## GENERAL DESCRIPTION

OB2365E is a highly integrated current mode PWM control IC optimized for high performance, low standby power and cost effective offline flyback converter applications.

At normal load condition, it operates in QR mode in high line input voltage. To minimize switching loss, the maximum switching frequency in QR mode is internally limited to 77 KHz. When the loading goes low, it operates in PFM mode with valley switching for high power conversion efficiency. When the load is very small, the IC operates in 'Extended Burst Mode' to minimize the standby power loss. Additionally, in the low line input voltage, the IC operates in fixed frequency (65KHz) CCM mode at the heavy loading. As a result, high conversion efficiency can be achieved in the whole loading range.

VCC low startup current and low operating current contribute to a reliable power on startup and low standby design with OB2365E.

OB2365E offers comprehensive protection coverage with auto-recovery including Cycle-by-Cycle current limiting (OCP), over load protection (OLP), VCC under voltage lockout (UVLO), external over temperature protection (OTP), and over voltage protection (OVP). Excellent EMI performance is achieved with On-Bright proprietary frequency shuffling technique.

The tone energy at below 23KHz is minimized in the design and audio noise is eliminated during operation.

OB2365E is offered in SOT23-6 package.

## APPLICATIONS

Offline AC/DC flyback converter for

- General power supply
- Power Adapter

## FEATURES

- Power on soft start reducing MOSFET Vds stress
- Multi-Mode Operation

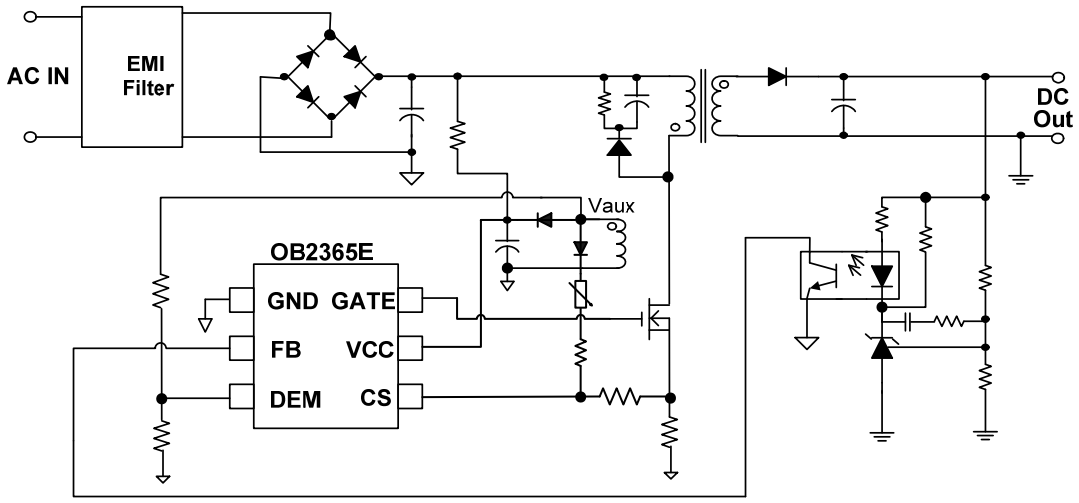
  77KHz maximum clamping frequency in QR mode @ Full Load in high line voltage

  65KHz minimum clamping frequency in CCM mode @ Heavy Load in low line voltage

  Valley switching operation @ Green mode

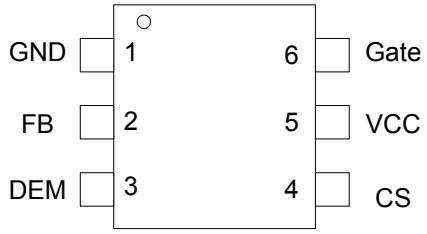
  Burst Mode @ Light Load & No Load
- Frequency shuffling for EMI
- Extended burst mode control for improved efficiency and low standby power design
- Audio noise free operation
- Comprehensive protection coverage
  - o VCC Under Voltage Lockout with hysteresis (UVLO)
  - o VCC Over Voltage Protection (VCC OVP)
  - o Cycle-by-cycle over current threshold setting for constant output power limiting over universal input voltage range
  - o Over Load Protection (OLP) with auto-recovery
  - o Brownout protection with auto-recovery
  - o Output Over Voltage Protection(Output OVP) with auto-recovery, and the OVP triggered voltage can be adjusted by the resistors connected between auxiliary winding and ground
  - o Adjust Over Temperature Protection(OTP) through CS pin with auto-recovery
  - o Output diode short protection with auto-recovery

