

AN1170

DGD0215 DGD0216 and DGD0211C Application Information

The DGD0215/16 and DGD0211C are High-Speed, Low-Side Gate Drivers, capable of source current of 1.9A and sink current of 1.8A. Low-Side Gate Drivers will optimally charge the gate of MOSFETs or IGBTs in a ground-based configuration. Below (Figure 1) is an example application using the DGD0216 with an IGBT in a PFC application; the aim of the DGD0216 is to optimally drive Q1 by quickly providing a charge on the gate when OUT becomes high. Typical PWM from the PFC control is 3.3V and the DGD0215/16 and DGD0211C convert the 3.3V to the value of VCC, often 12V. Because of their high-speed performance, the DGD0215/16 and DGD0211C are also well suited for low voltage power supplies. In this discussion, the important parameters needed to design in the DGD0215/16 and DGD0211C are discussed: Gate Driver component selection, decoupling capacitor discussion, and PCB layout suggestions.

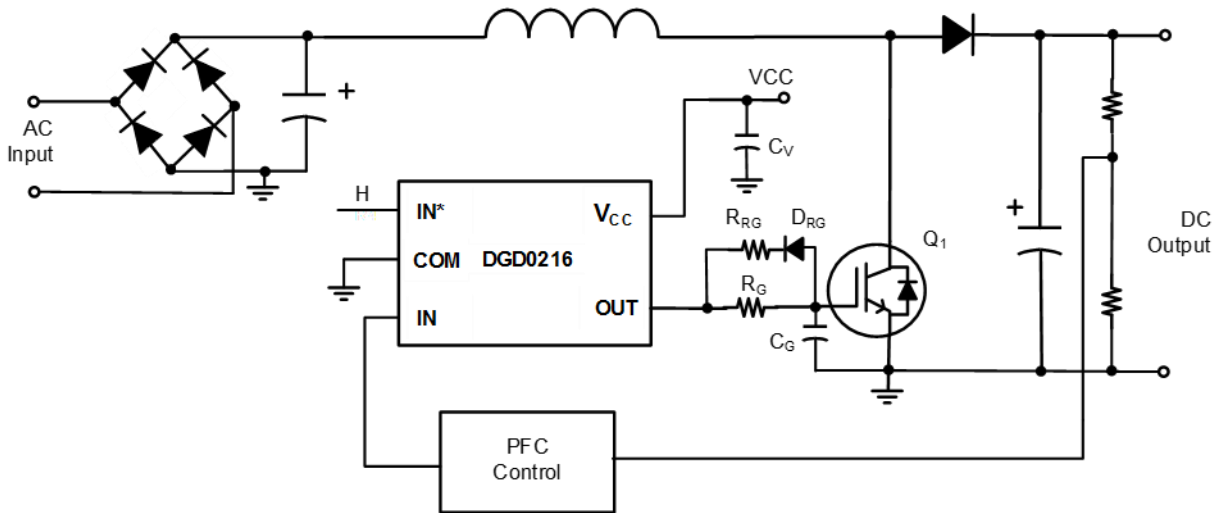


Figure 1. PFC application example using Low-Side Gate Driver DGD0216

Gate Component Selection

The most crucial time in the gate drive is the turn on and turn off of the IGBT; the aim is to perform this function quickly, but with minimal noise and ringing when the IGBT turns on. Too fast a rise/fall time can cause unnecessary ringing and poor EMI, and too slow a rise/fall time will increase switching losses in the IGBT.

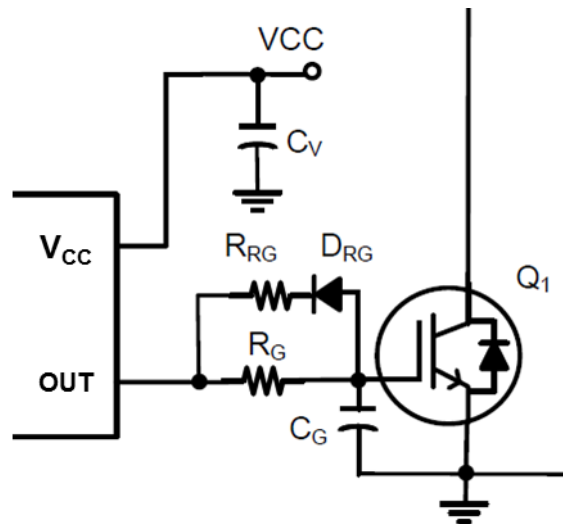


Figure 2. Gate Drive components for DGD0216

Considering the Gate Driver components for the DGD0216 in Figure 2, with the careful selection of R_G and R_{RG} , it is possible to selectively control the rise time and fall time of the gate drive to the IGBT. For turn on, all current will go from the IC through R_G and charge the IGBT gate capacitance, hence increasing or decreasing R_G will increase or decrease rise time in the application. With the addition of D_{RG} , the fall time can be separately controlled as the turn off current flows from the IGBT gate capacitance, through R_{RG} and D_{RG} to the driver in the IC to GND. So, increasing or decreasing R_{RG} will increase or decrease the fall time. Sometimes finer control is not needed and only R_G needs to be used.

