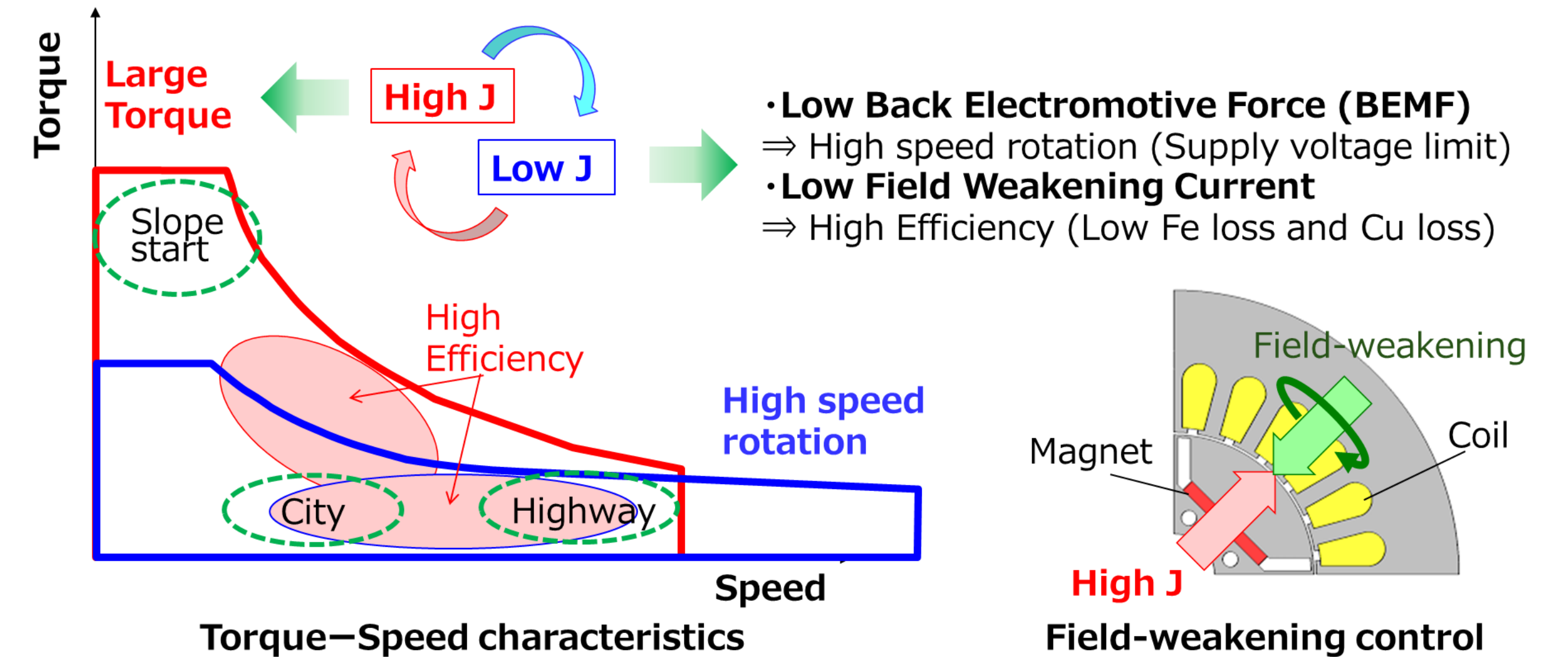


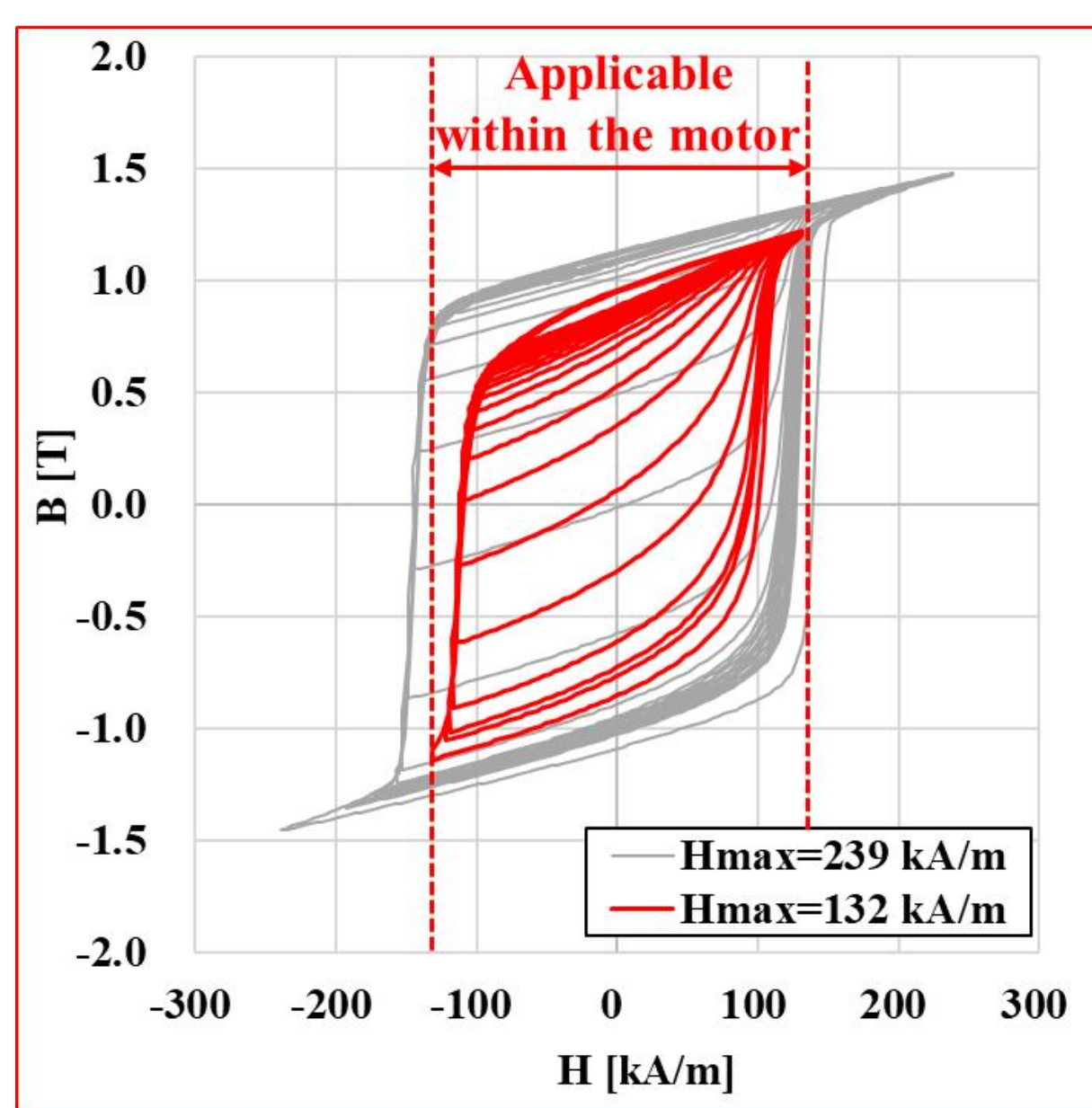
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Background and Objective

The variable magnetic flux permanent magnet synchronous motor (VMF-PMSM) is expected to achieve high efficiency over a wide operating range by switching the magnetization states of the VMF-magnet. To achieve the desired torque, the relationship between the electrical control and the operating point of the VMF-magnet should be grasped. This presentation will show the approach for directly measuring the operating point of the VMF-magnet.



