TS19702
APPLICATION NOTE

Designing with the TS19702 Single-Stage High Power Factor Corrector LED Driver

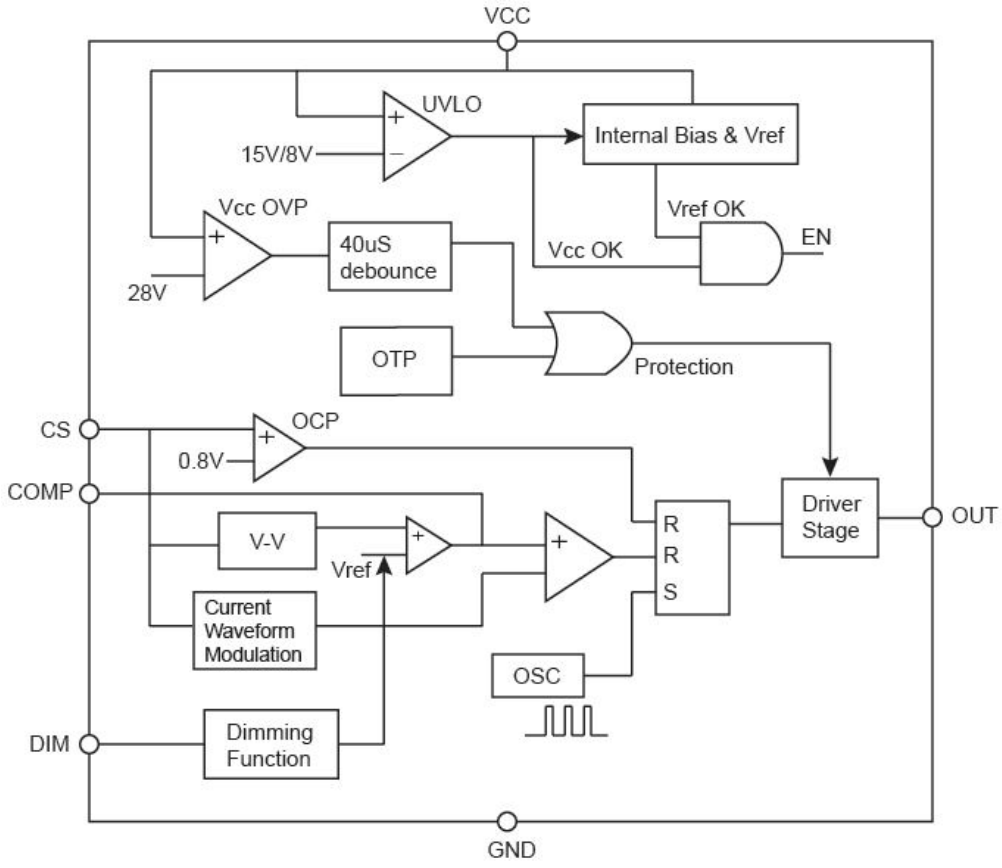
Description

TS19702 is special design for high power factor correct, accurate constant current and high performance single stage LED Driver. It is suitable for universal input voltage range, simple circuit design, low BOM cost for LED Applications The DIM pin provides linear dimming and over temperature by external control. The compensation control circuit only needs a capacitor connected from COMP pin to GND pin. Constant output current can be set or adjust by a SENSOR resistor.

Features

- Accurate Constant Output Current Control for LED (<±3%)
- PF >0.9 @ 264Vac/50Hz
- High Efficiency >85% (Typ)
- Linear Dimming on DIM Pin
- Average Current / Fixed Frequency Control
- Gate Output Voltage Clamp
- LED Open Protection (OVP)
- LED Short Protection (SCP)
- Over Current Protection (OCP)
- Internal OTP Protection
- Low BOM Cost

Block Diagram



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Function Description

➢ VCC Pin – Start Up circuit & Under Voltage Lock Out

The TS19702 with very low start-up current reduces the power dissipation on the start-up resistor. A hysteresis UVLO comparator is implemented in the TS19702, then the turn-on and turn-off thresholds level are fixed at 15V and 8V respectively. This hysteresis ensures the start-up capacitor will be adequate to supply the chip during start-up. For quickly startup the LED driver, the start-up resistor should be matched with the startup capacitor.

