DIODES INCORPORATED

Lead-free Green

A Product Line of
Diodes Incorporated

ZETEX

ZXGD3105N8

SYNCHRONOUS MOSFET CONTROLLER IN SO-8

Description

ZXGD3105N8 synchronous controller is designed for driving a MOSFET as an ideal rectifier. This is to replace a diode for increasing the power transfer efficiency.

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 voltage and this is applied to the Gate via the driver. This action provides a rapid MOSFET turn off as Drain current decays to zero.

Applications

Flyback and Resonant Converters in:

- Low Voltage AC / DC Adaptors
- Set Top Box
- Computing Power Supplies - ATX and Server PSU
- Low Voltage DC / DC conversion

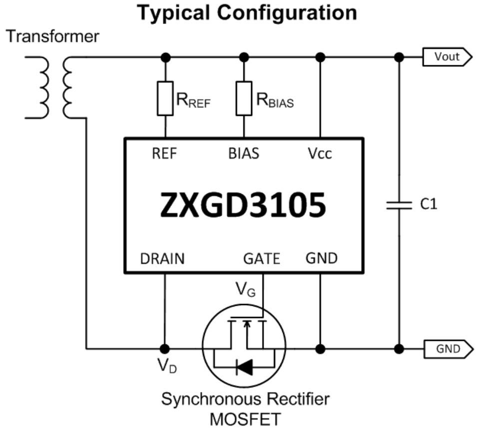
Features

- Low standby power with quiescent supply current < 1mA
- 4.5V operation enables low voltage supply
- Proportional gate drive for fast turn-off
- Operation up to 500kHz
- Critical Conduction Mode (CrCM) & Continuous Mode (CCM)
- Compliant with Eco-design directive
- **"Lead-Free", RoHS Compliant (Note 1)**
- **Halogen and Antimony free. "Green" Device (Note 2)**
- **Qualified to AEC-Q101 Standards for High Reliability**

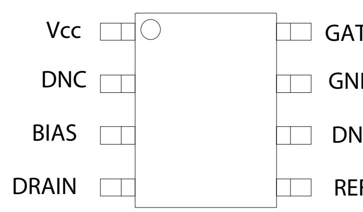
Mechanical Data

- 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
- Weight: 0.074 grams (approximate)

Typical Configuration



SO-8



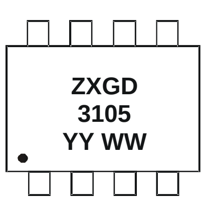
Top View
Pin-Out

Ordering Information (Note 3)

Product	Marking	Reel size (inches)	Tape width (mm)	Quantity per reel
ZXGD3105N8TC	ZXGD 3105	13	12	2500

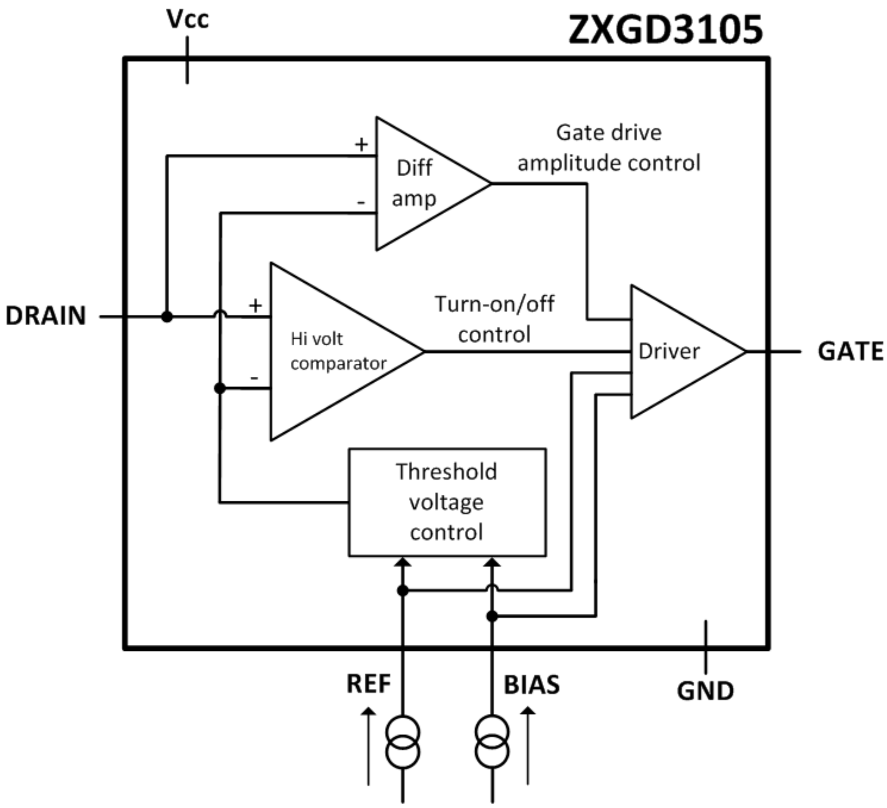
Notes: 1. No purposefully added lead
2. Diodes Inc's "Green" Policy can be found on our website at http://www.diodes.com
3. For packaging details, go to our website at http://www.diodes.com

Marking Information



ZXGD = Product Type Marking Code, Line 1
3105 = Product Type Marking Code, Line 2
YY = Year (ex: 11 = 2011)
WW = Week (01 - 53)

