

### GENERAL DESCRIPTION

OB8652x is a high precision offline LED lighting power switch with a GaN FET integrated. It can achieve low system cost for an isolated lighting application by primary side control in a single stage converter. It significantly simplifies the LED lighting system design by eliminating the secondary side feedback components and the opto-coupler. System cost can be reduced by improving frequency because of build-in GaN FET.

Quasi-resonant (QR) operation greatly improves the system efficiency. The advanced HV start-up technology is used to meet the start-up time and low standby power requirement. The constant output current is compensated for tolerance of transformer inductance variation.

OB8652x offers comprehensive protection coverage with auto-recovery features including LED open loop protection, LED short circuit protection, cycle-by-cycle current limiting, built-in leading edge blanking, Winding/diode short protection, VDD over voltage protection, VDD under voltage lockout (UVLO), etc.

OB8652x is offered in EASOP6/SOP8/LSOP8-7 package.

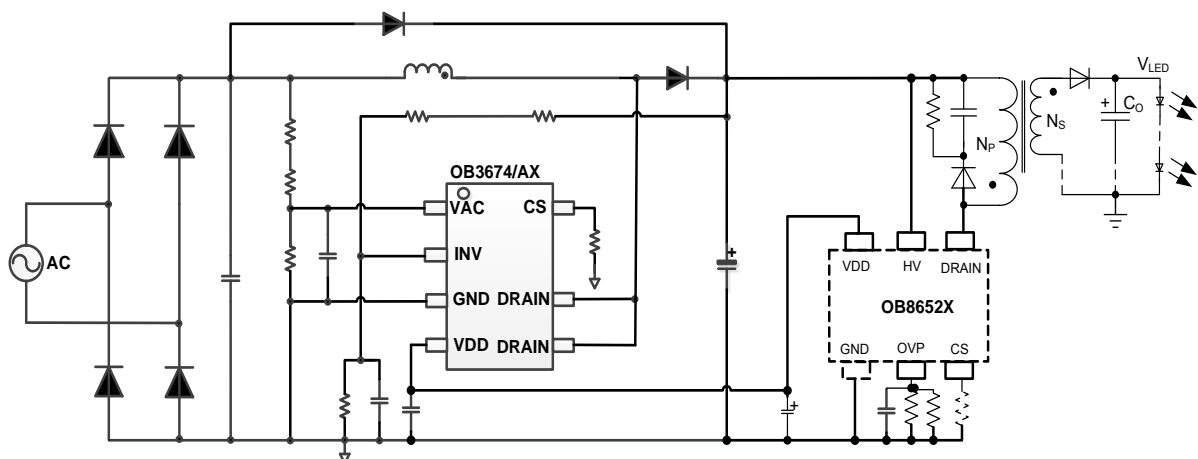
### FEATURES

- Build-in GaN FET
- Low system cost and high efficiency
- High precision constant current regulation
- HV start-up and low standby power
- Low PF PSR with quasi-resonant (QR) operation
- Programmable CC regulation
- LED short circuit protection
- LED open loop protection
- Winding/diode short protection
- Cycle-by-cycle current limiting
- Built-in leading edge blanking (LEB)
- VDD under voltage lockout with hysteresis
- VDD over voltage protection
- Power up to 100W with PFC input voltage
- Thermal fold-back control

### APPLICATIONS

- LED lighting

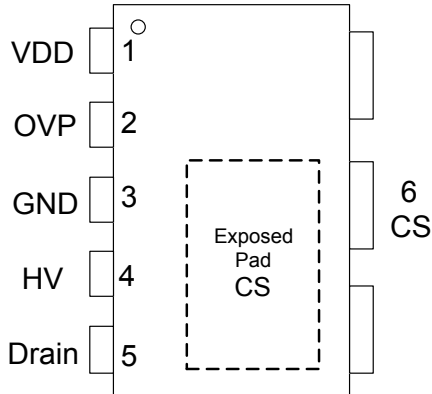
### TYPICAL APPLICATION



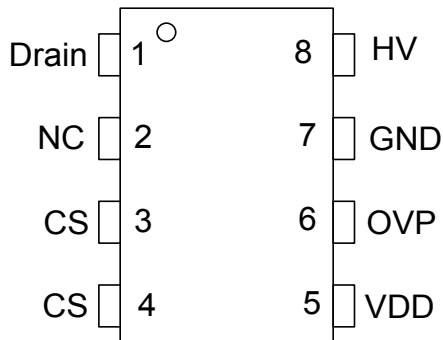
### GENERAL INFORMATION

#### Pin Configuration

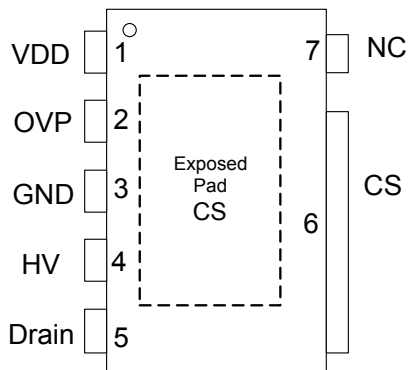
The pin map is shown as below for EASOP6.



