Permanent Magnet Synchronous Machine

PMSM – IPM - BLDC- SPM

The automotive and transportation industries comprise the core markets for PMSMs. This machine type is known for its power density (power per unit of size/weight), and its higher speed capacity. OPAL-RT's solutions provide resolver and encoder I/O interfaces and communications protocols to exchange time-accurate information and position sensor responses—crucial for the successful testing and simulation of this motor type.

Table 1: Overview of the PMSM model implementations available in the eFPGASIM product

Variable D-Q model — VDQ:	2 phase equivalent circuit model with a d-q rotating reference frame and variable inductance table according to the operating point **Pros:** Fast execution: ~ 100 ns, Low resource, Variable Ld – Lq, good for most operating condition **Cons:** No simulation of cogging torque and current harmonics
Spatial Harmonics model — SH:	3 phase detailed model with 3D table for flux, torque and inductance. **Pros:** Simulation of cogging torque and spatial/current harmonics, FEA based models, mechanical model on FPGA **Cons:** Slower execution: ~ 500 ns, High FPGA resource usage

The Table 2 describes the main specifications of the FPGA-Based PMSM machine models for application requiring very fast simulation and accurate results. OPAL-RT offers 2 main versions of the PMSM model on FPGA: SH and VDQ.

Table 2: PMSM model comparison table

	PMSM SH	PMSM VDQ
Machine topology	3 phase wye connected	
Maximum machine speed	300 kRPM	
Maximum current / voltage / power /Torque	Not limited	
Minimum Time Step	500 ns	100 ns
Calculation precision	Single Floating Point	
Compatibility with JMAG	From JMAG v10.5	No
Compatibility with Ansys Maxwell	Yes	No
Compatibility with infolytica MotorSolve	Yes	No
Electrical Machine Parameters	3D tables for phase inductance, magnet flux and torque tables I_d I_q and θ are dependent	Constant Ld Lq and magnet flux or 2D tables for L_d L_q and magnet flux I_d and I_q are dependent
Fixed L_d L_q mode (Basic)	No	Yes
Mechanical model	Basic inertia and friction mechanical model provided on CPU or FPGA. User can defined its own model on CPU or FPGA	Basic inertia and friction mechanical model provided on CPU. User can defined its own model on CPU or FPGA
Inductance / Torque / Flux table size	Up to 32x32x32 for 2 machines or 64x32x32 for 1 machine	128x128 for 2 machines
Cogging Torque / Current Harmonics	Yes	No
Saturation vs current amplitude	Yes	
Flux dependence on Speed or Temperature	Not supported	
Copper losses	Not supported	
Audience / Application	Engineers that have access or that build the machine design. For test that requires a model that reproduces the right current harmonics and cogging torque. Or for engineers that have access to the machine design and want to export this directly from Finite Element Analysis software to the real time simulation.	Engineers that have access to the basic machine parameters from manufacturer. For tests that doesn't require higher fidelity regarding the current and torque harmonics.
Recommended Platform	OP4510 OP560x OP5707	OP560x OP4510 OP5707 OP4200