TKL313SC Application Note

Ver.1.1

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All specifications may be changed without notice.

1. Description

The TKL313SC is a LED driver IC up to 10W(AC100V) and 20W(AC200V) output suitable for LED light bulb and LED straight bulb. It operates with AC direct input and realizes high efficiency and high power factor without flicker by switching ripples. High reliability is realized with simple circuit construction, and it can be applied for PMW and TRIAC dimming. HV-MOSFET control blocks which can control output power by outer configuration resistance are included.

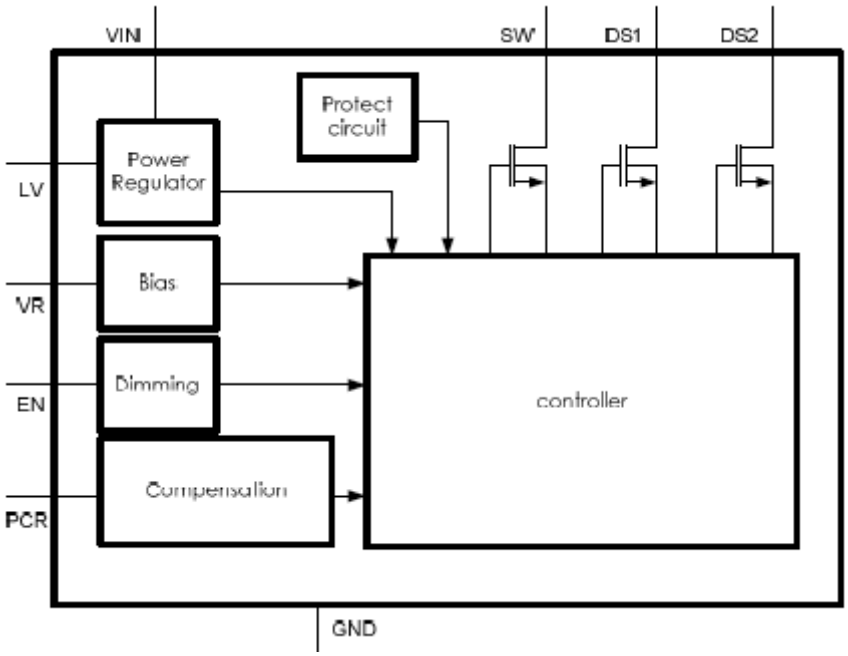
2. Features

- LED driver with non isolated direct connection to AC line
- Adaptable for AC100V(110V) and AC200V(220V)
- Capable of configuration of LED current
- High power factor
- High efficiency
- The driving circuit can be mounted on the same PCB of LEDs.
- Special circuit block for EMI reduction
- PWM dimmable
- TRIAC dimmable
- Power compensation function to keep out turning off and reduce flickering in case of input voltage drop.
- Current hold function to keep out turning off and reduce flickering on TRIAC dimming.
- Patent pending architecture realizes that minimum additional parts count and cost reduction and high reliability.
- Over Voltage Protection circuit
- Under Voltage Lock Out circuit
- Over Temperature Protection circuit
- Conformity with RoHS

Applications

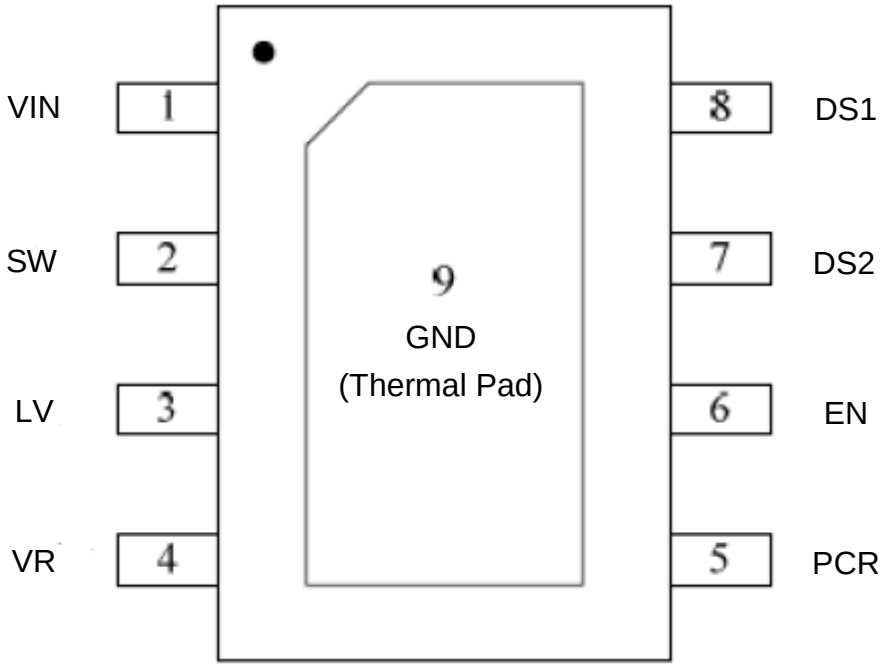
- LED light bulb, LED straight bulb
- Other indoor LED lighting system

