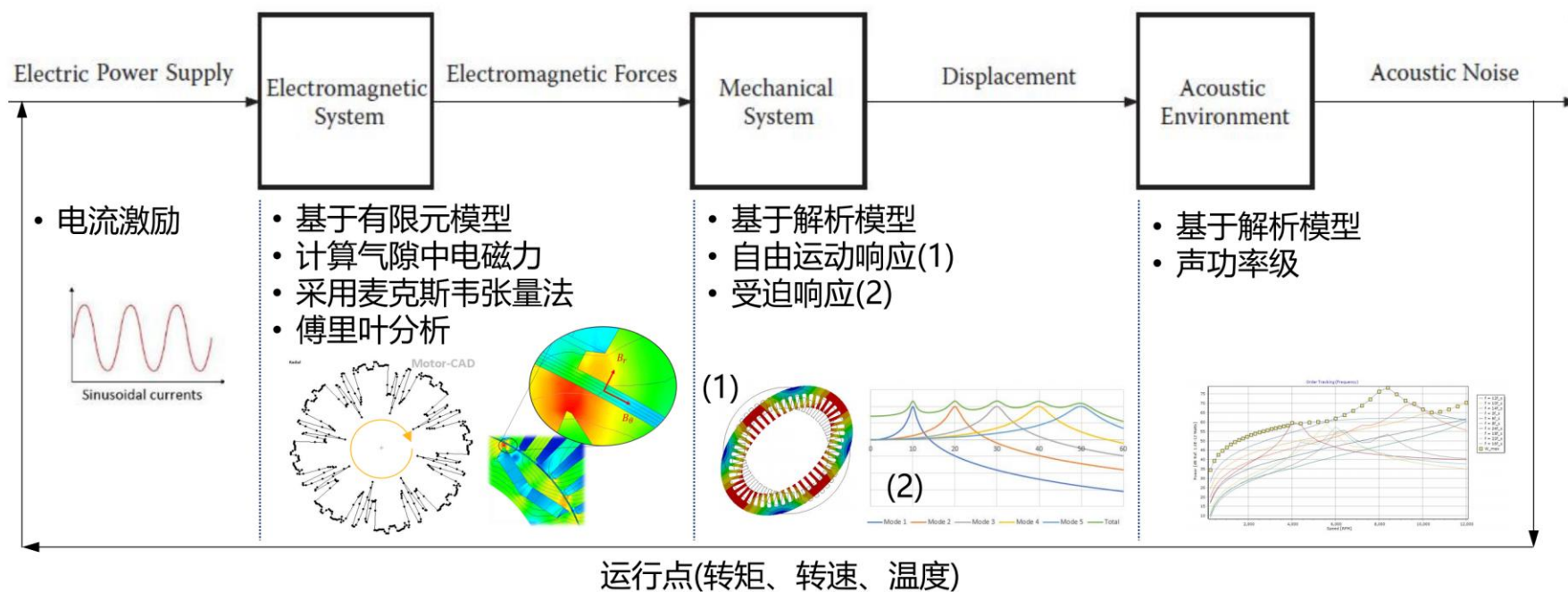


Motor-CAD_NVH分析介绍

Motor-CAD NVH 分析流程

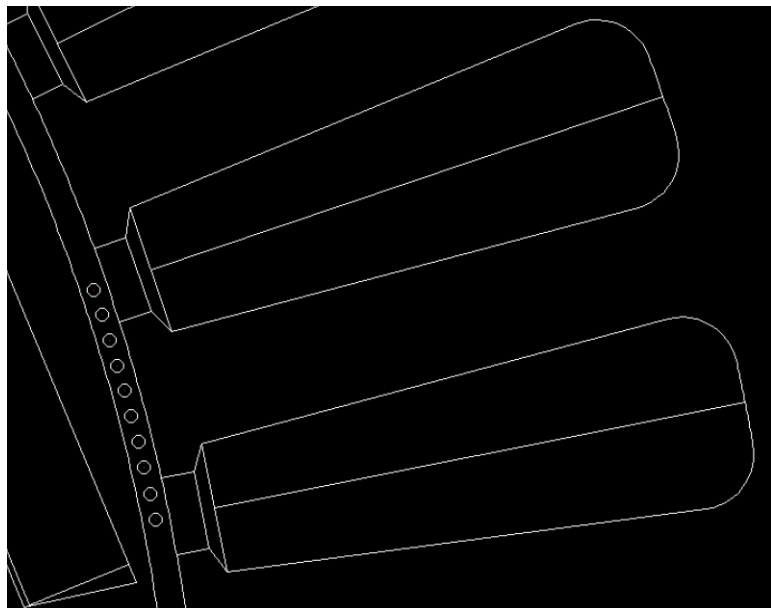


- 1. Motor-CAD电机电磁力计算**
- 2. Motor-CAD电机振动模态计算**
- 3. Motor-CAD电机振动噪声分析介绍**
- 4. Motor-CADNVH分析演示**

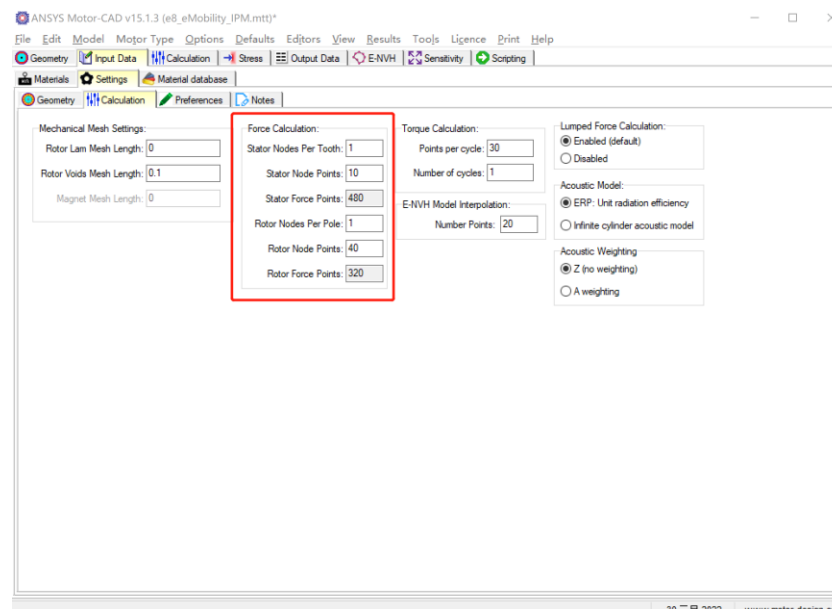
Motor-CAD电机电磁力计算方法：利用麦克斯韦应力张量法计算气隙中的电磁力；

因此，对气隙中大量点的计算是很有必要的，建议点之间的增量最下为0.5度；

支持电磁力导出，到外面做二次处理；



电磁力力点分布



电磁力计算设置

Motor-CAD电机电磁力计算方法：利用麦克斯韦应力张量法计算气隙中的电磁力；

计算公式：

$$f_r = \frac{1}{2\mu_0} [Br^2 - Bt^2] \quad \text{radial force density (pressure) in N/m}^2$$

$$f_t = \frac{1}{\mu_0} [Br Bt] \quad \text{tangential force density (pressure) in N/m}^2$$

