2022 R1 <u>Ansys</u> Motor-CAD 新技術

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- New NVH Solution
- Integration with Ansys
- Usability (UX)

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Engineering what's Anead.	
	CONTRACTOR AND AND AN



New NVH Solution Motor-CAD Standalone



NVH: Analysis Workflow



Operating point (torque, speed, temperatures)

NVH simulation loop: single and multiple operating points



NVH: Excitation Forces

- 1D and 2D Time and Frequency analysis of radial forces using • Motor-CAD Electromagnetic FEA Solver.
- Force calculations for single/multiple operating points
- Campbell diagram shows dominant harmonics across speed range
- Force export for high fidelity NVH analysis in dedicated tools •
- Available for BPM, SYNCREL and SRM machine types •



Multiple operating point calculations

1D Time & Space Force Analysis









2D Frequency Domain Force Analysis





NVH: Structural Analysis

- Based on fast analytical structural models
- Free motion response:
 - Modal Analysis based on equivalent thin ring model
 - Calculate natural frequencies of stator structure
- Forced response:
 - Static displacement calculation
 - Effect of resonance visualised as magnification factor
 - Dynamic displacement calculation
 - Dynamic velocity provides input into acoustic models
 - Dynamic acceleration direct measure for vibration



Dynamic displacement and magnification factors



NVH: Acoustic analysis

- Based on fast analytical acoustic models
- Spectrograms and spatiograms quantify acoustic response across speed range
- Order tracking provides further insight for root cause analysis and identifying measures to reduce noise





- New Motor-CAD NVH Solution:
 - Quickly compare noise for different motor concepts
 - Easily identify the cause of any motor noise early on
 - Provide the tools to enable a motor designer to make changes to reduce noise
- Avoid noise issues before they become a problem.



Integration with Ansys



Ansys optiSLang Export (1/3)

- Allows users to create a fully set-up optiSLang project ready to run based upon a base machine design in Motor-CAD. Template based optimisation.
- No scripting required, removes a significant amount of the workflow. Can go from a Motor-CAD file to an optiSLang MOP just via GUI interaction.
- Also useful for more experienced users. The exported script can be used as a template to customise and create more complex procedures. Fully compatible with the current Python node methodology.
- Available for BPM, SYNCREL and IM machine types.





Ansys optiSLang Export (2/3)

- User can pick from a range of input parameters and specify upper and lower bounds.
- Geometry, magnetic model and winding parameters.
- Outputs (requirements/constraints and objectives) can then be specified. Peak & continuous performance, mechanical analysis, torque ripple, duty cycle analysis, volume and mass.

nput Parameters Requirements Obje	ectives Summary To	est Run	
Radial Geometry	~		
Parameter	Value	Min Value	Max Value
Stator Lam Dia	130		
Stator Bore Ratio	0.6154		
Slot Depth Ratio	0.7229		
Tooth Width Ratio	0.4916		
Slot Opening Ratio	0.4116		
Sleeve Thickness Ratio	0		
Rotor Lam Ratio	0.6		
Banding Thickness Ratio	0		
Shaft Ratio	0.3205		
Shaft Hole Ratio	0		
Magnet Arc Ratio	0.8886		
Slot Corner Radius	0		
Tooth Tip Depth	1		
Tooth Tip Angle	30		
Magnet Thickness	4		
Magnet Reduction	0		

🇱 ANSYS optiSLang Export

Input Parameter	Input Parameters Requirements Objectives Summary Test Run												
Add Requi	irement Delet	e Selecte	d Requirements	Clear	AII R	equirements							
Туре	Variable		Requirement			Operating Point			Operating Format				
Peak	✓ Torque	~ >	100	Nm	at	(Speed) 3000	rpm		Speed 🗸				
Continuous	✓ Power	~ >	5000	Watt					Max value 🗸				
Terrus ringle	Percentage		5	•/	-+	(Speed)			Second (Mary				
Torque rippie		~ <	5	10	dl	5000	_ ipm		Speed/Max				
Duty cycle	 Efficiency 	~ >	90	%					~				

Ansys optiSLang Export (3/3)

- A summary of the optimisation is shown before exporting. Users just have to specify the optiSLang exe to be used and the export directory. Everything else should be handled by the install.
- Test run feature also available. This shows the Python script that will be used and allows users to see the output values for the current design and roughly how long a single run takes.

