SYNCHRONOUS MOSFET CONTROLLER IN SO8

Description

The ZXGD3104 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 the 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. The detector's output voltage is then proportional to the MOSFET Drain-Source voltage, and this is applied to the Gate via the driver. This action provides a rapid MOSFET turn-off at zero Drain current.

Features

- 5-25V V_{CC} Range
- Operating up to 250kHz
- Suitable for Discontinuous Conduction Mode (DCM), Critical Conduction Mode (CrCM), and Continuous Conduction Mode (CCM) Operation
- Turn-Off Propagation Delay 15ns and Turn-Off Time 20ns
- Proportional Gate Drive Control
- Detector Threshold Voltage -10mV
- Standby Current 5mA
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **Qualified to AEC-Q101 Standards for High Reliability**

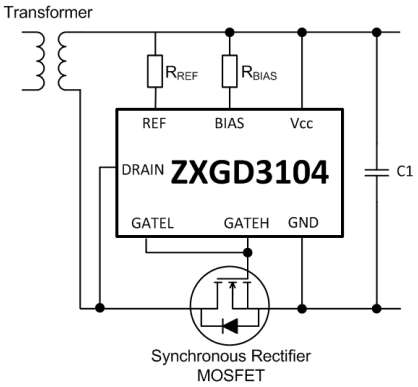
Applications

- Flyback Converters in:
  - ≥90W Laptop Adaptors

Mechanical Data

- Case: SO-8
- Case material: Molded Plastic. "Green" Molding Compound. UL Flammability Rating 94V-0
- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Matte Tin Finish – Solderable per MIL-STD-202, Method 208 e3
- Weight: 0.074 grams (Approximate)

Typical Configuration



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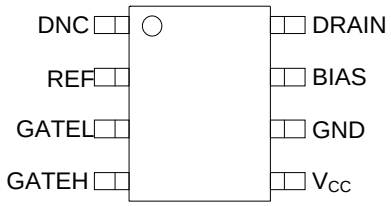


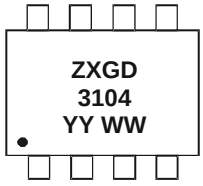
Top View
Pin-Out

Ordering Information (Note 4)

Product	Marking	Reel Size (inches)	Tape Width (mm)	Quantity per Reel
ZXGD3104N8TC	ZXGD3104	13	12	2,500

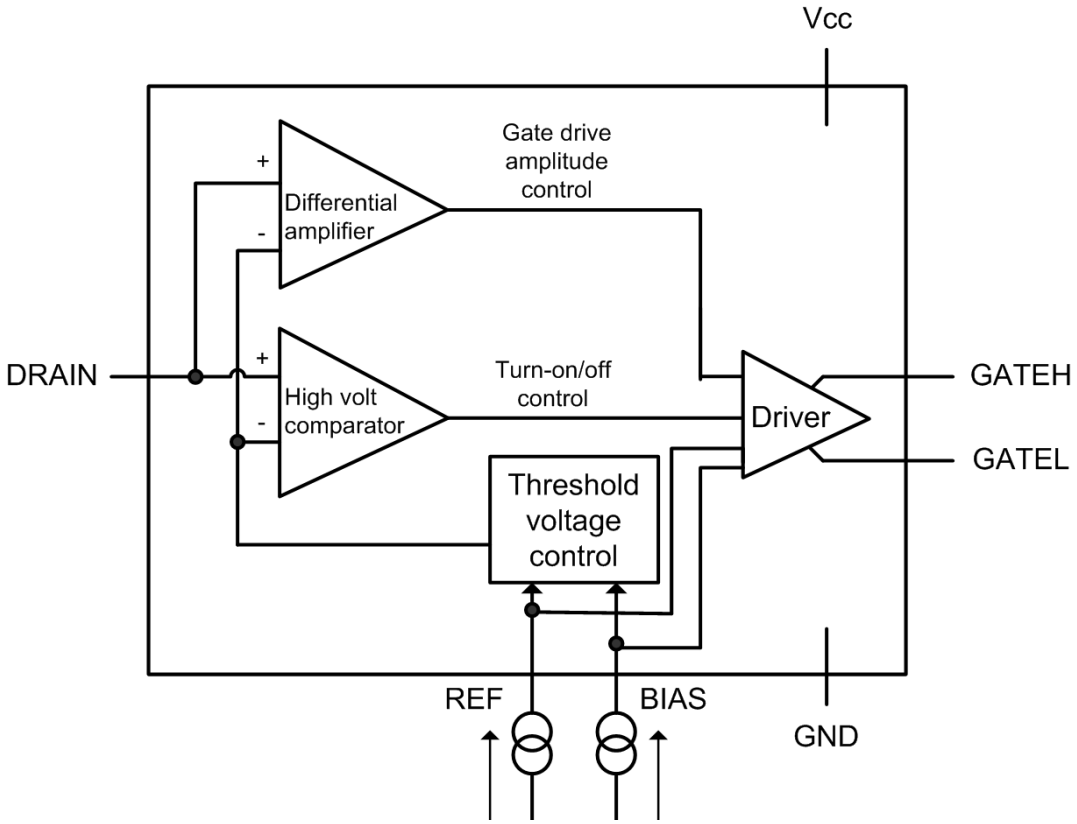
Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine1500ppm total Br + Cl) and <1000ppm antimony compounds.
4. For packaging details, go to our website at http://www.diodes.com/products/packages.html.