## TYPICAL APPLICATION



## GENERAL INFORMATION

### Pin Configuration




### Ordering Information

| Part Number | Description |
|---|---|
| OB2365EMP | SOT23-6,Halogen-free in T&R |

### Package Dissipation Rating

| Package | RθJA(℃/W) |
|---|---|
| SOT23-6 | 200 |

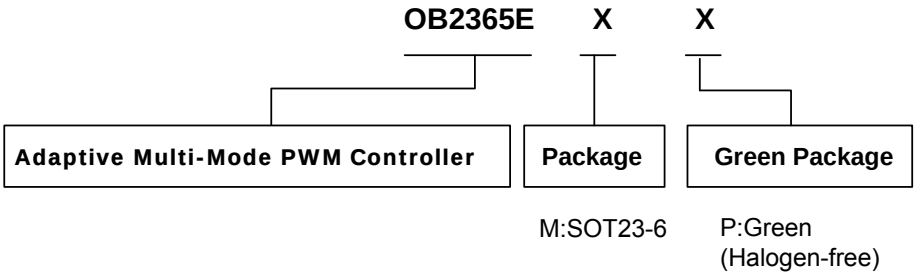
### Recommended operating condition

| Symbol | Parameter | Range |
|---|---|---|
| VCC | VCC Supply Voltage | 12 to 26V |

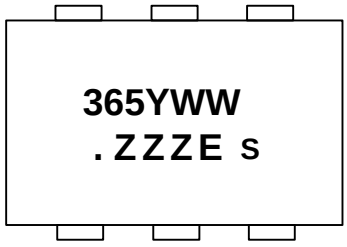
### Absolute Maximum Ratings

| Parameter | Value |
|---|---|
| VCC DC Supply Voltage | 29.5V |
| FB Input Voltage | -0.3 to 7V |
| CS Input Voltage | -0.3 to 7V |
| DEM Input Voltage | -0.3 to 7V |
| Min/Max Operating Junction Temperature TJ | -40 to 150 ℃ |
| Operating Ambient Temperature $T_A$ | -40 to 85 ℃ |
| Min/Max Storage Temperature Tstg | -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.




