximum safe operating conditions, refer to Section 6.0, "Electrical Characteristics."

Parameter	Symbol	Value	Units
DC supply voltage range (pin 8)	V_{CC}	-0.3 to 18	V
OUTPUT (pin 6)		-0.3 to 4.0	V
BLEEDER output (pin 1)		-0.3 to V_{CC}	V
V_{SENSE} input (pin 4, I ≤ 10mA)		-0.7 to 4.0	V
V_{IN} input (pin 2)		-0.3 to 18	V
I_{SENSE} input (pin 5)		-0.3 to 4.0	V
I_{IN} input (pin 3)		-0.7 to 4.0	V
Power dissipation at T_A ≤ 25°C		TBD	mW
Maximum junction temperature	$T_{J\,MAX}$	150	°C
Storage temperature	T_{STG}	-65 to 150	°C
Thermal Resistance Junction-to-PCB Board Surface Temperature	ψ_{JB} (Note 1)	75	°C/W
ESD rating per JEDEC JESD22-A114		2,000	V
Latch-Up test per JEDEC 78		±100	mA

Notes:

Note 1. ψ_{JB} (Psi Junction to Board) provides an estimation of the die junction temperature relative to the PCB surface temperature. This data is measured at the ground pins (pin7) without using any thermal adhesives.

CR5608

AC/DC Digital Power Controller for
Single-Stage High Power Factor Dimmable LED Drivers

iWatt
Power Management Simplified Digitally™

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
V_{IN} SECTION						
Start-Up voltage threshold	$V_{IN(ST)}$	T_A= 25°C, pulse width ≥ 500µs		0.72		V
Overvoltage shutdown threshold	$V_{IN(OVP)}$	T_A = 25°C	1.512	1.68	1.848	V
Input impedance	Z_{VIN}	After start-up	2.438	2.5	2.563	kΩ
V_{IN} range	V_{IN}	After start-up	0		1.8	V
Line fequency range	f_{IN}		45		66	Hz
V_{SENSE} SECTION						
Input leakage current	$I_{BVS(VSENSE)}$	V_{SENSE} = 2V			1	µA
Nominal voltage threshold	$V_{SENSE(NOM)}$	T_A= 25°C, negative edge	1.521	1.536	1.551	V
Output OVP threshold	$V_{SENSE(MAX)}$	T_A= 25°C, negative edge	1.65	1.7	1.75	V
Configuration current source	$I_{CFG(VSENSE)}$		475	500	525	µA
OUTPUT SECTION						
Output low level ON-resistance	$R_{DS\_ON\_LO(BJT)}$	I_{SINK} = 50mA		1		Ω
Maximum switching frequency (Note 2)	$f_{SW(BJT)}$			90		kHz
Maximum driving current	$I_{DRV(MAX)}$			90		mA
BLEEDER SECTION						
Output low level ON-resistance	$R_{DS\_ON\_LO(BLEEDER)}$	I_{SINK} = 5mA		22		Ω
Output high level ON-resistance	$R_{DS\_ON\_HI(BLEEDER)}$	I_{SOURCE} = 5mA		45		Ω
Switching frequency	$f_{SW(BLEEDER)}$			160		kHz
V_{CC} SECTION						
Maximum operating voltage	$V_{CC(MAX)}$				16	V
Start-Up threshold	$V_{CC(ST)}$		12	13.5	14.5	V
Under-voltage lockout threshold	$V_{CC(UVL)}$		5.5	6	6.5	V
Operating current	I_{CCQ}			TBD		mA

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6.0 Electrical Characteristics (continued)

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
I_{SENSE} SECTION						
I_{SENSE} short protection reference	V_{RSENSE}			0.16		V
Over-current limit threshold	V_{OCP}			1.5		V
Configuration current source	$I_{CFG(ISENSE)}$		475	500	525	µA
I_{IN} SECTION						
I_{IN} pin operation voltage	V_{IIN}			0.3		V

Notes:

Note 1.   Adjust V_{CC} above the start-up threshold before setting at 12V.

Note 2.   Operating frequency varies based on the line and load conditions. See the "Theory of Operation" section for more details.

Note 3.   These parameters refer to digital preset values, and they are not 100% tested.

CR5608

AC/DC Digital Power Controller for
Single-Stage High Power Factor Dimmable LED Drivers

iWatt
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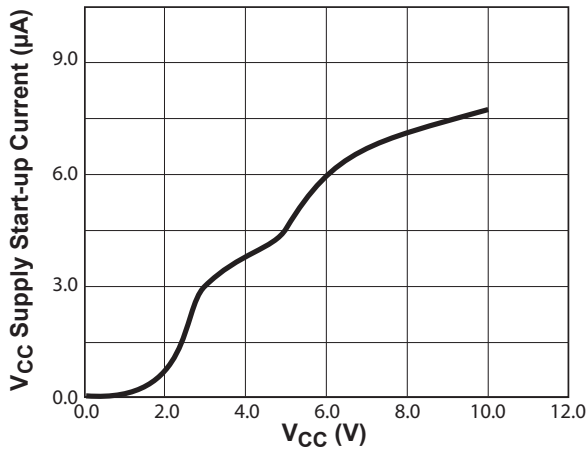## 7.0 Typical Performance Characteristics