Marking Information



ZXGD = Product Type Marking Code, Line 1
3104 = Product Type Marking Code, Line 2
YY = Year (ex: 11 = 2011)
WW = Week (01 - 53)

Functional Block Diagram



Pin Number	Name	Description and Function
1	DNC	**Do Not Connect** Leave pin floating.
2	REF	**Reference** This pin is connected to V_{CC} via resistor, $R_{REF.}$ Select R_{REF} to source 2.16mA into this pin. Refer to Table 1 in Application Information section.
3	GATEL	**Gate Turn-Off** This pin sinks current, I_{SINK}, from the synchronous MOSFET Gate.
4	GATEH	**Gate Turn-On** This pin sources current, I_{SOURCE}, to the synchronous MOSFET Gate.
5	V_{CC}	**Power Supply** This is the supply pin. It is recommended to decouple this point to Ground closely with a ceramic capacitor.
6	GND	**Ground** This is the ground reference point. Connect to the synchronous MOSFET Source terminal.
7	BIAS	**Bias** This pin is connected to V_{CC} via resistor, R_{BIAS}. Select R_{BIAS} to Source 3mA into this pin. Refer to Table 1 in Application Information section.
8	DRAIN	**Drain Connection** This pin connects directly to the synchronous MOSFET Drain terminal.

Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

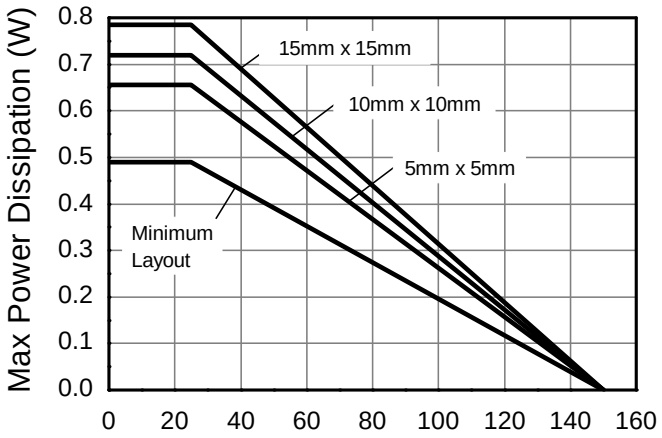
Characteristic	Symbol	Value	Unit
Supply Voltage, Relative to GND	V_{CC}	25	V
Drain Pin Voltage	V_D	-3 to 180	V
Gate Output Voltage	V_G	-3 to V_{CC} +3	V
Gate Driver Peak Source Current	I_{SOURCE}	2.5	A
Gate Driver Peak Sink Current	I_{SINK}	7	A
Reference Voltage	V_{REF}	V_{CC}	V
Reference Current	I_{REF}	25	mA
Bias Voltage	V_{BIAS}	V_{CC}	V
Bias Current	I_{BIAS}	100	mA

Thermal Characteristics (@T_A = +25°C, unless otherwise specified.)

