



**STAR  
Global  
Conference  
2012  
19 - 21 March**

**One Conference, a World of Engineering Success**

***SPEED*: Software for Electric Machine  
Design and Analysis**

Markus Anders



# What is *SPEED*?



- ⊗ **The leading design software for electric machines**
- ⊗ **Detailed analysis with finite-element links or finite-embedded solver for**
  - Motors, Generators and Alternators
  - including inverters and other electronic controls
- ⊗ **Application areas (main)**
  - Automotive including electric & hybrid vehicles
  - Aerospace
  - Industrial and automation
  - Domestic appliances
  - Power tools
  - Medical systems
- ⊗ **Over 150 corporate accounts**
  - Over 1500 users
  - A Worldwide Distributors Network including support
  - Operating in all industrialized countries



# What is *SPEED*?



## ⊗ *SPEED* brings authority in electrical machine theory and design

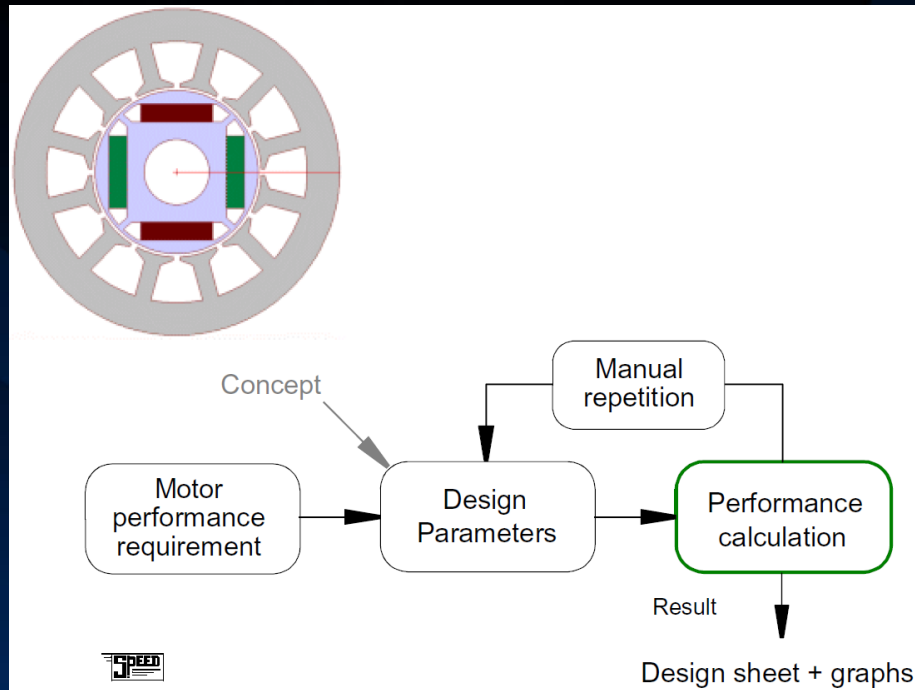
- based on a vast range of applications in real product design
- much more than just a calculator

## ⊗ Not just software, but as well as

- Training,
- Technical support,
- Documentation (manuals, tutorials and electrical machine theory books)
- Engineering services and
- Consulting through the distributors

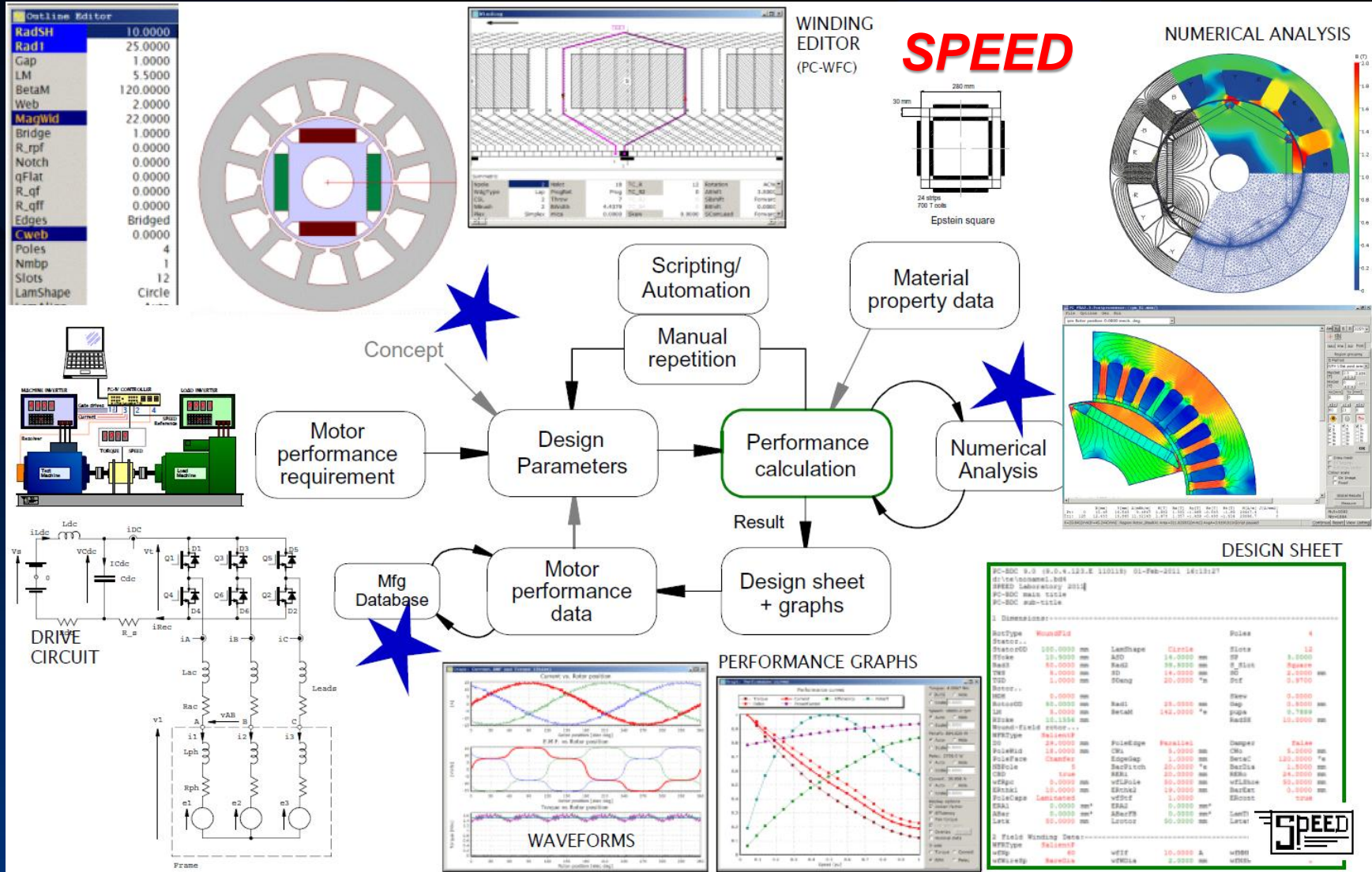


# Electric machine calculations: In general



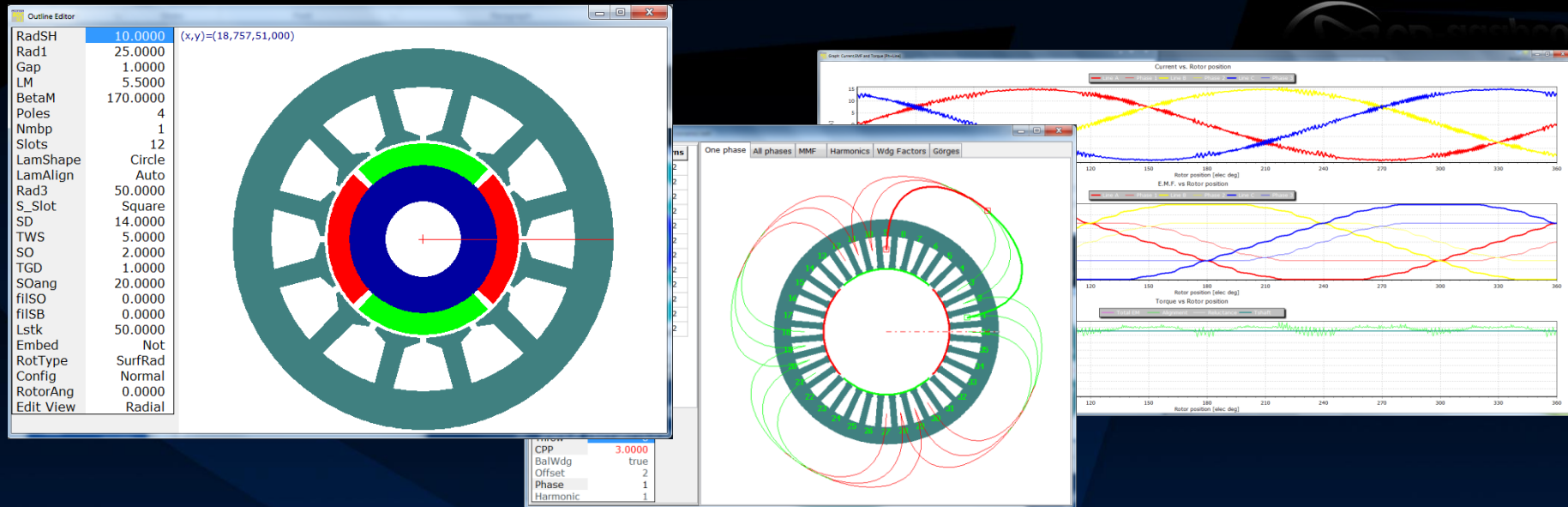


# Electric machine calculations using *SPEED*: not to replace the designer but provide a **fast** calculation tool to try ideas





# The *SPEED* Software



- ⊗ **Analytical based so gives near instantaneous calculation speeds**
  - input dimensions, select materials and drive and calculate performance
    - Initial Design – 10 Minutes
    - Optimized Design – within hours
- ⊗ **Specialised user interface to ease data input and interpretation of results**
  - dedicated geometry and winding editors
  - produces performance graphs to aid understanding
- ⊗ **Detailed analysis with finite-element links or**
  - The embedded finite-element solver for key problems