3. Block Diagram



Internal circuit block

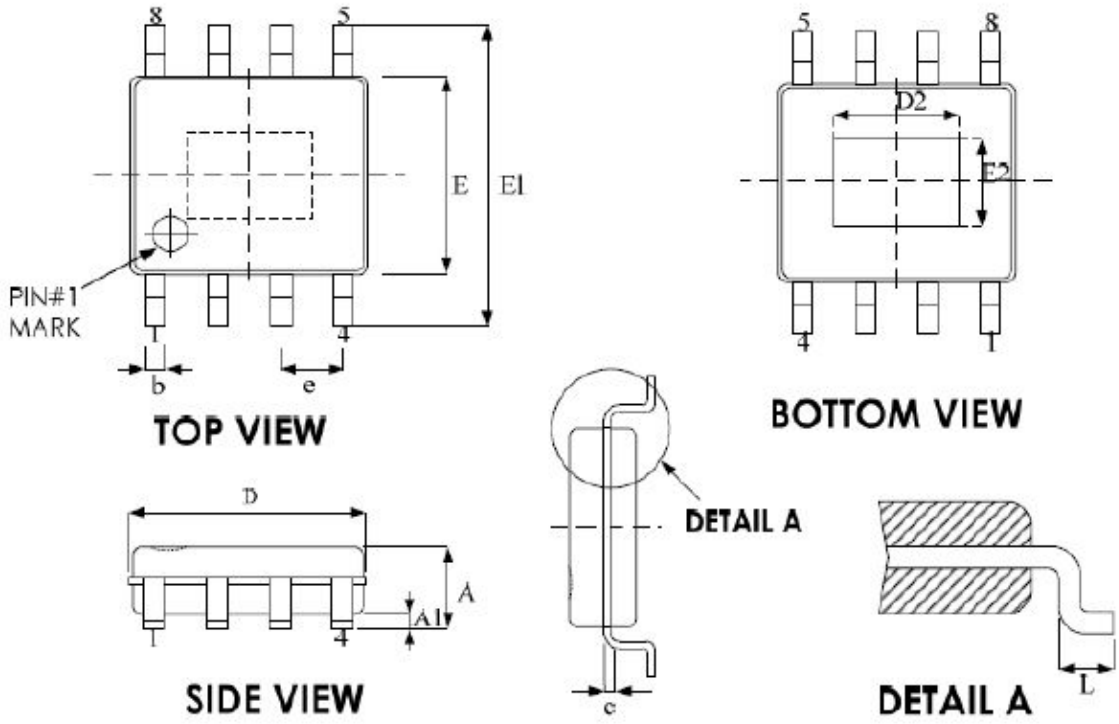
4. Pin Configuration



Pin #	Symbol	Function
1	VIN	**Power supply input** Power source voltage is from 80V to 240V. Non rectified voltage cannot be inputted.
2	SW	**String 1sink current (switching) input** It is connected to cathode of LED string 1.
3	LV	**Internal power output** It is via an internal regulator and is to be connected a capacitor for stable operation.
4	VR	**Output adjustment** A resistor is connected to it for LED current adjustment.
5	PCR	**Power compensation configuration** A resistor is connected to it for compensation ratio setting.
6	EN	**PWM dimming input** Logical signal is inputted to it on dimming. It is not connected with internal pull up in case of no dimming.
7	DS2	**String 3 sink current input** It is connected to cathode of LED string 3.
8	DS1	**String 2 sink current input** It is connected to cathode of LED string 2.
9	GND	**Ground connection (Back pad for heat radiation)**

5. Package Outline

Package Outline Drawing
E-SOP-8 (150 mil)



Symbol	Dimension in mm	
	Min	Max
A	1.35	1.75
A1	0.00	0.25
b	0.33	0.51
c	0.17	0.25
D	4.80	5.00
E	3.81	4.00
E1	5.79	6.20
e	1.27 BSC	
L	0.41	1.27

Exposed pad

	Dimension in mm	
	Min	Max
D2	2.84	3.10
E2	2.06	2.31

6. Electrical Characteristics

Absolute maximum ratings

Parameter	Ratings	Condition
VIN maximum input voltage	700V	
SW, DS1, DS2 maximum input voltage	500V	
LV, VR, PCR, EN maximum input voltage	6V	
Acceptable ESD voltage	2kV	HBM
	200V	MM
Operating ambient temperature	-25～+125℃	
Maximum junction temperature	150℃	
Storage temperature	-65～+150℃	
Soldering temperature	260℃	10sec

Electrical Characteristics

Ta=25℃, VIN=AC110V in case without notice

Parameter	Symbol	Values			Unit
		MIN	TYP	MAX	
Input voltage (in case 110V)	VIN	80		130	V
Input voltage (in case 220V)	VIN	200		240	V
Input current	IIN		2		mA
Additional resistance	Rext	180		400	kΩ
Accuracy of LED current	Iout	-5		5	%
OVP voltage	VOVP			400	V
LED current (Rext=300kΩ)	ILED		60		mA
PWM frequency	FPWM			200	kHz
PWM duty	DPWM			100	%
UVLO voltage	VUVLO		4		V
ON threshold voltage	VEN			1.2	V
OFF threshold voltage	VEN	0.4			V
OTP temperature	OTP		150		℃
OTP hysteresis	OTP		50		℃

7. Thermal characteristics

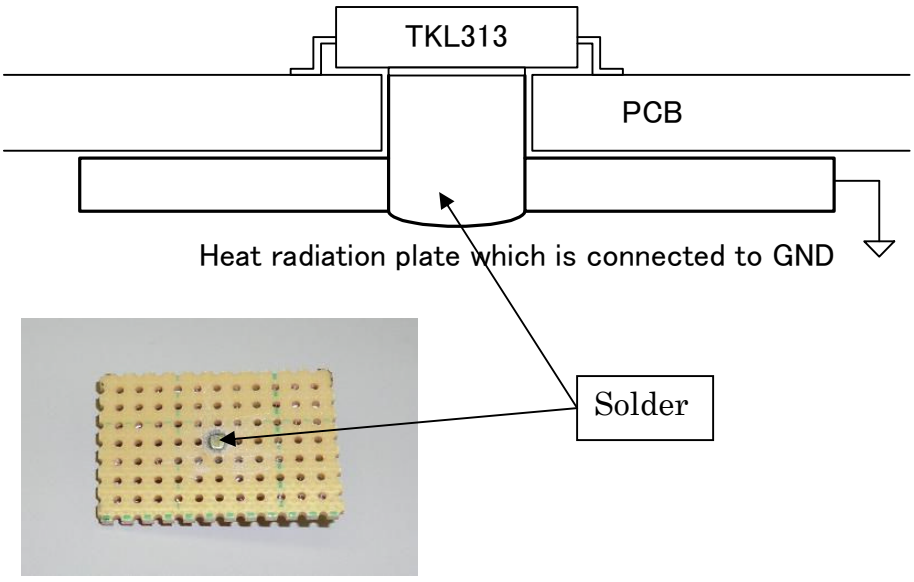
Thermal resistance

Parameter	Ratings	Condition
θ_{JA} (Junction-Ambient)	75℃/W	JEDEC 51-7
θ_{JC} (Junction-Case)	15℃/W	