Characteristic		Symbol	Value	Unit
Power Dissipation Linear Derating Factor	(Note 5)	P_D	490 3.92	mW mW/°C
	(Note 6)		655 5.24	
	(Note 7)		720 5.76	
	(Note 8)		785 6.28	
Thermal Resistance, Junction to Ambient	(Note 5)	$R_{\theta JA}$	255	°C/W
	(Note 6)		191	
	(Note 7)		173	
	(Note 8)		159	
Thermal Resistance, Junction to Lead	(Note 9)	$R_{\theta JL}$	135	°C/W
Operating Temperature Range		T_J	-40 to +150	°C
Storage Temperature Range		T_{STG}	-55 to +150	

Notes:
5. For a device surface mounted on minimum recommended pad layout FR4 PCB with high coverage of single sided 1oz copper, in still air conditions; the device is measured when operating in a steady-state condition.
6. Same as Note (5), except Pin 5 (V_{CC}) and Pin 6 (GND) are both connected to separate 5mm x 5mm 1oz copper heatsinks.
7. Same as Note (6), except both heatsinks are 10mm x 10mm.
8. Same as Note (6), except both heatsinks are 15mm x 15mm.
9. Thermal resistance from junction to solder-point at the end of each lead on Pin 5 (V_{CC}) and Pin 6 (GND).

Thermal Derating Curve



Derating Curve

ESD Rating

Characteristic	Value	Unit
ESD for Human Body Model	2,000	V
ESD for Machine Model	300	

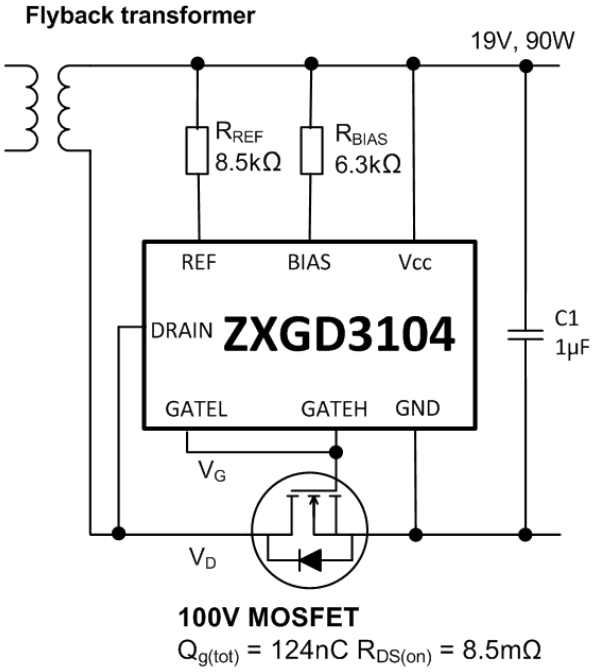
Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)

V_{CC} = 19V; R_{BIAS} = 6.3kΩ; R_{REF} = 8.5kΩ

Characteristic		Symbol	Min	Typ	Max	Unit	Test Condition
Input and Supply							
Quiescent Current		I_Q	—	5.16	—	mA	V_D ≥ 0V
Gate Driver							
Turn-Off Threshold Voltage (Notes 10 & 11)		V_T	-16	-10	0	mV	V_G = 1V
Gate Output Voltage	(Notes 10 & 11)	$V_{G(off)}$	0	0.73	1.0	V	V_D ≥ 1V
	(Notes 10 & 12)	V_G	12.5	14	V_{CC}		V_D = -50mV
			17	18	V_{CC}		V_D = -100mV
Switching Performance for $Q_{G(tot)}$ = 124nC (Note 13)							
Turn-On Propagation Delay		$t_{d(rise)}$	175	250	325	ns	— Refer to Switching Waveforms in Fig. 1
Turn-Off Propagation Delay		$t_{d(fall)}$	11	15	20		
Gate Rise Time		t_r	335	480	625		From 10% of V_G to 10V
			530	760	990		From 10% to 90% of V_G
Gate Fall Time		t_f	35	50	65		Continuous Conduction Mode

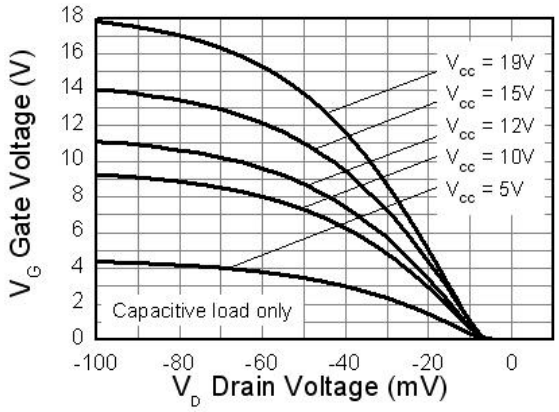
Notes: 10. GATEH connected to GATEL
11. R_H = 100kΩ, R_L = O/C
12. R_L = 100kΩ, R_H = O/C
13. Refer to test circuit below.

