## GENERAL DESCRIPTION

OB3398 is a primary side regulation off-line LED lighting controller which can achieve accurate LED current. It significantly simplifies LED lighting system design by eliminating the secondary side feedback circuitry. Proprietary Constant Voltage (CV) and Constant Current (CC) control is integrated as shown in the figure below.
The LED current (CC control) can be adjusted externally by the resistor Rs at CS pin.
OB3398 offers comprehensive protection coverage with auto-recovery features including Cycle-by-Cycle current limiting, VDD clamp and UVLO. Excellent EMI performance is achieved with On-Bright proprietary frequency shuffling technique.
OB3398 is offered in SOT23-5 package.

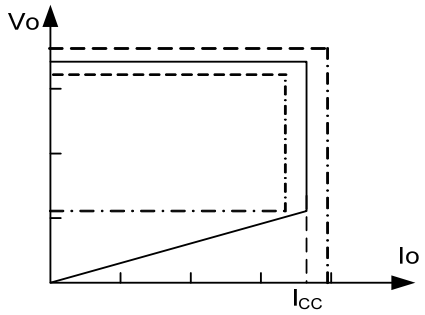



Fig.1. Typical CC/CV Curve

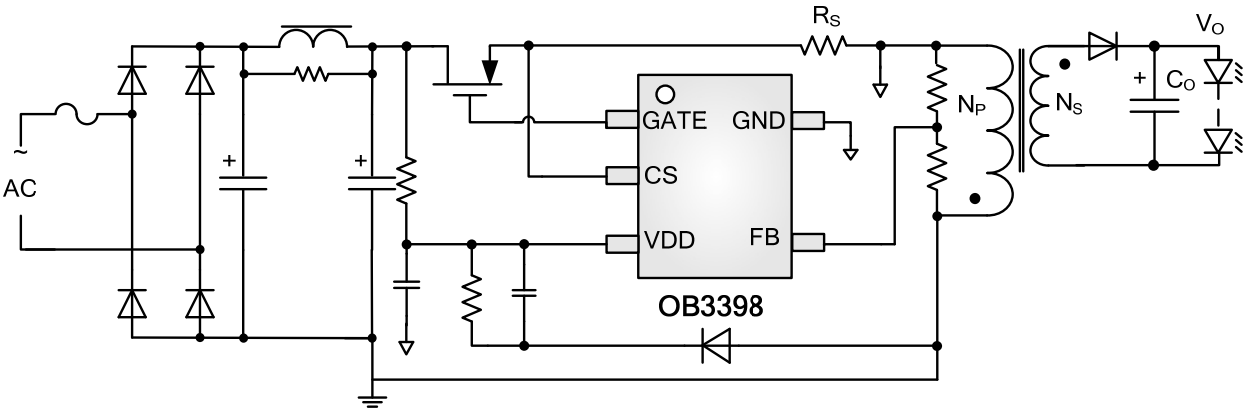
## FEATURES

- High Precise Constant Current Regulation at Universal AC input
- Primary-side Sensing and Regulation Without TL431 and Opto-coupler
- Floating PSR control scheme with two transformer windings
- Adjustable Constant Current and Output Power Setting
- Built-in Primary winding inductance compensation
- Built-in Leading Edge Blanking (LEB)
- Cycle-by-Cycle Current Limiting
- VDD Under Voltage Lockout with Hysteresis (UVLO)
- Over temperature protection (OTP)
- VDD Clamp

## APPLICATIONS

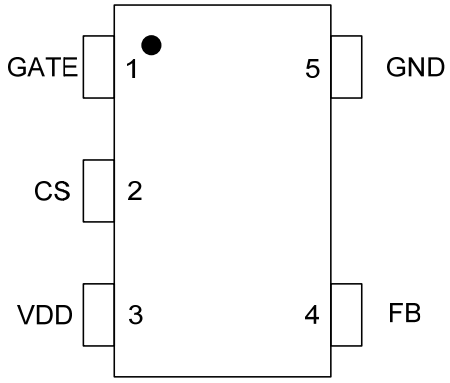
Low Power AC/DC offline SMPS for
- LED applications

