

## SYNCHRONOUS RECTIFIER CONTROLLER

### Description

The ZXGD3101 is intended to drive MOSFETS configured as ideal diode replacements. The device is comprised of a differential amplifier detector stage and high current driver. The detector monitors the reverse voltage of the MOSFET such that if body diode conduction occurs a positive voltage is applied to the MOSFET's Gate pin.

Once the positive voltage is applied to the Gate the MOSFET switches on allowing reverse current flow. The detectors' output voltage is then proportional to the MOSFET Drain-Source reverse voltage drop and this is applied to the Gate via the driver. This action provides a rapid turn off as current decays.

### Application

- Flyback Converters in:
  - Adaptors
  - LCD Monitors
  - Server PSU's
  - Set Top Boxes
- LLC Converter in:
  - High Power Adaptors
  - LCD TV
  - Street Lighting

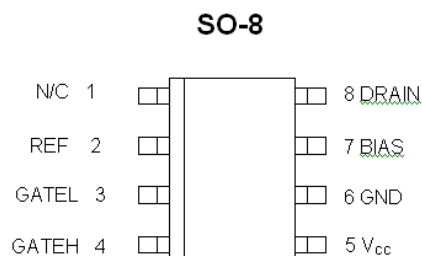
Refer to documents: AN54, AN69, DN90, DN91 and DN94 available from the website

### Features

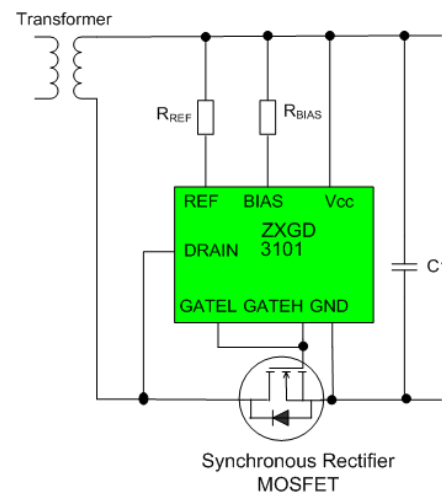
- Turn-off propagation delay 15ns and turn-off time 20ns.
- Suitable for Discontinuous Mode (DCM), Critical Conduction Mode (CrCM) and Continuous Mode (CCM) operation
- Compliant with Energy Star V2.0 and European Code of Conduct V3
- Halogen Free part
- 5-15V V<sub>CC</sub> range

### Mechanical Data

- Case: SO-8
- Marking Information: See Page 13



Pin out details



Typical Configuration

### Ordering Information

| Product      | Status | Package | Marking  | Reel size (inches) | Tape width (mm) | Quantity per reel |
|--------------|--------|---------|----------|--------------------|-----------------|-------------------|
| ZXGD3101N8TC | Active | SO-8    | ZXGD3101 | 13                 | 12              | 2500              |

**ZXGD3101N8**
**SYNCHRONOUS RECTIFIER CONTROLLER**
**Maximum Ratings**

| Parameter                                     | Symbol       | Limit              | Unit             |
|---|--------------|--------------------|------------------|
| Supply voltage (Note 1)                       | $V_{CC}$     | 15                 | V                |
| Continuous Drain pin voltage (Note 1)         | $V_D$        | -3 to 180          | V                |
| GATEH and GATEL output Voltage (Note 1)       | $V_G$        | -3 to $V_{CC} + 3$ | V                |
| Driver peak source current                    | $I_{SOURCE}$ | 4                  | A                |
| Driver peak sink current                      | $I_{SINK}$   | 7                  | A                |
| Reference current                             | $I_{REF}$    | 25                 | mA               |
| Bias voltage                                  | $V_{BIAS}$   | $V_{CC}$           | V                |
| Bias current                                  | $I_{BIAS}$   | 100                | mA               |
| Power dissipation at $T_A = 25^\circ\text{C}$ | $P_D$        | 490                | mW               |
| Operating junction temperature                | $T_J$        | -40 to +150        | $^\circ\text{C}$ |
| Storage temperature                           | $T_{STG}$    | -50 to +150        | $^\circ\text{C}$ |

**Thermal Characteristics**

| Parameter                    | Symbol          | Value | Unit               |
|------------------------------|-----------------|-------|--------------------|
| Junction to ambient (Note 2) | $R_{\theta JA}$ | 255   | $^\circ\text{C/W}$ |
| Junction to lead (Note 3)    | $R_{\theta LA}$ | 120   | $^\circ\text{C/W}$ |

**ESD Rating**

| Model      | Rating | Unit |
|------------|--------|------|
| Human Body | 4000   | V    |
| Machine    | 400    | V    |

Notes:

1. All voltages are relative to GND pin
2. Mounted on minimum 1oz weight copper on FR4 PCB in still air conditions.
3. Output Drivers - Junction to solder point at end of the lead 5 and 6

**SYNCHRONOUS RECTIFIER CONTROLLER**
**Electrical Characteristics** @T<sub>A</sub> = 25°C, V<sub>CC</sub> = 10V, R<sub>BIAS</sub> = 1.8kΩ, R<sub>REF</sub> = 3kΩ