To prevent the LED driver from being damaged, the TS19702 is implemented an OVP function on the VCC pin. When the VCC pin voltage is higher than the OVP threshold voltage 28V, the output of teh gate driver circuit will be shut down immediately to stop the switching of the power MOSFET. The VCC pin OVP function is an auto recovery type protection. If the OVP condition happens, the pulses will be stopped and never recovery unless the VCC pin voltage is down to the UVLO off level.

The VCC pin voltage is supplied from the LED strings. For getting the correct bias voltage of VCC from the output, there should choose a clamping zener diode and a ultrafast diode in series. A 600V ultrafast diode is recommended when the input voltage is up to 264Vac. The zener diode is selected as shown in below formula:

$$Vz = V_{LED}\text{-}18V$$

➢ Out Pin Driver

The output driver is clamped to 13.5V by an internal clamping circuit. When VCC is higher than 13.5V, the internal clamping circuit of OUT pin will never be higher than 13.5V. This function avoids the damage to MOSFET which usually comes from the undesired over-voltage gate signals. The maximum duty-cycle of internal oscillator is around 90%, and the minimum duty-cycle time is around 410nS . The frequency of the oscillator is fixed on 45KHz.

➢ Over Temperature Protection/Dimming Function

Put a NTC thermistor on DIM pin for setting the external OTP protection. In the DIM pin, there is one comparator for latch-off mode protection. While the voltage on this pin is lower than 0.25V, the MOSFET will be shut down. When the voltage is in the range of 0.3 to 3.0V, the TS19702 is operating on the linear dimming range. While the voltage is higher than 3V, the TS19702 is operating on the normal status

➢ COMP Pin Feedback Compensation Network

The design of compensation network is very important for the PFC controller. It affects the PF and stability performance of the system. For keeping a constant value of Vcomp in one cycle of AC mains, *the* bandwidth should be lower than around 1/10 mains frequency. The design of a compensation network could use a 1uF capacitor to stabilize the feedback control loop.

➢ CS Pin for LED Current Setting

The reference voltage of the error amplifier is 0.2V. So the ILED is setting as shown in below formula：

$$I_{LED} = 0.2V/\text{Sensor R}$$

For getting more accurate output current and PF performance, the applicable range of V_{LED} is recommended as shown in below:

Input Voltage	V_{LED}
90V/60Hz~132V/60Hz	20V~60V
180V/50Hz~264V/50Hz	45V~100V
90V/60Hz~264V/50Hz	30V~60V

Inductor Design

An example for detailing the design of inductor is shown as below

Step 1:

$$Iin\ rms = \frac{Po}{Vin\ min(ac) * \eta * PF}$$

Po：Output Power

Vin min (ac)：Min. AC input voltage

η：Setting →0.85~0.9

PF：Setting →0.9~0.95

Step 2:

$$Iin\ pk = \sqrt{2}\ Iin\ rms$$

Step 3:

ΔI=K*Iin pk

K：Setting →0.1~0.5

Step 4:

$$Don = \frac{V_{LED}}{Vin\ min(dc)}$$

Step 5:

$$Ton = \frac{Don}{fosc}$$

Step 6:

$$L = \frac{(Vin\ min(dc) - V_{LED}) * Ton}{\Delta I}$$

Step 7:

The current density of copper wire is selected between 400~500 cmil/A.