## TYPICAL APPLICATION



## GENERAL INFORMATION

### Pin Configuration
SOT23-5.




### Ordering Information

| Part Number | Description |
|---|---|
| OB3398MP | SOT23-5, Pb-free,T&R |

### Package Dissipation Rating

| Package | RθJA (℃/W) |
|---|---|
| SOT23-5 | 200 |

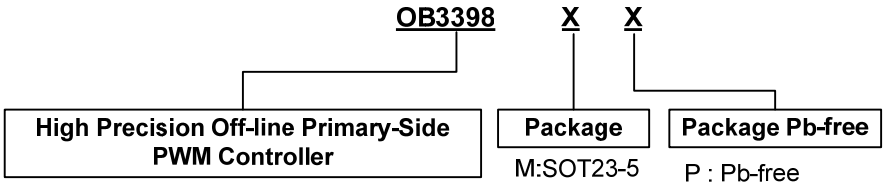
### Absolute Maximum Ratings

| Parameter | Value |
|---|---|
| Gate Voltage | -0.3 to 25V |
| VDD Voltage | -0.3 to $V_{DD}$_clamp |
| CS Input Voltage | -0.3 to 7V |
| FB Input Voltage | -0.3 to 7V |
| Min/Max Operating Junction Temperature $T_J$ | -40 to 150 ℃ |
| Operating Ambient Temperature $T_A$ | -40 to 85 ℃ |
| Min/Max Storage Temperature $T_{stg}$ | -55 to 150 ℃ |
| Lead Temperature (Soldering, 10secs) | 260 ℃ |

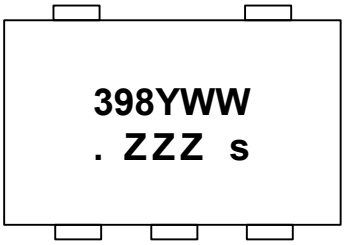
**Note:** Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum-rated conditions for extended periods may affect device reliability.

### Recommended Operating Condition

| Symbol | Parameter | Range |
|---|---|---|
| VDD | VDD Supply Voltage | 12 to 25 V |



