

Motor-CAD Circuit Editor

Description

This document gives a brief description of how to use the Motor-CAD circuit editor. In this case we use the circuit editor to couple the Motor-CAD thermal network to a separate thermal network developed by the user to represent a flange mounted gear box. The circuit editor can be used to set up thermal models for all kinds of device connected to the motor or to represent the thermal circuit for the equipment in which the motor is enclosed.

Motor-CAD Model Without Gearbox

Below we see a typical thermal model of a BPM motor as automatically created by Motor-CAD. In this case we are modeling the default BPM motor in Motor-CAD with a simple TENV housing that has a mix of natural convection and radiation cooling from the simple housing. We can model more sophisticated cooling types such as water jackets, wet rotor cooling, through ventilation, TEFC, if we wished. The cross-section of the machine is shown below:

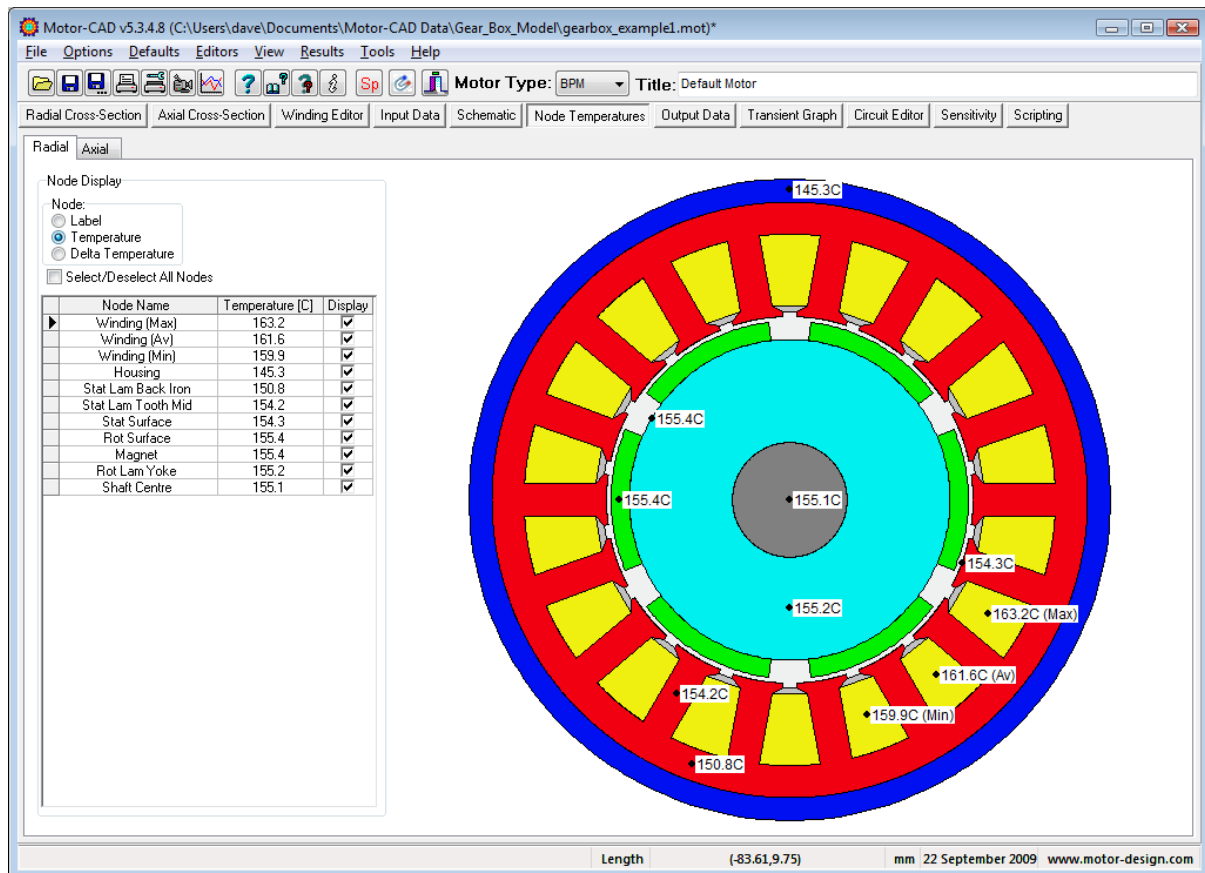
The screenshot displays the Motor-CAD v5.3.4.8 software interface. The main window shows a cross-section of a motor with a red stator, yellow rotor, and blue housing. The interface includes a menu bar (File, Options, Defaults, Editors, View, Results, Tools, Help), a toolbar, and a title bar (Motor Type: BPM, Title: Default Motor). The main workspace is divided into several tabs: Radial Cross-Section, Axial Cross-Section, Winding Editor, Input Data, Schematic, Node Temperatures, Output Data, Transient Graph, Circuit Editor, Sensitivity, and Scripting. The Radial Cross-Section tab is active, showing a detailed cross-section of the motor. The parameters are organized into two tables:

