

## Constant Current Regulated Buck Controller with Active Power Factor Correction

### Features

- High Voltage JFET Technology is Applied for Direct Power Supply of IC with No MLCC Buffer
- Capacitance Amplifier Technology is Applied for Loop Compensation with No MLCC Compensation
- Real Time Compensating Technology for High Precision ( $\pm 3\%$ ) LED Current Control, Excellent Line and Load Regulation
- Soft Driving and Critical Conduction Mode Operation for Low EMI Optimization with Both Conduction and Radiation
- Constant On Time Control for Active PFC for High Power Factor ( $>0.95$ ) and Low THD ( $<15\%$ )
- Build-in 800V JFET and Integrated 650V MOSFET for 440 Vac Operation and 4kV Surge Capability
- Programmable Current Dropping At Both Low Line (e.g.  $<180$  Vac) and High Line (e.g.  $> 350$  Vac) for Thermal and Reliability Performance
- Selected Output OVP for Kinds of Applications
- Maximum Switching Frequency Clamping for System Reliability and High Efficiency
- SOP7 Package

### Protection

- Built-In Soft Start
- Thermal Regulation
- LED Open and Short Protection
- Cycle by Cycle Current Limit
- Leading Edge Blanking for Current Sensing
- Leading Edge Blanking for Zero Crossing Detection
- VCC Under Voltage Lock Out (UVLO) and Clamping

### Application

- Non-isolated APFC BUCK LED Driver

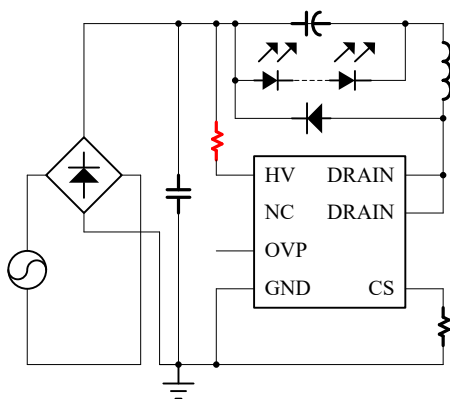


Fig. 1. Typical application circuit

- Recommended Operation Conditions With India Line Voltage (90-440Vac)

Input Power	Output Spec.	Part No.
20W Batten	90V/200mA	YT2302EHS7
24W Panel	72V/280mA	YT2302FHS7

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## Package and Ordering Information

Part No.	Material Type	Package	Operating Temperature	Built-in MOSFET SPEC	Packing Method
YT2302EHS7	Green	SOP7	-40°C to 105°C	650V3.7ohm	Tape 4000 pcs/Reel
YT2302FHS7	Green	SOP7	-40°C to 105°C	650V2.7ohm	Tape 4000 pcs/Reel

## Pin Configuration

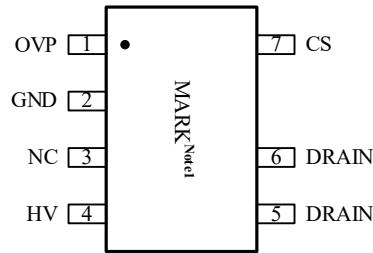


Fig. 2. Pin configuration for SOP7

Note 1: Please refer to the “Marking Rule”.

## Pin Definition

Pin No.	Name	Description
1	OVP	Over Voltage Protection.
2	GND	Ground.
3	NC	No Connection.
4	HV	High Voltage Input to The Internal JFET for Power Supply and Line Detection. <b>A 15kohm Resistor Should be Connected from This Point to The HV Pin to Withstand the Surge.</b>
5、6	DRAIN	Internal HV MOSFET Drain.
7	CS	Current Sense. Connect A Resistor to GND to Sense the Inductor Current.