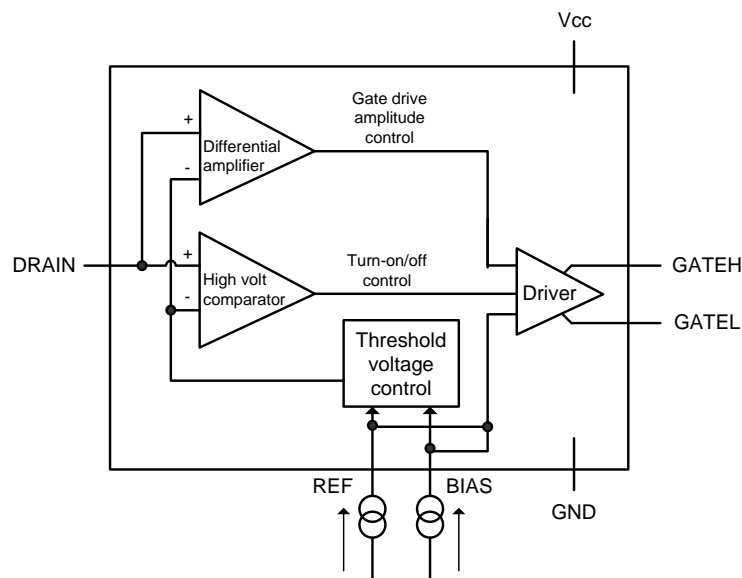
| Parameter                          | Symbol              | Conditions                              | Min. | Typ. | Max. | Unit |
|------------------------------------|---------------------|---|------|------|------|------|
| Input and supply characteristics   |                     |   |      |      |      |      |
| Operating current                  | I <sub>OP</sub>     | V <sub>DRAIN</sub> ≤ -200m V            | -    | 3    | -    | mA   |
|                                    |                     | V <sub>DRAIN</sub> ≥ 0V                 | -    | 8    | -    |      |
| Gate Driver                        |                     |   |      |      |      |      |
| Turn-off Threshold Voltage(Note 4) | V <sub>T</sub>      | V <sub>G</sub> = 1V, (Note 5)           | -45  | -16  | 0    | mV   |
| GATE output voltage (Note 4)       | V <sub>G(off)</sub> | V <sub>DRAIN</sub> ≥ 0V, (Note 5)       | -    | 0.6  | 1    | V    |
|                                    | V <sub>G</sub>      | V <sub>DRAIN</sub> = -60mV, (Note 6)    | 5.0  | 7.5  | -    |      |
|                                    |                     | V <sub>DRAIN</sub> = -80mV, (Note 6)    | 7.0  | 8.5  | -    |      |
|                                    |                     | V <sub>DRAIN</sub> = -100mV, (Note 6)   | 8.4  | 9    | -    |      |
|                                    |                     | V <sub>DRAIN</sub> ≤ -140mV, (Note 6)   | 9.2  | 9.4  | -    |      |
|                                    |                     | V <sub>DRAIN</sub> ≤ -200mV, (Note 6)   | 9.3  | 9.5  | -    |      |
| GATEH peak source current          | I <sub>SOURCE</sub> | V <sub>GH</sub> = 1V                    |      | 2.5  | -    | A    |
| GATEL peak sink current            | I <sub>SINK</sub>   | V <sub>GL</sub> = 5V                    |      | 2.5  | -    | A    |
| Turn on Propagation delay          | t <sub>d1</sub>     | C <sub>L</sub> = 2.2nF, (Notes 6 and 7) |      | 525  |      | ns   |
| Turn off Propagation delay         | t <sub>d2</sub>     |   |      | 15   |      | ns   |
| Gate rise time                     | t <sub>r</sub>      |   |      | 305  |      | ns   |
| Gate fall time                     | t <sub>f</sub>      |   |      | 20   |      | ns   |

Notes:

- GATEH connected to GATEL
- R<sub>H</sub> = 100kΩ, R<sub>L</sub> = O/C
- R<sub>L</sub> = 100kΩ, R<sub>H</sub> = O/C
- Refer to Fig 6: test circuit and Fig 7: timing diagram on Page 12