The pin map is shown as below for SOP8.



The pin map is shown as below for LSOP8-7.



#### Ordering Information

| Part Number   | Description                   |
|---------------|-------------------------------|
| OB8652VCQP-V  | EASOP6, Halogen-free in Tube  |
| OB8652VCQPA-V | EASOP6, Halogen-free in T&R   |
| OB8652UCP-H   | SOP8, Halogen-free in Tube    |
| OB8652UCPA-H  | SOP8, Halogen-free in T&R     |
| OB8652CCQP-H  | EASOP6, Halogen-free in Tube  |
| OB8652CCQPA-H | EASOP6, Halogen-free in T&R   |
| OB8652DIEP-V  | LSOP8-7, Halogen-free in Tube |
| OB8652DIEPA-V | LSOP8-7, Halogen-free in T&R  |
| OB8652DCQP-V  | EASOP6, Halogen-free in Tube  |
| OB8652DCQPA-V | EASOP6, Halogen-free in T&R   |

**Note:** All Devices are offered in Halogen-free Package if not otherwise noted.

#### Package Dissipation Rating

| Package | R <sub>θJA</sub> (°C/W) | R <sub>θJC</sub> (°C/W) |
|---------|-------------------------|-------------------------|
| EASOP6  | 68                      | 8                       |
| SOP8    | 90                      | 25                      |
| LSOP8-7 | 54                      | 5                       |

#### Recommended Operating Ratings

| Parameter         | Value |
|-------------------|-------|
| Body Surface Max. | 135°C |

