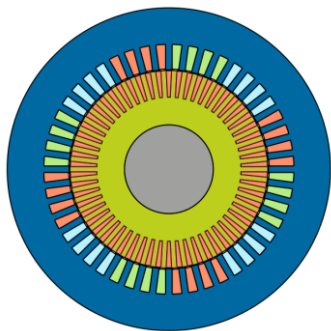
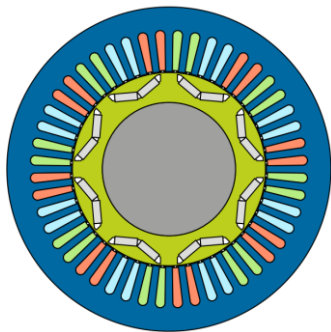
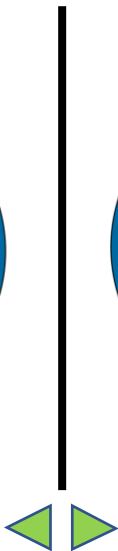


INDUCTION Vs SYNCHRONOUS ELECTRICAL MACHINES: 8 KEY e-NVH DIFFERENCES



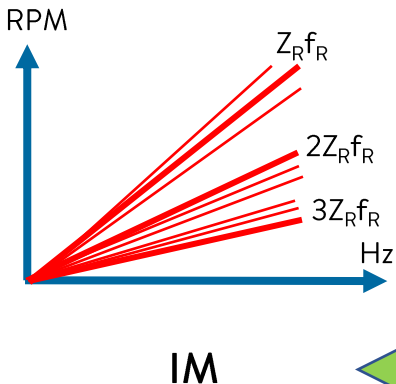
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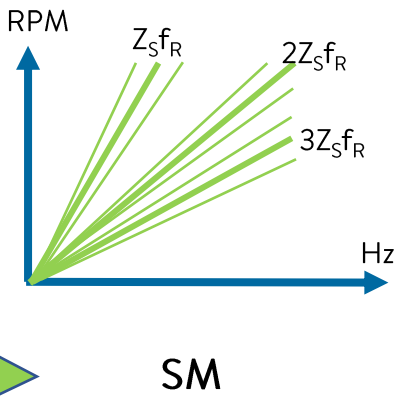
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#1: Frequency signature

For integer-slot machine, orders occurs around multiples of the **rotor slot** passing frequency $Z_R f_R$

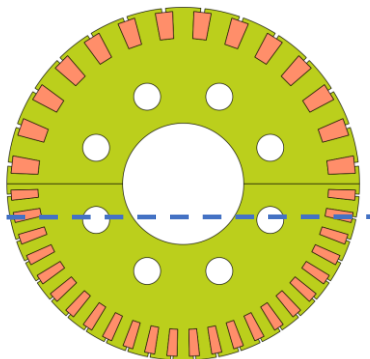


For integer-slot machine, orders occurs around multiples of the **stator slot** passing frequency $Z_S f_S$



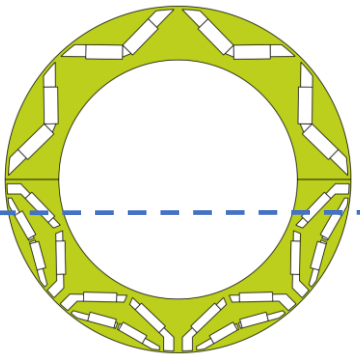
#2: Influential parameters

A key design parameter for induction machine is the **rotor slot number**



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A key design parameter for synchronous machine is the **pole shape**



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#3: Order Tracking analysis

Excitation orders HX may **not be integers**, e.g. H56.33, and depend on load state (slip), making **Order Tracking tricky**

$$X = k_r Z_R \pm 0, 2p / (1 - s)$$

($k_r=1, 2, 3...$ is related to the rank of rotor permeance harmonics)

IM

Excitation orders HX are **integers**, e.g. H48, and independent of load state, making **Order Tracking easy**

$$X = h_r 2p$$

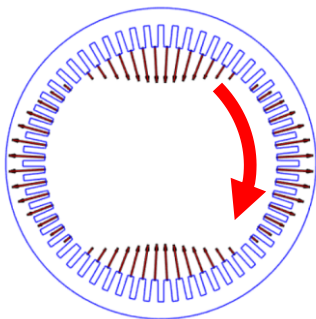
($h_r=1, 2, 3...$ is related to the rank of rotor magnetomotive force harmonics)

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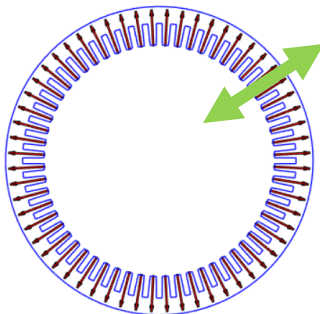
#4: Main noise issues

