

## WS3252 High Precision CC/CV Primary-Side PWM Controller

### Features

- 5uA ultra-low startup current
- 2mA Low operating current
- $\pm 5\%$  Constant Voltage Regulation at Universal AC input
- Primary-side Sensing and Regulation Without TL431 and Opto-coupler
- Programmable CV and CC Regulation
- Built-in Primary winding inductance compensation
- Programmable cable drop compensation
- Built-in soft start
- Built-in Leading-edge blanking
- Cycle by cycle over current protection (OCP)
- VCC over voltage clamp & under voltage lockout( UVLO)
- Maximum Gate output voltage clamped at 12V
- Frequency jittering

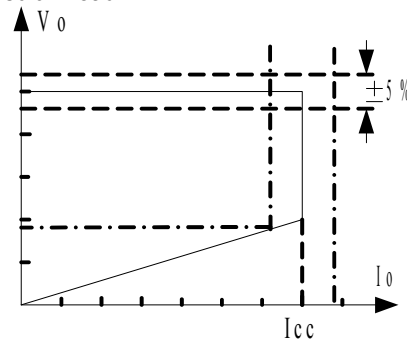
### Applications

- Low power AC/DC offline SMPS for
- Cell Phone Charger
  - Digital Cameras Charger
  - Small Power Adapter
  - Auxiliary Power for PC, TV etc.
  - Linear Regulator/RCC Replacement

### General Description

WS3252 is a high-integrated offline PWM controller, optimized for high performance low power AC/DC charger and adapter application.

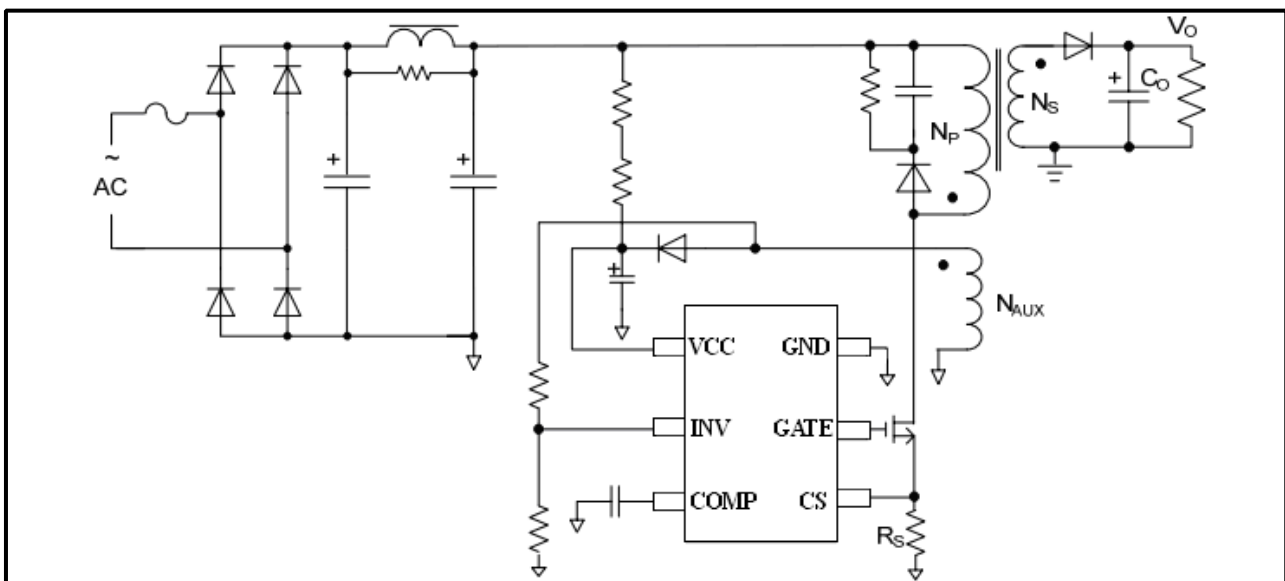
WS3252 operates in primary-side sensing and regulation. Consequently, opto-coupler and TL431 could be eliminated, thus reduce the cost. It can achieve  $\pm 5\%$  constant voltage precision in full input voltage range. CC/CV Control as shown in fig.1. In CC Control, the current and output power setting can be adjusted externally by the sense resistor  $R_s$  at CS pin. In CV control, multi-mode operations are utilized to achieve high performance and high efficiency. In addition, good load regulation is achieved by the built-in cable drop compensation. Device operates in PFM in CC mode as well at large load condition and it operates in PWM with frequency reduction at light/medium load.