## Internal Block Diagram

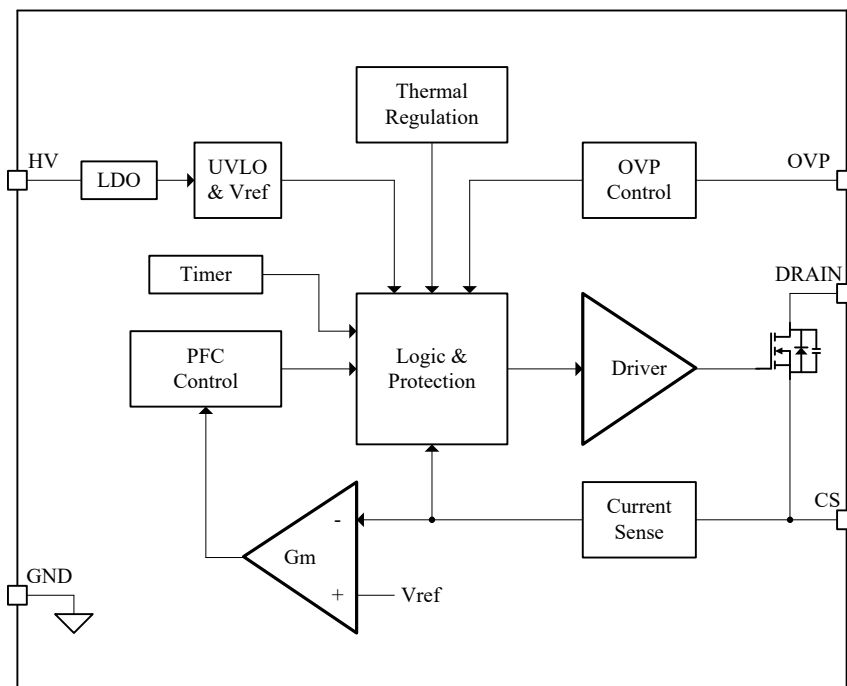


Fig. 3 Internal block diagram

## Absolute Maximum Ratings<sup>Note2</sup>

Parameters	Symbol	Range	Units
“HV” voltage range	$V_{HV}$	-0.3 ~ 800	V
“CS” and “OVP” voltage range	$V_{CS}, V_{OVP}$	-0.3 ~ 6	V
Guaranteed minimum “DRAIN” voltage <sup>Note3</sup>	$V_{DS\_min}$	650	V
ESD Human mode <sup>Note4</sup>	$ESD_{hbm}$	3000	V
Operating junction temperature range	$T_j$	-40 ~ 150	°C
Ambient temperature range	$T_a$	-40 ~ 105	°C
Storage Temperature Range	$T_{stg}$	-40 ~ 150	°C
Welding temperature (< 20 s welding)	$T_{lead}$	260	°C
Junction to ambient thermal resistance	$\theta_{thja}$	145	°C/W

Note 2: Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device.

Note 3: Depending on the different built-in MOSFET SPEC, see the corresponding relationship between the model and the built-in MOSFET.

Note 4: Electrical components and circuit boards will be aware of the situation in the discharge is not easy. Although this product has a special electrostatic protection circuit, but in the case of high-energy electrostatic discharge, the chip may have damage and loss of function or performance degradation. Therefore, users still need to take appropriate preventive measures ESD.