Heat radiation

Driving current is limited in the IC and the power consumption turn to heat. Heat radiation from the back pad of IC is indispensable. The back pad is GND electrically, and needs to be connected to external GND. When the heat radiation is not enough and OTP operates immediately, LED turns off after short time

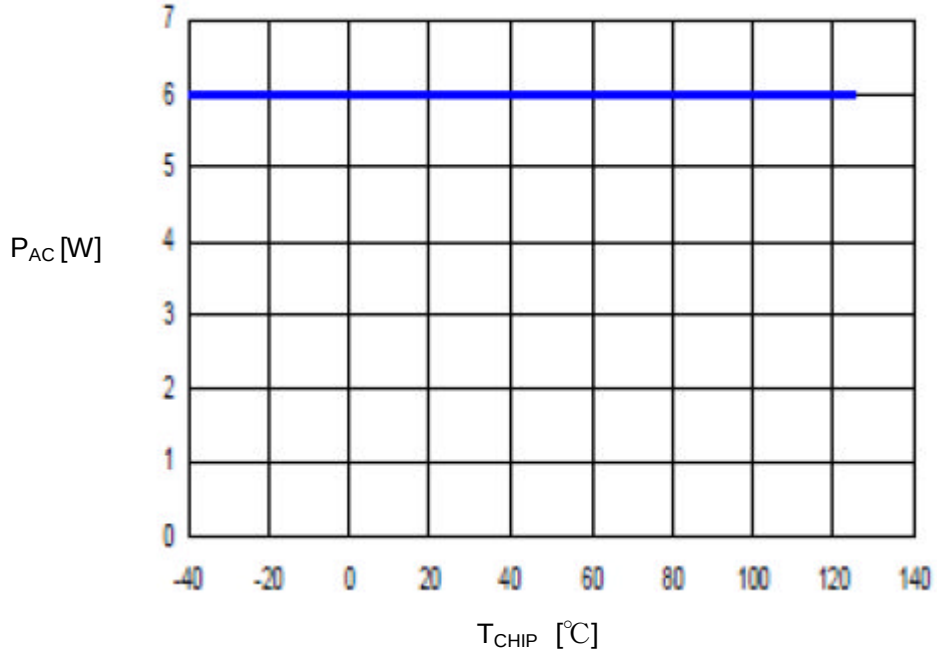
Example of mounting for heat radiation
The figure shows an example of soldering from the other side after the IC is mounted on the pattern side of a universal board. Designers make a hole (around ϕ 3mm) in the board and fix IC before soldering, and solder to the back pad through the hole from the other side as shown in the figure. Please note that designers must not solder the other IC pins, and connect the pad to the GND of circuit electrically.



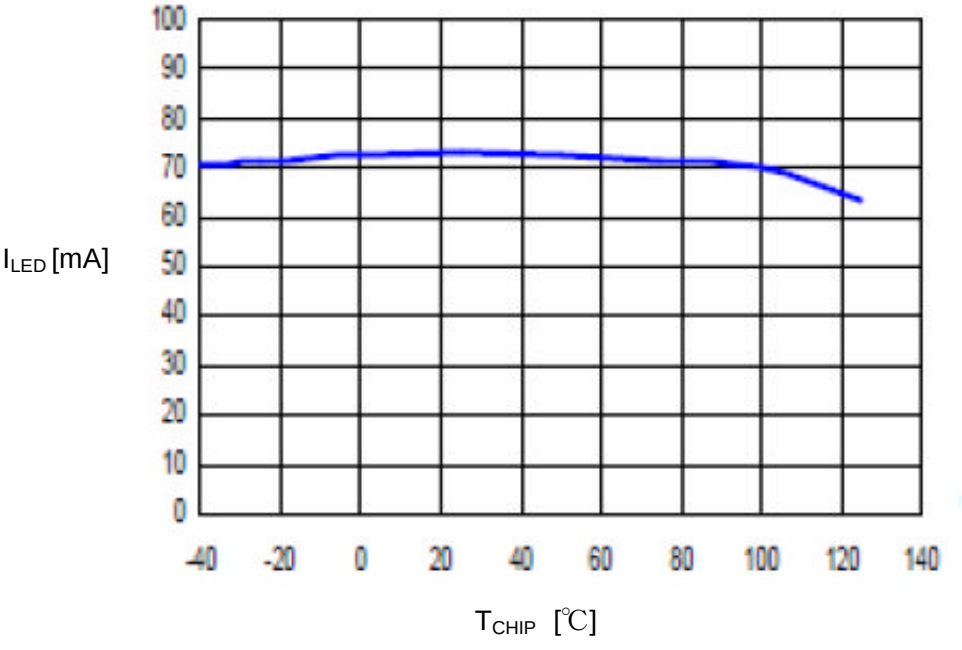
An example of dropped soldering
through a hole in a universal board.

The input power is constant to 125 ℃ regardless of the chip temperature as shown in the figure. IC includes a temperature compensation circuit which adjusts driving current in inversely proportional to the temperature over 100 ℃. The trends of driving current by temperature rise are as follows.