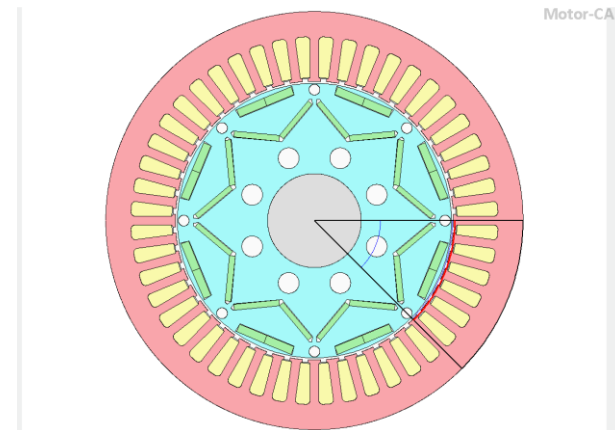
$$F_r = f_r \bullet L_{stk} \bullet L_{arc} \quad \text{radial force (pressure) in N}$$

$$F_t = f_t \bullet L_{stk} \bullet L_{arc} \quad \text{tangential force (pressure) in N}$$

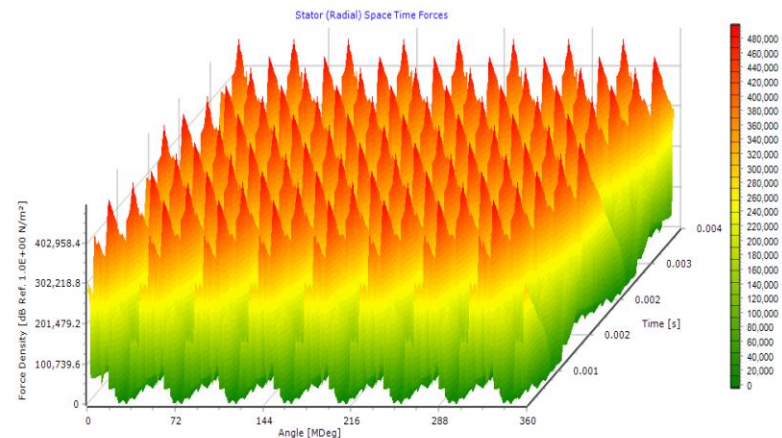
L_{stk} magnetic axial length = shortest of magnet, rotor lam and stator lam length (neglecting ducts)

L_{arc} length of arc over which the force is acting

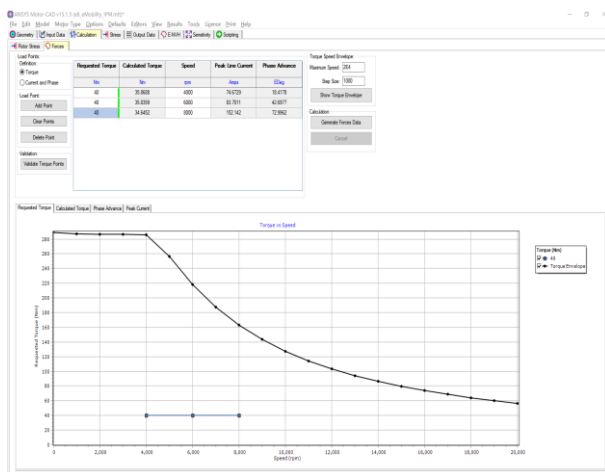
The definition of L_{arc} will depend on whether the force is calculated for the built-in force performance tests or for a user-defined path



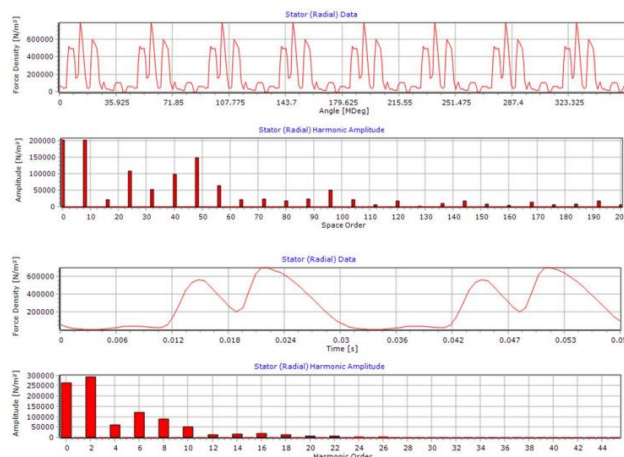
- Motor-CAD电磁FE求解器计算1D\2D时域和频域径向电磁力
- 可计算单或多运行点的电磁力
- 可导出电磁力至专业工具中进行高保真度NVH分析
- 支持BPM, Im, BPMOR, SYNCREL和SRM 电机类型