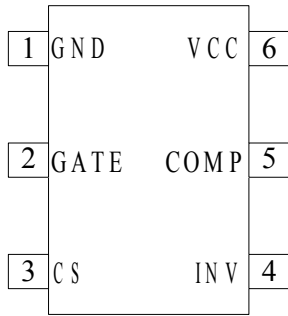
WS3252 offers power on soft start control and protection coverage with auto-recovery features including Cycle-by-Cycle current limiting, VCC OVP, VCC clamp and UVLO. The gate-driven output is clamped to maximum 12V to protect the internal MOSFET. Excellent EMI performance is achieved by using the soft-switching and frequency jittering at the totem-pole-gate-drive output. The WS3252 is the ideal substitute of the linear power supply or the RCC-mode power, for a better performance of the whole switch power system and a lower cost.

WS3252 is available in SOT23-6 package.

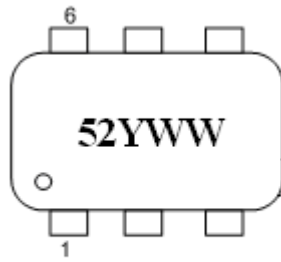
### Typical Application Circuit



**Pin Definition and Device Marking**



SOT23-6



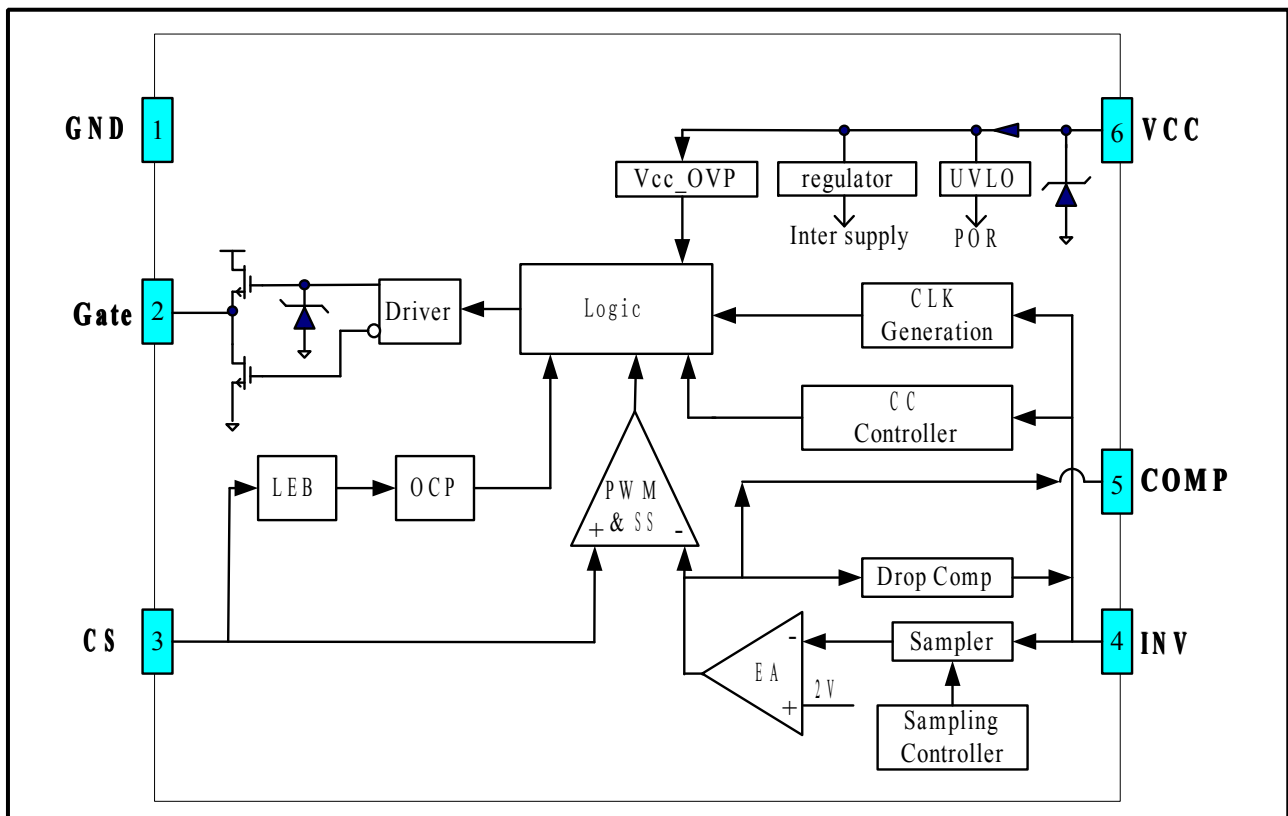
SOT23-6

52: WS3252  
Y: Year Code(0-9)  
WW: Week Code (1-52)

**Pin Function Description**

Pin Name	Pin Number	Pin Type	Function Description
GND	1	GND	Ground.
GATE	2	Gate-driven output	Totem-pole gate driver output for power MOSFET.
CS	3	Current Monitoring	Current sense input.
INV	4	Feedback Input	The voltage feedback from auxiliary winding. Connected to resistor divider from auxiliary winding reflecting output voltage. PWM duty cycle is determined by EA output and current sense signal at pin3.
COMP	5	Loop Compensation	Loop Compensation for CV Stability
VCC	6	Power	Power supply

**Block Diagram**



## Ordering Information

Package	IC Marking Information	Purchasing Device Name
6-Pin SOT23-6, Pb-free	WS3252TP	WS3252TP

## Recommended Operating Condition

Symbol	Parameter	Value	Unit
VCC	VCC supply voltage	10~30	V
TA	Operating temperature	-20~85	°C

## Absolute Maximum Ratings

Symbol	Parameter	Value	Unit
VCC	DC supply voltage	30	V
VINV	INV input voltage	-0.3~7	V
VCS	CS input voltage	-0.3~7	V
VCOMP	COMP input voltage	-0.3~7	V
TJ	Max. Operating junction temperature	150	°C
TSTG	Min./Max. Storage temperature	-55~150	°C
ICC	VCC Clamp Continuous Current	10	mA