Increasing turn on and turn off has the effect of limiting ringing and noise due to parasitic inductances, hence with a noisy environment, it may be necessary to increase the gate resistors. Gate component selection is a compromise of faster rise time with more ringing, and a poorer EMI but better efficiency, contrasted with a slower rise time with better EMI, better noise performance but poorer efficiency. The exact value depends on the parameters of the application and system requirements. R_G values are typically between 5Ω and 50Ω , optimal value decided by IGBT gate capacitance and drive current of gate driver. R_{RG} values are typically between 3Ω and 20Ω , optimal value decided by IGBT gate capacitance and drive current of gate driver.

The gate to source capacitor C_G is also used to minimize ringing and noise and to provide overall stability if the gate driver and IGBT are not the optimal match. Most systems will not need C_G (increasing the gate resistor can decrease ringing and provide system stability) but if required, then $C_G = 1nF$ is a good typical value.

V_{CC} Decoupling Capacitors

For optimal operation, V_{CC} decoupling is crucial for all Gate Driver ICs. With poor decoupling, larger V_{CC} transients will occur at the IC when switching.

As shown in Figure 2, C_V is the decoupling capacitor. C_V is used to decouple faster edge changes to V_{CC} and should be a low ESR ceramic capacitor placed close to the V_{CC} pin (see Layout section). This component provides stability when V_{CC} is quickly pulled down with load from the IC; typical values are $0.1\mu F$ to $1\mu F$.

Inputs and Device Response

The inputs of the DGD0215, DGD0216 and the DGD0211C, and the input to output function, are the main difference between the three Low- Side Gate Drivers. Below, the inputs and input to output response are described for each device.

For the DGD0215/16, the IC PWM inputs, IN and IN*, are very high impedance inputs with a pull-down resistor for IN and a pull-up resistor for IN*. The pull-up and pull-down resistors on IN* and IN have an approximate value of $500k\Omega$ (see Figure 3).

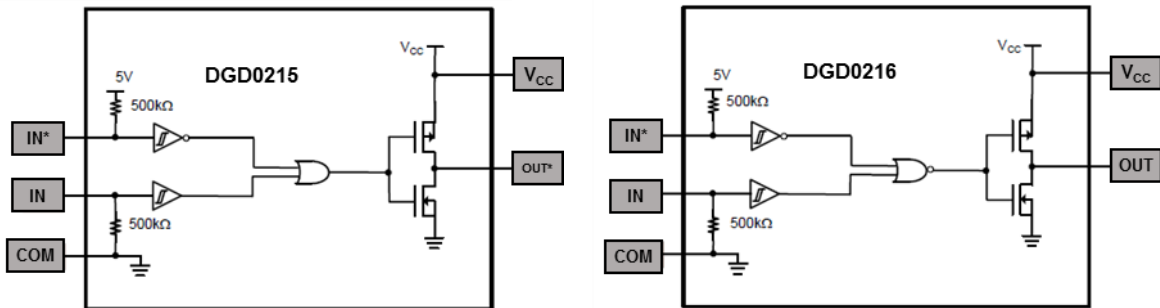


Figure 3. Input logic and functional block diagram for DGD0215 and DGD0216.

The DGD0215/16 is typically used by driving one input and keeping the other input in a known state. To drive the PWM on the IN pin, and for best noise performance, it is suggested to connect the IN* directly to H (see Figure 1, i.e. 3.3V or 5.0V). To drive the PWM on the IN* pin, and for best noise performance, it is suggested to connect the IN pin directly to GND. The table shown in Figure 4 indicates the input/output response table of the DGD0215/16.

IN	IN*	DGD0215 (OUT*)	DGD0216 (OUT)
H	H (open)	L	H
L	H (open)	H	L
L (open)	H	H	L
L (open)	L	L	H

Figure 4. Input/output response table for the DGD0215 and DGD0216.

