Developing a 25 kW SiC-Based DC Fast Charger (DCFC)

Part 1: Structure of a Fast EV Charger & Key Electrical Specifications

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DC fast charging (DCFC) market is thriving. Along with the acceleration in the adoption of electric vehicles (EVs), the demand for fast charging infrastructure is increasing. Growth projections range from 20% to 30% CAGR for the next five years. If you are an application, product, or design engineer working in the power electronics field, sooner or later, you could be involved in the design of one of such novel charging systems.

A fundamental question might arise here, especially if it is the first time you have faced such a challenge. How and where should I begin? What are the critical design considerations, and how should I address them?

onsemi helps designers address such a challenge, as we'll demonstrate by developing a 25 kW DC fast charger based on SiC power integrated modules (PIM).

Figure 1. 25 kW DC Fast Charger Reference Design (Left ï PFC Stage, Right ï Dwt867 Active Bridge

Table 1. REQUIREMENTS OF THE 25 ïKW DC FAST CHARGER

Complete System PFC + DC ïDC Converter		
AC Input	Voltage Input Rating	Three ïphase 400 Vac (EU), 480 Vac (US)
	Max. Input Current	40 A
	Frequency	50/60 Hz
	Power Factor	>0.99
	Efficiency	>96%
DC Output	Output Voltage	200 V to 1000 V
	Max. Output Power	25 kW
	Max. Output Current	50 A
Protections	Output	OVP, OCP, SC
	Input	UVP, OVP, inrush current
	Internal	DESAT (gate driver), thermal (NTC on power device)
User Interface	Push Buttons	Yes
	GUI	Yes. STRATA ïbased GUI for system evaluation
Communication Buses	Internal	SPI, I^2C
	External	Isolated CAN, USB, UART
Environmental	Operating Temperature	0 ¢C to 40 ¢C
Max. Mechanical Dimensions	PCB	450 x 300 x 280 mm (PFC and DC ïDC stacked)
Standards	Regulation	Following guidelines described in EN55011 Class A. Will not be tested.
	EV Systems	Following guidelines described in IEC 61851. Will not be tested

THE DEVELOPMENT PROCESS

Our team follows the logic of hardware development processes of power conversion. The work starts with the definition of the actual DC charger power stage based on the requirements for the application. Summarized in the table in our case, these are per the market's needs and follow the guidelines of IECï68515. These requirements help the team understand their target.

The first feasibility studies help validate the initial requirements and assumptions, integrated as part of the system design that encompasses (in this project's scope) hardware, software, thermal management and mechanical design, prototyping, and validation. All the essential system variables and most critical compromises and tradeïoffs for the solution happen during the feasibility studies.

Multiple iterations carry out these tasks and sub-designs, where outputs and assumptions from one part feed back to another. Two of the main design activities that provide significant outputs to move forward are:

- Power simulations with SPICE models
- Control simulation using MATLAB ® and Simulink ®

Power simulations are crucial to confirm the assumptions on working voltage and currents, losses, cooling requirements, selection of power, and passive components, among others. Once an implementation plan is ready, control simulations, including the power parameters, are carried out to confirm that the control loops are effectively executed with the power design.

Proving the design with the power and the control simulations greenlights the schematics drawing, PCB layout, and prototype manufacturing. (Once the board was developed, we carried out hardware bringïup, functionality testing, and system characterization. Please refer to Lessons Learned: Developing a 25 kW DC Fast EV Charging Module. In this reference note, we present a simplified summary of the design process that we will describe in detail below.) Developing a 25 kW EV DC charger from scratch entails more than that; the most valuable takeaways will come as we solve the challenges and issues along the way. (*Please watch four webinar series of "Designing Silicon Carbide (SiC) based DC Fast Charging System" for more details.)

WHAT IS COMING?

In subsequent parts of this reference design series, we will be taking a closer look at some of the design and validation stages. The following topics will be addressed:

- Part 2: Solution Overview
- Part 3: The threeïphase PFC rectification stage
- Part 4: The dual active fullïbridge DCïDC stage
- Part 5: Control algorithms, modulation schemes and feedback
- Part 6: Gate driver system for SiC power modules
- Part 7: Auxiliary power units for 800 V bus
- Part 8: Thermal management

If you have a question about 25 kW SiCïBased Fast DC Charger or this reference design series, please contact Technical Support.