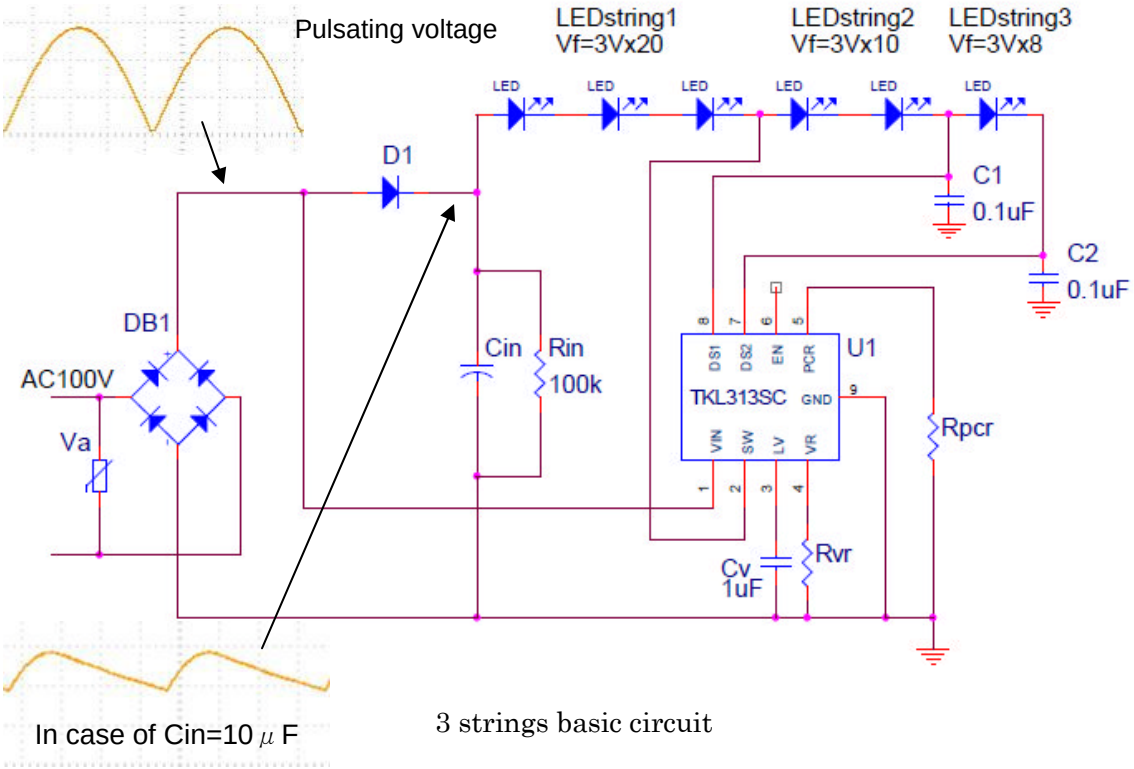
Chip temperature and input power



Chip temperature and LED driving current



8. Circuit Examples



3 strings basic circuit

Basic operation

The figure shows a basic circuit. There are three LED strings (series) which are LED string1, LED string2 and LED string3. IC operates as follows.

①IC turns on the DS1 input and LEDs of string 1 and 2 when the input voltage to the LED series exceeds total Vf of both strings.

②IC turns off the DS1 and turns on the DS2 and all LEDs when the input voltage to the LED series exceeds total Vf of string 1,2 and 3.

Determination of total number of LEDs

Designers need to adjust the total number of LEDs according to the cases regardless of IC has a function of pulsating voltage sense on VIN, discriminates 100V or 200V automatically. Designers adjust the optimum LED series number after the selection of which is significant, efficiency or power factor as LED driver.

When Vp is maximum input voltage and Vft is total Vf of LED series.

In case of AC100V input

Vp＝100×1.41＝141V

①In case efficiency is significant, adjust to Vft =Vp×0.8＝112.8V

For example Vf=3V of one LED, the total number is more than Vft / Vf＝112.8/3＝37.

②In case power factor is significant, adjust to Vft = Vp×0.7＝98.7V

For example Vf=3V of one LED, the total number is around Vft / Vf＝98.7/3＝32.

In case of AC200V input

Vp＝200×1.41＝282V

①In case efficiency is significant, adjust to Vft = Vp×0.8＝225.6V

For example Vf=3V of one LED, the total number is more than Vft / Vf＝225.6/3＝75.

②In case power factor is significant, adjust to Vft = Vp×0.7＝197.4V

For example Vf=3V of one LED, the total number is around Vft / Vf＝197.4/3＝66.

Determination of the divisional ratio of LED series number

The ratio of LED number depends on the presence of smoothing capacitor Cin.

①Without Cin：Power factor comes to near 100%, but flicker is remarkable.

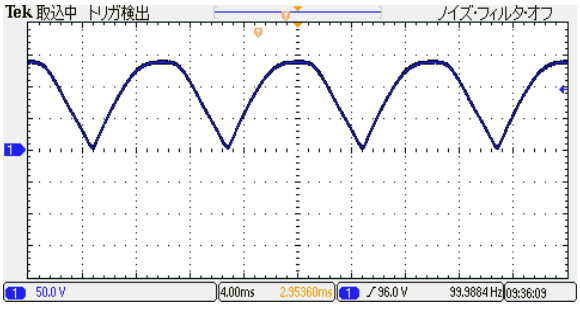
②With Cin：The more capacitance increases, the more power factor decreases. The flicker is reduced because capacitance fills valley of pulsating wave and reduces OFF term.

If designers increase LED number of string 1 and decrease LED number of other strings, it is advantageous from the point of LED light power, because ON term of string 1 increases in proportional to capacitance Cin. If the number of string 1 is too high, THD increases and power factor decreases. For example of total 36 series

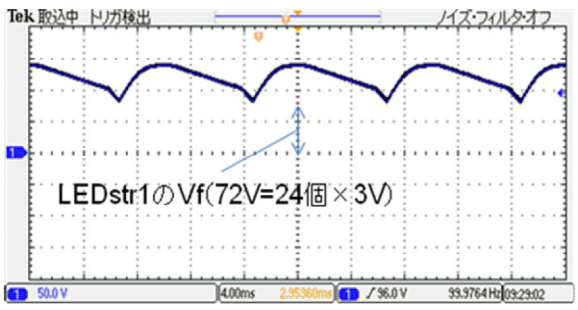
①Without Cin：18 series (string 1), 12 series (string 2), 6 series (string 3)

②With Cin：24 series (string 1), 10 series (string 2), 2 series (string 3)

Designers can calculate Cin on the basis of 65V valley fill at 3.3μF in case Vp=141V under actual measurement. If the capacitance exceeds 3.7μF=3.3μF×72V／65V, makes voltage over Vf when summation of string1 is Vf=72V(24pcs×3V). LED OFF term is eliminated with it.