nput Parameters:			Input Parameters Requirements Objectives Summary lest Hun	
Variable	Min Value	Max Value	Control:	
Stator Lam Dia	100	200		
Stator Bore Ratio	0.5	0.8	Start Test Tun Stop Refresh Script	
Tooth Width Ratio	0.4	0.6		
Shatt Ratio	0.2	5		
Magnet mickness	5	5	Script:	
			1 ######	
equirements:			2 ###Motor-CAD to optiSLang coupled export script###	
Peak Shaft Torque > 1	00 Nm at 3000 rpm		3 ######	
			4	
Continuous Shaft Power > 5000 Watts	at maximum point on speed cu	irve	5 import win32com.client	
T Pro-1- (M-) (-) [%] - E %	+ E000		6 import os	
Torque Hipple (MSVW) [4] < 5 % 8	at 5000 rpm, maximum current		7 import time as timeModule	
Average Efficiency (Point by Point) > 90 %			8 from os import getowa	
			9 from os.path import join, dirhame, exists, basename	
			10 from collections import ordereduct	
hiantivae			11 from come import locatione, strictme, steep, time	
Minimise Weig	ht Magnet		12 From Scipy To Import Foldman	
Minimise Activ	re Volume		15 ### To be filled in by user if not being used with export ## /	2
			16 ###	2
			17	
			18 refdir = 'To be filled in by user or optislang'	
			19 motFileName = 'To be filled in by user or optislang (no .mot ex'	ension)'
			20	
			21 ###	(
SLang Exe Location:			<	
Program Files\Dynardo\ANSYS optiSLang\2021 R	2\optislang.exe		Change	
timisation Export Folder:			I lest fuil outputs will appear here upon compretion.	
\Workspace\Motor-CAD64\Dev\RobertKelly\Outpu	t\optiSLangExport		Change	



Export of geometries to Ansys Discovery (1/4)

- Export of 3D geometries from Motor-CAD into Discovery for use in Ansys Toolset.
- Is achieved using Python scripting
- Ability to have export of geometry that is not available in Motor-CAD template.
 - Export custom geometry in Motor-CAD defined from dxf





Export of geometries to Ansys Discovery (2/4)





Export of geometries to Ansys Discovery (3/4)



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Thermal Analysis in Ansys Discovery (4/4)

- Geometry exported from Motor-CAD can then be used for more detailed analysis in Ansys Discovery
- This example shows thermal analysis of the machine in Ansys Discovery





Granta Material Database (1/2)

Large database of Magnet and Electrical Steel materials from Granta are now included with Motor-CAD (>800 materials).

- Import materials from Granta databases.
- Granta licence required to access these materials.

٢	Import Material Database								– 🗆 X
	Material	Туре	Thermal Conductivity	Specific Heat	Density	Resistivity	Temp. Coef. of Resistivity	Magnet BH Values	Notes ^
	Units		W/m/°C	kJ/kg/*C	kg/m³	Ohm.m			