Test Circuit

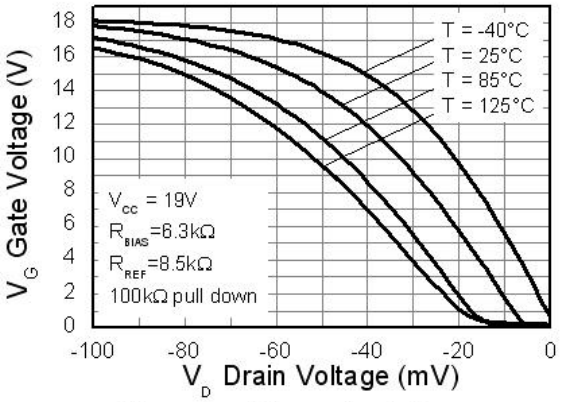


Test conditions
Primary side input voltage = 400V
Switching frequency = 65kHz
Discontinuous conduction mode

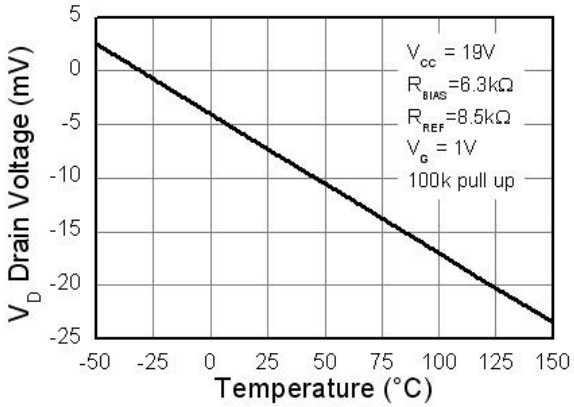
Typical Electrical Characteristics (@T_A = +25°C, unless otherwise specified.)



