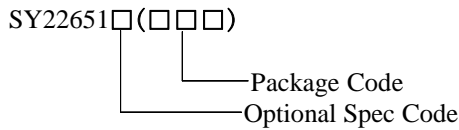


General Description

The SY22651S is a DC/DC Buck controller targeting at LED lighting applications with analog dimming. It adopts the proprietary control architecture to achieve an accurate regulation of LED current and Quasi-Resonant valley turn-on high efficiency operation. The SY22651S supports analog dimming function and it has a linear dimming curve. It integrates open/short LED protection and eliminates the auxiliary winding with floating topology, thus minimizing the component count and board size.

Ordering Information



Ordering Number	Package type	Note
SY22651SFAP	SO8	----

Features

- Linear Dimming Curve.
- Wide Range Voltage Output.
- Optional Over Voltage Protection Mode.
- CV Mode for Bias Supply when $V_{ADIM}=0V$.
- Valley Turn-on to Achieve Low Switching Losses.
- Single Winding Inductor with Floating Topology.
- 200mA Sourcing Current and 600mA Sinking Current Drive Capability.
- Low Start up Current: 34 μ A Typical.
- Reliable Short LED and Open LED Protection.
- Reliable Short ISEN Resistor Protection.
- Compact Package: SO8.

Applications

- LED Lighting

Typical Applications

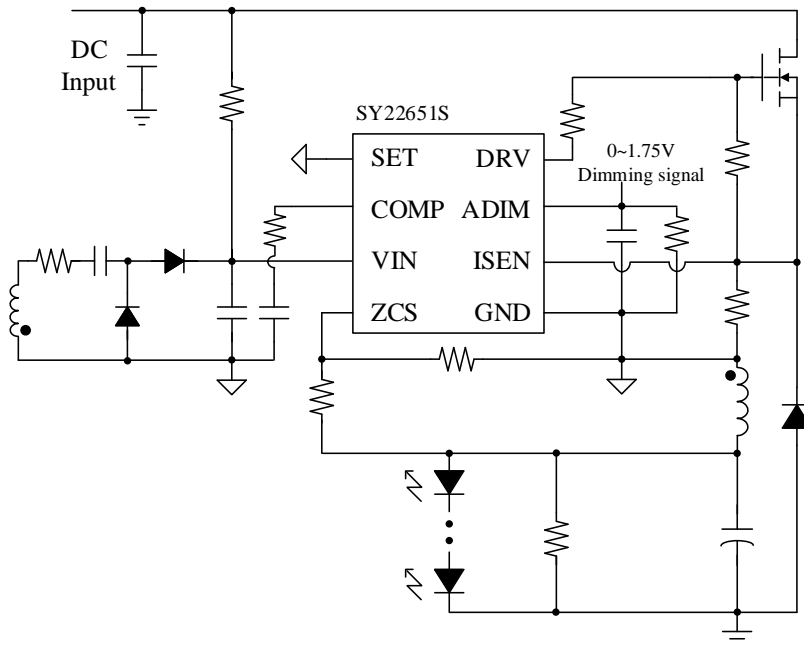
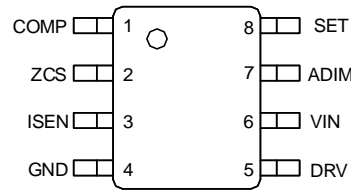


Figure.1 Schematic Diagram

Pinout (top view)



(SO8)

Top Mark: FMBxyz (device code: FMB, *x=year code*, *y=week code*, *z=lot number code*)

Pin Name	Pin number	Pin Description
COMP	1	Loop compensation pin. Connect a RC network across this pin and GND pin to stabilize the control loop.
ZCS	2	Inductor current zero-crossing detection pin. This pin receives the output voltage by a resistor divider and detects the inductor current zero crossing point. This pin also provides over voltage protection. If the voltage on this pin is above V_{ZCS_OVP} , the IC would enter over voltage protection mode.
ISEN	3	Current sense pin. Connect this pin to the source of the MOSFET. Connect the sense resistor across the source of the MOSFET and the GND pin. (Current sense resistor R_s : $R_s = \frac{V_{REF}}{I_{OUT}}$)
GND	4	Ground pin
DRV	5	Gate driver pin. Connect this pin to the gate of the MOSFET.
VIN	6	Power supply pin. This pin also provides output over voltage protection along with ZCS pin.
ADIM	7	External dimming pin. Bypass this pin to GND with enough capacitance to hold on internal voltage reference.
SET	8	OVP mode set pin. If this pin is high, IC latch when OVP; if this pin is low, IC work in hiccup mode when OVP.