	Arnold N48H	Magnet	8.7	470	7500	1.8E-6	0	135	Neodymium magnet - Arnold - N48H. Data provided by MagWeb and
	Arnold N48M	Magnet	8.7	470	7500	1.8E-6	0	137	Neodymium magnet - Arnold - N48M. Data provided by MagWeb and
	Arnold N48SH	Magnet	8.7	470	7500	1.8E-6	0	112	Neodymium magnet - Arnold - N48SH. Data provided by MagWeb and
	Arnold N50	Magnet	8.7	470	7500	1.8E-6	0	138	Neodymium magnet - Arnold - N50. Data provided by MagWeb and
	Arnold N50H	Magnet	8.7	470	7500	1.8E-6	0	135	Neodymium magnet - Arnold - N50H. Data provided by MagWeb and
	Arnold N50M	Magnet	8.7	470	7500	1.8E-6	0	116	Neodymium magnet - Arnold - N50M. Data provided by MagWeb and
	Arnold N52	Magnet	8.7	470	7500	1.8E-6	0	140	Neodymium magnet - Arnold - N52. Data provided by MagWeb and
	Arnold N52M	Magnet	8.7	470	7500	1.8E-6	0	166	Neodymium magnet - Arnold - N52M. Data provided by MagWeb and
	Arnold N55	Magnet	8.7	470	7500	1.8E-6	0	115	Neodymium magnet - Arnold - N55. Data provided by MagWeb and
	AT&M ATMAX33H	Magnet	8.7	470	7300	1.5E-6	0	46	Neodymium magnet - AT&M - ATMAX33H. Data provided by MagWeb
	AT&M ATMAX45H	Magnet	8.7	470	7300	1.5E-6	0	133	Neodymium magnet - AT&M - ATMAX45H. Data provided by MagWeb
	AT&M ATMAX50M	Magnet	8.7	470	7300	1.5E-6	0	113	Neodymium magnet - AT&M - ATMAX50M. Data provided by MagWeb
	BJMT N48UHa	Magnet	8.7	470	7500	1.5E-6	0	107	Neodymium magnet - BJMT - N48UHa. Data provided by MagWeb and
	BJMT N50UH	Magnet	8.7	470	7500	1.5E-6	0	106	Neodymium magnet - BJMT - N50UH. Data provided by MagWeb and
	BJMT N52UH	Magnet	8.7	470	7500	1.5E-6	0	106	Neodymium magnet - BJMT - N52UH. Data provided by MagWeb and
	Bunting N33SH	Magnet	8.7	470	7500	1.5E-6	0	71	Neodymium magnet - Bunting - N33SH. Data provided by MagWeb and
	Bunting N33UH	Magnet	8.7	470	7500	1.5E-6	0	52	Neodymium magnet - Bunting - N33UH. Data provided by MagWeb and
	Bunting N35H	Magnet	8.7	470	7500	1.5E-6	0	75	Neodymium magnet - Bunting - N35H. Data provided by MagWeb and
	Bunting N50	Magnet	8.7	470	7500	1.5E-6	0	141	Neodymium magnet - Bunting - N50. Data provided by MagWeb and
	Daido Electronics ND-31HR	Magnet	8.7	470	7600	1.35E-6	0	52	Neodymium magnet - Daido Electronics - ND-31HR. Data provided by
	Daido Electronics ND-31SHR	Magnet	8.7	470	7700	1.35E-6	0	47	Neodymium magnet - Daido Electronics - ND-31SHR. Data provided by
	Daido Electronics ND-35HR	Magnet	8.7	470	7600	1.35E-6	0	52	Neodymium magnet - Daido Electronics - ND-35HR. Data provided by
	Daido Electronics ND-39R	Magnet	8.7	470	7600	1.35E-6	0	77	Neodymium magnet - Daido Electronics - ND-39R. Data provided by
<									>
									Found 637 materials Import Selected Cancel