### Marking Information

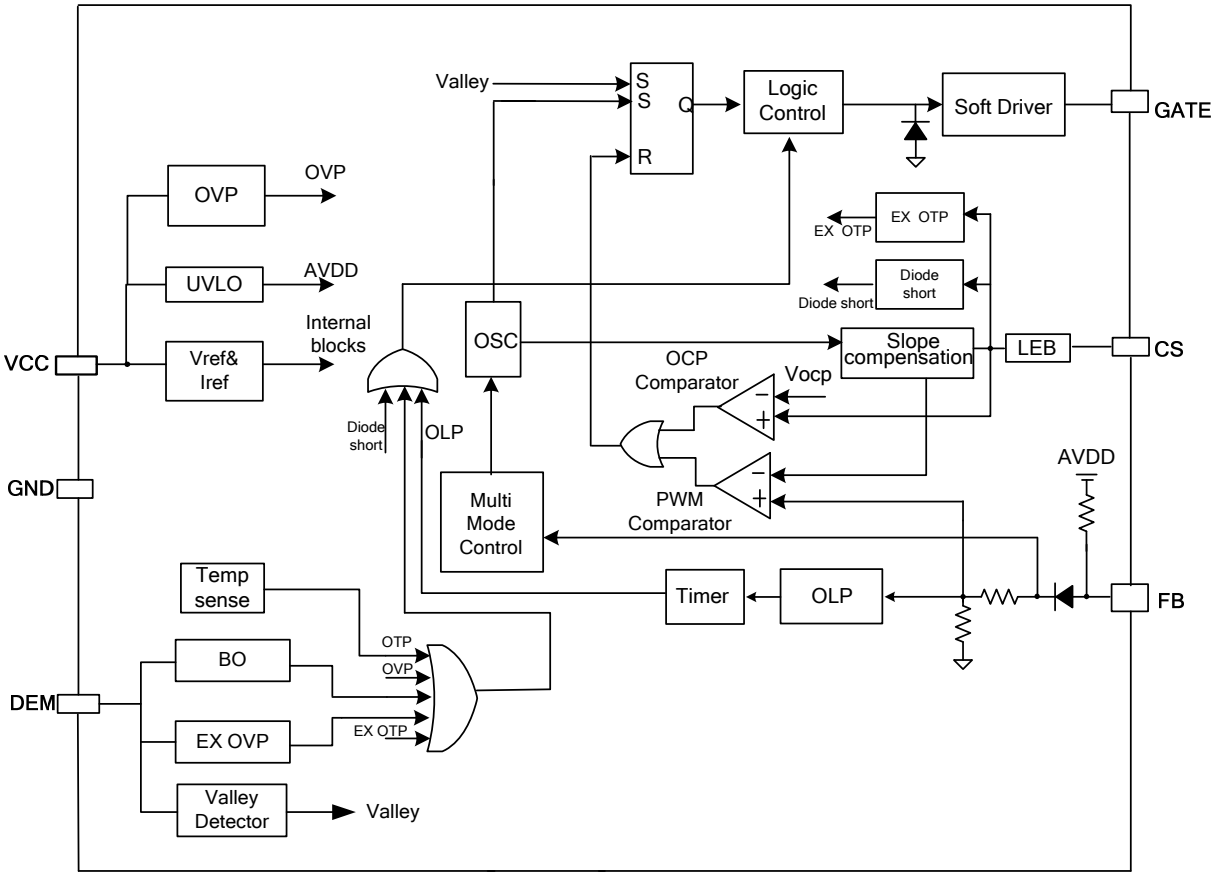



Y:Year Code
WW:Week Code(01-52)
ZZZ: Lot code
E: Character code
S: Internal code

## TERMINAL ASSIGNMENTS

| Pin Name | I/O | Description |
|---|---|---|
| VCC | P | Power Supply |
| CS | I | Current sense input. This pin is also connected to an auxiliary winding of the PWM transformer through a NTC resistor and a diode for over temperature protection. |
| Gate | O | Totem-pole gate driver output for power MOSFET |
| GND | P | Ground |
| DEM | I | Multiple functions pin. Connecting two resistors from Vaux to ground can adjust output OVP trigger voltage, Brown-in/Brown-out trigger current and detect transformer core demagnetization. |
| FB | I | Feedback input pin. The PWM duty cycle is determined by voltage level into this pin and the current-sense signal at Pin CS. |

## FUNCTIONAL BLOCK DIAGRAM



## ELECTRICAL CHARACTERISTICS

($T_A$ = 25℃, VCC=18V, unless otherwise noted)

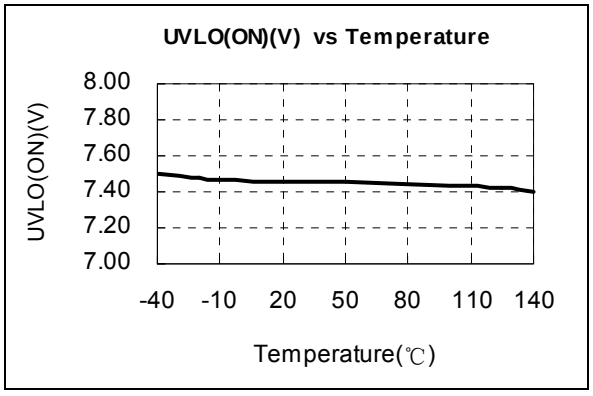
| Symbol | Parameter | Test Conditions | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| **Supply Voltage (VDD)** | | | | | | |
| Istartup | VCC Start up Current | VCC=UVLO(OFF)-1V, measure leakage current into VCC | | 2 | 5 | uA |
| I_VCC_Operation | Operation Current | VDD=18V,CS=4V, FB=3.5V,measure I(VCC) | | 2 | 3 | mA |
| I_VCC_Burst | Burst Current | CS=0V,FB=0.5V, measure I(VCC) | | 0.3 | 0.5 | mA |
| UVLO(ON) | VCC Under Voltage Lockout Enter | | 6.8 | 7.3 | 7.8 | V |
| UVLO(OFF) | VCC Under Voltage Lockout Exit (Recovery) | | 16 | 17 | 18 | V |
| Vpull-up | Pull-up PMOS active | | | 10 | | V |
| OVP | VCC Over Voltage Protection threshold voltage | FB=3V,CS=0V. Slowly ramp VCC, until no gate switching. | 26.5 | 28 | 29.5 | V |
| **Feedback Input Section(FB Pin)** | | | | | | |
| $V_{FB}$ Open | $V_{FB}$ Open Loop Voltage | | | 5.1 | | V |
| Avcs | PWM input gain ΔVFB/ΔVCS | | | 3.3 | | V/V |
| Maximum duty cycle | Max duty cycle @ VCC=18V,VFB=3V,VCS=0V | | 75 | 80 | 85 | % |
| Vref_green | The threshold enter green mode | | | 2.1 | | V |
| Vref_burst_H | The threshold exits burst mode | | | 1.33 | | V |
| Vref_burst_L | The threshold enters burst mode | | | 1.23 | | V |
| $I_{FB}$_Short | FB pin short circuit current | Short FB pin to GND and measure current | | 0.16 | | mA |
| $V_{TH}$_OLP | Open loop protection, FB Threshold Voltage | | | 4.4 | | V |
| Td_OLP | Open loop protection, Debounce Time | | | 60 | | ms |
| $Z_{FB}$_IN | Input Impedance | | | 30 | | KΩ |
| **Current Sense Input(CS Pin)** | | | | | | |
| SST_CS | Soft start time for CS peak | | | 2.5 | | ms |
| T_blanking | Leading edge blanking time | | | 330 | | ns |
| Td_OC | Over Current Detection and Control Delay | From Over Current Occurs till the Gate driver output start to turn off | | 80 | | ns |
| $V_{TH}$_OC | Internal Current Limiting Threshold Voltage with zero duty cycle | | | 0.5 | | V |
| $V_{TH}$_OC_Clamp | OCP CS voltage clamper | | | 0.72 | | V |
| $V_{TH}$_OTP (Note1) | CS pin external OTP threshold | | 0.28 | 0.30 | 0.32 | V |
| TD_OTP (Note1) | External OTP debounce time | FB > Vref_burst_H | | 60 | | ms |
| **DEM pin** | | | | | | |
| Ibrown-in | Brown-in threshold current | | 100 | 107 | 114 | uA |