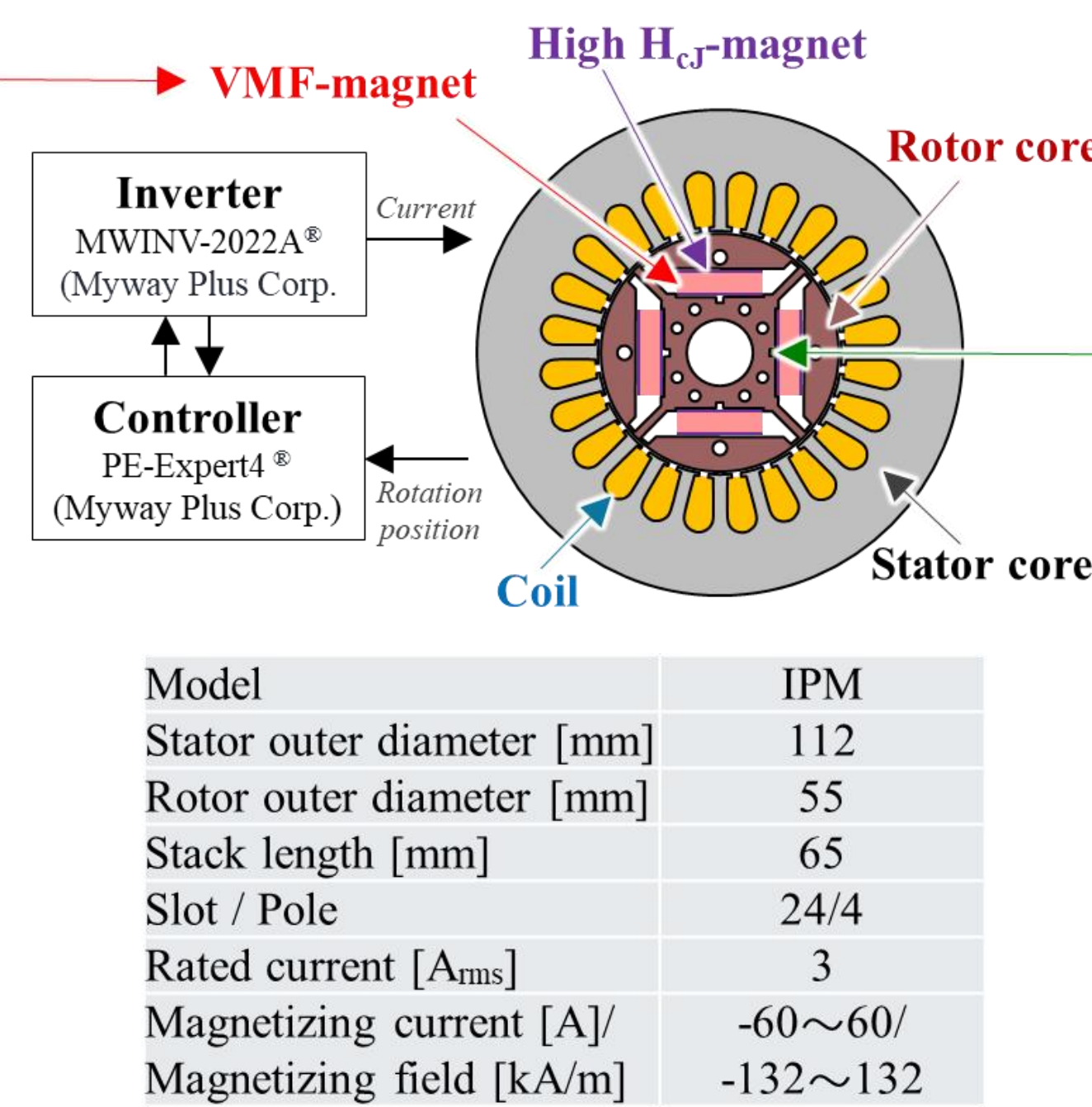
Methods



Variable Magnetic Flux magnet

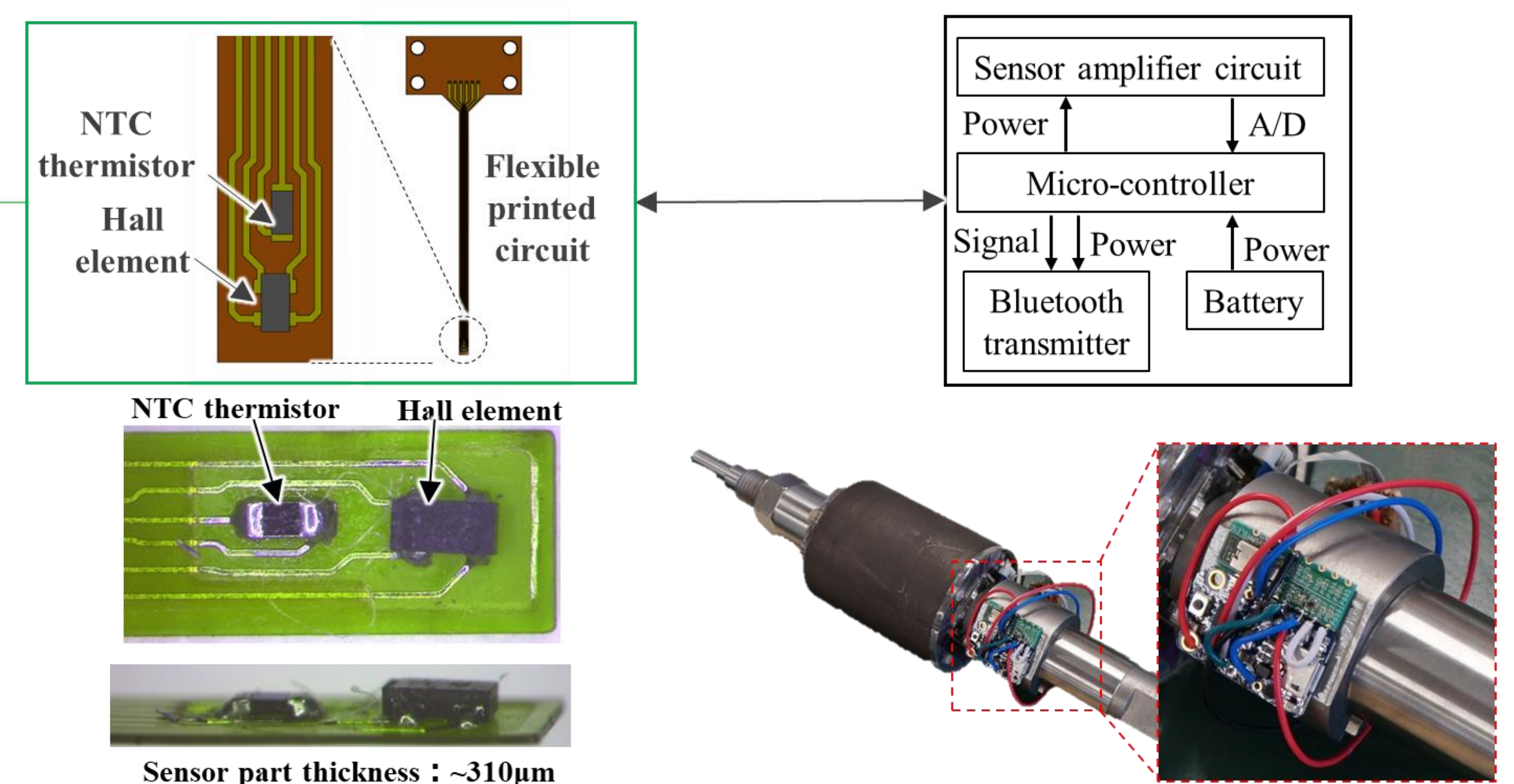
The rotor magnet consisted of a series lamination of the VMF-magnet [1] and the high coercive field magnets.

