

Bodo's Power Systems®

Drive Engineering and Circuitry

17 mm technology: Rectifiers, IGBTs and drivers for motor control

The IGBT is seen as the power semiconductor solving problems, combining the advantages of bipolar and field effect technology, thus making it easy to control even large power converters. Modern solutions are realized in 17 mm stack height, which increases the clearance distance in electric control cabinets. But only the adequate driver gets all advantages of an IGBT.

By Wolf-Dieter Roth, HY-LINE

An IGBT (Insulated Gate Bipolar Transistor) can be controlled with a high impedance, like a tube, like the Thyratrons in the early days of power electronics. But in contrast to a Thyristor the IGBT can be switched off any time like a MOSFET. At the same time the forward voltage of the IGBT is limited like the forward voltage of a bipolar-transistor. On the other hand it does not need a permanent control current to stay in conductive mode. So it combines the best of both technologies and is a robust component, which can be used in power electronics in many different ways, e.g. for motor-control.

Like rectifier diodes power IGBTs are put in robust modular housings, which can be screwed on heat sinks and can be connected with bus bars. Up to now the standard height of these modules was 30 mm. Thus the creeping distance in air between the bus bars and the cover (or the door) of the control box was relatively small, if boxes had been designed for flat modules.

Standardised construction height of 17 mm

The newest generation of IGBTs in the Econo-Dual-Housing needs only a total height of 17 mm – a reduction of 13 mm. Now this space is additionally available for clearance distance. At the same time this is the 6th generation of the IGBT-manufacturer

Mitsubishi [1], who is represented by HY-LINE Power Components [2]: After Planar-, Trench- and lastly CSTBT-technology (Carrier Stored Trench Bipolar Transistor) now Advanced CSTBT is state of the art.

The 17 mm IGBT modules of Mitsubishi are available in single-version up to sevenfold version for 600 V, 1200 V and 1700 V reverse bias and for a current range of 50 A to 1000 A.



Figure 1: Powersem rectifier modules and Mitsubishi IGBT modules

thereto the rectifier bridges of Powersem [3] in 17 mm height can be used, which are also provided by HY-LINE Power Components.

Hence the rectifiers in 17 mm height and the IGBTs in 17 mm height can be connected in one level with bus bars (Figure 1).

The driver is essential

An IGBT can be controlled easier than other components, but the controlling is not trivial: It is not enough to connect a simple signal line – to build up a soundly controllable converter with IGBTs you need specific control logic.

Besides the driver has a big influence to the efficiency of the power semiconductor: small inaccuracy in switching already leads to higher power dissipation and minor degrees in efficiency as well as transient characteristics caused by too long or -worse- too short



Figure 2: Concept IGBT driver 2SP0115T assembled ready to go on Mitsubishi CM 200 DX-24S 17 mm IGBT module

dead times, by switching too quick or too slow. Especially three phase bridge circuits are dependent on exact driving to avoid performance-losses or even switching-failures, which put the costly module at risk and could lead to fatal consequences due to the high power ratings.

Small errors in controlling could produce big damages

Besides simple IGBT modules you will also find modern IPMs (Intelligent Power Modules) with their own integrated protection circuit. IPMs do not provide galvanic isolation though and limit potential performance characteristics by the constant protection circuit. Consequently, additional discrete, external components are still necessary, having bad influence on reliability and costs. Furthermore self-contained shutdown of power semiconductors in equipment with multi-level handling makes no sense and accordingly can destroy the semiconductor and the complete construction – a controlled shutdown is absolutely necessary in this case. Finally the driver should only become active with the correct supply voltage being available to avoid inaccurate switching operations.

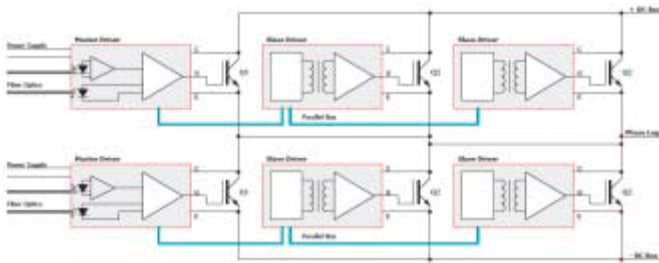


Figure 3: Direct Master/Slave paralleling with optic coupling avoids problems with multiple optic coupling and differing delay times resulting from this.

