Sequoia Microelectronics

SQ6212/SQ6214

Off-Line Low Cost Driver with Active PFC and Integrated MOSFET

Features

- **Active PFC function by One Cycle Control (OCC)**
- **Integrated 600V power MOSFET**
- **Continuous Inductor Current Mode (CICM)**
- **PF > 0.95 over full voltage range**
- **±3% output LED current accuracy by Average Current control**
- **High efficiency > 0.85 (typ.)**
- **Fixed frequency at 45kHz with Spread Spectrum to reduce EMI filter cost**
- **Open Loop Protection (OVP)**
- **Short Circuit Protection (SCP)**
- **Over Current Protection (OCP)**
- **Over Temperature Protection (OTP)**
- **Very low BOM cost**
- **Available in SOP-8 package**
- **RoHS compliant and Pb free**
- **2N60 built-in MOSFET – SQ6212**
  4N60 built-in MOSFET – SQ6214

Typical Applications

- **LED lamp for decorative lighting**
- **E26/E27 and T8 LED lighting fixtures**

Product Description

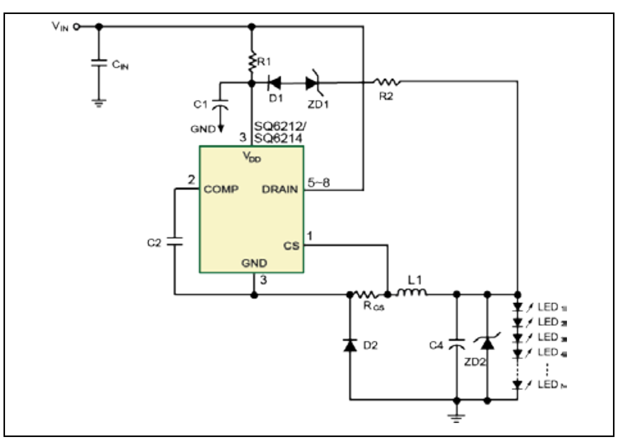
The SQ6212/SQ6214 is a highly integrated constant current PWM controller with active high power factor correction, high precision output current and high-efficiency for universal input voltage. This IC uses one-cycle-control (OCC) to achieve high PFC in continuous inductor current mode (CICM) for efficient operation of LED strings. The PF can reach up to 0.95 throughout the universal AC line voltage ranging from $90V_{AC}$ to $265V_{AC}$. This IC includes an internal high voltage switching MOSFET controlled with fixed frequency (f_{OSC}) of approximately 45kHz The average current feedback control scheme provides good line regulation of ±3% of the output current throughout the full voltage range.

The SQ6212/SQ6214 uses high side current sensing for continuous current on the current sense pin. The COMP pin can be used to set the soft-start timing.

The SQ6212/SQ6214 has pseudo-random oscillator hopping function (Spread Spectrum) to reduce EMI emission so that input EMI filter cost can be reduced. Typical frequency hopping range is approximately 5% around base frequency f_{OSC} of 45kHz.

The SQ6212/SQ6214 has multiple protections including short circuit protection, over current protection, open loop protection, under voltage protection, over voltage protection and over temperature protection. All protections have the automatic restart mechanism.

Typical Application Circuit



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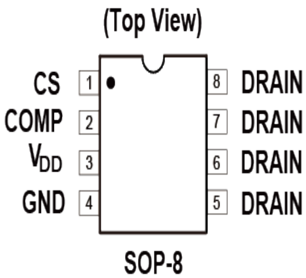
Pin Assignments and Ordering Information



Device	Packaging	Quantity of Tape & Reel
SQ6212 MST	SOP-8	3000
SQ6214 MST	SOP-8	3000

Pin Descriptions

Pin No.	Pin Name	Function
1	CS	**Current sense input pin**
		Senses and sets the LED string current. This pin is also used for OCC.
2	COMP	**Loop compensation input pin**
		A current feedback compensation capacitor is placed between this pin and GND to achieve stability of the voltage control loop.
3	V_{DD}	**Power supply input pin**
		Power source pin for internal control circuit.
4	GND	**Ground pin**
		Device ground. and Source pin of internal HV power MOSFET
5,6,7,8	DRAIN	**DRAIN input pin**
		Drain terminal of internal switching MOSFET.

Absolute Maximum Ratings (Note 1)

Symbol	Parametar	Ratings	Unit
V_{DD}	V_{DD} input pin voltage range to GND	-0.5 ~ +30	V
V_{CS}	CS input pin voltage range relative to GND	-0.3 ~ +7	V
V_{DRAIN}	DRAIN pin voltage range relative to GND	600	V
V_{COMP}	COMP pin voltage range relative to GND	-0.3 ~ +7	V
$P_{D(MAX)}$	Continuous power dissipation ($T_A = +85°C$) (Note 2)		
	8 Pin SOP-8 (de-rating 16mW/°C above +85°C)	0.4	W
T_J	Junction temperature	+150	°C
T_{STG}	Storage temperature range	-65 ~ +150	°C
θ_{JA}	Junction-to-ambient thermal resistance	160	°C/W

Note:

1. Exceeding these ratings could cause damage to the device. All voltages are with respect to ground. Currents are positive into, negative out of the specified terminal.
2. When the ambient temperature is high, the power dissipation has to decrease. It depends on T_{JMAX}, θ_{JA}, and the ambient T_A. The max. allowable power is $P_{D(MAX)} = (T_{JMAX} - T_A)/\theta_{JA}$, or the lower data in limit range.

