About parametric modeling

When simulating an electromagnetic device with software, it is useful to perform multiple experiments with one model. Unlike laboratory testing, one single model in Simcenter MAGNET can simulate a complete range of physical models, by using the parameterization feature.

Geometric features, materials, boundary conditions, and mesh values can be varied through a user-specified range of values, and the results used to generate a family of performance curves for making design decisions. By automating much of this process, Simcenter MAGNET increases the throughput of the software, enabling more design possibilities to be tested with less computer time and less user time.

Material changes use either the built-in library, or a user-specified material. Geometric changes can be used for two functions: for position changes and for shape changes. Various shapes can be tested by inputting a range of dimensions, for example, when varying the shape of a pole face to minimize fringing. Similarly, the effect of a range of positions of one piece of the model versus the other can be examined — for example, the position of one coil relative to another.

Note Your Simcenter MAGNET license file must include the parameterization feature before you can solve multiple problems.

See also

[About setting parameters]

[Description of parametric expressions]

[About user-defined parameters]

[Parameter precedence]

[Parameter inheritance rules]

About setting parameters

Parameters are set in the properties page of the objects to be parameterized. The values for the parameters are set using four types of expressions.

- **Text**: The value is entered as an alphabetic text string that must match the system or user-defined expression. For example, you can parameterize the materials of a component by entering the names of materials in the material library, such as PM10, PM12.

Note String parameter values are allowed to contain a % character if it is followed by a space, or is the last character of the string or variant array string element
(e.g. "Copper: 100% IACS" for Material parameter).

- **Number**: The value is entered as a single number. For example, a value for the maximum element length of a component is entered as 0.5.
- **Array**: The value is entered as a series of comma-separated numbers. For example, the position of a vertex is expressed as [3.2,4.76]. The array must be enclosed by square brackets.
- **Variant:** The Variant is a special data type that can be interpreted either as Text, Number, or Array, depending on the context. It is often used to link with other applications, as it allows to decide what the data is supposed to be upon reception.

Note String parameter values are allowed to contain a % character if it is followed by a space, or is the last character of the string or variant array string element
(e.g. "Copper: 100% IACS" for Material parameter).

Multiple expressions

Multiple expressions must be separated by a comma. For example:

- –1, 2, 3, 5.45
- [1,2,3], [4,5,6]
- –[0.5%in,1/sqrt(2)%in,10%in*sin(45%deg)], [0, 1, 2]

Instantiated models

A new model is created for each combination of parameter values. The models are shown in the Problem page of the Project bar.

Note All values shown in the Problem page are expressed in the MKSA system of units.

Display

The parameter properties page grid displays "parent-inherited parameter values" in bold and "import-inherited parameters" in *italics*.

See also

About parametric modeling

Description of parametric expressions

About user-defined parameters

Parameter precedence

Parameter inheritance rules

About parameter syntax

Simcenter MAGNET provides several system-defined parameters. You can also create your own parameters to suit your particular needs.

Expressions

Parameter expressions are specified in the Expression cell of the parameter properties page of the object to be parameterized.

There are four types of expressions:

Text

A text string is composed of any characters, apart from % (see note below) and $, since these have special significance. The value is entered as an alphabetic text string that must match the system or user-defined expression. For example, you can parameterize the materials of a component by entering the names of materials in the material library, such as PM10, PM12,CR10: Cold rolled 1010 steel. Text parameters are case-sensitive.

Note String parameter values are allowed to contain a % character if it is followed by a space, or is the last character of the string or variant array string element
(e.g. "Copper: 100% IACS" for Material parameter).

Number

An actual value (single number) or expression which can be evaluated to yield a number, e.g. 2/7, 1e-4 (automatically converted to decimal form), %x, 2%mm. The number must be in the accepted range.

Array

The value is entered as a series of comma-separated numbers and/or expressions which can be evaluated to yield numbers. For example, the position of a vertex is expressed as [3.2,4.76],[0,1,0], [10.5 %mm, -2.1%in], [0,%ID/2*cos(45%deg),0]. The array must be enclosed by square brackets. Arrays are used namely to input 3D positions.

Variant

The Variant is a special data type that can be interpreted either as Text, Number, or Array, depending on the context. It is often used to link with other applications, as it allows to decide what the data is supposed to be upon reception.

Note String parameter values are allowed to contain a % character if it is followed by a space, or is the last character of the string or variant array string element
(e.g. "Copper: 100% IACS" for Material parameter).