Thus it makes more sense to integrate the protection circuit in the control logic that is needed anyway and to place it in the driver. At failures like short-circuit, overload, controlling error, over- or subvoltage ordinary circuits fail quickly. In the case of high priced power components that is unpleasant – aside from the uncontrollable effects of high powers being out of control.

Galvanic Isolation

Moreover galvanic isolation is necessary in most cases, which can be realised inductively or optically. Optical fibres have not only the advantage of being adequate for high potential differences, but also of providing the transmitting medium at the same time. So optical fibres are the favoured solution for high voltages and cascaded IGBT circles, which for example are used for high-voltage direct-current transmission (HVDC-transmission). In addition they are resistant against transient characteristics, which can couple into the circuit though stray capacities in solutions with transformers or also optoelectronic couplers.

Contrary to optoelectronic couplers, which are too slow and do not offer enough isolation voltage for many applications, the transmission time of transformer-solutions is in the range of ns. Besides the transformer-solution is long time stable and therefore interesting for higher-frequency circuitry. Both coupling types can be integrated in a driver circuit quite well, whereas it would be quite complicated to realize galvanic isolation at the last moment, at the gate of the IGBT.

Integration in time

The common user could not and should not take care of these items, but these things could bring incomprehensible problems in the circuit, if they were not taken into account in the construction. At first view

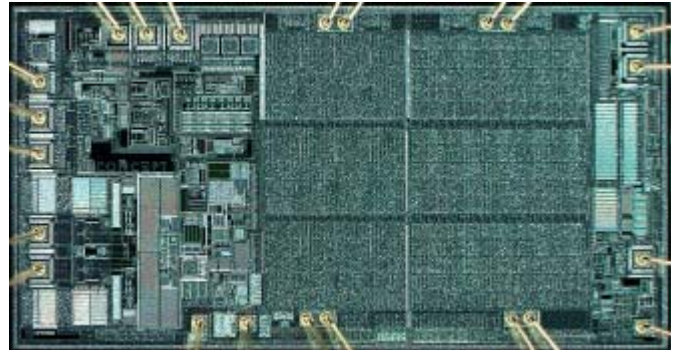


Figure 4: View on a highly integrated ASIC in a Concept IGBT driver

cost-saving self-made developments, which supply only the basic functions of driver circuits, could therefore not keep up with highly integrated, intelligent drivers in the long time, which are adapted to possible shortcomings of high-performance-IGBT-systems and avoid potential breakdown of the costly components by well-timed integrated protection. This is featured by the IGBT-drivers of Concept Technologie [4] (Figure 2).

In addition the Scale Plug-and-play IGBT-drivers of Concept are simple to mount: In their PCB design the drivers are tailored to the IGBT modules and are united with the IGBT module by soldering. So afterwards only one module has to be mounted, which contains the IGBT power module of Mitsubishi and the IGBT control circuit of Concept (Figure 3).

With Concept Scale-Drivers of the second generation paralleling of IGBT modules can be done more accurately than with standard circuits, because drivers can be decentralised and asymmetries of the IGBT-modules have no influence on controlling. Even in 6.5 kV systems with optical coupling paralleling of several modules via their own drivers and a common bus is no problem.

The drivers are available for the normal commercial (0°C to 70°C) and for the industrial temperature range (-40°C to 85°C). They also take care of aspects like the necessary creeping distance in air and on surfaces and take the required testing of partial discharge into account. The delay time is around 100 ns. The units come with transformers and DC-converters to switch the IGBT correctly and to control it – even on the High-Side.

In the co-operation of three different products a reliable and cost-efficient solution for converters and motor control units comes to your hand, which may be directly screwed into the equipment in the field without high development work.

- [1] Start Page HY-LINE Power Components: www.hy-line.de/power
- [2] Mitsubishi IGBT Modules of 6th generation: www.hy-line.de/nx6
- [3] Powersem Rectifiers: www.hy-line.de/powersem
- [4] Concept IGBT Drivers: www.hy-line.de/concept ; www.igbt-driver.com