Recommended Operating Conditions

Symbol	Parametar	Min.	Max.	Unit
$V_{DD\ DC}$	DC input supply voltage range, V_{DD} to GND pin	12	25	V
T_A	Ambient temperature range (Note 3)	-20	+85	°C

Note :

3. Maximum ambient temperature range is limited by allowable power dissipation.

Recommended Application Wattage

Part No.	V_{IN}=90V~132V	V_{IN}=180V~264V	Unit
SQ6212	13	16	W
SQ6214	16	23	W

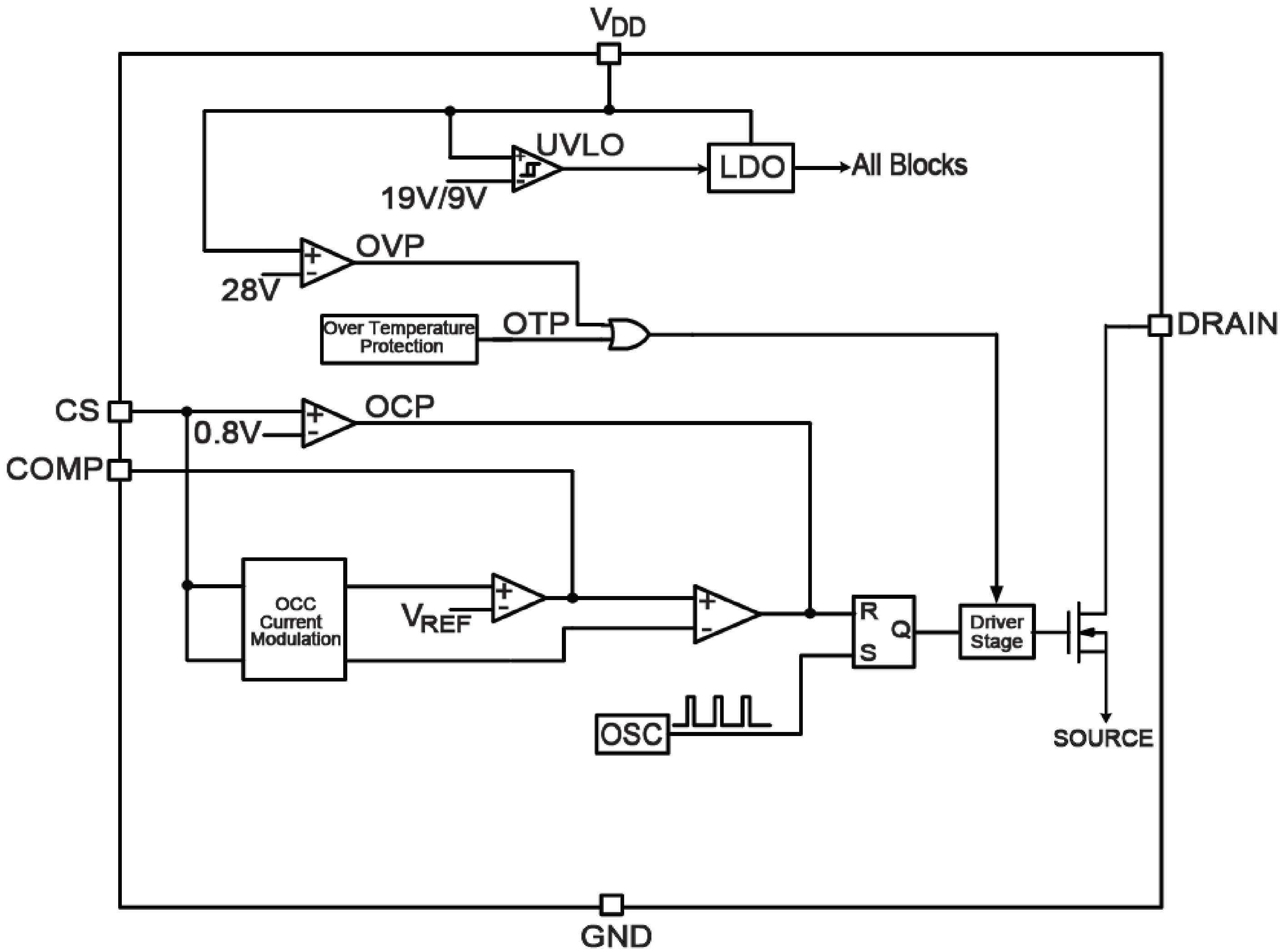
Electrical Characteristics

(Over recommended operating conditions unless otherwise specified. $T_A = +25°C$, $V_{DD} = 15V$)

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
Supply Voltage						
Startup Current	I_{ST}		20	30	μA	$V_{DD}=V_{DD(ON)}$ - 1V
Operating Current	I_{OP}		2	3	mA	
Operating Current at Protection (OCP, OVP, SCP, OTP)	I_{PR}		1	1.5	mA	
UVLO(off)	$V_{DD(OFF)}$	8	9	10	V	
UVLO(on)	$V_{DD(ON)}$	17	19	21	V	
OVP Level on V_{DD} Pin	V_{OVP}	27	28	30	V	
Voltage Compensation Feedback						
Feedback Reference Voltage	V_{COMP}	0.16		6	V	V_{DD} = 11V~25V
COMP sinking current	I_{COMP_SNK}		30		μA	C_{COMP} = 1μF
COMP sourcing current	I_{COMP_SRC}		30		μA	C_{COMP} = 1μF
Current Sensing Comparator						
Current sense reference	V_{CS}	0.19	0.20	0.21	V	
Over Current Protection	V_{OCP}	0.7	0.8	0.9	V	
Leading-Edge Blanking Time	t_{LEB}		400		ns	
Delay from CS to GATE	t_{DELAY}		100	220	ns	
Switching Frequency						
Switching Frequency(Note 4)	f_{OSC}	42	45	48	KHz	
Maximum Duty	D_{MAX}			90	%	
Frequency Jitter Range(Note 4)	$\Delta f_{OSC} / f_{OSC}$		±5		%	
Temp. Stability	Δf_{OSC_TEMP}			5	%	-40℃ ~ 125℃
Voltage Stability	Δf_{OSC_VDD}			3	%	V_{DD} = 11V~25V
MOSFET Section						
Drain-Source breakdown voltage(Note 4)	V_{DS_BR}		600		V	V_{GS} =0V, I_D =250μA
On resistance (SQ6212)	R_{DSON}		4		Ω	I_{DRAIN} = 500mA
On resistance (SQ6214)	R_{DSON}		2		Ω	I_{DRAIN} = 1A
Protections						
Thermal shut down	T_{SD}		150		°C	
Thermal shut down hysteresis	ΔT_{SD}		20		°C	

Note :
4. Parameters guaranteed by design, functionality tested in production.