# The *SPEED* software programs



⊗ The following machine types are available:

- brushless permanent magnet and wound-field AC synchronous

- PC-BDC

- induction

- PC-IMD

- switched reluctance

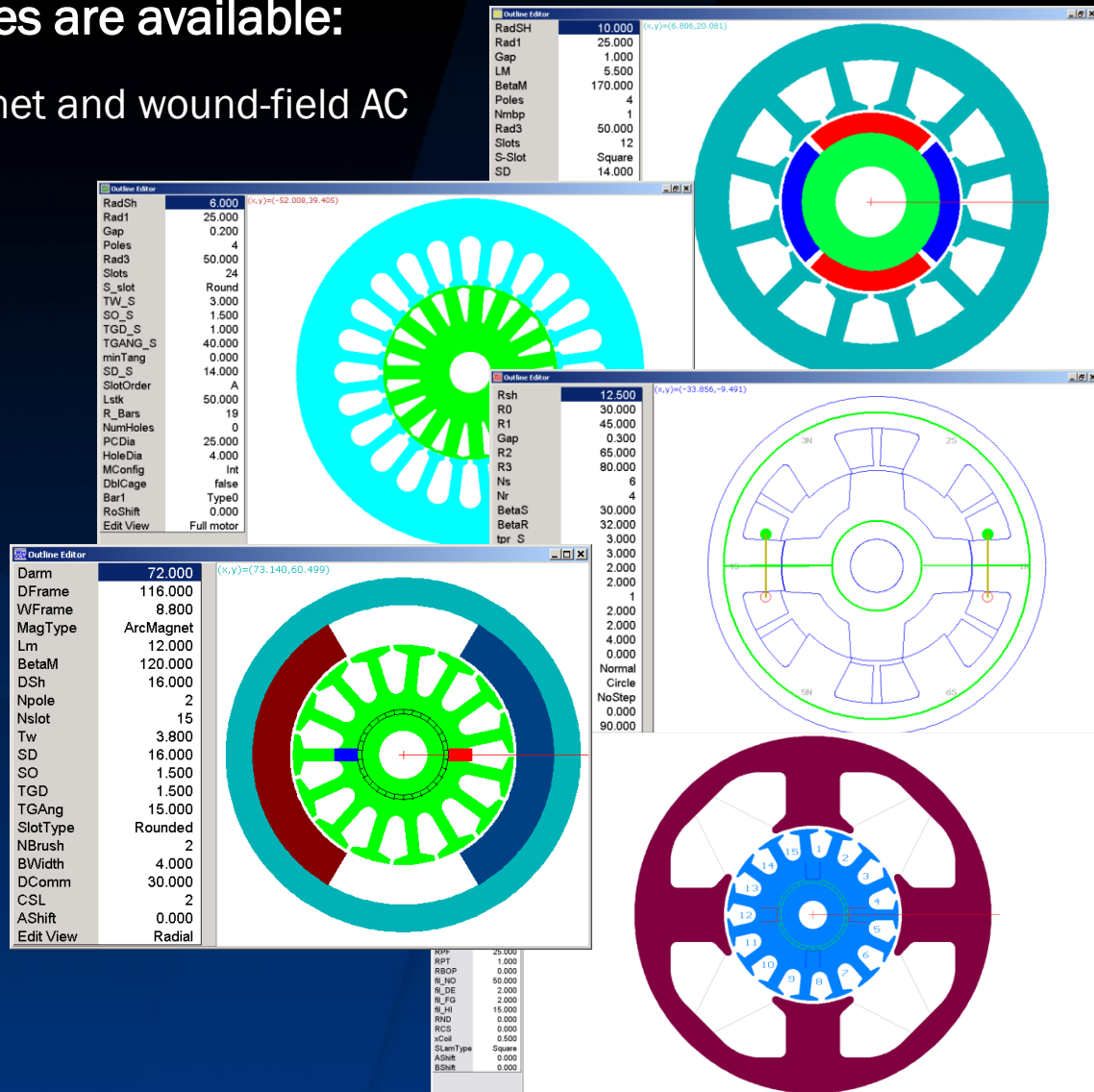
- PC-SRD

- direct current (PM)

- PC-DCM

- wound field and PM commutator

- PC-WFC





# The *SPEED* Software history (main programs)



1986 – Speed Laboratory set up

1987 – PC-SRD released (DOS)

1989 – PC-BDC released (DOS)

1992 – PC-DCM released (DOS)

1994 – PC-IMD released (DOS)

...

2000 – Release of full Windows versions

...

2004 – PC-WFC released

...

2011 – CD-adapco acquired SPEED in June 2011

Present – Release versions (2011):

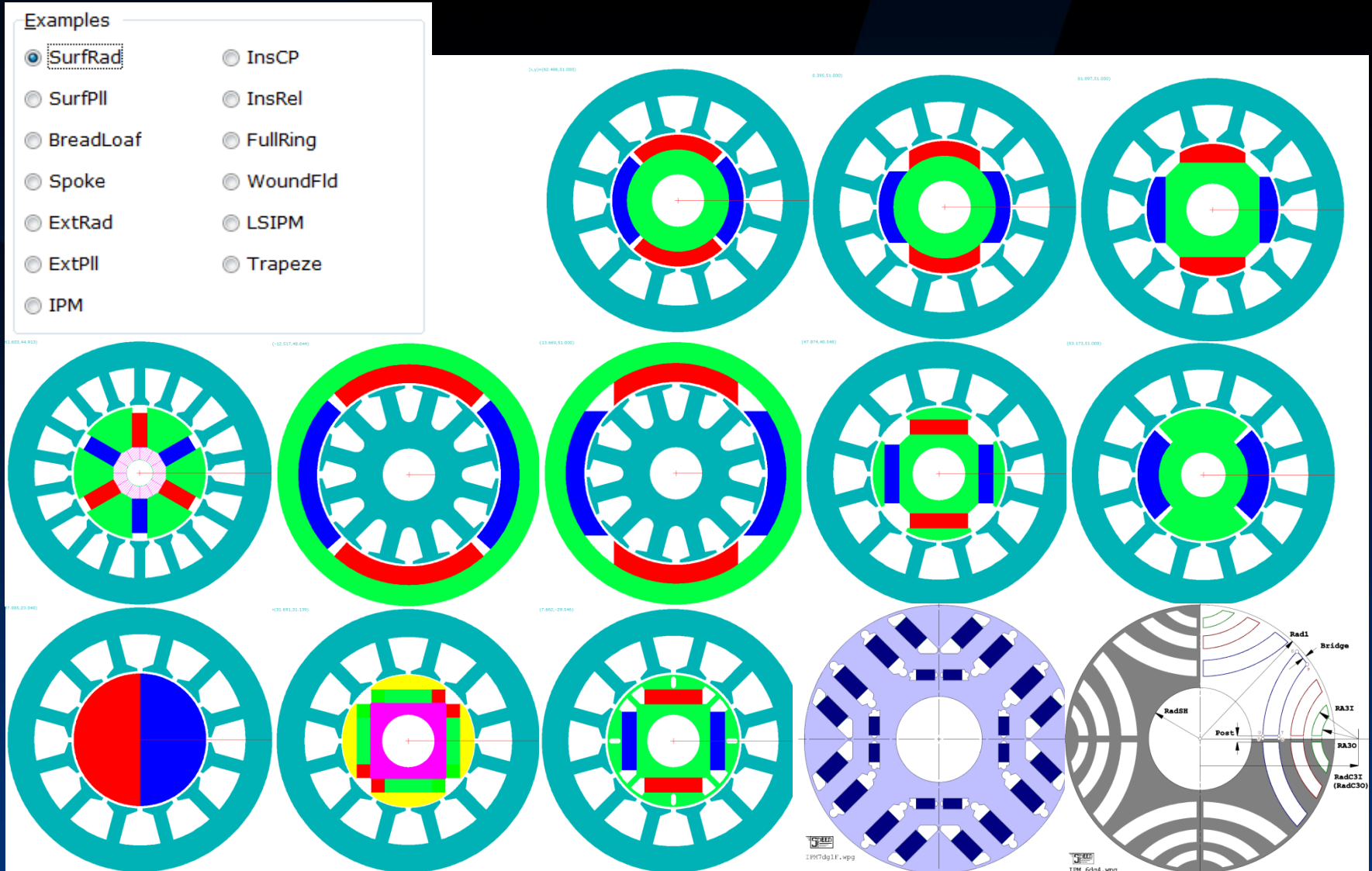
- PC-SRD 8.8, – PC-BDC 9.1
- PC-IMD 4.1, – PC-DCM 3.9 and
- PC-WFC 2.6

... Continuing development ...