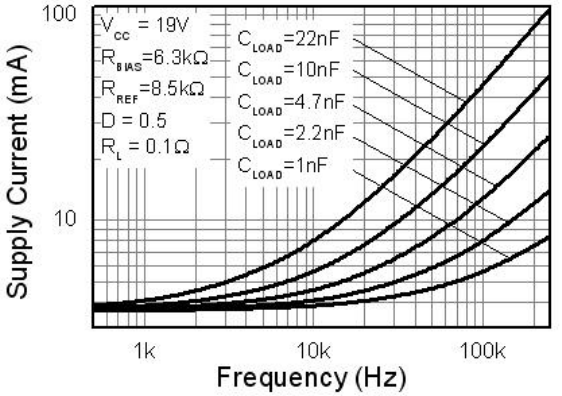
Transfer Characteristic



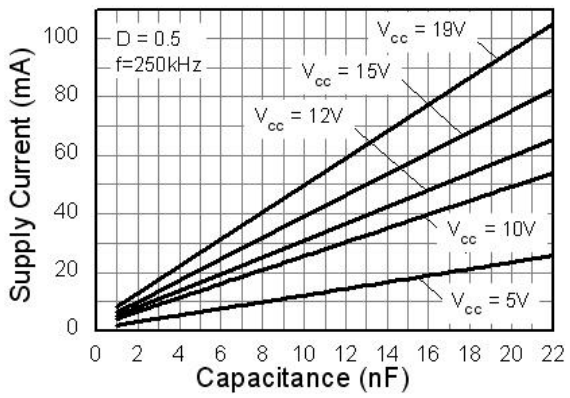
Transfer Characteristic



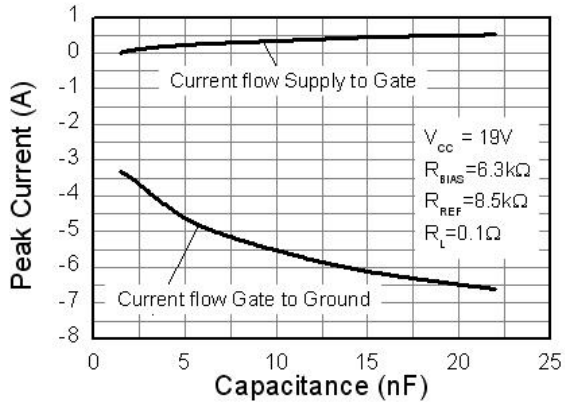
Drain Sense Voltage vs Temperature



Supply Current vs Frequency

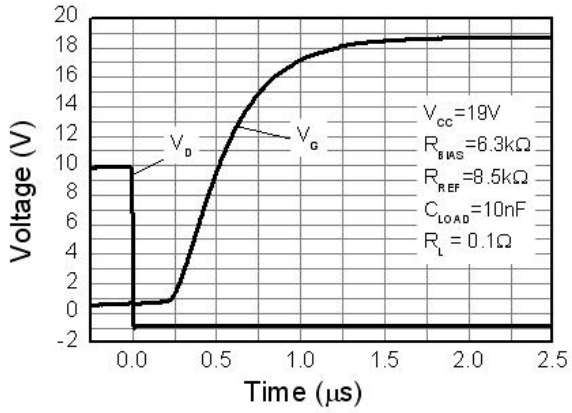


Supply Current vs Capacitive Load

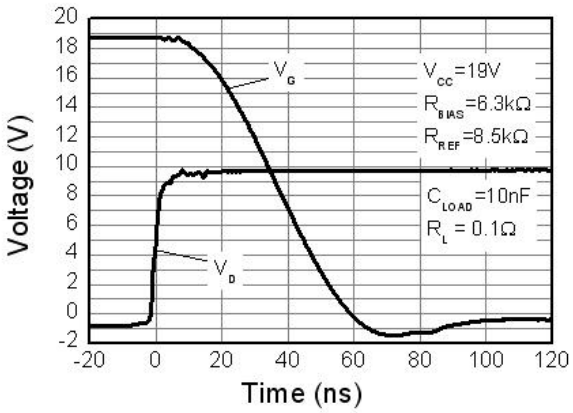


Gate Current vs Capacitive Load

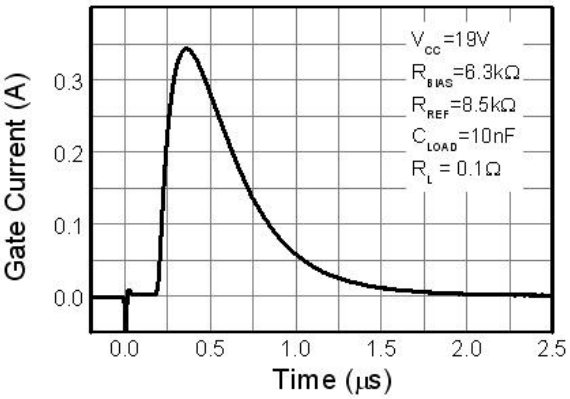
Typical Electrical Characteristics (Continued) (@T_A = +25°C, unless otherwise specified.)



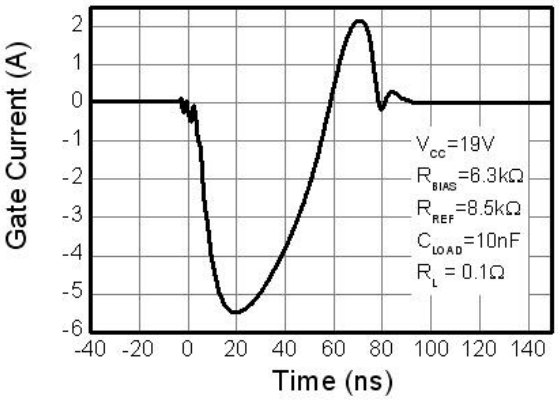
Switch On Speed



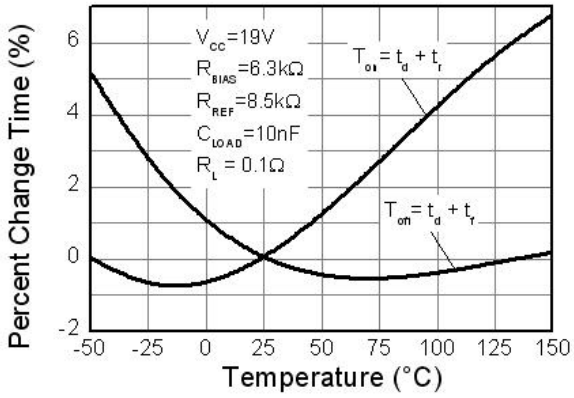
Switch Off Speed



Gate Drive On Current



Gate Drive Off Current



Switching vs Temperature

Application Information

Descriptions of the Normal Operation

The operation of the controller is described step-by-step with reference to the timing diagram in Figure 1.