For the DGD0211C, the IC PWM inputs, IN and IN*, are also very high impedance inputs with a pull-up resistor for IN and a pull-down resistor for IN*. The pull-up and pull-down resistors on IN* and IN also have an approximate value of 500kΩ (see Figure 5). The table shown in Figure 6 indicates the Input/Output relationship of the DGD0211C; when the inputs of the DGD0211C are open, the output is high (to V_{CC}).

IN	IN*	OUT
0	0	0
0	1	0
1	0	1
1	1	0

Figure 6. Input/output response table for the DGD0211C.

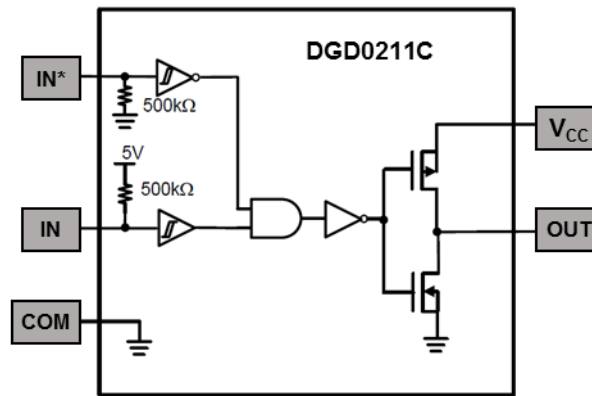


Figure 5. Input logic and functional block diagram for the DGD0211C.

Matching Gate Driver with MOSFET or IGBT

IC drive current and MOSFET/IGBT gate charge

Gate Driver ICs are defined by their output drive current, its ability to source current to the gate of the MOSFET/IGBT at turn on and to sink current from the gate of the MOSFET/IGBT at turn off. For the DGD0215/16 and DGD0211C the source and sink drive current is $I_{O+} = 1.9A$ and $I_{O-} = 1.8A$.

For a given MOSFET/IGBT, with the known drive current of the DGD0215/16 and DGD0211C, you can estimate how long it will take to turn on/off the MOSFET/IGBT with the equation:

$$t = Q_g / I$$

Q_g = total charge of the MOSFET/IGBT as provided by the datasheet

I = sink/source capability of the gate driver IC

t = calculated rise/fall time with the given charge and drive current

For example, consider the Diodes' DMN3009SK3, 30V 20A, $Q_g = 42nC$; with the DGD0215/16 and DGD0211C $I_{O+} = 1.9A$ then $t_r = 22ns$, and for $I_{O-} = 1.8A$, $t_f = 23ns$. These are estimates as the total charge given in the datasheet may not be the same conditions in the application. Also, the addition of a gate resistor will increase the t_r and t_f .

PCB layout suggestions

Layout also plays a considerable role since unwanted noise coupling, unpredicted glitches and abnormal operation could arise due to poor layout of the associated components. Figure 7 shows the DGD0215/16 and DGD0211C with parasitic inductances in the high current path (L_{P1} , L_{P2}) which would be caused by inductance in the metal of the trace. Considering Figure 7, the length of the tracks in red should be

minimized and the decoupling capacitor (C_v) should be placed as close to the IC as possible as well as using low ESR ceramic capacitors. And finally, the gate resistor (R_G) should be a surface mount device. These suggestions will reduce the parasitics due to the PCB traces.

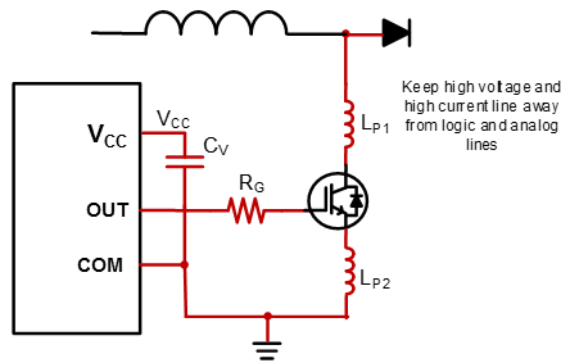


Figure 7. Layout suggestions for DGD0215/16 and DGD0211C, tracks in red should be as short as possible

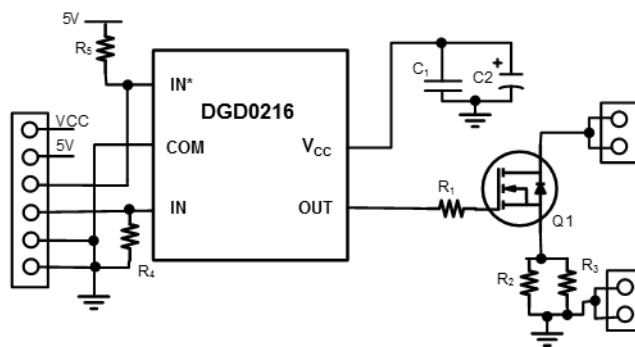


Figure 8. Schematic for layout example of DGD0216 shown in Figure 9.