Multiple expressions

Multiple expressions must be separated by a comma. For example:

- –1, 2, 3, 5.45
- [1,2,3], [4,5,6]
- –[0.5%in,1/sqrt(2)%in,10%in*sin(45%deg)], [0, 1, 2]

Arithmetic expressions

Numbers can be substituted by their arithmetic expression. The following are allowed in expressions:

+	addition	exp	natural exponential
-	subtraction	exp10	Base-10 exponential
*	multiplication	cos	cosine
/	division	sin	Sine
^	exponentiation	tan	tangent
abs	absolute value	acos	arccosine
sqrt	square root	asin	arcsine
step	unit step function	atan	arctangent
log	natural logarithm	floor	highest integer value smaller than x
log10	Base-10 logarithm	ceil	lowest integer value larger than x
		round	integer value closest to x

- The operators use conventional precedence rules.
- The argument of cos, sin, and tan is in radians.
- The result of acos, asin, and atan is in radians.
- Small case letters must be used for functions.
- The Min(A, B) function can be expressed as B step(A - B) + A (1-step(A - B)). Likewise, Max(A, B) can be expressed as A step(A - B) + B (1-step(A - B)).

Constants

The following defined constants are allowed in expressions:

"Pi" = 3.14159265358979323846264338327950288419716939937510582097494459230781640628620899862803482534211706 7

"PI" = %Pi

"pi" = %Pi

"g0" = 9.80665

"SpeedOfLightInFreeSpace" = 299792458

"c0" = %SpeedOfLightInFreeSpace

"PermeabilityOfFreeSpace" = 4e-7*%Pi

"mu0" = %PermeabilityOfFreeSpace

"PermittivityOfFreeSpace" = 8.85418781762e-12

"eps0" = %PermittivityOfFreeSpace

"StefanBoltzmann" = 5.670373e-8 (See http://physics.nist.gov/cgi-bin/cuu/Value?sigma)

"sigmaSB" = %StefanBoltzmann

User-defined parameters

User-defined parameters must be prefixed with the % character. For example, %Length

Units

Unless otherwise specified, all units are in the MKSA system of units and can be expressed in short form (e.g. %cm) or long form (e.g. % centimeters). Alternate units must be specified for each value.

Note Units must be prefixed with the % character and are case sensitive.

Short form	Long form	Short form	Long form
%cm	%centimeters	%km	%kilometers
%deg	%degrees	%MHz	%megahertz
%degC	%degreesCelsius	%m	%meters
%degF	%degreesFahrenheit	%um	%microns
%ft	%feet	%us	%microseconds
%GHz	%gigahertz	%mi	%miles
%g	%grams	%mm	%millimeters
%gee, %grav	%Gravities	%ms	%milliseconds
%Hz	%hertz	%mil	%mils
%hr	%hours	%min	%minutes
%in	%inches	%lb	%pounds
%K	%kelvin	%rad	%radians
%kg	%kilograms	%s	%seconds
%KHz	%kilohertz	%yd	%yards

Display

The parameter properties page grid displays "parent-inherited parameter values" in bold and "import-inherited parameters" in italics.

See also

About parametric modeling

About setting parameters

Description of parametric expressions

About user-defined parameters

Parameter precedence

Parameter inheritance rules

Parameter precedence

Properties of objects are represented using parameters. The following examines how the rules of precedence are applied to these parameters as they are used in different variations.

Models with no imported components

For a model with no imported components, a given property value for a given object will be obtained in one of three ways:

1. It will have a default value (e.g. PolynomialOrder defaults to 1).

2. It will inherit a value from a parameter assigned to a higher-level object in the object tree (e.g. if *MaximumElementSize* is set while editing a component's properties, then all its faces will automatically inherit that value).

3. It will have a value explicitly assigned to it (e.g. if a change is applied while editing the object's properties).

When a parameter is both specifically assigned and inherited, the specific parameter has precedence. If the specific parameter is cleared, then its value reverts to the inherited value.

Models with imported components

When a model contains imported components, the property assignment becomes more complicated. For example, the Simcenter MAGNET model "*SubModel.mn* " is imported into another "*AssemblyModel.mn* ", where it is given the name *SubModel#1*. In general, the properties of a component in *SubModel#1* will originally have the values in *SubModel.mn* . However, these values can be overridden by editing properties of *SubModel#1* components in *AssemblyModel.mn* . This results in two parameters for a given property: the original one assigned when *SubModel.mn* was created or last edited, and the overriding one assigned while editing *AssemblyModel.mn* . Obviously, the overriding parameter has precedence in this case. If the overriding parameter is deleted, then the value for the associated property reverts to the original value of the parameter in *SubModel.mn* .

