Synchronous Rectification Switcher Supporting CCM

1. Description

The TS16E01 is a compact secondary side synchronous rectification switcher which integrated controller and MOSFET for high performance flyback converters. It is compatible with DCM and QR operations.

The TS16E01 can generate its own supply voltage while with high-side rectification; this eliminates the need of auxiliary winding of the transformer, which is usually required to produce supply voltage.

The extremely low 10ns turn−off propagation delay time and high sink current (~4A) capability of the driver improve SR VDS stress at CCM mode.

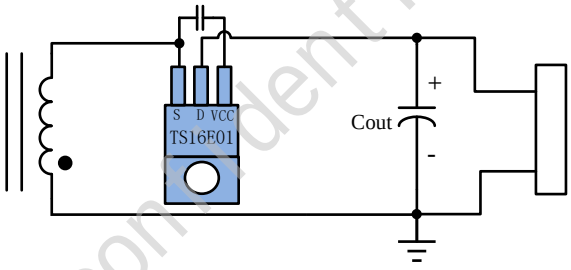
2. Typical Applications

- AC/DC Adapters for Mobile Phone and Notebook
- High Power density AC/DC Power Supplies
- Battery Powered System

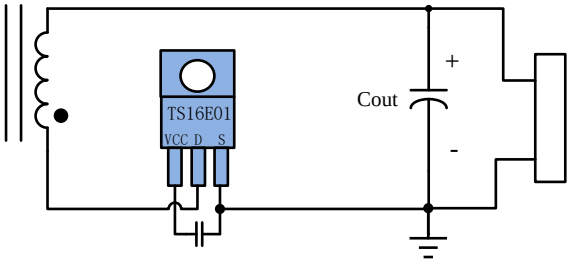
3. Features

- Integrated 10mΩ 100V Power MOSFET
- Operates in a wide output voltage range down to 3V voltage (self-supply)
- Self-supply for operations with low-side rectification and high–side rectification without an auxiliary winding
- 10ns Fast Turn-off and 25ns Turn-on Delay
- VG Clamping Circuit Works Well when VCC is Below 2V
- Supports CCM, DCM and QR Operations
- Precise 0V turn off for maximum efficiency
- Designed for <200kHz working frequency
- Available in TO-220 Package

4. Simplified Application



Used in high side rectification

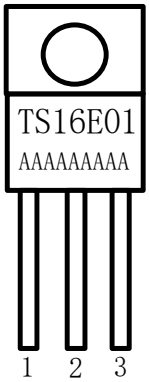


Used in low side rectification

5. Ordering Information

Ordering No.	Description
TS16E01TTA	TO-220 50pcs/tube 1000pcs/inner box

6. Package Reference



AAAAAAAAA: Lot code

TO-220

7. Pin Functions

Pin #	Name	Description
1	VCC	Inner Regulator Output, supply TS16E01
2	D	FET drain
3	S	Ground

7.1 Absolute Maximum Ratings (1)

VCC to S..... –0.3V to +20V
D to S..... –0.7V to 100V
Continuous Drain Current I_D.....35A
Pulsed drain current I_D,pulse(2).....100A
Continuous Power Dissipation....30W (TA = +25°C) (3)
Junction Temperature.....150°C

7.2 Recommended Operation Conditions

VCC to S…. ..... ……. .5V to 9.5V
D to S……..……..-0.7V to 100V
Maximum Junction Temp. (T_J)..... +125°C

7.3 Thermal Resistance (4)

	θ_{JA}	θ_{JC}
TO-220	**80**	**4.2** °C/W

Notes:

(1) Exceeding these ratings may damage the device.

(2) Repetitive Rating: Pulse width limited by maximum junction temperature;

(3) The maximum allowable power dissipation is a function of the maximum junction temperature T_J(MAX), the junction-to-case thermal resistance θ_{JC}, and the case temperature T_C. The maximum allowable continuous power dissipation at any case temperature is calculated by $P_D(MAX)=(T_J(MAX)-T_C)/\theta_{JC}$. Exceeding the maximum allowable power dissipation will cause excessive die temperature.