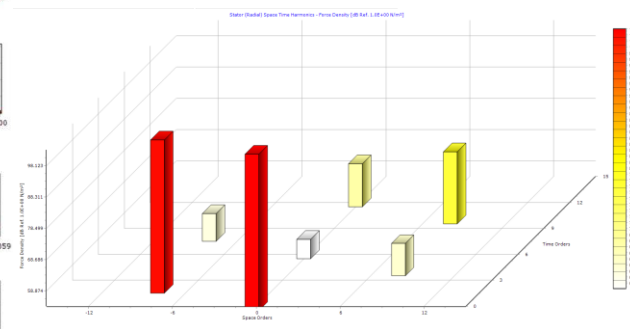
2D频时域电磁力分析



多工况计算



1D空间或时间电磁力分析

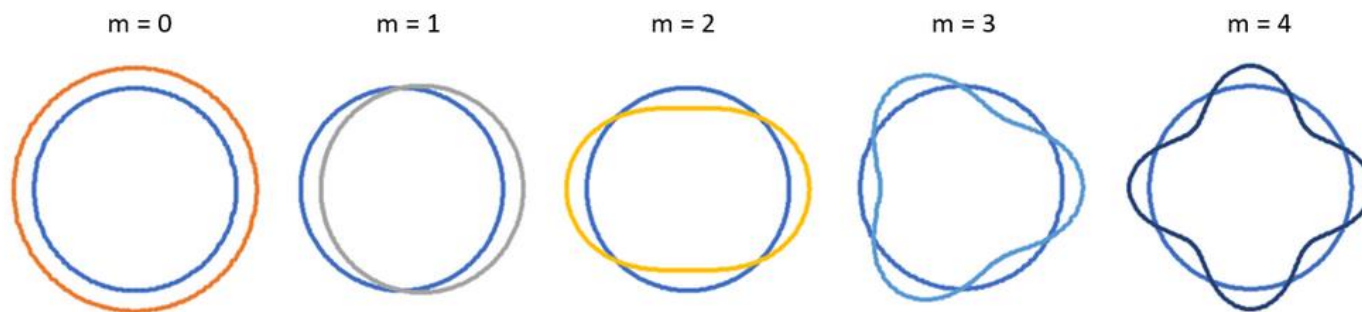


2D频域电磁力分析

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4. Motor-CADNVH分析演示

Motor-CAD采用等效圆环模型进行模态计算，计算了结构（单定子铁芯、定子铁芯+绕组、定子铁芯+绕组+机壳等）各模态的集中刚度、集中质量和固有频率；

由于Motor-CAD所采用的解析结构模型假设轴向力是恒定的，只考虑定子系统的纯周向振动模态；



模态计算公式：

$$f_m = \frac{1}{2\pi} \sqrt{\frac{K_m}{M_m}}$$

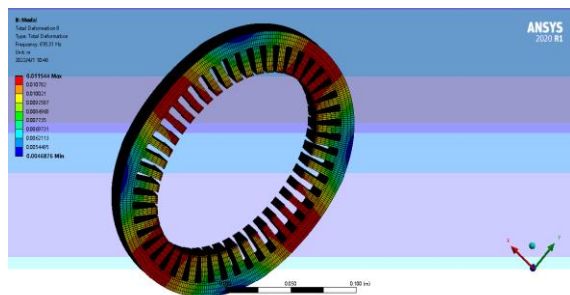
f_m natural frequency