Pulsating voltage without Cin



Smoothed wave with Cin=4μF

The assignment of the basic circuit is as follows.

String 1：20 series of LEDs(Vf=3V) , comes to total Vf=60V

String 2：10 series of LEDs(Vf=3V) , comes to total Vf=30V

String 3：8 series of LEDs(Vf=3V) , comes to total Vf=24V

LED total number is 38

Parts for constructing driver circuit

Va

Va is a varistor to be added to avoid the possibility of malfunctions or damages from noises and high voltage surges, which is around 271(AC100V), 471(AC200V). The circuit can operate without Va, but it is needed for the solution against surge.

C1, C2

C1 and C2 are capacitors to be added to avoid the possibility of damages from rush current, which are around 0.1 μ F and high voltage film capacitors. The circuit can operate without them normally.

DB1

DR1 is a diode bridge for full wave rectification.

D1

D1 is a diode which stops reversing charge from the smoothing capacitor. VIN detects pulsating wave under the reversing stop, so VIN is connected to the anode of D1. If a capacitor is connected to the anode of D1, IC cannot detect precisely and compensate power, and string 2 and 3 do not turn ON. If no capacitance on Cin, D1 is not needed.

Cin

Cin is a smoothing capacitor for reduction of flicker.

Rin

Rin is a resistor to discharge the capacitor after the circuit OFF.

Cv

Cv is a capacitor to stabilize the inner regulator operation.

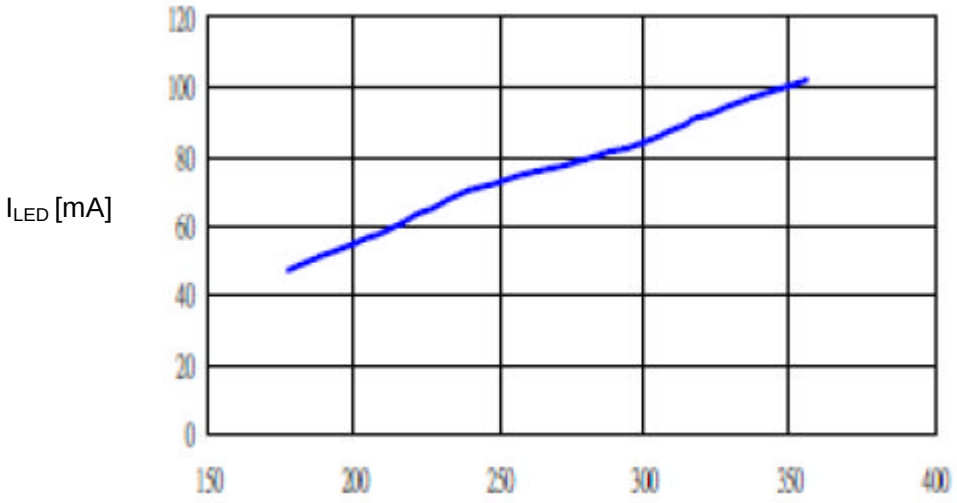
From 1uF to 2.2uF as the capacitance is recommended.

Rvr

Rvr is a resistor for configuration of LED current, has the range from 180k to 400k Ω.

The relationship between Rvr and LED current is shown.

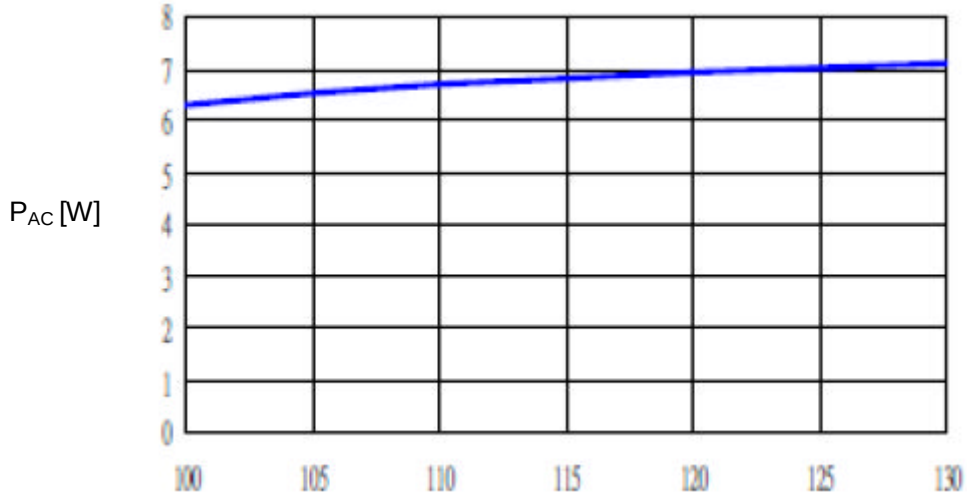
Rvr and LED current



Rpcr

The IC has power compensation function by detecting AC rectified voltage. When the voltage is high, IC decreases driving current, when the voltage is low, IC increases driving current. As a result of that, power Pac is almost constant although the Vac changes as shown in figure. Rpcr is a resistor which sets the compensation ratio.

Input voltage and power



Others

1. EMI filters are not needed because the circuit is not switching regulator as a chopper and a fly back converter and so on.

2. No measure is needed although spikes arise on the timing of ON/OFF for each strings in principle, because IC operates internal MOSFET using soft switching.

Protection functions

Over Voltage Protection

IC stops and protects LEDs when the voltage exceeds 400V, and retains off until VIN voltage decreases under 40V.

Under Voltage Lock Out

IC stops in case the internal voltage decreases under 4V, and remains off until the voltage exceeds 5V.