(4) Measured on JESDSD51-7, 4 layers PCB

8. Electrical Characteristics

T_A=25°C, unless otherwise noted.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
Internal MOS Section						
Internal MOS Rdson	R_{dson}	VGS=10V, Id=1A		10	18	mΩ
Drain to Source Breakdown	$V_{DSS(BR)}$	VCC=9.5V，Id=2mA	100			V
Supply Management Section						
VCC UVLO Rising	V_{CC_ON}		4.3	4.6	4.9	V
VCC UVLO Falling	V_{CC_OFF}		3.8	4	4.3	V
VCC UVLO Hysteresis	V_{CC_HYST}		0.25	0.6	0.75	V
VCC Regulation Voltage	V_{CC_REG}	V_D= 14V	9	9.2	9.5	V
Operating Current	ICC(5)	VCC=6V, Fsw=100KHz,	1.5	2.0	2.5	mA
Quiescent Current	$I_{q(VCC)}$	VCC=6.4V, Fsw=0Hz		350	550	μA
Mosfet Voltage Sensing						
Turn-On Propagation Delay	T_{D_on}			25	40	ns
Turn-Off Propagation Delay	T_{D_off}			10	15	ns
Turn On Blanking Time	T_{B_ON}	C_{LOAD} = 2.2nF	0.75	1.0	1.3	μs
Turn Off Blanking Time	T_{OFF}		250	300	350	ns
Gate Driver						
VG (Low)	VG_LOW	VCC=6.4V, ILOAD=0.1A	0	0.2	0.4	V
VG (High)	VG_HIGH	VCC=6.4V, ILOAD=0.1A	VCC-0.6	VCC-0.3	VCC	V

Note:

（1） ICC in the table is the current consumed by the internal controller when 2.2nF load capacitance and 100kHz operating frequency.