K_m lumped stiffness

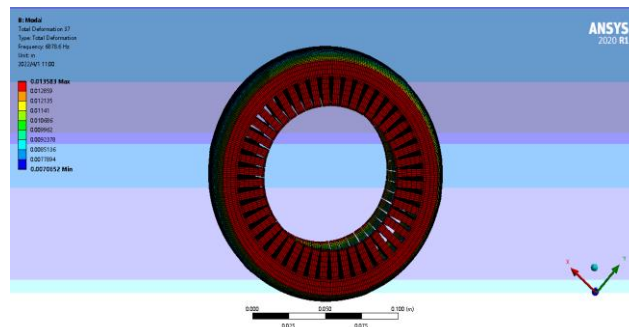
M_m lumped mass for a given mode m

Motor-CAD电机振动模态计算

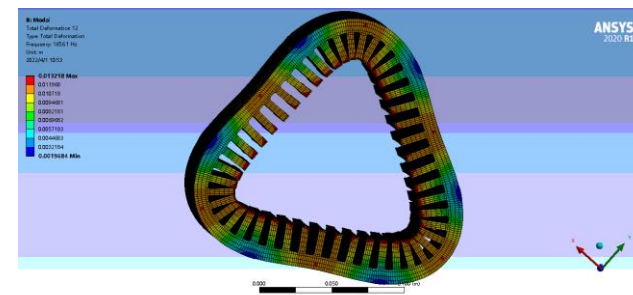
模态	Motor-CAD	Ansys Mechical	误差
(2, 0)	638.6Hz	618.31Hz	3.3%
(3,0)	1689.46Hz	1656.1Hz	2%
(4,0)	2982.46Hz	2991.4Hz	0.3%
(5,0)	4408.34Hz	4451.4Hz	1%
(0,0)	6697.29Hz	6878.6Hz	2.6%



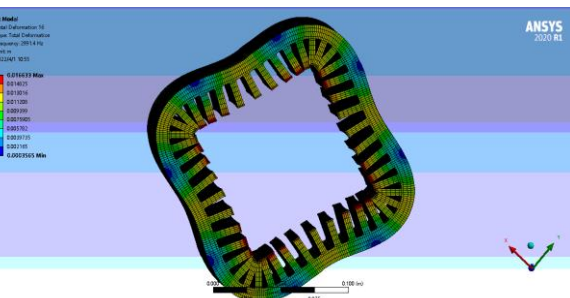
(2,0)



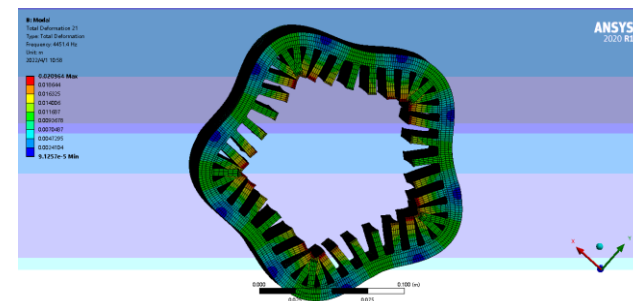
(0,0)



(3,0)



(4,0)