Due to coil magnetic field limitations caused by inverter capacity, the VMF-magnet was used in a low magnetic saturation state.



Motor

To operate the VMF-PMSM, a controller (PE-Expert3) and an inverter (MWINV-2022A) manufactured by Myway Plus Corp. were used.

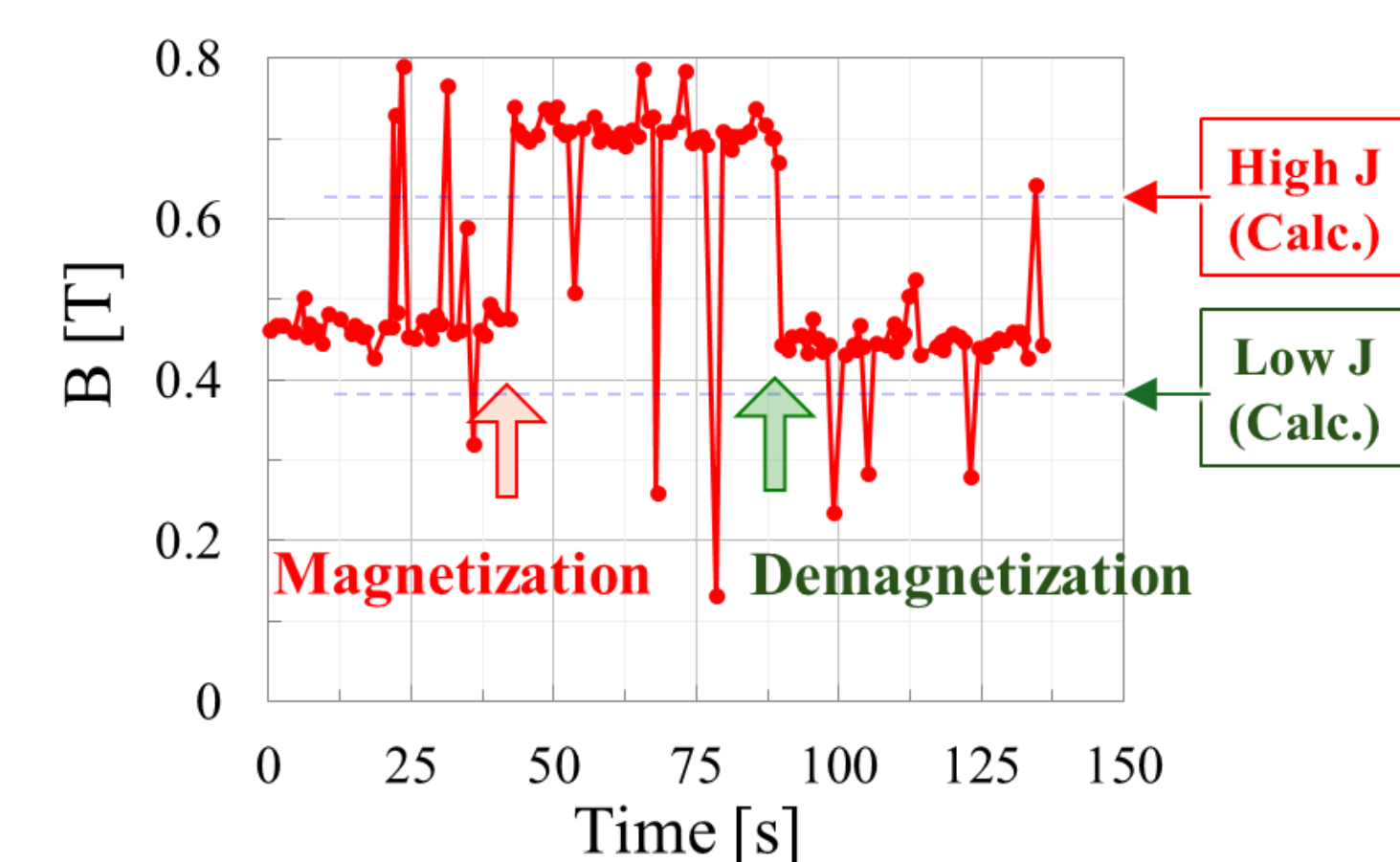


Sensor probe

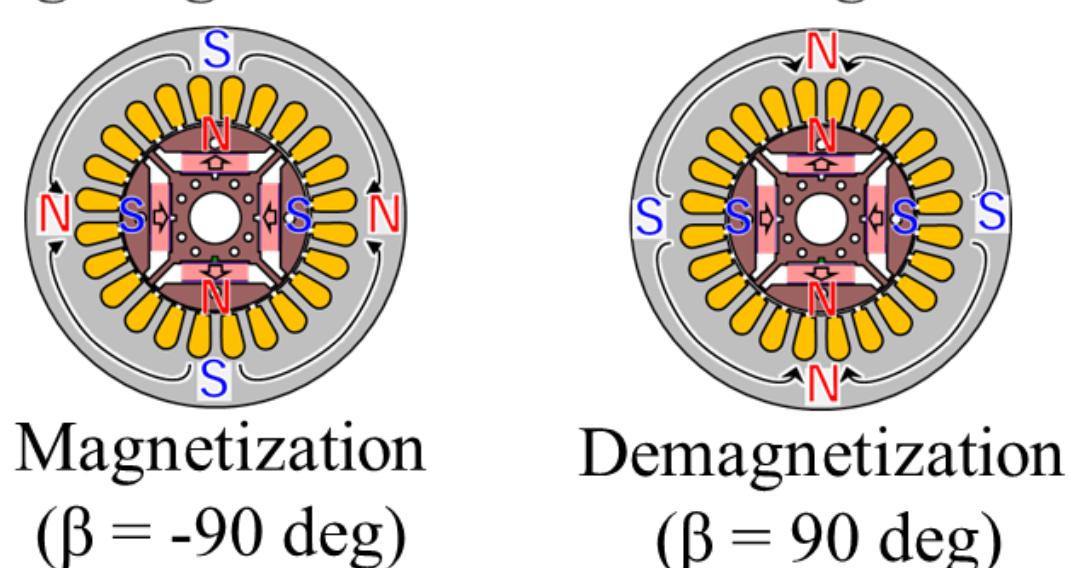
Signal conditioner on the rotor shaft

The sensor probe with a Hall element and an NTC thermistor was installed on the magnet surface opposite the gap to minimize the influence of the coil magnetic field. The sensor was electrically connected to a signal conditioner mounted on the rotor shaft, which includes a coin cell, a micro-controller, and a Bluetooth module for measurement and wireless communication.