Functional Block Diagram



Application Information

Function Description

The SQ6212/SQ6214 is a cost effective off-line PWM average current controller IC for buck converter topology with active PFC function by One Cycle Control (OCC) in continuous inductor conduction mode (CICM). The output current is set by an external resistor at CS pin. When a $19V_{DC}$ to $25V_{DC}$ appears at the V_{DD} pin through an external biasing circuit consisting of a resistor and a capacitor, as this voltage travels above the internally programmed turn-on threshold ($VDD_{(ON)}$) of 19V, the SQ6212/SQ6214 starts operating. The SQ6212/SQ6214 shuts off when V_{DD} drops below 9V ($VDD_{(OFF)}$). There is a 10V hysteresis. It is recommended to add a 10μF capacitor at V_{DD} pin. V_{DD} pin is also used to detect over voltage condition. If V_{DD} exceeds 28V, the SQ6212/SQ6214 will activate Over Voltage Protection (OVP) function by shutting down the GATE switching and operation will resume after V_{DD} reaches $V_{DD(OFF)}$. This OVP can be used to detect output open condition with proper selection of external devices to implement LED Open Loop Protection (OLP).

The SQ6212/SQ6214 uses One Cycle Control in CICM to obtain high PFC. This feature is implemented by high side sensing. The CICM can reduce the cost of input EMI filter. In order to achieve a high PF, the COMP pin must be maintained at a constant value during the entire operating switching cycle; therefore, a very low bandwidth filter is needed. Normally, a 1μF to 4.7μF capacitor is added at the COMP pin to construct an internal 10Hz low bandwidth integrator. As a result, the SQ6212/SQ6214 can achieve PF > 0.95 under universal input voltage range. This COMP pin can also be used for soft start function by selecting a correct value capacitor. A bulky input electrolytic capacitor can be eliminated with this PFC topology.

The high side current sensing scheme can generate a continuous current at CS pin. With average current mode control on continuous current at CS pin, the line regulation can be controlled practically within near 1% from $90V_{AC}$ to $265V_{AC}$.

The low start up current can reduce the power consumption during cold start with a high value external resistor for a good efficiency. During normal operation, the power is supplied from the output.

The SQ6212/SQ6214 is offered in standard SOP-8 package.

Start Up and Soft-Start

At initial cold start, it requires only typical 20μA as starting current to power up the IC, and this extremely low current allows a high resistance start-up resistor to reduce the power dissipation on it.

The COMP pin is used to provide a very low bandwidth filter for PFC which can also be used to implement the soft start function. By adjusting the value of the capacitor at the COMP pin, a 100ms soft start time can be achieved.

The SQ6212/SQ6214 operates at a fixed frequency set internally at 45KHz. At CS pin, a leading edge blanking delay of 400ns is provided that prevents false triggering of the current sensing comparator due to the leading edge spike caused by parasitical circuit.

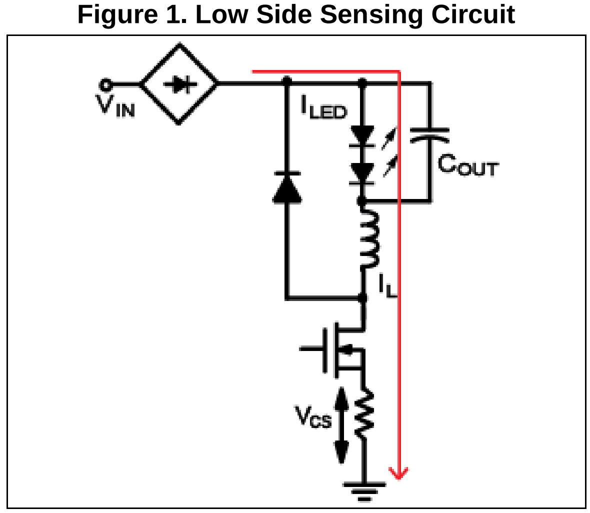
Spread Spectrum

The oscillator incorporates circuitry that introduces a small amount of frequency jitter, typically ± 4% frequency hopping range from base frequency (f_{OSC}) to minimize EMI emission. The modulation rate of the frequency jitter is set by pseudo-random frequency hopping to optimize EMI reduction for both average and quasi-peak voltage emissions.

High Side Sensing

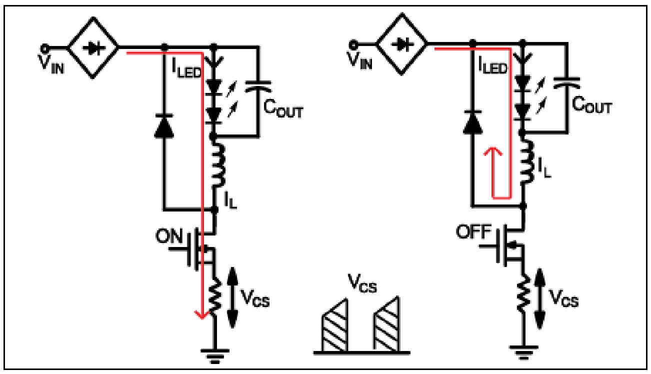
Traditional low side sensing is shown in Figure 1 and its charging and discharging cycles are shown in Figure 2.

Figure 1. Low Side Sensing Circuit



In Figure 1, even if the inductor current I_L can be modulated as sinusoidal, it does not guarantee the input current I_{IN} will be sinusoidal. This can easily be verified to see I_{IN} waveform changes by adding or removing C_{OUT}. The C_{OUT} is used commonly at output to reduce the flickering due to current ripples. The inductor current is regulated by controlling the MOSFET switch on and off and through sensing the current flow through sense resistor R_{CS}. The current sense voltage is a chopped waveform due to charging and discharging cycles.

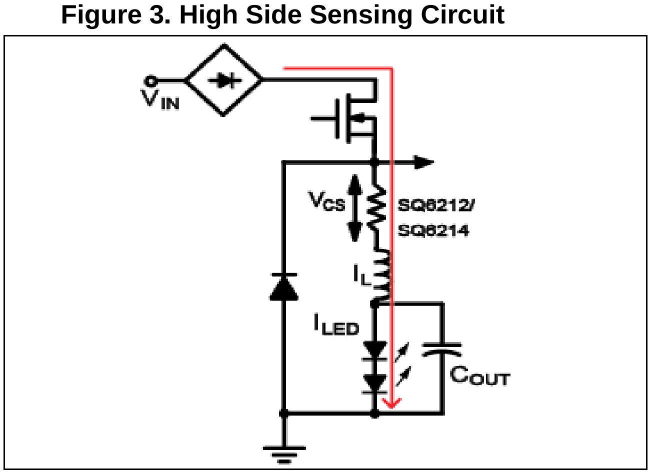
Figure 2. Low Side Current Sensing Charging and Discharging Cycles and V_{CS} Waveform



In low side sensing, the chopped dis-continuous waveform at CS pin (V_{CS}) depends on the duty cycle, it is obvious that current modulation is not straightforward in order to generate a sinusoidal input current following the input voltage by regulating the voltage or current at the CS pin.