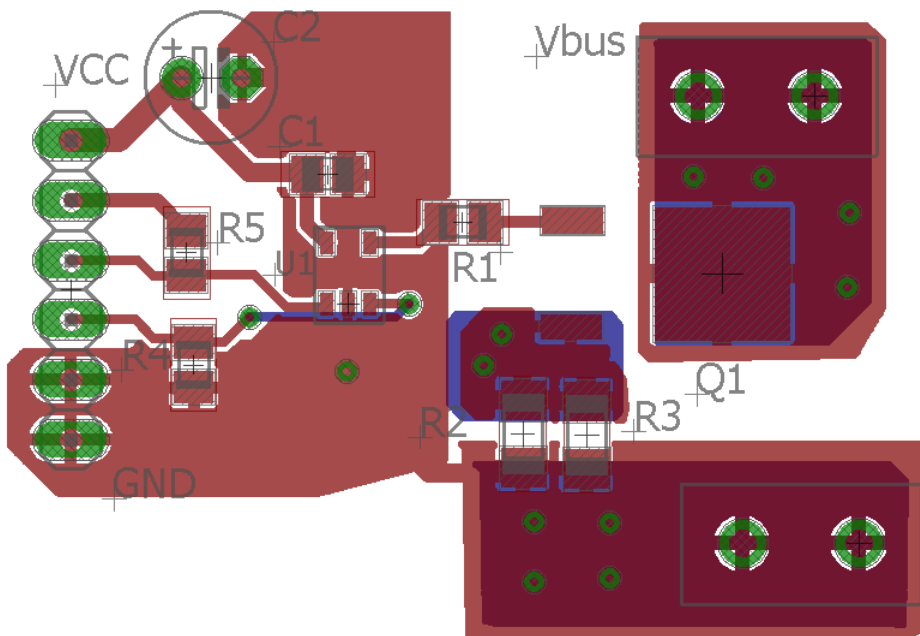


Figure 9. Layout of the schematic shown in Figure 8.

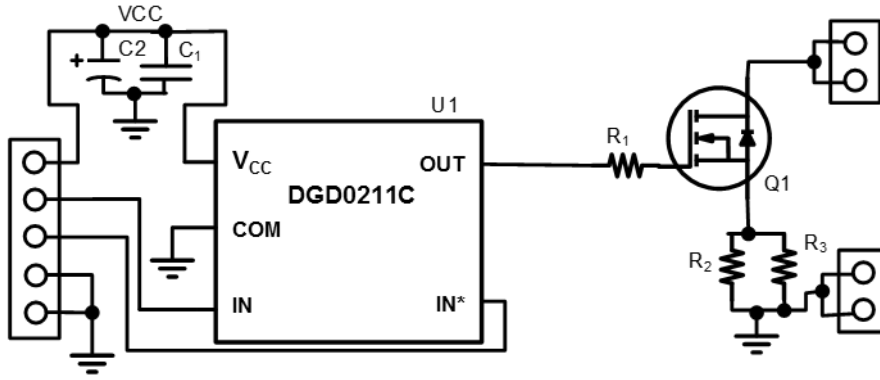


Figure 10. Schematic for layout example of DGD0211C shown in Figure 11.

