Version 1.1

DISCRETE
ANALOG
LOGIC

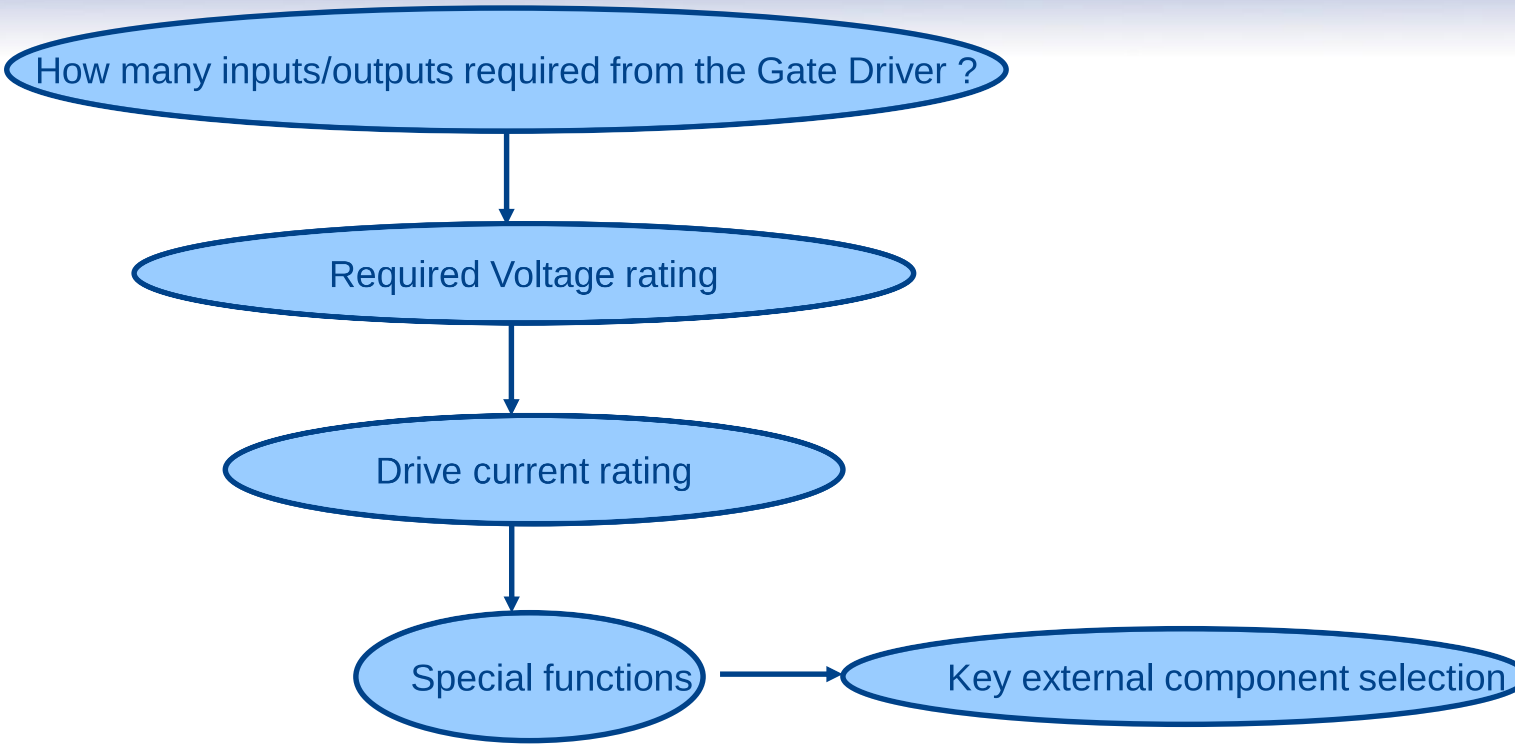
Gate Drivers

Presenter: Bipolar Business Unit

Date: November 2018

www.diodes.com

Selection and/or Design-in Criteria



Selection and/or Design-in Criteria

- How many inputs/output are provided for/by the Gate driver?
  - For the inputs, It depends on the choice of the micro controller and the control algorithm chosen by the designer
  - For 2 inputs, the choice is high-side / low-side gate driver
  - For 1 input, the choice is a half-bridge driver
  - Number of outputs depend on the number of half bridges that require driving

- How to select the voltage rating?
  - A conservative rule is to pick a voltage rating 3 times the operating voltage, with 1.5 times being a recommended minimum. However, this depends purely on the system requirements and usually set by the designer

  - Gate drivers always work with MOSFET/IGBT, best practise is to match the voltage rating of the chosen MOSFET/IGBT

Selection and/or design in criteria

❑ How much drive current is required?