## Marking Information

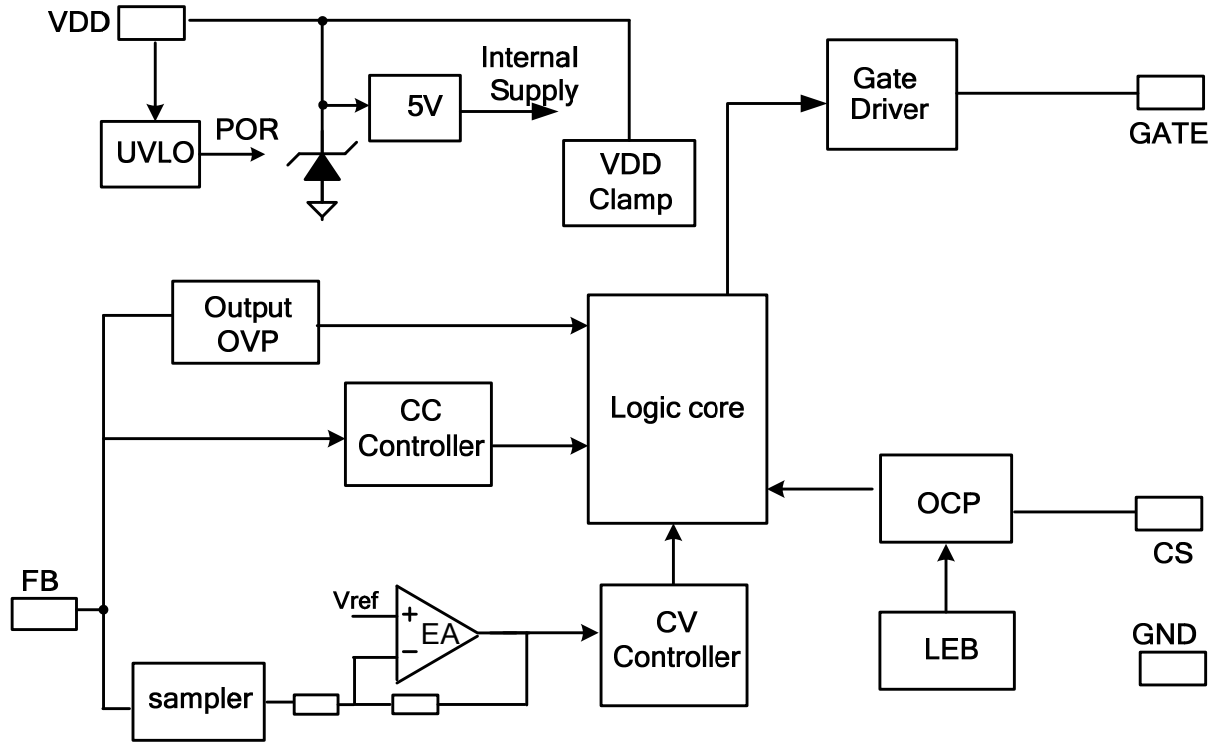



Y:Year Code
WW:Week Code(01-52)
ZZZ: Lot code
s: Internal code

## TERMINAL ASSIGNMENTS

| Pin Num | Pin Name | I/O | Description |
|---|---|---|---|
| 1 | GATE | O | Gate driver output |
| 2 | CS | I | Current sense input. |
| 3 | VDD | P | Power Supply |
| 4 | FB | I | Connected to resistor divider from primary winding or auxiliary winding to reflect output voltage. |
| 5 | GND | P | Ground |

## BLOCK DIAGRAM



## ELECTRICAL CHARACTERISTICS

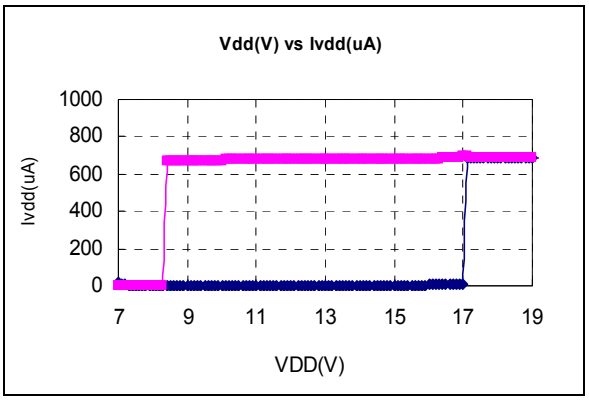
(TA = 25℃, VDD=16V, if not otherwise noted)