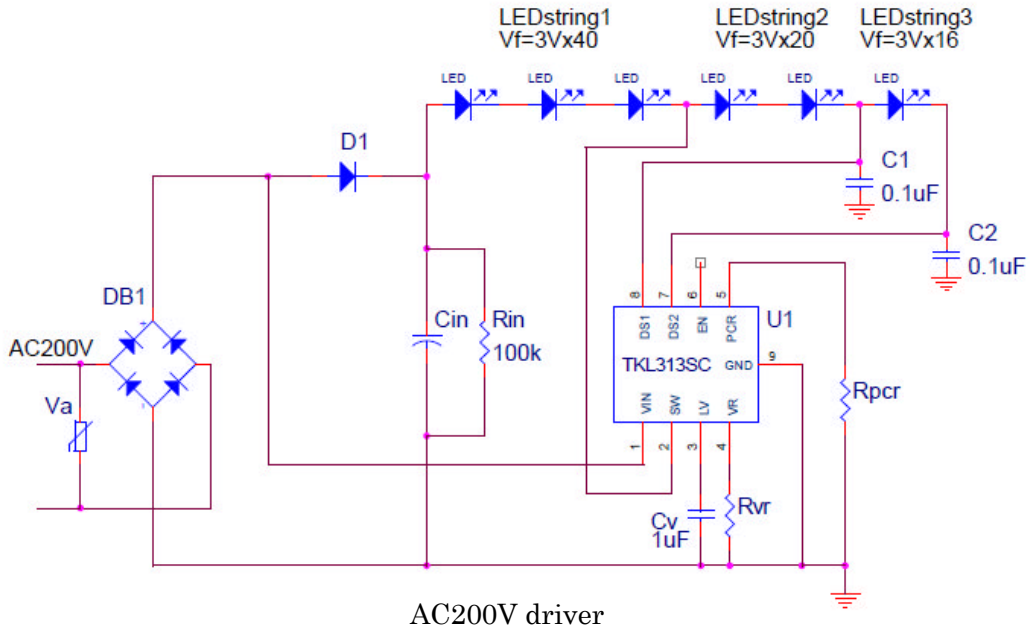
Over Temperature Protection

IC stops in case the ambient temperature exceeds 150℃, and retains off until the temperature decreases under 100℃.

9. Circuit Examples

AC200V input driver

When the LED number is doubled with attention to permissible voltage of parts, the circuit can operate under 200V. Designers can double LED voltage regardless of the same current as 100V circuit, the driver is capable of 20W maximum compared with 10W for 100V circuit as a result.

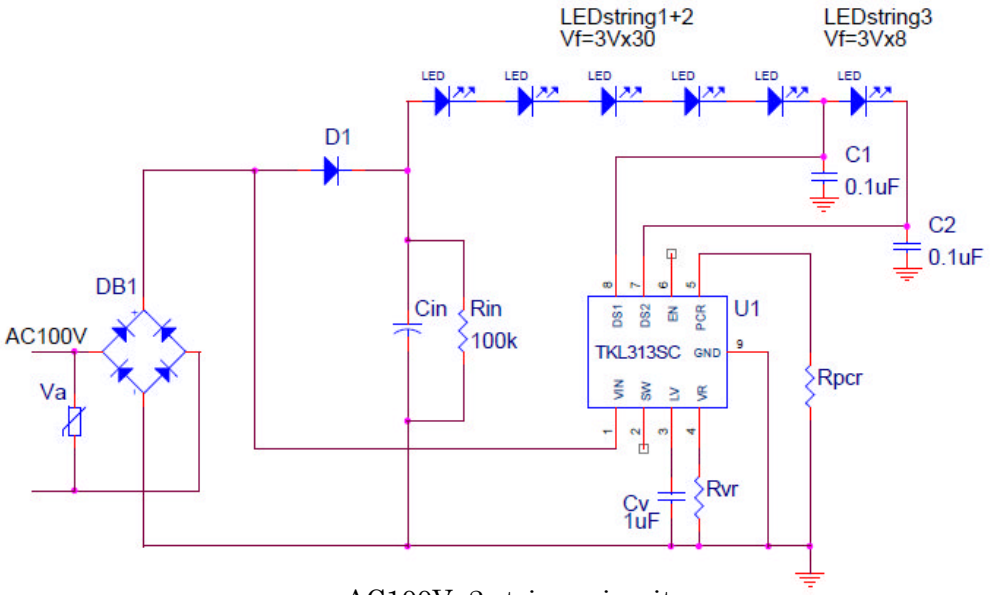


AC200V driver

2 strings driver

Designers can reduce LED wires and cost by integrating string 1 and 2.

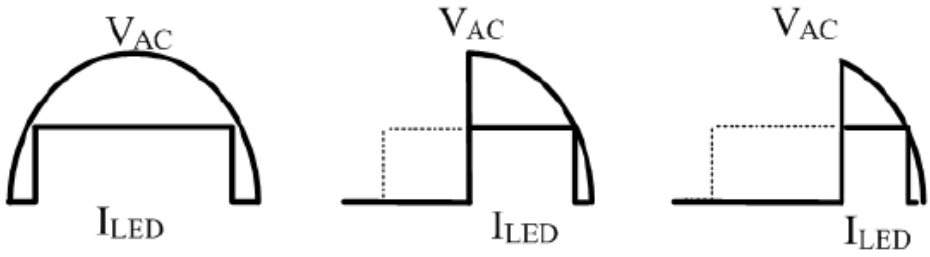
Power factor decreases because THD increases a little on the input in this case.