Results

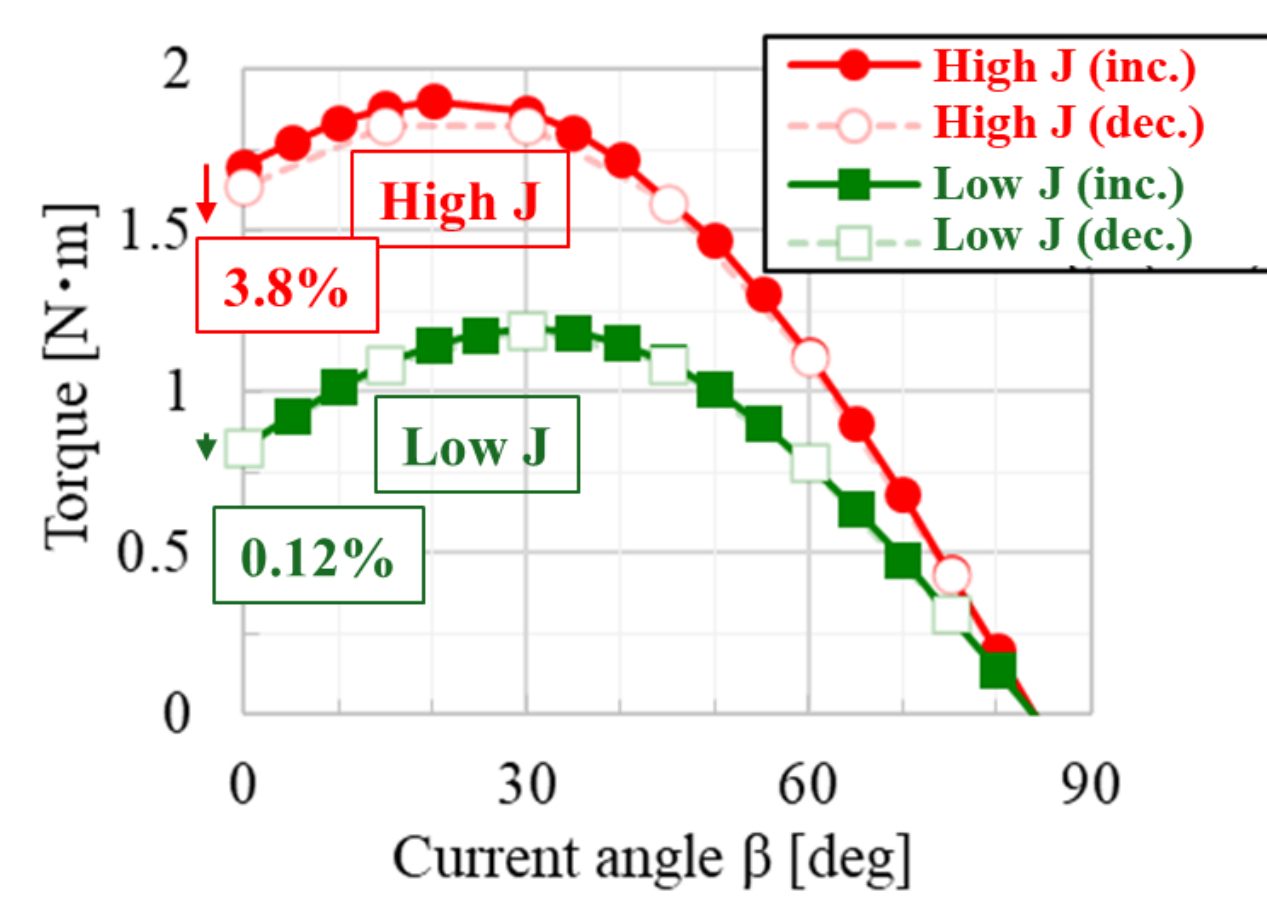


Magnetic flux density on the magnet during magnetization and demagnetization

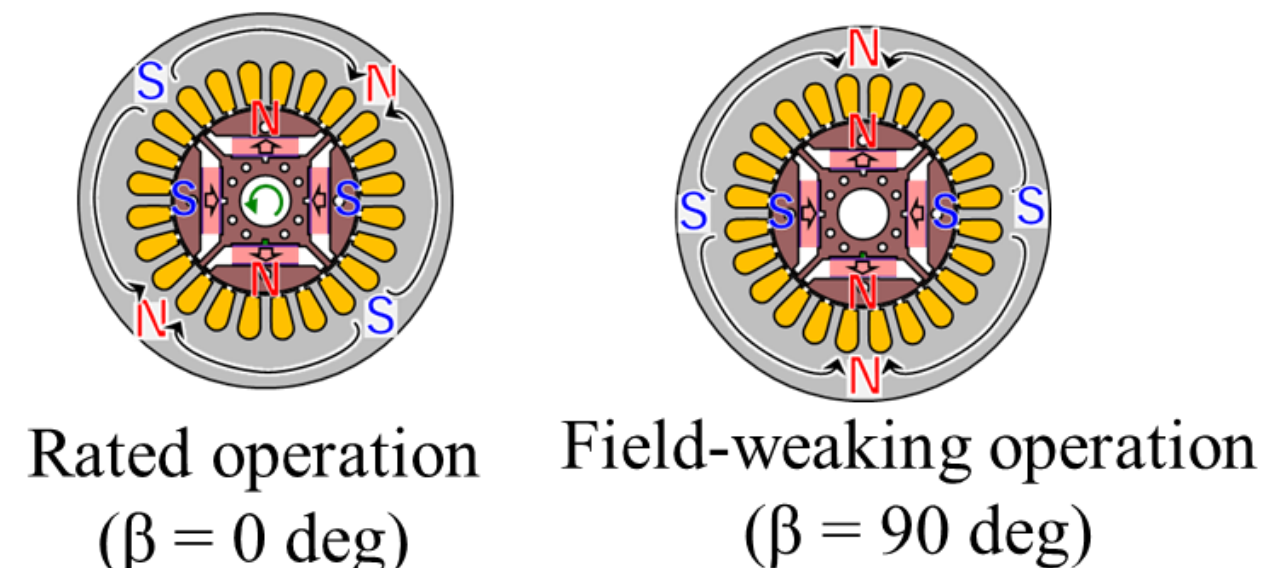


VMF-magnet is magnetized and demagnetized by d-axis current