Absolute Maximum Ratings (Note 1)

VIN, DRV	-----	-0.3V~25V
Supply current I _{VIN}	-----	7mA
SET	-----	-0.3V~23V
ZCS, ADIM	-----	-0.3V~1.8V
I _{SEN} , COMP	-----	-0.3~3.6V
Power Dissipation, @ T _A = 25°C SO8	-----	1.1W
Package Thermal Resistance (Note 2)		
SO8, θ _{JA}	-----	88°C/W
SO8, θ _{JC}	-----	45°C/W
Temperature Range	-----	-40°C to 150°C
Lead Temperature (Soldering, 10 sec.)	-----	260°C
Storage Temperature Range	-----	-65°C to 150°C

Recommended Operating Conditions (Note 3)

VIN, DRV	-----	8.5V~20V
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Block Diagram

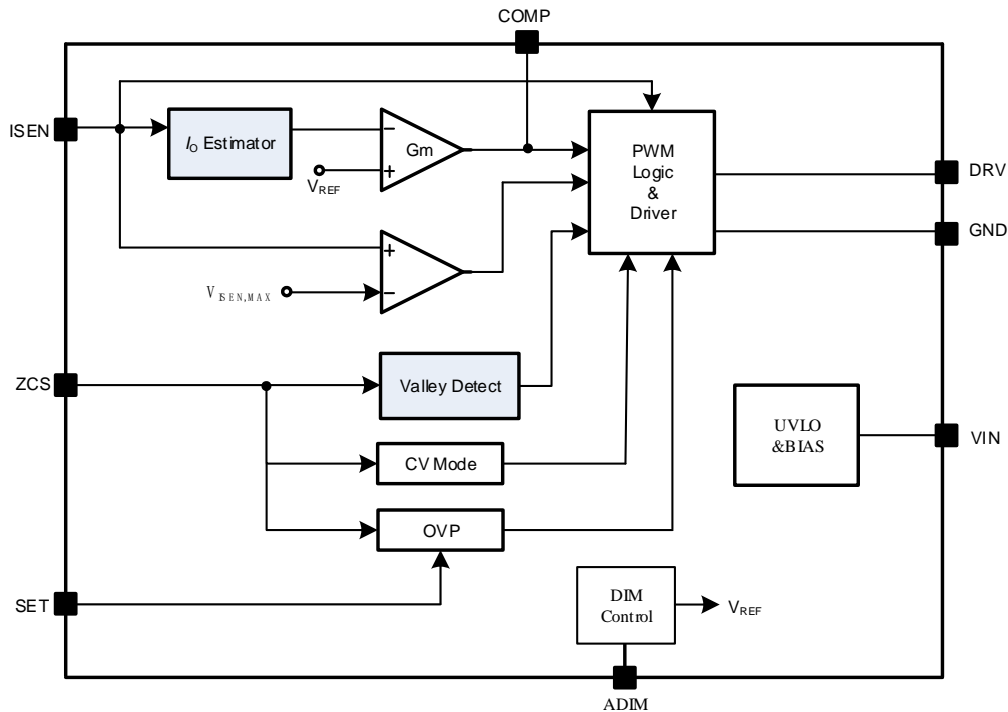


Figure.3 Block Diagram

Electrical Characteristics

($V_{IN} = 12V$ (Note 3), $T_A = 25^\circ C$ unless otherwise specified)

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Supply Section						
VIN Turn-on Threshold	V_{VIN_ON}		12.5	14.0	15.5	V
VIN Turn-off Threshold	V_{VIN_OFF}		6.7	7.3	8.0	V
VIN OVP Voltage	V_{VIN_OVP}			24		V
Start up Current	I_{ST}	$V_{VIN} < V_{VIN_ON}$	24	34	46	μA
Discharge Current in OVP Mode	I_{VIN_OVP}	$V_{VIN} = 15V$ (Note 4)	5	7	10	mA
Error Amplifier Section						
Internal Reference Voltage	V_{REF}		245	250	255	mV
Current Sense Section						
Current Limit Reference Voltage	V_{ISEN_MAX}		530	600	670	mV
ZCS Pin Section						
ZCS Pin OVP Voltage Threshold	V_{ZCS_OVP}		1.43	1.50	1.57	V
Gate Driver Section						
Gate Driver Voltage	V_{Gate}		9.5	12.0	14.5	V
Maximum Source Current	I_{SOURCE}		150	200	250	mA
Minimum Sink Current	I_{SINK}		500	600	800	mA
Max ON Time	T_{ON_MAX}	$V_{COMP} = 2.6V$		20		μs
Min ON Time	T_{ON_MIN}			350		ns
Max OFF Time	T_{OFF_MAX}			52		μs
Min OFF Time	T_{OFF_MIN}			0.5		μs
Maximum switching frequency	f_{MAX}			200		kHz
ADIM Function Section						
ADIM Enable ON	V_{ADIM_ON}		31	42	53	mV
ADIM Enable OFF	V_{ADIM_OFF}		24	35	46	mV
Thermal Section						
Thermal Fold back Temperature	T_{FB}			150		$^\circ C$
Thermal Shut down Temperature	T_{SD}			160		$^\circ C$
OVP Function Section						
OVP Mode Set Voltage	V_{OVP_SET}			0.9		V

Note 1: Stresses beyond the “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: θ_{JA} is measured in the natural convection at $T_A = 25^\circ C$ on a low effective single layer thermal conductivity test board of JEDEC 51-3 thermal measurement standard. Test condition: Device mounted on 2” x 2” FR-4 substrate PCB, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

Note 3: Increase VIN pin voltage gradually higher than V_{VIN_ON} voltage then turn down to 12V.

Note 4: Increase VIN pin voltage gradually higher than V_{VIN} , OVP voltage then turn down to 15V.

Operation

The SY22651S is a DC/DC Buck controller targeting at LED lighting applications with analog dimming function and wide range voltage output.

The SY22651S supports analog dimming function and it has a linear dimming curve.

In order to reduce the switching losses and improve EMI performance, Quasi-Resonant switching mode is applied, which means to turn on the power MOSFET at voltage valley.

the startup current of SY22651S is rather small (34μA typically) to reduce the standby power loss further.