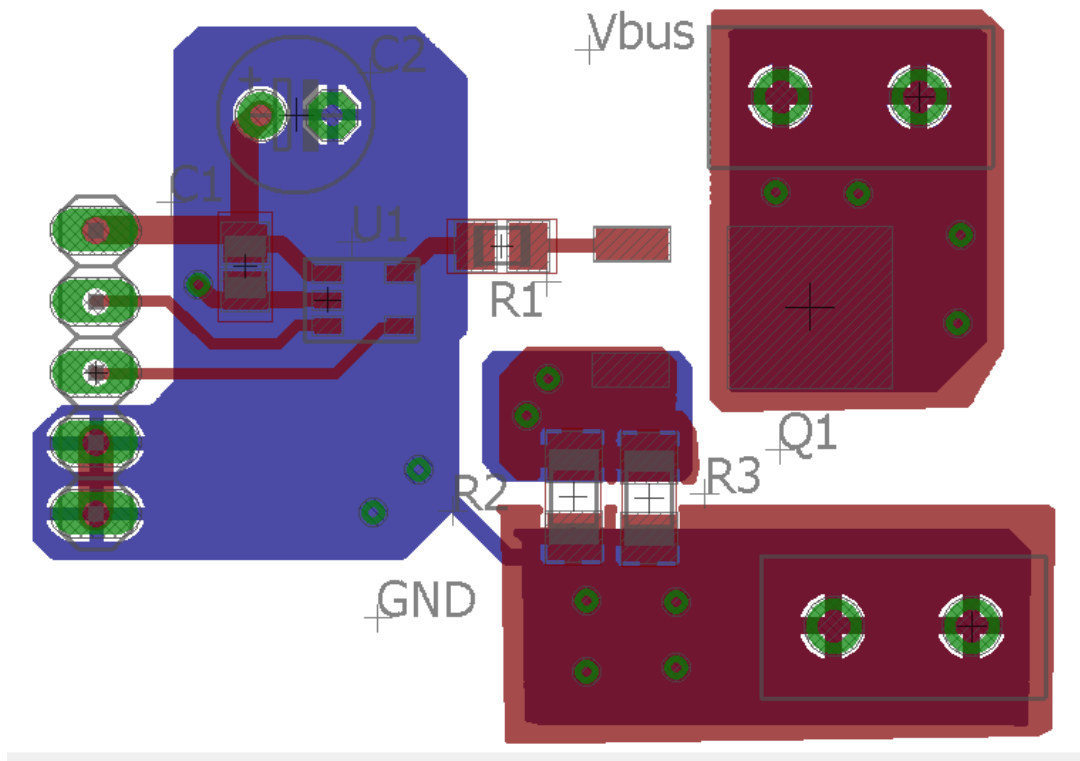


Figure 11. Layout example of the DGD0211C, schematic shown in Figure 10.

IMPORTANT NOTICE

1. DIODES INCORPORATED AND ITS SUBSIDIARIES (“DIODES”) MAKE NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO ANY INFORMATION CONTAINED IN THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).
2. The Information contained herein is for informational purpose only and is provided only to illustrate the operation of Diodes products described herein and application examples. Diodes does not assume any liability arising out of the application or use of this document or any product described herein. This document is intended for skilled and technically trained engineering customers and users who design with Diodes products. Diodes products may be used to facilitate safety-related applications; however, in all instances customers and users are responsible for (a) selecting the appropriate Diodes products for their applications, (b) evaluating the suitability of the Diodes products for their intended applications, (c) ensuring their applications, which incorporate Diodes products, comply the applicable legal and regulatory requirements as well as safety and functional-safety related standards, and (d) ensuring they design with appropriate safeguards (including testing, validation, quality control techniques, redundancy, malfunction prevention, and appropriate treatment for aging degradation) to minimize the risks associated with their applications.
3. Diodes assumes no liability for any application-related information, support, assistance or feedback that may be provided by Diodes from time to time. Any customer or user of this document or products described herein will assume all risks and liabilities associated with such use, and will hold Diodes and all companies whose products are represented herein or on Diodes’ websites, harmless against all damages and liabilities.
4. Products described herein may be covered by one or more United States, international or foreign patents and pending patent applications. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks and trademark applications. Diodes does not convey any license under any of its intellectual property rights or the rights of any third parties (including third parties whose products and services may be described in this document or on Diodes’ website) under this document.
5. Diodes products are provided subject to Diodes’ Standard Terms and Conditions of Sale (<https://www.diodes.com/about/company/terms-and-conditions/terms-and-conditions-of-sales/>) or other applicable terms. This document does not alter or expand the applicable warranties provided by Diodes. Diodes does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel.
6. Diodes products and technology may not be used for or incorporated into any products or systems whose manufacture, use or sale is prohibited under any applicable laws and regulations. Should customers or users use Diodes products in contravention of any applicable laws or regulations, or for any unintended or unauthorized application, customers and users will (a) be solely responsible for any damages, losses or penalties arising in connection therewith or as a result thereof, and (b) indemnify and hold Diodes and its representatives and agents harmless against any and all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim relating to any noncompliance with the applicable laws and regulations, as well as any unintended or unauthorized application.
7. While efforts have been made to ensure the information contained in this document is accurate, complete and current, it may contain technical inaccuracies, omissions and typographical errors. Diodes does not warrant that information contained in this document is error-free and Diodes is under no obligation to update or otherwise correct this information. Notwithstanding the foregoing, Diodes reserves the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes.
8. Any unauthorized copying, modification, distribution, transmission, display or other use of this document (or any portion hereof) is prohibited. Diodes assumes no responsibility for any losses incurred by the customers or users or any third parties arising from any such unauthorized use.

Copyright © 2021 Diodes Incorporated

www.diodes.com