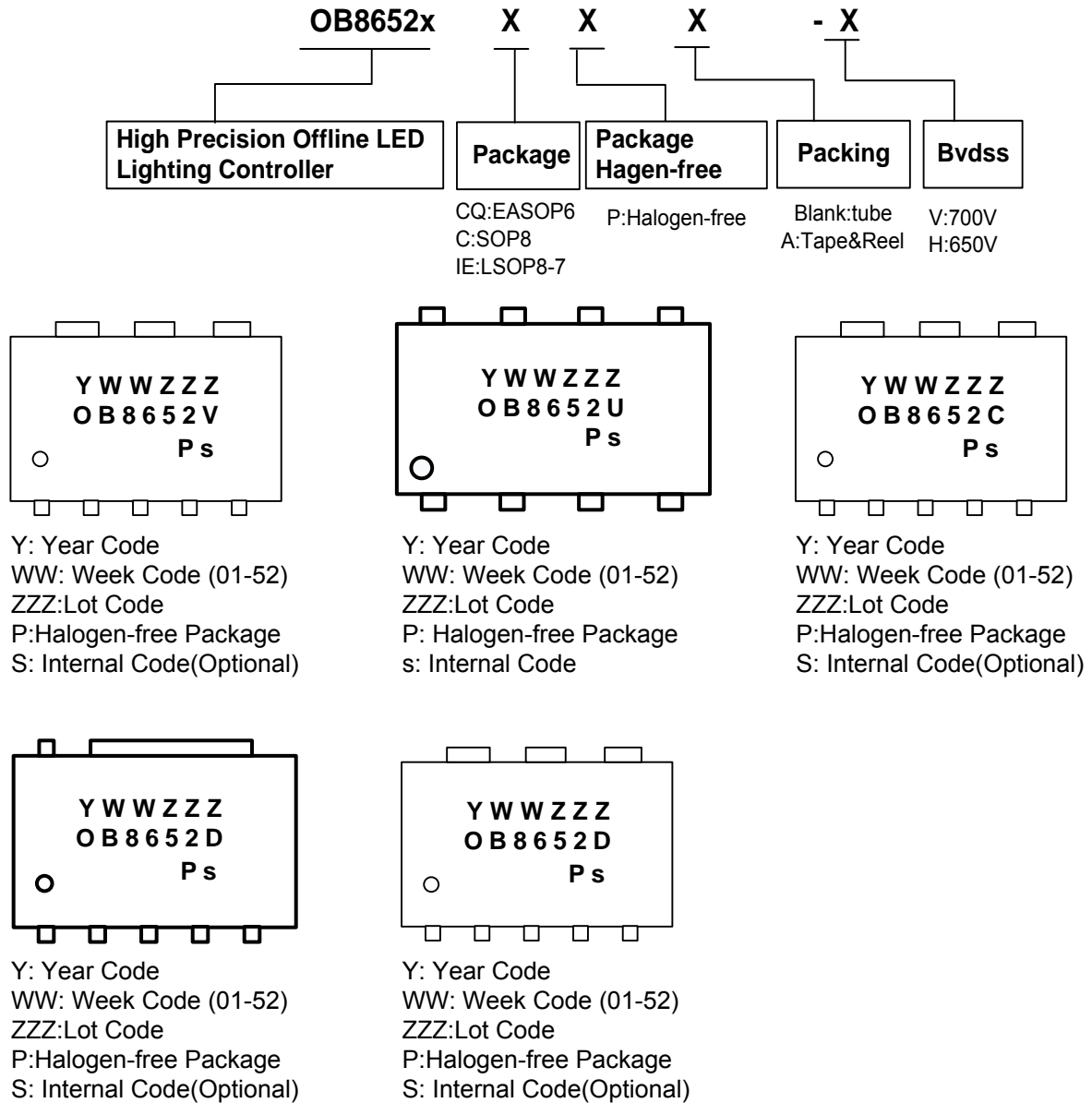
#### Absolute Maximum Ratings

| Parameter   | Value                         |
|---|-------------------------------|
| VDD Voltage   | -0.3 to 35V                   |
| OVP Voltage   | -0.3 to 7V                    |
| CS Input Voltage                                      | -0.3 to 7V                    |
| HV Input Voltage                                      | -0.3 to 700V                  |
| Drain Voltage   | -0.3 to BV <sub>dss</sub>     |
| Pulsed Drain Voltage                                  | -0.3 to 750V <sup>Note2</sup> |
| Min/Max Operating Junction Temperature T <sub>J</sub> | -40 to 150 °C                 |
| Min/Max Storage Temperature T <sub>stg</sub>          | -55 to 150 °C                 |
| Lead Temperature (Soldering, 10secs)                  | 260 °C                        |

**Note1:** 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.

**Note2:** The pulsed Drain voltage is relaxed to 750V for surge ratings during repetitive events that are <300ns.

### Marking Information



**TERMINAL ASSIGNMENTS for EASOP6**

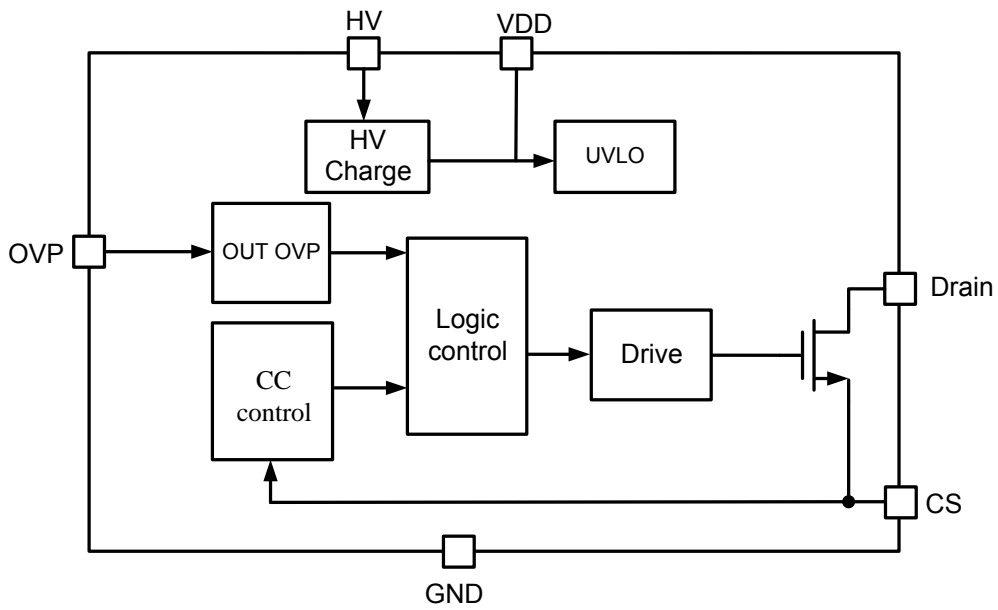
| Pin Num     | Pin Name | I/O | Description                     |
|-------------|----------|-----|---------------------------------|
| 1           | VDD      | P   | Power supply input              |
| 2           | OVP      | I/O | Over voltage protection setting |
| 3           | GND      | P   | Power Ground                    |
| 4           | HV       | P   | HV power supply                 |
| 5           | Drain    | P   | GaN Drain terminal              |
| 6           | CS       | I/O | Current sense input.            |
| Exposed Pad | CS       | I/O | Current sense input.            |