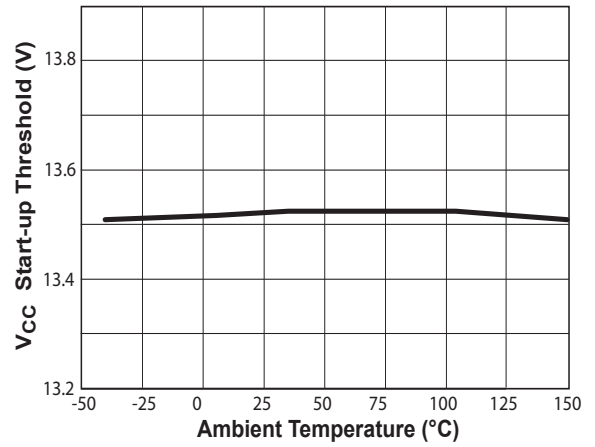*Figure 7.1 : V$_{CC}$ vs. V$_{CC}$ Supply Start-up Current*
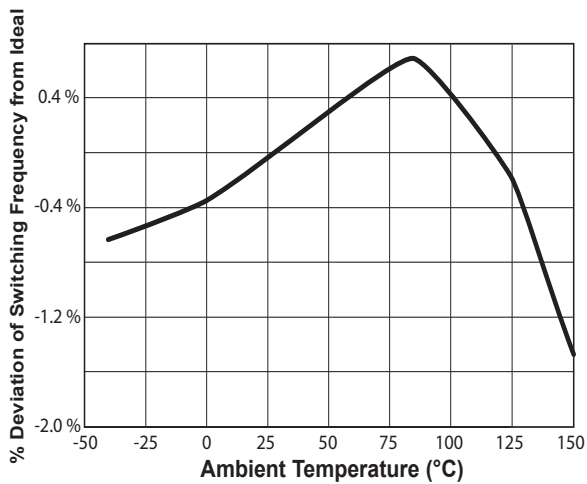

Figure 7.2 : Start-Up Threshold vs. Temperature

*Figure 7.3 : % Deviation of Switching Frequency to
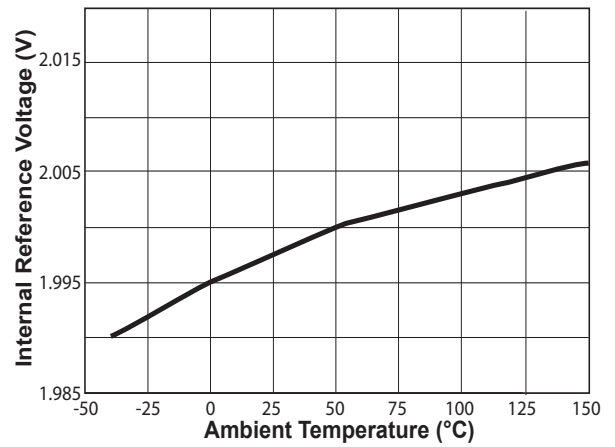Ideal Switching Frequency vs. Temperature*

Figure 7.4 : Internal Reference vs. Temperature

CR5608

AC/DC Digital Power Controller for
Single-Stage High Power Factor Dimmable LED Drivers

8.0 Functional Block Diagram

The CR5608 comprises two function blocks:

- Dimmer interface and dimmer mode control

- LED current regulation and dimming control

The dimmer interface and dimmer mode control block (shown in Figure 8.1) analyzes the rectified AC waveform and determines whether a dimmer is connected on the line. Based on the detected dimmer type, different control strategies are applied to bleeder circuit.

The LED current regulation and dimming control block controls the buck-boost or flyback converter. It switches the main BJT to supply the current to LED load. The current

regulation is determined by the transformer primary-side peak current (I_{SENSE} pin), the magnetic flux status of transformer (V_{SENSE} pin) and the input voltage waveform (V_{IN} pin) (Refer to section 9.4 for details). During the operation, the peak primary current follows the shape of the input voltage waveform. If no dimmer is detected, the CR5608 operates in no dimmer mode operation, which regulates the averaged output current to the nominal value in spite of input voltage variation. If a leading-edge or trailing-edge dimmer is detected, the CR5608 switches to dimmer mode operation. The CR5608 adjusts the average output current based on the averaged input voltage value.
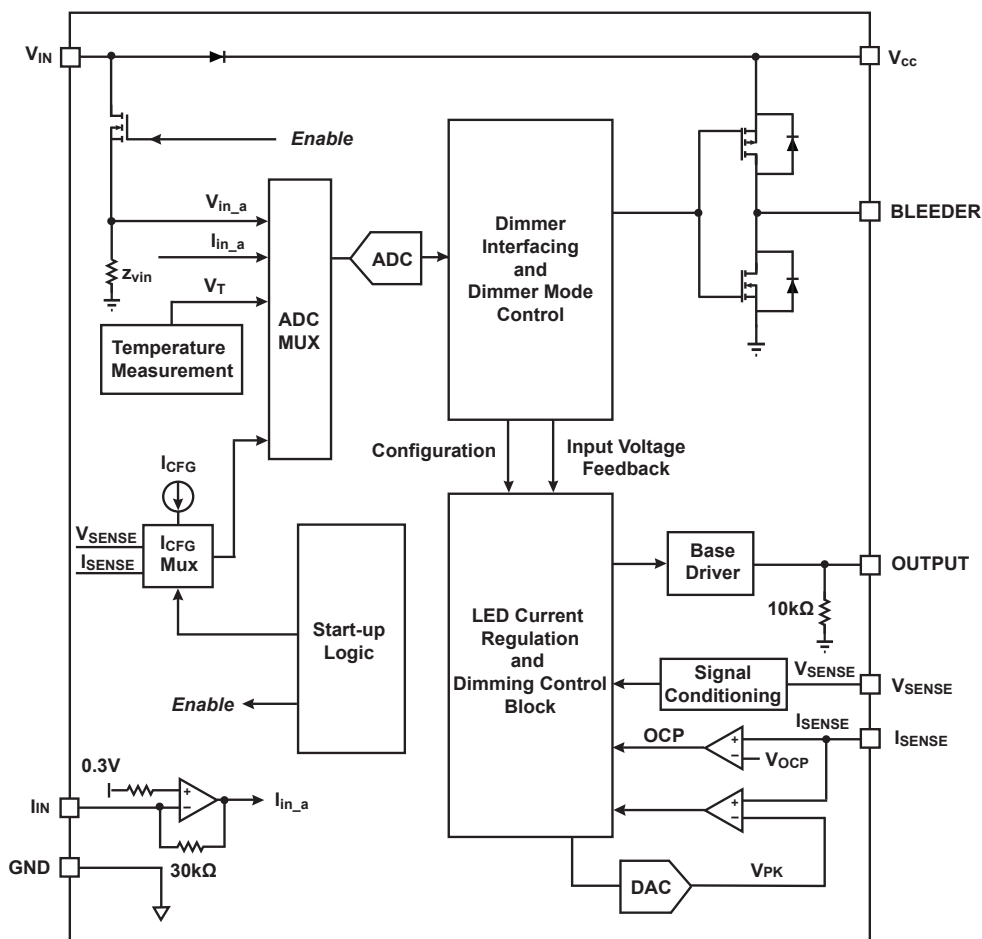