Granta Material Database (2/2)

Material	Туре	Thermal Conductivity	Specific Heat	Density	Resistivity	Temp. Coef. of Resistivity	Lamination Thickness	Kh (Steinmetz)	Kh (Bertotti Classical)	Kh (Bertotti Maxwell)	Keddy	Kexc (Bertotti Classical)	Kexc (Bertotti Maxwell)	Alpha (Steinmetz)	Alpha (Bertotti Classical
] Units		W/m/°C	kJ/kg/°C	kg/m³	Ohm.m										
AK Steel M-19, 14mil, B-H	Steel	73	460	7650	6E-7	0	0.3556	0.0098487	1E-8	0.012140506	3.516	0.0034902617	0.0010193048	3.8936191	0.21083338
AK Steel M-19, 14mil, B-H	Steel	73	460	7650	6E-7	0	0.3556	0.0103687	1E-8	0.012099216	3.493	0.0034902668	0.0010203131	3.7933899	3.771283
AK Steel M-19, 14mil, B-H	Steel	73	460	7650	6E-7	0	0.3556	0.0100833	1E-8	0.012127253	3.500	0.0034902668	0.0010199599	3.8895978	3.8417903
AK Steel M-19, 19mil, B-H	Steel	73	460	7650	6E-7	0	0.4699	0.0320809	0.020013565	0.02443524	2.367	0.0017157506	0	1.5760826	3.177904
AK Steel M-19, 19mil, B-H	Steel	73	460	7650	6E-7	0	0.4699	0.0337749	0.019885978	0.024435392	2.275	0.0017195092	0	1.6688383	3.1888003
AK Steel M-19, 19mil, B-H	Steel	73	460	7650	6E-7	0	0.4699	0.0323765	0.020064888	0.024435347	2.324	0.0017140229	0	1.6107308	3.1794652
AK Steel M-22, 19mil	Steel	73	460	7650	4.93E-7	0	0.4699	0.0128121	0.0024926571	0.01161455	1E-5	0.00288052	0.0010523205	1.3541464	4.1303122
AK Steel M-36, 14mil	Steel	73	460	7650	4.3E-7	0	0.3556	0.0212281	0.013766035	0.031382519	3.615	0.0023091603	0	1.4307888	4.5146129
AK Steel M-36, 14mil, B-H	Steel	73	460	7650	4.3E-7	0	0.3556	0.0198638	0.014281608	0.031382549	3.686	0.0022694842	0	1.4372749	4.4805521
AK Steel M-36, 19mil	Steel	73	460	7650	5.99E-7	0	0.4699	0.0240954	0.0065738012	0.025189041	5.268	0.003195388	0.00061988943	2.3152706	4.0001708
AK Steel M-36, 19mil, B-H	Steel	73	460	7650	5.99E-7	0	0.4699	0.0243770	0.0065907569	0.025206367	5.270	0.0031925785	0.00061944705	2.2909577	4.0002275
Arcelor Mittal M195-35A,	Steel	73	460	7650	5.5E-7	0	0.35	0.0139076	0.0030323361	0.019936561	3.375	0.0022894765	0.00039421041	1.9046715	5
Arcelor Mittal M195-35A,	Steel	73	460	7650	5.5E-7	0	0.35	0.0135977	0.0030883219	0.019911512	3.416	0.0022778382	0.00039480982	1.5923014	4.990521
Arnold Arnon 5	Steel	73	460	7500	4.8E-7	0	0.127	0.0288929	0.024310678	0.020431521	1.962	0.00025697621	9.2125511E-5	1.6390069	1.7632324
Arnold Arnon 7	Steel	73	460	7500	4.8E-7	0	0.1778	0.0291107	0.0051178058	0.025811163	1.002	0.001608662	0.00048457757	1.4689412	5
Baosteel B50AH300	Steel	73	460	7700	4.5E-7	0	0.5	0.0205917	0.0069671065	0.024458437	6.683	0.0026750442	0.00022346182	1.8363704	2.2964503
Baosteel B50AH470	Steel	73	460	7750	4.5E-7	0	0.5	0.0243873	0.013323194	0.021072283	6.781	0.0024594978	0.00040172866	1.8017857	2.2454821
Baosteel B50AH600	Steel	73	460	7750	4.5E-7	0	0.5	0.0253009	0.010197435	0.017022005	1E-5	0.0036670065	0.0016648267	1.7474258	2.2408575
Baosteel B65A470	Steel	73	460	7650	4.4E-7	0	0.65	0.0294360	0.0088383634	0.018733631	1E-5	0.0038205625	0.00064272483	1.5349089	2.3662141
Baosteel B65A700	Steel	73	460	7750	3E-7	0	0.65	0.0418341	0.017626866	0.02735238	1E-5	0.0039310194	0	1.6514396	2.4056578
Baosteel B65A800	Steel	73	460	7800	2.9E-7	0	0.65	0.0542220	0.026917648	0.037277903	1E-5	0.0042497737	0	1.5729142	2.0944873
China Steel 35CS440, B-H	Steel	73	460	7700	3.9E-7	0	0.35	0.0262014	0.015847431	0.021155806	3.656	0.001736701	0.00040631808	1.6652162	2.2229116
China Steel 35CS550	Steel	73	460	7750	3E-7	0	0.35	0.0383944	0.025927433	0.028543076	3.956	0.0019303322	0.00045840698	1.6112524	1.8989656

_	Alloy_powder_core.gdb
AlNiCo_magnet.gdb	Cobalt_steel.gdb
Bonded_molded_magnet.gdb	Electrical_steel_grain_oriented.gdb
Ferrite_ceramic_magnet.gdb	Electrical_steel_non_grain_oriented.gdb
Neodymium_magnet.gdb	Ferrite_core.gdb
Neodymium magnet JL Mag.gdb	Iron_powder_core_plus_SMC.gdb
Constitute as half as a set adh	Metglas_and_nanocrystalline.gdb
Samarium_cobait_magnet.gdb	Nickel_steel.gdb





Usability (UX)



New tapered tooth SRM geometry

• New taper angle of stator pole option





Rounding of duct corners

Important for Emag and mechanical calculations

- Rectangular ducts
- Arc ducts
- Separate rounding parameter for each duct layer
- Stator, housing and rotor ducts



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Calibrated of Induction Machine equivalent circuit parameters

- Calibration of equivalent circuit multipliers from test data.
 - No-load test -> Lm and Rfe as functions of magnetizing current and Back EMF. Used for calibrating lookup data.
 - Load test -> L1, L2 and R2 as functions of speed.