Size (Diameter)	Current
0.2 mm	0.16 A
0.3 mm	0.36 A
0.4 mm	0.64 A
0.5 mm	1.00 A
0.6 mm	1.44 A

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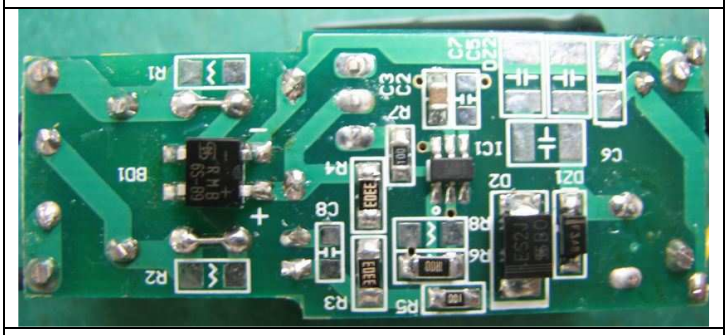
Design Case

Photo Graph of Demo Board

TOP View



Bottom View

Basic Specification of Demo Board

Parameter	Specification
Output Power	10 W
Input Voltage	90~264 VAC
Output Voltage	50V
Output Current	200mA
PF	>0.9
Efficiency	>85%
LED Specification	1W/350mA 16pcs in series
Ambient Temperature	25℃

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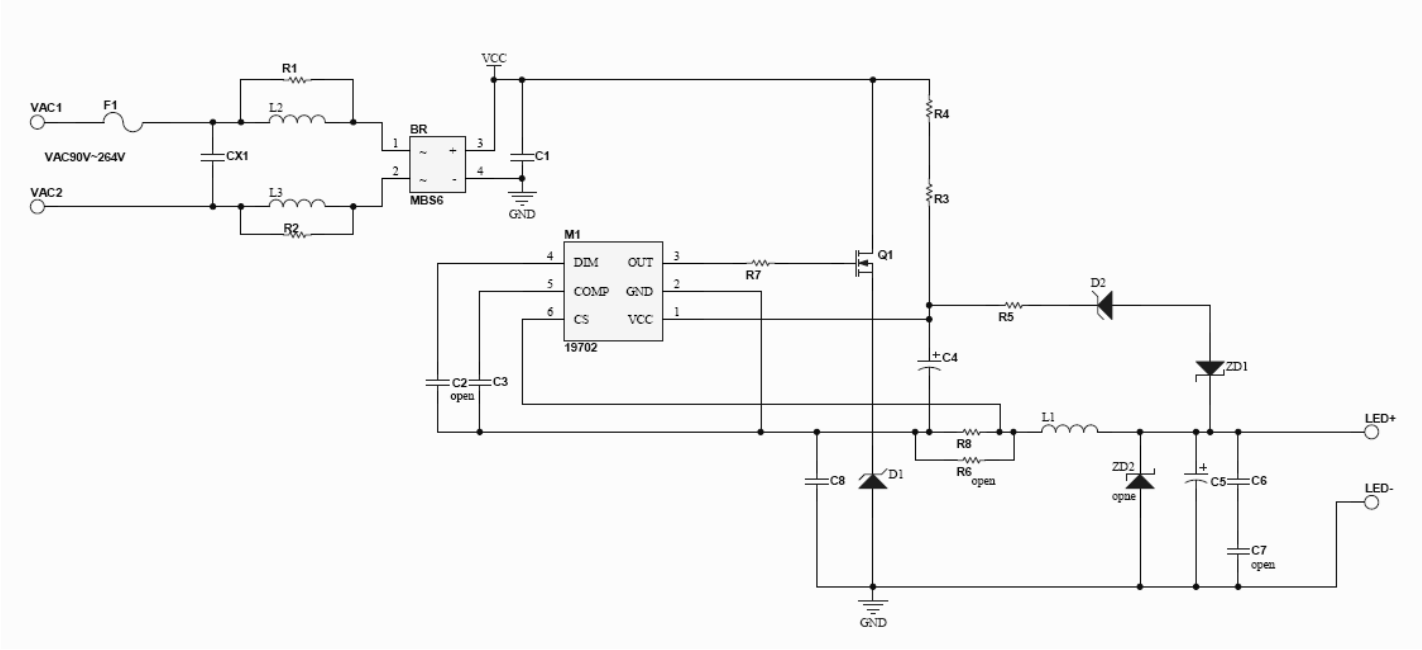
Application Circuit