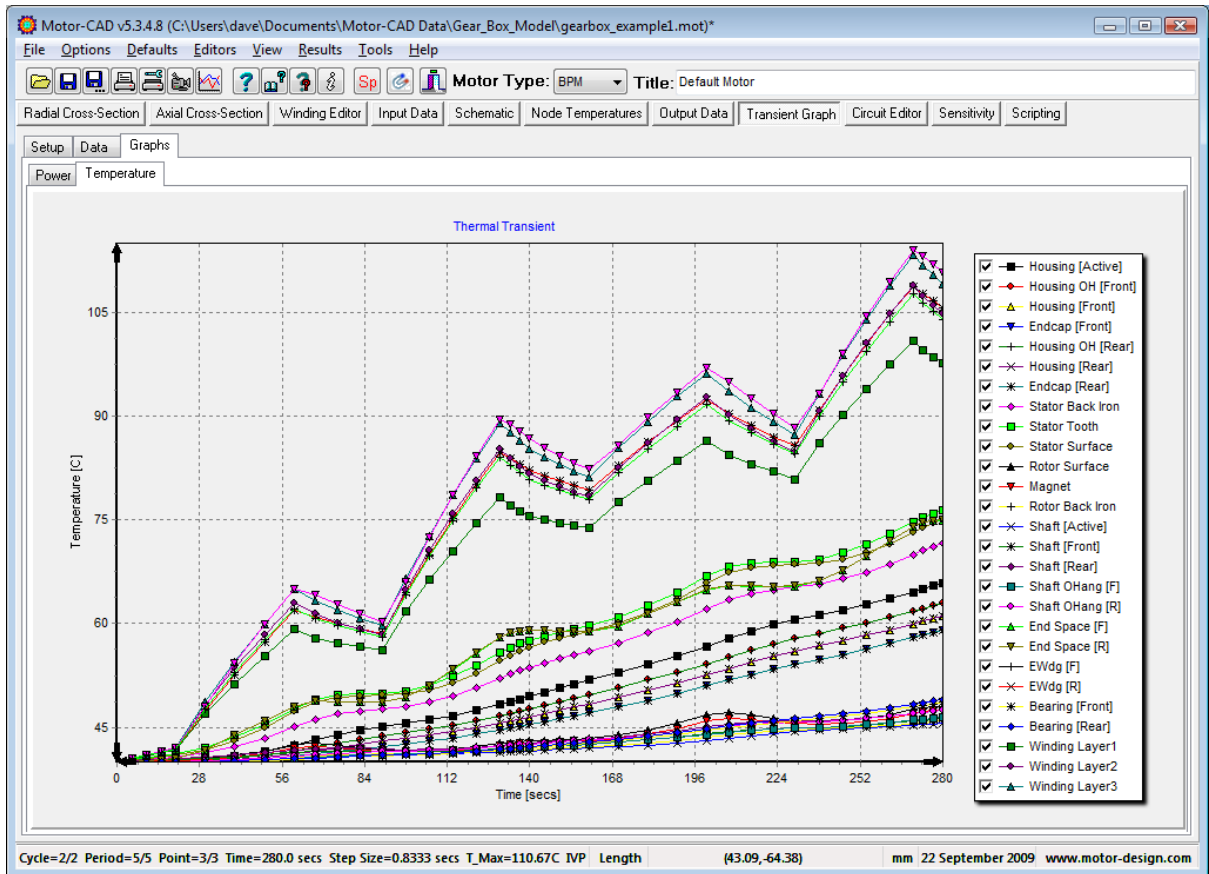
Stator Dims.		Rotor Dims.	
	Data		Data
Slot Number	18	Pole Number	6
Housing Dia	140	Magnet Thickness	4
Stator Lam Dia	130	Magnet Arc [ED]	140
Stator Bore	80	Airgap	1
Tooth Width	7	Banding Thickness	0
Slot Depth	18	Shaft Dia	25
Slot Corner Radius	0	Shaft Hole Diameter	0
Slot Opening	3		
Tooth Tip Depth	1		
Tooth Tip Angle	30		
Sleeve Thickness	0		
Plate Height	350		
Plate Width	350		
Stator Ducts	0		