# SPEED PC-BDC machine types

more than 40 basic standard templates





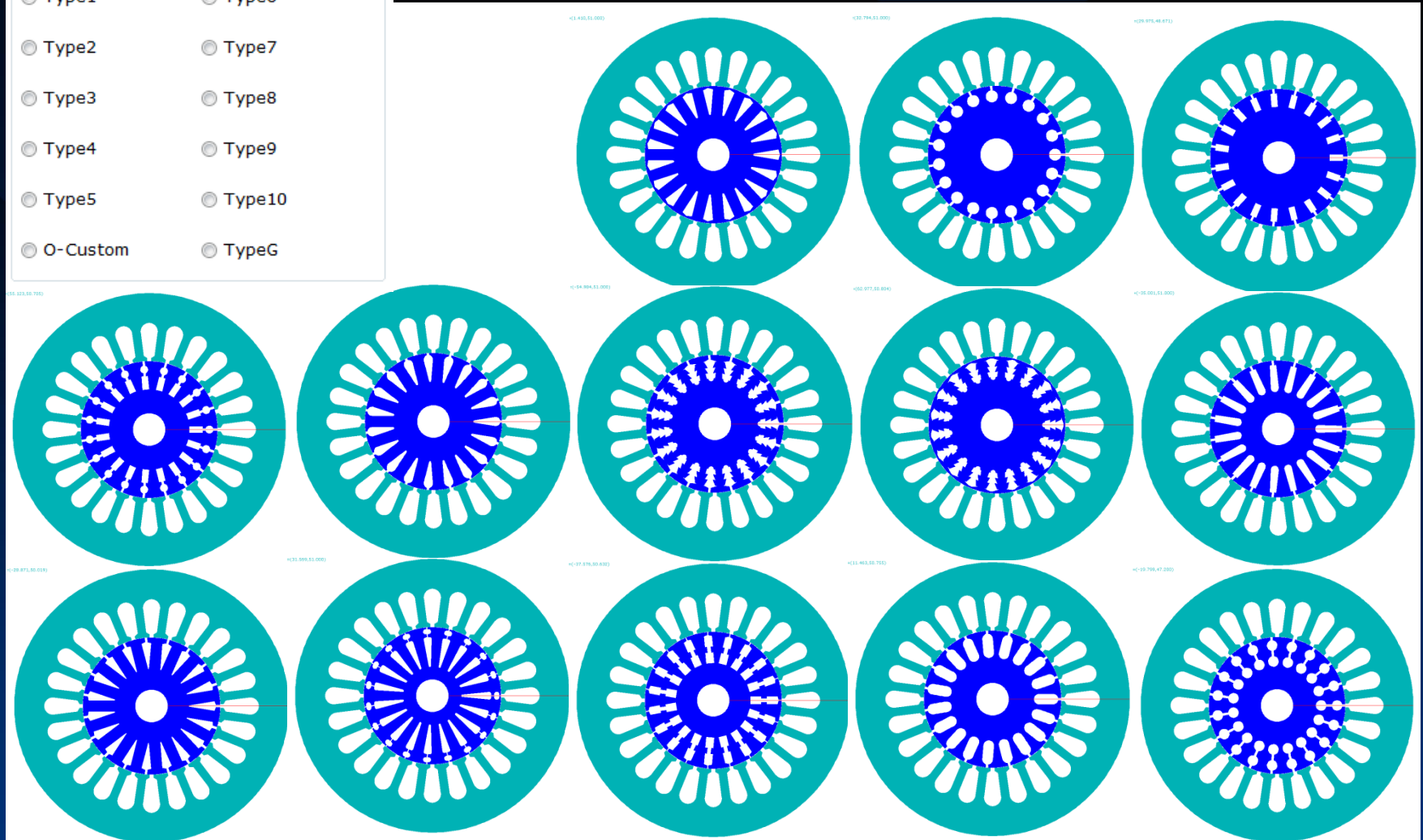
# SPEED PC-IMD machine types

more than 40 basic standard templates



Examples

- ☒ Type0
- ☐ Type1
- ☐ Type2
- ☐ Type3
- ☐ Type4
- ☐ Type5
- ☐ O-Custom
- ☐ C-Custom
- ☐ Type6
- ☐ Type7
- ☐ Type8
- ☐ Type9
- ☐ Type10
- ☐ TypeG

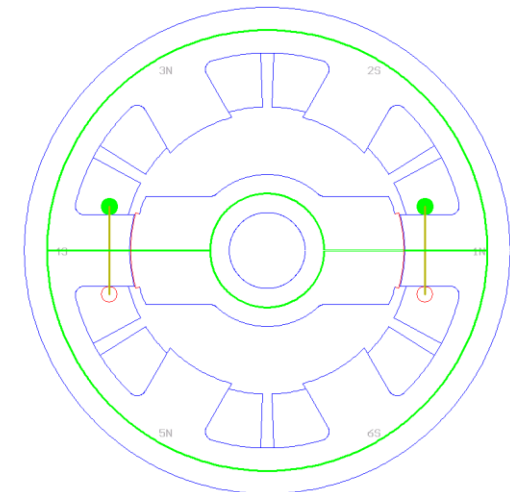
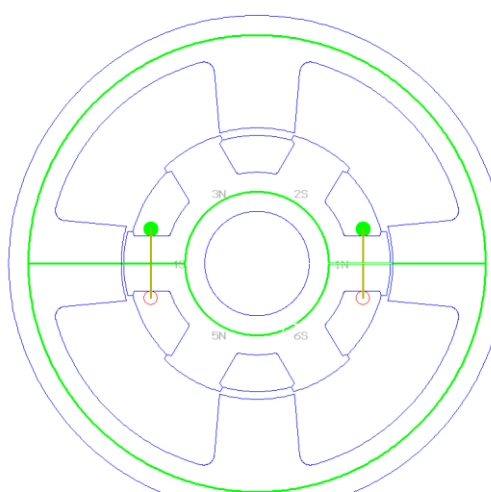
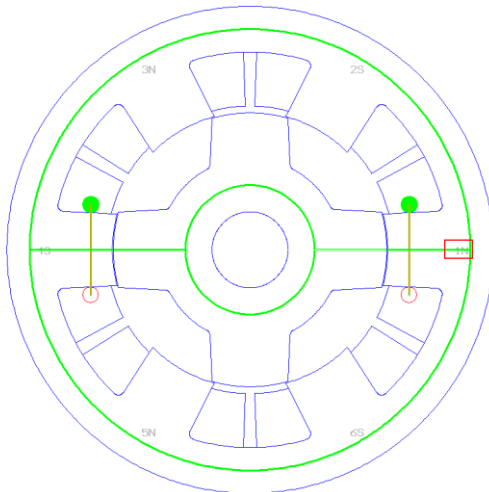
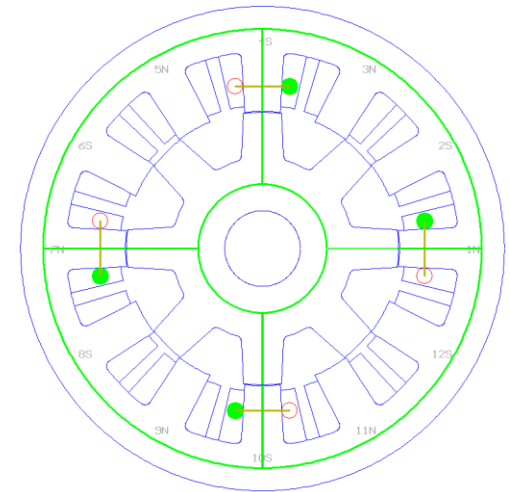
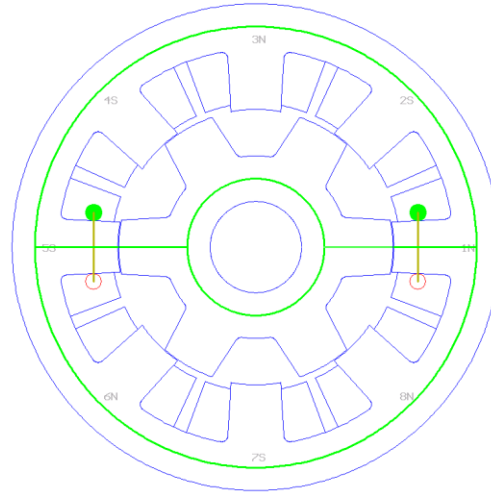




# SPEED PC-SRD machine types

## Examples

- ☒ A little 3-phase motor
- ☐ A little 4-phase motor
- ☐ A 3-phase 12/8 motor
- ☐ An outside-rotor motor
- ☐ A stepped-gap 6/2 motor

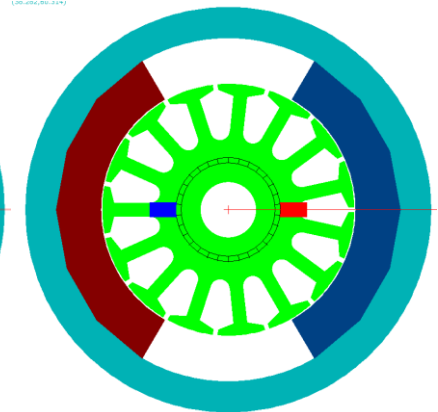
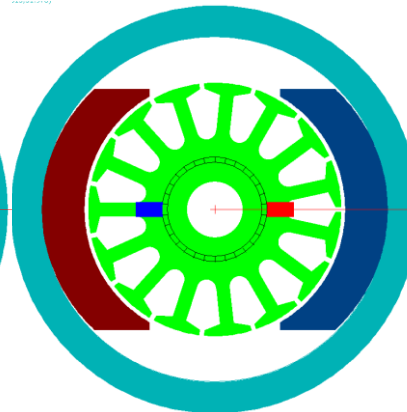
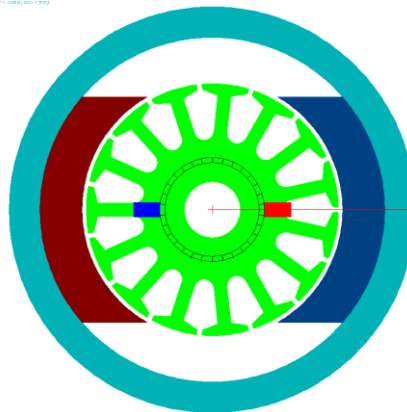
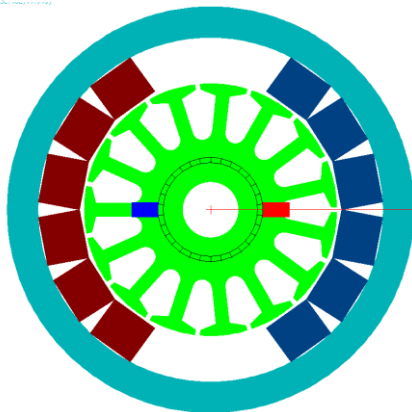
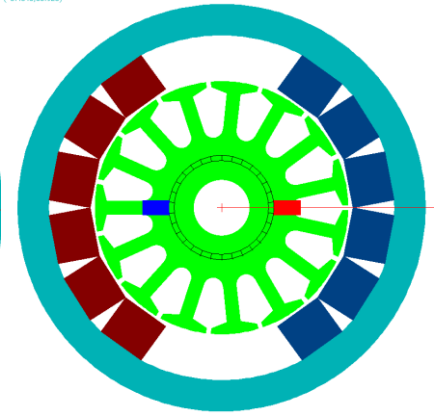
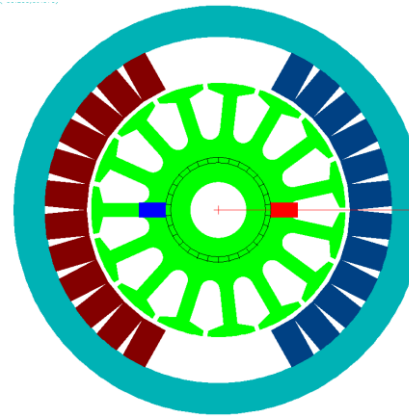
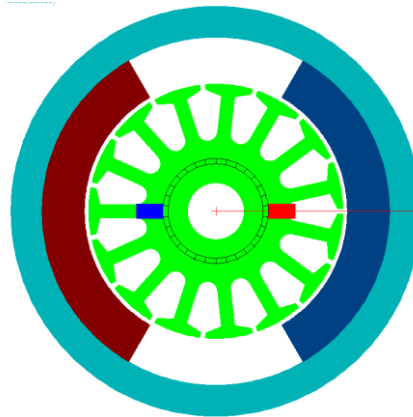




