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April 2019

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High-power motor drives: Infineon's modular prototyping concept

european business press

Modular concept for adaptable test setups for the electric future of transportation

A solution for prototyping high power motor drive applications

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Driving into the future, light electric vehicles (EVs) have been notably gaining more and more attention on the market of electric transportation. We can experience a renewed interest in these solutions due to the concerns about the increasing greenhouse gas emissions and air pollution, as well as the future availability and price of fossil fuels. Also, light EVs go beyond the environmental considerations only. They provide smooth operations and stronger acceleration, and they require less maintenance than their traditional, fossil-fueled counterparts.

As a rapidly growing demand is on the horizon for these vehicles, faster time-to-market enabled by modular prototyping is one of the key success factors for manufacturers who strive to gain (higher) market share in this segment.

In this article the author provides an insight into the power design challenges and exposes Infineon's modular concept for high power motor drive prototyping helping designers to unblock the possible bottlenecks in the R&D process for light EVs' motor drives.

Challenges in power design

Designing high power drive systems at low voltages (lower than 144 V) requires high current handling, and managing considerable thermal dissipation which is typically achieved by paralleling of semiconductor devices – primarily MOSFETs due to their low conduction and switching losses.

The extent of MOSFET paralleling is the main focus of performance versus cost optimization of the system where equal current sharing and switching performance optimization play essential roles in the hardware design.

While insulated metal substrate (IMS) PCB technology is the prevailing technology of choice due to its outstanding thermal performance, it is not the best suited solution for board rework processes that are necessary in the initial design phase quite often. But what is the solution then?

The solution: modularity for various test scenarios on a single platform

The overall approach is to enable rapid prototyping in the initial project design process, by providing an easy-to-use test setup for proof of concept designs and investigation of MOSFET technologies. The modular platform provides the user basic building blocks that are interconnected via onboard connectors, thus avoiding the need for lengthy layout design and assembly (reflow and rework soldering) processes. Furthermore the boards include several test points enabling easy probe connection and also provide some points of access for current measurements via Rogowski probes.

With scalability and versatility in mind, the modular concept is based on a power half-bridge building block (power board) comprising a single high-side and a single low-side MOSFET. The power board module can be used to construct various

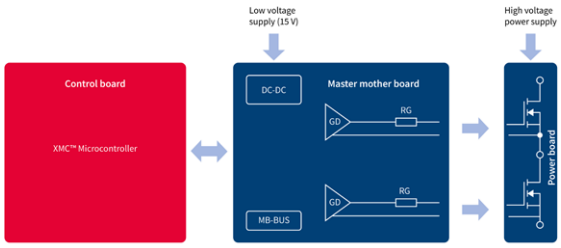

Figure 1: Block diagram of the modular prototyping platform from Infineon Technologies

power setups ranging from half-bridge through full-bridge to three-phase applications. Furthermore, the power board modules can be connected in parallel to increase the current handling capability of each phase. When paralleling the power boards, all the MOSFETs connected in parallel are driven by the same gate driver with the corresponding gate resistors provided individually for each MOSFET at the mother boards and the interconnection daughter boards.

Power connections and capacitor bank

Screw terminal power connectors are provided on power boards for the high current interconnection via copper bars - for each phase two copper bars form the DC bus connection that connects all the parallel half-bridges of that phase to the capacitor bank, and to the DC power source. Another copper bar connects the outputs of the paralleled half-bridges and provides the connection point for the motor.

The power boards feature Infineon's OptiMOS™ family of power MOSFETs in three different SMD power packages (TO-Leadless, D2PAK-7, D2PAK). The SMD packages enable increased heat dissipation in combination with the insulated metal substrate (IMS) PCBs

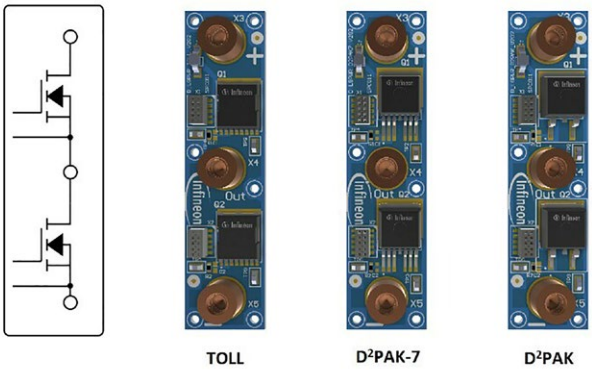

Figure 2: Half-bridge modules on IMS boards

Gate driver – mother and daughter boards

Separate modules – the mother boards – provide the system with the corresponding gate drivers. Connecting the mother board to a power board through onboard header connectors subsequently connects the gate driver IC outputs to the high- and low-side MOSFETs. The gate resistors (shown on the block diagram in Figure 1), as well as other components required for optimization of the gate drive signal, are situated on the FR-4 based mother board. This is to enable easy extraction and replacement of the resistors when experimenting with the component values.