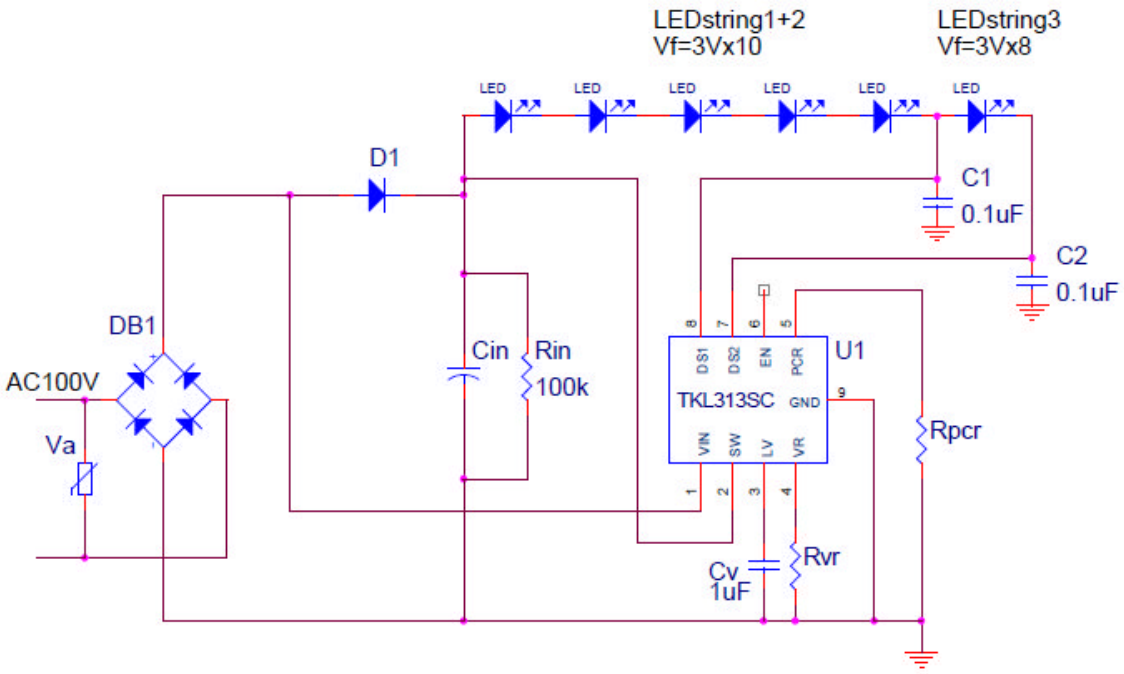


AC100V, 2 strings circuit

TRIAC dimming circuit

The basic circuit can operate under TRIAC dimming by ON/OFF according to firing angle. IC has a function of retaining LED current to reduce off-term and flicker when firing angle is too small. SW needs to be connected to the anode of string 1 for this function as follows.

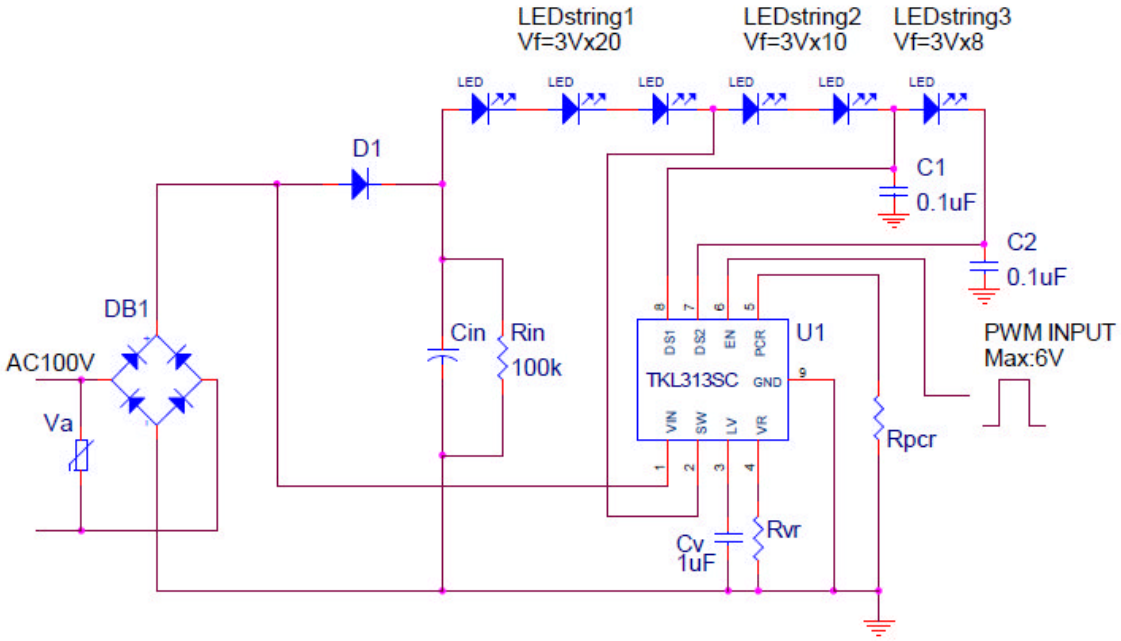




AC100V TRIAC dimming circuit

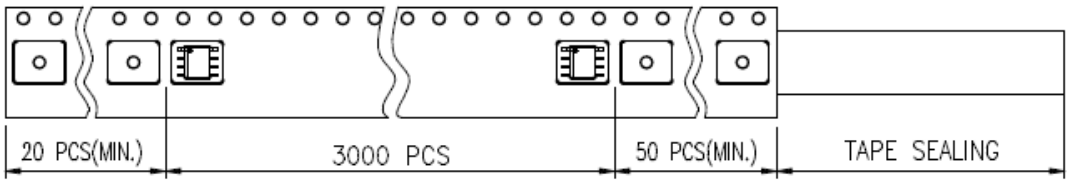
PWM dimming circuit

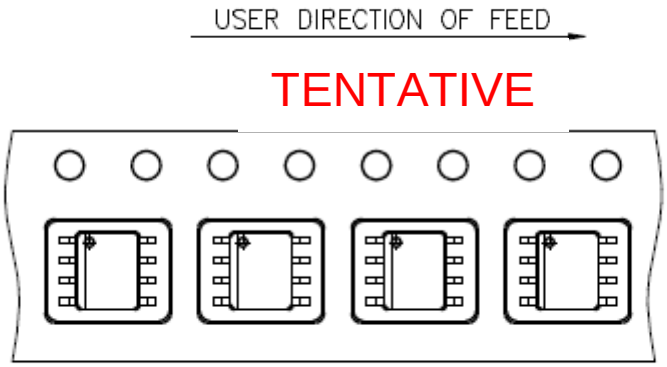
All strings turns ON when EN is opened under internal pull-up, the string 2 and 3 turn OFF when EN is connected to GND. IC can operate with PWM dimming in proportional to its duty by H/L logical input to EN. Maximum PWM frequency is 200kHz and maximum duty is 100%.