**SYNCHRONOUS RECTIFIER CONTROLLER**

**Schematic Symbol and Pin Out Details**



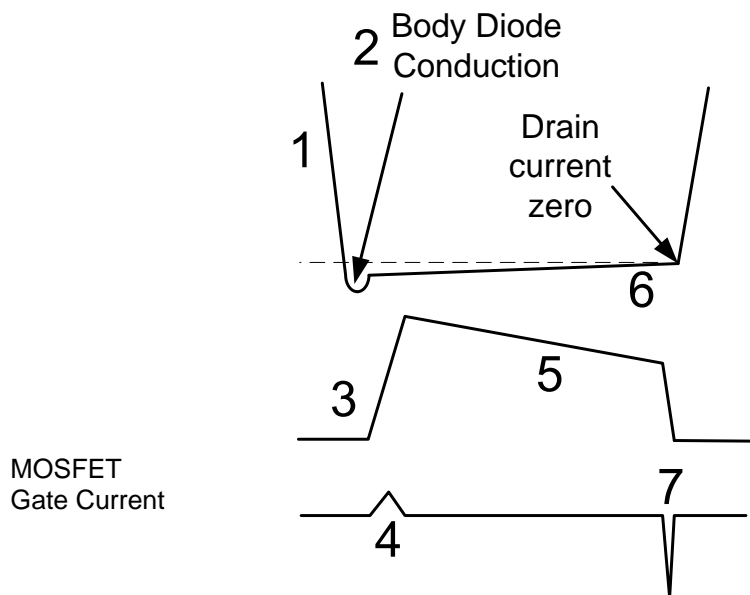
| Pin No. | Symbol   | Description and function   |
|---------|----------|--|
| 1       | NC       | <b>No connection</b><br>This pin can be connected to GND   |
| 2       | REF      | <b>Reference</b><br>This pin is connected to $V_{CC}$ via resistor, $R_{REF}$ . $R_{REF}$ should be selected to source approximately 3mA into this pin. (Note 8) |
| 3       | GATEL    | <b>Gate turn off</b><br>This pin sinks current, $I_{SINK}$ , from the synchronous MOSFET Gate.   |
| 4       | GATEH    | <b>Gate turn on</b><br>This pin sources current, $I_{SOURCE}$ , to the synchronous MOSFET Gate.  |
| 5       | $V_{CC}$ | <b>Power Supply</b><br>This is the supply pin. It is recommended to decouple this point to ground closely with a ceramic capacitor.                              |
| 6       | GND      | <b>Ground</b><br>This is the ground reference point. Connect to the synchronous MOSFET Source terminal.  |
| 7       | BIAS     | <b>Bias</b><br>This pin is connected to $V_{CC}$ via resistor, $R_{BIAS}$ . $R_{BIAS}$ should be selected to source 1.6 times $I_{REF}$ into this pin. (Note 9)  |
| 8       | DRAIN    | <b>Drain connection</b><br>This pin connects directly to the synchronous MOSFET Drain terminal.  |

Notes: 8. REF pin should be assumed to be at GND +0.7V.  
9. BIAS pin should be assumed to be at GND +0.3V.

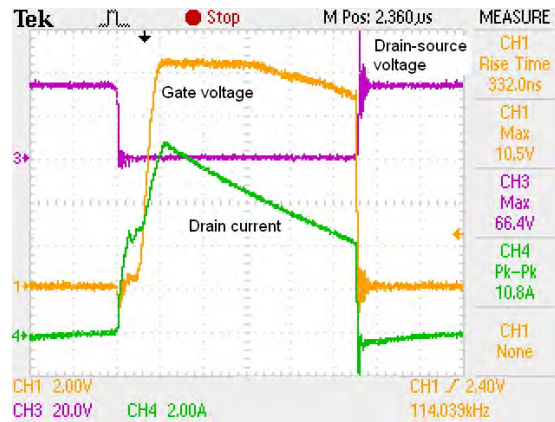
**SYNCHRONOUS RECTIFIER CONTROLLER**
**Operation**
**Normal Operation**

The operation of the device is described step-by-step with reference to the timing diagram below.

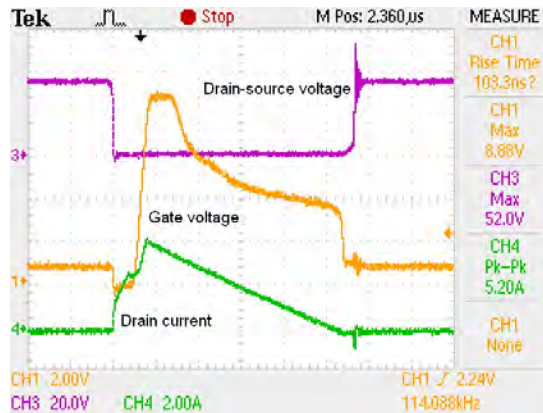
1. The detector monitors the MOSFET Drain-Source voltage.
2. When, due to transformer action, the MOSFET body diode is forced to conduct there is approximately -0.6V on the Drain pin.
3. The detector outputs a positive voltage with respect to ground, this voltage is then fed to the MOSFET driver stage and current is sourced out of the GATEH pin.
4. The current out of the GATEH pin is sourced into the synchronous MOSFET Gate to turn the device on.
5. The GATEH output voltage is now proportional to the Drain-Source voltage drop across the MOSFET due to the current flowing through the MOSFET.
6. MOSFET conduction continues until the drain current reaches zero.
7. At zero current the detector output voltage is zero and the synchronous MOSFET Gate voltage is pulled low by the GATEL, turning the device off.