# SPEED PC-DCM machine types

## Examples

- ☒ ArcMagnet
- ☐ Breadloaf
- ☐ BlockStl
- ☐ BlockAir
- ☐ PllSide
- ☐ Taper
- ☐ ArcFlat
- ☐ Melon





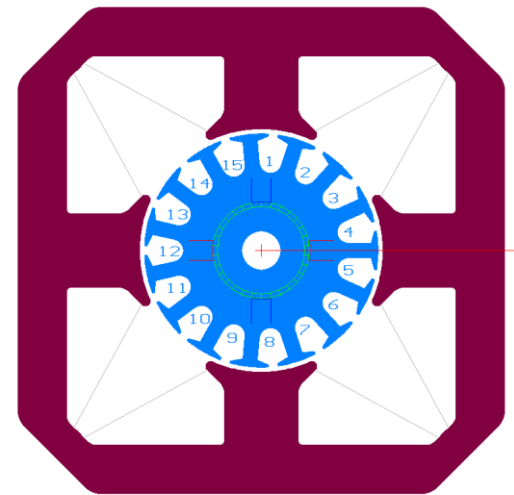
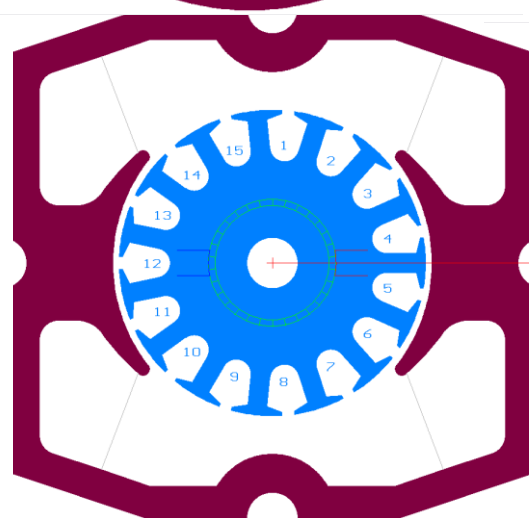
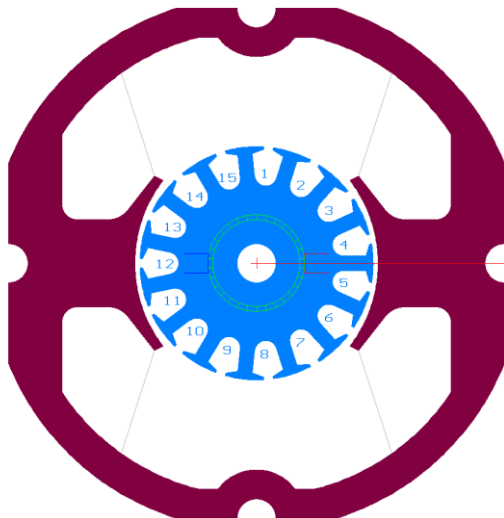
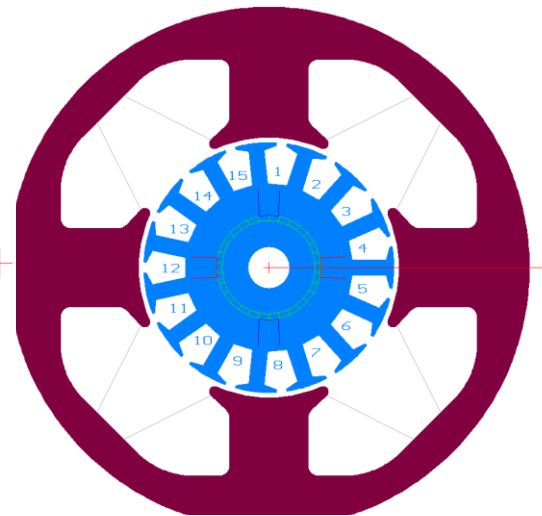
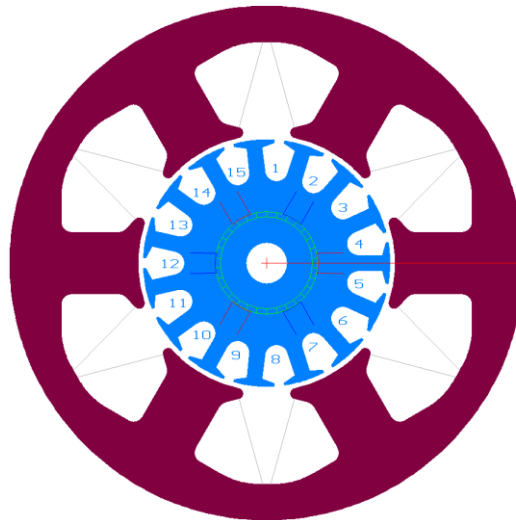
# SPEED PC-WFC machine types

## Examples

- ☒ WF Square 2 pole
- ☐ WF Round 2 pole
- ☐ WF Round 4 pole
- ☐ WF Square 4 pole
- ☐ WF Square 6 pole
- ☐ WF DimGroup=dg1 2 pole
- ☐ PM Arc magnet