**Electrical Characteristics**<sup>Notes</sup> (Unless otherwise specified,  $T_a = 25\text{ }^\circ\text{C}$ )

Parameter	Symbol	Conditions	Min	Typ.	Max	Units
<b>VCC</b>						
VCC Turn On Threshold	$V_{CC\_ON}$	$V_{CC}$ Rising			10	V
VCC Operating Current	$I_{CC\_OP}$			200	360	$\mu A$
<b>PWM</b>						
Minimum On Time	$T_{on\_min}$			1.1		$\mu s$
Maximum On Time	$T_{on\_max}$		6	7	8	$\mu s$
Minimum Off Time	$T_{off\_min}$			2		$\mu s$
Maximum Off Time	$T_{off\_max}$		500	600	700	$\mu s$
Maximum Frequency	$f_{max}$		108	120	130	$kHz$
<b>CS</b>						
Internal Reference Voltage	$V_{REF}$		0.204	0.210	0.216	V
CS Sampling Clamp Voltage	$V_{CS\_LMT}$		1.1	1.2	1.3	V
CS Leading Edge Blanking Time	$T_{LEB\_CS}$			350		ns
Switch off Delay Time	$T_{DELAY\_OFF}$			200		ns
<b>OVP</b>						
OVP Voltage With Resistor	$V_{OVP\_RES}$	$R_{OVP} = 510\text{ kohm}$	60			V
OVP Voltage With No Connection	$V_{OVP\_OPEN}$		105			V
OVP Voltage With GND Short	$V_{OVP\_SC}$		120			V
OVP Voltage With Resistor	$V_{OVP\_RES}$	$R_{OVP} = 120\text{ kohm}$	180			V
<b>MOSFET</b>						
Drain-Source Breakdown Voltage	$BV_{DSS}$		650			V
Drain-Source On Resistance	$R_{DS\_ON\_2302E}$			3.7		ohm
	$R_{DS\_ON\_2302F}$			2.7		
<b>Thermal Regulation</b>						
Thermal Regulation Temperature	$T_{OTR\_TH}$			145		$^\circ C$

Note 5: The max and minimum parameters specified are guaranteed by test, the typical value are guaranteed by design, characterization and statistical analysis.

## Application Suggestion

YT2302XHS7 is a high precision active PFC driver integrating 800V JFET and 650V power MOSFET, specially designed for non-isolated buck offline constant current LED lighting. Operating in critical conduction mode, the driver achieves high power factor, low THD and high efficiency.

## Start Up And Supply

When AC line is applied, main bus voltage can be built, then the JFET of the IC supply the inner operation. When the voltage of HV reaches VCC\_ON, PWM is enabled; If the voltage of HV drops below the VCC\_UVLO, PWM is disabled and restart is necessary.

## Principle of The Active Power Factor Correction (APFC)

Constant on time ( $T_{on}$ ) control with boundary conduction mode (BCM) operation is the key principle to achieve active power factor correction, thereby high power factor and low THD can be expected.

The power inductor is charged during the fixed  $T_{on}$  of the MOSFET,  $i_L$  increase linearly to the peak ( $i_{pk}$ ) from zero; when MOSFET turned off, the freewheeling diode release the inductor current,  $i_L$  decrease linearly from  $i_{pk}$  to zero and next switching cycle is triggered.

Fig. 4 shows the Key waveforms of the CC controlled buck with APFC.

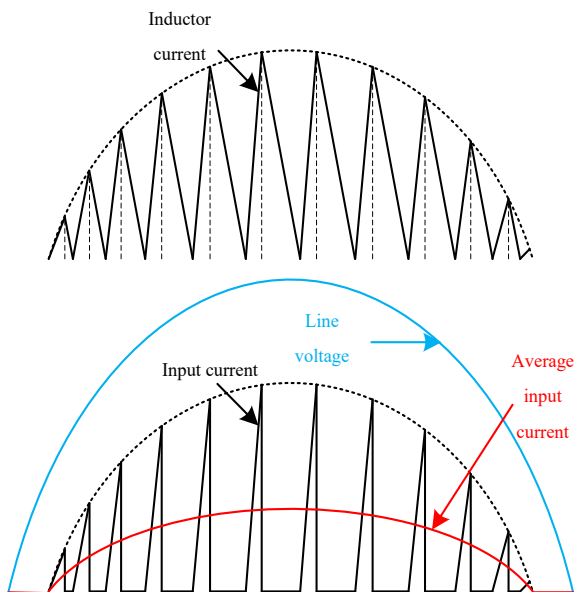


Fig. 4 Key waveforms of the CC controlled buck with APFC

## Constant Current Control

In order to achieve high precision ( $\pm 3\%$ ) output current ( $I_o$ ) control, excellent line and load regulation, YT2302XHS7 operates in BCM and makes the real time sensing to the inductor current.  $I_o$  can be calculated with formula (1)

$$I_o = \frac{V_{ref}}{R_{cs}} \quad (1)$$

Where  $V_{ref}$  is the reference voltage,  $R_{cs}$  is the current sensing resistance.