Functional Block Diagram



Pin #	Pin Name	Pin Function and Description
1	**Vcc**	**Power supply** This supply pin should be closely decoupled to ground with a ceramic capacitor.
2	**DNC**	**Do not connect** Leave pin floating.
3	**BIAS**	**Bias** Connect this pin to Vcc via R_{BIAS} resistor. Select R_{BIAS} to source 0.54mA into this pin. Refer to Table 1 and 2, in Application Information section.
4	**DRAIN**	**Drain sense** Connect directly to the synchronous MOSFET drain terminal.
5	**REF**	**Reference** Connect this pin to Vcc via R_{REF} resistor. Select R_{REF} to source 1.02mA into this pin. Refer to Table 1 and 2, in Application Information section.
6	**DNC**	**Do not connect** Leave pin floating.
7	**GND**	**Ground** Connect this pin to the synchronous MOSFET source terminal and ground reference point.
8	**GATE**	**Gate drive** This pin sinks and sources the I_{SINK} and I_{SOURCE} current to the synchronous MOSFET gate.

Maximum Ratings @T_A = 25°C unless otherwise specified

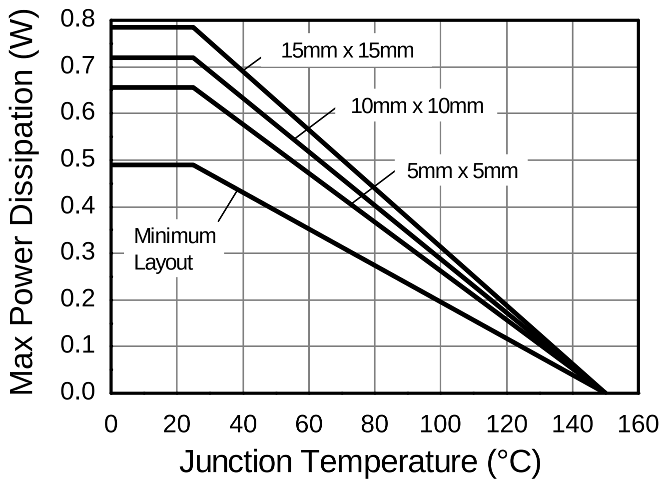
Characteristic	Symbol	Value	Unit
Supply voltage, relative to GND	V_{CC}	15	V
Drain pin voltage	V_D	-3 to 100	V
Gate output voltage	V_G	-3 to V_{CC} + 3	V
Gate Driver peak source current	I_{SOURCE}	4	A
Gate Driver peak sink current	I_{SINK}	9	A
Reference voltage	V_{REF}	V_{CC}	V
Reference current	I_{REF}	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 4)	P_D	490 3.92	mW mW/°C
	(Note 5)		655 5.24	
	(Note 6)		720 5.76	
	(Note 7)		785 6.28	
Thermal Resistance, Junction to Ambient	(Note 4)	$R_{\theta JA}$	255	°C/W
	(Note 5)		191	
	(Note 6)		173	
	(Note 7)		159	
Thermal Resistance, Junction to Lead	(Note 8)	$R_{\theta JL}$	135	°C/W
Operating Temperature Range		T_J	-40 to +150	°C
Storage Temperature Range		T_{STG}	-50 to +150	

Notes:
4. 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.
5. Same as note (4), except pin 1 (V_{CC}) and pin 7 (GND) are both connected to separate 5mm x 5mm 1oz copper heatsinks.
6. Same as note (5), except both heatsinks are 10mm x 10mm.
7. Same as note (5), except both heatsinks are 15mm x 15mm.
8. Thermal resistance from junction to solder-point at the end of each lead on pin 1 (V_{CC}) and pin 7 (GND).

Thermal Derating Curve



Derating Curve

ESD Rating

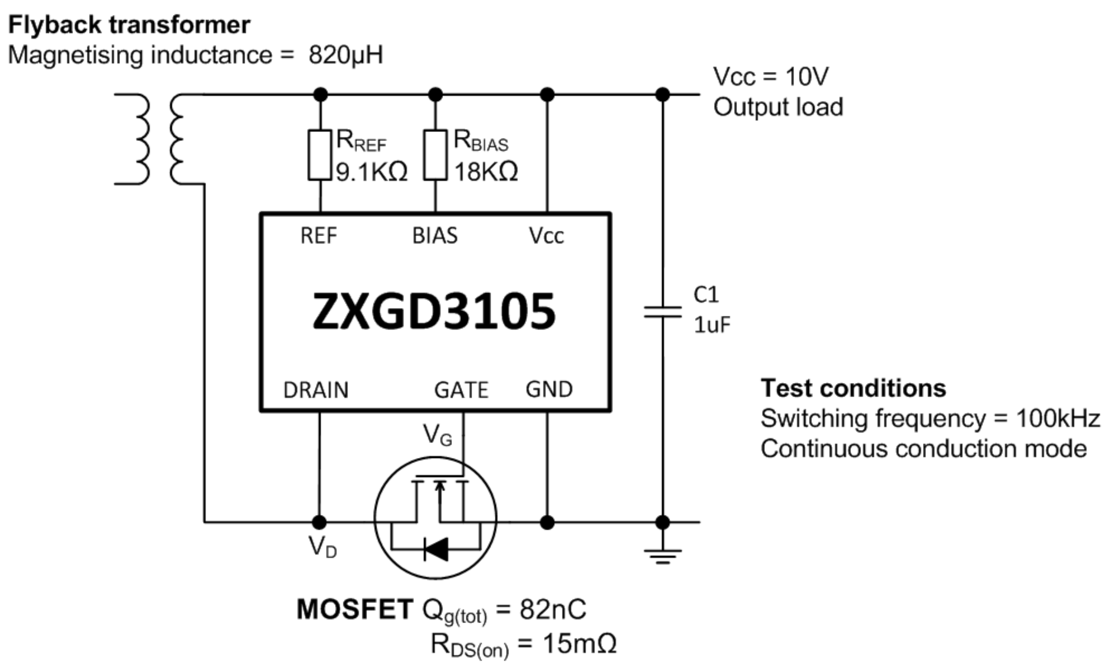
Characteristic	Value	Unit
ESD for Human Body Model	4000	V
ESD for Machine Model	200	

