HIGH POWER FACTOR FLYBACK PWM CONTROLLER

DESCRIPTION

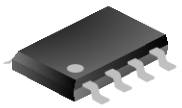
SD7530 is a high power factor flyback PWM controller special for LED lighting applications.

SD7530 features a high performance analog multiplier for power factor correction (PFC), zero current detector (ZCD) to ensure TM operation. It integrates a current sensing comparator with built-in leading-edge blanking, and a totem-pole output stage capable of -600mA /800mA current suited for big MOSFET.

SD7530 has a built-in soft-start circuit to avoid the over voltage output under light load start, reduce MOSFET's voltage stress, and improve circuit's reliability.

SD7530 has a built-in output short-circuit protection circuit, in this way the current of the system is considerably reduced to avoid the damage to IC.

SD7530 includes V_{CC} under voltage lockout, V_{CC} over voltage protection, and over temperature protection, etc.



SOP-8-225-1.27

APPLICATIONS

* LED Daylight lamp

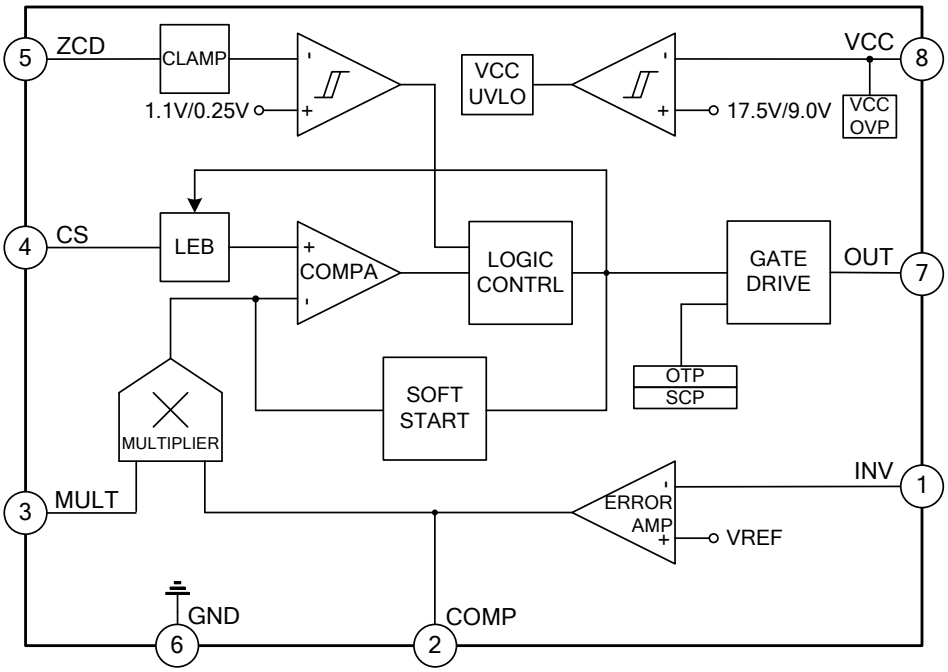
FEATURES

* Transition Mode (TM) operation
* High-performance analog multiplier
* Built-in restart timer
* Integrate digital LEB
* Low start-up current (5μA)
* Audio noise free
* Built-in soft start circuit
* Very low power dissipation of output short-circuit protection (SCP)
* V_{CC} under vltage lockout with hysteresis (UVLO)
* V_{CC} over-voltage protection (VCCOVP)
* Over temperature protection (OTP)

ORDERING INFORMATION

Part No.	Package	Marking	Material	Packing
SD7530S	SOP-8-225-1.27	SD7530S	Halogen free	Tube
SD7530STR	SOP-8-225-1.27	SD7530S	Halogen free	Tape&Reel

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

Characteristics	Symbol	Rating	Unit
Supply voltage (I_{CC}<20mA)	V_{CC}	40	V
Peak drive output current	I_{OH}/I_{OL}	-600/800	mA
Voltage on analog input and output pins	-	-0.3 ~ 8	V
Maximum current of zero current detector	-	±10	mA
Power dissipation (ambient temperature: 50°C)	P_{diss}	0.65	W
Operating temperature range	T_{amb}	-40~+120	°C
Storage temperature range	T_{stg}	-55~+150	°C
Junction temperature	T_j	+150	°C
Thermal resistance from chip surface to the ambient	$R_{th(j-a)}$	150	°C/W °C/W