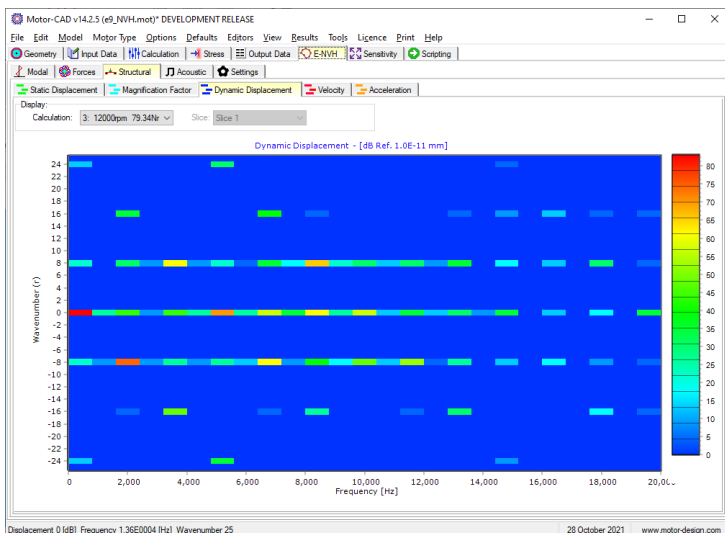


(5,0)

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Motor-CAD电机噪声分析介绍

振动计算方法：以激励源数据为输入，基于模态叠加法对定子的振动响应进行计算分析



振动位移

$$\hat{\chi}_{mn}^d = \hat{\chi}_{mn}^s H_{mn}$$

$$\hat{\chi}_{mn}^s$$

the magnitude of the radial Static Displacement

$$H_{mn}$$

the magnitude of the Magnification Factor

$$\hat{a}_{mn} = \hat{v}_{mn} w_n$$

$$w_n = n w$$

$$\hat{v}_{mn}$$

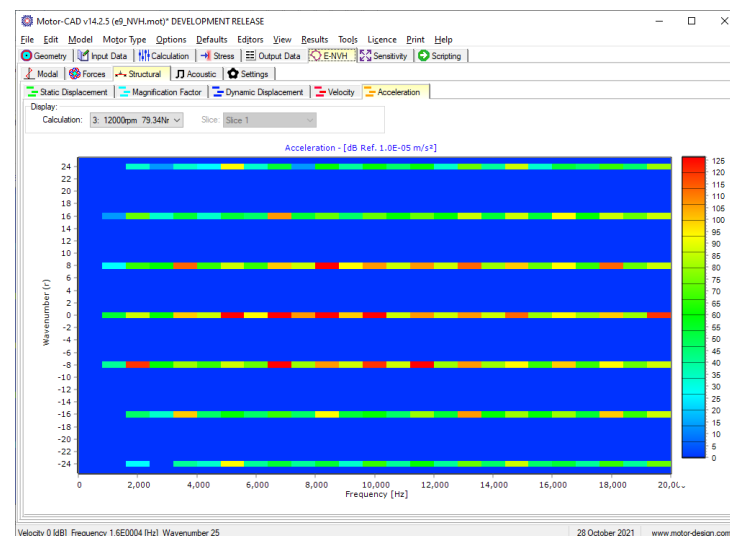
the magnitude of the radial Velocity.

$$w_n$$

the excitation pulsation

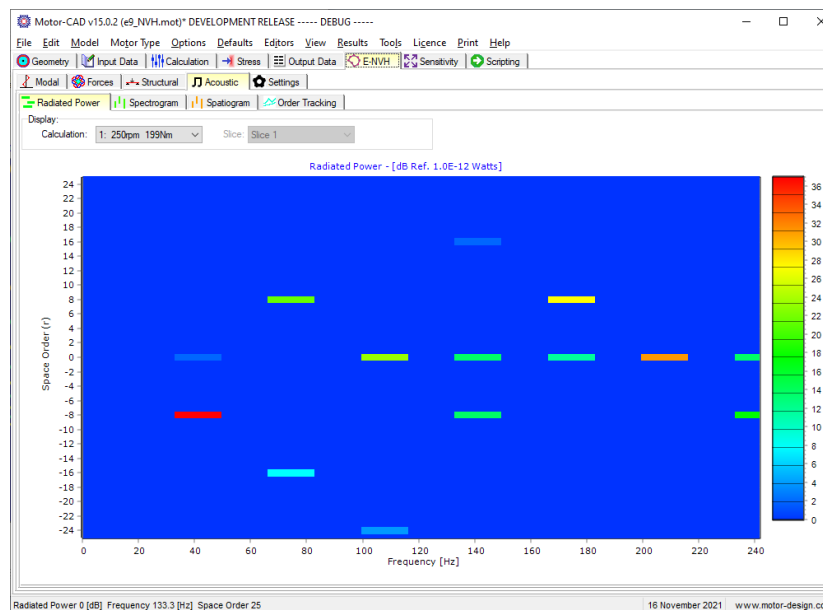
$$w$$

the fundamental pulsation (electrical).