Figure 8.1 : CR5608 Functional Block Diagram

CR5608

AC/DC Digital Power Controller for
Single-Stage High Power Factor Dimmable LED Drivers

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9.0 Theory of Operation

9.1 System Start Up

This section provides information about CR5608 system start up, which includes the IC startup, wall dimmer detection, and the LED current soft start.

9.1.1 IC Startup

When AC voltage is applied, the V_{IN} pin is open by default so that the active startup switch (Q3 in Figure 11.1) is switched on and the V_{CC} capacitors (C4 and C5 in Figure 11.1) are charged through resistor R3 and Q3. When the V_{CC} voltage reaches start-up threshold $V_{CC(ST)}$, the CR5608 control logic is activated and the IC starts up. The V_{IN} pin is connected to Z_{VIN} resistor.
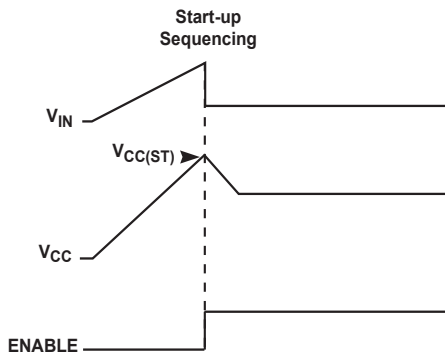

Figure 9.1 : Start-up Sequencing Diagram

9.1.2 Wall Dimmer Detection

Basic phase-cut wall dimmers are: leading-edge dimmers and trailing-edge dimmers. If the AC voltage rises at the phase-cut edge, the dimmer is called leading-edge dimmer (shown in Figure 9.2). Otherwise, it is called trailing-edge dimmer (shown in Figure 9.3). The leading-edge dimmer is TRIAC based (R-type, RL-type); the trailing-edge dimmer is MOSFET or IGBT-based (RC-type).
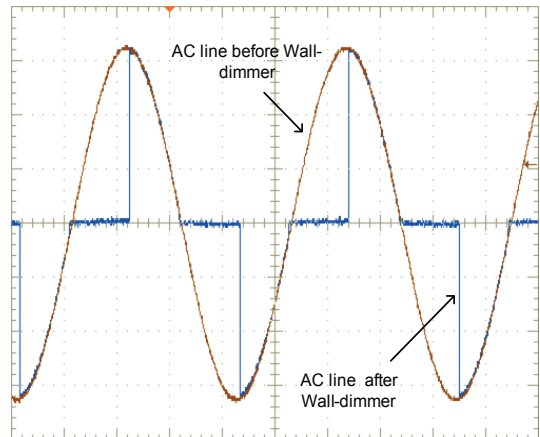

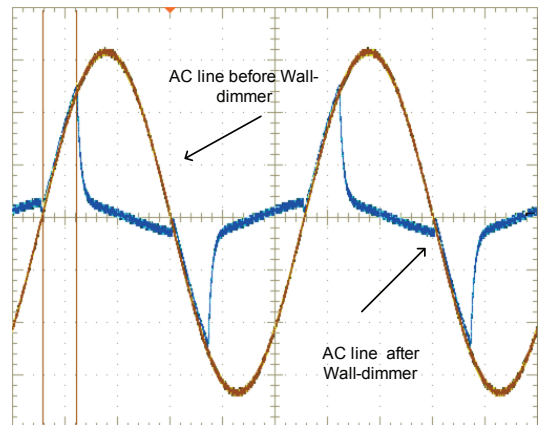Figure 9.2 : Leading-Edge Wall Dimmer Waveforms

Figure 9.3 : Trailing-Edge Wall Dimmer Waveforms

The dimmer detection stage occurs in the CR5608 immediately after the IC starts up. The CR5608 drives the bleeder switch (Q2 in Figure 11.1) constantly on to do current sinking during the wall dimmer detection. The purposes of current sinking at startup are:

- Provide current sinking to latch the leading-edge dimmer during the phase-cut in normal operation.

- Place a low impedance resistance on the AC line to accurately detect whether a dimmer is connected and the type of dimmer connected.

Determine dimmer type by looking at the slope of the input AC voltage and the dimming phase angle. A fast rising edge of the input voltage shows a leading-edge dimmer. Otherwise, a trailing-edge dimmer or no dimmer is detected.

CR5608

AC/DC Digital Power Controller for
Single-Stage High Power Factor Dimmable LED Drivers

After the dimmer type is determined, the CR5608 must qualify the AC input signal before delivering current to the LED load. If under any condition the CR5608 sees the V_{in_a} signal above $V_{IN(ST)}$ for 500µs continuously and the AC line frequency is within the range, the AC input signal is qualified. Otherwise, the CR5608 continuously monitors the AC input signal until it sees a qualified AC input signal and then starts to deliver current to the LED load. If the V_{CC} drops under $V_{CC(UVL)}$ in this process, the CR5608 resets and the V_{CC} voltage charges up again for a new startup.

9.1.3 LED Current Soft-Start

After the CR5608 qualifies the AC input signal, the buck-boost or flyback converter immediately starts to deliver current to the LED load. A soft-start algorithm is applied to the buck-boost or flyback converter to gradually ramp up the LED current.