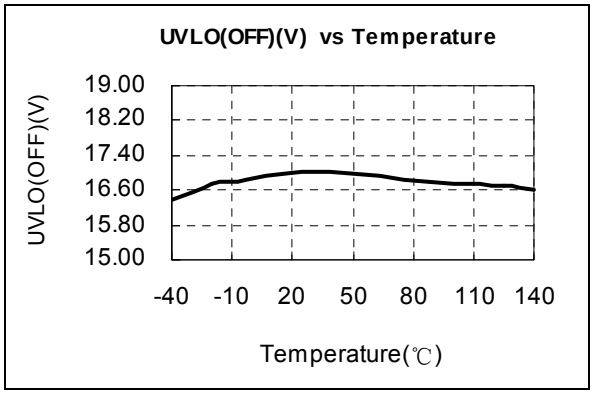
| | | | | | | |
|---|---|---|---|---|---|---|
| Ibrown-out | Brown-out threshold current | | 95 | 100 | 105 | uA |
| Td_BO | Brown-out protection, Debounce Time | | | 30 | | ms |
| Voutput_ovp | Voltage threshold for adjustable output OVP | | 2.85 | 3 | 3.15 | V |
| Td_output_ovp | Output OVP debounce time | | | 6 | | Cycles |
| **In-chip OTP** | | | | | | |
| OTP enter | | | | 150 | | ℃ |
| OTP exit | | | | 120 | | ℃ |
| **Oscillator** | | | | | | |
| Fosc_max_QR | Average max clamp oscillation frequency in QR mode | VDD=15V, FB=3V, | | 77 | | KHz |
| ∆f_OSC_max_QR | Max clamp oscillation frequency jittering | | | ±7 | | % |
| Fosc_min_CCM | Min clamp oscillation frequency in CCM mode | VDD=15V,FB=3V, | | 65 | | KHz |
| ∆f_OSC_CCM | Min clamp oscillation frequency jittering | | | ±7 | | % |
| F_shuffling | Shuffling frequency | | | 240 | | Hz |
| ∆f_Temp | Frequency Temperature Stability | | | 1 | | % |
| ∆f_VCC | Frequency Voltage Stability | | | 1 | | % |
| F_Burst | Burst Mode Switch Frequency | | | 23 | | KHz |
| **Gate driver** | | | | | | |
| VOL | Output low level @ VDD=18V, Io=5mA | | | | 1 | V |
| VOH | Output high level @ VCC=18V, Io=20mA | | 6 | | | V |
| V_clamping | Output clamp voltage | | | 11 | | V |
| T_r | Output rising time 1.2V ~ 10.0V @ CL=2000pF | | | 250 | | ns |
| T_f | Output falling time 10.0V ~ 1.2V @ CL=2000pF | | | 60 | | ns |