## Zero Current Detection (ZCD) and Valley

### Switching Technique

The zero crossing of the inductor current is detected for PWM turn-off signal, thereby the valley turn-on of the MOSFET and BCM operation of the inductor current can be achieved.

### Maximum Off Time

Maximum off time ( $T_{off\_max}$ ) is set to avoid the condition that ZCD block missing the zero crossing event of the inductor current.

### Minimum Off Time

Minimum off time ( $T_{off\_min}$ ) is set to limit the maximum switching frequency ( $f_{sw\_max}$ ), then the switching loss and EMC performance can be guaranteed. As shown in Fig. 5, PWM is triggered at the first valley after  $T_{off\_min}$ .

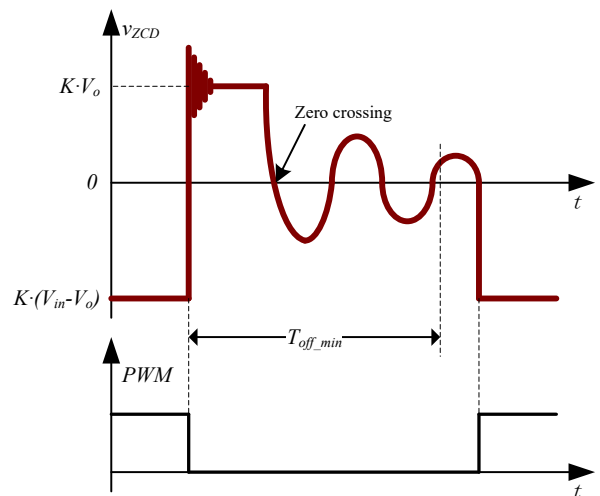


Fig. 5 Minimum off time

### ZCD Blanking

Fig. 6 shows ZCD blanking time ( $T_{LEB\_ZCD}$ ) is set to avoid the fault trigger by the oscillation after the turn off.

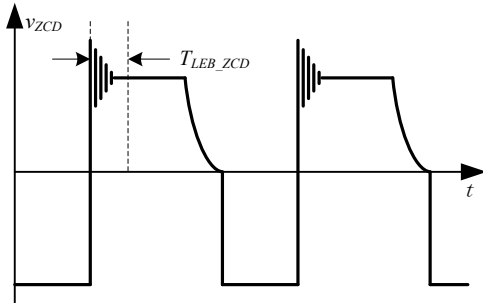


Fig. 6 ZCD blanking

### CS Blanking

Fig. 7 shows CS blanking time ( $T_{LEB\_CS}$ ) is set to avoid the fault trigger by the oscillation after the turn on.