Electrical Characteristics @T_A = 25°C unless otherwise specified

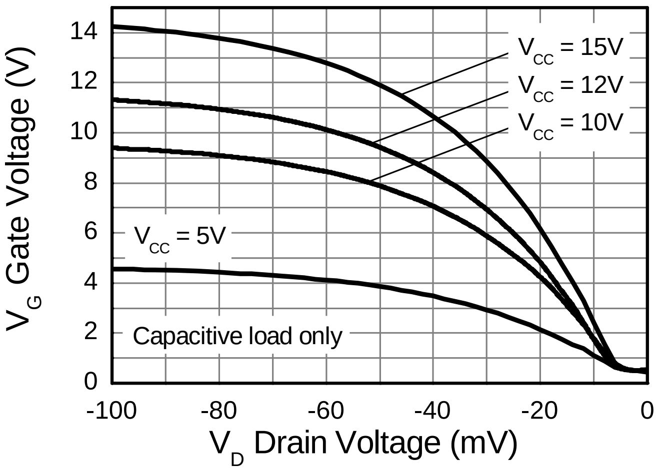
V_{CC} = 10V; R_{BIAS} = 18kΩ (I_{BIAS} = 0.54mA); R_{REF} = 9.1kΩ (I_{REF} = 1.02mA)

Characteristic	Symbol	Min	Typ	Max	Unit	Test Condition	
Input Supply							
Quiescent current	I_Q	-	1.56	-	mA	$V_{DRAIN} \geq 0mV$	
Gate Driver							
Gate peak source current	I_{SOURCE}	-	2	-	A	Capacitive load: C_L = 20nF	
Gate peak sink current	I_{SINK}	-	7	-			
Detector under DC condition							
Turn-off Threshold Voltage	V_T	-20	-10	0	mV	V_G = 1V	Capacitive load only
Gate output voltage	$V_{G(off)}$	-	0.2	0.6	V	$V_{DRAIN} \geq 1V$	
	V_G	5.0	7.8			V_{DRAIN} = -50mV	
		8.0	9.4			V_{DRAIN} = -100mV	
Switching Performance							
Turn-on propagation delay	$t_{d(rise)}$	-	70	-	ns	Rise and fall measured 10% to 90% Refer to application test circuit below	
Gate rise time	t_r	-	175	-			
Turn-off propagation delay	$t_{d(fall)}$	-	15	-			
Gate fall time	t_f	-	20	-			