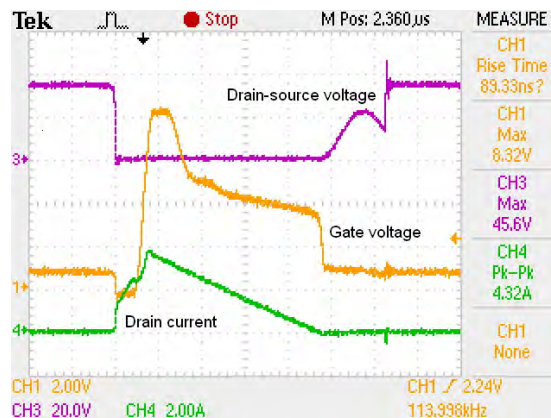
**SYNCHRONOUS RECTIFIER CONTROLLER**



**1a) Continuous Conduction Mode (CCM)**



**1b) Critical Conduction Mode (CrCM)**

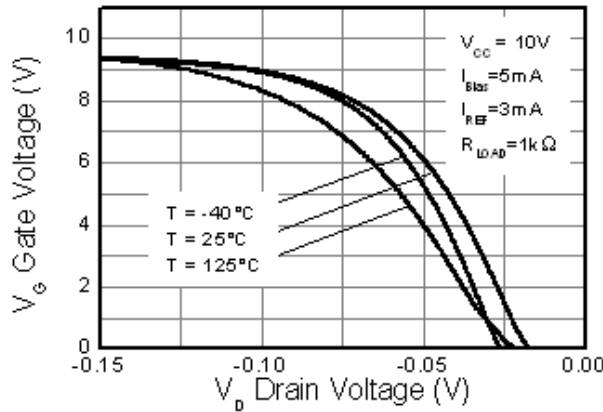


**1c) Discontinuous Conduction Mode (DCM)**

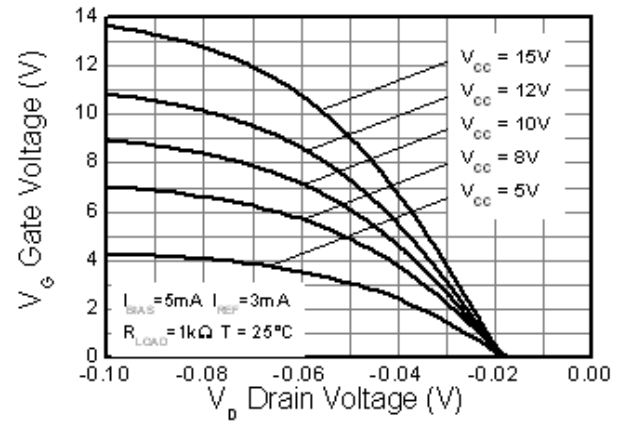
**Figure 1: Typical waveforms**

**SYNCHRONOUS RECTIFIER CONTROLLER**

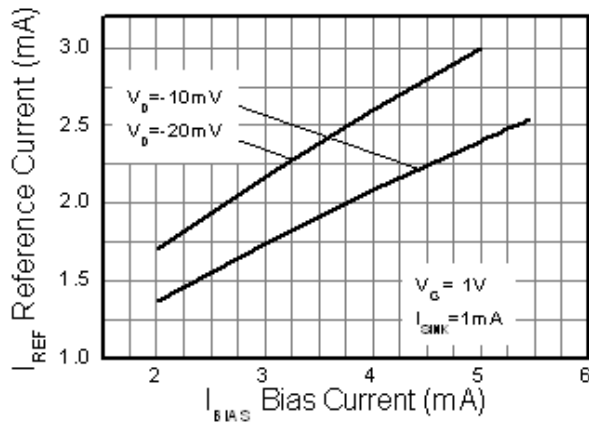
**Typical Characteristics**



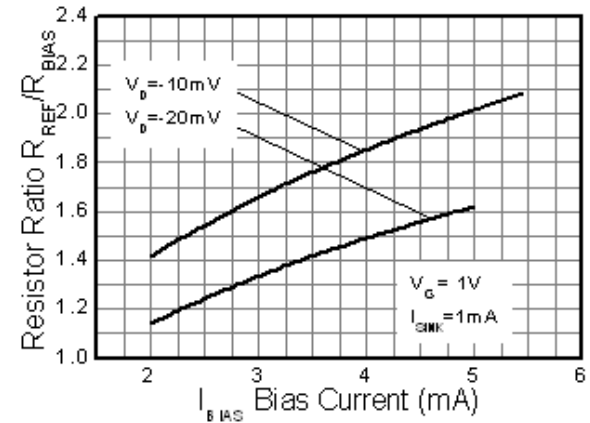
**Transfer Characteristic**



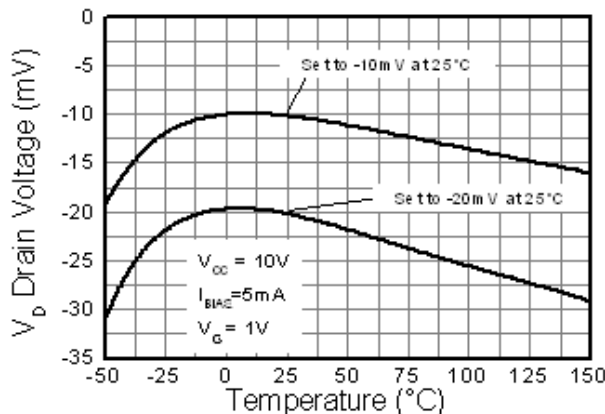
**Transfer Characteristic**



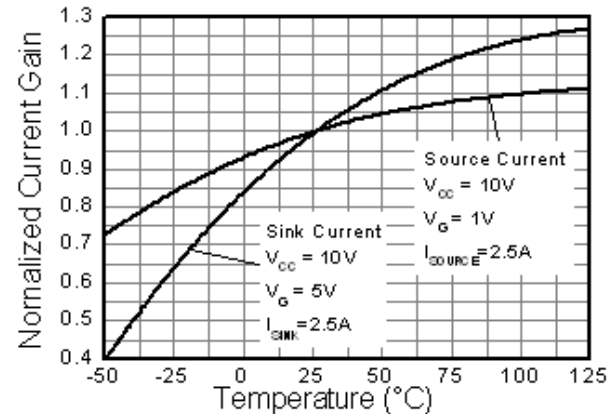
**Bias Current vs Reference Current**



**Bias Resistor vs Reference Resistor**



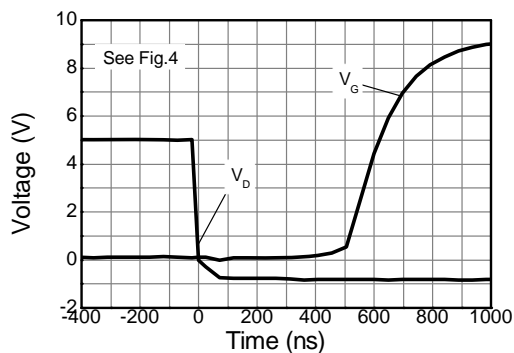
**Drain Sense Voltage vs Temperature**



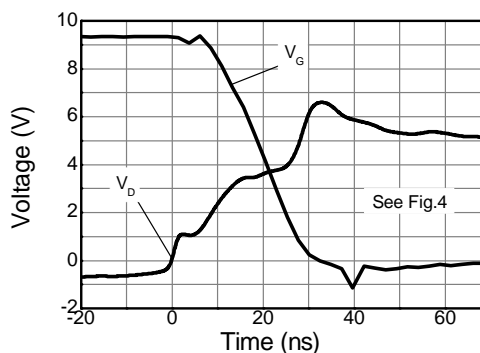
**Output Current vs Temperature**

**SYNCHRONOUS RECTIFIER CONTROLLER**

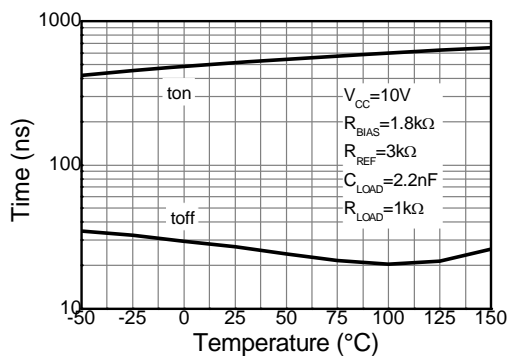
**Typical Characteristics**



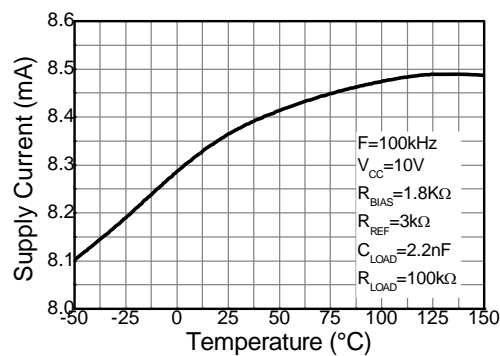
**Switch On Speed**



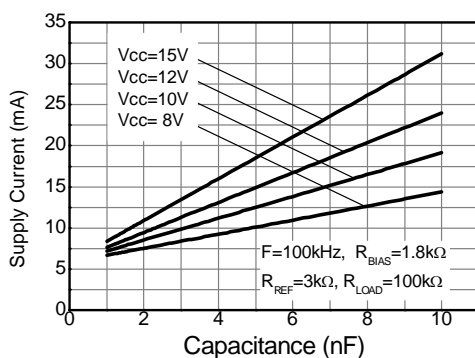
**Switch Off Speed**



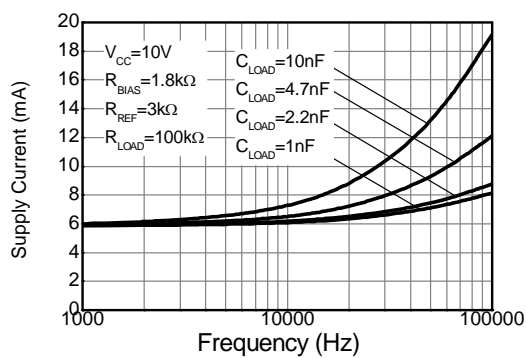
**Switching vs Temperature**



**Supply Current vs Temperature**

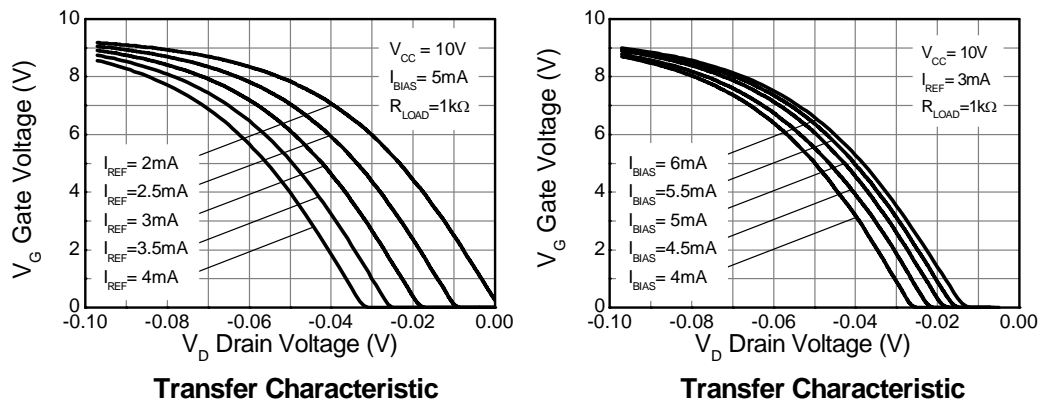