If a dimmer is connected, the driver starts immediately into leading-edge or trailing-edge mode operation (refer to section 9.3.1 and 9.3.2 for details) to interface with the dimmer. If no dimmer is connected, the driver starts no-dimmer mode operation (refer to section 9.3.3 for details).

9.2 Dimming Curve

The CR5608 adjusts the output current to a certain ratio of the nominal output current when the leading-edge or trailing-edge dimmer is detected. This ratio is called the dimming percentage. A typical mapping between the dimmer phase angle and the dimming percentage is shown in Figure 10.6. Four different dimming curves can be selected by the I_{SENSE} pin configuration (refer to section 9.5 for details). All dimming curves fall within the limits of the NEMA SSL6 standard (shown in Figure 10.6). The CR5608 updates the dimming percentage based on the averaged input voltage. For the lowest bleeder loss, option 1 selction is recommended.

9.3 Dimmer Interface and Dimmer Mode Control Block Operation

This section provides information about CR5608 dimmer interface and dimmer mode control block's operation, which includes leading-edge dimmer mode, trailing-edge dimmer mode, and no-dimmer mode.

As shown in Figure 11.1, the bleeder circuit comprises switch Q2, resistor R4 and resisto R5. The switching frequency of the bleeder circuit is 160kHz. During the operation, the duty ratio of Q2 varies to draw the current from the input.

9.3.1 Leading-Edge Dimmer Mode

If a leading-edge dimmer is detected, the bleeder control operates in two modes after the startup of LED driver: full bleeder mode and input current compensation mode.

The CR5608 monitors the input voltage continuously. When V_{in_a} falls below 0.3V, the bleeder control enters into the full bleeder mode. In the full bleeder mode, the bleeder switch (Q2) is fully switched on (100% duty ratio). This provides a low impedance load for the dimmer to charge its internal timing circuit when the dimmer is turned off.

When V_{in_a} exceeds 0.3V, the bleeder control enters into the input current compensation mode. In this mode, the CR5608 uses the I_{IN} pin to detect the input current. If the input current sense value drops below 0.18V, the beeder circuit is enabled to maintain the holding current.

To prevent the disturbance caused by the sudden change of the bleeder control mode, the CR5608 makes the smooth transition during the mode change.

The peak value of the primary winding current I_{pk} is determined by the voltage generated on the current-sense resistor: $I_{pk} = V_{pk}/R10$. Under leading-edge dimmer mode operation, V_{pk} is designed to be proportional to the input voltage shape with a lower limit of 0.2V.

9.3.2 Trailing-Edge Dimmer Mode

If a trailing-edge dimmer is detected on the line, the bleeder control operates in two modes: full bleeder mode and no bleeder mode.

When the phase-cut edge of the input voltage is detected, the bleeder control enters into the full bleeder mode. The bleeder switch (Q2) is fully turned on to quickly discharge the input capacitors.

When V_{in_a} exceeds 0.2V, the bleeder control enters into the no bleeder mode. In no bleeder mode, the Q2 is fully turned off. In order to prevent the disturbance caused by the sudden change of the bleeder control mode, CR5608 makes a smooth transition during the mode change.

Under trailing-edge dimmer mode operation, V_{pk} is designed to be proportional to the input voltage shape with a lower limit of 0.2V.

9.3.3 No Dimmer Mode

For no dimmer on the line, the CR5608 operates in no-dimmer mode for optimal power factor and minimum harmonic distortion. The bleeder is kept turned off. V_{pk} is

CR5608

AC/DC Digital Power Controller for Single-Stage High Power Factor Dimmable LED Drivers

designed to be proportional to the input voltage shape with a lower limit of 0.1V.

9.4 Output Current Regulation and Dimming Control Block Operation

This section provides information about CR5608 output current regulation and dimming control block operation. The output current regulation and dimming control block incorporates the iWatt-patented PrimAccurate™ technology.

9.4.1 Output Current Regulation at Nominal Input Condition

In CR5608, peak current regulation is achieved by forcing the peak value of the primary-side current to follow the reference curve in every switching cycle. Figure 9.4 shows the basic principle of this peak current regulation.
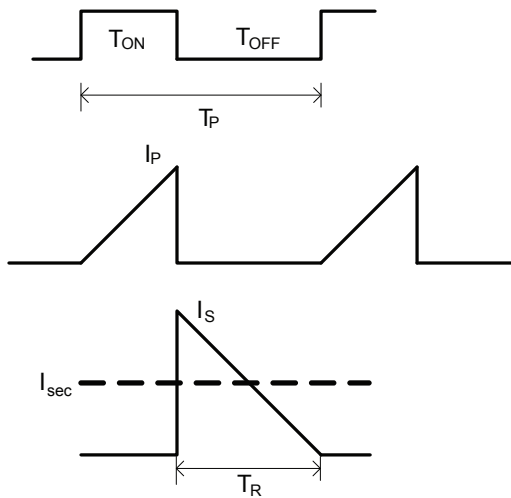

Figure 9.4 : Cycle-to-Cycle Peak Current Regulation

The buck-boost or flyback converter operates in critical discontinuous conduction mode (CDCM) if the switching frequency of main BJT does not exceed the frequency limit. Otherwise, if the switching frequency reaches the frequency limit, the power converter operates in discontinuous conduction mode (DCM). When the main switch BJT (Q1 in Figure 11.1) turns on, the transformer primary winding current ramps up linearly and energy builds up in the transformer. The CR5608 turns off the BJT when the primary winding current reaches the peak current regulation level. At this moment, the transformer maintains the magnetic flux so that the energy in the transformer generates the secondary winding current that equals to the peak primary winding current multiplied by primary-secondary turns-ratio. Then the secondary winding current ramps down linearly until all the energy in transformer is discharged. After the energy in

the transformer is discharged, the CR5608 starts the next switching cycle.