**TERMINAL ASSIGNMENTS for SOP8**

| Pin Num | Pin Name | I/O | Description                     |
|---------|----------|-----|---------------------------------|
| 1       | Drain    | P   | GaN Drain terminal              |
| 2       | NC       |     |                                 |
| 3/4     | CS       | I/O | Current sense input.            |
| 5       | VDD      | P   | Power supply input              |
| 6       | OVP      | I/O | Over voltage protection setting |
| 7       | GND      | P   | Power Ground                    |
| 8       | HV       | P   | HV power supply                 |

**TERMINAL ASSIGNMENTS for LSOP8-7**

| Pin Num     | Pin Name | I/O | Description                     |
|-------------|----------|-----|---------------------------------|
| 1           | VDD      | P   | Power supply input              |
| 2           | OVP      | I/O | Over voltage protection setting |
| 3           | GND      | P   | Power Ground                    |
| 4           | HV       | P   | HV power supply                 |
| 5           | Drain    | P   | GaN Drain terminal              |
| 6           | CS       | I/O | Current sense input.            |
| 7           | NC       |     |                                 |
| Exposed Pad | CS       | I/O | Current sense input.            |

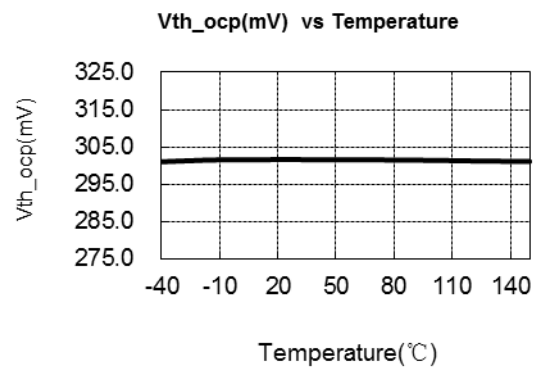
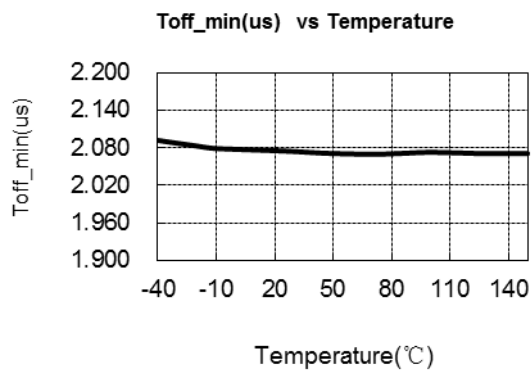
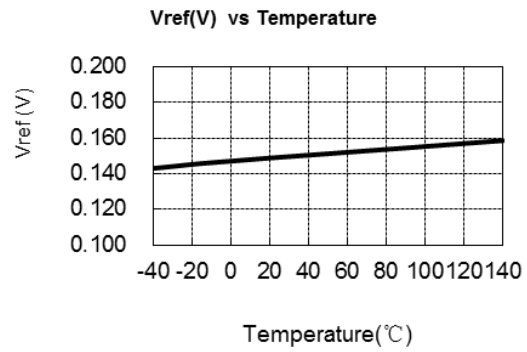
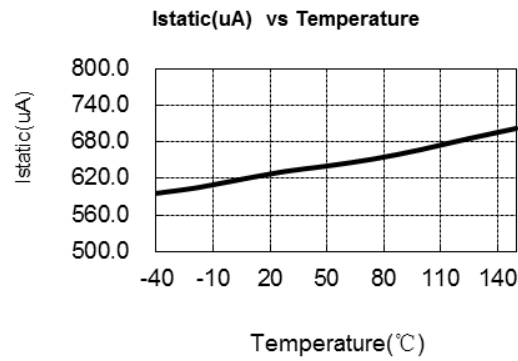
**BLOCK DIAGRAM**


