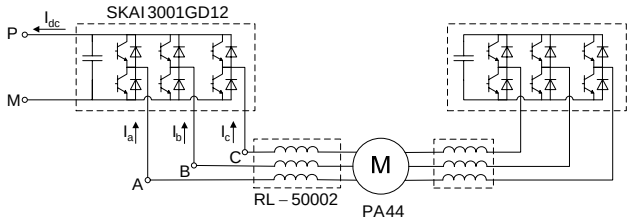
Demonstration of Boost Phase Control Algorithm

John Kajs – SAIC, Austin TX
Dr. Peter Mongeau, ePower, Westborough MA

Objective of Algorithm

Boost Phase Control is a potential algorithm for reducing inverter and generator Losses for a system which is using 'inverter' hardware for interfacing between a PM machine and a DC bus. Algorithm is suitable for both motoring and generating and is suitable when AC/DC voltage ratio (L-L Pk)/Vdc is close to 1.0. Algorithm is similar to 6-step control (1 gate for each IGBT for each electrical cycle), but is different in that it purposely includes a not-gated duration which provides some potential for lower AC voltage than available with 6-step gating.

Basic Experimental Setup

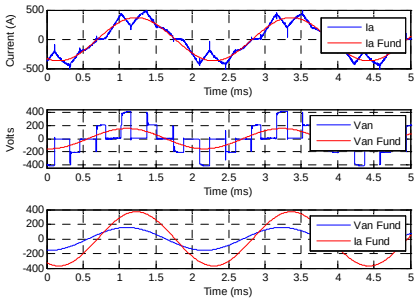


Methodology

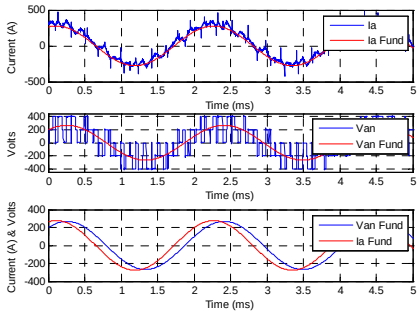
Using available PGU hardware and COTS inverter hardware performing an experimental validation of BPC vs 5 kHz and 10 kHz PWM. Measurements include both electrical (100 ksamp, 5 MHz power analyzers for AC & DC measurements) and thermal (coolant flow, inlet & output coolant temperatures, various thermocouples.

Speed (RPM)	Iq Commands	Notes
1000	50, 100, 150 & 200	Waited for approx thermal equil. for 200
1250	50, 100, 150 & 200	
1500	50, 100, 150 & 200	Waited for approx thermal equil. for 200
1750	50, 100, 150 & 200	
2000	50, 100, 200 & 300	Waited for approx thermal equil. for 300
2250	50, 100, 200 & 300	
2500	50, 100, 200 & 300	Flux weakening required for higher Iq

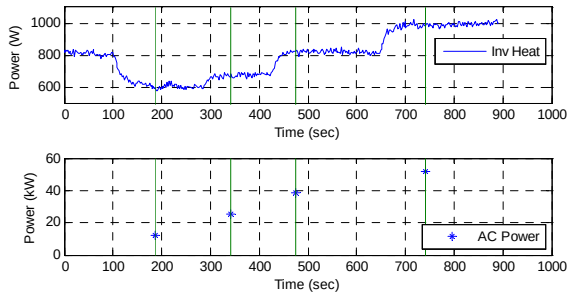
Typical Test Data



Boost Phase Control at 2000 RPM & Max Power

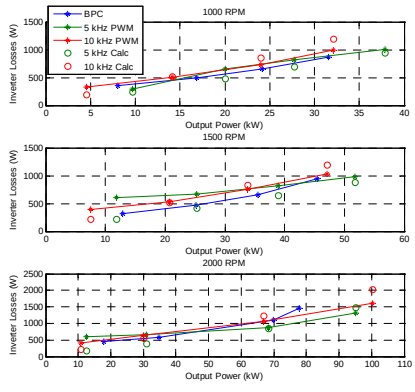


10 kHz PWM at 2000 RPM & Max Power

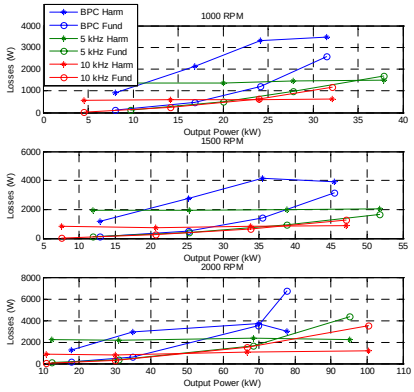


Thermal with 5 kHz PWM & 1500 RPM

Analysis Summary



Inverter losses



Machine Electrical Distribution

Testing not yet fully complete.

Analysis indicated that losses in inverter will be lower and that losses in machine are expected to be very close or lower.

Initial BPC gating hardware limited turn on delays to >0 degrees. Result is that BPC has unnecessarily high reactive currents.

Delays need to be <0 degrees to have comparable fundamental reactive current for BPC as PWM

Delays <0 Degrees are gating algorithm dependent (being changed)

Reasonable agreement between inverter losses for PWM from Thermal measurements and online Semikron estimates

BPC estimates were based on gating working correctly (not yet true)

Path Forward

Improving BPC gating to reduce reactive currents for BPC Algorithm
Improving thermal measurements to get better heat removal measurements from generator