SY22651S provides reliable protections such as Short Circuit Protection (SCP), Open LED Protection (OLP), Over Temperature Protection (OTP), etc.

SY22651S is available with SO8 package.

Applications Information

Start up

After DC BUS is powered on, the capacitor C_{VIN} between VIN and GND pin is charged up by BUS voltage through a start-up resistor R_{ST} . Once V_{VIN} rises up to V_{VIN_ON} , the internal blocks start to work. V_{VIN} will be pulled down by internal consumption of IC until the auxiliary winding of transformer could supply enough energy to maintain V_{VIN} above V_{VIN_OFF} .

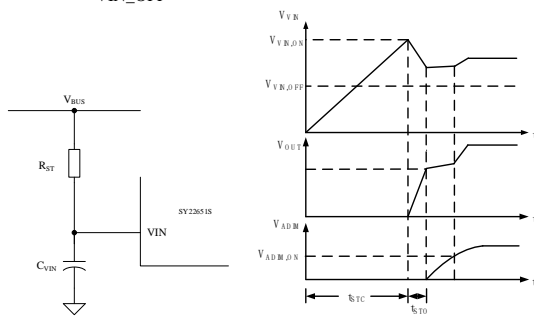


Fig.4 Start up

The whole start up procedure is divided into four sections shown in Fig.4. t_{STC} is the C_{VIN} charged up section, and t_{STO} is the output voltage build-up section. The start-up time t_{ST} is composed of t_{STC} and t_{STO} , and usually t_{STO} is much smaller than t_{STC} .

t_{STO} is fast start-up stage, which will help to create output voltage quickly. After t_{STO} , if V_{ADIM} is less than V_{ADIM_ON} ,

IC enters into CV mode. When V_{ADIM} is larger than V_{ADIM_ON} , IC works in peak current mode.

The start-up resistor R_{ST} and C_{VIN} are designed by rules as below:

(a) Preset start-up resistor R_{ST} , make sure that the current through R_{ST} is larger than I_{ST} and smaller than 1mA.

$$\frac{V_{BUS}}{1mA} < R_{ST} < \frac{V_{BUS}}{I_{ST}} \quad (1)$$

Where V_{BUS} is the BUS line voltage

(b) Select C_{VIN} to obtain an ideal start up time t_{ST} , and ensure the output voltage is built up at one time.

$$C_{VIN} = \frac{\left(\frac{V_{BUS}}{R_{ST}} - I_{ST}\right) \times t_{ST}}{V_{VIN_ON}} \quad (2)$$

(c) If the C_{VIN} is not big enough to build up the output voltage at one time. Increase C_{VIN} and decrease R_{ST} , go back to step (a) and redo such design flow until the ideal start up procedure is obtained.

Internal pre-charge design for quick start up

In P3, V_{COMP} is pre-charged by internal current source until it is over the initial voltage V_{COMP_IC} . V_{COMP_IC} can be programmed by R_{COMP} . Such design is meant to reduce the start-up time shown in Fig.5.

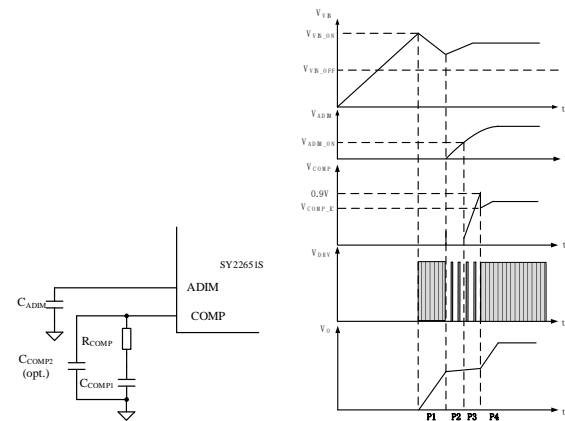


Fig.5 Pre-charge scheme in start up

The voltage pre-charged V_{COMP_IC} in start-up procedure can be programmed by R_{COMP} :

$$V_{COMP_IC} = 0.9V - 300\mu A \times R_{COMP} \quad (3)$$

Where V_{COMP_IC} is the pre-charged voltage of COMP pin.

Generally, a small capacitance of C_{COMP} is necessary to stabilize the system loop (10nF is recommended).

The voltage pre-charged in start-up procedure can be programmed by R_{COMP} ; On the other hand, larger R_{COMP} can provide larger phase margin for the control loop; A small ceramic capacitor is added to suppress high frequency interruption (10pF~100pF is recommended if necessary)

Shut down

After DC BUS is powered off, the energy stored in the BUS capacitor will be discharged. When the power supply for IC is not enough, V_{VIN} will drop down. Once V_{VIN} is below V_{VIN_OFF} , the IC will stop working and V_{COMP} will be discharged to zero.

Constant-current control

The switching waveforms are shown in Fig.6.