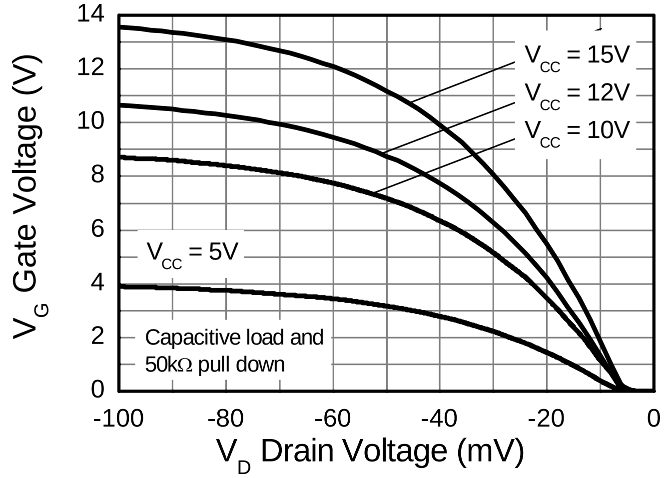
Test Circuit for Switching Performance



Typical Electrical Characteristics @T_A = 25°C unless otherwise specified



Transfer Characteristic



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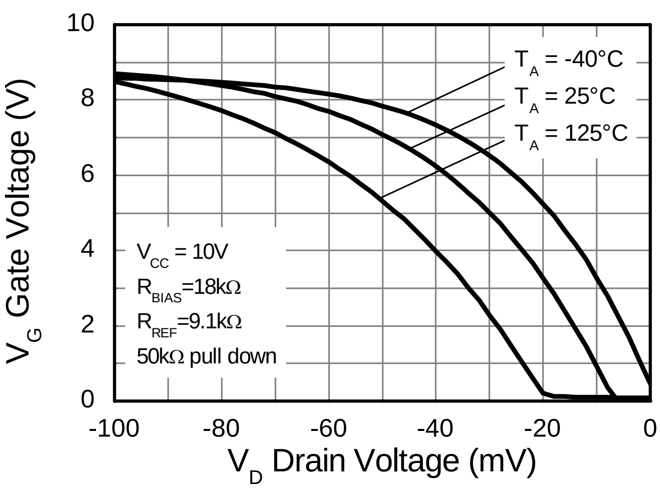
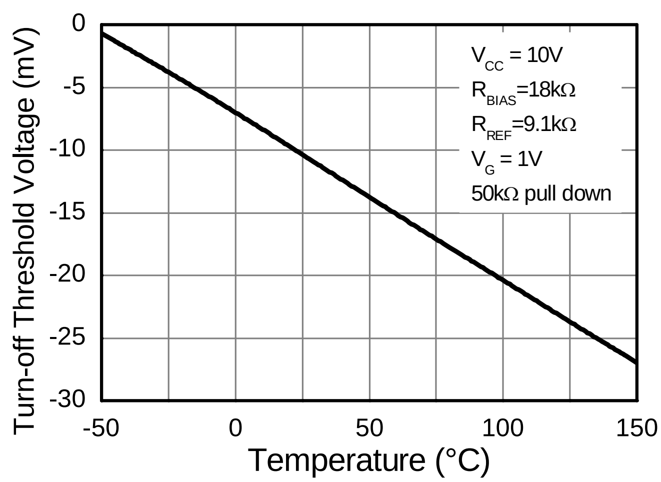
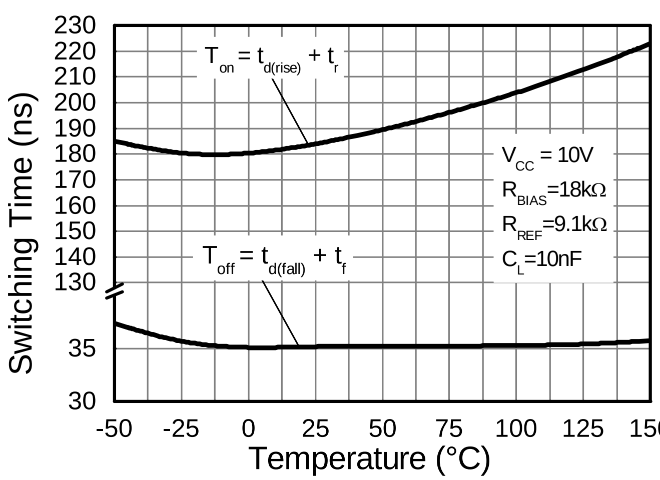