ELECTRICAL CHARACTERISTICS(Unless otherwise stated, V_{CC}=22V； C_O=1nF； -25°C<T_{amb}<125°C)

Characteristics	Symbol	Test condition	Min.	Typ.	Max.	Unit
Power supply						
Operating voltage range	V_{CC}	After start-up	10.5	--	32	V
Turn-on threshold	V_{CCon}	*	16.5	17.5	18.5	V
Turn-off threshold	V_{CCoff}	*	8.0	9.0	10.0	V
Hysteresis voltage	V_{CChys}		--	8.5	--	V

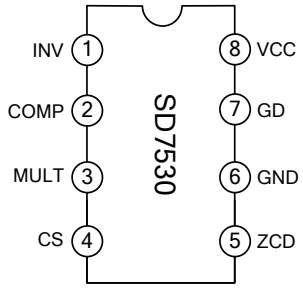
Characteristics	Symbol	Test condition	Min.	Typ.	Max.	Unit
Clamp voltage	V_z	I_{CC}=20mA	--	40	--	V
VCC OVP	VCC_{ovp}		32	34	36	V
Supply current						
Start current	I_{ST}	Before start-up, V_{CC}=15V	--	5	10	μA
Quiescent current	I_Q	No switch	--	4	6	mA
Operating current	I_{CC}	f=70kHz	--	5	7	mA
Multiplier						
Input bias current	I_{MULT}	V_{MULT} = 0 ~ 4V	--	--	-1	μA
Input voltage range	V_{MULT}	Linear operation range	0~3	--	--	V
Gain **	K	V_{MULT}=1V, V_{COMP}=4V	0.32	0.38	0.44	1/V
Maximum output slope	$\frac{\Delta V_{CS}}{\Delta V_{MULT}}$	V_{MULT}=0 ~ 1V V_{COMP}=upper clamp voltage	1.0	1.1	--	V/V
Error amplifier						
Voltage feedback input threshold	V_{REF}	T_{amb}=25°C	2.45	2.5	2.55	V
		10.5V< V_{CC} <32V *	2.44	--	2.56	
Linear regulation	-	V_{CC} =10.5V~ 32V	--	2	5	mV
Input bias current	I_{INV}	V_{INV} = 0 ~ 3V	--	--	-1	μA
Voltage gain	G_V	Open loop	60	80	--	dB
Gain bandwidth product	G_B		--	1	--	MHz
Source current	I_{COMP}	V_{COMP}=4V, V_{INV}=2.4V	-2	-3.5	-5	mA
Sink current	I_{COMP}	V_{COMP}=4V, V_{INV}=2.6V	4	5.5	7	mA
Upper clamp voltage	V_{COMP}	I_{source}=0.5mA	5.0	6.0	6.5	V
Lower clamp voltage	V_{COMP}	I_{sink}=0.5mA *	2.0	2.25	2.4	V
Current sense comparator						
Input bias current	I_{CS}	V_{CS}=0V	--	--	-1	μA
Delay to output	$t_{d(H-L)}$		--	200	400	ns
Current sense clamp	V_{CS}	V_{COMP}=Upper clamp V_{MULT}=1.5V	1.0	1.08	1.16	V
Current sense offset	V_{offset}	V_{MULT}=0V	--	25	--	mV
		V_{MULT}=2.5V	--	5	--	
Zero current detector						
Input bias current	I_{ZCD}	V_{ZCD}=1 ~ 4.5V	--	2	--	μA
Detect threshold	$V_{th(det)}$	V_{ZCD} rise ***	--	1.1	--	V
		V_{ZCD} fall ***	--	0.25	--	V
Detect hysteresis	HY(det)	***	--	0.85	--	V
Upper clamp voltage	V_{ZCD}	I_{ZCD}=2.5mA	6.3	6.8	7.3	V
Lower clamp voltage	V_{ZCD}	I_{ZCD}=-2.5mA	-0.3	0	0.3	V
Source current capability	I_{src}		-2.5	--	--	mA
Sink current capability	I_{snk}		2.5	--	--	mA
Restart timer						
Restart timer period	$t_{d(rst)}$		31	38	45	μs