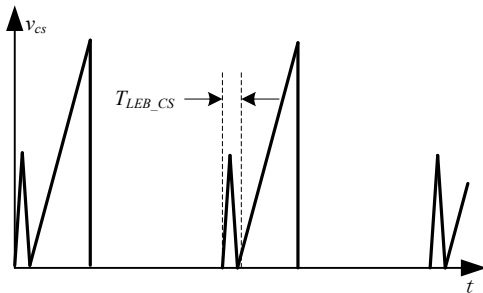


Fig. 7 CS blanking

### Cycle by Cycle Current Limiting

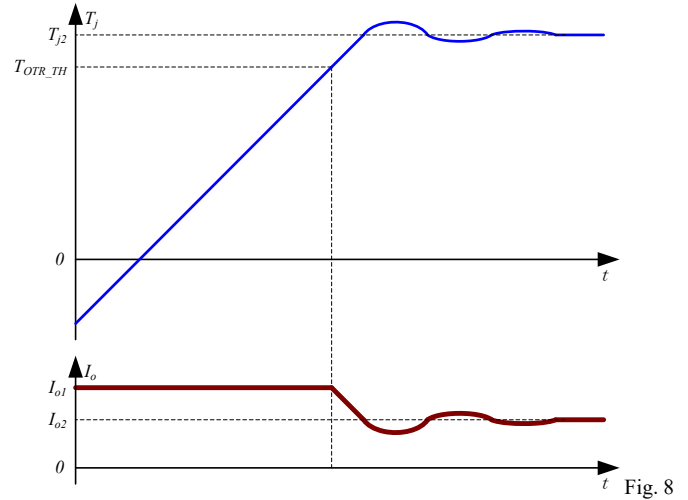
When LED short or inductor saturation happens, CS pin voltage ( $V_{CS}$ ) goes higher than regulation. However, CS voltage limit ( $V_{CS\_LMT}$ ) can help to stop PWM cycle by cycle to protect the MOSFET and the other power devices.

### Over Temperature Regulation (OTR)

When the junction temperature goes higher than the threshold of the over temperature regulation ( $T_{OTR\_TH}$ ), chip will reduce the output current ( $I_o$ ) by reducing the internal reference ( $V_{ref}$ ). This is helpful to regulation the system temperature, guarantees the stability of both the driver and LED chip, and improves the reliability of the LED lighting system. Fig. 8 shows the principle of the over temperature regulation, where  $I_{o1}$  is the output current before OTR triggered;  $I_{o2}$  is the output current during OTR triggering and the junction temperature is  $T_{j2}$  for  $I_{o2}$ .

### Over Voltage Protection

With different setting to OVP pin, customers can get



Principle of the over temperature regulation

4 levels OVP for right application. Here we give the suggestion for maximum load voltage according to corresponding OVP lever with minimum 15kohm HV resistor.

OVP setting	OVP threshold	Max LED voltage
$R_{OVP} = 510\text{ kohm}$	60V	54V
Open to GND	105V	95V
Short to GND	120V	110V
$R_{OVP} = 120\text{ kohm}$	180V	160V

### Current Dropping

Programmable current dropping at both low line (e.g. <180 Vac) and high line (e.g. > 350Vac) is designed to reduce the temperature of the components and system to improve the thermal and reliability performance.