1. The controller monitors the MOSFET Drain-Source voltage.
2. When the MOSFET body diode is forced to conduct, due to transformer action, there is approximately -0.8V 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 Gate Pin.
4. The controller goes into proportional gate drive control – the Gate output voltage is proportional to the on-resistance-induced Drain-Source voltage drop across the MOSFET. Proportional gate drive ensures that MOSFET conducts for majority of the conduction cycle and minimizes body diode conduction time.
5. As the Drain current decays linearly toward zero, proportional gate drive control reduces the Gate voltage so the MOSFET can be turned off rapidly at zero current crossing. The Gate voltage is removed when the Drain-Source voltage crosses the detection threshold voltage to minimize reverse current flow.
6. At zero Drain current, the controller Gate output voltage is pulled low to $V_{G(off)}$ to ensure that the MOSFET is turned off.

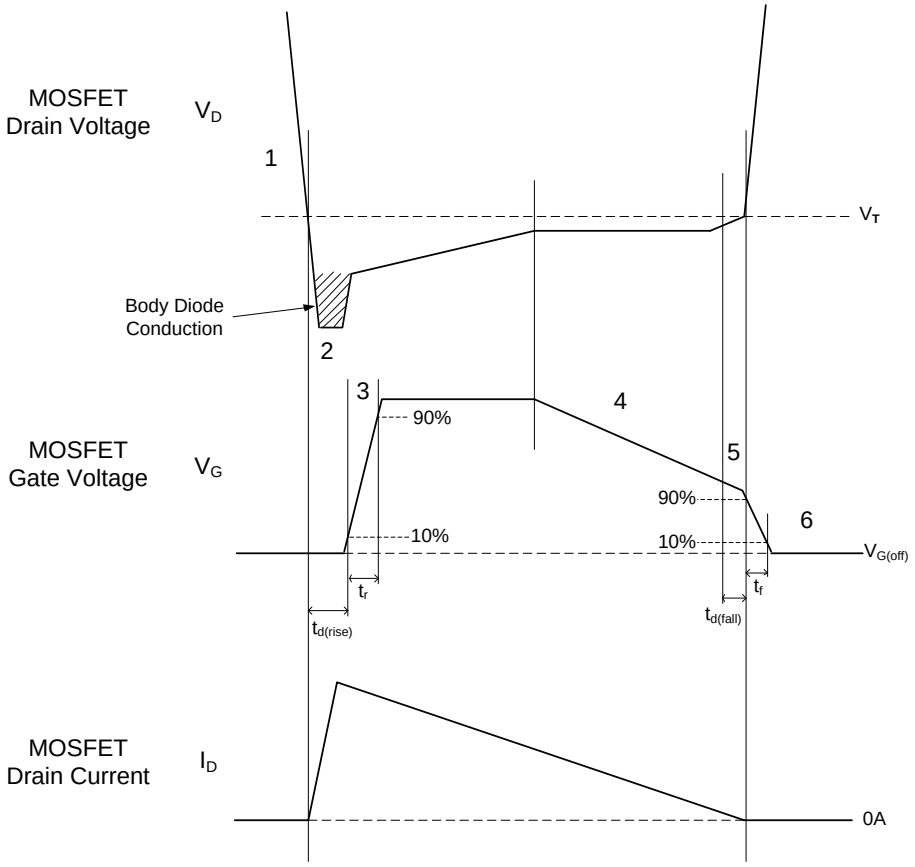


Figure 1: Timing Diagram for a Critical Conduction Mode Flyback Converter

Application Information (Continued)

The purpose of the ZXGD3104 is to drive a MOSFET as a low V_F Schottky diode replacement in offline power converters. When combined with a low $R_{DS(ON)}$ MOSFET, it can yield significant power efficiency improvement, while maintaining design simplicity and incurring minimal component count. Figure 2 shows the typical configuration of ZXGD3104 for synchronous rectification in a 19V output flyback adaptor.