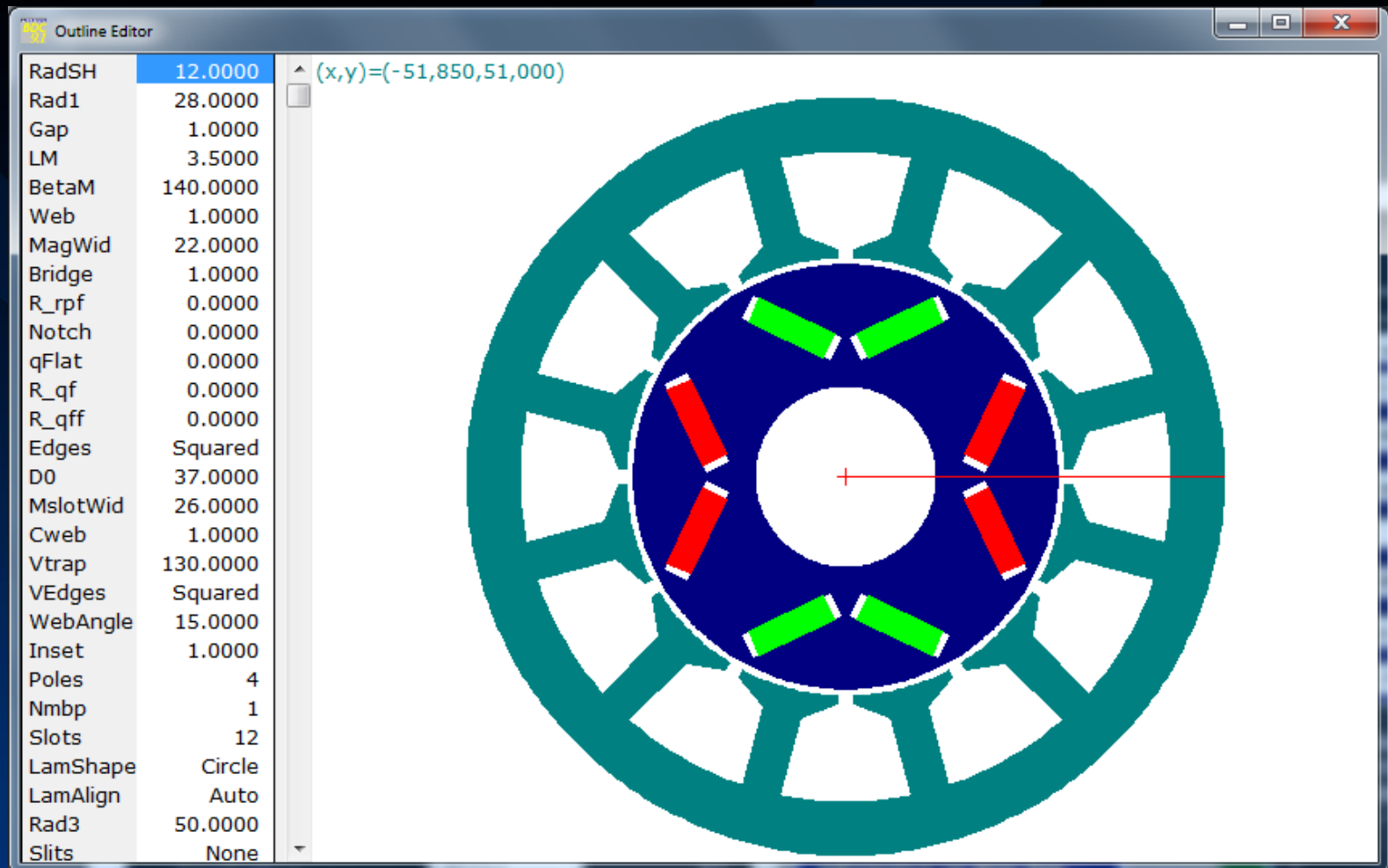
## Drive/Connex

- ☐ AC series
- ☐ DC series
- ☐ DC shunt
- ☐ DC sep ex



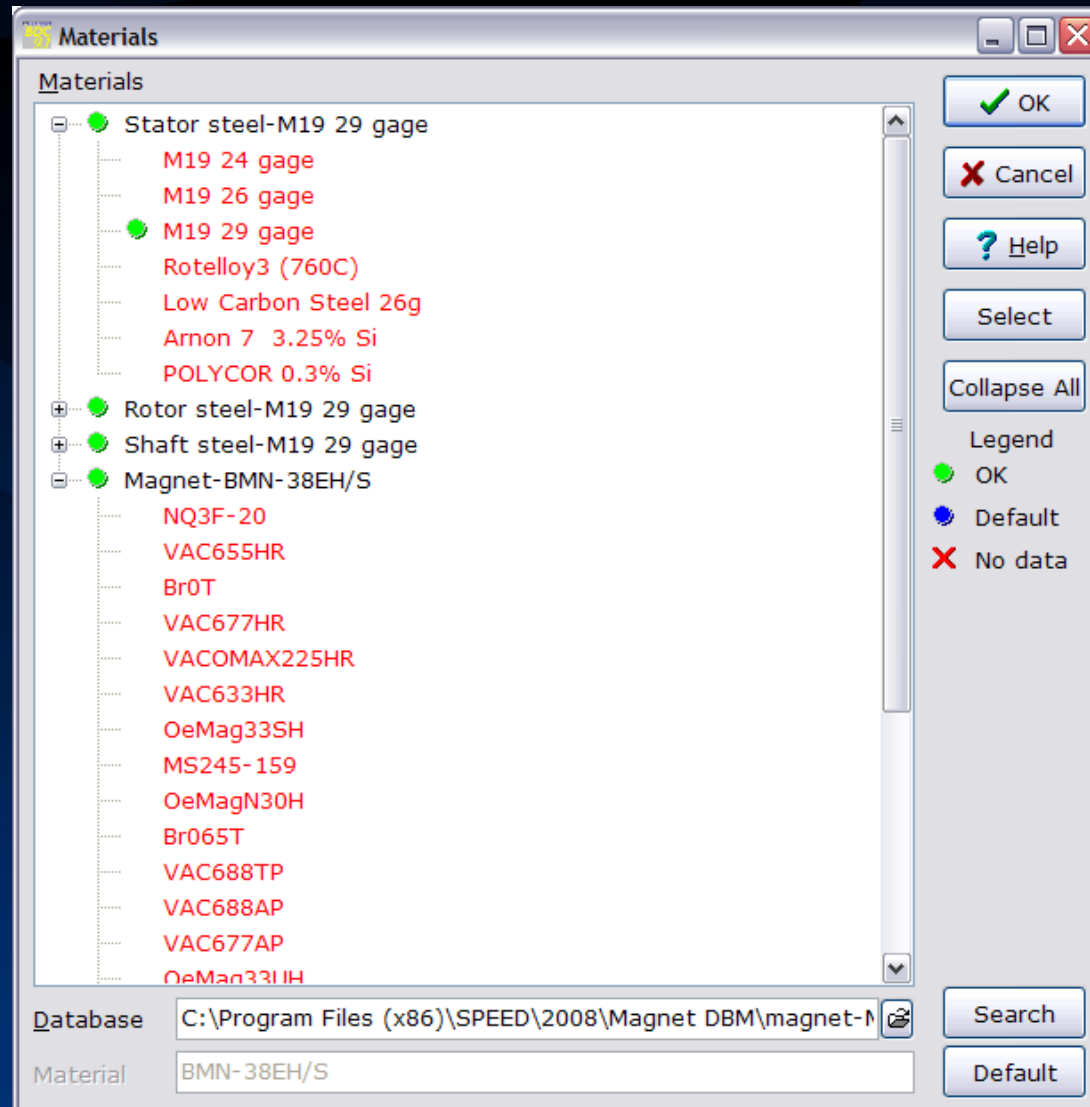


# *SPEED* in use: Define the geometry The outline editor



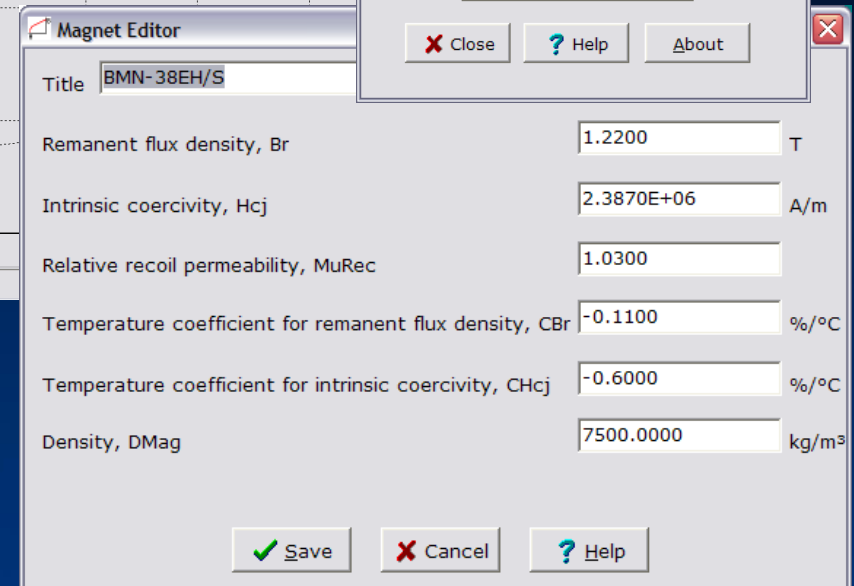
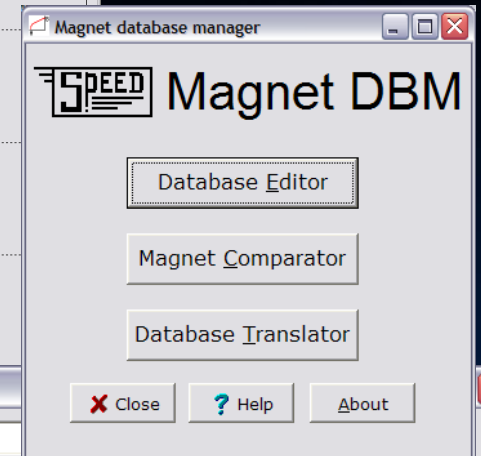
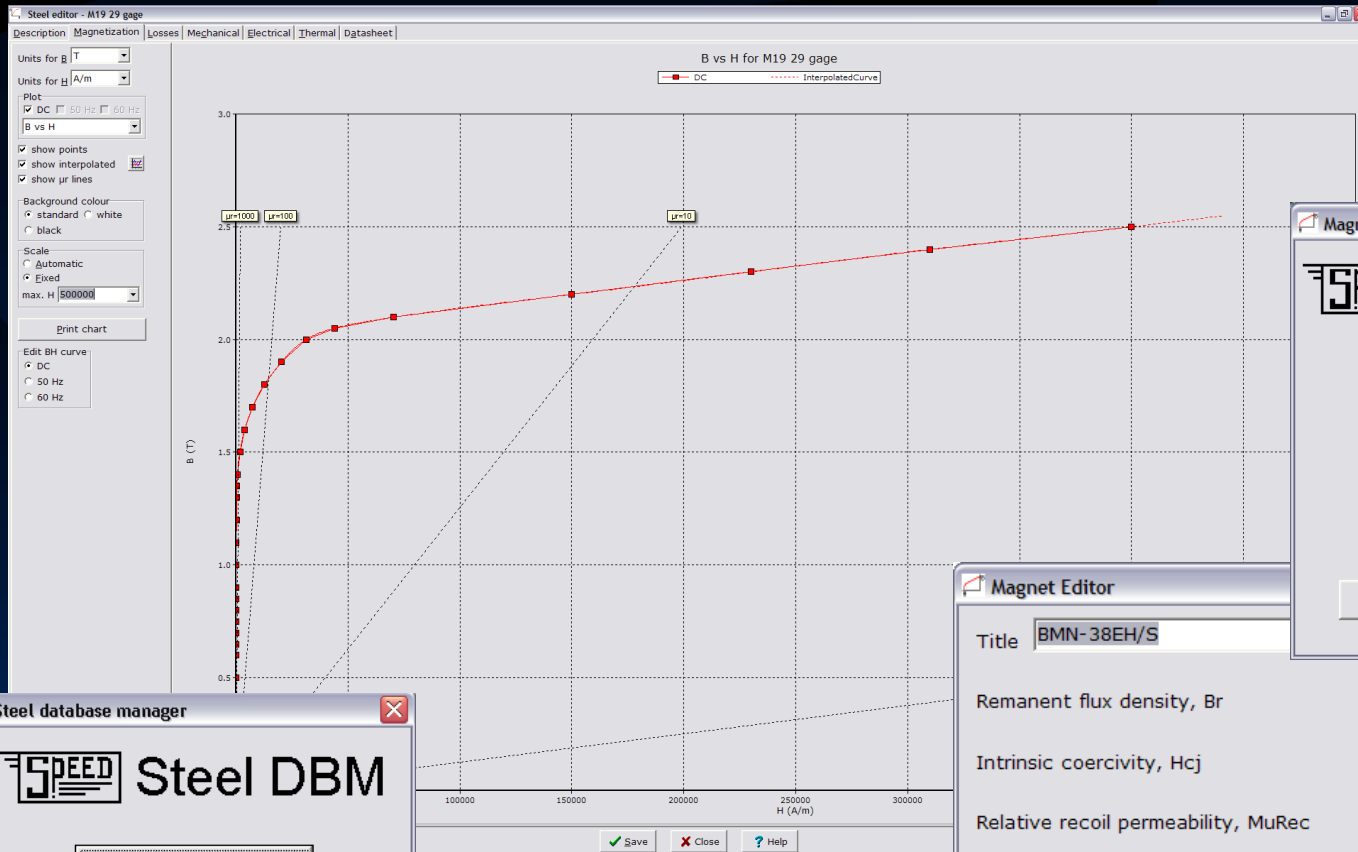