The example cited in the paragraph above creates two more sources for a property value:

1. It will inherit a value from a parameter assigned to a higher-level object in the object tree while editing the model that imports it (the overriding value assigned in AssemblyModel.*mn*).

2. It will have a value explicitly assigned to it while editing the model that imports it (the overriding value assigned in AssemblyModel.*mn*).

The order of precedence is **5-4-3-2-1** and it can be summarized by the following two rules:

Rule #1 - An overriding parameter, assigned while editing a model containing an imported model, always has precedence over parameters assigned while editing the original imported model. This includes parameters specifying values that inherit the value of the overriding parameter.

Rule #2 - When it is between two parameters assigned while editing the same model, the more specific parameter has precedence.

For example, if *MaximumElementSize* is set on *Face#1 of Component#1 in SubModel.mn* , and is set on *SubModel#1,Component#1 in AssemblyModel.mn* , then the one set in *AssemblyModel.mn* has precedence.

If *AssemblyModel.mn* is imported into yet another Simcenter MAGNET model, then there are again more sources for parameters, but the same general rules are obeyed.

See also

About parametric modeling

About setting parameters

About user-defined parameters

Parameter inheritance rules

About user-defined parameters

Simcenter MAGNET provides a set of system-defined parameters. You can also create your own parameters to suit your particular needs. The user-defined parameters are available for the current model only.

User-defined parameters are created in the General Model parameters page. After the parameter is created, it can be used within an expression of a system-defined parameter or within another user-defined parameter.

Note The user-defined parameter must be prefixed with a % character when it is used within an expression. The parameter name cannot contain any spaces.

Note By default, user-defined parameters on a Parameter page are not sorted (i.e. they are displayed in the order they are defined). If there are several user-defined parameters, clicking on the first column header will sort them in ascending order. Clicking again will sort them in descending order. Clicking one more time will restore the default order (i.e. not sorted). If the user parameters are sorted, a small triangle marker is displayed on the first column header to indicate the sorting order. After sorting, the selection of the current cell is kept and is made visible in its new location on the grid. The sorting option for user parameters is stored as a model's preference.

See also

Create a user-defined parameter

Modify or delete a user-defined parameter

About the transformation parameters

You can transform the geometry of a component using the transformation parameters in the Component parameter page.

To rotate a component, use	RotationAngle RotationAxis TransformationCenter ***See*** Set the rotation parameter for a component
To scale a component, use	ScaleFactor TransformationCenter ***See*** Set the scale factor parameter for a component
To shift a component, use	ShiftVector ***See*** Set the shift parameter for a component
To mirror the position of a component, use	MirrorPlaneNormal TransformationCenter ***See*** Set the mirror parameter for a component

Tip You can also transform the geometry of a component, or a copy of a component, using the transformation commands on the Model menu. ***See*** About the component transformation dialogs.

List of parametric expressions

Click on the parameter name below for more information.

Boundary conditions	Component	Model
General	AdaptionIsDisabled	AdaptionIsDisabled
BoundaryConditionType	CurvatureRefinementAngle	AdaptionTolerance
Material	CurvatureRefinementMinimumElementSize	ApproximateSurface
PathsSpecificationMethod	CurvatureRefinementRatio	ConjugateGradientTolerance
SurfaceImpedance	EndPlaneTiltAngle	CreateImplicitCoils
Material Direction	EndPlaneTiltAxis	CurrentFlowCGTolerance
MaterialAxis	EndPlaneTiltCenter	CurvatureRefinementAngle
MaterialCenter	IsDisabled	CurvatureRefinementMinimumElementSize
MaterialDirection	Material	CurvatureRefinementRatio
MaterialDirectionType	MaterialAxis	GravitationalAcceleration

MaterialMagnetization
MaterialMagnetizationScaleFactor
MaterialXAxis
Transformations
MirrorPlaneNormal
RotationAngle
RotationAxis
ScaleFactor
ShiftVector
TransformationCenter
Thin plate
Thickness
Circuit
Capacitor
Value
Commutator
BrushResistance
BrushSeparationAngle
BrushWidth
DirectionIsReversed
MaximumContactResistance
MinimumContactResistance
ReferenceAngle
SectorSpacing
Current controlled switch
ComparisonSign
CurrentHysteresis
CurrentThreshold
InitialState
Current Source (+ Windings)
Current
CurrentOnAtTransientStart
CurrentPhase
NegativeVoltageLimit