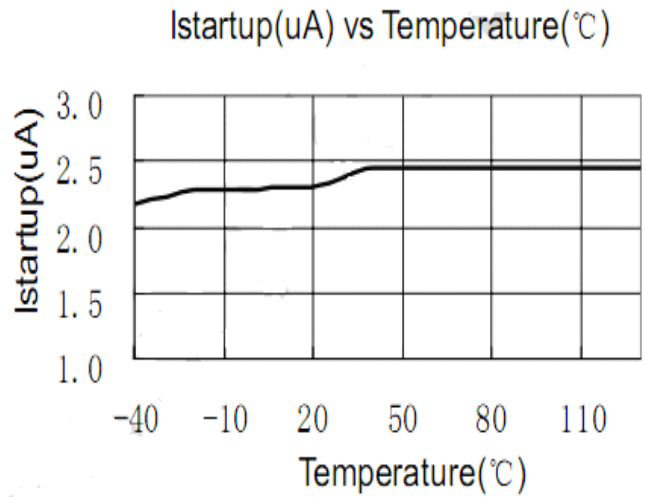
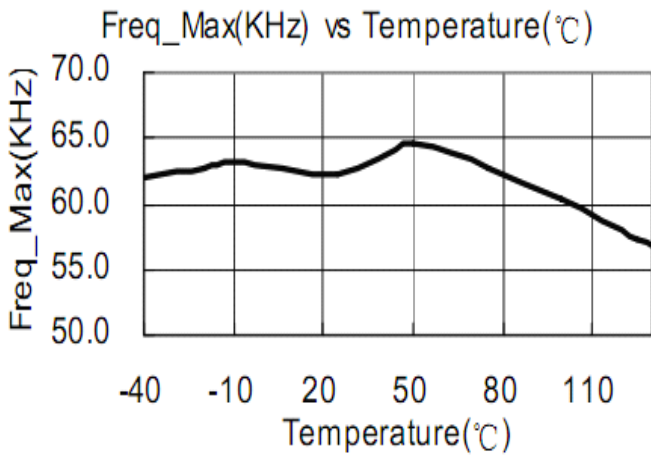
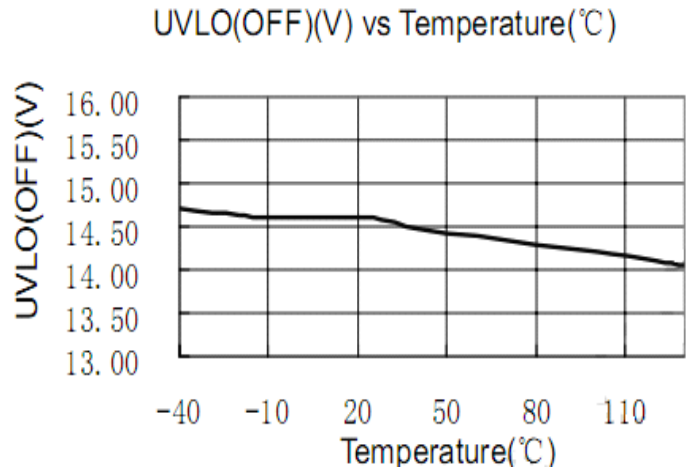
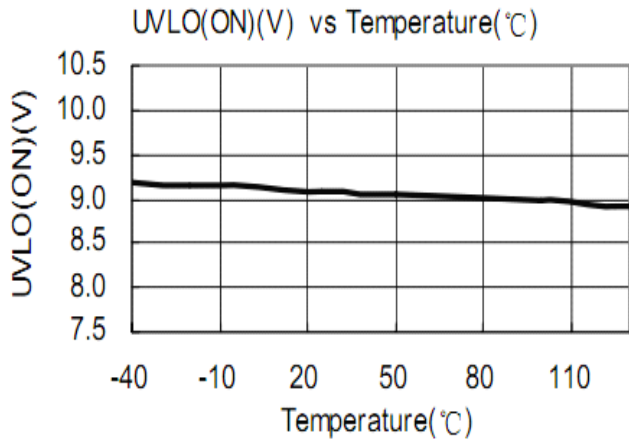
**Note:** Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated in the Recommended Operating Conditions section are not implied. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability.