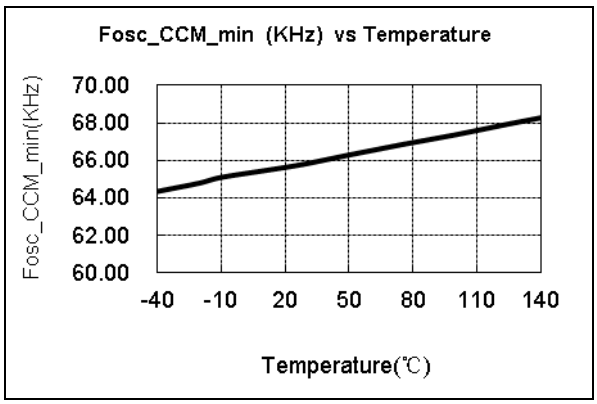
Note1: In burst mode output OTP is disable.

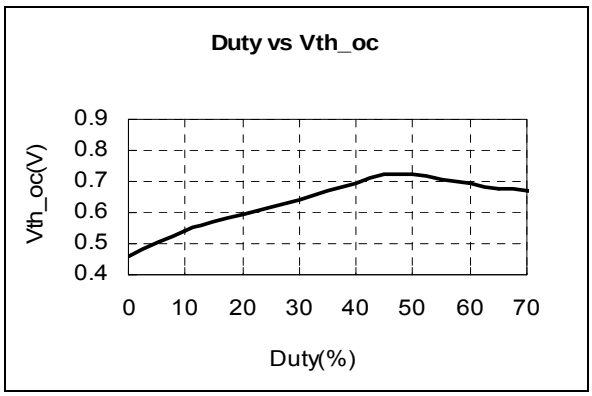
## CHARACTERIZATION PLOTS

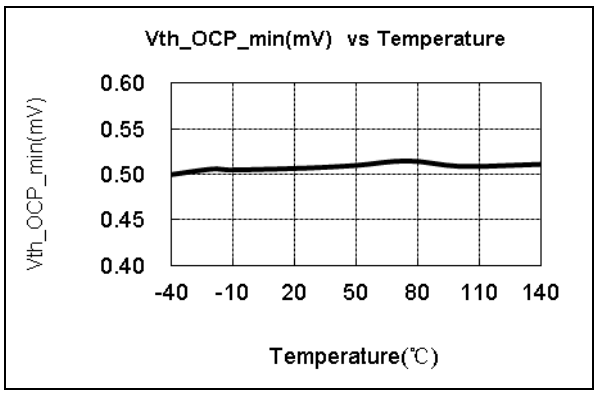
VDD = 18V, TA = 25℃ condition applies if not otherwise noted.

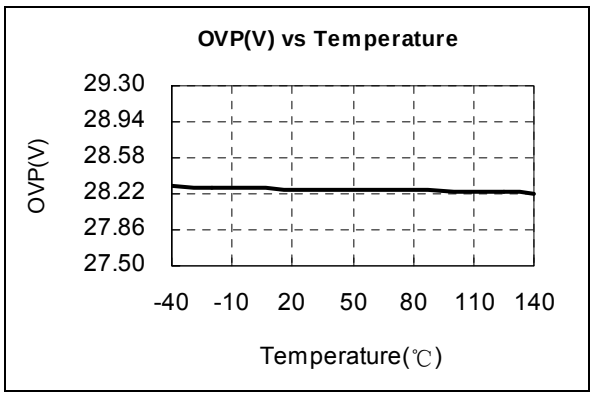


## OPERATION DESCRIPTION

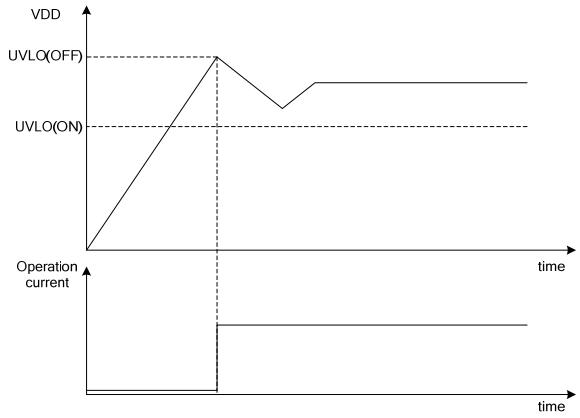
OB2365E is a highly integrated current mode PWM control IC optimized for high performance, low standby power and cost effective offline flyback converter applications. The 'extended burst mode' control greatly reduces the standby power consumption and helps the design easier to meet the international power conservation requirements.