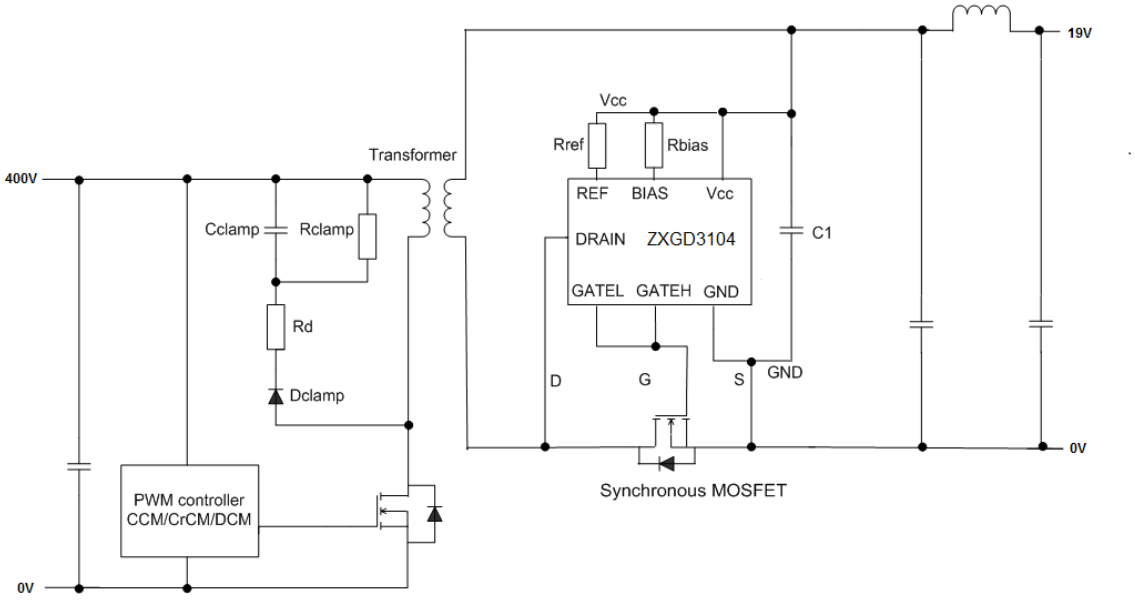


Figure 2: Example Connections in Flyback Power Supply

Application Information (Cont.)

Figure 3 shows operating waveforms for ZXGD3104 driving a MOSFET with $Q_{g(TOT)}$ = 124nC in a 19V output flyback converter operating in critical conduction mode.