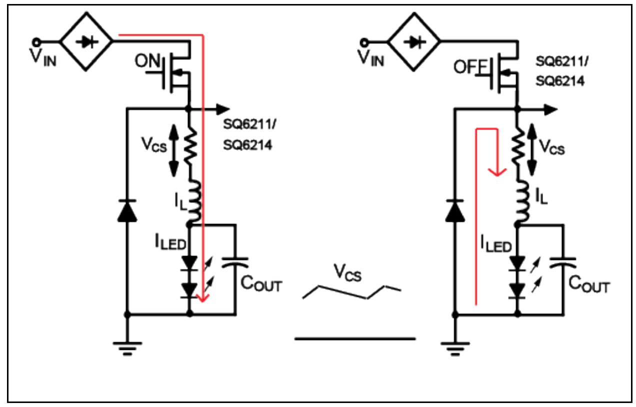
In contrast, the SQ6212/SQ6214 uses high side sensing topology as shown in Figure 3 and its corresponding charging and discharging paths are shown as in Figure 4.

Figure 3. High Side Sensing Circuit



In high side sensing, The sensing current is continuous as shown in Figure 4. If V_{CS} can be modulated as sinusoidal, then inductor current follows I_{CS} as sinusoidal and so does I_{IN}.

Figure 4. High Side Current Sensing Charging and discharging Cycles and V_{CS} Waveform



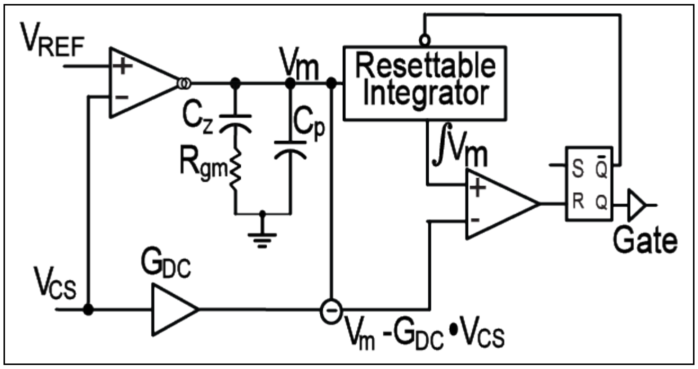
As a comparison, in high side sensing, regardless what PFC mode is used, the V_{CS} can be reckoned as constant in CCM operation; continuous triangular in BCM and dis-continuous triangular at DCM operation.

One Cycle Control (OCC)

In SQ6212/SQ6214, One Cycle Control (OCC) is used to generate PFC. OCC has many advantages over traditional PFC implementation with a multiplier. First of all, OCC does not need an input current reference, feed-forward filter and current amplifier compensation as needed by an analog multiplier. OCC only requires a simple sensing and compensation on output voltage and current sensing which are also needed by an analog multiplier circuit. Thus, OCC architecture can save pin count and components count on PC board. Without multiplier, a smaller IC can also be achieved. OCC has additional advantage; without input current reference, it is less sensitive to unregulated input voltage. Since it always monitors the V_{CS} condition in every cycle, it can provide very good load regulation too.

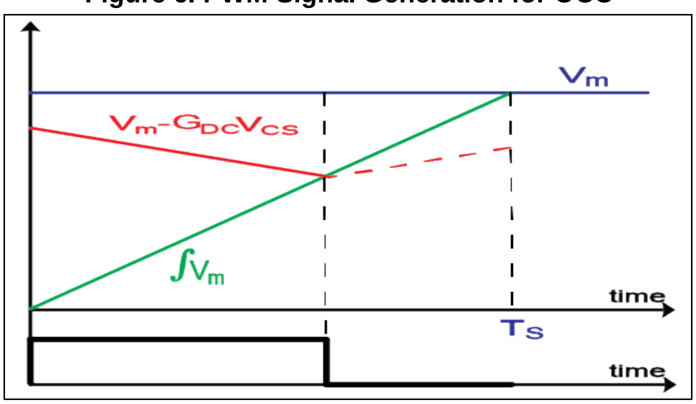
A simplified constant frequency OCC block diagram is shown in Figure 5. The output of the error amplifier by sensing the V_{CS} signal is integrated over the switching cycle to produce a ramp voltage which is compared to a voltage reference generated by a combination of the sum of the inductor current and the error voltage. This is then compared at the PWM comparator input to determine the duty cycle for the MOSFET switch.

Figure 5. Simplified One Cycle Control



In detail, the error amplifier is used to provide the loop compensation and to generate the error signal or modulation voltage V_m. The core of the OCC is a resettable integrator. It integrates the modulation voltage V_m to generate a variable slope ramp as the green line in Figure 6. Since the voltage loop bandwidth is very narrow around 10Hz, it can be considered constant during entire switching cycle. This means that the output of the integrator will be a linear ramp. The slope of the integrator ramp is directly proportional to the output voltage of the error amplifier V_m. The reference for the PWM comparator is obtained by subtracting (compensating) the voltage across the current sense resistor from the modulation voltage (V_m - G_{DC} • V_{CS}), this compensation is shown as the red slope in Figure 6. These two lines comparing with V_{COMP} at COMP pin determines the ON time or duty cycle by resetting an internal flip-flop. Set of the flip-flop is triggered by fixed frequency clock.

Figure 6. PWM Signal Generation for OCC



For an integrator, it can be a simple passive R-C type, but a linear active gm-C type is better because of its wider linear bandwidth. Figure 7 shows the comparison of integrator output for high side and low side sensing. It is obvious that continuous V_{CS} provides an easy way to regulate the current because the result of integration is independent of the duty cycle.