Characteristics	Symbol	Test condition	Min.	Typ.	Max.	Unit
Over Temperature Protection						
OTP	T_{OTP}		--	135	--	°C
Temperature hysteresis	T_{HYS}		--	15	--	°C
Gate driver						
Output low voltage	V_{OL}	I_{sink}=100mA	--	0.6	1.2	V
Output high voltage	V_{OH}	I_{source}=5mA	--	15	--	V
Peak drive source current	I_{srcpk}		-0.6	--	--	A
Peak drive sink current	I_{snkpk}		0.8	--	--	A
Voltage rise time	t_r		--	70	110	ns
Voltage fall time	t_f		--	40	70	ns
Output clamp voltage	V_{clamp}	I_{source}=5mA ; V_{CC}=32V	12	15	18	V

* All the parameters are in tracking
** The multiplier output is given by: $V_{CS} = K \times V_{MULT} \times (V_{COMP} - 2.5)$

*** Parameters guaranteed by design.

PIN CONFIGURATIONS



PIN DESCRIPTIONS

Pin No.	Pin Name	I/O	Description
1	INV	I	Inverting input of the error amplifier. The pin doubles as an ON/OFF control input.
2	COMP	I/O	Output of the error amplifier. A compensation network is placed between this pin and INV.
3	MULT	I	Main input to the multiplier.
4	CS	I	Input to the PWM comparator. The current flowing in the MOSFET is sensed through a resistor, the resulting voltage is applied to this pin.
5	ZCD	I	Input to the zero current detector.
6	GND	I/O	Ground.
7	GD	O	Gate driver output.
8	VCC	I/O	Supply voltage.

FUNCTION DESCRIPTION

SD7530 is a high power factor flyback PWM controller special for LED lighting applications. It operates in transition mode, it reduces the switch turn-on loss, improves the conversion efficiency and provides very good power factor correction.

V_{CC} UVLO and V_{CC} OVP

Peripheral/internal circuit at pin Vcc of SD7530 is shown in figure 1. At the beginning of the power on, capacitor C1 is charged by V_{IN} through start resistor R1, and V_{CC} increases slowly. As V_{CC} is up to 17.5V, IC starts to work and output driving pulse. Output voltage should be established in a period during which V_{CC} discharges and diode D2 is reverse biased, and IC is fully powered by start capacitor C1. When output voltage increases to a certain value, diode D2 is forward conduction by auxiliary winding L3's voltage, and then V_{CC} increases rapidly to the desired value. Fig. 2 shows the voltage waveform of V_{CC} during start.
IC enters under voltage status as V_{CC} is lower than 9.0V after start.
Moreover, the startup current of SD7530 is very low (less than 5uA), so large startup resistance R1 is recommended for low power dissipation.
If Vcc exceeds the internal reference 34V, IC enters over voltage protection (OVP), and turns off the PWM until next restart.

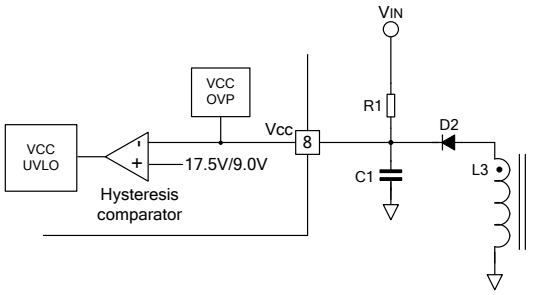


Fig.1 Internal /peripheral circuit at pin V_{CC}

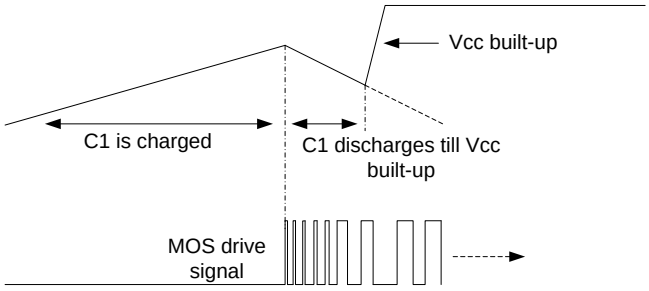


Fig. 2 the voltage waveform of V_{CC} during start

Error amplifier

Error amplifier of SD7530 and peripheral circuit are shown in fig.3. Error amplifier compares the voltage of pin INV which is fed back from output by optp-coupler with reference voltage (2.5V), amplifies the difference and outputs Vcomp. Generally, the bandwidth of PFC loop is less than 20Hz for better power factor correction, so compensation capacitor or resistor is connected between output (COMP) and inverting input (INV) of error amplifier in applications.