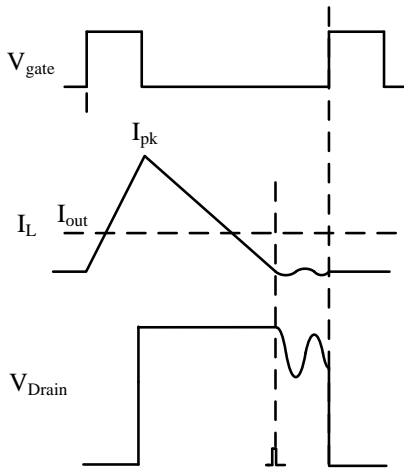


Fig.6 switching waveforms

The average current of the inductor can be detected by ISEN pin of the IC directly, which is applied to the negative input of the gain modulator. In static state, the positive and negative inputs are equal, as shown in Fig.7.

$$V_{REF} = I_{OUT} \times R_S \quad (4)$$

Finally, the output current I_{OUT} can be represented by

$$I_{OUT} = \frac{V_{REF}}{R_S} \quad (5)$$

Where V_{REF} is the internal reference voltage; R_S is the current sense resistor.

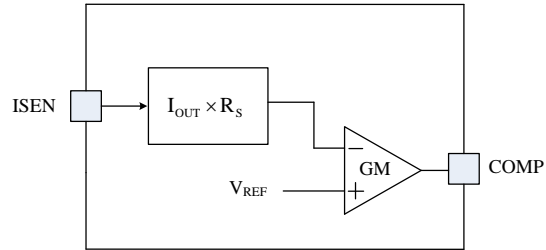


Fig.7 Output current detection diagram

V_{REF} is internal constant parameters, the R_S resistance can be expressed as follows, when the output current is known.

$$R_S = \frac{V_{REF}}{I_{OUT}} \quad (6)$$

Quasi-Resonant Operation

QR mode operation provides low turn-on switching losses for the converter. The voltage across drains and source of the MOSFET is reflected by a resistor divider across Inductor. ZCS pin detects the voltage via this resistor divider. When the voltage across drains and source of the MOSFET is at voltage valley, the MOSFET would be turned on.

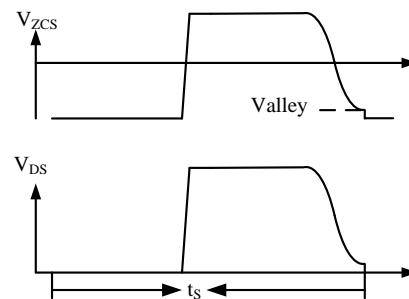


Fig.8 QR mode operation

CV Mode

When V_{ADIM} near to zero, IC and MCU still need bias power:

(1) If V_{ADIM} is greater than V_{ADIM_ON} , IC always works at CC mode.

(2) If V_{ADIM} is lower than V_{ADIM_OFF} , CV mode is triggered. IC works in CV mode to maintain V_{ZCS} nearby V_{ZCS_CV} (0.2V typically). R_{ZCS} could be adjusted to prevent LED flicker and bias supply enough.

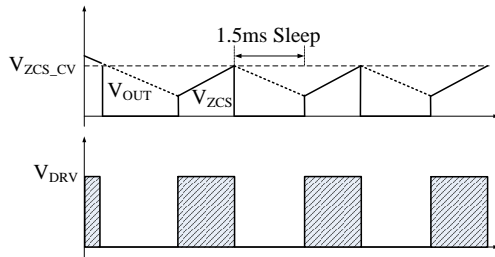


Figure.9 The working process of CV mode

In CV mode,

If V_{ZCS} is smaller than V_{ZCS_CV} , MOSFET turned off when ISEN voltage reach $V_{CV_ISEN_MAX}$ in every switching cycle, and turned on by QR.

If V_{ZCS} is greater than V_{ZCS_CV} , IC will sleep for 1.5ms, until V_{ZCS} is smaller than V_{ZCS_CV} .

The output of CV is decided by OVP.

$$V_{OUT_CV} = \frac{V_{OUT_OVP}}{7.5} \quad (7)$$

Over Voltage Protection (OVP) & Open LED Protection (OLP)

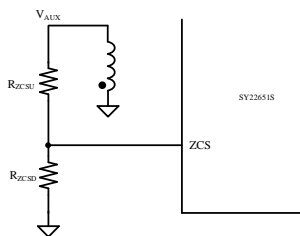


Fig.10 OVP & OLP

The output voltage is reflected by the auxiliary winding voltage of Buck inductor, and both ZCS pin and VIN pin provide over voltage protection function.

The operating mode in case of over voltage protection is determined by SET pin.

If V_{SET} is set to be less than V_{OVP_SET} , SY22651S work in hiccup mode when over voltage protection is triggered. When the load is null or large transient happens, the output voltage will exceed the rated value. When V_{ZCS} exceeds V_{ZCS_OVP} , the over voltage protection is triggered and the IC will discharge V_{VIN} by an internal current source I_{VIN_OVP} . Once V_{VIN} is below V_{VIN_OFF} , the IC will shut down and be charged again by BUS voltage through

start up resistor. If the over voltage condition still exists, the system will operate in hiccup mode.

If V_{SET} is set to exceed V_{OVP_SET} , SY22651S will latch up when over voltage protection is triggered. When V_{ZCS} exceeds V_{ZCS_OVP} within 256us, the over voltage protection is triggered and the IC disable DRV pin output. This state will remain until the power off and V_{VIN} is less than V_{RESET} (1.9V typically).