### ELECTRICAL CHARACTERISTICS

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

| Symbol                              | Parameter                         | Test Conditions                   | Min   | Typ.  | Max   | Unit |
|-------------------------------------|-----------------------------------|-----------------------------------|-------|-------|-------|------|
| <b>Supply Voltage (VDD) Section</b> |                                   |                                   |       |       |       |      |
| Istatic                             | Static current                    | no loading                        |       | 0.7   |       | mA   |
| UVLO(OFF)                           | VDD under voltage lockout exit    |                                   |       | 14    |       | V    |
| UVLO(ON)                            | VDD under voltage lockout on      |                                   |       | 5.5   |       | V    |
| VDD_OVP                             | VDD Over Voltage Protection       |                                   |       | 27    |       | V    |
| VDD_CLAMP                           | VDD clamp voltage                 |                                   |       | 26    |       | V    |
| <b>Current Sense Input Section</b>  |                                   |                                   |       |       |       |      |
| TLEB                                | LEB time                          |                                   |       | 200   |       | ns   |
| Vth_ocp                             | Over Current Threshold            |                                   |       | 300   |       | mV   |
| <b>OVP Section</b>                  |                                   |                                   |       |       |       |      |
| Vo_ovp                              | Vout voltage when OVP             | Rovp=18K ohm,<br>Tdem>2us, N=3.75 |       | 48    |       | V    |
| <b>QR Section</b>                   |                                   |                                   |       |       |       |      |
| Fmax                                | Maximum Clamping Frequency        |                                   |       | 250   |       | KHz  |
| Toff_max                            | Maximum Off Time                  |                                   |       | 540   |       | us   |
| Toff_min                            | Minimum Off Time                  |                                   |       | 2     |       | us   |
| Ton_max                             | Maximum On Time                   |                                   |       | 5     |       | us   |
| <b>Error Amplifier Section</b>      |                                   |                                   |       |       |       |      |
| Vref                                | Error Amplifier Reference Voltage |                                   | 0.147 | 0.150 | 0.153 | V    |
| <b>OTP Section</b>                  |                                   |                                   |       |       |       |      |
| T <sub>thermal</sub>                | Thermal regulation threshold      |                                   |       | 135   |       | °C   |

| Product \ Parameter | BVdss(V)<br>Drain-Source Breakdown Voltage |      |     | Id (A)<br>Drain-Source Peak Current |      |      |
|---------------------|--|------|-----|-------------------------------------|------|------|
|                     | Min  | Typ. | Max | Min                                 | Typ. | Max  |
| OB8652VCQP-V        | 700  |      |     |                                     |      | 1.2  |
| OB8652UCP-H         | 650  |      |     |                                     |      | 0.7  |
| OB8652CCQP-H        | 650  |      |     |                                     |      | 1.75 |
| OB8652DIEP-V        | 700  |      |     |                                     |      | 2.6  |
| OB8652DCQP-V        | 700  |      |     |                                     |      | 2.6  |

**CHARACTERIZATION PLOTS**

### OPERATION DESCRIPTION

OB8652x is a primary-side-control fly-back PWM power switch specialized for LED lighting application with a GaN FET integrated. It operates in primary side sensing and regulation, thus opto-coupler and TL431 are not required. OB8652x works at Quasi-Resonant operation with maximum working frequency clamping, which can improve the efficiency of LED lighting system design.

#### Start up Control

OB8652x integrates HV startup circuit. When power on, HV startup circuit charges the capacitor connecting between VDD and ground from HV pin. When the VDD voltage is higher than UVLO(OFF), OB8652x is turned on. When the VDD voltage is lower than VDD\_LOW, OB8652x stops switching. At the startup, OB8652x operates at open loop and over-current protection is set cycle-by-cycle until close loop is built up.

#### LED Constant Current Regulation

The LED output current can be approximated as:

$$I_{LED} = \frac{N}{2} \cdot \frac{V_{ref}}{R_{CS}} \quad (1)$$

N — Turn ratio of primary side winding to secondary side winding.

Rcs — The sensing resistor connected between the GaN FET source and GND.

Vref — Internal reference voltage.

#### Current Sensing and Leading Edge Blanking

Cycle-by-Cycle current limiting (OCP) is offered in OB8652x. The switching current is detected by a sense resistor connected between the CS pin and GND. An internal leading edge blanking circuit chops off the sense voltage spike at initial GaN on state due to snubber diode reverse recovery. The current limit comparator is disabled at this blanking time and thus the initial GaN cannot be turned off during this blanking time.

#### VDD Over Voltage Protection

When VDD is higher than 27V (typical), VDD OVP protection is triggered and OB8652x stops switching. The fault condition can not be removed until the VDD is powered down.

#### Programmable LED Open Circuit Protection / OVP

The OB8652x provide programmable output over voltage protection. When LED string is open, output over voltage protection is triggered and OB8652x stops switching. The fault condition can not be removed until the VDD is powered down. The threshold voltage of OVP is set by a resistor Rovp connected between OVP pin and ground. The resistance is given by

$$R_{ovp} = \frac{N \cdot V_{o\_ovp} + 82.5V}{14.595mA} \quad (2)$$

Where N is the ratio of transformer between primary winding and secondary winding, Vo\_ovp is the output voltage when output is open. And the resistance range of Rovp should be 8K~20K for Vo\_ovp setting.

#### LED Short Circuit Protection

When LED string is short, LED short circuit protection is triggered and OB8652x stops switching. The fault condition can not be removed until the VDD is powered down.

#### Winding/diode short protection

When winding/diode is short, winding/diode short protection is triggered and OB8652x stops switching. The fault condition can not be removed until the VDD is powered down.