振动加速度

噪声计算方法：以定子系统外表面的机械振动速度为输入，解析计算定子系统辐射的升功率级噪声



辐射噪声

$$W_{mn} = \frac{1}{2} \rho c \sigma v_{mn}^2 S$$

v_{mn}^2 the magnitude of the radial Velocity

ρ the density of the medium (for air at room temperature, = 1.186 kg/m³).

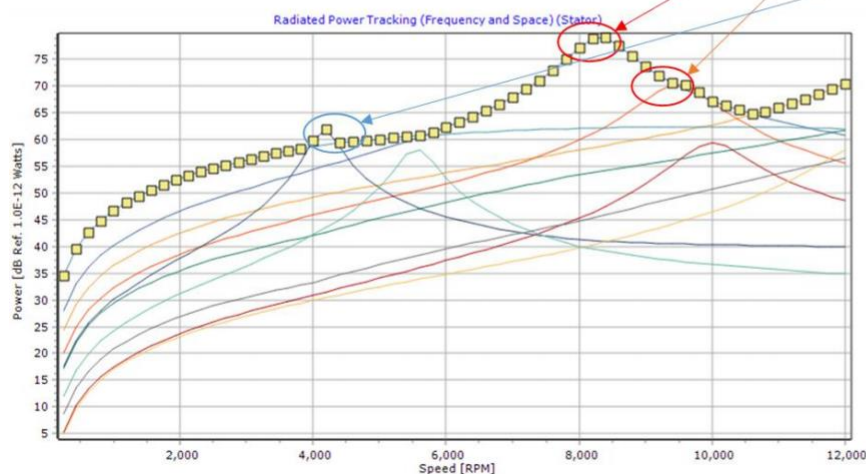
c the speed of sound in the medium (for air at room temperature, = 344 m/s).

σ the radiation factor. This parameter is ActiveX only and set to 1 by default (plane radiator assumption).

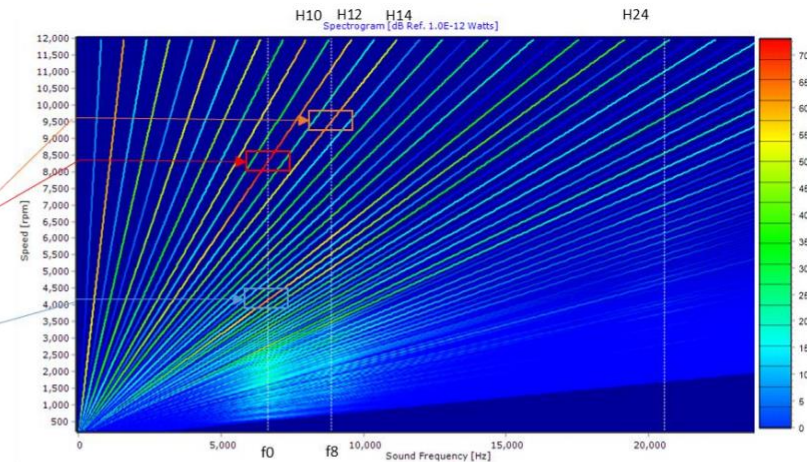
S the stator outer surface

Motor-CAD电机噪声分析介绍

噪声计算方法：以定子系统外表面的机械振动速度为输入，解析计算定子系统辐射的升功率级噪声



噪声阶次曲线



噪声color MAP

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