# *SPEED* in use: Select material from the material database



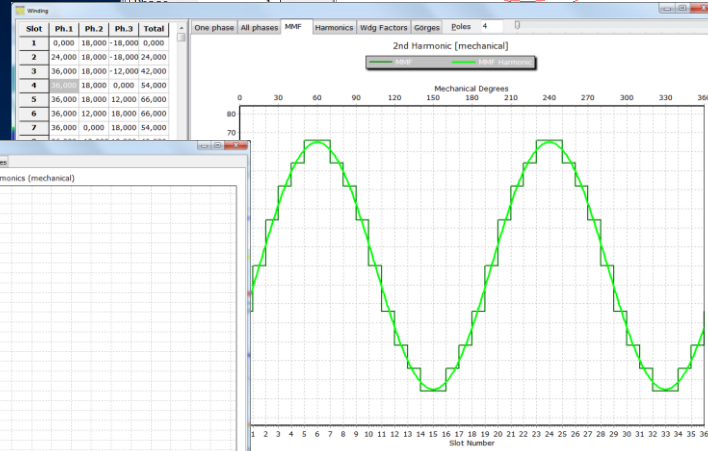
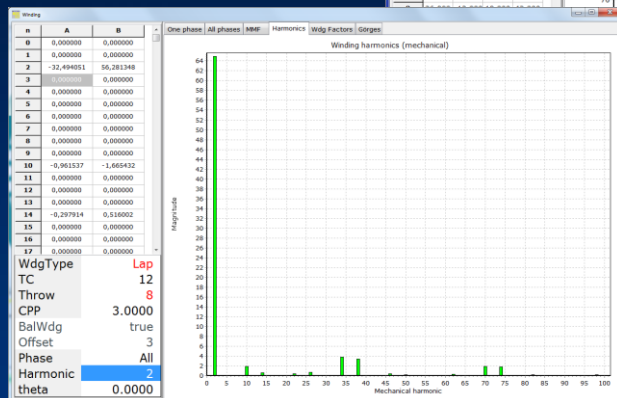
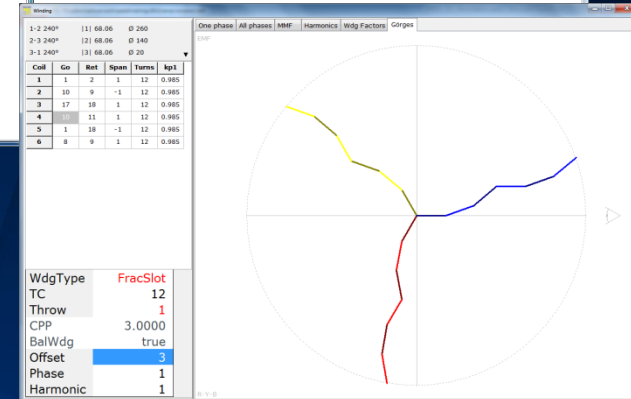
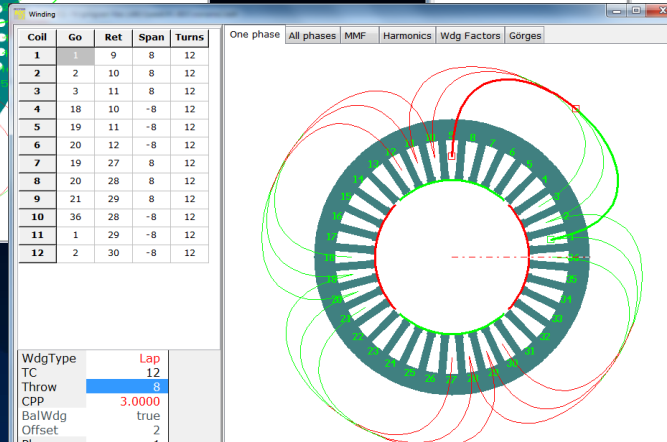
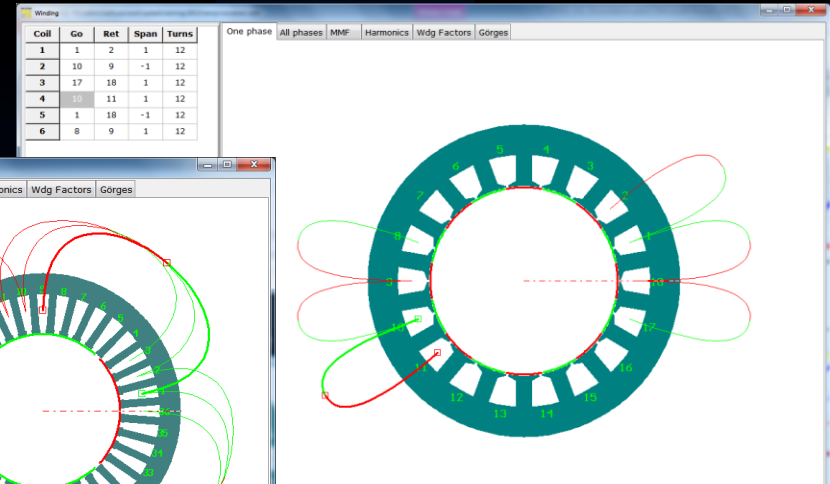
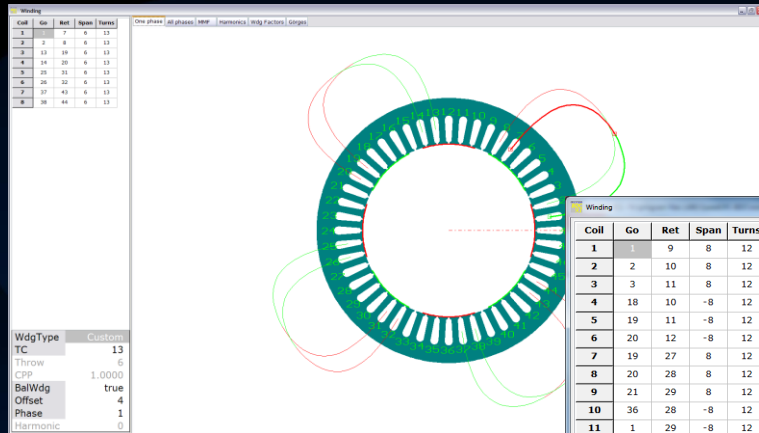


# SPEED in use: Definition of the material using the Data Base Manager programs





# SPEED in use: Definition of the winding – The winding editor





# SPEED in use: The Template editor – input data for calculation options, temperature, control parameters, etc.



Template Editor

Windings

Connex	Wye	Throw	8	CPP	3.0000	TC	12
WdgType	Lap	PPATHS	4	PCWire	0.0000	TCCWire	0.3930
NSH	1	NSH2	1	NSHA	1	WireDens	8890.0000
WireSpec	SFill	SFg	0.4000	wb	2.0000	InsThick	0.0000
WireSpec2	None	Wire2	2.0000	wb2	2.0000	InsThk2	0.0000
WireSpecA	None	WireA	2.0000	wbA	2.0000	InsThkA	0.0000
WireCR	0.0000	WireCR2	0.0000	WireCRA	0.0000		
Ext	0.0000	XET	1.0000	EndFill	0.5000	CoilFill	1.0000
X_R	1.0000	Rext	0.0000				

Slot insulation parameters

TopStick	false	wTstick	0.0000	hTstick	0.0000	Liner	0.4000
TwjWid	2.0000	TwjLeg	3.5000	TwjThk	0.0000	ct_Liner	0.2000
PhsWid	2.0000	PhsLeg	3.5000	PhsThk	0.0000		

Multi-phase

NumPoly	1	uM12d	0.0000	uM23d	0.0000	uM31d	0.0000
PolyOffs	1	uM12q	0.0000	uM23q	0.0000	uM31q	0.0000
Vs2							