As shown in Figure 9.4, the averaged secondary current of the transformer can be expressed by an equation as shown below.

$$I_{sec} = 0.5 \times N_{TR} \times I_{pk} \times T_R / T_P \qquad (9.1)$$

where I_{pk} is the peak value of primary winding current. N_{TR} is the primary-secondary turns ratio. T_R is the secondary winding current ramp-down time, or the transformer reset time. T_P is the entire period.

The I_{pk} is determined by the voltage generated on the current-sense resistor: $I_{pk} = V_{pk} / R10$. Therefore, the equation can be written as:

$$I_{sec} = 0.5 \times N_{TR} \times V_{pk} / R10 \times T_R / T_P \qquad (9.2)$$

As described in section 9.3, the reference waveform of V_{pk} is proportional to the input voltage shape. Therefore, V_{pk} value varies from one switching cycle to another.

In the steady state, the average output current is equal to the average transformer secondary current over one half the AC cycle. Therefore, the average output current can be obtained by averaging equation 9.2 over one half-AC-cycle.

In CR5608, the nominal output current $I_{out\_avg(NOM)}$ can be determined by the equation 9.3.

$$I_{out(avg)(NOM)} = 0.5 \times N_{TR} / R10 \times 0.35V \times \eta \qquad (9.3)$$

η is the current regulation efficiency

Therefore, the nominal output current $I_{out\_avg(NOM)}$ can be determined by the turns-ratio and current sensing resistor value.

9.4.2 Dimming Control

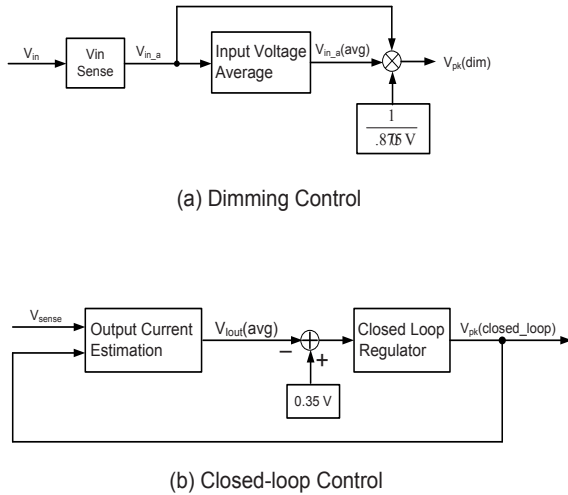(a) Dimming Control

(b) Closed-loop Control

Figure 9.5 : Output Current Regulation

In CR5608, the reference V_{pk} waveform is determined by the sensed V_{IN} signal and the estimated output current (shown in Figure 9.5).

Under dimming control, the reference waveform V_{pk} is generated by equation 9.4.

$$V_{pk}(\text{dim}) = V_{in\_a} * \frac{V_{in\_a}(avg)}{0.875\,V}$$

(9.4)

Where V_{pk}(dim) is the V_{pk} value under dimming control, V_{in_a} is the sensed V_{in} value inside CR5608 chip, V_{in_a}(avg) is the averaged value of V_{in_a} over one half-AC-cycle. If the estimated output current value is less than the nominal value $I_{out(avg)(NOM)}$, CR5608 stays in the dimming control [shown in Figure 9.5(a)]. When V_{in} changes, V_{pk} also adjusts accordingly to change the output current.

If the output current value is equal to or higher than the nominal value $I_{out(avg)(NOM)}$, CR5608 switches to the closed loop control immediately. Under the closed loop control, V_{pk}(closed_loop) regulates the output current to the 100% of the nominal value regardless of input voltage (shown in Figure 9.5 (b)).

9.5 V$_{SENSE}$ and I$_{SENSE}$ Configuration Function

At start-up, a current source in the controller drives the configuration current I_{CFG} (500µA) into V_{SENSE} and I_{SENSE} pin alternatively after V_{CC} reaches $V_{CC(ST)}$. The CR5608 reads their pin voltages respectively to determine the configuration options. V_{SENSE} pin configuration selects the temperature de-

rating start points. I_{SENSE} pin configuration selects the dimming curves. By connecting resistors R8, R9, and R13 with different values to V_{SENSE} and I_{SENSE} pins respectively, different dimming curves and temperature starting points are selected. Table 9.1 and 9.2 show the temperature starting points and the dimming curves respectively vs. the resistor values.

V$_{SENSE}$ CFG Option Number	V$_{SENSE}$ Pin Resistors (R8//R9 in Fig. 11.1)		Temperature Derating Starting Point T$_{DERATE(ST)}$(°C) (Fig. 9.6)
	Typical Value(kΩ)	Tolerance	
0	0.72	≤ 5%	100
1	1.38	≤ 5%	105
2	2.30	≤ 5%	110
3	3.60	≤ 5%	115

Table 9.1 V$_{SENSE}$ Pin Configuration Resistor Values

I$_{SENSE}$ CFG Option Number	I$_{SENSE}$ Pin Resistors (R10 in Fig.11.1)		Dimming Curve Number (Fig. 10.6)
	Typical Value(kΩ)	Tolerance	
0	0.5	≤ 5%	option 1
1	1.2	≤ 5%	option 2
2	2.20	≤ 5%	option 3
3	3.60	≤ 5%	option 4

Table 9.2 I$_{SENSE}$ Pin Configuration Resistor Values

9.6 Protection Features

This section provides information about CR5608 protection features.

9.6.1 Output Over-Voltage/LED Open Protection

The CR5608 includes a function that protects against an output over-voltage.