OCC operation usually contains a current loop. The current loop sustains the sinusoidal profile of the average input current based on the PWM duty cycle on the input line voltage to determine the corresponding input line current. Thus, the current loop uses the embedded input voltage signal to command the average input current following the input voltage. This is true as long as it operates in continuous conduction mode. There might be some amount of distortion of the current waveform as the line cycle moves toward the zero crossing and the device operates at very light load given that the inductor has a finite inductance. The resultant harmonic current under these operating conditions will be within the Class D specification of EN61000-3-2, and therefore not an issue.

Figure 7. Comparison of Integrator Outputs

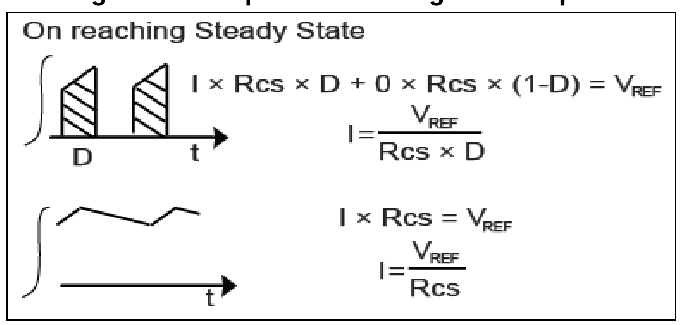
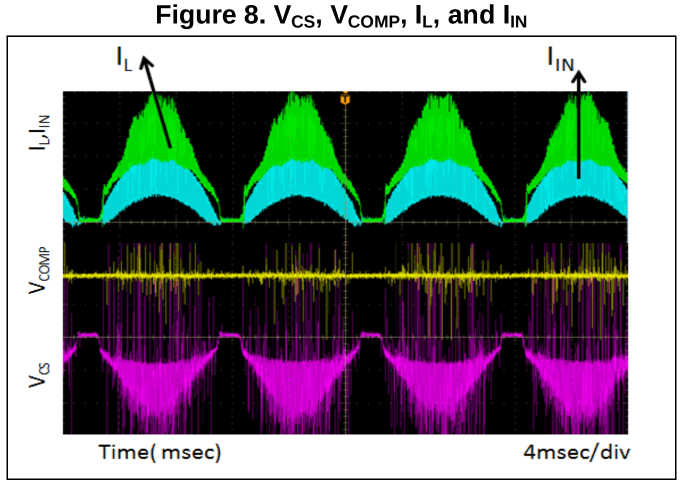


Figure 8 shows the waveforms of V_{CS}, V_{COMP}, input current (I_{IN}) and inductor current (I_L) in CCM operation.

Figure 8. V_{CS}, V_{COMP}, I_L, and I_{IN}

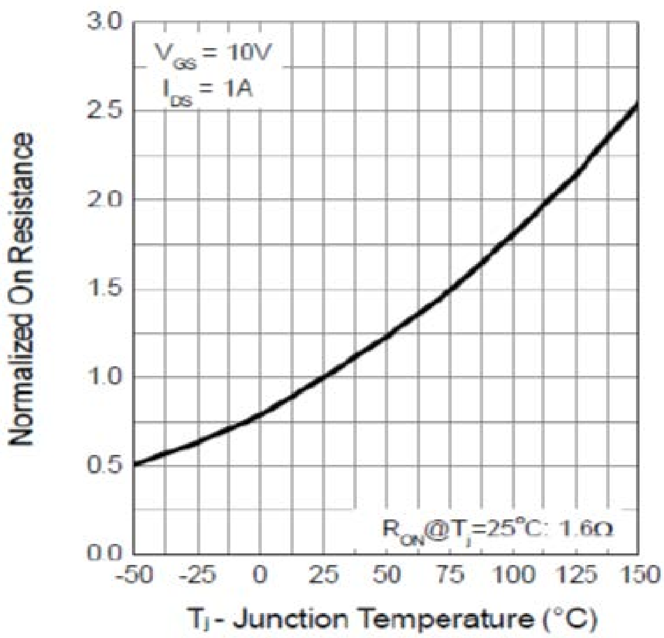


Built-in MOSFET

This 600V breakdown N-channel enhancement MOSFET provides excellent low $R_{DS(ON)}$ and high performance to support up to 20W or 350mA output current applications.

The MOSFET gate is driven by an optimal V_{GS} = 10V internally. The typical $R_{DS(ON)}$ is 2/4Ω at 25°C and 3.5/7Ω at 100°C respectively for SQ6214/SQ6212 which significantly reduces the heat dissipation in high power applications. The MOSFET $R_{DS(ON)}$ characteristics diagram with respect to temperature is shown in Figure 9.

Figure 9. $R_{DS(ON)}$ vs. Junction Temperature



Short Circuit Protection (SCP)

The short circuit protection is provided when accidentally the LED output is shorted. This protection can be implemented through UVLO feature. When the LED output is shorted, V_{DD} biasing from the output will be disabled, and the start-up circuit cannot supply enough power, so V_{DD} starts dropping. When V_{DD} hits $V_{DD(OFF)}$, the SQ6212/SQ6214 becomes inactive until V_{DD} starts charging up to $V_{DD(ON)}$. After SQ6212/SQ6214 resumes its normal operation, it detects short circuit condition again and repeats the hiccup process until the short circuit condition is removed.

Over Current Protection (OCP)

The SQ6212/SQ6214 also provides an over current protection function on the CS pin. If the internal circuit detects that CS pin exceeds 0.8V, the GATE signal will be turned off. V_{DD} biasing will be stopped, and the start-up circuit cannot supply enough power, so V_{DD} starts dropping. When V_{DD} hits $V_{DD(OFF)}$, the SQ6212/SQ6214 becomes inactive until V_{DD} starts charging up to $V_{DD(ON)}$. After the SQ6212/SQ6214 resumes its normal operation, it detects over current condition and repeats the hiccup process until the condition is removed.

Open Voltage Protection (OVP)

When V_{DD} voltage is higher than 28V, the GATE drive will be turned off and the V_{DD} biasing will be terminated. Then a hiccup process will be activated which is similar to short circuit protection and over current protection. With proper external circuit, the OVP function can be used to implement the open loop protection by detecting a voltage surge on the V_{DD} pin through the biasing circuit from the output when the LED loading is not present.