MaterialBHACInterpolationFactor
MaterialBHACOption
MaterialCenter
MaterialConductivityScaleFactor
MaterialDirection
MaterialDirectionType
MaterialIncludeRayleighRegion
MaterialIronLossAdjustmentFactor
MaterialMagnetization
MaterialMagnetizationScaleFactor
MaterialMagnetStrengthScaleFactor
MaterialReverseMagnetizationDirection
MaterialStackingFactor
MaterialXAxis
MaximumElementSize
MeshLayers
MeshLayerUseExtrusion
MeshLimitSurfaceMeshModification
MeshRefinementIsDisabled
MirrorPlaneNormal
PolynomialOrder
RotationAngle
RotationAxis
ScaleFactor
ShiftVector
SolverHysteresisMethod
SolverIgnoresDemagnetization
SolverIgnoresEddyCurrents
SolverIgnoresIronLoss
StartPlaneTiltAngle
StartPlaneTiltAxis
StartPlaneTiltCenter
SweepAxis
SweepCenter

HAdaptionIsOn
HAdaptionRefinement
MaterialBHACInterpolationFactor
MaterialBHACOption
MaterialConductivityScaleFactor
MaterialIncludeRayleighRegion
MaterialIronLossAdjustmentFactor
MaterialReverseMagnetizationDirection
MaterialStackingFactor
MaximumElementSize
MaximumNumberOfAdaptiveSteps
MeshAllowUnconstrainedHoles
MeshAllowUnconstrainedCavities
MeshingMethod
MeshingTolerance
MeshLayerMaximumExposedAspectRatio
MeshLayerMinimumAspectRatio
MeshLimitSurfaceMeshModification
MeshRefinementControlRegions
MinimumNumberOfNewtonSteps
MotionCollisionDetectionIsOn
MotionSprings
NewtonTolerance
NewtonToleranceAtMaximumStep
NumberOfNewtonSteps
PAdaptionIsOn
PAdaptionRefinement
PermanentModelMaterials
PolynomialOrder
PolynomialOrderAugmentedLayers
PolynomialOrderIsMinimized
ProblemGenerationMode
SaveSolutionSinglePrecision
SolutionSweepDistance

PositiveVoltageLimit

PWLWaveformPhase

WaveFormType

WaveFormValues

Diode

JunctionVoltage

OffResistance

OnResistance

ResistanceRatio

Inductor

InitialCurrent

Value

Position controlled switch

ConductanceVsPosition

IsPeriodic

ResistanceVsPosition

SwitchPositions

SwitchTogglesOnSpeedSignChange

Resistor

Value

Switch

ısPeriodic

SwitchTimes

Voltage controlled switch

ComparisonSign

InitialState

VoltageHysteresis

VoltageThreshold

Voltage Source (+ Windings)