The output voltage is monitored by the V_{SENSE} pin. The ratio between the V_{SENSE} pin voltage and output voltage is equal to the auxiliary to secondary winding turns-ratio multiplied by the V_{SENSE} resistor divider ratio (R8 and R9 in Figure 11.1). If the voltage at the V_{SENSE} pin exceeds $V_{SENSE(MAX)}$, the CR5608 shuts down its output pins (BLEEDER pin and OUTPUT pin) immediately. As a result, the bleeder and the power converter circuits are turned off. After the output pin shutdown, the CR5608 remains powered, which discharges the V_{CC}. To avoid over-charging the output voltage, the

CR5608

AC/DC Digital Power Controller for Single-Stage High Power Factor Dimmable LED Drivers

CR5608 employs an extended discharge time as described below if V_{CC} does not drop below V_{CC_UVL}. Otherwise, when V_{CC} drops below V_{CC_UVL}, the CR5608 resets itself and then initiates a new soft-start cycle.

Under the fault condition, the CR5608 tries to start up for three consecutive times. If all three start-up attempts fail, the CR5608 enters an inactive mode, during which the CR5608 does not respond to the V_{CC} power-on requests. The CR5608 is activated again after it sees 29 start-up attempts. Typically, this extended discharge time is around three to five seconds.

9.6.2 Output Short Protection

The CR5608 includes a function that protects against an output short-circuit fault.

When output is shorted, V_{SENSE} stays low. As a result, output short fault is detected, and the CR5608 shuts down its output pins (BLEEDER pin and OUTPUT pin) immediately. After the output pins' shutdown, the CR5608 remains powered which discharges the V_{CC}. To avoid excessive power stress due to auto-restart, the CR5608 employs an extended discharge time as described in section 9.6.1 if V_{CC} does not drop below V_{CC_UVL}. Otherwise, when V_{CC} drops below V_{CC_UVL}, the CR5608 resets itself and then initiates a new soft-start cycle.

To support applications with high output capacitance, output short protection is not activated in the initial LED current soft start period. This allows the voltage to build up in the output capacitor without mis-triggering the protection.

9.6.3 Temperature De-Rating and Over-Temperature Protection

The CR5608 can detect and protect against over-temperature events. The CR5608 uses an internal sensor for temperature measurement.

When the monitored temperature reaches $T_{DERATE(ST)}$, the maximum output current limit begins to reduce linearly from 100% to 70% of the nominal value until the temperature reaches the $T_{DERATE(FINISH)}$ threshold as shown in Figure 9.6, where $T_{DERATE(FINISH)} = T_{DERATE(ST)} + 20°C$. At $T_{DERATE(FINISH)}$, the maximum output current limit is clamped to 70%. If the temperature further increases to $T_{OTP(START)}$, the CR5608 shuts down.

The CR5608 remains in shutdown mode as long as the monitored IC temperature is above $T_{OTP(START)}$. If the detected temperature falls below $T_{OTP(START)}$ at anytime, the device starts up. From $T_{DERATE(FINISH)}$ to $T_{DERATE(ST)}$, the maximum output current limit increases linearly from 70% to 100% as shown in Figure 9.6. The device goes back to normal operation if the sensed IC temperature falls below $T_{DERATE(ST)}$. This bi-directional operation enables the LED current thermal fold-back instead of an abrupt shut-down of the LED current.

The values of $T_{DERATE(ST)}$, $T_{DERATE(FINISH)}$ and $T_{OTP(START)}$ can be adjusted through V_{SENSE} pin resistors (R8 and R9 in Figure 11.1).
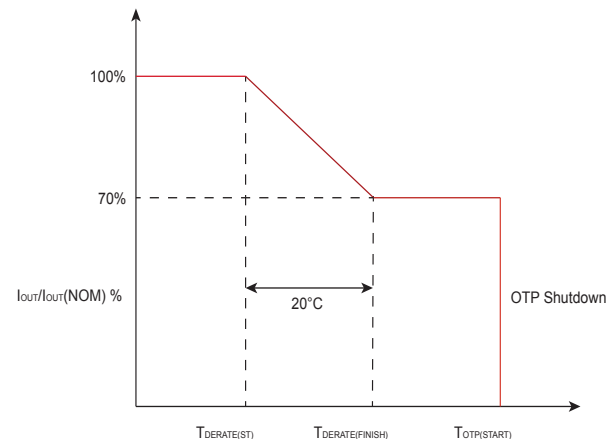

Figure 9.6 : Temperature DeRating and OTP

9.6.4 Over-Current Protection

Over-current protection (OCP) is built into the CR5608.

With the I_{SENSE} pin, the CR5608 is able to monitor the primary peak current of the buck-boost or flyback converter. This allows for cycle-by-cycle peak current control and limit. When the primary peak current multiplied by the I_{SENSE} pin sensing resistor (R10 in Figure 11.1) is greater than V_{OCP}, over-current is detected and the CR5608 immediately turns off the OUTPUT pin base drive until the next cycle. The OUTPUT pin sends out a switching pulse in the next cycle, and the switching pulse continues if V_{OCP} is not reached; or, if V_{OCP} is reached, the switching pulse switches off again.

9.6.5 Current Sensing Resistor Short Protection

The CR5608 uses a BJT as its main switch for the buck-boost or flyback converter. If the current sensing resistor is shorted, there is a potential danger of the over-current condition not being detected. Thus the CR5608 is designed to detect this sense-resistor short fault. When the sense-resistor short fault is detected, CR5608 shuts down its output pins (BLEEDER pin and OUTPUT pin) immediately. After the output pins shutdown, the CR5608 remains powered, which discharges the V_{CC}. In order to prevent over stress of power circuit components, the CR5608 employs an extended discharge time as described in section 9.6.1 if V_{CC} does not

drop below $V_{CC(UVL)}$. Otherwise, when V_{CC} drops below $V_{CC(UVL)}$, the CR5608 resets itself and then initiates a new soft-start cycle.

9.6.6 AC Input Over-Voltage Protection

The CR5608 supports the over-voltage protection of AC input.