Below the tables is a large 'Redraw' button and two checkboxes: 'Draw plate' and 'Draw base'. The status bar at the bottom shows 'Length (47.62,70.77) mm | 22 September 2009 | www.motor-design.com'.

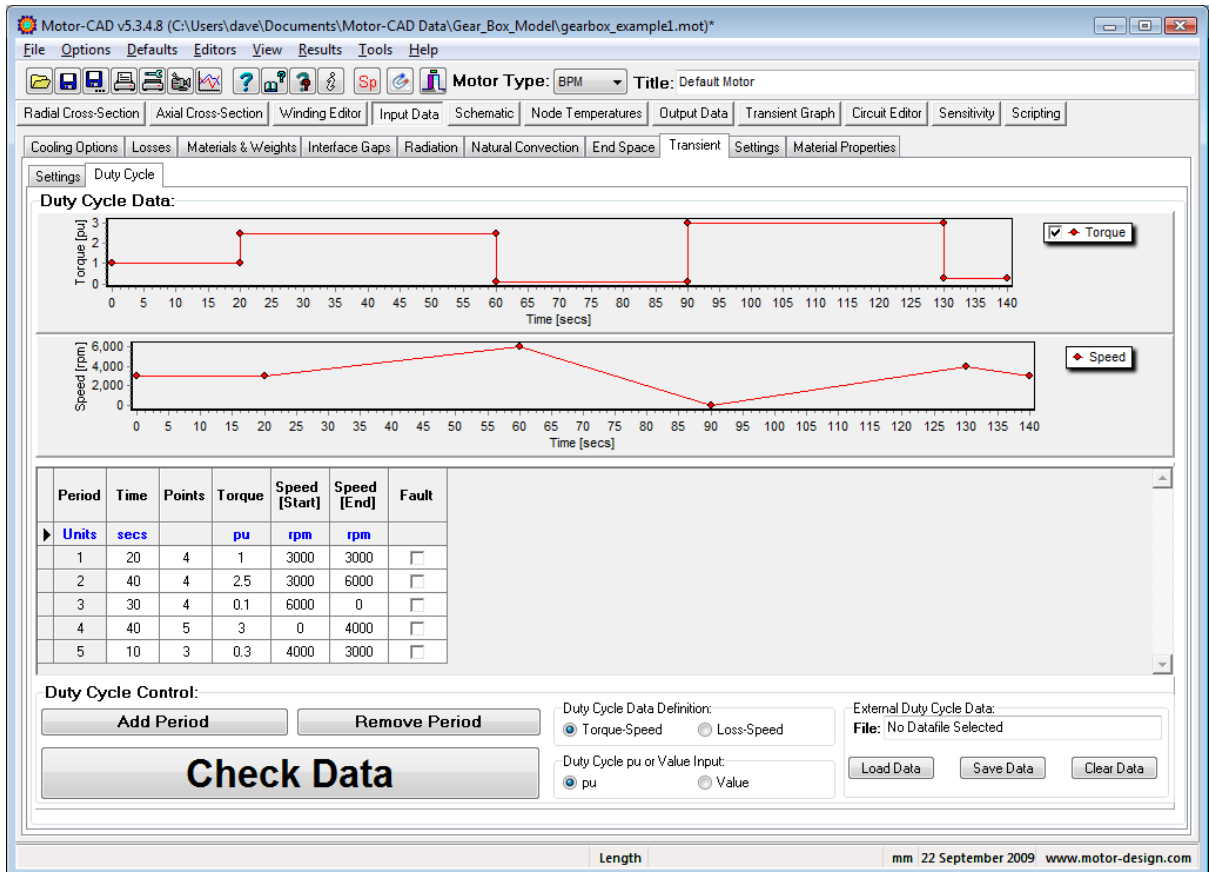
The colours are the same in the schematic as the components in the cross-section editor.