2 Motor-CAD v14.2.0.10 (No File)* DEBU	JG		🇱 Motor-CAD v14.2.0.10 (No File)* -	DEBUG		- 🗆 X			
le Edit Model MotorType Options [Defaults Editors View Results Tools Li	icence Print Help	File Edit Model MotorType Options Defaults Editors View Results Tools Licence Print Help						
Geometry 📘 Winding 🚺 Input Data	Calculation 🛛 🤣 E-Magnetics 📄 🎫 Output Data	Graphs Sensitivity Scripting	💿 Geometry 📘 Winding 🔯 hput Data 🛛 👫 Calculation 🛛 🧭 E-Magnetics 🛛 🧮 Output Data 🛛 🖄 Graphs 🛛 🖉 Scripting						
🖌 Materials 🔦 Settings 🦂 Material databas	e]		📩 Materials 🏠 Settings 🖂 Materi	al database					
Geometry Calculation	Granhe Helossae Profesancee		🚫 Geometry 🛛 🔗 E-Magnetics 🛛 🚺	Calculation 🛛 🚧 Graphs 🛛 🛊	🗱 Losses 🛛 🖍 Preferences 🛛	Notes 🚼 Calibration			
Magnetice settings:			No Load Test Load Test						
	Manufacturing Factors	End Winding Inductance Calculation	Operating point:	Magnetizing Inductance	Core Loss Resistance				
Rotor Iron:		Rosa and Grover (default)	Frequency: 50	Test Data Calibration Fa	ctor				
 Laminated (default) 	Armature EWdg length multiplier:		Max Voltage (Peak): 100	Magnetizing Current	Magnetizing Inductance	Magnetizing Inductance (Lm)			
◯ Solid	EWdg Inductance multiplier: 1	() Hanseinan	Max Voltage (RMS): 70.71	Amps	mH	🔽 — Motor-CAD Data 🔽 — Calibrated Data 🔽 — User Data			
O Non Magnetic	Equivalent Circuit Inductance Multipliers:	End Ring Inductance Calculation:		0	120	Calibration Factors			
amination Stacking Factor [Potor]: 0.97	Definition:	 Richter (default) 	Calculate Motor-CAD Data	0.5	142				
Clates lass	 Constant value (default) 	O Liwschitz-Garick		1	146	148 0.985			
Laminated (default)	 Calibrated 	Equivalent Circuit Skewing Effect Method:	Use calibrated lookup data	2	146	146			
Solid	Magnetizing Inductance: 1	Richter (default)				142 0.97			
O Non Magnetic		○ Veinatt				T 140 0.965			
	Stator Leakage Inductance: 1	O Venior				Ē 138			
Lamination Stacking Factor [Stator]: 0.97	Rotor Leakage Inductance: 1					2 136 0.955 g			
Stacking factor calculation:						t 134 0.945 m			
O Ignore Stacking Factor	Go to Calibration Tab					0.94 B			
Stacking Factor (axial length)		4				128 0.935			
Stacking Factor (saturation)(default)	Length Adjustment Factors:					126 0.93			
	Stator saturation multiplier: 1			Paste Data	Clear All Data	124 0.92			
	Rotor saturation multiplier: 1			Add Data Pairt	Dalata Data Baist	122 0.915			
	Magnetic axial length multiplier: 1			Add Data Point	Delete Data Point				
				Cal	ibrate	Magnetizing current (rms) [A]			



Magnet Data Fitting

New functionality to use demagnetisation curves:

- Similar functionality to iron losses, each point needs a temperature, B value and H value
- Calculate magnet parameters from the data to use in Motor-CAD model:
 - Br(Tref)
 - HcJ(Tref)
 - α
 - β
 - μr
 - Squareness factor
- Can specify reference temperature to increase accuracy for most 'useful' magnet temperature







DXF Import Interface

- Interface showing imported dxf
- Easier to check imported dxf geometry

	DXF Import – 🗆 🗙
	Import
DXF Import – □ ×	File: C:\Workspace\Motor-CAD64\Main\Main\Output\Motor-CAD Data\test.c Select File Display Clear DXF Import Close
Import	
File: C:\Workspace\Motor-CAD64\Main\Main\Output\Motor-CAD Data\test.c Select File Display Clear DXF Import Close	Context Selection: DAF Dimensions:
Context Selection: Magnetic (not used) Mechanical (not used) Height: 116	Magnetic (not used) Mechanical (not used) Themal (empty)
Themal (empty)	
Position (-36.48,65.22) mm	Position (24.10,36.48) mm

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Insys

Multiphase Winding improvement

• New option to specify the multiphase offset between phasegroups





Concentric winding improvement

- Improved Concentric winding options
- Added winding when have non integer number of coils per pole
- e.g. For 36 slots 4 poles have average of 1.5 coils per pole





Improved custom conductor placement

- Improved interface for specifying each conductor locations in slot.
- Important for designs where AC winding losses are significant.