## Electrical Characteristics (TA=25°C, VCC=16V, if not otherwise noted)

<b>Supply Voltage (VCC)</b>						
symbol	parameter	Test condition	Min	Typ	Max	Unit
I_VCC_ST	Start up current	VCC=13V		5	20	uA
I_VCC_OP	Operation Current	VCC=18V,INV=2V,CS=0V		2	3	mA
UVLO_ON	Turn on threshold Voltage	VCC falling	8.2	9.0	10.5	V
UVLO_OFF	Turn-off threshold Voltage	VCC rising	13.5	14.8	16.0	V
VCC_Clamp	VCC Zener Clamp Voltage	IVCC=10mA	28	29	31	V
OVP	Over voltage protection Threshold	Ramp VCC until gate shut down	27	28.3	30	V
<b>Error Amplifier Section</b>						
Vref_EA	Reference voltage for EA		1.97	2	2.03	V
Gain	DC gain of EA			60		dB
I_comp_max	Max. Cable compensation current	INV=2V,COMP=0V		37.5		uA
<b>Current Sense Section</b>						
TLEB	Leading edge Blanking Time			625		ns
Z <sub>sense</sub>	Input impedance		50			kΩ
T <sub>D</sub> _OC	OCP control delay			110		ns
V <sub>TH</sub> _OC	OCP threshold		0.88	0.91	0.94	V
T <sub>ss</sub>	Soft start time			17		ms
<b>Oscillator Section</b>						
Freq_Max <sup>1</sup>	IC Maximum frequency		55	60	65	khz
Freq_Nom	System nominal switch frequency			50		khz
Freq_startup		INV=0V,COMP=5V		14		khz
Δf/Freq	Frequency shuffling range			±6		%
<b>Gate Driver Output Section</b>						
VOL	Output Low Level	Io=20mA			1	V
VOH	Output High Level	Io=20mA	6			V
V <sub>clamp</sub>	Output Clamp Voltage Level			12		V
T <sub>r</sub>	Output Rising Time	CL=0.5nF		650		ns
T <sub>f</sub>	Output Falling Time	CL=0.5nF		40		ns

**Note:** 1. Freq\_Max indicates IC internal maximum clock frequency. In system application, the maximum operation frequency of 60kHz nominal occurs at maximum output power or the transition point from CV to CC.

**Typical Operating Characteristics**



**Function Description**

WS3252 is a high-integrated offline PWM controller, optimized for high performance low power AC/DC charger and adapter application. WS3252 operates in primary-side sensing and regulation. Consequently, opto-coupler and TL431 could be eliminated, thus reduce the cost. High precision CC/CV control can meet most adapter and charger application requirements.

**Startup Current and Startup Control**

Startup current of WS3252 is designed to be extremely low at 5uA, so that VCC could be charged up above UVLO threshold level and device starts up quickly. A large value startup resistor can therefore be used to minimize the power loss, predigest the design of startup circuit and provides reliable startup in application.

**Operating Current**

The operating current of WS3252 is low at 2mA. Excellent efficiency is achieved with low operating current together and multi-mode control circuit.

**CC/CV Operation**

WS3252 is designed to produce good CC/CV control characteristic as shown in the fig.1. In charger applications, a discharged battery charging starts in the CC portion of the curve until it is nearly full charged and smoothly switches to operate in CV portion of the curve. In an AC/DC adapter, the normal operation occurs only on the CV portion of the curve. The CC portion provides output current limiting. In CV operation, the output voltage is regulated through the primary side control. In CC operation mode, WS3252 will regulate the output current constant regardless of the output voltage drop.

**Principle of Operation**

To achieve high precision CC/CV control, system needs to be designed in DCM mode for flyback system. In DCM mode, the output voltage can be sensed via the auxiliary

winding. During MOSFET turn-on time, the load current is supplied from the output filter capacitor Co. The current in the primary winding ramps up. When MOSFET turns off, the primary current transfers to the secondary at the amplitude of

$$I_s = \frac{N_p}{N_s} * I_p$$

The auxiliary voltage reflects the output voltage, given by

$$V_{AUX} = \frac{N_{AUX}}{N_s} * (V_o + \Delta V)$$

Where  $\Delta V$  indicates the drop voltage of the output Diode.

Via a resistor divider connectrd between the auxiliary winding and INV, the auxiliary voltage is sampled at the end of the demagnetization and it is hold until the next sampling. The sampled voltage is compared with Vref(2V) and the error is amplified. The error amplifier output COMP reflects the load condition and controls the PWM switching frequency to regulate the output voltage, thus the constant output current can be achieved.

When sampled voltage is below Vref and error amplifier output COMP reaches its maximum, the switching frequency is controlled by the sampled voltage thus the output voltage to regulate the output current, thus the constant output current can be achieved.

**Adjustable CC point and Output Power**

In WS3252, the CC point and maximum output power can be externally adjusted by eaternal current sense resistor Rs at CS pin. The output power is adjusted through CC point change. The larger Rs, the smaller CC point is, and the smaller output power becomes, and vice versa.