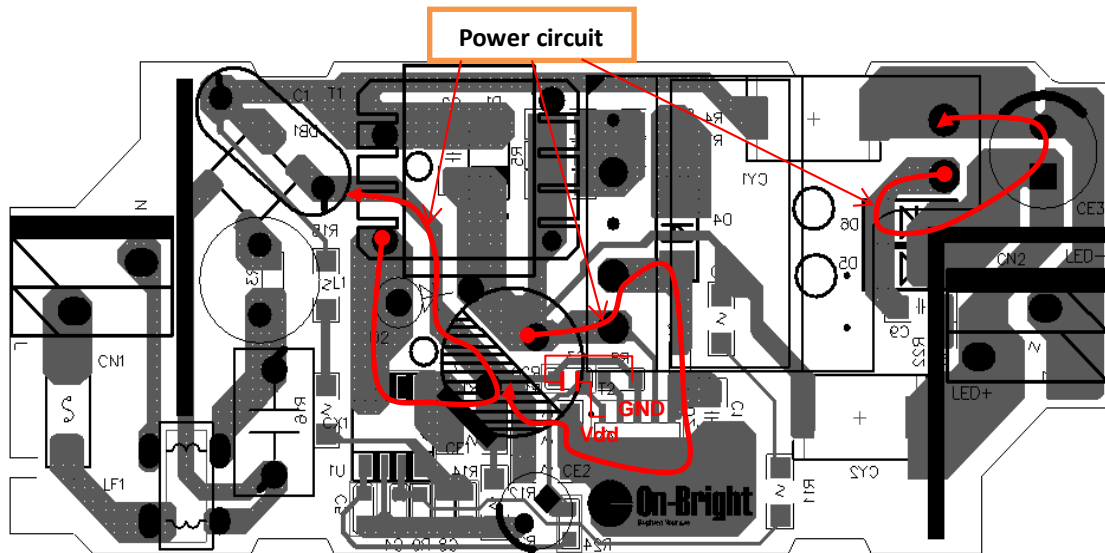
#### Thermal Fold-back Protection

OB8652x provides thermal fold-back function to control LED output current. When temperature is up to 135°C (typical) and the output current of system will be adjusted according to the sensed temperature. The output current will be reduce to about half of the setting value at 155°C (typical).



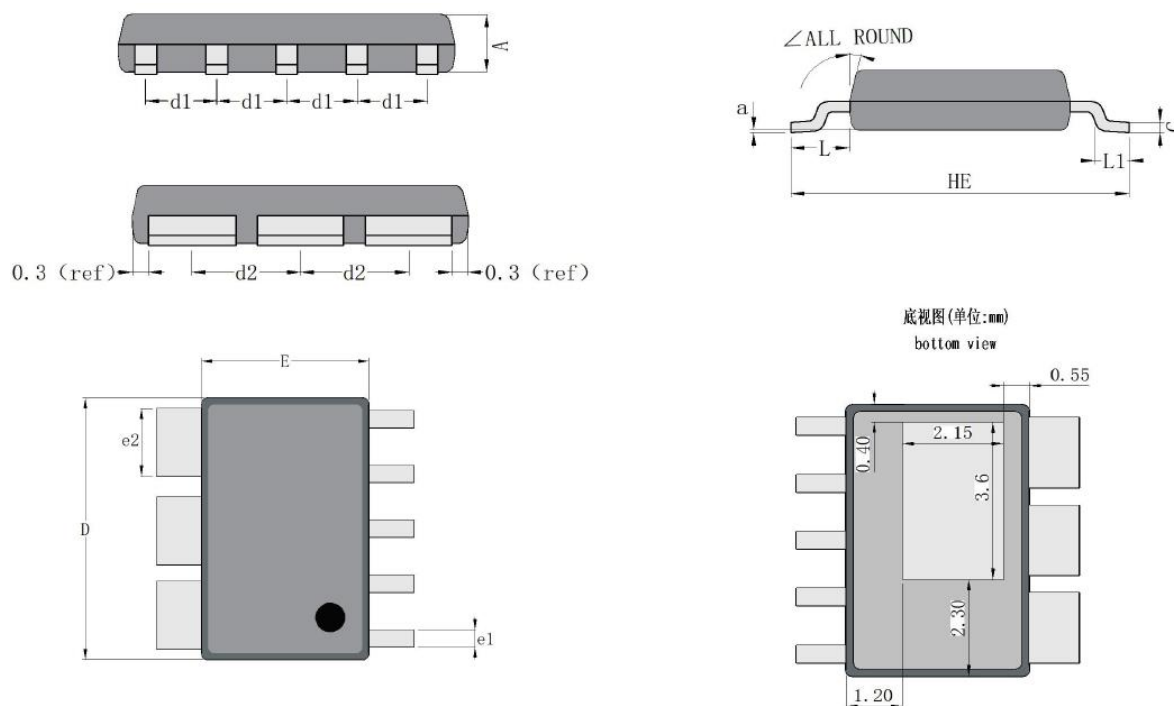
## Layout Consideration

- 1) As shown in the picture, the power loop should be as small as possible to reduce the high-frequency noise.
- 2) The capacitor should be placed to the nearest location between VDD and GND pins.
- 3) In order to reduce interference from power ground, The ground of CS resistor should be connected with the IC GND first, then tied together at negative pole of the input capacitor.