9. Block Diagram

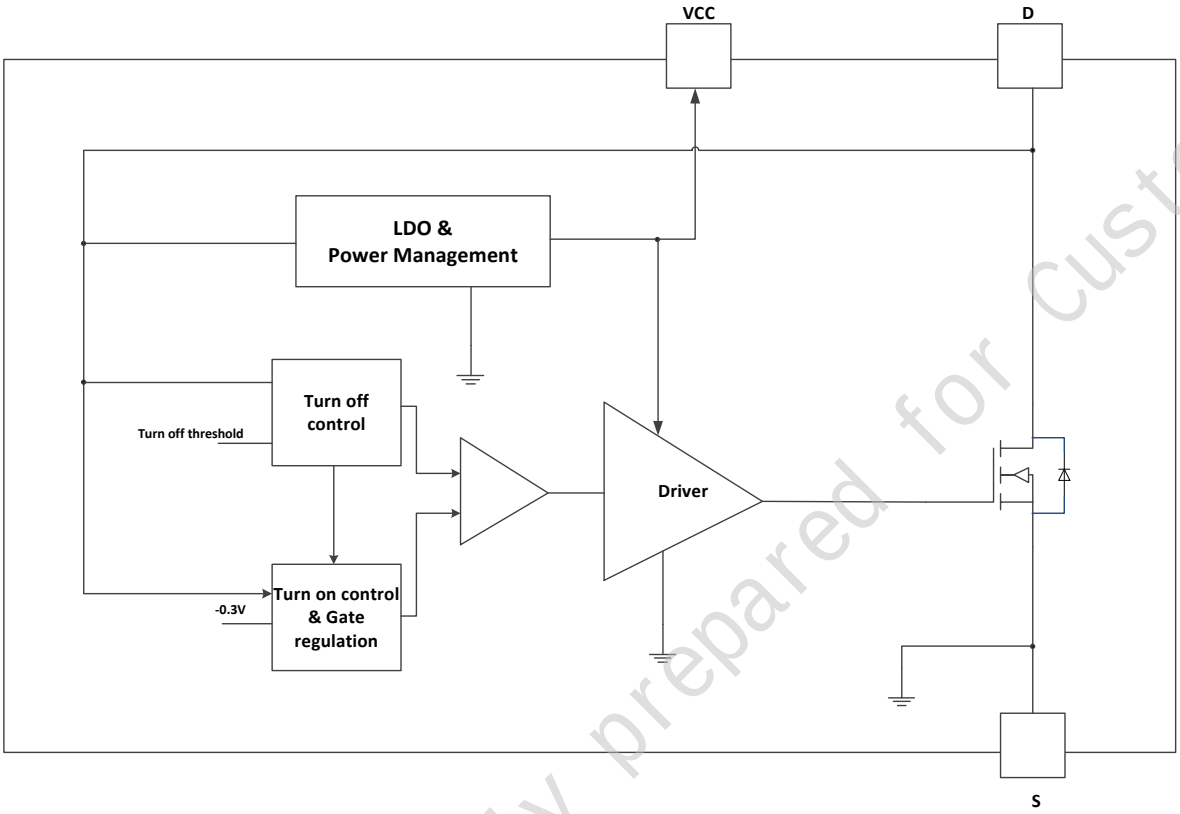


Figure 1. Functional Block Diagram

10. Operation Descriptions

TS16E01 is a high-performance synchronous rectifier which can replace the Schottky diode rectification in the flyback converter to improve efficiency, which supports DCM, CCM and QR operations. The extremely low 10ns turn−off propagation delay time and high sink current (~4A) capability of the driver improve SR VDS stress at CCM mode, particularly at the conditions of startup and VOUT shorts to ground. A great flexibility for system designing is brought by Self-supply which supports operations with both low-side rectification and high–side rectification without an auxiliary winding.

11. Conduction Phase

After SR VG turns on, a minimum blanking time T_{B_ON} is required to prevent the parasitic ringing from falsely turning off SR VG. The minimum turn-on blanking time is around 1.0us for TS16E01, during which the turn off threshold is increased to 2V. Right before T_{B_ON} timer expires, TS16E01 starts monitoring V_{DS} against a -40mV value to determine if internal VG needs to be slowly discharged. This operation adjusts V_{DS} of SR MOSFET to be around -40mV until the current through SR MOSFET drops to zero. In CCM mode, VG is prepositioned to be lower than VCC by V_{DS} adjusting scheme so that VG is turned off even faster; In DCM/QR mode, this V_{DS} adjusting design makes V_{DS} cross 0V exponentially faster, which combines with the 10ns turn-off propagation delay to make turn-off timing more accurately regardless of the accuracy of turn-off threshold.

12. Turn off Phase

TS16E01's turn-off threshold is different at different time. Within the minimum turn-on blanking time T_{B_ON}, V_{DS} turn-off threshold is 2V which is the same as V_{B_OFF}. After the minimum turn-on blanking time T_{B_ON}, the turn-off threshold is around 0V, that combines with extremely fast 10ns turn-off propagation delay and 4A VG pull-down (sinking) current, synchronous rectifier is able to be turned off not too early which causes more SR FET body diode conduction time and more negative turn-off ringing, or not too late which creates risk of shoot through between primary side and SR side.

13. Typical Implementations

TS16E01 supports both high side rectification and low side rectification to replace Schottky diode without the need of auxiliary winding as shown in Figure 2 and Figure 3. VCC is powered from pin D and regulated at ~9V even when Vout is much lower than 5V. A 0.1uF bypass capacitor is suggested to regulate the bias voltage and reduce noise coupling from switching.