InitialCurrent

NegativeCurrentLimit

PositiveCurrentLimit

PWLWaveformPhase

SourceCapacitance

SweepDistance

SweepSegments

SweepStart

SweepType

Temperature

TransformationCenter

TransientAveragePowerLossStartTime

TransientAveragePowerLossStopTime

Component edges

CurvatureRefinementAngle

CurvatureRefinementMinimumElementSize

CurvatureRefinementRatio

EdgeDiscretization

MaximumElementSize

MeshLayers

Component faces

ApproximateSurface

CurvatureRefinementAngle

CurvatureRefinementMinimumElementSize

CurvatureRefinementRatio

MaximumElementSize

MeshLayers

MeshLimitSurfaceMeshModification

Component vertices

MaximumElementSize

MaximumElementSizeRadius

Position

Constructive Solid Geometry (CSG) components

AdaptionIsDisabled

BlockHeight

BlockLength

BlockWidth

ConeBaseRadius

ConeHeight

SolverDllHysteresis

SolverDllNonlinearEJ

SolverDllNonlinearHB

SolverDllNonlinearJE

SolverExcessConvergedNewtonIterations

SolverExcessNewtonIterations

SolverHysteresisMethod

SolverIgnoresDemagnetization

SolverIgnoresEddyCurrents

SolverIgnoresIronLoss

SolverIgnoresRedundantCoils

SolverIterationMethod

SolverMaterialType

SolverTechnique

SolverUnconvergedNewtonIterationsCGTolerance

SourceFrequency

Temperature

TimeStepMaximumDelta

TimeStepMethod

TimeStepMinimumDelta

TimeStepNewtonBehavior

TimeStepOrder

TimeSteps

TimeStepStorageInterval

TimeStepStorageMethod

TimeStepStorageStartTime

TimeStepStorageUserTimes

TimeStepTolerance

ToleranceToSwitchFromHToPAdaption

TransientAveragePowerLossStartTime

TransientAveragePowerLossStopTime

TransientInitialCondition

UseCoilMesh

UseCoilMeshDCResistance

SourceInductance
SourceResistance
Voltage
VoltageOnAtTransientStart
VoltagePhase
WaveFormType
WaveFormValues
Coils
Coil attributes
AdditionalInductance
AdditionalResistance
CoilSourceType
CoilType
SourceCapacitance
SourceInductance
SourceResistance
NumberOfTurns
PermitSolidCoilTurns
StrandArea
Source waveform
Current
CurrentPhase
InitialCurrent
NegativeCurrentLimit
NegativeVoltageLimit
PositiveCurrentLimit
PositiveVoltageLimit
PWLWaveformPhase
Voltage
VoltagePhase
WaveFormType
WaveFormValues
Solving
CurrentFlowCGTolerance

CurvatureRefinementAngle
CurvatureRefinementMinimumElementSize
CurvatureRefinementRatio
CylinderBaseRadius
CylinderHeight
CylinderTopRadius
IsDisabled
Material
MaterialAxis
MaterialBHACInterpolationFactor
MaterialBHACOption
MaterialCenter
MaterialConductivityScaleFactor
MaterialDirection
MaterialDirectionType
MaterialIncludeRayleighRegion
MaterialIronLossAdjustmentFactor
MaterialMagnetization
MaterialMagnetizationScaleFactor
MaterialMagnetStrengthScaleFactor
MaterialReverseMagnetizationDirection
MaterialStackingFactor
MaterialXAxis
MaximumElementSize
MeshLayers
MeshLayerUseExtrusion
MeshLimitSurfaceMeshModification
MeshRefinementIsDisabled
MirrorPlaneNormal
PolynomialOrder
PrismBaseRadius
PrismHeight
PrismTopRadius
PyramidBaseRadius

UseLegacyPolynomialOrder
Imported model
AdaptionIsDisabled
CurvatureRefinementAngle
CurvatureRefinementMinimumElementSize
CurvatureRefinementRatio
IsDisabled
Material
MaterialAxis
MaterialBHACInterpolationFactor
MaterialBHACOption
MaterialCenter
MaterialConductivityScaleFactor
MaterialDirection
MaterialDirectionType
MaterialIncludeRayleighRegion
MaterialIronLossAdjustmentFactor
MaterialMagnetization
MaterialMagnetizationScaleFactor
MaterialMagnetStrengthScaleFactor
MaterialReverseMagnetizationDirection
MaterialStackingFactor
MaterialXAxis
MaximumElementSize
MeshChunkID
MeshLayers
MeshLayerUseExtrusion
MeshRefinementIsDisabled
MirrorPlaneNormal
MotionSprings
PolynomialOrder
RotationAngle
RotationAxis
ScaleFactor

HasCoilForm

UseCoilMesh

UseCoilMeshDCResistance

PyramidHeight

RotationAngle

RotationAxis

ScaleFactor

ShiftVector

SolverHysteresisMethod

SolverIgnoresDemagnetization

SolverIgnoresEddyCurrents

SolverIgnoresIronLoss

SphereRadius

Temperature

TorusMajorRadius

TorusMinorRadius

TransformationCenter

TransientAveragePowerLossStartTime

TransientAveragePowerLossStopTime

ShiftVector

SolverHysteresisMethod

SolverIgnoresDemagnetization

SolverIgnoresEddyCurrents

SolverIgnoresIronLoss

Temperature

TransformationCenter

TransientAveragePowerLossStartTime

TransientAveragePowerLossStopTime

Motion component

BumperLowerPosition

BumperLowerRestitutionCoefficient

BumperUpperPosition

BumperUpperRestitutionCoefficient

ExternalLoad

ExternalLoadVsPosition

ExternalLoadVsPositionMovingBackward

ExternalLoadVsPositionMovingForward

ExternalLoadVsSpeed

ExternalLoadVsTime

ExternalMass

ExternalMassCenterOfGravity

ExternalMassMomentOfInertia

FrictionViscousCoefficient

Mass

MassCenterOfGravity

MassMomentOfInertia

MassMomentOfInertiaMatrix

MotionAxis

MotionCenter

MotionDirection

MotionSourceType

MotionType

PositionAtStartup

PositionVsTime

SpeedAtStartup

SpeedVsTime

SpringConstant

SpringRestPosition

StopLowerPosition

StopUpperPosition