### Startup Current and Start up Control

Startup current of OB2365E is designed to be very low 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 yet achieve a reliable startup in application.

### Operating Current

The Operating current of OB2365E is low at 2mA (typical). Good efficiency is achieved with OB2365E low operation current together with the 'extended burst mode' control features.

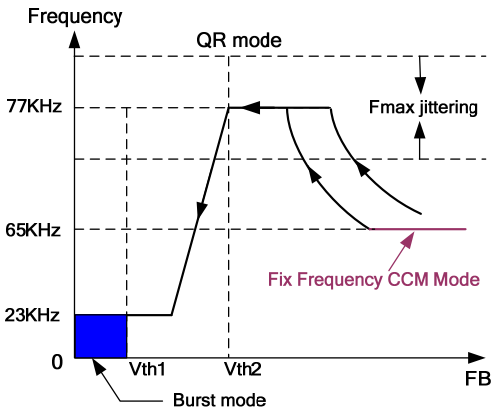



### Soft Start

OB2365E features an internal 2.5ms (typical) soft start to soften the electrical stress occurring in the power supply during startup. It is activated during the power on sequence. As soon as VCC reaches UVLO(OFF), the CS peak voltage is gradually increased from 0.05V to the maximum level. Every restart up is followed by a soft start.

### Multi Mode Operation for High Efficiency

OB2365E is a multi-mode QR/PWM controller. The controller changes the mode of operation according to line voltage and load conditions.




At full load conditions, there are two situations: firstly, if the system input is in low line input range, the IC operates in 65K fixed frequency CCM mode. Thus, small size transformer can be used with high power conversion efficiency. Secondly, if the system input is in high line input range, the IC operates in QR mode. In this way, high power conversion efficiency can be achieved in the universal input range when system is at full loading conditions.

At normal operating conditions (Vth2<VFB), the system operates in QR mode. The frequency varies depending on the line voltage and the load conditions. Therefore, the system may actually work in DCM when the average 77KHz frequency clamping is reached.

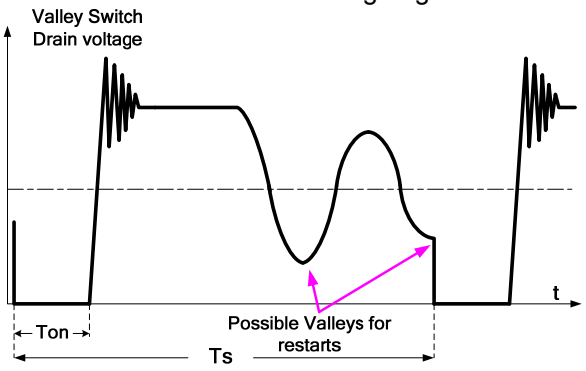
At light load conditions (Vth1<VFB<Vth2), the system operates in PFM (pulse frequency modulation) mode for high power conversion efficiency. Generally, in flyback converter, the decreasing of load results in voltage level decreasing at FB pin. The controller monitors the voltage level at FB and control the switching frequency. However, the valley switching characteristic is still preserved in PFM mode. That is, when load decreases, the system automatically skip more and more valleys and the switching frequency is thus reduced. In such way, a smooth frequency fold-back is realized and high power conversion efficiency is achieved.

At no load or very light load conditions (VFB<Vth1), the system operates in On-Bright's proprietary "extended burst mode". In the extended burst mode, the switching frequency at below 23KHz is minimized to avoid audio noise during operation.

### Demagnetization Detection

The transformer core demagnetization is detected by monitoring the voltage activity on the auxiliary windings through DEM pin. This voltage features a flyback polarity. After the on time (determined by the CS voltage and FB voltage), the switch is off and the flyback stroke starts. After the flyback stroke, the drain voltage shows an oscillation with a frequency of approximately $1/2\pi\sqrt{L_pC_d}$, where $L_p$ is the primary self inductance of primary winding of the transformer and $C_d$ is the capacitance on the drain node.

The typical detection level is fixed at -50mV at the DEM pin. Demagnetization is recognized by detection of a possible "valley" when the voltage at DEM is below -50mV in falling edge.




### Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting is offered in OB2365E current mode PWM control. 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 internal power MOSFET on state due to snubber diode reverse recovery and surge gate current of power MOSFET. The current limiting comparator is disabled and cannot turn off the internal power MOSFET during the blanking period. The PWM duty cycle is determined by the current sense input voltage and the FB input voltage.