of ± 60 A ($\beta = \mp 90$ deg) during 50 ms during a 600 rpm rotation at 26°C.

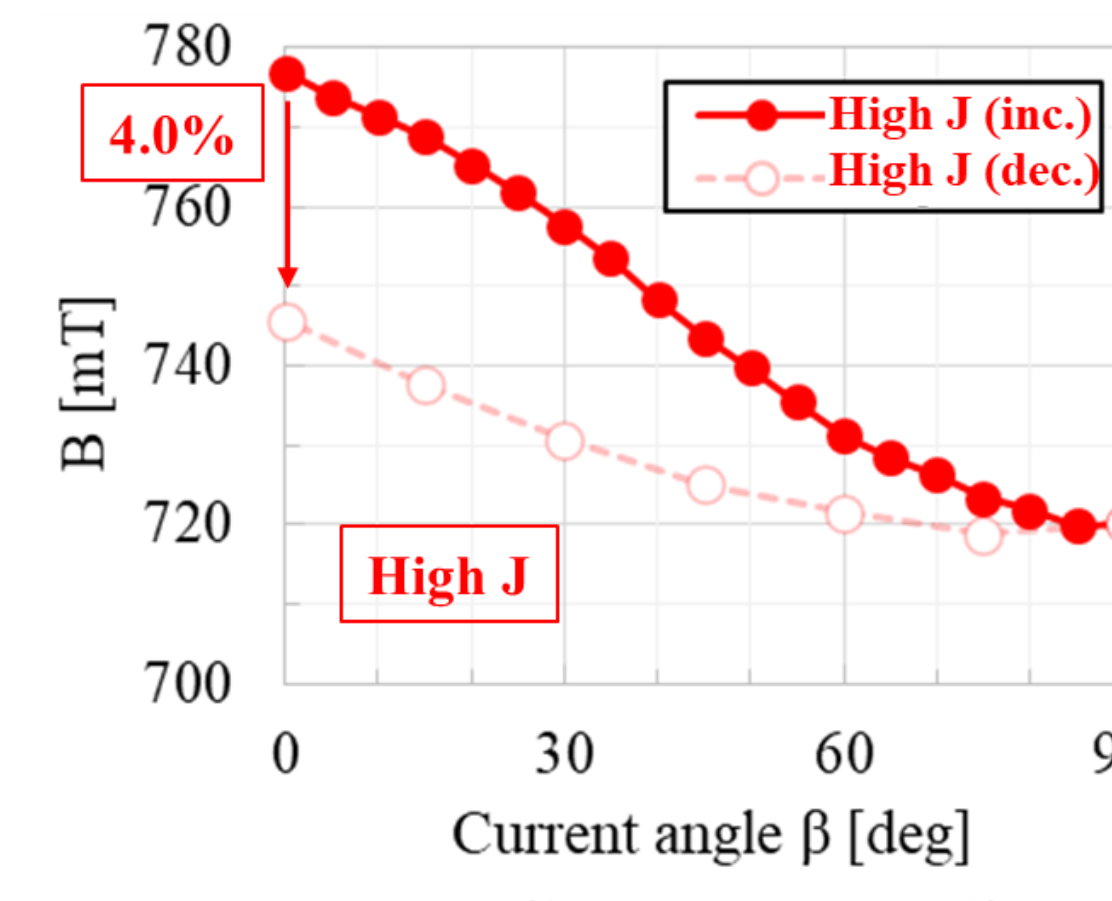
Real-time flux density changes due to magnetization and demagnetization of a VMF-Magnet can be observed.