For integer-slot machine, main magnetic noise issues come from **rotating harmonic forces** $r=2, 4, 6\dots$



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For integer-slot machine, main magnetic noise issues come from **pulsating harmonic forces** $r=0$

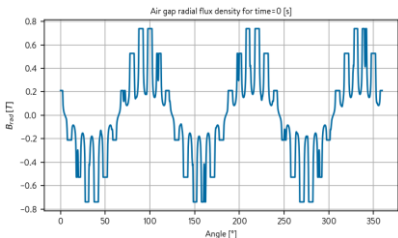


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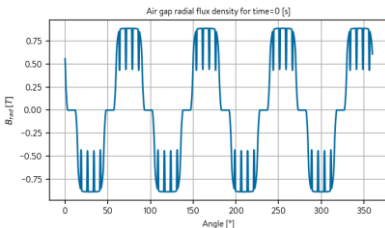
#5: Origin of forces

Magnetic forces under **no-load** come from the square of **stator flux density**, which is perturbed by **stator and rotor slotting** effects.

Magnetic forces in **open-circuit** come from the square of **rotor flux density**, which is perturbed by **stator slotting** effects.



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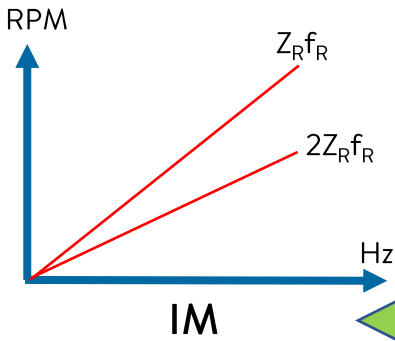


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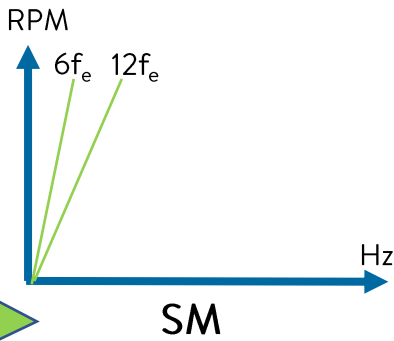


#6: Strong coupling effects

Strong coupling **may induce Rotor Slot Harmonics** in stator currents, resulting in pulsating harmonic forces at **multiples of $Z_R f_R$**

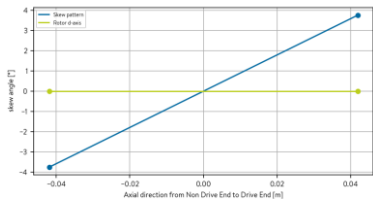


Strong coupling **always induces Back EMF Harmonics** in stator currents, resulting in pulsating harmonic forces at **multiples of $6f_e$**



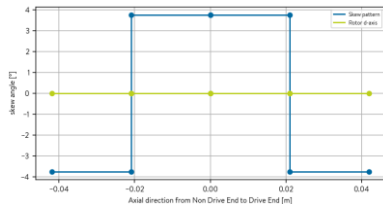
#7: Skewing effects

Squirrel cage skew induces **axial magnetic forces** due to **bar current skew**. V-shape skew cannot easily be manufactured so these forces remain.



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PM step-skew induces **axial magnetic forces** due to **magnet fringing fields**. V-shape skew is a standard technique to cancel these forces.



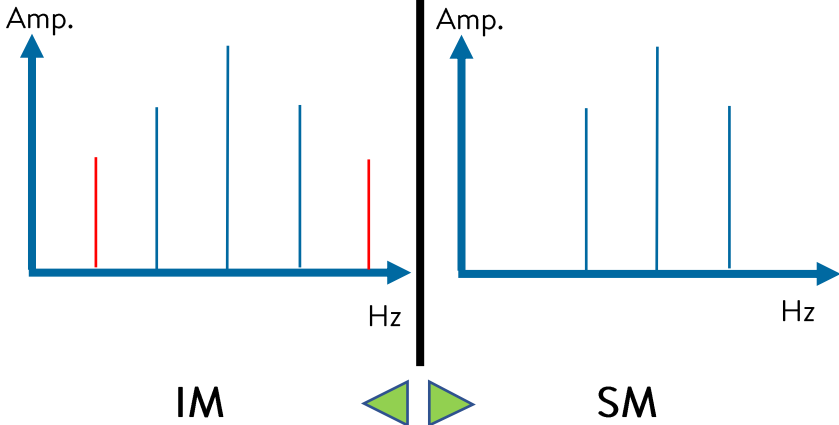
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#8: Saturation effects

Saturation produces new harmonic forces both in terms of frequency and wavenumber.

Saturation does not produce new harmonic forces.



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