IGBT drivers correctly calculated

What you must know when dimensioning an IGBT driver

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Introduction

The correct selection and dimensioning of IGBT drivers often involves questions or uncertainties. This is in part due to the specifications of the IGBTs themselves. Thus there is a widespread assumption that the value of the input capacitance *Ciss* specified in the IGBT data sheets corresponds to the input capacitance that is actually effective in the application. Many a developer - gifted in other respects - has fallen into this trap in the past....

The procedure described below has proved its worth for the correct dimensioning of a drive circuit in terms of power rating.

Determining the gate charge and gate capacitance of IGBTs

The most important parameter that must be known for the correct power dimensioning of the driver is the gate charge. And yet this parameter is in many cases not given in the IGBT data sheet or else the conditions (which voltage rise at the gate) under which this charge applies are not clearly specified.

However, the gate charge can be determined relatively simply by measurement. For this purpose, the IGBT must be driven by a driver. It is best to use the particular driver designed for it. Otherwise, the circuit must at least be able to generate the gate voltage required for the application (for example ±15V). In the first instance, the measurement can be performed without a voltage in the load circuit.

The gate charge is calculated from the formula $Q = \int idt = C \bullet \Delta U$

To determine Q, the gate voltage is measured and integrated (most simply with an oscilloscope). The voltage rise ΔU (driver or gate voltage) can be simultaneously displayed on the oscilloscope during the measurement (see Fig. 1).

The formula $C_{IN} = \frac{Q}{\Delta U}$ can now be used to calculate the effective input capacitance.

Note: In this application note, the input capacitance effective in the application and relevant for the design of a driver is given the designation C_{IN}.

Note on Ciss and rule of thumb for conversion

The value *Ciss* specified in the data sheets does not represent any useful parameter for the application. It is measured with a measuring bridge. The measuring voltage used in this process is too small to attain the *gate threshold voltage*, so that the internal feedback effects occurring during switching (Miller effects) are not included in the specification. In this measurement configuration, a voltage of 25 V is applied at the collector for this purpose. At this voltage, the capacitances are smaller than at Vce=0V. The value *Ciss* can therefore be used only for a direct comparison of IGBTs.

As a rule of thumb, our experience with IGBTs from SIEMENS and EUPEC has shown that the following conversion for the input capacitance yields sufficient accuracy:

$C_{IN} \cong 5 \bullet Ciss$

The value Ciss can be obtained from the data sheet.

Calculation of the drive power

The stored energy in the input capacitance is calculated as follows:

$W = ½\, C_{IN} \bullet \Delta U^2$

It should be noted that ΔU is the total voltage rise at the gate, i.e. 30 V at a drive voltage of ±15 V.

As the gate is recharged twice with each clock pulse, the power required to drive an IGBT can be calculated as follows:

$P = f \bullet C_{IN} \bullet \Delta U^2$

Or, if the gate charge was previously determined by measurement:

$P = f \cdot Q \cdot \Delta U$

A driver must therefore consume this power for each IGBT in order to drive it. The gate of the IGBT itself is recharged practically without losses. The losses occur in the external or internal gate resistors (integrated in the IGBT module or IGBT chip).

Note: It should be noted that the calculated power represents the actual net driving power. Additional losses occur in the driver circuit and in the driver's voltage supply circuit. The power at the output of the integrated DC/DC converter is specified for the intelligent drivers from CONCEPT. For the half-bridge drivers, the total converter power is specified, so that half of the specified output power is still available for each channel. It is also needed to supply the power consumed by the driver electronics. This is made up of the internal consumption of the driver (a constant, static component) and the losses in the driver's final stage (an application-dependent component).

The static internal consumption of the drivers is as follows:

IHD215/280/680 per channel,	approx.	0.4W
IHD580Fx per channel,	approx.	0.8W
IGD608/615Ax total,	approx.	0.5W
IGD508/515Ex (without optical components)	approx.	0.5W

In the IGD508/515, the internal consumption of the optical transmitter and receiver should be additionally included in the calculation. As the 5-V supply for the optical receiver is also derived from the internal 16-V supply by means of a linear controller, the current-carrying capacity of the receiver must be multiplied by 16V and not by 5 V.

The internal consumption of a driver channel can be measured as follows: The input-side voltage supply (upstream of the DC/DC converter) is switched off. In its place, the 16-V supply is applied directly to the Cs and COM pins (on the secondary-side blocking capacitor). The current-carrying capacity of the driver in the static state (without a clock pulse at the input) as well as its current consumption at the required clock frequency can now be read off directly from the ammeter inserted into the feeder line.

Calculation of the gate current

The maximum output current of the driver must be equal to or greater than the maximum gate current, that can be calculated from $I_{G\,\max} = \dfrac{\Delta U}{R_{G(\min)}}$.

It should be noted that ΔU is the total voltage rise at the gate, i.e. 30 V at ±15V driving, and that $R_{G(min)}$ is the smallest value of the gate resistance when different gate resistors are used for turning on and off.

Choice of suitable driver

In selecting a suitable driver in terms of power, the following points must be observed:

1) The driver must be able to deliver the required power.
2) The maximum output current of the driver must be equal to or greater than the maximum gate current.

The input current must not exceed the maximum current-carrying capacity specified in the data sheet or at least not do so repeatedly. This should be observed and checked particularly at high gate capacitances (parallel circuits) and for relatively low clock frequencies. The same applies for intermittent pulse packets. In both cases, although the mean current-carrying capacity - measured with an ammeter - is lower than the data sheet value, the greater effective value of the input current can nevertheless lead to an overload of the DC/DC converter in the driver. When performing the check, the current must be measured with a DC current probe (or a shunt) and an oscilloscope inserted between the input-side blocking capacitor and the supply- voltage terminal of the driver.