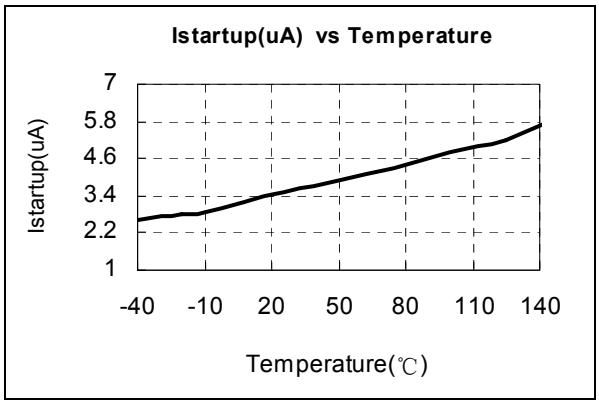
| Symbol | Parameter | Test Conditions | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| **Supply Voltage (VDD) Section** | | | | | | |
| $I_{startup}$ | Startup Current | VDD=UVLO_OFF-1V | | 4 | 20 | uA |
| $I_{DD\ op}$ | Operation Current | Operation supply current FB=1V, CS=0V, VDD= 20V | - | 0.45 | 1 | mA |
| UVLO(ON) | VDD Under Voltage Lockout Enter | VDD falling | 7.3 | 8.3 | 9.3 | V |
| UVLO(OFF) | VDD Under Voltage Lockout Exit | VDD rising | 15.5 | 16.5 | 17.5 | V |
| $V_{DD}$_clamp | Maximum VDD operation voltage | $I_{DD}$=20mA | | 25 | | V |
| **Current Sense Input Section** | | | | | | |
| TLEB | LEB time | | | 500 | | ns |
| Vth_oc | Over current threshold | | 492 | 500 | 508 | mV |
| Td_oc | OCP Propagation delay | | | 100 | | ns |
| **Frequency Section** | | | | | | |
| Freq_Max[Note] | IC Maximum frequency | | 103 | | | KHz |
| Toff_min | Minimum Toff | | | 4.0 | | us |
| F_min | Minimum frequency | | | 103 | | Hz |
| ∆f/Freq | Frequency shuffling range | | | ±7 | | % |
| **Error Amplifier section** | | | | | | |
| Vref_EA | Reference voltage for EA | | 1.14 | 1.2 | 1.26 | V |
| Gain | DC gain of EA | | | 40 | | |
| Vth_OVP | Load OVP threshold voltage | | | 1.4 | | V |
| **Gate Driver Section** | | | | | | |
| VOL | Ouput low level @ VDD=14V, Io=5mA | | | | 1 | V |
| VOH | Ouput high level @ VDD=14V, Io=20mA | | 6 | | | V |
| V_clamping | Output clamp voltage | | | 10 | | V |
| T_r | Output rising time 1V~ 9V@ CL=500pF | | | 95 | | ns |
| T_f | Output falling time 9V~1V@ CL=500pF | | | 50 | | ns |
| **On chip Over temperature Section** | | | | | | |
| T_otp | Over temperature protection trigger point | | | 135 | | ℃ |
| T_otp_rec | Over temperature protection recovery point | | | 120 | | ℃ |

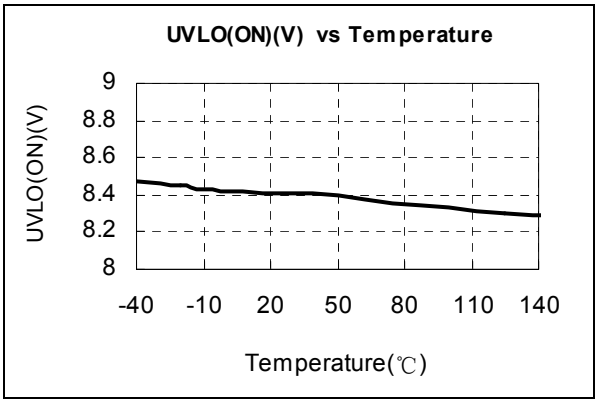
**Note:**

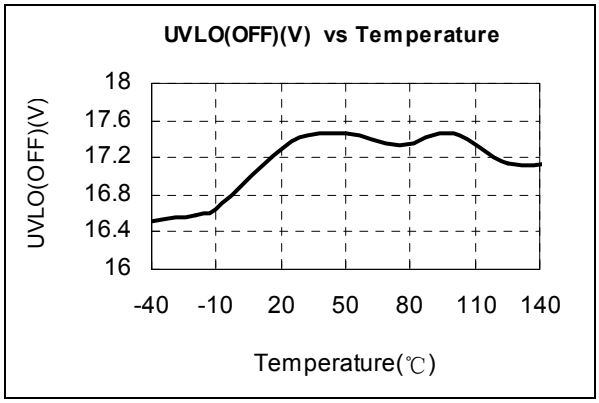
1. Freq_Max indicates IC internal maximum clock frequency. In system application, the maximum operation frequency of 103KHz nominal occurs at maximum output power or the transition point from CV to CC.