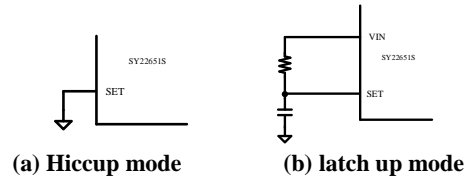


Fig.11 OVP SET

The resistor divider is related with the OVP function.

$$\frac{V_{ZCS_OVP}}{V_{OVP}} = \frac{N_{AUX}}{N_P} \times \frac{R_{ZCSD}}{R_{ZCSU} + R_{ZCSD}} \quad (8)$$

Where V_{OVP} is the output over voltage specification; R_{ZCSU} and R_{ZCSD} compose the resistor divider. The ratio of R_{ZCSU} to R_{ZCSD} could be induced from equation (8).

Short Circuit Protection (SCP)

When the output is shorted, the output voltage is clamped to zero. Valley signal cannot be detected by ZCS. Without valley detection, MOSFET cannot be turned ON until maximum off time t_{OFF_MAX} is matched. If MOSFET is turned ON by t_{OFF_MAX} 64 times continuously, IC will be shut down and enter into hiccup mode.

If the output voltage is not low enough to disable valley detection in short condition, V_{VIN} will drop down without power supply. Once V_{VIN} is below V_{VIN_OFF} , the IC will shut down and be charged again by the BUS voltage through the start-up resistor. If the short circuit condition still exists, the system will operate in hiccup mode.

Dimming Mode

Analog Dimming Mode

SY22651S supports 0~1.75V dimming. the output current is regulated by the voltage on ADIM pin. If V_{ADIM} is lower than V_{ADIM_OFF} , the output current is decreased to zero; When V_{ADIM} is increased from V_{ADIM_OFF} to V_{ADIM_ON} , the output current is created and

the value is 2.4 percent of full load output current; When V_{ADIM} is higher than 1.75V, the output current continues to increase until it reaches 120 percent of the full load output current.

As showed below, the available dimming range of V_{ADIM} is from 42mV to 1750mV.

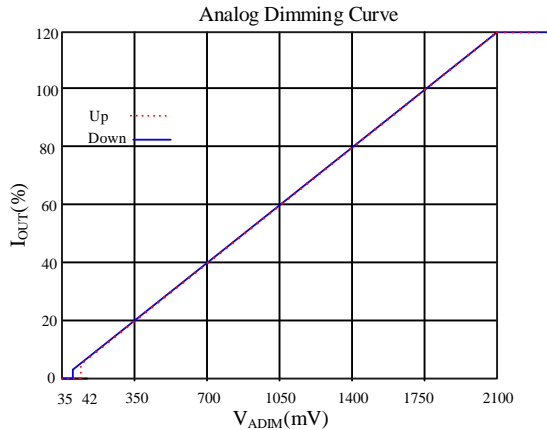


Fig.12 Dimming cure of analog dimming

For further dimming depth

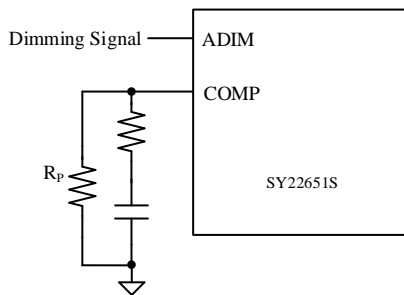


Fig.13 Further Dimming depth circuit

For further dimming depth, R_P is added to achieve it and 2M is recommended.

ADIM capacitor

A capacitor C_{ADIM} need be connected across ADIM pin and GND pin to obtain a smooth voltage waveform of the dimming signal duty cycle. C_{ADIM} is selected by

$$C_{ADIM} \geq \frac{10^{-3}}{f_{DIM}} \text{ F} \cdot \text{Hz} \quad (9)$$

Where f_{DIM} is the frequency of PWM dimming signal that supplies power to ADIM.

Power Device Design

MOSFET and Diode

When the operation condition is with maximum input voltage and full load, the voltage stress of MOSFET and output power diode is maximized;

$$V_{MOS_DS_MAX} = V_{BUS_MAX} \quad (10)$$

$$V_{D_R_MAX} = V_{BUS_MAX} \quad (11)$$

Where V_{BUS_MAX} is the maximum input DC voltage.

When the operation condition is with minimum input voltage and full load, the current stress of MOSFET and power diode is maximized.

Inductor (L)

In Quasi-Resonant mode, each switching period cycle t_s consists of three parts: current rising time t_1 , current falling time t_2 and quasi-resonant time t_3 shown in Fig.13.

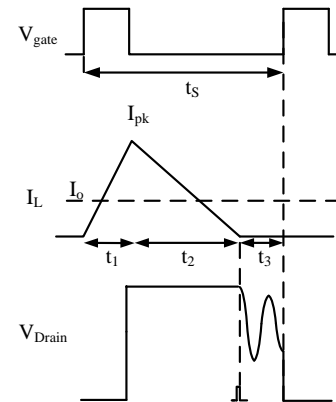


Fig.14 switching waveforms

The system operates in peak current mode. The ON time increases with the input DC voltage decreasing and the load increasing. When the operation condition is with minimum input DC voltage and full load, the ON time is maximized. Thus, the minimum switching frequency f_{S_MIN} happens at minimum input voltage and maximum load condition; Meanwhile, the maximum RMS current through MOSFET happens.