**Supply Current vs Capacitive Load**



**Supply Current vs Frequency**



**SYNCHRONOUS RECTIFIER CONTROLLER**


## Component Selection

It is advisable to decouple the ZXGD3101 closely to  $V_{CC}$  and ground due to the possibility of high peak gate currents with C1 in Figure 2.

The proper selection of external resistors  $R_{REF}$  and  $R_{BIAS}$  is important to the optimum device operation. Select a value for resistor  $R_{REF}$  to give a reference current,  $I_{REF}$ , of  $\sim 3\text{mA}$ . The value of  $R_{BIAS}$  must then be 0.6 times the value of  $R_{REF}$  giving a bias current,  $I_{BIAS}$ , of  $\sim 1.6$  times  $I_{REF}$ . This provides a recommended typical offset voltage of  $\sim 20\text{mV}$ .

External gate resistors are optional. They can be inserted to control the rise times which may help with EMI issues, power supply consumption issues or dissipation within the part.

$$R_{REF} = (V_{CC} - 0.7V) / 0.003$$

$$R_{BIAS} = (V_{CC} - 0.3V) / 0.005$$

## Layout considerations

The Gate pins should be as close to the MOSFET Gate as possible. Also the ground return loop should be as short as possible. The decoupling capacitor should be close to the  $V_{CC}$  and Ground pin, and should be a X7R type.

For more detailed information refer to application note AN54..