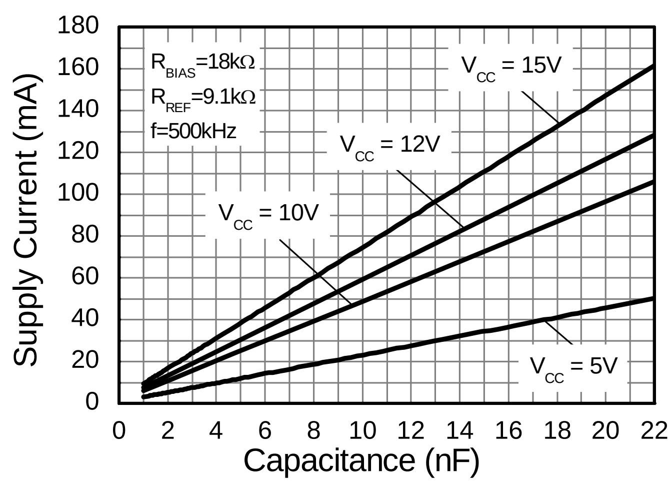
Transfer Characteristic



Turn-off Threshold Voltage vs Temperature

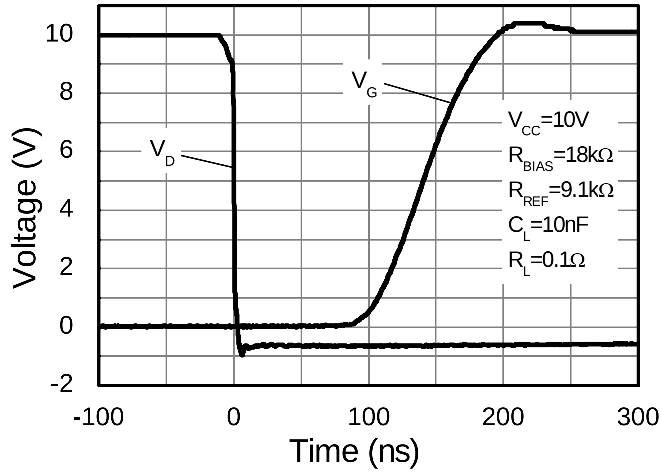


Switching vs Temperature

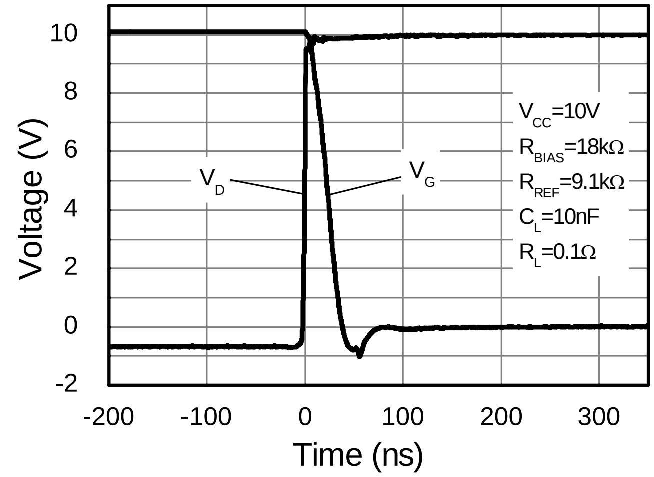


Supply Current vs Capacitive Load

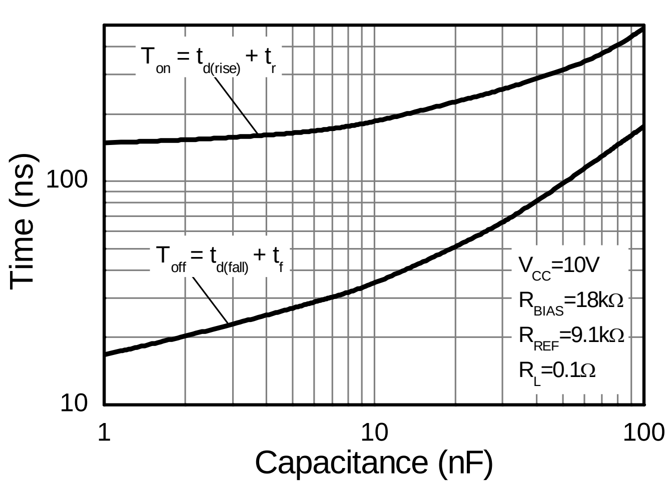
Continued - Typical Electrical Characteristics @T_A = 25°C unless otherwise specified



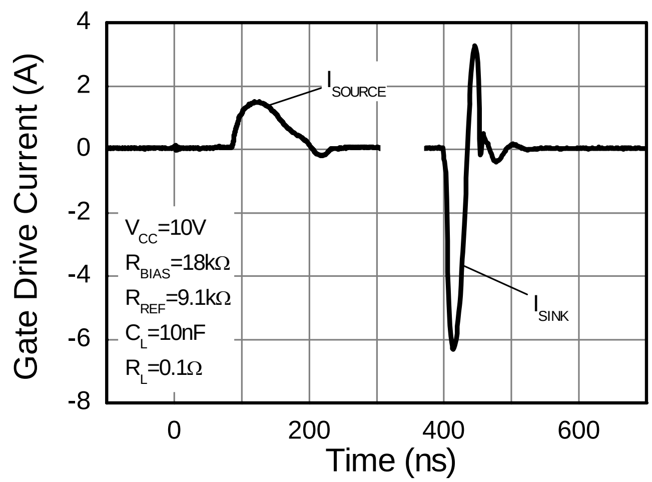
Switch On Speed



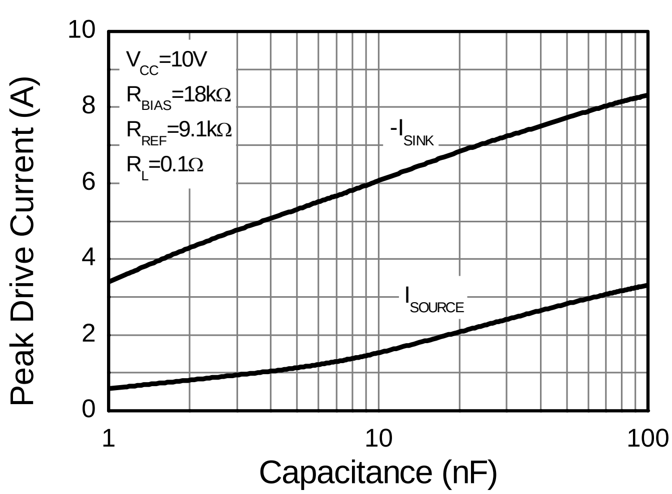
Switch Off Speed



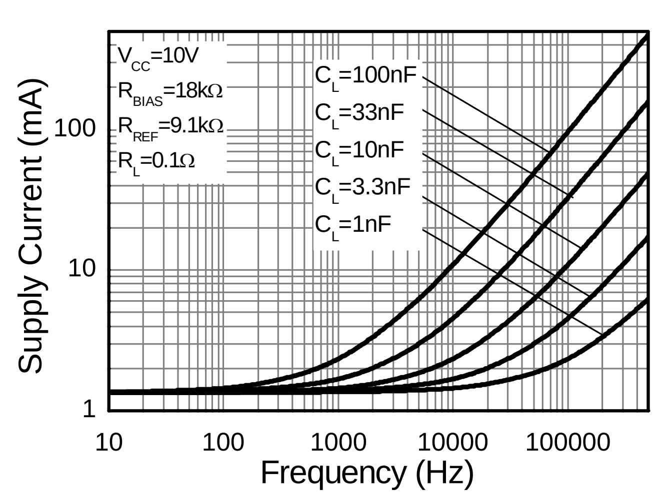
Switching vs Capacitive Load



Gate Drive Current



Gate Current vs Capacitive Load



Supply Current vs Frequency

Application Information

The purpose of the ZXGD3105 is to drive a MOSFET as a low-V_F Schottky diode replacement in isolated AC/DC converter. When combined with a low $R_{DS(ON)}$ MOSFET, the controller can yield significant power efficiency improvement, whilst maintaining design simplicity and incurring minimal component count. Figure 1 shows the typical configuration of ZXGD3105 for synchronous rectification in a low output voltage Flyback converter.