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Load / save winding pattern

- New option to load or save a winding pattern from a file
- Also enabled for ActiveX





Python scripting interface

- User interface to allow users to run python scripts.
- Gives full functionality of Python to user scripts.
- Examples:
 - Generate non template geometries
 - Calculate currents during EMag calculations
 - Calculate heat transfer coefficients during thermal calcs
 - Calculate losses in thermal calcs
 - Automate workflows with Ansys tools (Maxwell, Discovery, Fluent)





Improved custom output

• User interface to allow users to run python scripts for custom outputs.

 Image: Second state of the second s

Vorive C E-Magnetics 2

Maximum torque possible (DQ) (For Phase Advance of 25.98 ED

Average torque (virtual work) Average torque (loop torque) Torque Ripple (MsVw) Torque Ripple (MsVw) [%] Speed limit for constant torque (For Phase Advance of 0 EDeg) No load speed Speed limit for zero q axis current Electromagnetic Power Input Power Total Losses (on load) Output Power System Efficiency Shaft Torque Power Factor [Waveform] (lagging Power Factor Angle [Waveform] Power Factor [THD] Power Factor [Phasor] (lagging) Power Factor Angle [Phasor] Load Angle [Phasor] Phase Terminal Voltage (ms) [P Rotor Inertia Shaft Inertia Total Inertia Torque per rotor volume

- Very flexible able to get:
 - Calculated values
 - Graph values
 - Thermal circuit values
 - FEA result values

			Custom Output Edit	or				_		×
			Output Editor Settinge							
			Setunga			2				
			New Custom Output	Delete Custom Output	ıt	Evaluate Custom Outputs				
			Custom Output	t Name		Output	Notes	Enabled	^	
										
			Torque ripp	ble		21.1	Custom Note		_	
			Average Tor	que		100.84	Custom Note		_	- 1
			l orque ripple	ratio		0.21	Custom Note		_	
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			Python Expression							
			1 #	Output-2						
			2							
			3 # EXAMPLE (501201						
			5 # Find var:	iables with Activ	eXParameter tabl					
			6 # Double c.	lick or use butto	n to add to scri	pt .				
			7							
			8 # Get Moto:	rCAD variables						
			9 AvTorqueVW	= GetVariable("A	wTorqueVW")					
			10 11 TormeBinn	leMeUu = CetVaria	ble ("TormeRippl	Meller")				
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e Options D	efaults Editors View	Results loois	Licence Print Help			/ AvTorqueVW),2)				
Input Data	Calculation @ E-Magr	etics == Output Da	ata 🖉 Graphs 😰 Sensitivity 💽 Scripting							
Phasor Diagram	Equivalent Circuit	Strain Plux Densities	🐺 Losses 🛛 🜄 Winding 🗶 Miscellaneous 🛛 🤞	Materials T(x) Custom						
	Value	Units	 Variable 	Value	Units ^					
	120.22	Nm	Flux Linkage D (Q axis current)	63.654	mVs					
eg)	100.01			70 0004						
	100.84	Nm	Flux Linkage Q (Q axis current)	70.8921	mvs mVo					
	21.097	Nm	Flux linkage Q (On load)	70.4421	mVs					
	20.954	%								
	5320.8	rpm	Torque Constant (Kt)	0.377084	Nm/A					
	8120	mm	Motor Constant (Km)	3 71193	Nm/(Watts^0.5)					
	INF	rpm	Back EMF Constant (Ke) (fundamental)	0.441008	Vs/Rad					
	42173	Watts	Stall Current	27253.1	Amps					
	42917	Watts	Stall Torque	10276.7	Nm					
	41177	Watts	Cogging Period	75	MDeg					
	95.947	%	Cogging Frequency	3200	Hz					
			Fundamental Frequency	266.667	Hz					
	98.303	Nm	Mechanical Frequency	66.6667	Hz					
,	0.07000		Optimum Skewing Angle	7.5	MDeg					
D	47 751	EDea	Magnetic Symmetry Factor	8						
	47.731	LUCY	(Automatic calculation)	0						
	0.6587		Magnetic Axial Length (Slice 1)	150	mm					
	0.66913	ED	Torque ripple	21.1	Notes: Custom Note					
	40 48 294	EDeg	Torque riople ratio	0.21	Notes: Custom Note					
asor]	115.31	Volts		0.21	Contraction of the second method					
	0.028234	kg.m ²								
	0.00049545	kg.m²			I					
	0.020720	ka m²								
	50 500	k New /m-1								
	50.569	kNm/m ³	v		~					
	50.569	kNm/m ³	•	3 December 2021	www.motor-design.com					



SYNC machine Rotor Damper Bars

• New modelling of rotor damper bars

0	ANSYS Motor-CAD v15.1.1 (SYNC	_Generator_DamperBars_ACLoad.mot)*
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<u>File Edit Model Motor Type Options Defaults Editors View Results Tools Licence Print Help</u>