AC100V, PWM dimming 3 string circuits

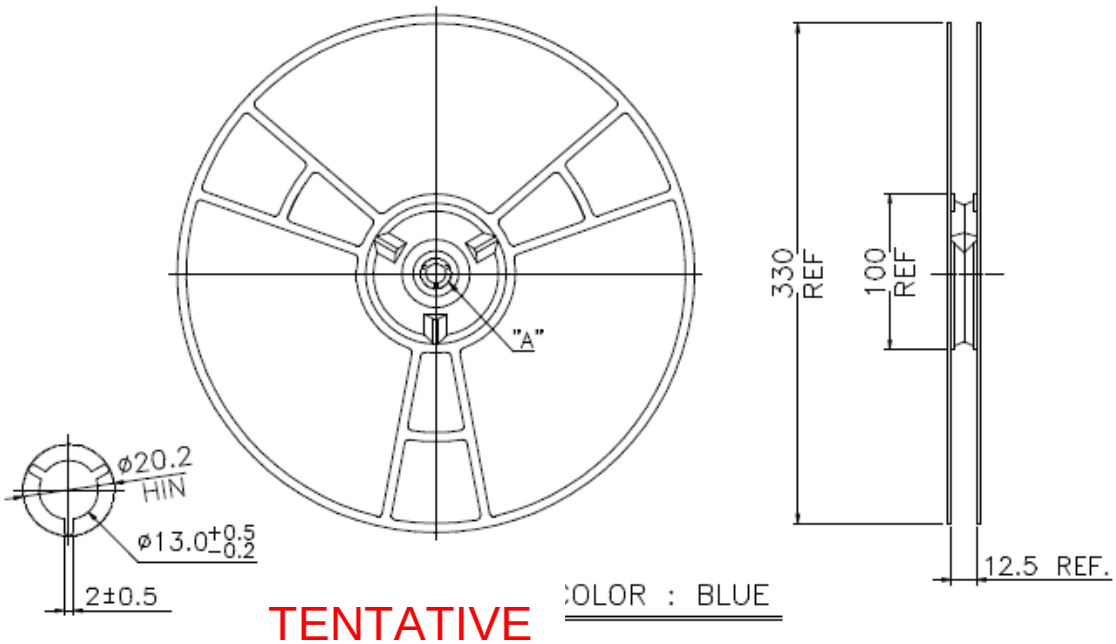
10. Tape and Reel configuration





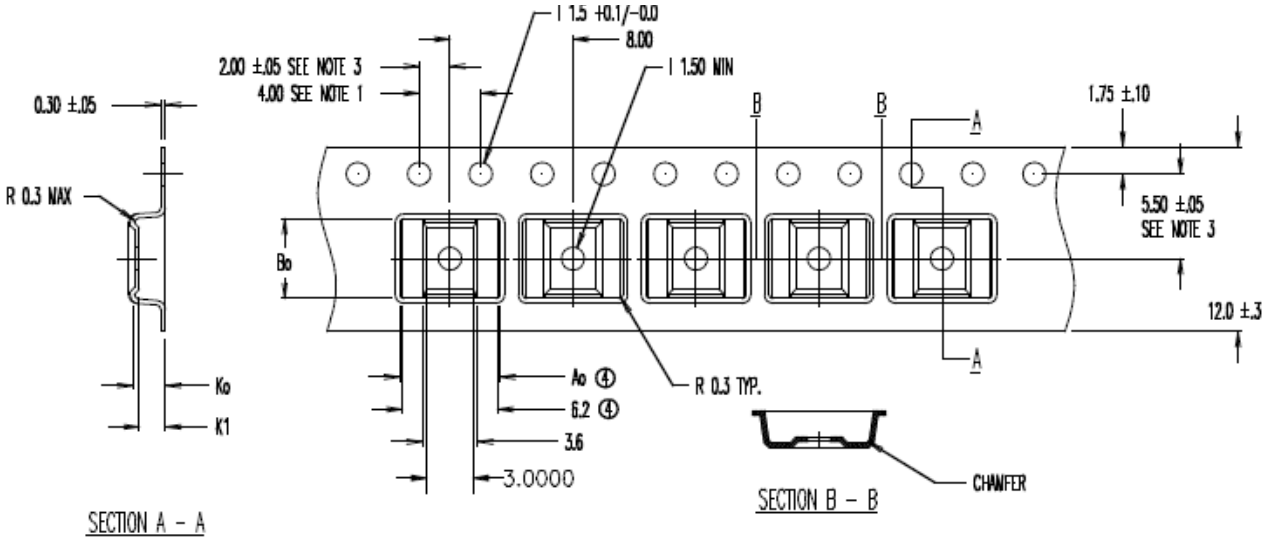
SOP 8N(150mil)

3000 EA/PER REEL 1 REEL/BOX



TENTATIVE

COLOR : BLUE



④① Ao = 6.50
Bo = 5.20
Ko = 2.10
K1 = 1.70

1. 10 sprocket hole pitch cumulative tolerance ±0.2mm
2. Camber not to exceed 1mm in 100mm.
3. Material is Anti-static Black Advantek Polystyrene.
4. Ao and Bo measured on a plane 0.3mm above the bottom of the pocket.
5. Ko measured from a plane on the inside bottom of the pocket to the top surface of the carrier.
6. Pocket position relative to sprocket hole measured as true position of pocket hole.

Revision history

Revision	Contents	Date
1.0	New release	2014.9
1.1	Explanation modification	2014.10

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