Over Temperature Protection (OTP)

Thermal protection is added due to buck topology can generate large heat when operated in high voltage input. The over temperature protection shut down feature is provided to turn off the MOSFET when junction temperature (T_J) reaches 150°C. There is a 20°C hysteresis to re-start the MOSFET.

Design Example

Let us design an LED lamp driver with the SQ6212 to meet the following specifications :

Input : Universal AC, $85V_{AC}$ ~ $264V_{AC}$

Output : 200mA

Loading : String of 16 LEDs (V_F = 3.1V max. each)

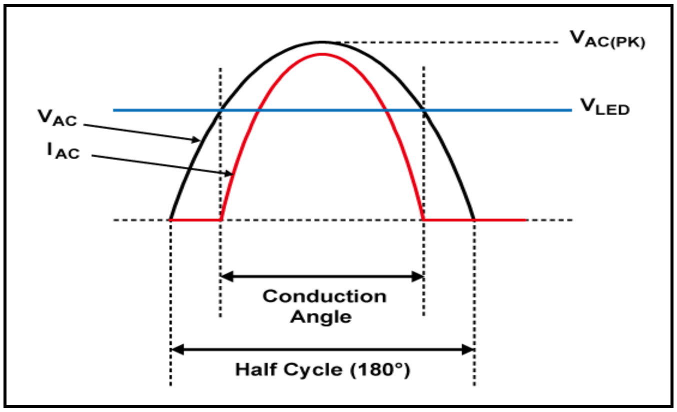
V_{OUT} = 50V

1. LED DC Output Voltage Selection

The LED output voltage is probably the most important design parameter of the buck PFC, and is the starting point for a design. Fundamentally, the output voltage level must be lower than the minimum rated AC line peak voltage. If the output voltage is too low, due to buck characteristics, the voltage drop across the MOSFET will be too high and the conversion efficiency will be poor. However, the output voltage must be sufficiently lower than the minimum AC line peak to allow a reasonable conduction angle. Figure 10 shows the trade-off between the level of the LED output voltage and the conduction angle.

OCC can support high voltage loading with good performance and excellent line regulation over the full voltage range; however, it is recommended the LED output voltage should be set low enough to ensure at least a 50% conduction angle at the lowest line voltage. For full range input, the output voltage should be set less than 60V for better current accuracy, high PF and low harmonic distortion due to wider conduction angle. If operating only in single high voltage of $180V_{AC}$ – $265V_{AC}$, the output voltage can be set to 100V or higher.

Figure 10. Buck PFC Line Current Conduction Angle



Conduction angle can be calculated as a percentage of the AC line half-cycle (or indeed full-cycle) that the buck PFC is forward biased, during which line current can be drawn:

$$\theta_{COND(\%)} = \frac{2}{\pi} \times \cos^{-1}\left(\frac{V_{LED}}{\sqrt{2} \times V_{AC}}\right) \quad (1)$$

2. Output Bulk Capacitor C_O Selection

The output ripple voltage of the buck PFC varies with line voltage, and will typically be a much higher percentage of the DC regulated value. This is due to the power transfer from the AC line only occurs during the conduction angle, when the instantaneous AC line voltage is greater than the output voltage. During switching is off, the bulk capacitor must supply all of the load current until the AC line voltage increases above the output voltage level again. Since the dead-time interval will be longer at a lower line voltage, then the output ripple voltage will be higher at a lower line voltage. For this reason, the 100 ~ 120Hz ripple-current rating required for the buck PFC bulk capacitor could be substantial, and could be the limiting factor in the choice of output capacitance. In addition, the output capacitors will need to carry the high-frequency ripple current from the PFC choke, as well as some additional ripple current drawn by the second regulation stage. The output ripple voltage at any operating point can be estimated as follows:

$$\Delta V_{LED} = \frac{P_{OUT}}{C_O \times V_{LED}} \times \frac{1-\theta_{COND(\%)}}{2 \times f_L} \quad (2)$$

where

P_{OUT} is the output load power drawn

C_O is the bulk capacitance.

$\theta_{COND(\%)}$ is the conduction angle at the AC line of interest (as a decimal percentage of total cycle - e.g., a 50% conduction angle expressed as 0.5).

f_L is the AC line frequency.

If ΔV_{LED} is 30% of V_{LED} and $\theta_{COND(\%)}$ is 75% in this case, then from equation (2), C_O can be calculated as

$$C_O = \frac{P_{OUT}}{\Delta V_{LED} \times V_{LED}} \times \frac{1-\theta_{COND(\%)}}{2 \times f_L}$$

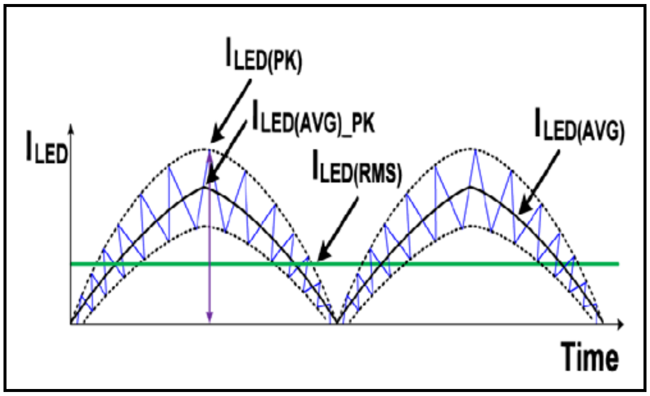
or

$$C_O = \frac{10}{(0.3 \times 50) \times 50} \times \frac{1-0.75}{2 \times 45} = 37\mu F$$

3. Setting Sense Resistor R_{CS}

When the buck converter topology is selected for this design example as shown in Figure 13, the output LED current $I_{LED(AVG)}$ can be shown in Figure 11 which follows input waveform for high PF in CICM operation. The 200mA is the RMS value of the I_{LED} as represented by the green line $I_{LED(RMS)}$ in Figure 11. However, there is a