If the V_{in_a} is higher than V_{IN_OVP} for continuous 2ms within every 16ms period, and this condition lasts for eight consecutive half AC cycles, the CR5608 shuts down its output pins. As a result, both bleeder and power converter circuits are turned off. After the shutdown the external circuits, the V_{CC} is discharged because the CR5608 remains powered. The iW3616 employs an extended discharge time (as described in section 9.6.1) before restart if V_{CC} does not drop below $V_{CC(UVL)}$. Otherwise, when V_{CC} drops below $V_{CC(UVL)}$, the CR5608 resets itself and then initiates a new soft-start cycle.

CR5608

AC/DC Digital Power Controller for
Single-Stage High Power Factor Dimmable LED Drivers

iWatt
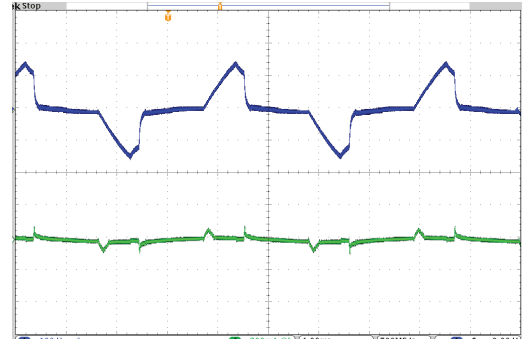*Power Management Simplified Digitally™*

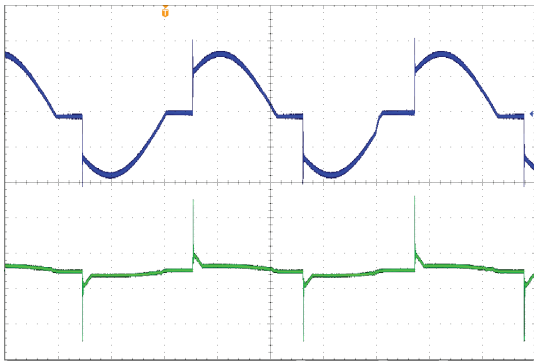# 10.0 Performance Characteristics
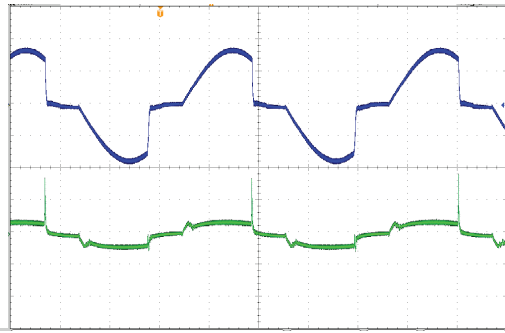
Time (4.0ms/div)

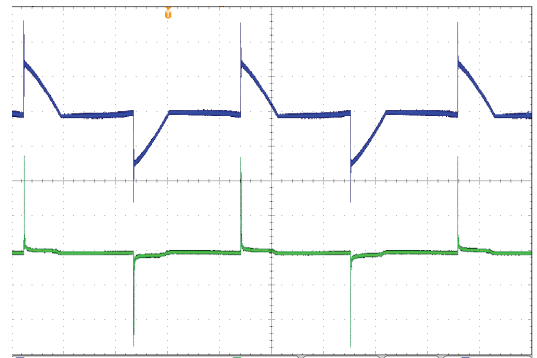*Figure 10.1 : Trailing-Edge Dimmer*

Time (4.0ms/div)
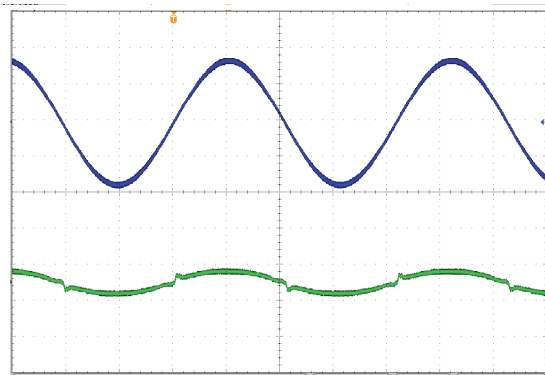
Figure 10.2 : Trailing-Edge Dimmer 2

Time (4.0ms/div)

Figure 10.3 : Leading-Edge Dimmer

Time (4.0ms/div)

Figure 10.4 : Leading-Edge Dimmer 2
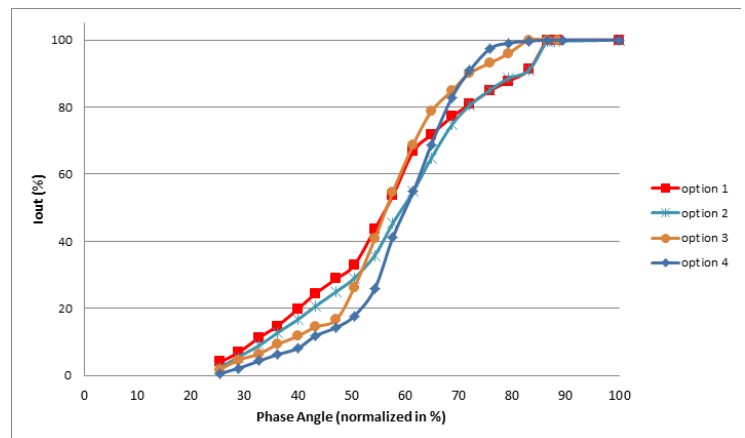

Time (4.0ms/div)