**SYNCHRONOUS RECTIFIER CONTROLLER**

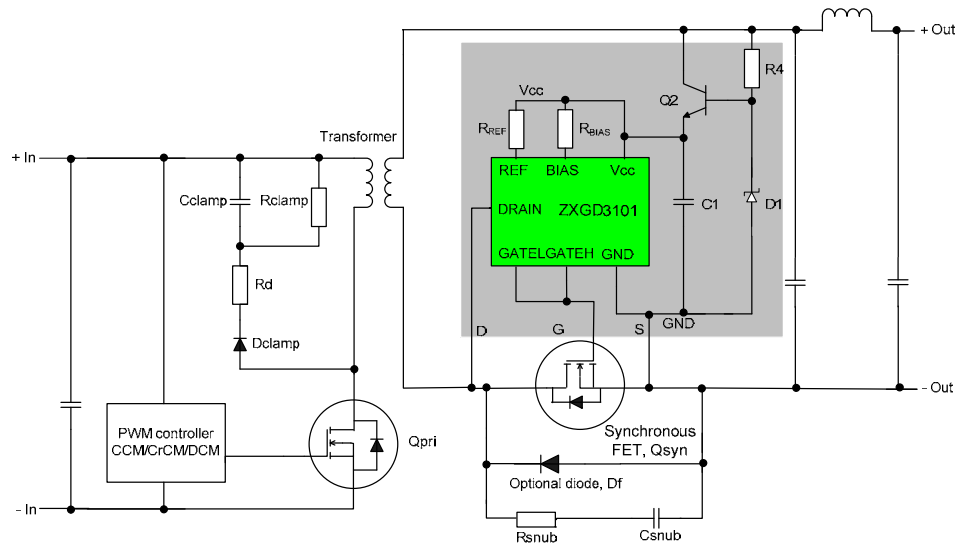


Figure 2 Example connection for low side synchronous rectification

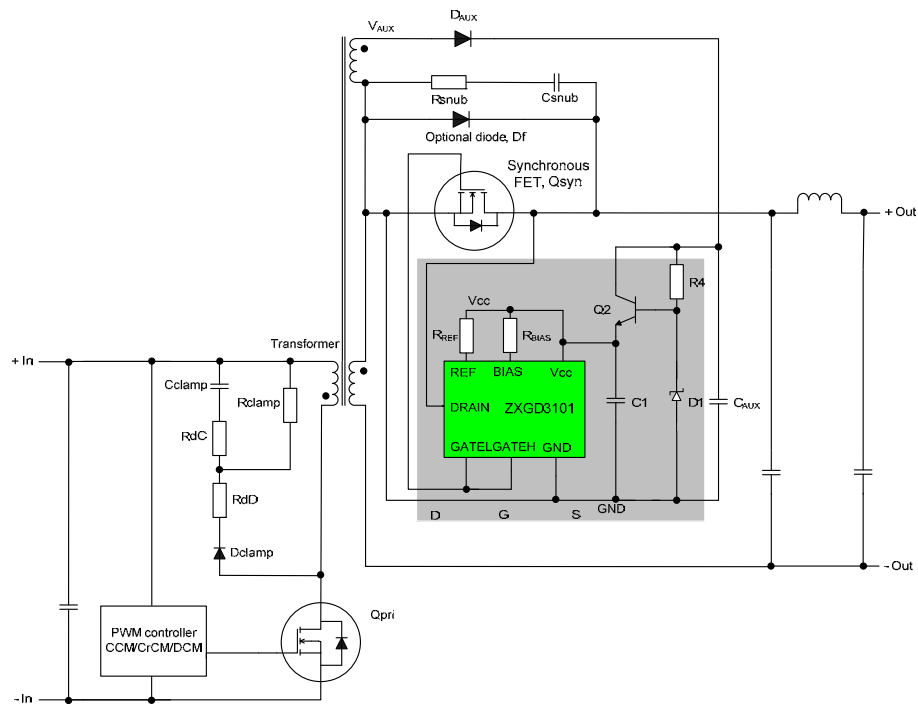


Figure 3: Example connection for high side synchronous rectification

**SYNCHRONOUS RECTIFIER CONTROLLER**

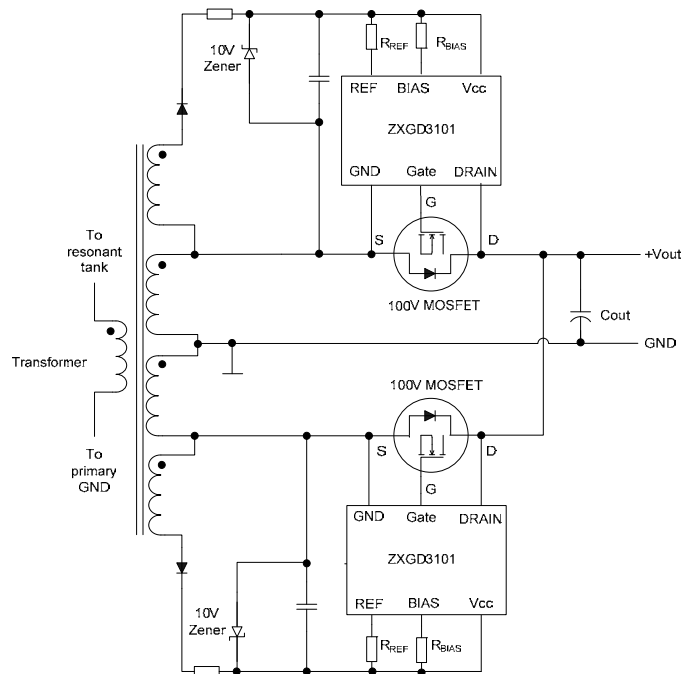


Figure 4: Example connections for LLC converter

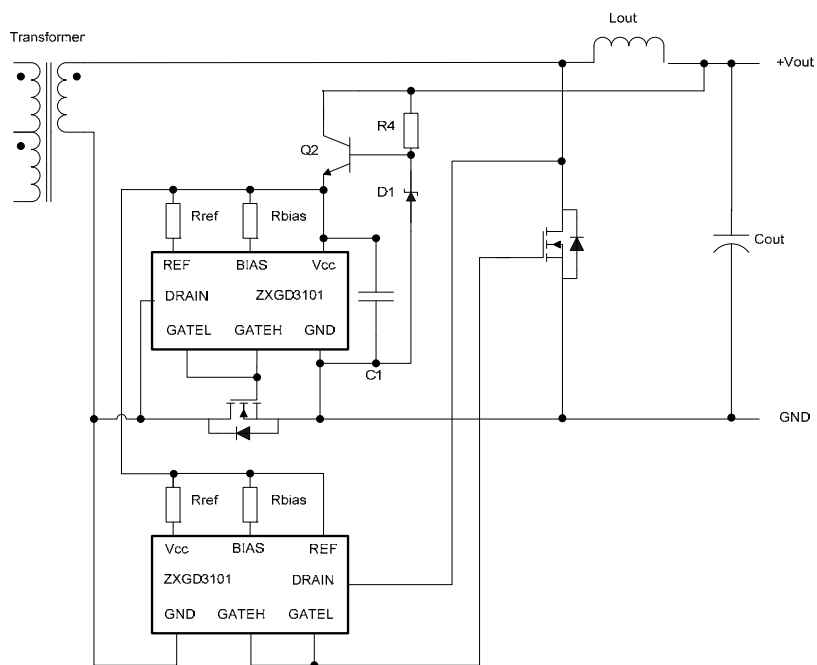


Figure 5: Example connections for Forward converter