Bill of Material

No.	Reference	Part number	Package	Quantity	Manufacture
1	IC1	TS19702CX6	SOT-26	1	TSC
2	R3,R4	SMD 1206 330kΩ 5% 1/4W	1206	2	
3	R5,R7	SMD 0805 10Ω 5% 1/8W	0805	2	
4	R6	SMD 1206 1Ω 1% 1/4W	1206	1	
5	C3	SMD 0805 1uF/25V 10% X7R	0805	1	
6	BD1	Bridge Diode 0.8/600V RMB6S	MBS	1	TSC
7	D1	Super Fast Diode SF38G	DO-201AD	1	TSC
8	DZ1	Zener Diode 31V/0.8W BZD27C33P	Sub SMA	1	TSC
9	D2	Super Fast Diode ES2J 2A/600V SMB	DO-214AA	1	TSC
10	C1	Capacitor-MPP 0.1uF/450V 105℃ 10%		1	
11	C4	10uF 50V 5*11 E-CAP	5*11	1	
12	C5	Capacitor-EC 1uF/400V	8*11.5	1	
13	CX1	Capacitor-X1 0.1uF/300V 20% 13x12x6	13*12*6mm	1	
14	Q1	MOSFET TSM2NB60CH 2A/600V	TO-251	1	TSC
15	F1	FUSE 1.25A/250V	8.4*4*8.4mm	1	
16	L1	CHOKE 3.3mH	DR10*20	1	