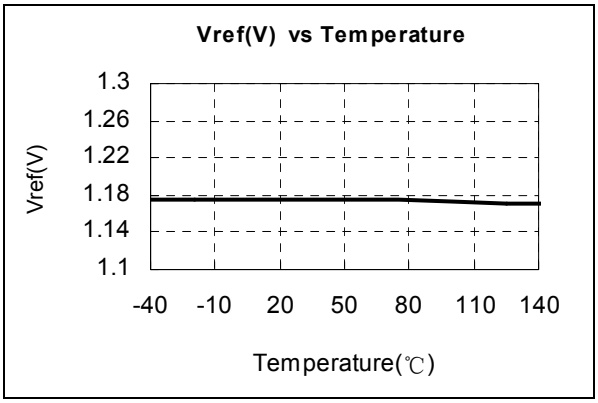
## CHARACTERIZATION PLOTS

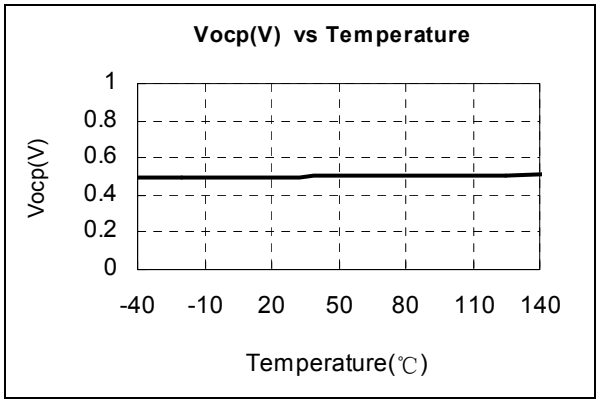


## OPERATION DESCRIPTION

OB3398 is a cost effective PWM controller optimized for off-line LED lighting applications. Based on floating flyback converter topology working in DCM mode, it operates in primary side sensing and regulation, thus opto-coupler and TL431 are not required. Proprietary built-in CC control can achieve high precision LED current meeting LED lighting application requirements.

**Startup Current and Start up Control**

Startup current of OB3398 is designed to be very low so that VDD could be charged up above UVLO threshold and starts up quickly. A large value startup resistor can therefore be used to minimize the power loss in application.

**Operating Current**

The Operating current of OB3398 is as low as 0.45mA(Typ.). Typical good efficiency is achieved with the low operating current together with 'Multi-mode' control features.

**Principle of CC Operation**

To support OB3398 proprietary CC control, system needs to be designed in DCM mode for flyback system (Refer to Typical Application Diagram on page1). The LED output current $I_{LED}$ is given by:

$$I_{LED} = \frac{1}{2} L_P \cdot F_{SW} \cdot I_{PK}^2 \cdot \eta / V_O \qquad (1)$$

Where Lp indicates the inductance of primary winding, Ipk is the peak current of primary winding.

Refer to the equation 1, the change of the primary winding inductance results in the change of the constant output current. 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

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

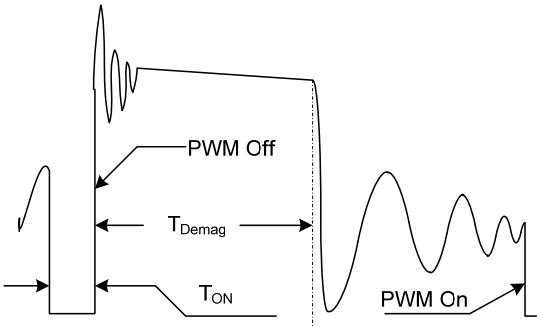



Figure.1 Primary voltage waveform

Since $T_{Demag}$ is inversely proportional to the inductance, as a result, the product *Lp* and *fsw* is constant, thus output current will not change as primary winding inductance changes. Up to ±7% variation of the primary winding inductance can be compensated.

The output LED current is

$$I_{LED} = \frac{1}{4} \cdot N \cdot \frac{V_{th\_oc}}{R_s} \qquad (3)$$

Where N is the ratio of transformer between primary winding and secondary winding.

**Adjustable CC point and Output Power**

In OB3398, the CC point and maximum output power can be externally adjusted by external current sense resistor Rs at CS pin as illustrated in Typical Application Diagram. 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 as shown in Fig.2.