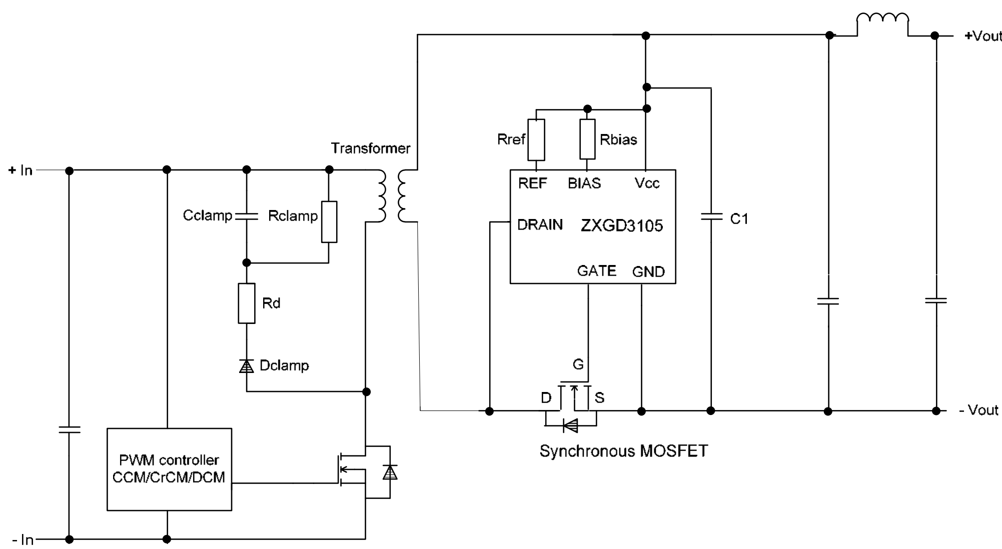


Figure 1 - Typical Flyback application schematic

Threshold voltage and resistor setting

Proper selection of external resistors R_{REF} and R_{BIAS} is important for optimum device operation. R_{REF} and R_{BIAS} supply fixed current into the I_{REF} and I_{BIAS} pin of the controller. I_{REF} and I_{BIAS} combines to set the turn-off threshold voltage level, V_T. In order to set V_T to -10mV, the recommended I_{REF} and I_{BIAS} are 1.02mA and 0.54mA respectively.

The values for R_{REF} and R_{BIAS} are selected based on the Vcc voltage. If the Vcc pin is connected to the power converter's output, the resistors should be selected based on the nominal converter's output voltage. Table 1 provides the recommended resistor values for different Vcc voltages.

Supply, Vcc	Bias Resistor, R_{BIAS}	Reference Resistor, R_{REF}
5 V	9.6 kΩ	4.3 kΩ
10 V	18 kΩ	9.1 kΩ
12 V	24 kΩ	11 kΩ
15 V	30 kΩ	15 kΩ

Table 1 – Recommended resistor values for different Vcc voltages

Functional descriptions

The operation of the device is described step-by-step with reference to the timing diagram in Figure 2.

1. The detector stage monitors the MOSFET Drain-Source voltage.

2. When, due to transformer action, the MOSFET body diode is forced to conduct there is a negative voltage on the Drain pin due to the body diode forward voltage.

3. When the negative Drain voltage crosses the turn-off Threshold voltage V_T, the detector stage outputs a positive voltage with respect to ground after the turn-on delay time $t_{d(fall)}$. 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 MOSFET on-resistance-induced Drain-Source voltage. Proportional gate drive ensures that MOSFET conducts during majority of the conduction cycle to minimize power loss in the body diode.

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 falls to 1V 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 off.