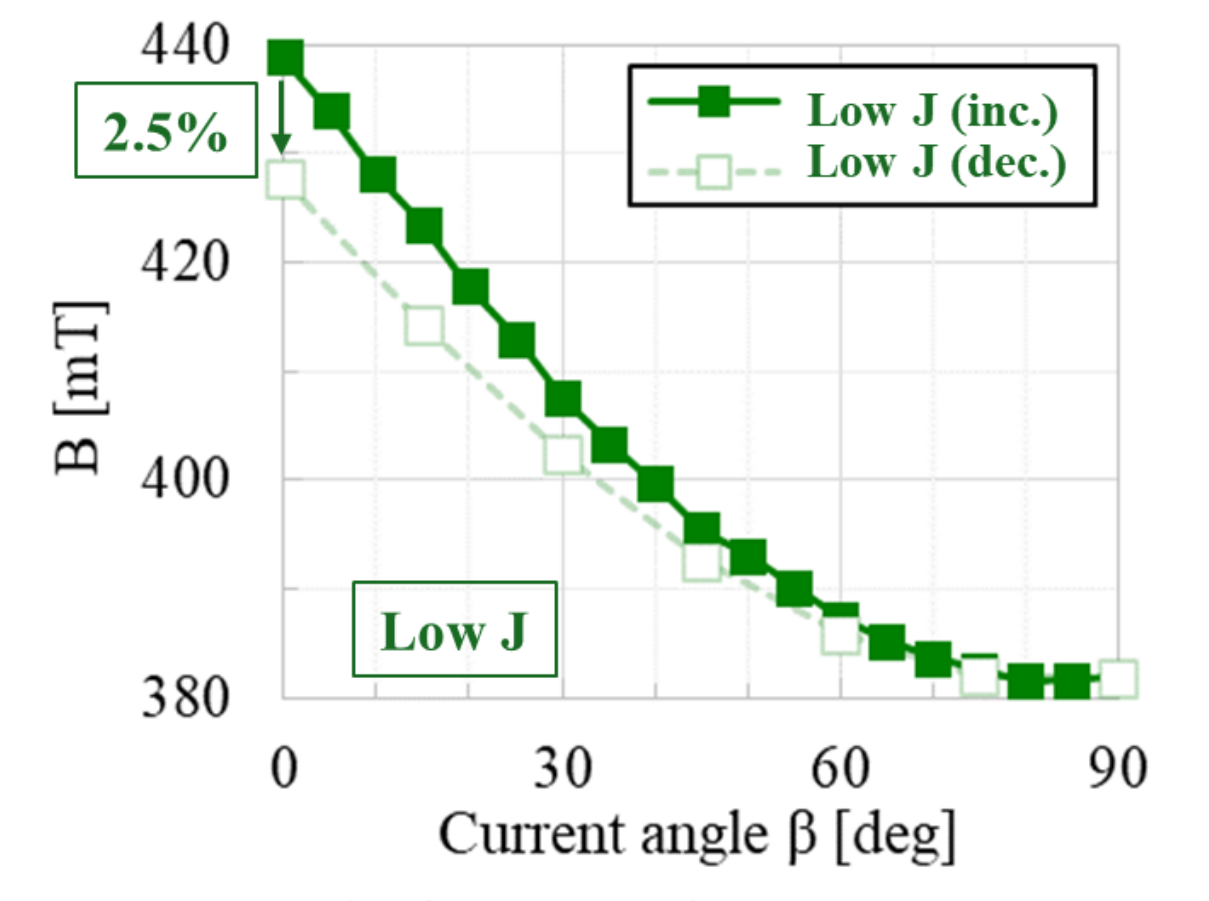
Current angle (β) - Torque Curve in High J and Low J states while increasing and decreasing of β



The magnet torque at rated operation of 3 A in High J state at $\beta = 0$ deg decreased by 3.8% after a field weakening operation up to $\beta = 90$ deg, which corresponded to a 4.0% decrease in the magnet magnetic flux density, while the magnet torque in Low J state decreased by 0.12% after a field weakening operation, which deviated from 2.5% decrease in the magnet magnetic flux.



Current angle (β) - Magnet magnetic flux density while increasing and decreasing of β



Conclusion

- VMF-PMSM system with real-time measurement was developed.
- Since the experimental magnetic flux density do not necessarily explain the behavior of magnet torque, further investigation is needed to clarify the deviations.