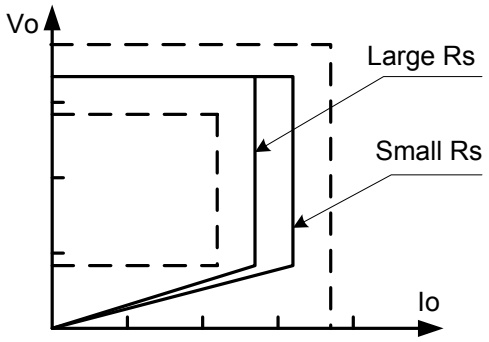



Figure.2 Adjustable output power by changing Rs

**Operation switching frequency**

The switching frequency of OB3398 is adaptively controlled according to the load conditions and the operation modes. No external frequency setting components are required. The operation switching frequency at maximum output power is set to 103K Hz internally.

For flyback operating in DCM, The maximum output power is given by

$$P_{O\max} = \frac{1}{2} \eta L_P F_{SW} I_{pk}^2 \qquad (4)$$

Where Lp indicate the inductance of primary winding and Ipk is the peak current of primary winding.

The principle of CC operation sets the product *Lp* and *fsw* to be a constant, thus the maximum output power and constant current in CC mode will not change as primary winding inductance changes. Up to +/-7% variation of the primary winding inductance can be compensated.

**CV / OVP Mode**

When LED string is open, an output voltage condition is monitored independently by the voltage at FB pin. During normal operation, the voltage at FB pin is regulated at 1.2V (typ.), with dummy load over Pmin.

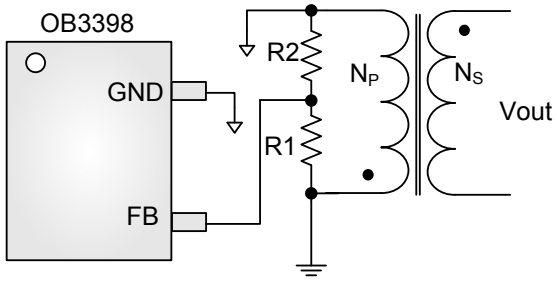



Figure.3 FB Section Circuit

$$V_{OUT} = \frac{N_S}{N_P} \times \frac{R1+R2}{R2} \times V_{ref\_CV}$$

R1 —Resistor connected between the FB pin and the input capacitor GND, the value suggested is 330Kohms~1Mohms

R2 —Resistor connected between the FB pin and the GND pin of IC, the value suggested is 5Kohms~15Kohms

$$P_{min} = \frac{1}{2} \times \left( \frac{Vth\_oc}{R_{CS}} \right)^2 F_{min} L_{priamry}$$

$V_{th\_oc}$ — Over current protection threshold voltage

$F_{min}$ — Minimum switching frequency, which is 103Hz (typ.)

If the dummy load is less than $P_{min}$, the output voltage rises up. If the voltage at FB pin exceeds a threshold of approximately 1.4V (typical), the over-voltage protection function is activated and the switching is turned off immediately.

$$V_{OVP} = \frac{N_S}{N_P} \times \frac{R1+R2}{R2} \times V_{vth\_OVP}$$

**CC Line Regulation**

Adjust the R1 for better CC line regulation, while driving different type MOSFET. The larger MOSFET, the smaller R1 needed. R1 allow the change from 330K to 1M ohms to cover all the applications. If the resistance is too large, it causes the interference due to the floating ground, too small resistance results the efficiency decreased at HV AC line.

**Frequency shuffling for EMI improvement**

The frequency shuffling (switching frequency modulation) is implemented in OB3398. The oscillation frequency is modulated so that the tone energy is spread out. The spread spectrum minimizes the conduction band EMI and therefore eases the system design.

**Current Sensing and Leading Edge Blanking**

Cycle-by-Cycle current limiting is offered in OB3398. The switch current is detected by a sense resistor into the CS pin. An internal leading edge blanking circuit chops off the sensed voltage spike at initial power MOSFET on state so that the external RC filtering on sense input is no longer needed. The PWM duty cycle is determined by the current sense input voltage and the EA output voltage.