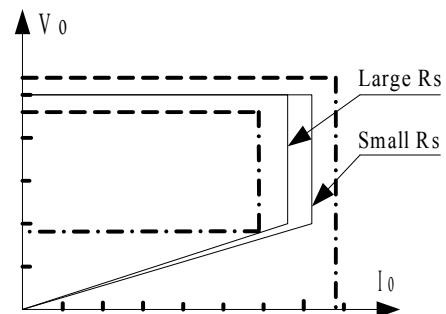


Fig.2 Adjustable output power by changing Rs

### Operation switching frequency

The switching frequency of WS3252 is adaptively controlled according to the load conditions and the operation modes. The operation switching frequency at maximum output power is set to 60KHz internally. In DCM mode, the maximum output power is given by

$$P_{oMAX} = \frac{1}{2} L_p F_{SW} I_p^2$$

Where  $L_p$  indicate the inductance of primary winding and  $I_p$  is peak current of primary winding.

The change of the primary winding inductance results in the change of the maximum output power and constant output current in CC mode. To compensate the change from variations of primary winding inductance, the switching frequency is locked by an internal loop such that the switching frequency is

$$F_{SW} = \frac{1}{2T_{Demag}}$$

Since  $T_{Demag}$  is inversely proportional to the inductance, as a result, the product  $L_p$  and  $F_{sw}$  is constant, thus the maximum output power and constant current in CC mode will not change as primary winding inductance changes. Up to  $\pm 10\%$  variation of the primary winding inductance can be compensation.

### Frequency Shuffling

Excellent EMI performance is achieved by using frequency jittering in WS3252

### Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting is offered in WS3252. The switch current is detected by a sense resistor into the sense pin. An internal leading edge blanking circuit chops off the sense voltage spike at initial MOSFET on state due to snubber diode reverse recovery so that the external RC filtering on sense input is no longer required. The current limit comparator is disabled and thus cannot turn off the internal MOSFET during the blanking period. PWM duty cycle is determined by the current sense input voltage and the EA output voltage.

### Programmable Cable Drop Compensation

Cable drop compensation is implemented to achieve good load regulation in WS3252. An offset voltage is generated at INV by an internal current flowing into the resistor divider. The current is inversely proportional to the voltage across pin COMP, as a result, it is inversely proportional to the output load current, thus the drop due to the cable loss can be compensated. As the load current decreases from full-load to no-load, the offset voltage at INV will increase. It can also be programmed by adjusting the resistance of the divider to compensate the drop for various cable lines used.