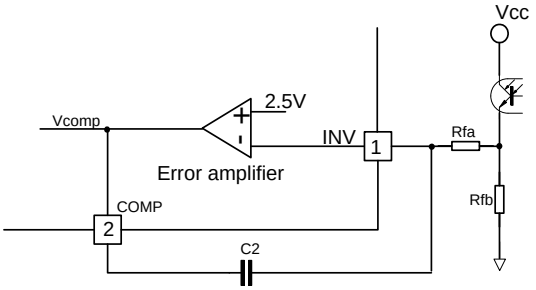


Fig.3 Error amplifier and peripheral circuit

Multiplier

Multiplier of SD7530 and peripheral/internal circuit are shown in figure 4. Input voltage V_{IN} (output of rectifier bridge) is connected to input of multiplier through pin MULT after voltage dividing by R1a, R1b, and the other input of multiplier is output of error amplifier. Input voltage Vmult at pin MULT is half-sine voltage signal, but output voltage of multiplier Vmo is the half-sine voltage with same phase and different amplitude of input voltage Vmult, and controls the peak inductor current to change simultaneity, so that half-sine input average current is available.

Input and output of multiplier is expressed as:

$$Vmo = K \times Vmult \times (Vcomp - 2.5)$$

Where, K is the gain. (typical value for SD7530 is 0.38)

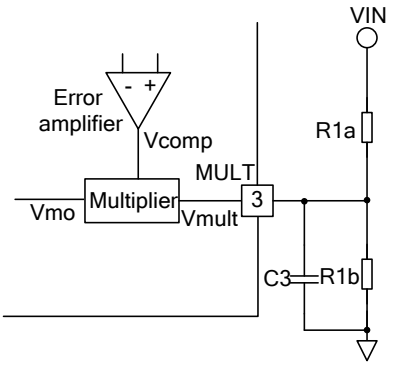


Fig.4 Multiplier and peripheral circuit

Inductor current detection (turn off MOSFET)

Current sense comparator of SD7530 and peripheral circuit are shown in figure 5. It is used for detecting inductor peak current to turn off MOSFET and make the system to stop working. Sense resistor Rs is connected between source of MOSFET and ground, and the voltage of sense resistor can be behaved on inductor current, which acts as the non-inverting input of current sense comparator through pin CS, compared with output of multiplier, which acts as the inverting input. If peak voltage of sense resistor increases to the limited value of multiplier output, current sense comparator's output overturns to turn off MOSFET.

LEB is added at pin CS to chops off the sense voltage spike at MOSFET on state due to snubber diode reverse recovery.

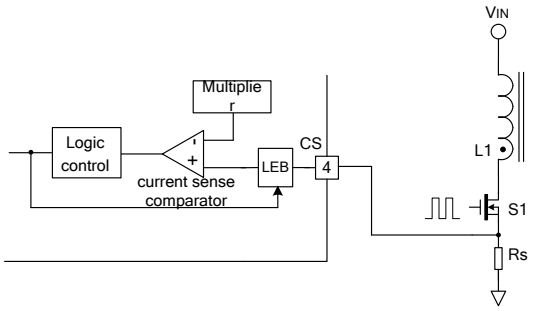


Fig 5. Current sense comparator and peripheral circuit

Zero current detection (turn on MOSFET)

Zero current comparator of SD7530 and peripheral circuit are shown in Fig.6. Zero current detector is used for detecting zero-crossing of inductor current and turning on MOSFET. Dotted terminal of auxiliary winding L3 is connected to pin ZCD via a resistor Rzcd. When inductor current decreases to zero, voltage at dotted terminal is lower than 0.25V, gate drive signal of MOSFET turns to high and MOSFET is turned on, and 0.85V hysteresis is set to avoid error actions.

Clamp circuit at pin ZCD clamps the voltage in 0V~6.0V.

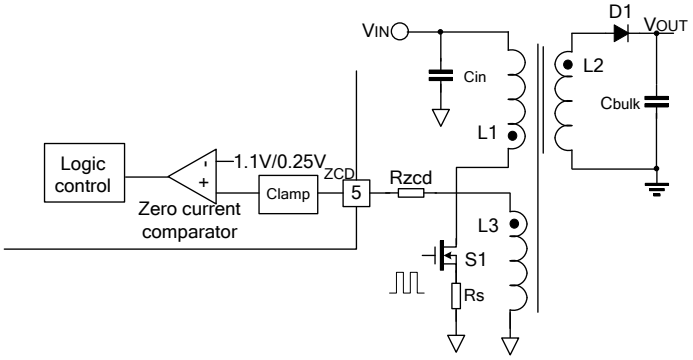


Fig. 6 Zero current comparator and peripheral circuit

Fig. 7 shows the detailed voltage waveforms for zero current detection. After MOSFET is turned off and before the inductor current decreases to zero, the voltage at pin ZCD keeps high and is given as:

$$V_{ZCD} = \frac{(Vo - Vin)}{n}$$

Where, n is the turns ratio of the primary windings L1 and auxiliary windings L3.