Figure 10.5 : No Dimmer

Figure 10.6 : Dimming Curve

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11.0 Typical Application Schematic
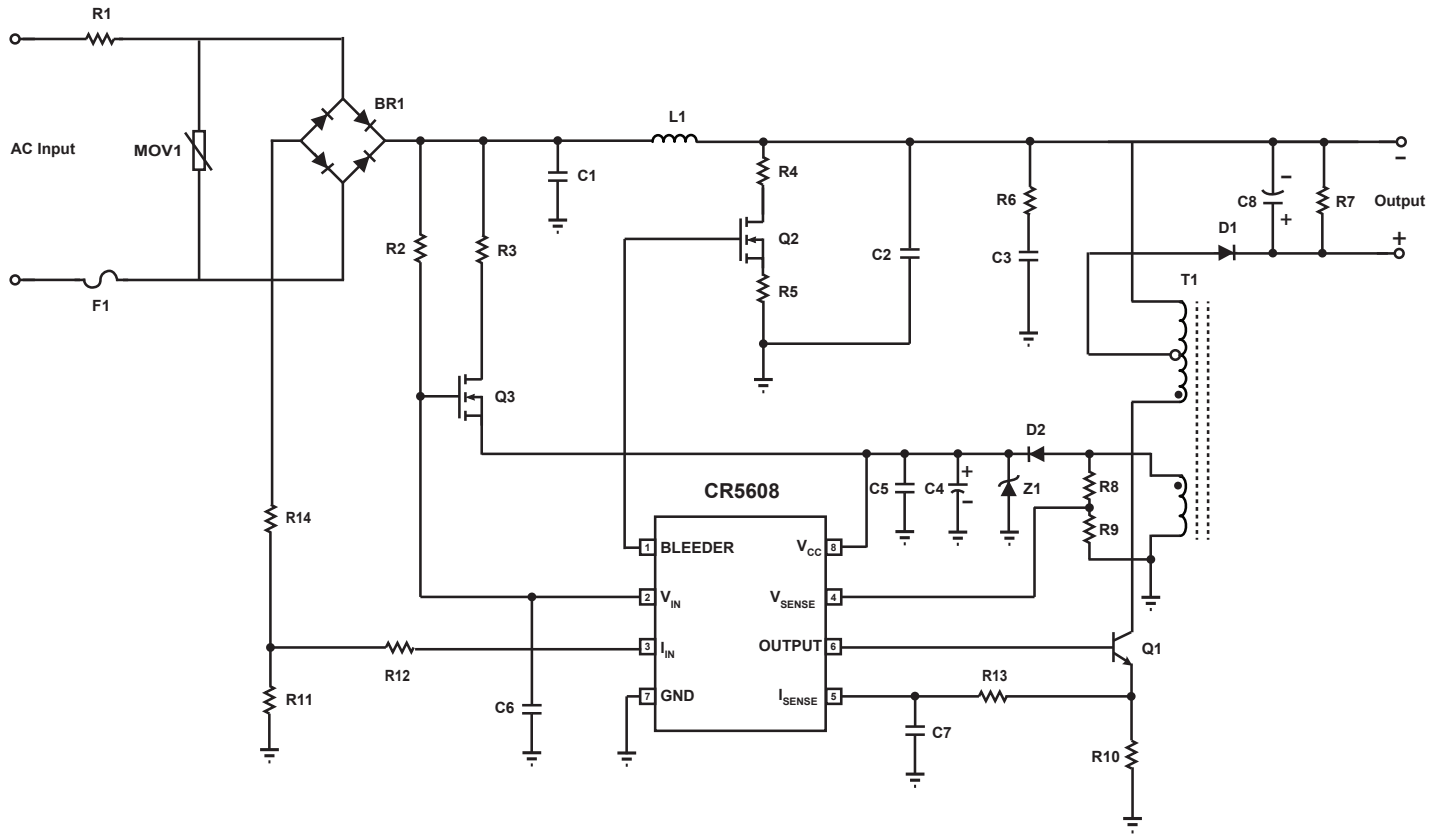
Figure 11.1 : CR5608Typical Application Circuit

12.0 Physical Dimensions

8-Lead Small Outline (SOIC) Package

TOP VIEW

SIDE VIEWS
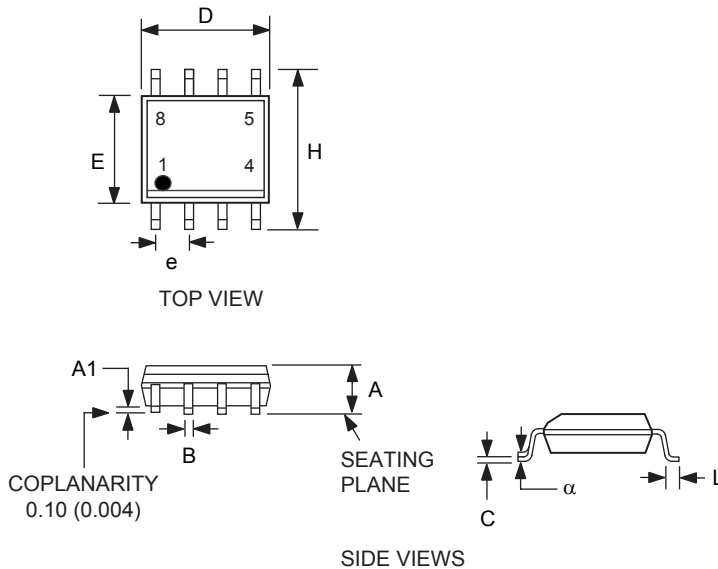
Symbol	Inches		Millimeters	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.0040	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
D	0.189	0.197	4.80	5.00
E	0.150	0.157	3.80	4.00
e	0.050 BSC		1.27 BSC	
H	0.228	0.244	5.80	6.20
L	0.016	0.049	0.40	1.25
α	0°	8°		

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
        10 s immersion < 270˚C

Dimension D does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm per end. Dimension E1 does not include interlead flash or protrusion. Interlead flash or protrusion shall not exceed 0.25 mm per side.

The package top may be smaller than the package bottom. Dimensions D and E1 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.

13.0 Ordering Information

Part Number	Options	Package	Description
CR5608-03	120V$_{AC}$/230V$_{AC}$ Input	SOIC-8	Tape & Reel[1]

Note 1: Tape & Reel packing quantity is 2,500/reel.

CR5608

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Trademark Information

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iWatt semiconductors are typically used in power supplies in which high voltages are present during operation. High-voltage safety precautions should be observed in design and operation to minimize the chance of injury.