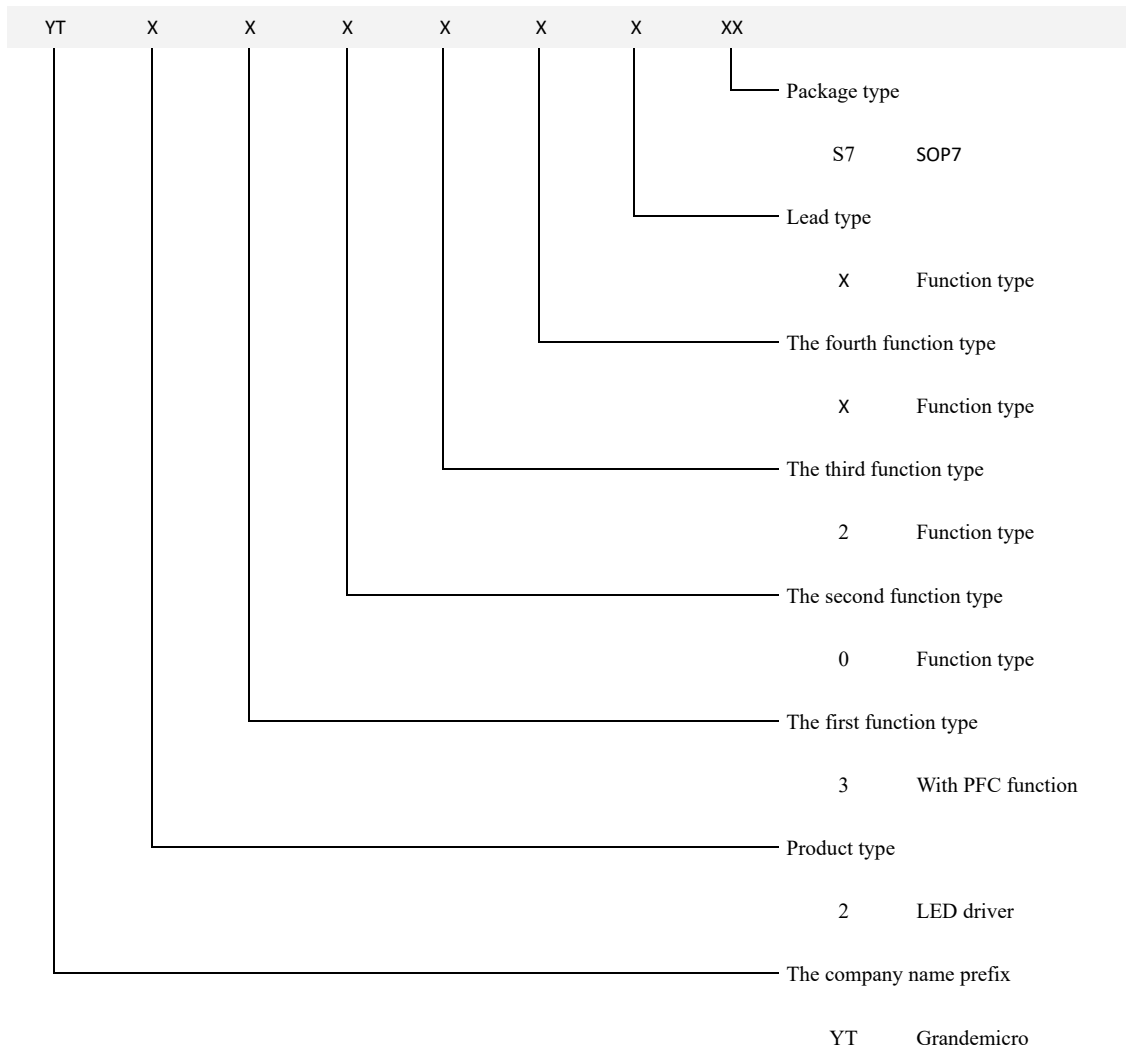
### Restart after Protection

When PWM is stopped by any protection, chip increases the power dissipation to force VCC UVLO happen. Chip can only be restarted by VCC UVLO to remove the protection scheme.

### PCB Design Guide

1. Current sensing resistor ( $R_{cs}$ ) shall be placed very close to the chip, minimize the loop from CS pin to  $R_{cs}$  and GND pin.
2. Separate the power ground and the signal ground.
3. Minimize the loop from input capacitor ( $C_{in}$ ) to MOSFET and the freewheeling diode to improve the system stability and EMC performance.