Figure 11. I_{LED} current waveform



certain error associated with this current sensing method that needs to be accounted for. This error is introduced by the difference between the peak $I_{LED(PK)}$ and the average $I_{LED(AVG)}$ current in the inductor. The peak current of the $I_{LED(AVG)}$ can be calculated as;

$$I_{LED(AVG)\_PK} = I_{LED(RMS)} \times \sqrt{2}$$

$$= 200mA \text{ x } 1.414 = 282mA \qquad (3)$$

If the peak-to-peak ripple current through the LED is set at 30% of $I_{LED(AVG)\_PK}$ or 85mA, the sensing resistor should be as follows :

$$R_{CS} = \frac{V_{CS(PK)}}{I_{LED(PK)}}$$

$$= \frac{V_{CS(AVG)} \times \frac{\pi}{2}}{1.15 \times \sqrt{2} \times I_{LED(RMS)}} \approx \frac{200x\frac{\pi}{2}}{324} \approx 0.96\Omega \qquad (4)$$

Where $V_{CS(AVG)}$ is 200mV. Be noted that $V_{CS(AVG)}$ is used in finding R_{CS} because $I_{LED(AVG)}$ is interested. And

$$V_{CS(PK)} = V_{CS(AVG)} \times \frac{\pi}{2} \qquad (5)$$

4. Inductor L1 Selection

Referring to the typical buck application circuit in Figure 13, the inductor value can be calculated from the desired peak-to-peak LED ripple current in the inductor.

Since the ripple current is selected to be 30% of nominal current $I_{LED(AVG)}$ at 282mA, and the total LED string voltage drop V_{LED} is 50V, following equations can be used to find the inductor value. The definitions of these parameters can be found in Figure 12.

$$D_{MAX} = \frac{V_{LED}}{\eta \times V_{IN(MIN)}} \qquad (6)$$

$$t_{ON} = \frac{D}{f_{OSC}} \qquad (7)$$

$$L1 \geq \frac{(V_{IN} - V_{LED}) \times t_{ON}}{0.3 \times \sqrt{2} \times I_{LED(RMS)}} \qquad (8)$$

If efficiency η is targeted at 0.85 and operating frequency is set internally at 45KHz, then

$$D_{MAX} = \frac{V_{LED}}{\eta \times V_{IN(MIN)}} = \frac{50}{0.85 \times 85 \times 1.414} \approx 0.489$$

From equation (7), the corresponding t_{ON} will be:

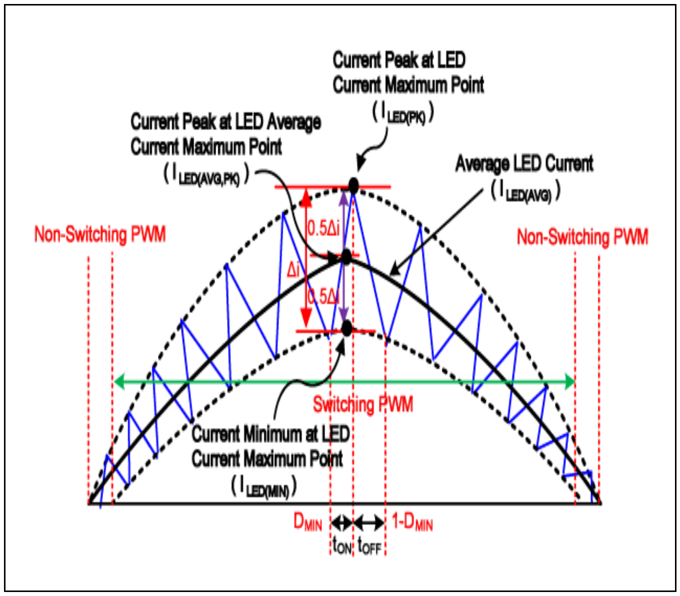
$$t_{ON} = 22\mu s \times 0.489 = 10.76\mu s$$

The required minimum value of the inductor is given by equation (9),

$$L1 \geq \frac{(85 \times 1.414 - 50) \times 10.76\mu}{0.3 \times 282m} \approx 8.92mH$$

So selecting L1 = 9mH

Figure 12. LED Current Waveform



5. Ultra-Fast Freewheel Diode D1 Selection

Due to hard turn-off of the freewheeling diode, it increases the diode reverse-recovery power loss and switching noise, a fast reverse recovery diode is needed to reduce the power loss. Usually, the reverse recovery characteristics of ultra-fast rectifiers at $I_F = 0.5A \sim 1.0A$ is not provided in the manufacturer's data books. The designer may want to experiment with different diodes to achieve the best performance. Normally, a less than 35ns fast recovery time diode can be used with good result. In this example, we can select D1 with Fairchild

ES1J with $V_{RRM} = 600V$ (V_{RRM} is the maximum reverse voltage), $t_{RR} = 35ns$ ($I_F = +0.5A$, $I_R = -1.0A$, $I_{RR} = -0.25A$) and $C_J \approx 6pF$ ($V_R > 50V$, V_R is the DC reverse voltage).

6. Start-up Resistor and Biasing Zener Selections

SQ6212/SQ6214 requires as low as 20µA and 19V ($V_{DD(ON)}$) at V_{DD} pin to start the circuit so that the power consumption can be minimized. At the same time, the V_{DD} pin capacitor is charging. The start-up time can be adjusted by selecting correct combination of resistor and capacitor. Usually, a 10µF capacitor and a higher than 500KΩ resistor are used. Be noted, if the resistor is too small, the start-up power consumption will be higher, and if the resistor is too high, the operating input voltage cannot go to too low. $V_{DD(OFF)}$ is set at 9V. This hysteresis is to allow the capacitor to have enough energy to supply the power to the IC.