When expanding an individual phase with additional power board modules connected in parallel, the gate driver signals from the mother board of the phase are propagated to the paralleled MOSFETs through interconnections formed via daughter board modules, which also provide the additional gate resistors for each of the MOSFETs they are interfacing with. The daughter boards – when used – are stacked on top of the corresponding mother board via provided header connectors that form a parallel bus of the gate driver signals.

Both mother and daughter boards provide an additional ceramic capacitor connected to the DC power line at the point of connection to the corresponding power board. This provides a high frequency handling capacitor to each of the power boards with lowest possible series parasitics, thus stabilizing the DC bus voltage during the high speed switching transitions of the half-bridge.

Control board connection

The master mother board interfaces with a microcontroller based control board at X3 header connector (see Figure 3). The control board (typically Infineon's XMC™ demonstration board: drive card XMC4400) is used to provide all the control signals for the gate drivers, and can receive any of the optional sensor signals. The supply for the control board is provided by a buck regulator at the master mother board. A basic firmware with GUI package for open loop V/f induction motor control is provided to enable a quick and simple start, and test of the setup.

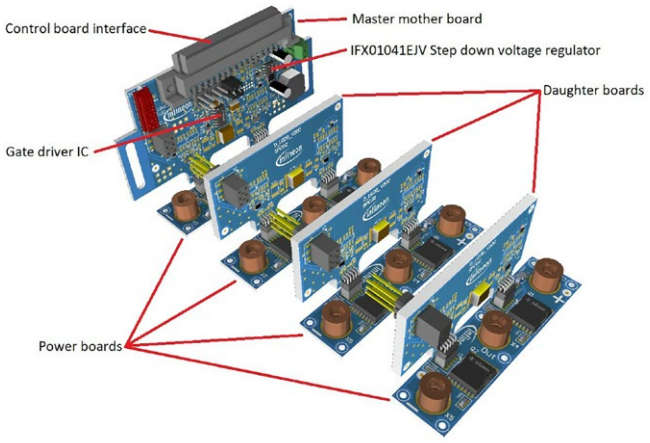

Figure 3: Adding power boards in parallel

Multi-phase system, mother boards and MB bus

When expanding to a two- or three-phase system, the gate driver for phase "U" is provided by the master mother board (also interfacing the control board directly) while the gate drivers for the additional phases ("W" and "V") are provided by mother boards as shown in Figure 4. The control signals for the additional mother boards are extended to the mother board bus at the master mother board, and propagated via a ribbon cable to the mother boards. The mother board bus also provides the 15 V supply for the gate drivers and their enable signals.

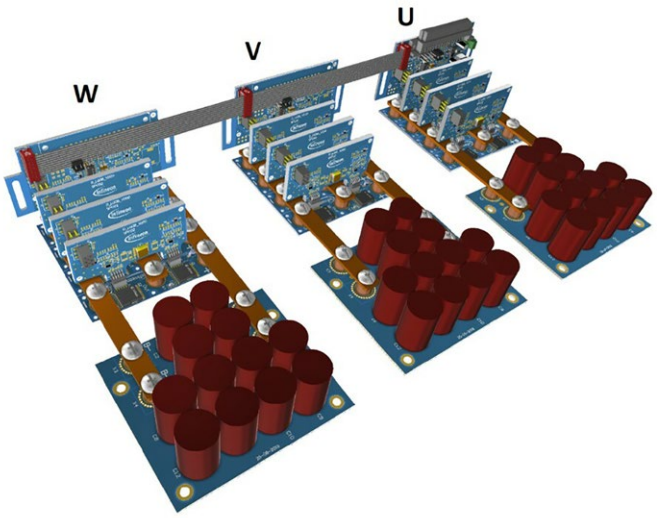

Figure 4: B6 motor drive implemented with the scalable power demonstration boar

Conclusion

The market of light EVs is quite dynamic. Due to the rapidly growing market demand, reliable solutions supporting faster time-to-market are required. Infineon's modular approach for motor drive prototyping can be a key enabler for manufacturers to reduce test cycles and efforts to bring concepts to life sooner than with a traditional testing platform.

For more information about the low voltage drives scalable power demonstration board and the featured products, please visit the below listed websites and scan the QR code to watch video:

- www.infineon.com/LVD-scalable-power-demo-board
- www.infineon.com/OptiMOS
- www.infineon.com/EiceDRIVER
- https://www.infineon.com/kit-xmc4400-dc-v1