Note: The ripple of the driver's input current, that must be transformed by the DC/DC converter integrated in the driver, can be reduced by configuring the secondary-side blocking capacitors with minimum inductance and close to the driver and by selecting types with minimum ESR values.

Example calculation

A suitable driver is to be found for a 200A IGBT module from SIEMENS of type BSM200GB120DN2 that is to be driven with a clock frequency of 8 kHz.

The first parameter to be measured is the gate charge (see Fig. 1).

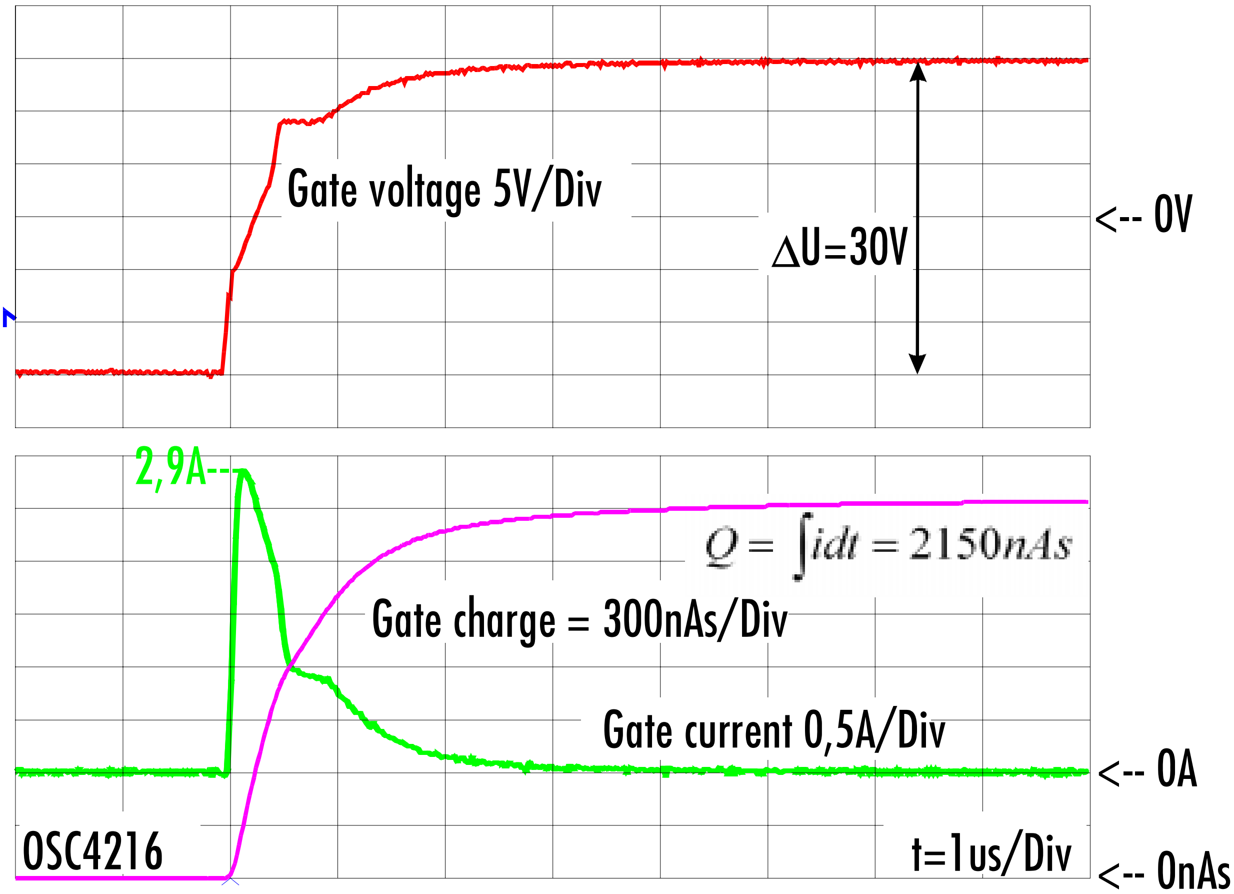

Fig. 1 Gate voltage, gate current and gate charge with BSM200GB120DN2

The two values Q and ΔU can be obtained by measurement (Fig. 1):

Q = 2150nAs ΔU = 30V

Application Note

The gate capacity can now be calculated:

$$C_{IN} = \frac{Q}{\Delta U} = \frac{2150nAs}{30V} = 71{,}6nF$$

The required driver power is then:

$P = f \bullet Q \bullet \Delta U = 8kHz \bullet 2150nAs \bullet 30V = 0{,}516W$

Next, the 0.4W internal consumption of the driver is added:

0.516W + 0.4W = 0.916W

The losses dependent on the clock frequency are essentially negligible at 8 kHz. As the gate voltage also has a value of just under ±14V and is thus smaller than the ±15V used in the calculation, ample reserve is still available.

The gate current at a gate resistance of 4.7 Ω is then:

$$I_{G\max} = \frac{\Delta U}{R_G} = \frac{30V}{4{,}6\Omega} = 6{,}4A$$

The driver suitable for this application is thus the IHD280 intelligent half-bridge driver with a converter power of 2 W (1W per channel) and a maximum gate current of 8 A.

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