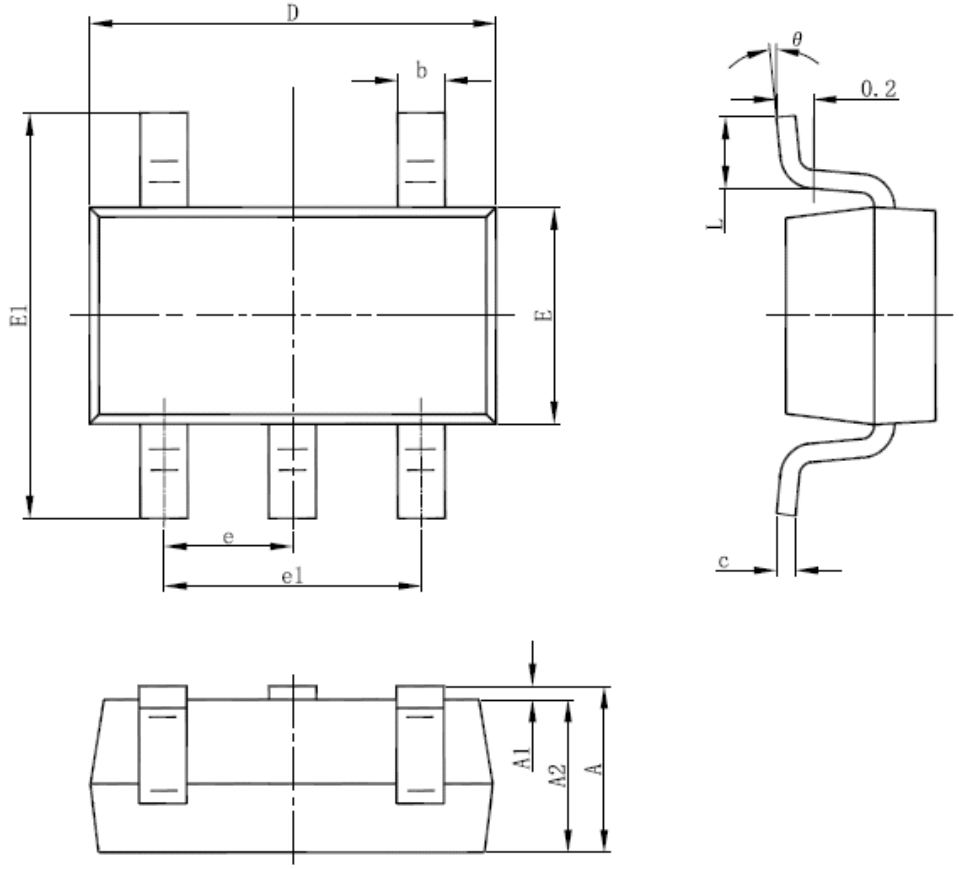
**Protection Control**

Good power supply system reliability is achieved with its rich protection features including Cycle-by-Cycle current limiting (OCP), VDD clamp, on-chip OTP, and Under Voltage Lockout on VDD (UVLO).

VDD is supplied by transformer primary winding output. The output of OB3398 is shut down when VDD drops below UVLO (ON) limit and the power converter enters power on start-up sequence thereafter.

## PACKAGE MECHANICAL DATA

5-Pin Plastic SOT (SOT23-5)




| Symbol | Dimensions In Millimeters | | Dimensions In Inches | |
|---|---|---|---|---|
| | Min | Max | Min | Max |
| A | 1.000 | 1.450 | 0.039 | 0.057 |
| A1 | 0.000 | 0.150 | 0.000 | 0.006 |
| A2 | 0.900 | 1.300 | 0.035 | 0.051 |
| b | 0.300 | 0.500 | 0.012 | 0.020 |
| c | 0.080 | 0.220 | 0.003 | 0.009 |
| D | 2.800 | 3.020 | 0.110 | 0.119 |
| E | 1.500 | 1.726 | 0.059 | 0.068 |
| 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° |

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