Inductance

XL							
Lext							
CalcLg							
PSSlot							

Control

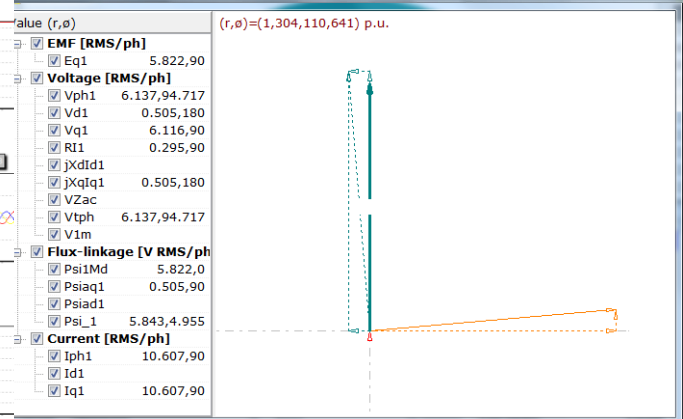
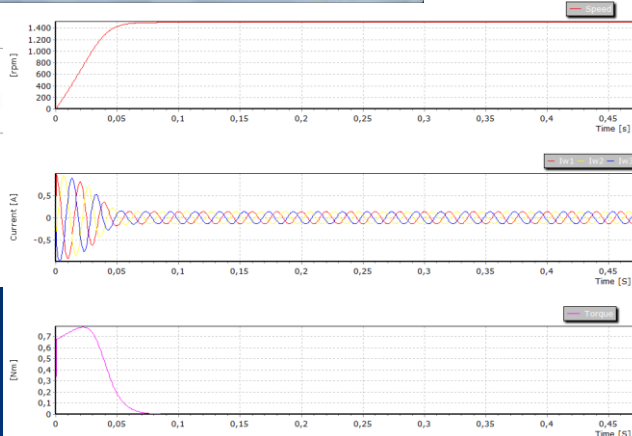
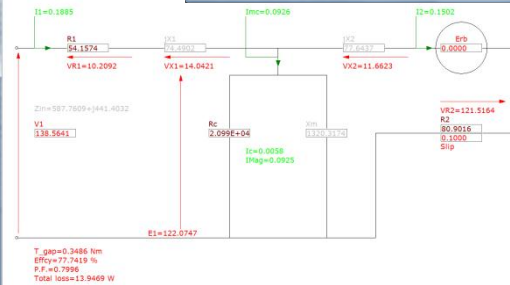
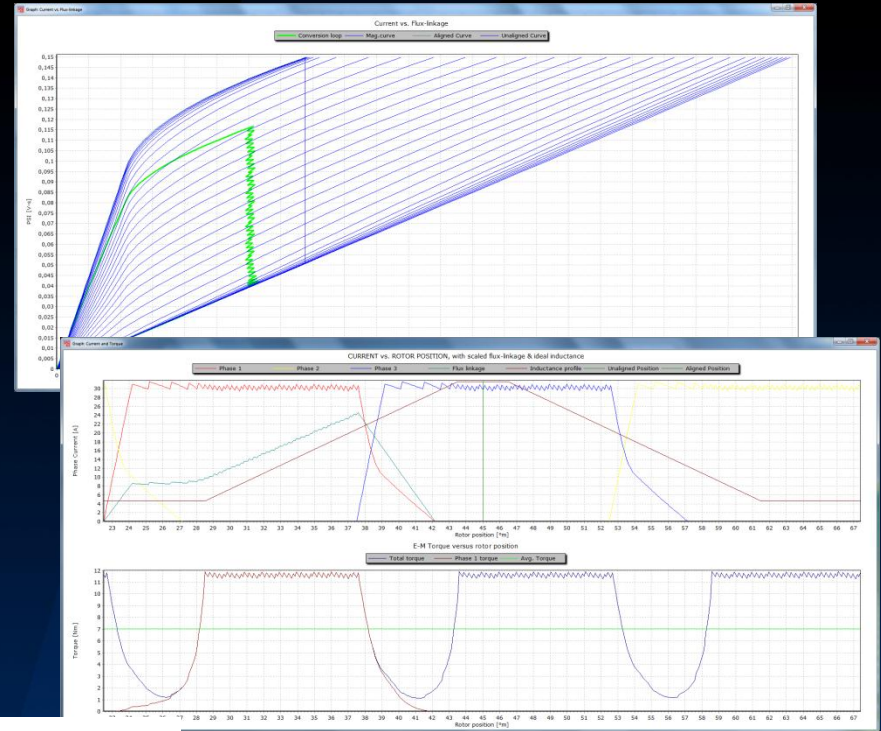
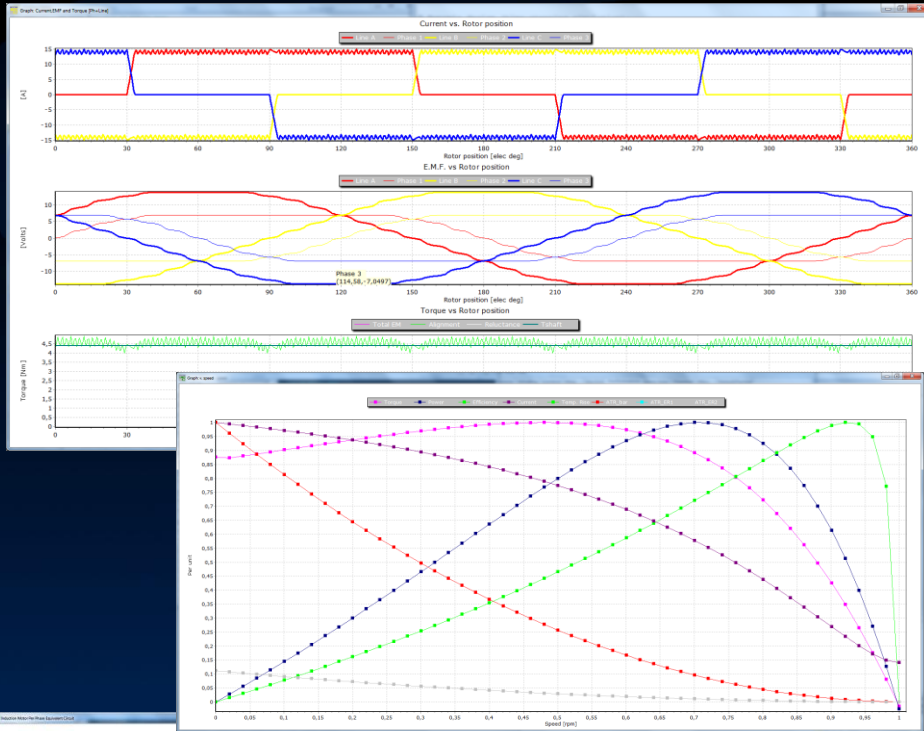
RPM	400.0000	Vs	24.0000	Drive	Sine	DCSource	Fixed DC
ISP	15.0000	DuCy	0.5000	Sw_Ctl	ISP_HB	gamma	0.0000
HBA	8.0000	HBtype	Constant	dq0	false	alpha6	0.0000
ChopType	Soft	FixfChop	ISChop12	fChop	0.0000	uCFR	600.0000
SVmode	Auto	VGCoefft	1.0000	u_MSVM	0.8000	MIX	1.0000
uVdm	0.0000	uVqm	0.0000	PGain	1.0000	IGain	0.0000
G_d	1.0000	G_q	1.0000	G_dq	0.0000	G_qd	0.0000
NumPoly	1	PolyOffs	1	SolvMG	true	MIX3	0.0000
Bifilar	false	NphUni	4	kBif	0.0000	ISPSpec	Peak

Drive Circuit Parameters

Rac	0.0000	Lac	0.0000	Vd	0.6000	R_s	0.0000
Vq	0.0000	Rq	0.0000	eDet	off	UBkDiode	true
t_q	0.0000	Rd	1.0000	Rdc	0.0000	Ldc	0.0000
Vz	72.0000	Cdc	0.0000				



# SPEED in use: Graphical Output – graphical feedback available





# SPEED in use: Output design sheet – large range of numerical values available



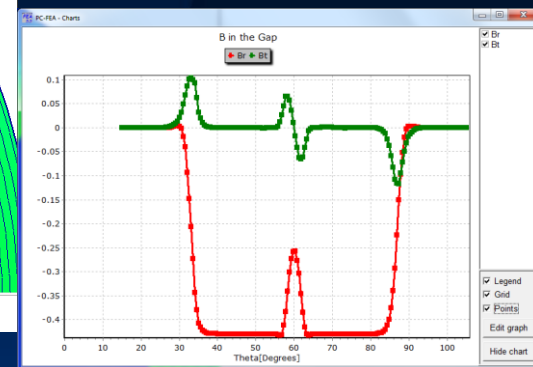
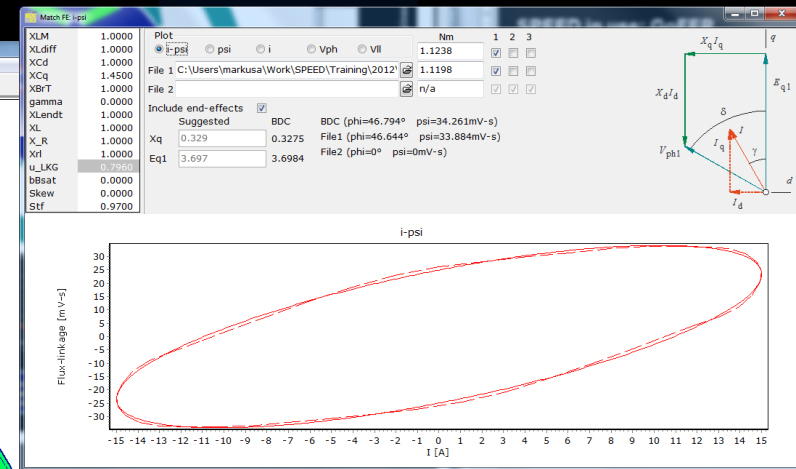
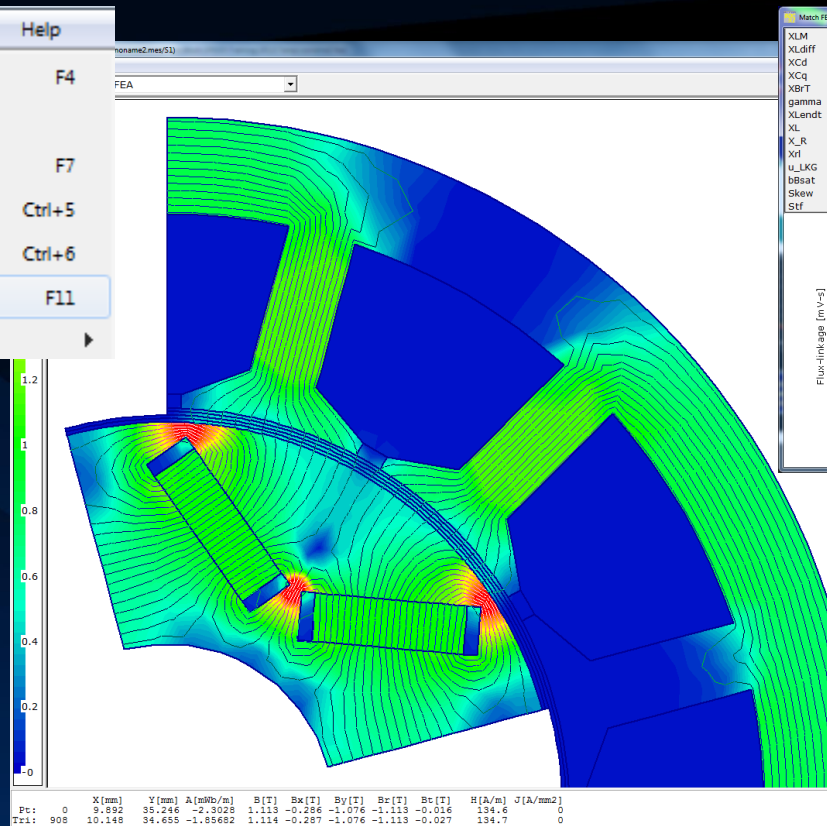
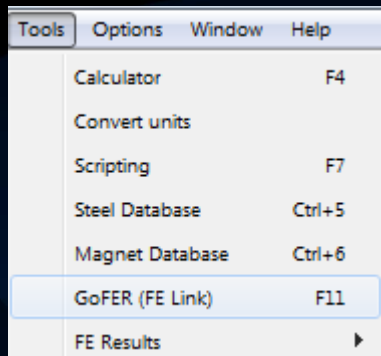
Tabbed Design Sheet					
Dimensions Material Control Winding Mag. Circuit Dynamic Thermal Core Loss Misc.					
7 Dynamic design (time-stepping simulation):-----					
OpMode	Motoring	Vs	24.0000 V	RPM	400.0000 rpm
Tshaft	4.2641 Nm	Pshaft	178.6133 W	Eff	92.0873 %
WCu	9.3360 W	WFe	6.0115 W	WWF	0.0000 W
WTotal	15.3475 W	TempRise	5.0000 °C	Jrms	1.1289 A/mm <sup>2</sup>
IWpk	15.7706 A	IWav	9.5175 A	IWrms	10.5832 A
ILpk	15.7706 A	ILav			
IQchpk	15.8353 A	IQchav			
IQcmpk	15.8353 A	IQcmav			
IDchpk	15.8105 A	IDchav			
IDcmpk	15.8105 A	IDcmav			
IDC_W	8.2358 A	WConv			
IDC_P	8.2326 A	WSwitch			
Tgap	4.4076 Nm	Tei			
Tloop	4.4040 Nm				
WRac	0.0000 W	W_Rs			