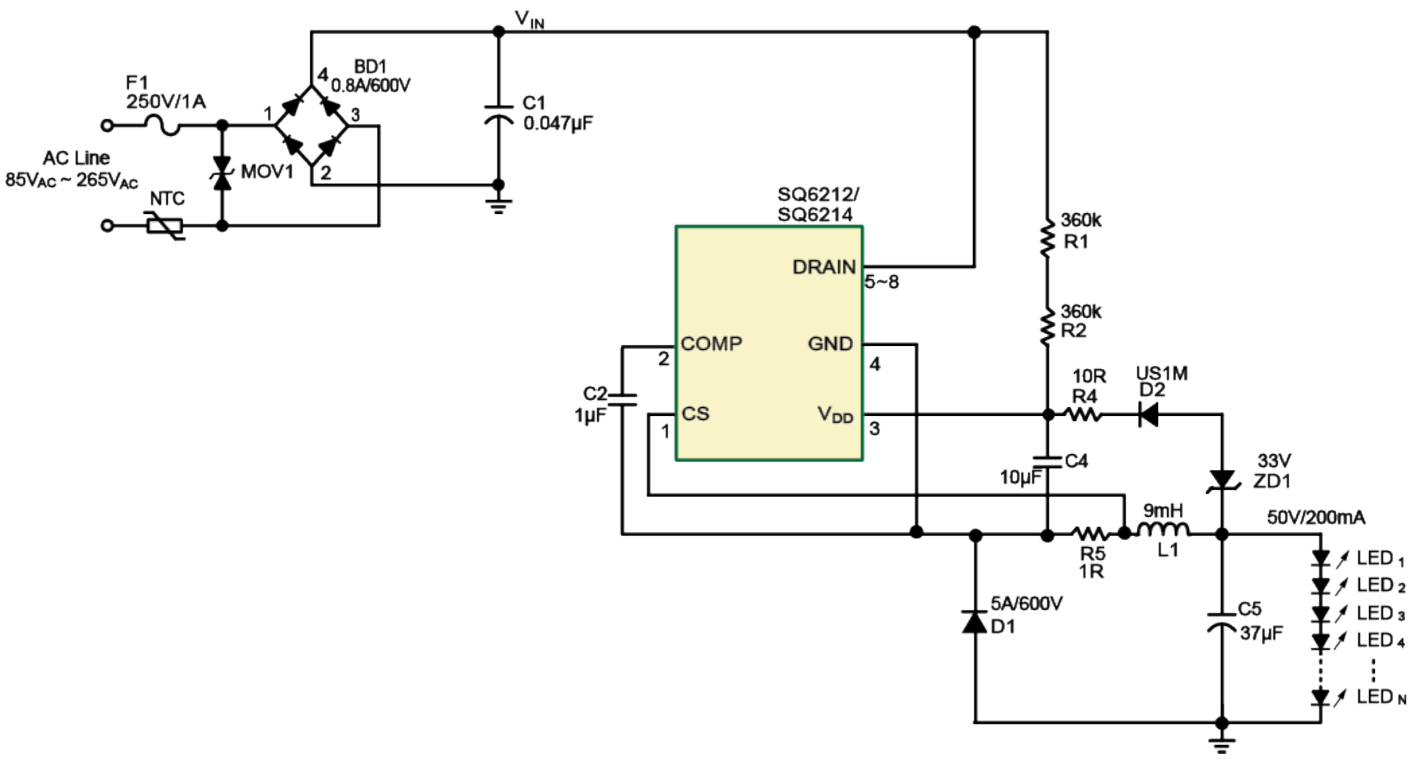
After successful initial power up, V_{DD} is then biased from LED output. For proper operation, the Zener diode in Figure 13 needs to have clamping voltage set by

$$V_Z = V_{LED} - 18V$$

7. COMP pin Capacitor Selection

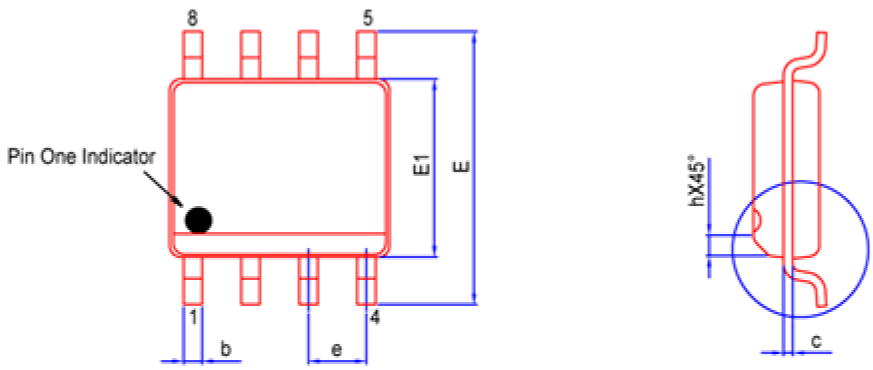
The capacitor at the COMP pin is very important in PFC control loop because it will impact the system stability and the total harmonic distortion (THD). In order to keep V_{COMP} constant during an operating cycle, a very small bandwidth filter is required. Usually, it is set at less than 10Hz. The simplest compensation circuit uses a 1µF - 4.7µF capacitor at the COMP pin can achieve the goal.

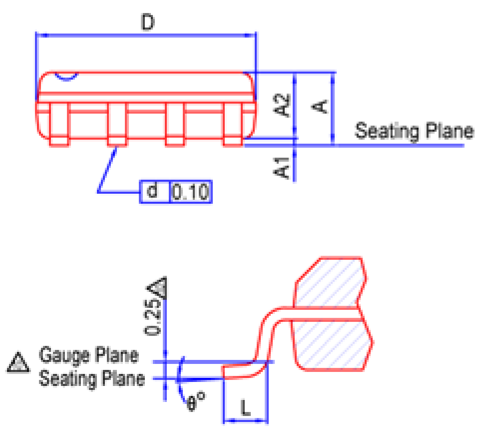
Figure 13. A Complete Application Circuit by Adopting the SQ6212/SQ6214



Package Outline Dimensions

Package Type: SOP-8



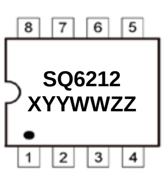


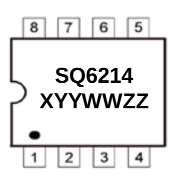
Symbols	Min.	Max.
A	–	1.75
A1	0.10	0.25
A2	1.25	–
b	0.31	0.51
c	0.10	0.25
D	4.90 BSC	
E	6.00 BSC	
E1	3.90 BSC	
e	1.27 BSC	
L	0.40	1.27
h	0.25	0.50
θ°	0	8

Unit : mm

Marking Information

SOP-8





X = A/T Site, YY = Year, WW = Working Week, ZZ = Device Version

Revision History

Revision	Date	By	Contents
V0.1	2014, March. 12	Web	First version