Typical waveforms

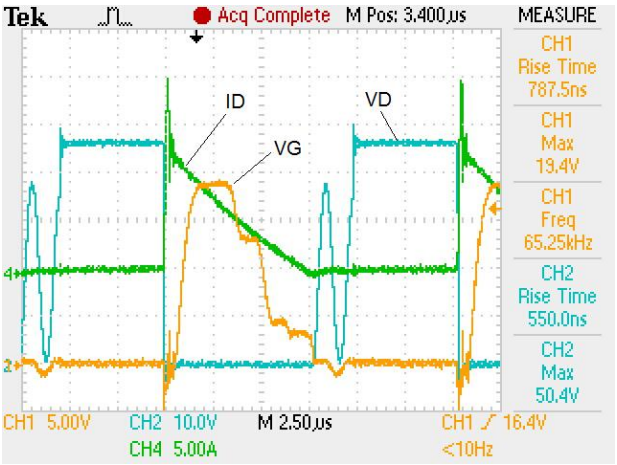


Fig 3a: Critical Conduction Mode, Operating for MOSFET with $Q_{g(TOT)}$ = 124nC

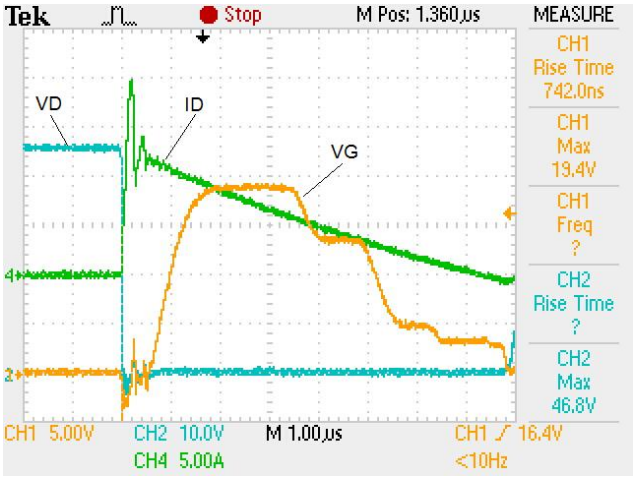


Fig 3b: Typical Switching Waveform

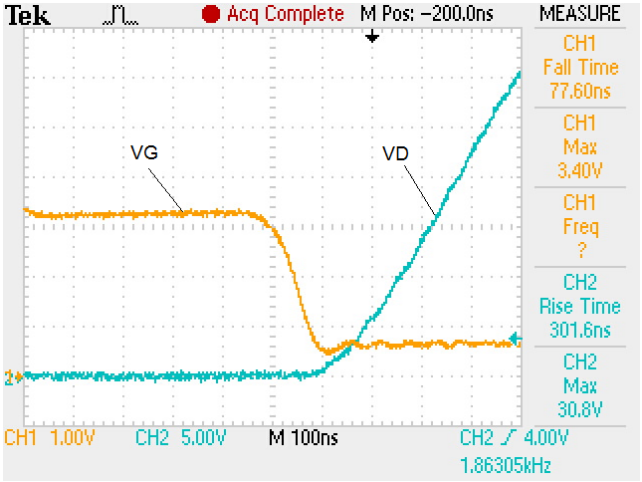


Figure 3c: Close-Up of Typical Turn-Off Waveform

Application Information (Cont.)

Design Considerations

It is advisable to decouple the ZXGD3104 closely to V_{CC} and ground due to the possibility of high peak gate currents with a 1µF X7R type ceramic capacitor C1 as shown in Figure 2. Also the Ground return loop should be as short as possible.

To minimize parasitic inductance-induced premature turn-off of the synchronous controller, always keep the PCB track length between ZXGD3104's Drain input and the MOSFET's Drain to less than 10mm. Low internal inductance SMD MOSFET packages are also recommended for high switching frequency power conversion to minimize MOSFET body diode conduction loss.

The Gate Pins should be as close to the MOSFET's gate as possible. External gate resistors are optional. They can be inserted to control the rise and fall time which may help with EMI issues.

The careful selection of external resistors R_{REF} and R_{BIAS} is important to the optimum device operation. Select a value for resistor R_{REF} and R_{BIAS} from Table 1 based on the desired V_{CC} value. This provides the typical ZXGD3104's detection threshold voltage of -10mV.

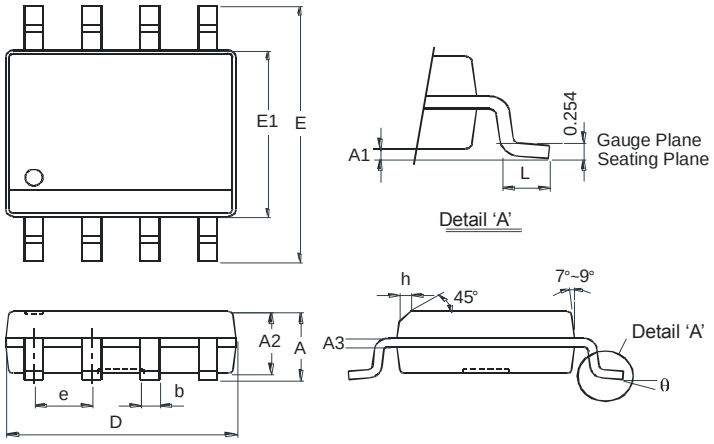
Table 1: Recommended Resistor Values for Various Supply Voltages

V_{CC}	R_{BIAS}	R_{REF}
5V	1.6kΩ	2kΩ
10V	3.3kΩ	4.3kΩ
12V	3.9kΩ	5.1kΩ
15V	5.1kΩ	6.8kΩ
19V	6.3kΩ	8.5kΩ

Package Outline Dimensions

Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

SO-8



SO-8		
Dim	**Min**	**Max**
A	-	1.75
A1	0.10	0.20
A2	1.30	1.50
A3	0.15	0.25
b	0.3	0.5
D	4.85	4.95
E	5.90	6.10
E1	3.85	3.95
e	1.27 Typ	
h	-	0.35
L	0.62	0.82
θ	0°	8°
All Dimensions in mm		

Suggested Pad Layout

Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

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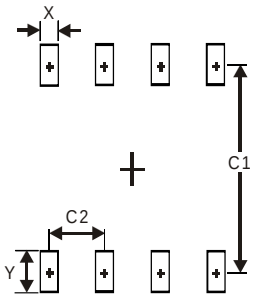

Dimensions	Value (in mm)
X	0.60
Y	1.55
C1	5.4
C2	1.27

Note: For high voltage applications, the appropriate industry sector guidelines should be considered with regards to creepage and clearance distances between device Terminals and PCB tracking.

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