Once the minimum frequency f_{S_MIN} is set, the inductance of the transformer could be calculated. The design flow is shown as below:

(a) Preset minimum frequency f_{S_MIN}

(b) Compute relative t_s, t_1

$$t_s = \frac{1}{f_{s_MIN}} \quad (12)$$

$$t_1 = \frac{t_s \times (V_{OUT} + V_{DF})}{(V_{BUS_MIN} + V_{DF})} \quad (13)$$

$$t_2 = t_s - t_1 \quad (14)$$

Where V_{DF} is the forward voltage of the diode.

(c) Design inductance L

$$L = \frac{(V_{BUS_MIN} - V_{OUT}) \times t_1 \times \eta}{2 \times I_{OUT}} \quad (15)$$

Where η is the efficiency; P_{OUT} is rated full load power;

(d) Compute inductor maximum peak current $I_{L_PK_MAX}$.

$$I_{L_PK_MAX} = \frac{(V_{BUS_MIN} - V_{OUT}) \times t_1}{L} \quad (16)$$

Where $I_{L_PK_MAX}$ is the maximum inductor peak current;

(e) Compute the RMS current of Buck inductor

$I_{L_RMS_MAX}$ is inductor RMS current

$$I_{L_RMS_MAX} = \frac{1}{\sqrt{3}} \times I_{L_PK_MAX} \quad (17)$$

(f) Compute RMS current of the MOSFET

$$I_{MOS_RMS_MAX} = \sqrt{\frac{t_1}{3t_s}} \times I_{L_PK_MAX} \quad (18)$$

Inductor design (N)

These parameters below are necessary:

Necessary parameters	
Inductance	L
inductor maximum current	$I_{L_PK_MAX}$
inductor maximum RMS current	$I_{L_RMS_MAX}$

The design rules are as followed:

(a) Select the magnetic core style, identify the effective area Ae.

(b) Preset the maximum magnetic flux ΔB

$$\Delta B = 0.3 \sim 0.33T$$

(c) Compute the primary turns N

$$N = \frac{L_M}{\Delta B \times Ae} \times \frac{V_{ISEN_MAX}}{R_{ISEN}} \quad (19)$$

(d) Select an appropriate wire diameter

With $I_{L_RMS_MAX}$, select appropriate wire to make sure the current density ranges from 4A/mm² to 10A/mm².

(e) If the winding area of the core and bobbin is not enough, reselect the core style, go to (a) and redesign the transformer until the ideal transformer is achieved.

Output capacitor Cout

Output current ripple ΔI_o is,

$$\Delta I_o = \sqrt{\frac{I_{L_PK_MAX}^2}{3} - I_o^2} \quad (20)$$

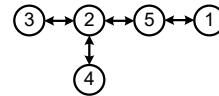
Choose proper output capacitance to satisfy current ripple.

Layout

(a) To achieve better EMI performance and reduce line frequency ripples, the input should be connected to the BUS line capacitor first, then to the switching circuit.

(b) The circuit loop of all switching circuit should be kept small.

(c) The connection of ground is recommended as:



Ground ①: ground node of current sample resistor

Ground ②: ground of GND pin

Ground ③: ground of ADIM capacitor

Ground ④: ground of signal trace except GND pin

Ground ⑤: ground of bias supply capacitor

(d) Bias supply trace should be connected to the bias supply capacitor first instead of GND pin. The bias supply capacitor should be put beside the IC.

(e) Loop of 'Source of MOSFET - current sample resistor - GND pin' should be kept as small as possible.

(f) The resistor divider connected to ZCS pin is recommended to be put beside the IC.

(g) The control circuit is recommended to be put outside the power circuit loop.

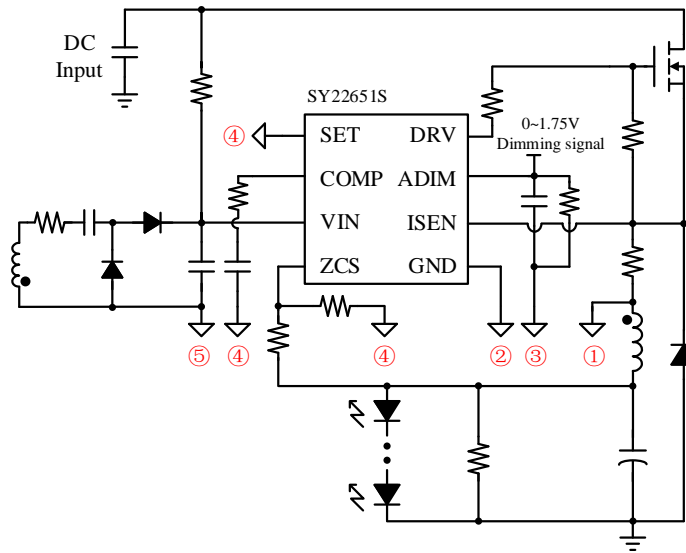


Fig.15 Ground connection recommended

Design Example

A design example of typical application is shown below step by step.