- ❑ Information about the required gate charge to raise the gate voltage to the desired level is essential

- ❑ Gate charge information is provided by the MOSFET manufacturer in their datasheet, usually for a gate voltage of 10V

- ❑ Now that we know the required gate charge, we choose the drive current rating depending on the rise and fall times we are targeting. The equation to use is Qg = Igate * time

  Example: Qg = 50nc. Required Tr = 50ns and Tf = 25ns.
  Igate (source) = 50/50 = 1A of source current.
  Igate(sink) = 50/25 = 2A of sink current.

- ❑ The above calculation provides you with a minimum figure. Often it is not easy to find a tailored gate driver. Best practice is to choose a gate driver with higher than the required rating and use series gate resistors to limit the source and sink currents

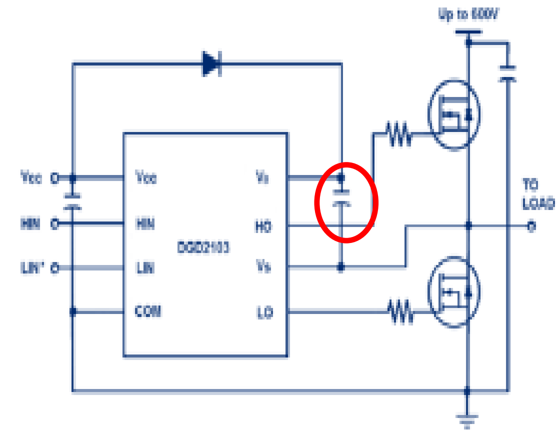
Selection and/or Design-in Criteria

- **Special functions**
  - **Some applications need special functions like inbuilt and/or adjustable dead time, enable option, shoot through prevention logic, delay matching etc. to ensure the selected gate driver comes with the required optional features.**
- **Key external component selection**
  - **Boot strap capacitor selection**
  - **Gate resistor selection**
  - **Layout recommendations for managing switch node noise**

Bootstrap Capacitor Selection

The capacitance of the bootstrap capacitor should be high enough to provide the charge required by the gate of the high-side MOSFET. As a general guideline, it is recommended to make sure the charge stored by the bootstrap capacitor is about 50 times more than the required gate charge at operating V_{CC} (usually about 10V to 12V).

The formula to calculate the charge in C_{BS} to provide sufficient gate charge is shown below; Q = C * V where Q is the gate charge required by the external MOSFET . C is the bootstrap capacitance and V is the bootstrap voltage V_{BS}



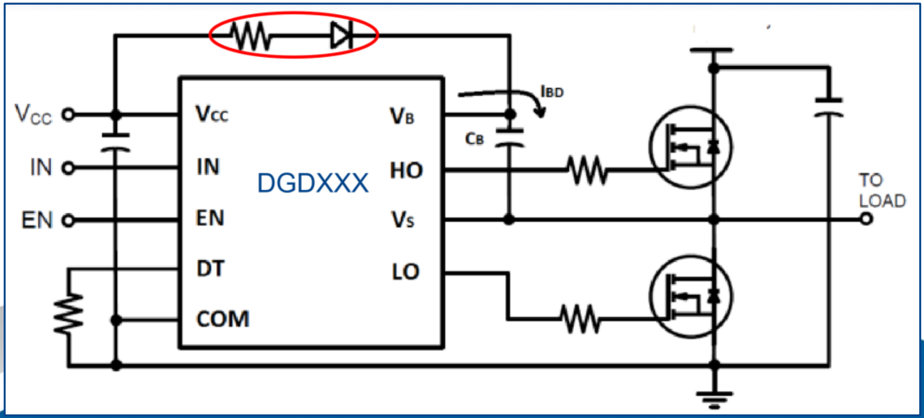
Example: To switch a high-side MOSFET that requires 20nC of gate charge to raise its gate voltage to 10V, the capacitor size can be calculated as below;

QG(MOSFET) = C(BOOTSTRAP) * V(BOOTSTRAP) * 50

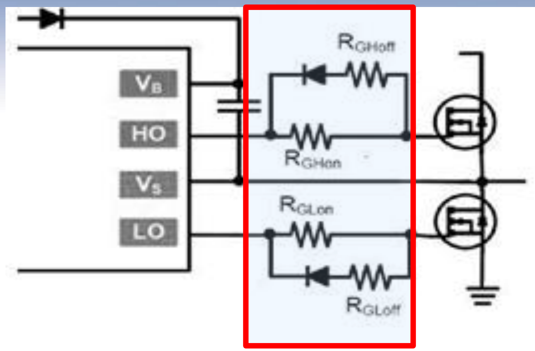
$C_{BS} = Q_G / V_{BS} =$ 20nC / 10V * 50 = 100nF