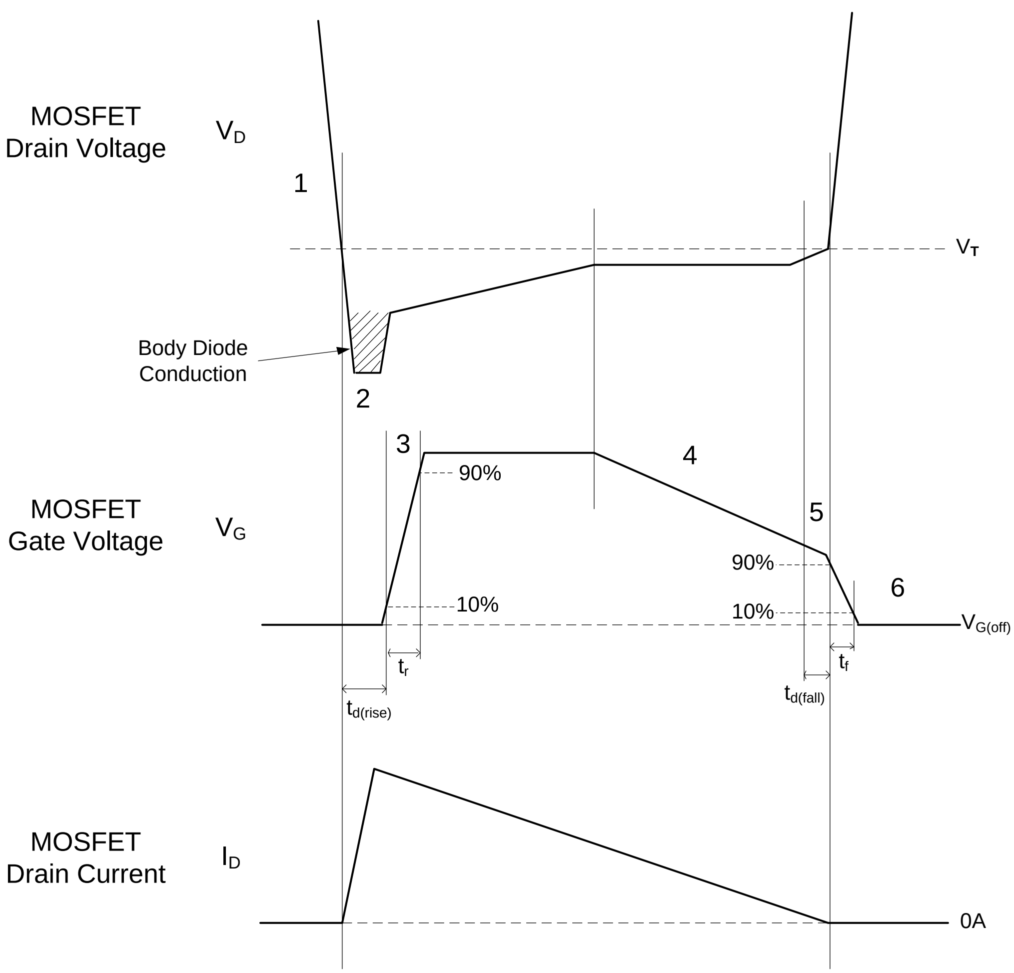


Figure 2 - Timing diagram for a critical conduction mode Flyback converter

Gate driver

The controller is provided with single channel high current gate drive output, capable of driving one or more N-channel power MOSFETs. The controller can operate from Vcc of 4.5V to drive both standard MOSFETs and logic level MOSFETs.

The Gate pins should be as close to the MOSFET's gate as possible. A resistor in series with GATE pin helps to control the rise time and decrease switching losses due to gate voltage oscillation. A diode in parallel to the resistor is typically used to maintain fast discharge of the MOSFET's gate.

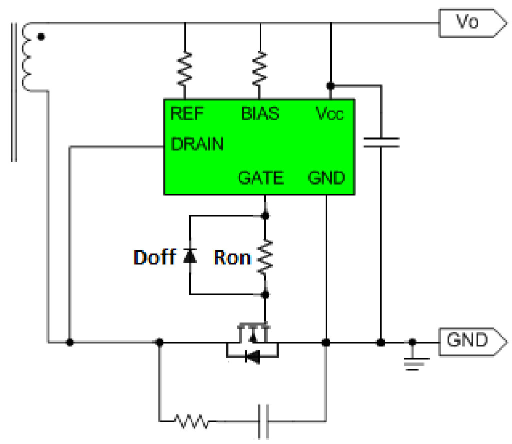


Figure 3 - Typical connection of the ZXGD3105 to the synchronous MOSFET

Quiescent current consumption

The quiescent current consumption of the controller is the sum of I_{REF} and I_{BIAS}. For an application that requires ultra-low standby power consumption, I_{REF} and I_{BIAS} can be further reduced by increasing the value of resistor R_{REF} and R_{BIAS}.

Bias Current I_{BIAS}	Ref Current I_{REF}	Bias Resistor R_{BIAS}	Ref Resistor R_{REF}	Quiescent Current I_Q
0.25mA	0.61mA	39.2KΩ	15.4KΩ	0.86mA
0.35mA	0.81mA	28.0KΩ	11.5KΩ	1.16mA
0.46mA	0.99mA	21.5KΩ	9.3KΩ	1.45mA
0.50mA	1.00mA	19.6KΩ	8.9KΩ	1.50mA
0.55mA	1.13mA	17.8KΩ	8.1KΩ	1.68mA
0.80mA	1.66mA	12.1KΩ	5.6KΩ	2.46mA

Table 2 – Quiescent current consumption for different resistor values at Vcc=10V

I_{REF} also controls the gate driver peak sink current whilst I_{BIAS} controls the peak source current. At the default current value of I_{REF} and I_{BIAS} of 1.02mA and 0.54mA, the gate driver is able to provide 2A source and 6A sink current. The gate current decreases if I_{REF} and I_{BIAS} are reduced. Care must be taken in reducing the controller quiescent current so that sufficient drive current is still delivered to the MOSFET particularly for high switching frequency application.

Layout guidelines

When laying out the PCB, care must be taken in decoupling the ZXGD3105 closely to V_{CC} and ground with 1µF low-ESR, low-ESL X7R type ceramic bypass capacitor. If the converter's output voltage is higher than 15V, a series voltage regulator between the converter's output voltage and the Vcc pin, can be used to get a stable Vcc voltage.

GND is the ground reference for the internal high voltage amplifier as well as the current return for the gate driver. So the ground return loop should be as short as possible. Sufficient PCB copper area should be allocated to the Vcc and GND pin for heat dissipation especially for high switching frequency application.