During MOSFET off but inductor current is not zero, the inductor current is supplied to the load through secondary winding L2 and diode D1, and decreases linearly to zero, at the mean while the diode D1 is reverse blocked and MOSFET S1 junction capacitor is resonant with the primary windings L1 and input capacitor Cin. Then the drain voltage of MOSFET is going down, voltage at pin ZCD also decreases. When the drain voltage decreases to V_{IN}, the voltage at dotted terminal of auxiliary winding L3 is zero. Due to MOSFET is still off, the drain voltage continuously decreases until the voltage at pin ZCD is lower than 0.25V, then MOSFET is on. When the drain voltage decreases to zero, the resonance stops and the inductor current increases linearly.

As shown in Fig. 7 below, this characteristic allows turning on MOS with low voltage for decreasing the switch turn-on loss

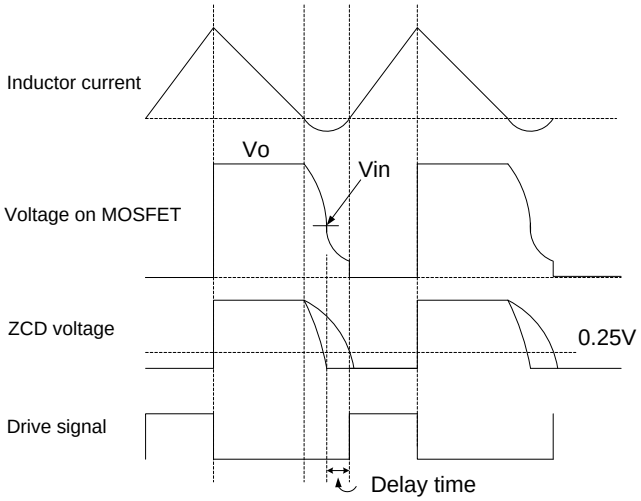


Fig. 7. The detailed voltage waveforms for zero current detection

Output short-circuit protection

SD7530 integrates output short-circuit protect(SCP) circuit. If output load's short-circuit state is detected by IC, PWM will be turned off automatically, and V_{CC} will gradually decrease until IC restarts automatically.

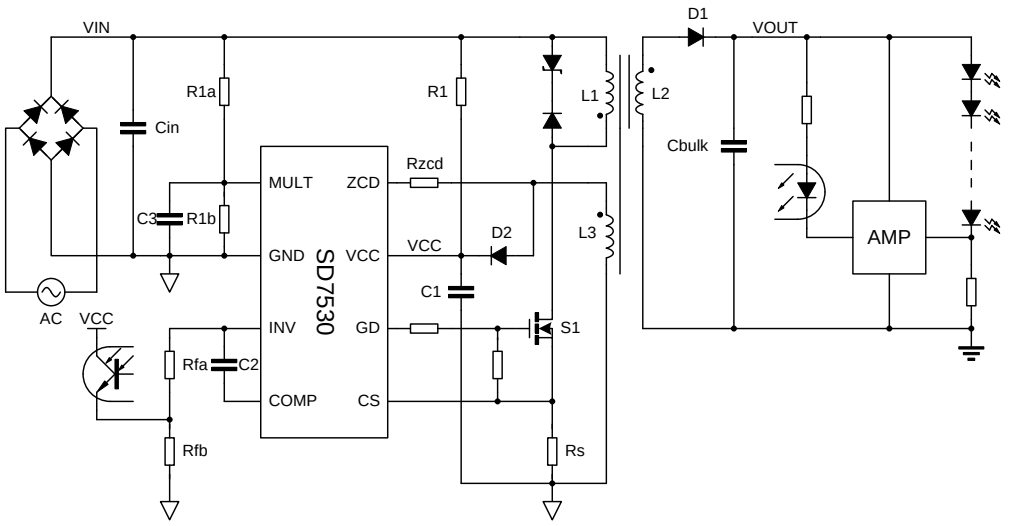
Soft start

SD7530 integrates soft-start circuit, which is used to reduce the voltage stresses and current surges of IC during start up. This circuit first clamps the output voltage of multiplier at a low level, then improves the output voltage gradually during start up. So that PWM can increase gradually from zero to the steady state.