💿 Geometry 📘 Armature Winding 📙 Field Winding 🗽 Input Data 👫 Calculation 🕼 E-Magnetics 🧮 Output Data 🖉 Graphs 💱 Sensitivity 🔷 Scripting

🔨 Drive | 🖉 E-Magnetics | 🏂 Phasor Diagram 🐺 Equivalent Circuit | 🄅 Rux Densities | 🌞 Losses | 🌄 Winding | 🛦 Miscellaneous | 🙈 Materials

Variable	Value	Units	^	Variable	Value	
Phase Resistance	1.568	Ohms		Field Winding Resistance	0.3095	+
D Axis Inductance	108.4	mH		Field Winding Inductance	268.1	
Q Axis Inductance	140.7	mH		Field Winding Reactance	84.24	
Stator Slot Leakage Inductance	10.12	mH		Referred Field Winding Reactance	105.5	
Stator Differential Leakage Inductance	2.629	mH				
Amature End Winding Inductance (Rosa and Grover)	1.704	mH		Field Winding Leakage Inductance	193.1	
Stator Leakage Inductance (Total)	14.45	mH		Referred Field Winding Leakage Inductance	241.8	Т
Magnetizing Inductance (D Axis)	93.93	mH		Field Winding Leakage Reactance	60.67	Т
Magnetizing Inductance (Q Axis)	126.3	mH		Referred Field Winding Leakage Reactance	75.97	Т
						Τ
D Axis Reactance	34.05	Ohms		Damper Bar Slot Leakage Inductance	0.001459	T
Q Axis Reactance	44.2	Ohms		Damper Bar Differential Leakage Inductance	0.0004342	T
Stator Slot Leakage Reactance	3.179	Ohms		Damper End Ring Inductance (front)	0.0002482	
Stator Differential Leakage Reactance	0.8259	Ohms		Damper End Ring Inductance (rear)	0.0002695	T
Armature End Winding Reactance	0.5353	Ohms		Damper End Ring Inductance	0.0002589	T
Stator Leakage Reactance (Total)	4.54	Ohms		Inter-Bar Damper End Ring Inductance (front)	2.458E-005	T
Magnetizing Reactance (D Axis)	29.51	Ohms		Inter-Bar Damper End Ring Inductance (rear)	2.669E-005	
Magnetizing Reactance (Q Axis)	39.66	Ohms		Inter-Bar Damper End Ring Inductance	2.563E-005	
Damper Bar Resistance	0.0004092	Ohms		Damper Cage Leakage Inductance (total)	0.002152	
Damper End Ring Resistance (front)	1.853E-006	Ohms		Damper Cage Leakage Reactance (total)	0.000676	
Damper End Ring Resistance (rear)	3.705E-006	Ohms		Referred Damper Cage Leakage Inductance	36.67	
Damper End Ring Resistance	2.779E-006	Ohms		Referred Damper Cage Leakage Reactance (total)	11.52	
Damper Cage Resistance (total)	0.0004372	Ohms				
				First Order Transient Reactance (D Axis)	25.79	
Rotor to Stator Transform for Impedance	1.704E004			First Order Transient Reactance (Q Axis)	44.2	
Referred Damper Bar Resistance	6.972	Ohms		Second Order Transient Reactance (D Axis)	12.22	
Referred Damper End Ring Resistance	0.04735	Ohms		Second Order Transient Reactance (Q Axis)	13.47	
Referred Damper Cage Resistance (total)	7.45	Ohms	¥			





RotorAir B=0.012T µR=1 J= 0A/mm2 C= 0AT Area= 3976mm2

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– 🗆 X

Units

Ohms

mH Ohms

Ohms

mΗ

mΗ

Ohms

Ohms

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Ohms

mH

Ohms

Ohms

Ohms

Ohms

Ohms

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Improved AC winding loss calculation

- Now able to make a full FEA AC winding loss calculation using a custom dxf geometry
- Custom stator lamination shape can be used.
- Conductors can be positioned in slot.





New geometry ratios for IM machines

- Expanding on the BPM/SYNCREL ratios from V14.
- Useful for optimisation and required for Ansys optiSLang export.





Endwinding overhang calculation

- New option for automatic calculation of endwinding overhang.
- Overhang used for thermal calculations based on winding pattern.