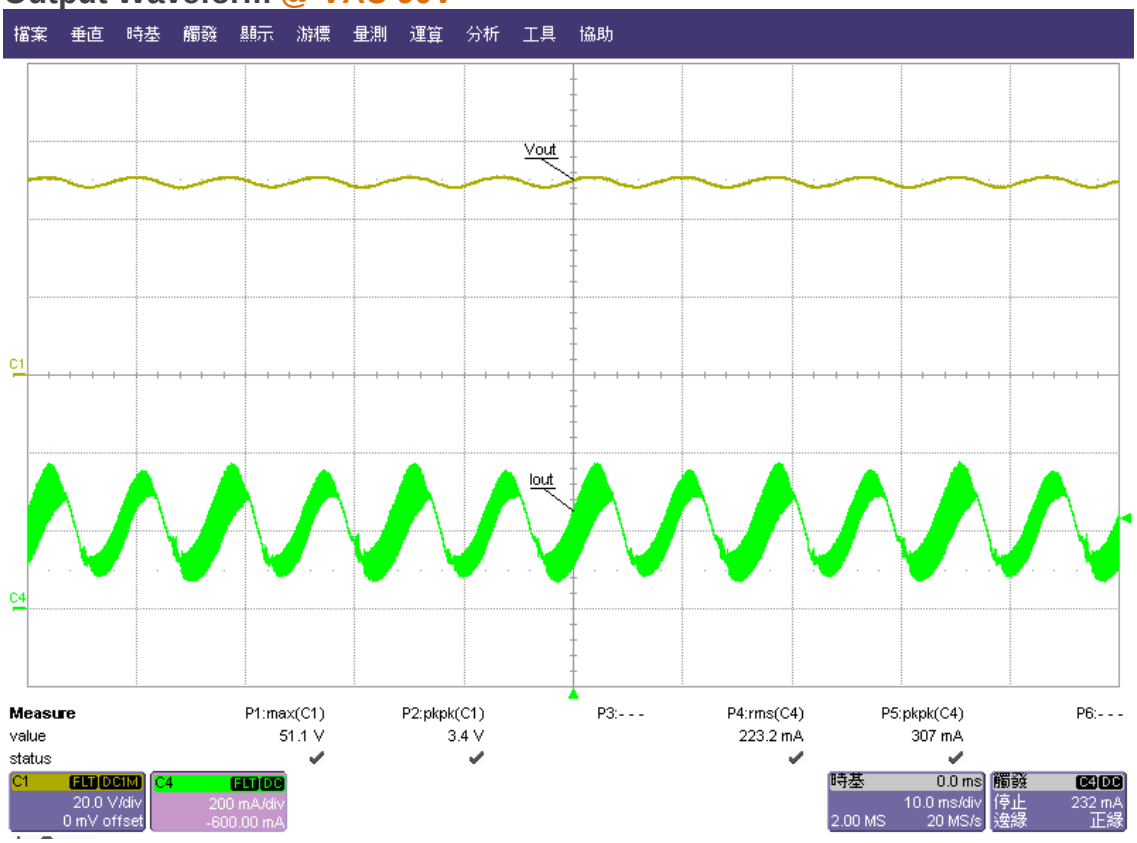
Demo Board Performance

Test Condition & Result

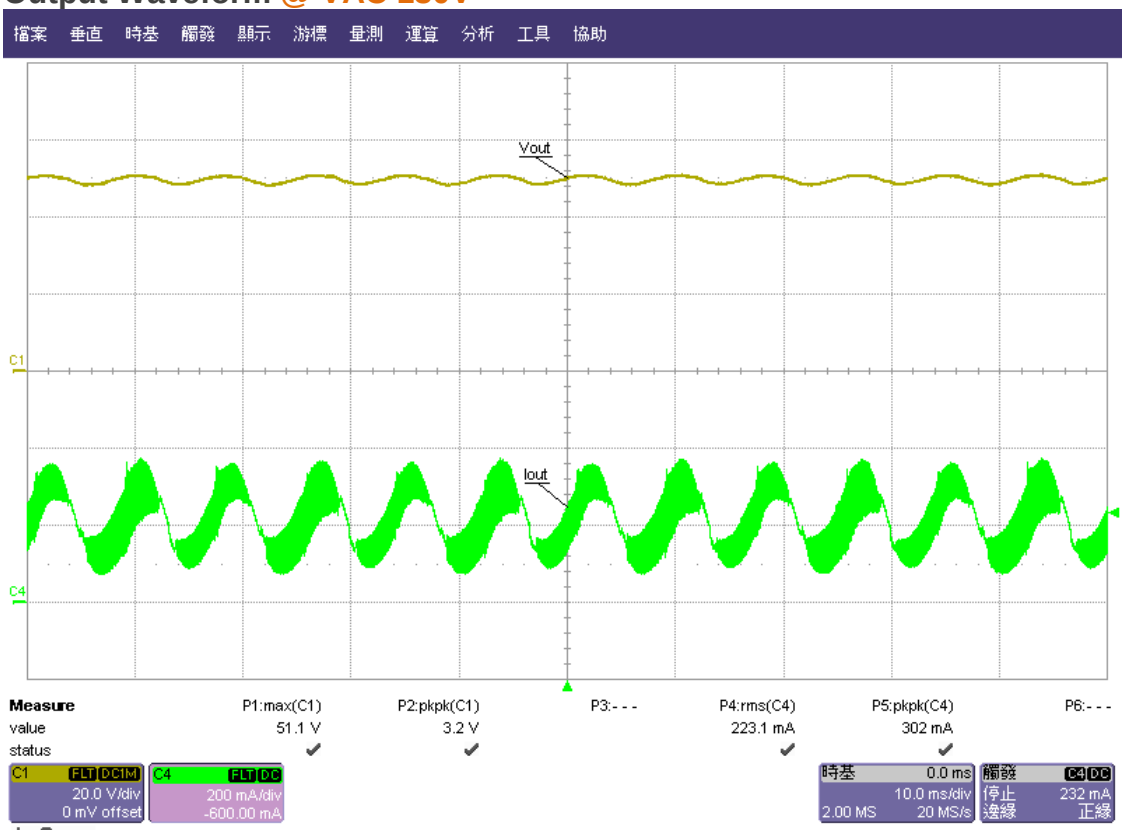
V_{AC} (V)	90	115	130	180	220	240	264
I_{IN} (A)	0.13	0.10	0.09	0.07	0.06	0.05	0.05
V_{OUT} (V)	50	50	50	50	50	50	50
I_{OUT} (A)	0.20	0.20	0.20	0.20	0.20	0.20	0.20
P_{IN} (W)	11.3	11.5	11.6	12.1	12.3	12.5	12.7
P_{OUT} (W)	9.9	9.9	9.9	9.9	9.95	9.95	9.95
Efficiency (%)	87.3	86.1	85.6	82.1	80.8	79.7	78.5
Power Factor	0.9797	0.9792	0.9764	0.9613	0.9418	0.9287	0.9096