Any stray inductance involved by the load current may cause distortion of the drain-to-source voltage waveform, leading to premature turn-off of the synchronous MOSFET. In order to avoid this issue, drain voltage sensing should be done as physically close to the drain terminals as possible. The PCB track length between the controller Drain pin and MOSFET's terminal should be kept less than 10mm. MOSFET packages with low internal wire bond inductance are preferred for high switching frequency power conversion to minimize body diode conduction.

After the primary MOSFET turns off, its drain voltage oscillates due to reverse recovery of the snubber diode. These high frequency oscillations are reflected across the transformer to the drain terminal of the synchronous MOSFET. The synchronous controller senses the drain voltage ringing, causing its gate output voltage to oscillate. The synchronous MOSFET cannot be fully enhanced until the drain voltage stabilizes.

In order to prevent this issue, the oscillations on the primary MOSFET can be damped with either a series resistor Rd to the snubber diode or an R-C network across the diode. Both methods reduce the oscillations by softening the snubber diode's reverse recovery characteristic.

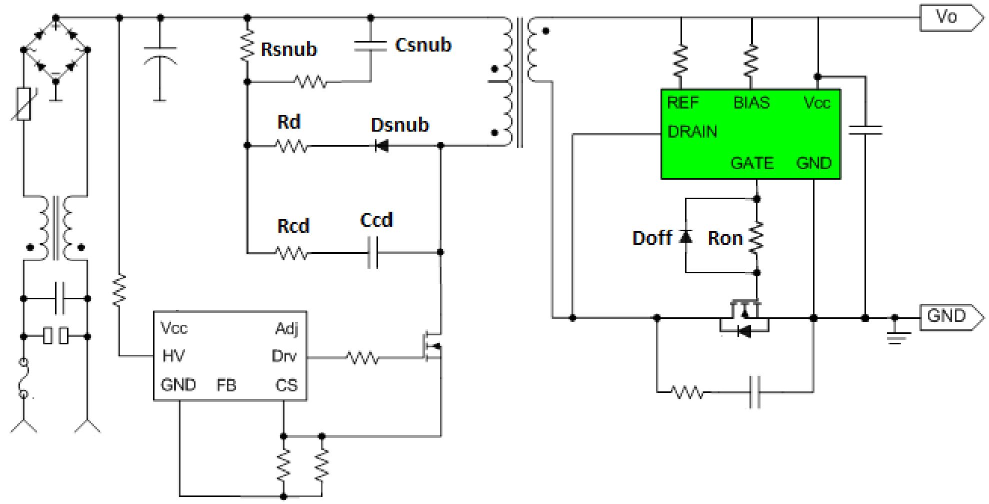
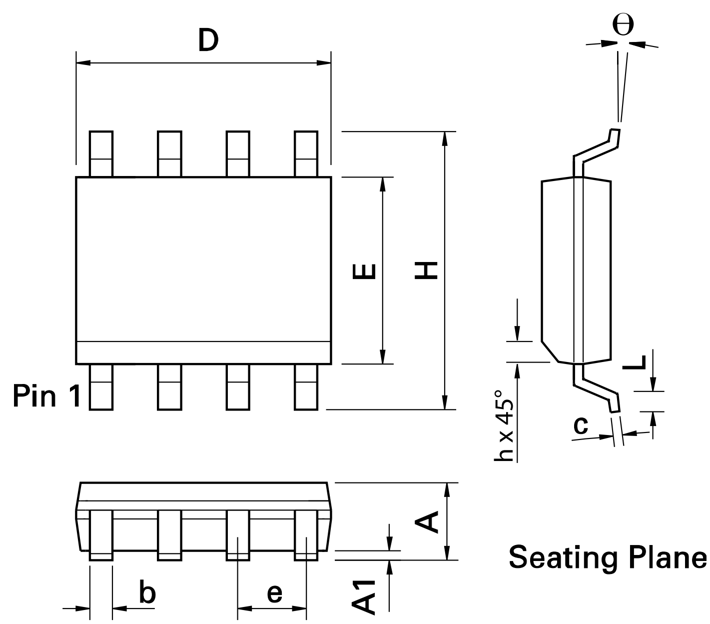


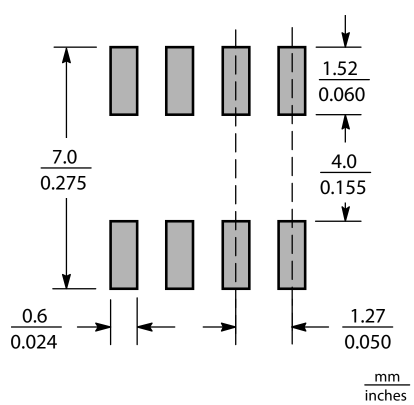
Figure 4 - Primary side snubber network to reduce drain voltage oscillations

Package Outline Dimensions



DIM	Inches		Millimeters		DIM	Inches		Millimeters	
	Min.	Max.	Min.	Max.		Min.	Max.	Min.	Max.
A	0.053	0.069	1.35	1.75	e	0.050 BSC		1.27 BSC	
A1	0.004	0.010	0.10	0.25	b	0.013	0.020	0.33	0.51
D	0.189	0.197	4.80	5.00	c	0.008	0.010	0.19	0.25
H	0.228	0.244	5.80	6.20	θ	0°	8°	0°	8°
E	0.150	0.157	3.80	4.00	h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27	-	-	-	-	-

Suggested Pad Layout



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