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# Multiphysics Modeling of Power Electronic Devices

This work will model the power electronic devices in two steps: loss modeling and thermal modeling for IGBTs, MOSFETs, and power diodes. There will be no specific devices used; just general device parameters found from a market survey at different voltage/current ratings. This section covers how these modeling methods are designed for each respective device.

### MOSFET Loss Modeling

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Modeling of the MOSFETs will be done largely using the examples in the application note by Graovac et al., 2006. This method also considers the losses of the body diode, so for MOSFET applications, no extra parallel diode will be included. Table 1 lists all input/output information for the MOSFET loss block. For inputs, , , , and are used to calculate the amplitude of . The switch location information is required for timing of the power pulse relative to the instantaneous phase current value.

Table 1: Inputs and outputs used for device modeling.

|  |  |
| --- | --- |
| **Input** | **Output** |
| RMS Phase Current () | Sine Wave Pulsed Power Output () |
| Electrical Frequency () |
| Modulation Index () |
| Power Factor () |
| Switch Location |

#### Loss Modeling in Two-Level Voltage Source Converter Topologies:

From Graovac et al., the average device losses over a fundamental period in three-phase motor drive applications can be defined as follows:

Where is used to find switching loss estimates for the MOSFET and Diode from an LUT derived from datasheet parameters.

In total, these losses are summed together to determine the periodic average losses of the device with respect to the fundamental frequency,

As presented in the IPOSIM documentation from Infineon, the periodic average is then used to create a half-sine wave pulsed power waveform with amplitude

This half-sine pulse should be applied in-phase with the RMS phase current through the MOSFET. For example, for a high-side MOSFET, this pulse should be applied in-phase with the positive half-cycle of the phase current. For a low-side MOSFET, the pulse should be applied in the negative half-cycle.

**NOTE:** This method is limited in that it is only valid for SPWM switching methods. Other loss calculations will need to be done for other switching methods such as SVM.

#### Loss Modeling in Modular Multilevel Converter (MMC) Topologies

The paper by Zhang et al., 2019 presents a new loss modeling method that is more suitable for MMC topologies considering the DC arm current bias.

### IGBT Loss Modeling

### Diode Loss Modeling