Bootstrap Diode selection

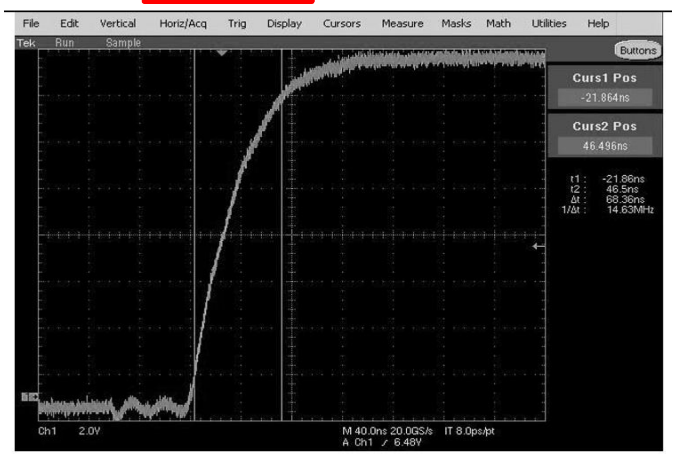
- Some of the DGDXXX series gate drivers come with an internal bootstrap diode
- Where an external bootstrap diode is necessary, designer should choose its voltage and current ratings appropriately
  - V_R rating of the bootstrap diode should be >= the voltage rating of the gate driver OR the MOSFETs, whichever is lower.
    - Though the average current flowing though the bootstrap diode under normal operation is very small, it is important to consider the start-up current. When the system is first powered, there will be an inrush current flowing into the bootstrap diode
    - Inrush current is directly proportional to the size of the bootstrap capacitance. Larger the capacitance, larger will be the inrush current. Hence it is important to follow the design recommendations in the previous slide while choosing the capacitor. Also a series current limiting resistor is recommended almost every time
    - Optimum capacitor size and appropriate series resistance combination is important to avoid any unnecessary stresses on the bootstrap diode



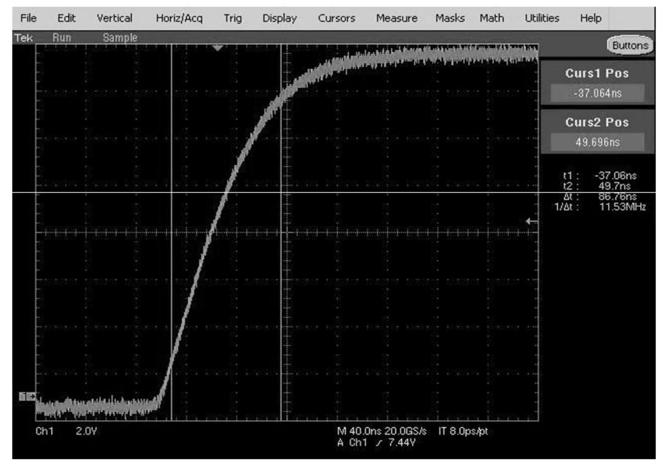
Gate Resistor Selection



- A typical gate drive current control circuit is shown here.
- By adjusting the R_{Gon} and R_{Goff} resistors respectively, the rise and fall times can be controlled individually
- The effect of the gate resistance on the switching time is shown in the below example, where the on-time is increased from 68ns to 86ns



DGD2106 with RGLon = 3Ω & Tr = 68ns



DGD2106 with RGLon = 100Ω & Tr = 86ns

Switch Node Noise Management

- Switch node shown in the figure as V_S, is the noisiest node in the half-bridge circuits.

- DGDxxxx series gate drivers come with a good 50V/ns immunity at the switch node, however for meeting certain EMI specifications a few layout techniques are recommended below

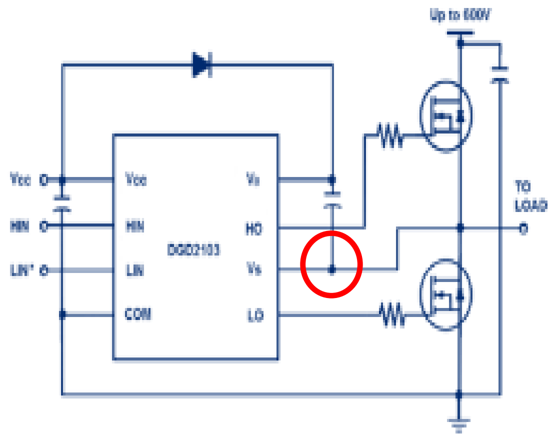
  - Tracks connecting the HO and LO pins to the gates must be made as wide and short as possible

  - A correct combination of high side and low side gate resistance help minimise the switch node noise significantly

  - The track length between the high side MOSFET’s source pin and low side MOSFET’s drain pin must be as short as possible

  - Decoupling capacitors must be placed as close as possible between the Vcc and COM pins

  - Low ESR capacitors are ideal for boot strapping applications



Thank you