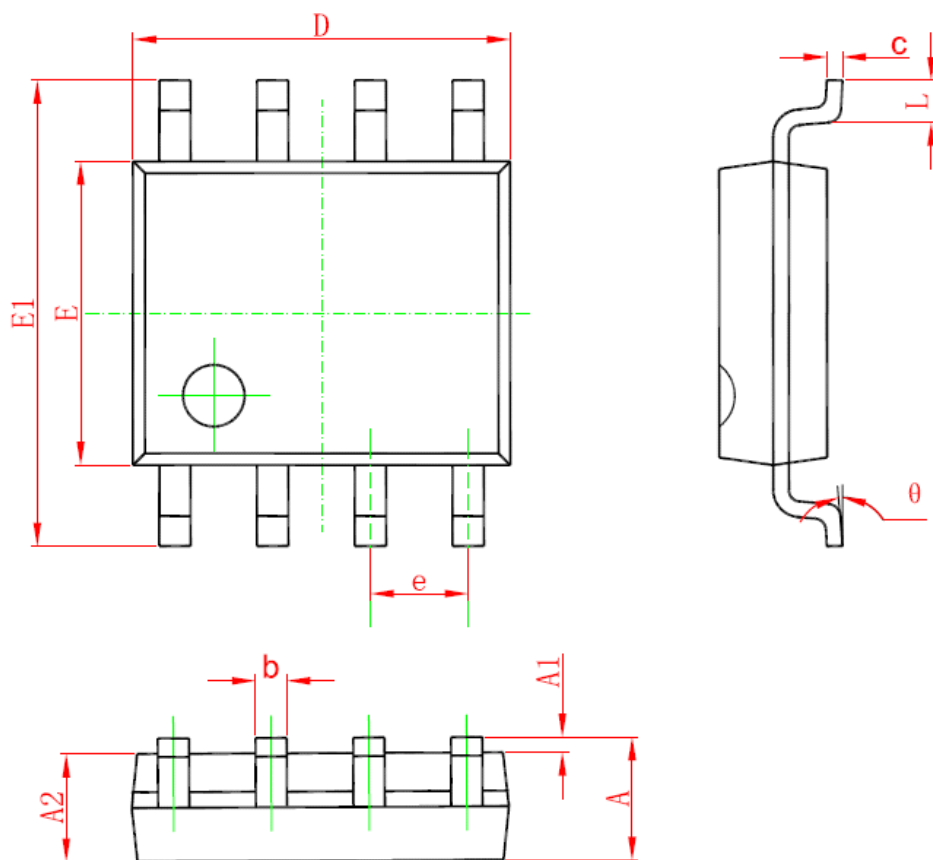
### PACKAGE MECHANICAL DATA

#### EASOP6



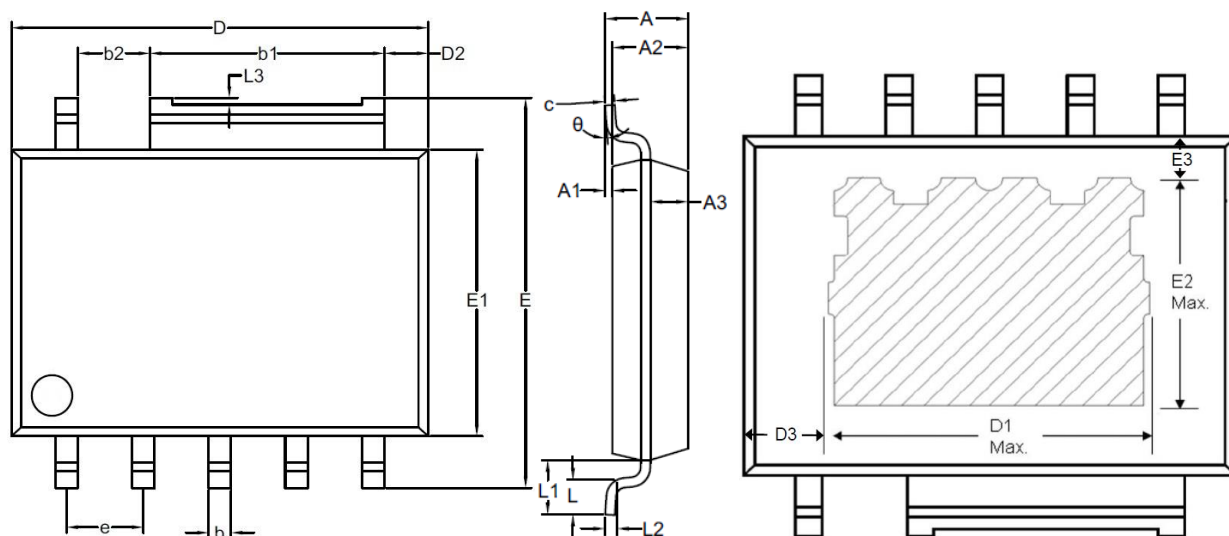
| Symbol | Dimensions In Millimeters |      | Dimensions In Inches |       |
|--------|---------------------------|------|----------------------|-------|
|        | Min                       | Max  | Min                  | Max   |
| A      | 1.05                      | 1.25 | 0.041                | 0.049 |
| C      | 0.15                      | 0.22 | 0.006                | 0.009 |
| D      | 6.00                      | 6.40 | 0.236                | 0.252 |
| E      | 3.70                      | 4.10 | 0.146                | 0.161 |
| HE     | 5.90                      | 6.10 | 0.232                | 0.240 |
| d1     | 1.25                      | 1.35 | 0.049                | 0.053 |
| d2     | 1.95                      | 2.05 | 0.077                | 0.081 |
| e1     | 0.35                      | 0.45 | 0.014                | 0.018 |
| e2     | 1.55                      | 1.65 | 0.061                | 0.065 |
| L      | 0.95                      | 1.15 | 0.037                | 0.045 |
| L1     | 0.40                      | 0.80 | 0.016                | 0.031 |
| a      | 0.20 (REF)                |      | 0.008 (REF)          |       |

## SOP8



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min                       | Max   | Min                  | Max   |
| A      | 1.350                     | 1.750 | 0.053                | 0.069 |
| A1     | 0.050                     | 0.250 | 0.002                | 0.010 |
| A2     | 1.250                     | 1.650 | 0.049                | 0.065 |
| b      | 0.310                     | 0.510 | 0.012                | 0.020 |
| c      | 0.100                     | 0.250 | 0.004                | 0.010 |
| D      | 4.700                     | 5.150 | 0.185                | 0.203 |
| E      | 3.700                     | 4.100 | 0.146                | 0.161 |
| E1     | 5.800                     | 6.200 | 0.228                | 0.244 |
| e      | 1.270 (BSC)               |       | 0.050 (BSC)          |       |