		Check Da	Umagnet aspect ratio (inter): 1 Magnet separation: 0.1		
Show Leakage (default) Thermal Graph Colours: Individual Component (default)			None (default) Single definition for al Minimum Quantities: Back iron thickness: Shaft separation: Vmagnet aspect ratio:		
End Winding Overhang: User Specified Automatic Calculation (default) Blown Over Flow Arrows: Do not Show Leakage	Flow Arrows: O Do Not Scale Scale (default)	Radial cross section drawing: Stator rotation: 0 Rotor rotation: 0	Comer Rounding (Rotor Lamination): None (default) Single definition for all Comer Rounding (Magnets):		
Endcap Specification: C Endcap - Winding Spacing Endcap Thickness (default) End Winding Specification: Winding Gaps Winding Expansion (default)	Fin Input Options:	Bow Arrows: Head width: 8 Tail width: 2 Scaling: 1 Min. Length: 20 Spacing Factor: 0.1	OpenGL 3D Settings: 3D Curve Precision 8 Low High No. Radial Duct 3D Arrows : 8		
ANSYS Motor-CAD v15.1.1 (No I Eile Edit Model Motor Type Geometry , Winding Materia Cooling * Losses & Materia Models @Geometry , Wir Cooling & Cooling , Wir	File)* Ωptions Defaults Editors Vie t Data Mill Calculation F Temp als] Interfaces Mill Radiation ndmg ﷺ Cooling ∰ Losses J	w <u>B</u> esults Tools Ligence <u>P</u> r eratures <u>≣</u>] Output Data ∑3 Se <mark>∰</mark> Natural Convection � End S ✔ Preferences � End Space €	int Help nativity O Scripting ipace O Settings Aterial database (; Convergence ≪ Transient Misce	Ilaneous 🕞 Notes	X





IM1PH machine added operating points

- Added operating point specifications for:
 - Torque / Frequency

and

- Power / Frequency

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File Edit Model MotorType Options Defi	aults Editors View Results	Tools Licence	Print Help		<u>F</u> ile <u>E</u> dit <u>M</u> odel M	lo <u>t</u> or Type <u>O</u> p	otions <u>D</u> efault	s Ed <u>i</u> tors	<u>V</u> iew <u>R</u> esu	ilts Too <u>l</u> s	Licence Print	<u>H</u> elp						
Geometry Winding Minut Data	Iculation	netice EE Output D	ata Canbe 52 Sensitivity Scrinting		Geometry Wind	ing 🛛 🛃 Input D	Data 🛛 🚺 Calcul	ation 🛛 <table-cell-rows> Dr</table-cell-rows>	ive 🛛 🧇 E-N	Magnetics	📰 Output Data 📔	Graphs	Sensitivity	🛛 🕤 Scripti	ng			
Geometry Winding More Mode: Operating Mode: Operating Mode: Operating Mode: Operating Point Definition: Operating Point Definition: Operating Point Definition: Operating Point Definition: Speed / Sig Onwer / Frequency Sig / Frequency Sig / Frequency Sig / S	Isclation → Drive ② E-Magr Skew : Skew Angle: □ Temperatures : Amature Winding Temperature: Bar Temperature: End Ring Temperature: Stator Lamination Temperature: Rotor Lamination Temperature: Airgap Temperature: Destrict Temperature:	etetics Image: Compute Definition: Skew Definition: Skator Rotor Rotor 40 140 140 20 20 20 20 20 20 20	ta @ Graphs @ Scinativity ♥ Scinoting E-Magnetic ++ Thermal Coupling: No couping (default) E-Magnetic -+ Thermal Coupling: E-Magnetic curverged Solution Performance Tests: Analyto: Analyto: Scingle Load Point Locked Rotor No Load Point Breakdown (Pul-Out) Point Torque / Speed Characteristic Restaure Scingle Charact		0.17 0.16 0.14 0.14 0.16 0.16 0.14 0.13 0.12 0.11	rig i por c	e ∐ ∠Losses	Airgap F	Ux Density On load S	Power To Shaft Torque	I would be a provide the provided	Airgap Torq	y ⊵ Acce	Ieration reakdown Sh	aft Torque]		
AC Mains (voltage driven) Inverter Fed (current driven) Voltage Drive: Definition: Peak Peak Voltage: 100 RMS Voltage: 70.71	Bearing Temperature [R]	20	Rotor Stresses: Centrifugal Forces Cancel Solving		0.1 E 0.09 0.07 0.06 0.06 0.04 0.03 0.02 0.01 0.04 0.03 0.02 0.01 0.00 0.01 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00	200 40	0 600	800	1,000	1,200	1.400 1.600 Speed [rpm]	1,800	2,000	2,200	2,400	2,600	2,800	3,000
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