Note: The **Efficiency & Power Factory** will be affect by Power MOSFET, Capacitor and Inductor selection.

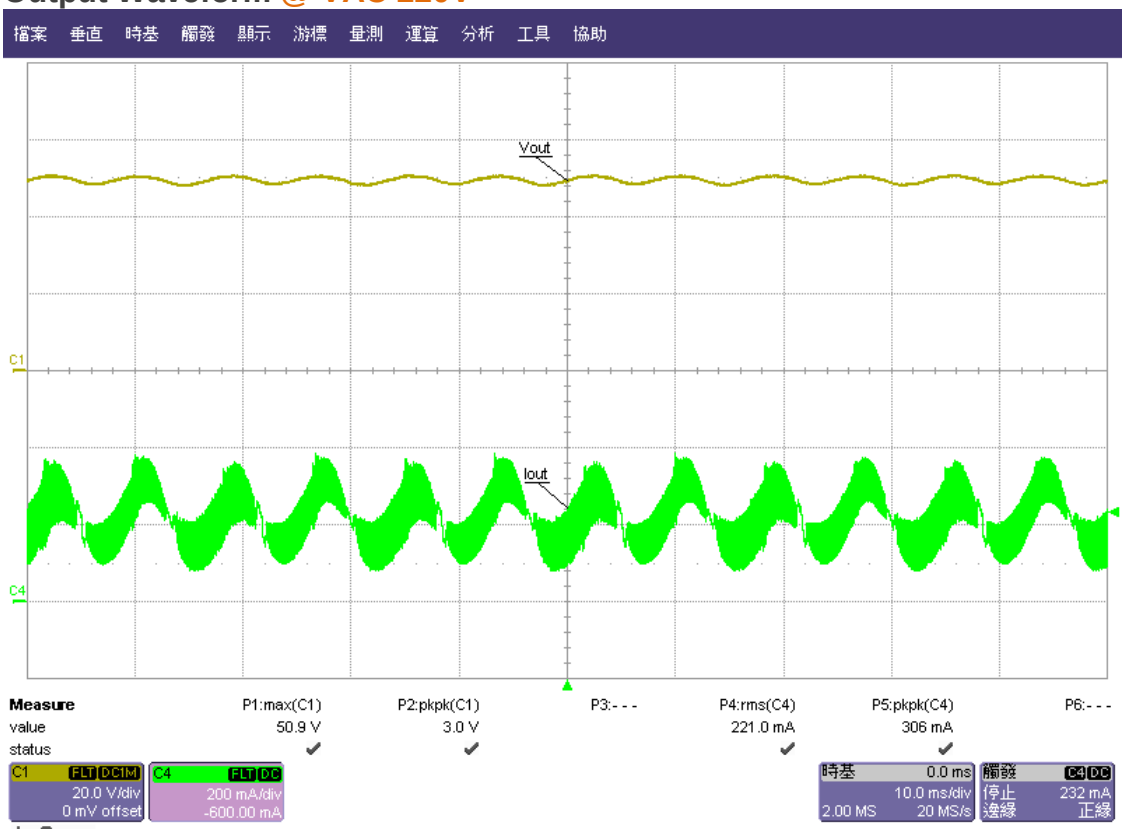
Output Waveform @ VAC 90V



Output Waveform @ VAC 130V



Output Waveform @ VAC 220V



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Output Waveform @ VAC 264V