### Internal Synchronized Slope Compensation

Built-in slope compensation circuit adds voltage ramp into the current sense input voltage for PWM generation. This greatly improves the close loop stability at CCM and prevents the sub-harmonic oscillation and thus reduces the output ripple voltage.

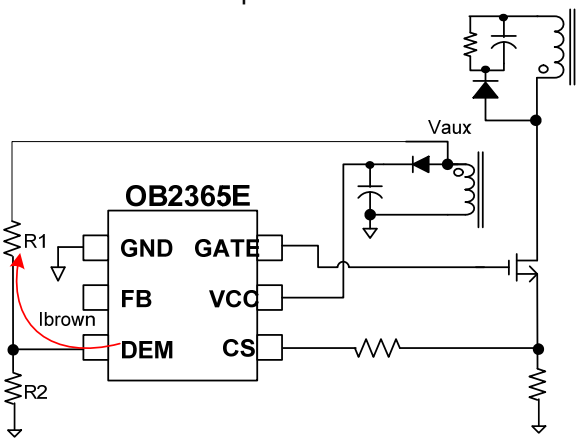
### Driver

The power MOSFET is driven by a dedicated gate driver for power switch control. Too weak the gate driver strength results in higher conduction and switch loss of MOSFET while too strong gate driver strength results the compromise of EMI.

A good tradeoff is achieved through the built-in totem pole gate design with right output strength and dead time control. The low idle loss and good EMI system design is easier to achieve with this dedicated control scheme.

### Multiple Functions of Brown-in/Brown-out and Output OVP

When the power MOSFET is turn on, the voltage on auxiliary windings is negative which make our Brown-in/Brown-out protection feasible.




$$I_{AUX} = \frac{0.1}{R2} + \frac{0.1 - V_{AUX}}{R1}$$

R1: The resistor connected from DEM to AUX.

R2: The resistor connected from DEM to ground.

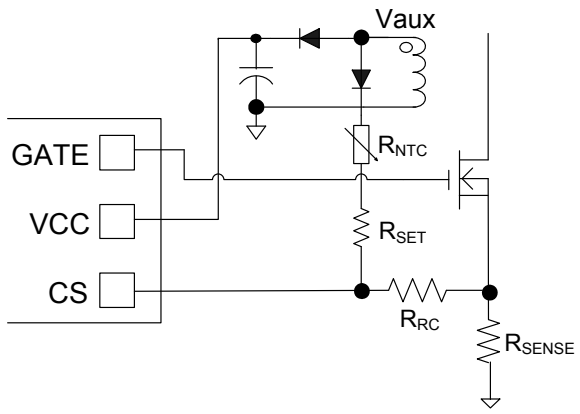
When system starts up, if $I_{AUX} < I_{brown\_in}$, Brown-in auto-recovery protection is triggered after 2 Gate cycles debounce. When the system enters the normal operation mode, if $I_{AUX} < I_{brown\_out}$, Brown-out auto-recovery protection is triggered after 30ms debounce.

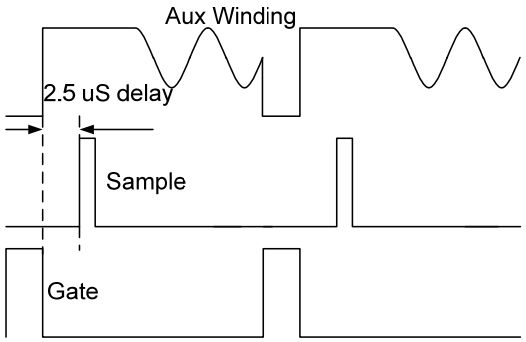
For output OVP detection, when Gate is off, $V_{DEM}$ is equal to $V_{AUX}$*R2/(R1+R2). If $V_{DEM}$ is larger than 3V (typical), OVP auto-recovery protection is triggered after 6 Gate cycles debounce. By selecting proper R1 and R2 resistance, output OVP level can be programmed.

$$V_{AUX} = \frac{3*(R1+R2)}{R2}$$

**Output Over Temperature Protection**

An output over voltage protection is implemented in the OB2365E by sensing the auxiliary voltage:




The auxiliary winding voltage is a well-defined replica of the output voltage. The OTP works by sampling the plateau voltage at CS pin during the flyback phase. OB2365E can sample this flat voltage level after a delay time to perform over temperature protection. This delay time is used to ignore the voltage ringing from leakage inductance of PWM transformer.