#1. Identify design specification

Design Specification			
V _{BUS}	380~420V	V _{OUT}	50~150V
I _{OUT}	500mA	η	96%

#2. Inductor design (L)

Refer to Power Device Design

Conditions			
V _{BUS,MIN}	380V	V _{BUS,MAX}	420V
P _{OUT}	75W	F _{S,MIN}	70kHz

(a) F_{S,MIN} is preset

$$F_{S,MIN} = 70\text{kHz}$$

(b) Compute the switching period t_s and ON time t₁.

$$t_s = \frac{1}{F_{S,MIN}} = 14.29\mu\text{s}$$

$$t_1 = \frac{t_s \times (V_{OUT} + V_{DF})}{(V_{BUS,MIN} + V_{DF})} = \frac{14.29\mu\text{s} \times (150\text{V} + 1\text{V})}{(380\text{V} + 1\text{V})} = 5.66\mu\text{s}$$

$$t_2 = t_s - t_1 = 14.29\mu\text{s} - 5.66\mu\text{s} = 8.63\mu\text{s}$$

(c) Compute the inductance L

$$L = \frac{(V_{BUS,MIN} - V_{OUT}) \times t_1 \times \eta}{2 \times I_{OUT}} = \frac{(380\text{V} - 150\text{V}) \times 5.66\mu\text{s} \times 0.96}{2 \times 0.5\text{A}} = 1249.7\mu\text{H}$$

Choose L=1200uH;

(d) Compute inductor maximum peak current I_{L,PK,MAX}.

$$I_{L,PK,MAX} = \frac{(V_{BUS,MIN} - V_{OUT}) \times t_1}{L} = \frac{(380\text{V} - 150\text{V}) \times 5.66\mu\text{s}}{1200\mu\text{H}} = 1.085\text{A}$$

Where I_{L,PK,MAX} is the maximum inductor peak current;

(e) Compute RMS of the inductor current I_{L,RMS,MAX}

$$I_{L,RMS,MAX} = \frac{1}{\sqrt{3}} \times I_{L,PK,MAX} = \frac{1}{\sqrt{3}} \times 1.085\text{A} = 0.626\text{A}$$

#3. Select power MOSFET and power diode

Refer to Power Device Design

Known conditions at this step			
V _{BUS,MAX}	420V	η	96%
V _{OUT}	150V		

Compute the voltage and the current stress of MOSFET:

$$I_{MOS_RMS_MAX} = \sqrt{\frac{t_1}{3t_s}} \times I_{L,PK_MAX} = \sqrt{\frac{5.66\mu s}{3 \times 14.29\mu s}} \times 1.085A = 0.394A$$

#4. Set VIN pin

Refer to Start up

Conditions			
V _{BUS,MIN}	380V	V _{BUS,MAX}	420V
I _{ST}	34μA (typical)	V _{VIN_ON}	14.5V (typical)
		t _{ST}	500ms (designed by user)

(a) R_{ST} is preset

$$R_{ST} < \frac{V_{BUS}}{I_{ST}} = \frac{380V}{34\mu A} = 11.17M\Omega$$

$$R_{ST} > \frac{V_{BUS,MAX}}{1mA} = \frac{420V}{1mA} = 420k\Omega$$

Set R_{ST}

$$R_{ST} = 510k\Omega \times 2 = 1020k\Omega$$

(b) Design C_{VIN}

$$C_{VIN} = \frac{\left(\frac{V_{BUS,MIN}}{R_{ST}} - I_{ST}\right) \times t_{ST}}{V_{VIN_ON}}$$

$$= \frac{\left(\frac{380V}{1020k\Omega} - 34\mu A\right) \times 500ms}{14.5V}$$

$$= 11.67\mu F$$

Set C_{VIN}

$$C_{VIN} = 10\mu F$$

#5 Set COMP pin

Refer to **Internal pre-charge design for quick start up**

Parameters designed			
R _{COMP}	1.0kΩ	V _{COMP_IC}	900mV
C _{COMP1}	10nF	C _{COMP2}	NC

#6 Set current sense resistor to achieve ideal output current

Refer to **Constant-current control**

Known conditions at this step			
V _{REF}	0.25V	I _{OUT}	0.5A

The current sense resistor is

$$R_s = \frac{V_{REF}}{I_{OUT}} = \frac{0.25V}{0.5A} = 0.5\Omega$$

#7 set ZCS pin

Refer to **Over Voltage Protection (OVP) & Open Loop Protection (OLP)**

First, Set R_{ZCSD}=10kΩ.

Then compute R_{ZCSU}

Conditions			
N _P	100	N _{AUX}	6
V _{ZCS_OVP}	1.50V	V _{OVP}	165V
V _{OUT}	150V		
Parameters designed			
R _{ZCSD}	10kΩ		

$$R_{ZCSU} = \frac{(V_{OVP} \times \frac{N_{AUX}}{N_P} - V_{ZCS_OVP}) \times R_{ZCSD}}{V_{ZCS_OVP}} = \frac{(165V \times \frac{6}{100} - 1.5V) \times 10k\Omega}{1.5V} = 56k\Omega$$

R_{ZCSU} is set to

$$R_{ZCSU} = 56k\Omega$$

#8 set ADIM pin

Refer to **Analog Dimming Mode**

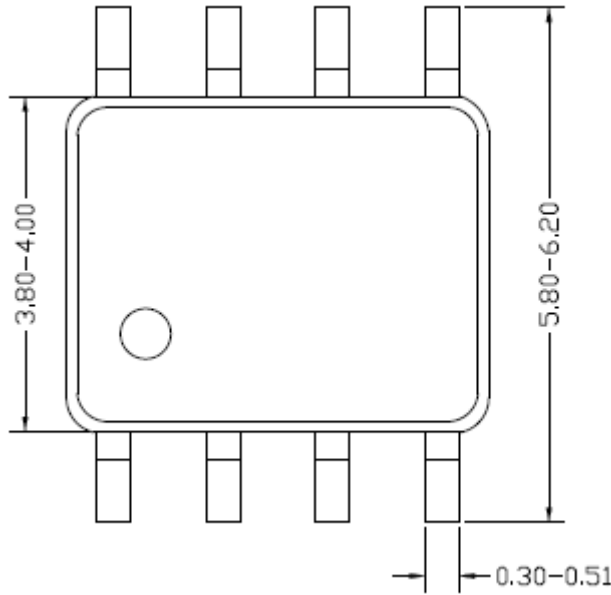
$$C_{ADIM} \geq \frac{10^{-3}}{f_{PWM}} F \times Hz = \frac{10^{-3}}{1000} F = 1\mu F$$