### Gate Drive

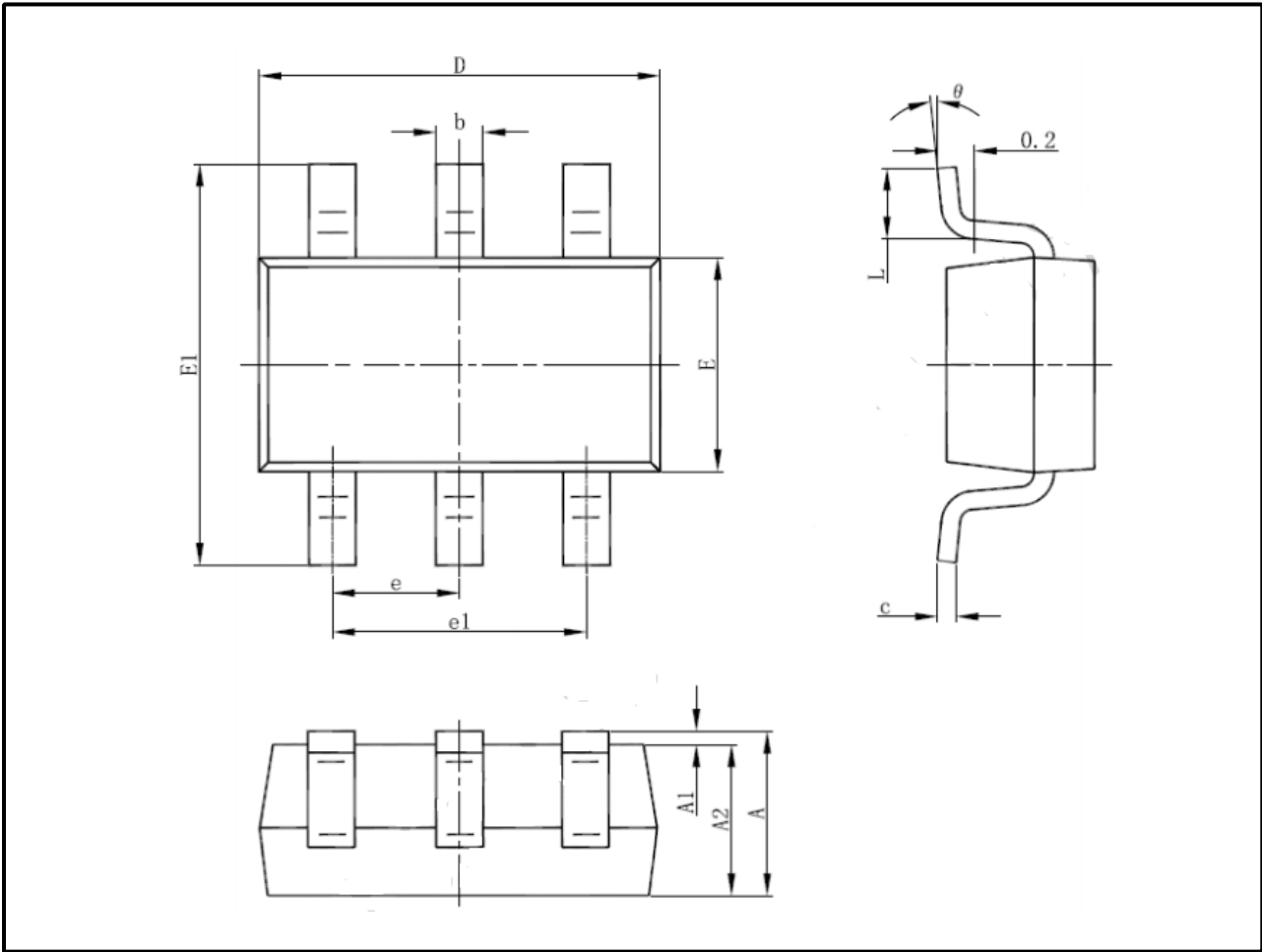
The gate drive strength which is too weak leads to over switch loss of MOSFET while too strong gate drive output compromises in the over EMI. A good tradeoff between output strength and dead time control is achieved through the design of the built-in totem pole gate. The low standby dissipation and good EMI system design is easier to achieve through this dedicated device. For MOSFET gate protection, an internal 12V clamp is added at higher than expected VCC input.

### Protection Controls

Excellent system stability is achieved by the comprehensive protection of WS3252. Including Cycle-by-Cycle current limiting (OCP), VCC Clamp, Under Voltage Lockout on VCC (UVLO).

Device restarts when VCC voltage drops below UVLO limit. It is clamped when VCC is higher than threshold value. The power MOSFET is shut down when VCC drops below UVLO limit and device enters power on start-up sequence thereafter.

**SOT23-6 Package Outline Dimensions**



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.000	1.300	0.039	0.051
A1	0.000	0.150	0.000	0.006
A2	1.000	1.200	0.039	0.047
b	0.300	0.500	0.012	0.020
c	0.100	0.200	0.004	0.008
D	2.800	3.020	0.110	0.119
E	1.500	1.700	0.059	0.067
E1	2.600	3.000	0.102	0.118
e	0.950(BSC)		0.037(BSC)	
e1	1.800	2.000	0.071	0.079
L	0.300	0.600	0.012	0.024
θ	0°	8°	0°	8°