**SYNCHRONOUS RECTIFIER CONTROLLER**

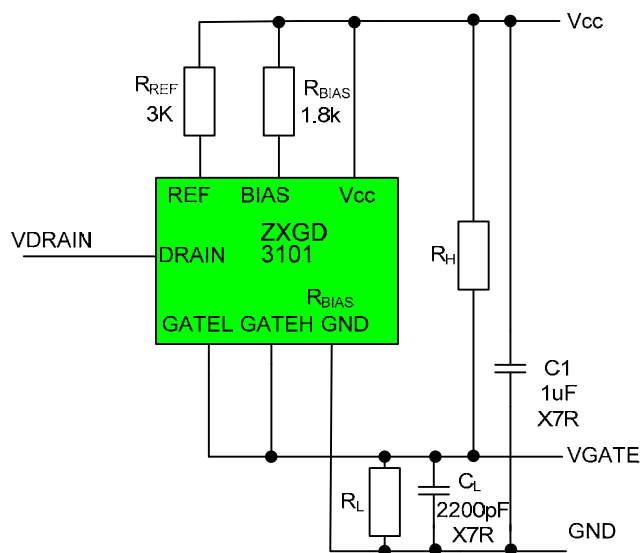
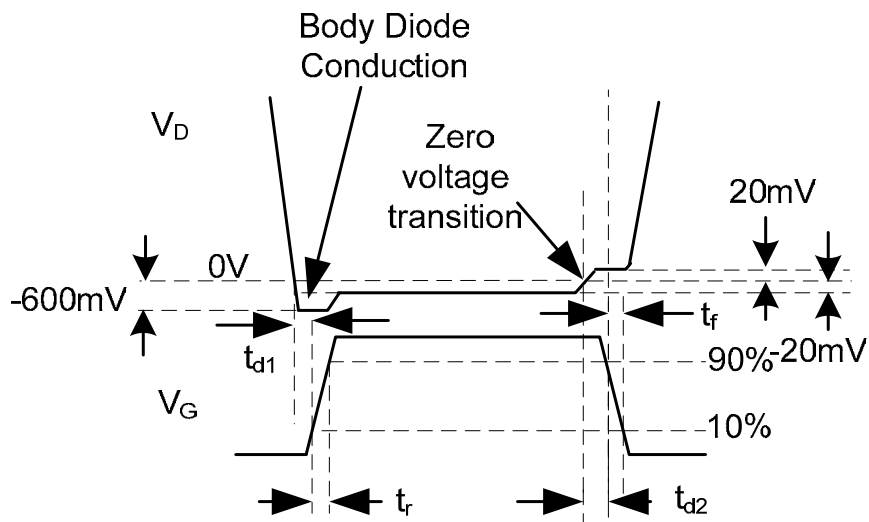


Figure 6: Test circuit



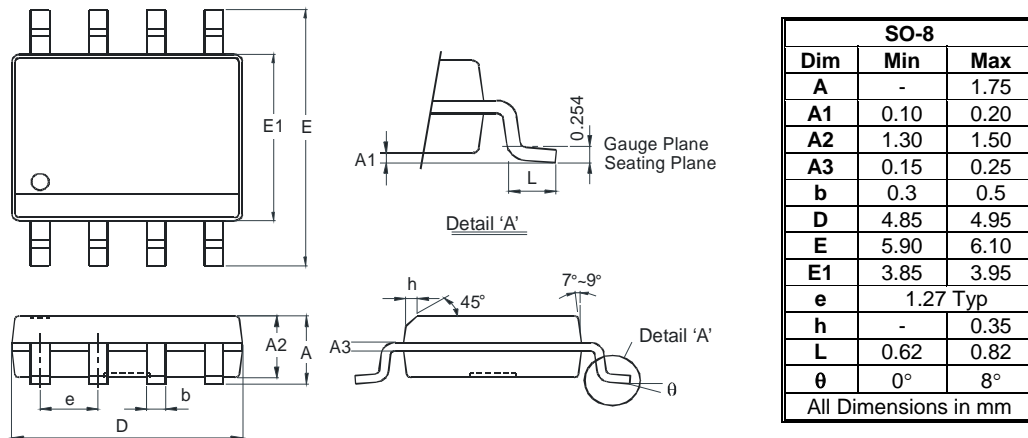
NOTE GATEH AND GATEL ARE CONNECTED

Figure 7: Timing Diagram

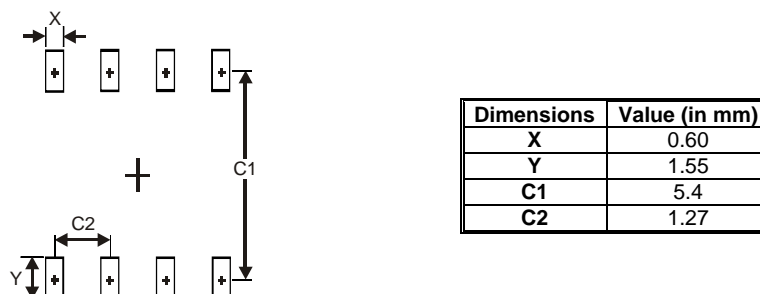
**ZXGD3101N8**

**SYNCHRONOUS RECTIFIER CONTROLLER**

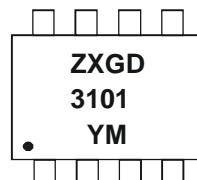
**Package Outline and Dimensions**



**Suggested Pad Layout**



**Marking Information**



ZXGD3101 = Product Type Marking Code  
YM = Date Code Marking  
Y = Year (ex. W = 2009)  
M = Month (ex. 9 = September)

**Date Code Key**

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|------|------|------|------|------|------|------|------|
| Code | W    | X    | Y    | Z    | A    | B    | C    |

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Code  | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | O   | N   | D   |

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