Hence C_{ADIM} is set to

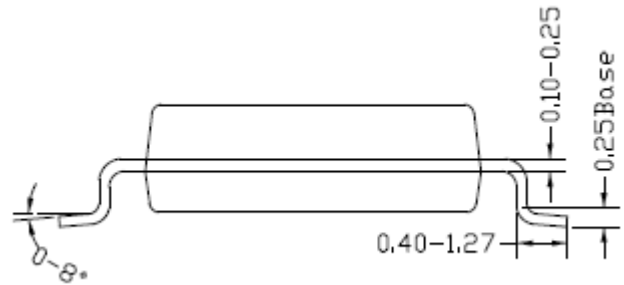
$$C_{ADIM} = 2.2\mu F$$

#9 final result

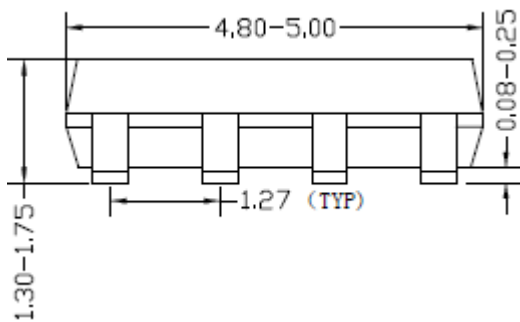
SO8 Package outline & PCB layout design



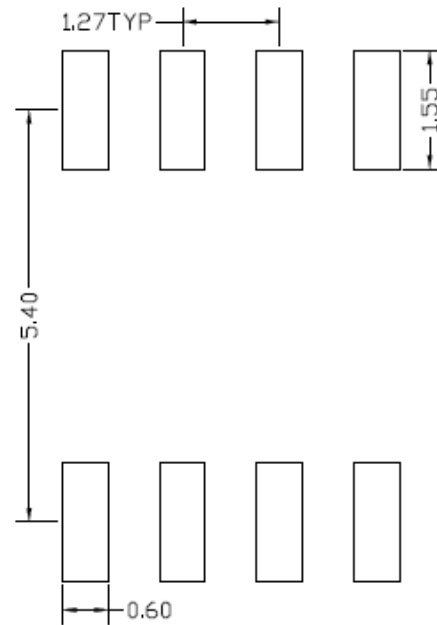
Top view



Side view



Front view

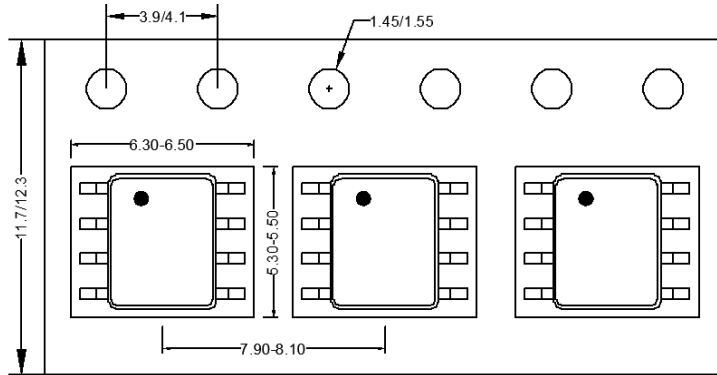


**Recommended Pad Layout
(Reference only)**

Notes: All dimension in millimeter and exclude mold flash & metal burr.

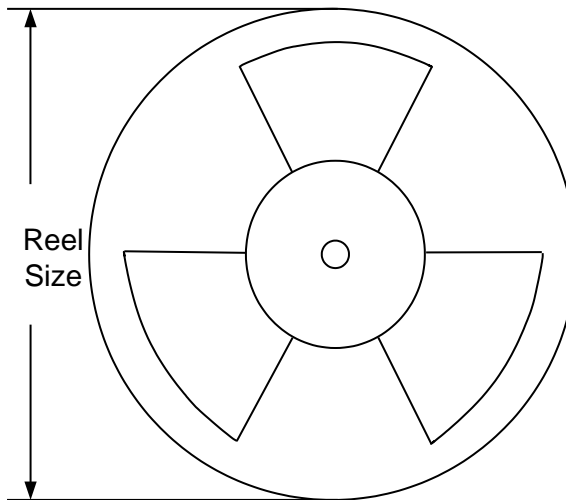
Taping & Reel Specification

1. Taping orientation for packages (SO8)



Feeding direction →

2. Carrier Tape & Reel specification for packages



Package type	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
SO8	12	8	13"	400	400	2500

Revision History

The revision history provided is for informational purpose only and is believed to be accurate, however, not warranted. Please make sure that you have the latest revision.

Date	Revision	Change
May 15,2023	Revision 0.9	Initial Release

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