Tabbed Design Sheet					
Dimensions Winding Control Mag Eq.Cct Performance Core loss Thermal Misc. Rated/Partial					
5 Equivalent circuit parameters : -----					
R1	54.1574 ohm	X1	74.4902 ohm	X1unsat	74.4902 ohm
R2	80.9016 ohm	X2	77.6437 ohm	X2unsat	77.6437 ohm
Rc	20994.4771 ohm	Xm0	1374.1894 ohm	Xm	1320.3174 ohm
Rbar	71.8944 ohm	REndRing	9.0072 ohm	Erb	0.0000 V
R_rotor	8.9812E-05 ohm	X_rotor	8.6195E-05 ohm	XErb	1.0000
EQcct	SPEED	RcLoc	GapFlux		
DeepBar	Boldea	K_r	1.0002	K_x	1.0000
		XKr_DB	1.0000	XKr_DB	1.0000
EndLeak	SPEED	CoilFill	1.0000	kEndCoil	1.0000
		XXlend	1.0000	XX2end	1.0000
DiffLeak	CGV	DiffSat	false	Alzz	Normal
LkSat	None	kXL1	1.0000	kXL2	1.0000
kzz	1.0000	kX1slot	1.0000	kX2slot	1.0000
Xkzz	1.0000	XkX1slot	1.0000	XkX2slot	1.0000
XXm	1.0000	XXL1	1.0000	XXL2	1.0000
Unsaturated reactance components..					
X1slot	29.4070 ohm	Xlend	8.7473 ohm	X1diff	36.3359 ohm
X1belt	6.1439 ohm	X1zz	30.1920 ohm	X1skew	0.0000 ohm
X2slot	38.4448 ohm	X2end	2.8630 ohm	X2diff	36.3359 ohm
X2belt	6.1439 ohm	X2zz	30.1920 ohm	X2skew	0.0000 ohm
L-circuit parameters..					
alpha_TL	1.0588	uX1oX2	1.0000	X1oX2	0.9594
XL_L	165.9149 ohm	Rc_L	23536.3184 ohm		
R2_L	90.6965 ohm	Xm_L	1397.9611 ohm		



# SPEED in use: GoFER

## Go to Finite-Elements and Return



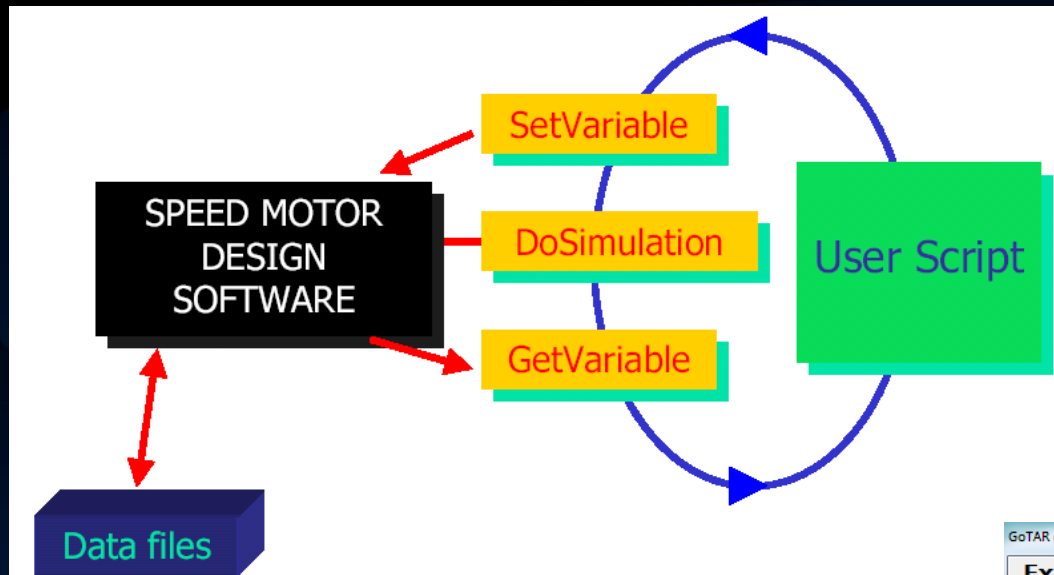
... or use the embedded FE-solver directly (PC-BDC only)

### Embedded FEA Parameters

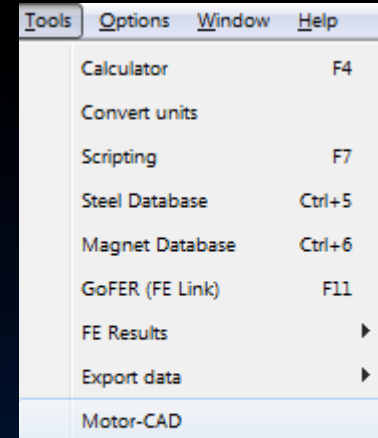
ipsiCalc	PC- <b>FEA</b>	DDFE	FEdqDD(Q)	MatchFES	true	ipsiStep	18
SolDom	Default	FEpoles	1	IncShaft	false	Stator0	Slot c/l
MagMode	BrTEff/XBrT	AGLayers	4	UseFaces	true	FEBeep	true
FEEMFwfm	false	Id_min	1.0000	Iq_min	1.0000	FEUpsi	true
FEShow	false	PhysShim	false	FEAir	1.0000	MaxAngle	120.0000
SolTol	1.0000E-07	MaxIter	99	IncVirt	true		



# SPEED in use: Scripting (ActiveX)



GoTAR: Go to Thermal Analysis and Return



```
Script Editor - C:\Program Files (x86)\Speed\SPUD\manual\Automation examples\VBScript\sbcd1.vbs
File Edit Options Help
Global values for speed of programming
Dim S(100)
Dim G(100)
Dim T(100)
Dim E(100)
Dim P(100)

Sub CalcTorqueSpeedCurve (MinSpeed,MaxSpeed,NStep,Threshold,MinGamma,MaxGamma)
Dim SpeedStep
Dim Gamma
' Loop along the speeds as specified...
For SpeedStep = 0 to NStep

Speed = MinSpeed + (SpeedStep) * ((MaxSpeed-MinSpeed) / (NStep))
S(SpeedStep) = Speed
Call Design.SetVariable (piRPM, S(SpeedStep))

Gamma = 0
If Speed > Threshold then
Gamma = MinGamma + (Speed-Threshold) * (MaxGamma-MinGamma) / (MaxSpeed-Threshold)
end if
Call Design.SetVariable (piGamma, Gamma)
G(SpeedStep) = Gamma

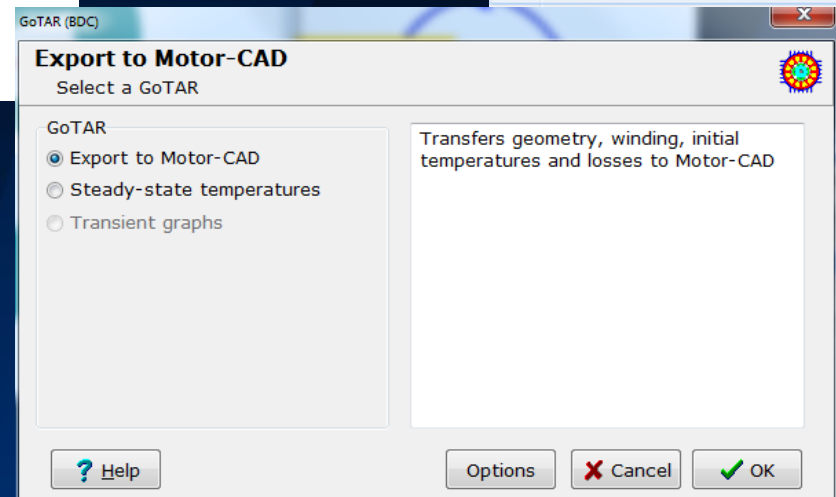
Design.DoDynamicSimulation

T(SpeedStep) = Design.GetVariable (piTshaft) ' was piTorqueSh 4/7/3
E(SpeedStep) = Design.GetVariable (piEff)
P(SpeedStep) = Design.GetVariable (piPshaft)
next
end sub

sub main
Result = Design.LoadFromFile ("d:\pbcde\delphi\ipm7.bd4")
If Result <> 0 then

```

SPEED motor design software



ActiveX links allows automated linkage to other software packages such as Visual Basic, Matlab, Motor-CAD and more ...