The sampling voltage level is compared with internal threshold voltage 0.3V. If the sampling voltage exceeds the OTP trip level, an internal counter starts counting subsequent OTP events. If OTP events are detected in consecutive 60mS, the controller assumes a true OTP and the system enters into auto recovery.

**Protection Controls**

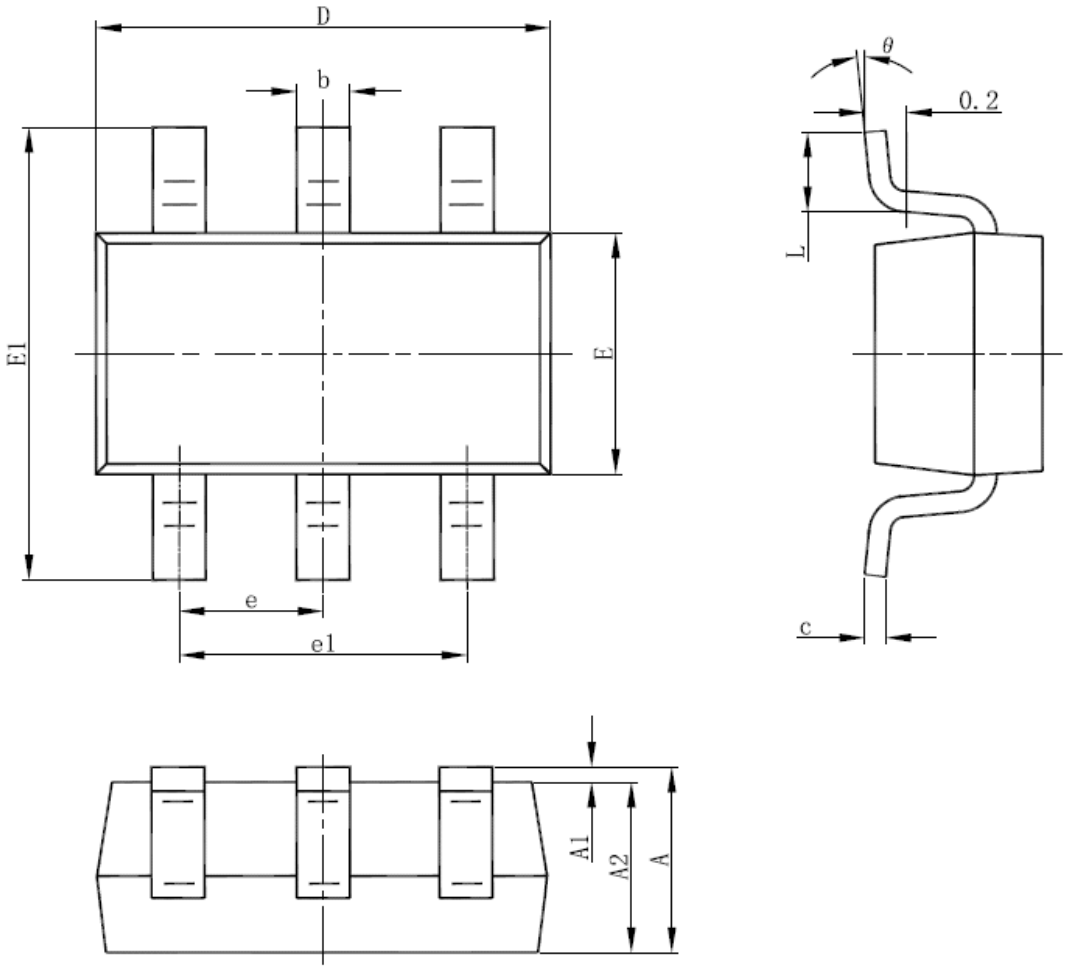
Good power supply system reliability is achieved with auto-recovery protection features including Cycle-by-Cycle current limiting (OCP), Under Voltage Lockout on VDD (UVLO), Over Temperature Protection (OTP), Brownout Protection, VCC and output Over Voltage Protection (OVP).

With On-Bright proprietary technology, the OCP is line voltage compensated to achieve constant output power limit over the universal input voltage range.

At overload condition when FB input voltage exceeds power limit threshold value for more than Td_OLP, control circuit reacts to shut down the converter. It restarts when VDD voltage drops below UVLO limit.

## PACKAGE MECHANICAL DATA

### SOT-23-6L PACKAGE OUTLINE DIMENSIONS




| 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° |

## IMPORTANT NOTICE

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On-Bright Electronics Corp. reserves the right to make corrections, modifications, enhancements, improvements and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete.

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