| L      | 0.400                     | 1.270 | 0.016                | 0.050 |
| θ      | 0°                        | 8°    | 0°                   | 8°    |

### LSOP8-7



| Symbol | Dimensions In Millimeters |       | Dimensions In Inches |       |
|--------|---------------------------|-------|----------------------|-------|
|        | Min                       | Max   | Min                  | Max   |
| A      | 1.60                      | 1.95  | 0.063                | 0.077 |
| A1     | 0.05                      | 0.15  | 0.002                | 0.006 |
| A2     | 1.50                      | 1.70  | 0.059                | 0.067 |
| A3     | 0.75                      | 0.85  | 0.030                | 0.033 |
| b      | 0.48                      | 0.56  | 0.019                | 0.022 |
| b1     | 5.18                      | 5.26  | 0.204                | 0.207 |
| b2     | 1.57                      | -     | 0.062                | -     |
| c      | 0.18                      | 0.25  | 0.007                | 0.010 |
| D      | 9.15                      | 9.35  | 0.360                | 0.368 |
| D1*    | -                         | 5.60  | -                    | 0.220 |
| D2     | 0.865                     | 1.085 | 0.034                | 0.043 |
| D3     | 1.73                      | 1.93  | 0.068                | 0.076 |
| E      | 8.55                      | 8.75  | 0.337                | 0.344 |
| E1     | 6.25                      | 6.45  | 0.246                | 0.254 |
| E2*    | -                         | 3.85  | -                    | 0.152 |
| E3     | 1.10                      | 1.30  | 0.043                | 0.051 |
| e      | 1.70 (BSC)                |       | 0.067 (BSC)          |       |
| L      | 0.69                      | 0.79  | 0.027                | 0.031 |
| L1     | 1.15 (REF)                |       | 0.045 (REF)          |       |
| L2     | 0.25 (REF)                |       | 0.010 (REF)          |       |
| L3     | -                         | 0.15  | -                    | 0.006 |
| θ      | 0°                        | 8°    | 0°                   | 8°    |

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