## Marking Rule

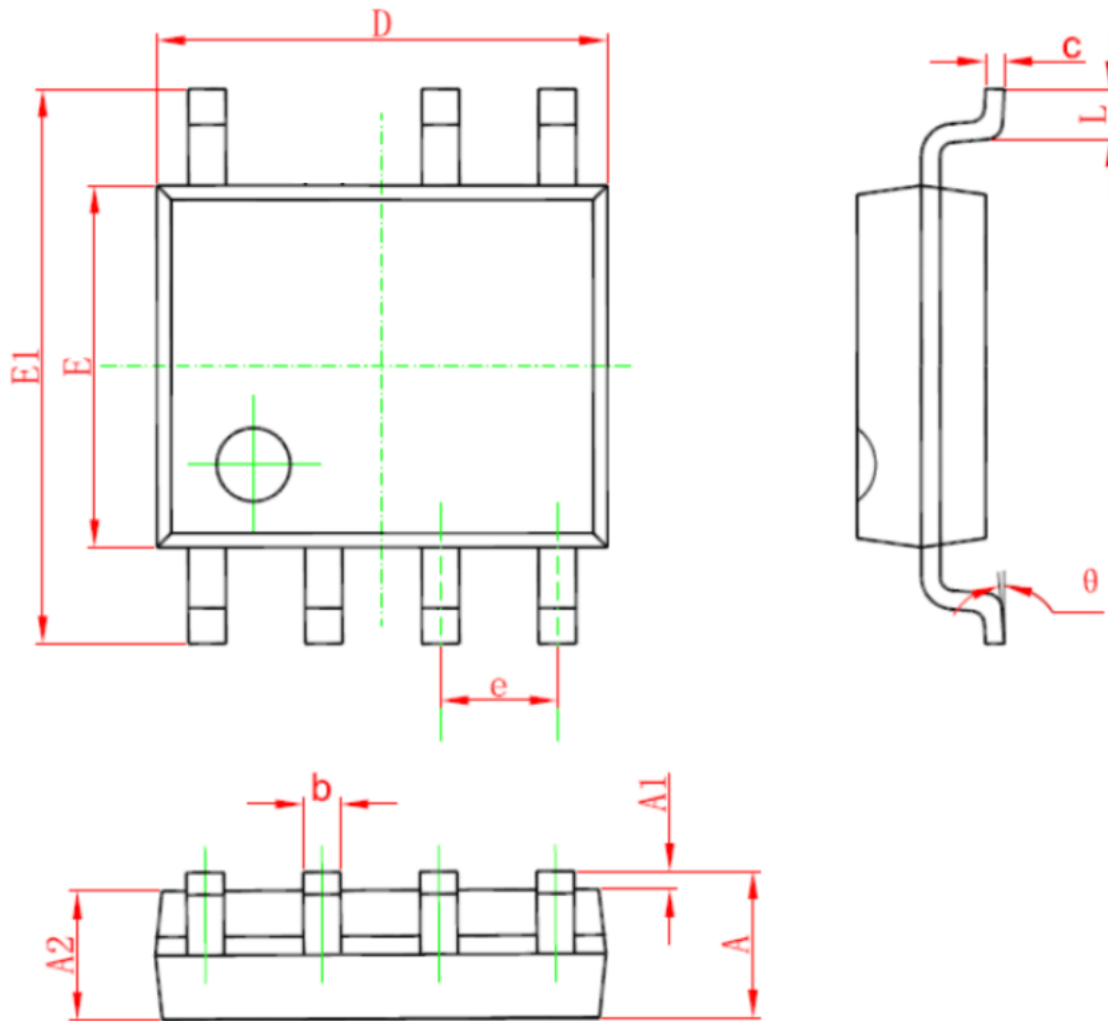


## Naming Rule

	Part No. Date Code Special Note
Part No.	YT2302EH, YT2302FH
Date Code	P: Packing site; Y: Year; W: Week; S: Series; F: MOSFET.
Special Note	Use obvious mark like “H”, “L” to distinguish the key features like CS reference or OVP reference etc. if necessary.

# Package

SOP7



Symbol	Size (mm)		Size (inch)	
	Min.	Max.	Min.	Max.
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270		0.050	
L	0.400	1.270	0.016	0.050
$\theta$	0°	8°	0°	8°

## Version History

Version	Date	Description
A0	Jun. 2022	Draft
A1	Aug. 2022	Released
A2	June 2023	Update the MOS information
A3	Sep. 2023	Remove D version MOS, add G version MOS
A4	Nov. 2023	Change G version MOS to H version MOS due to the packaging issue.
A5	Dec. 2023	Update the CS reference to 210mV
A6	Jan. 2024	Remove H version MOS
A7	April 2025	Increase the D version MOSFET for kinds of applications
A8	Dec. 2025	Remove D version MOS Update OVP voltage