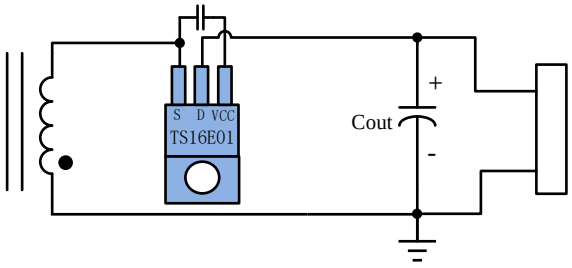


Figure 2. The High side rectification

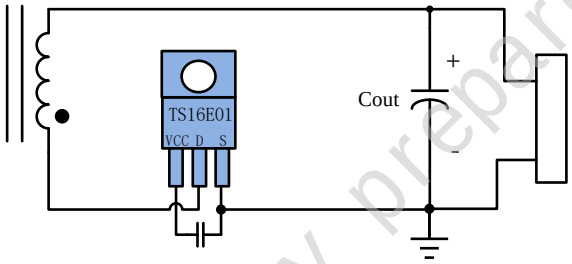
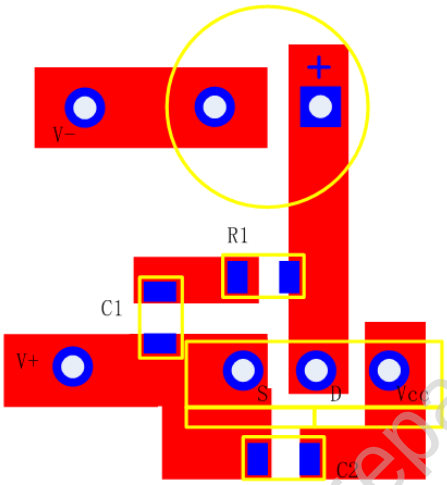


Figure 3. The low side rectification

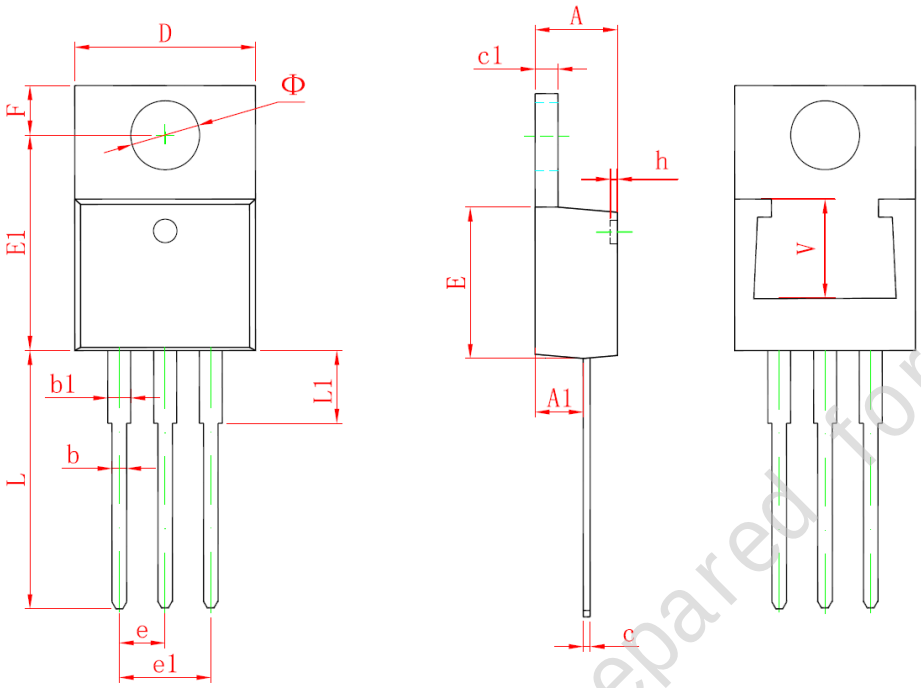
14. Layout Guidelines

To improve the switching characteristics and the SR vds stress, The following layout rules are suggested to follow.

1) Locate the VCC bypass capacitor close to TS16E01.
2) Minimize the loop area formed by C_{VCC} connections to VCC and S pins.
3) Cut the pins as short as possible to minimize the loop area formed by C_{VCC}、 VCC and S pins.



15. Package Information (TO-220)



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	4.470	4.670	0.176	0.184
A1	2.520	2.820	0.099	0.111
b	0.710	0.910	0.028	0.036
b1	1.170	1.370	0.046	0.054
c	0.310	0.530	0.012	0.021
c1	1.170	1.370	0.046	0.054
D	10.010	10.310	0.394	0.406
E	8.500	8.900	0.335	0.350
E1	12.060	12.460	0.475	0.491
e	2.540 TYP.		0.100 TYP.	
e1	4.980	5.180	0.196	0.204
F	2.590	2.890	0.102	0.114
h	0.000	0.300	0.000	0.012
L	13.400	13.800	0.528	0.543
L1	3.560	3.960	0.140	0.156
Φ	3.735	3.935	0.147	0.155
V	5.600 REF.		0.220 REF.	