Over temperature protection

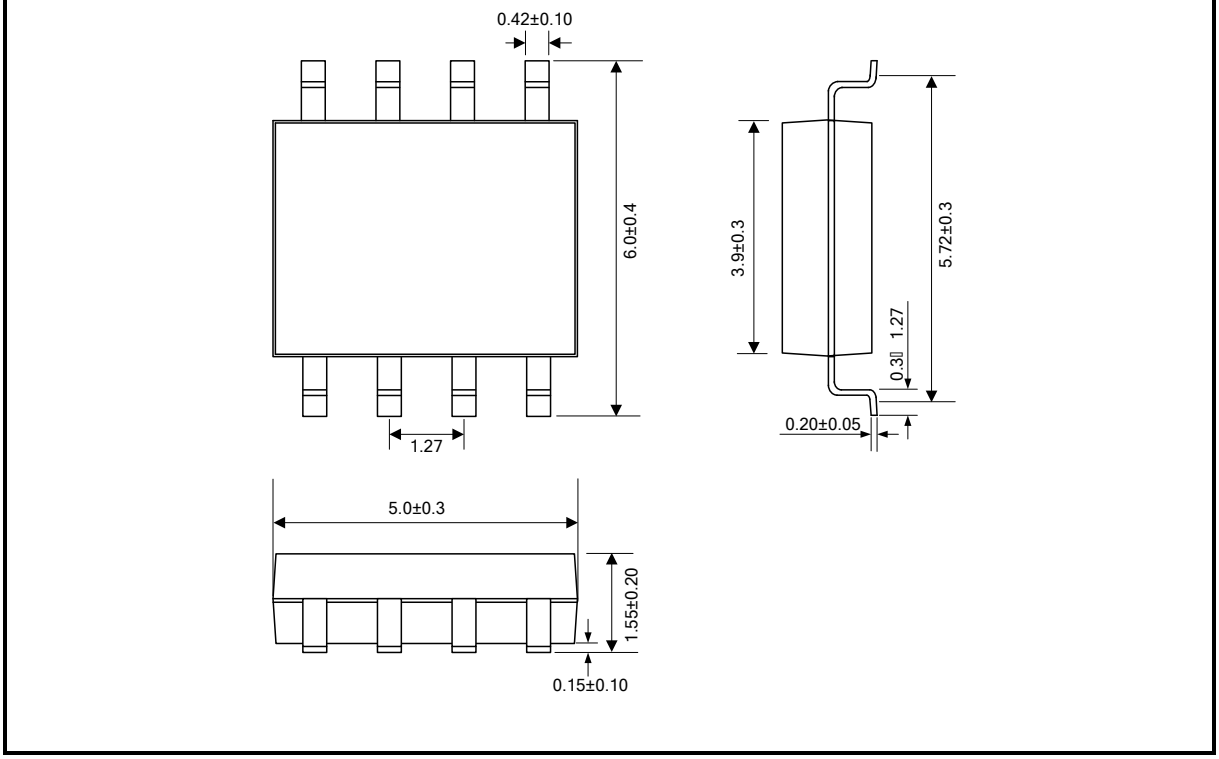
SD7530 integrates over temperature protect(OTP) circuit. IC is shutdown when the temperature is higher than 135°C and recovers when temperature decreases to 120°C.

TYPICAL APPLICATION CIRCUIT



PACKAGE OUTLINE

SOP-8-225-1.27 UNIT: mm



MOS DEVICES OPERATE NOTES:

Electrostatic charges may exist in many things. Please take following preventive measures to prevent effectively the MOS electric circuit as a result of the damage which is caused by discharge:

- The operator must put on wrist strap which should be earthed to against electrostatic.
- Equipment cases should be earthed.
- All tools used during assembly, including soldering tools and solder baths, must be earthed.
- MOS devices should be packed in antistatic/conductive containers for transportation.

Disclaimer :

- **Silan reserves the right to make changes to the information herein for the improvement of the design and performance without further notice! Customers should obtain the latest relevant information before placing orders and should verify that such information is complete and current.**
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- **Silan will supply the best possible product for customers!**

ATTACHMENT

Revision History

Date	REV	Description	Page
2012.10.25	1.0	Initial release	
2013.07.24	1.1	Delete the information of SD7530A	