Predicted temperatures can also be shown on the motor cross-section and transient results using temperature v time graphs:



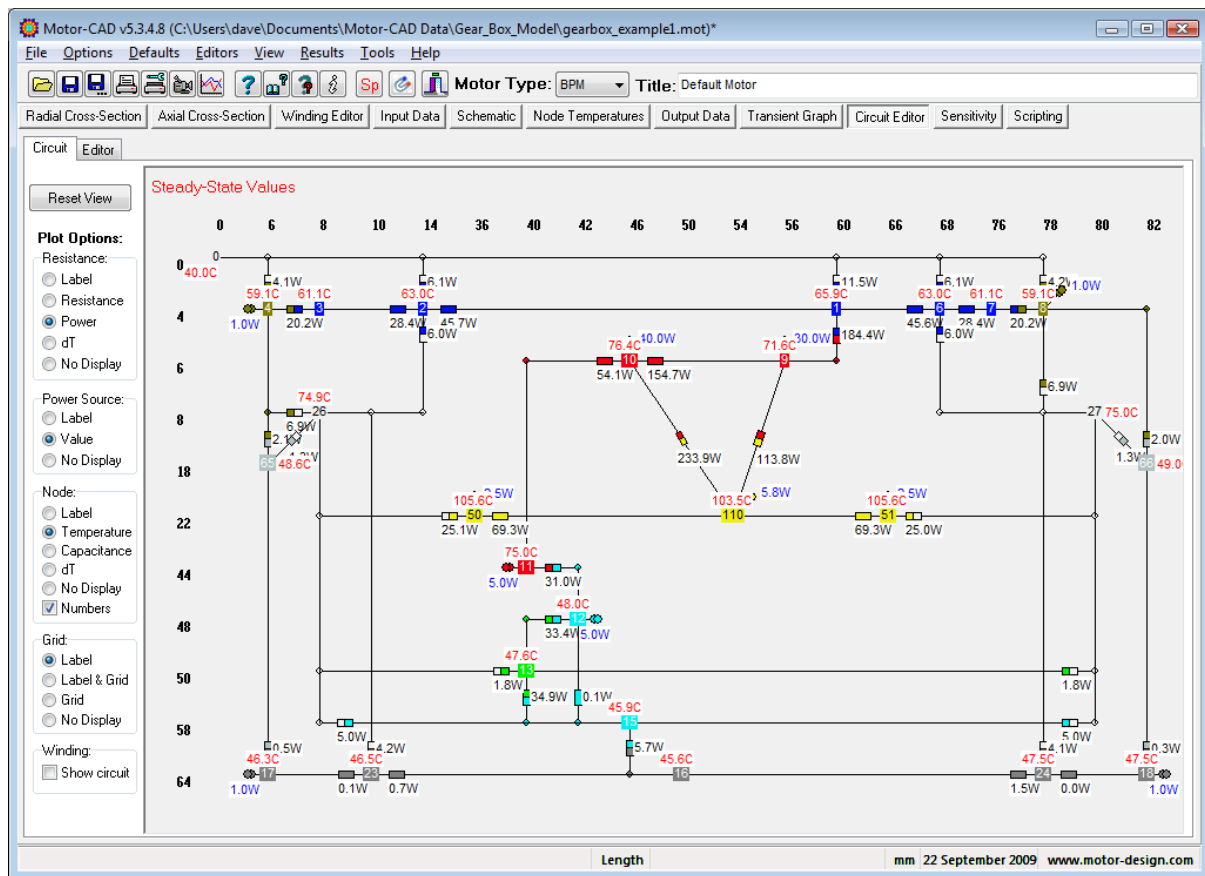


In the above analysis the transient was for the duty cycle load (2 cycles of the load in this case) shown below:



Motor-CAD Circuit Editor

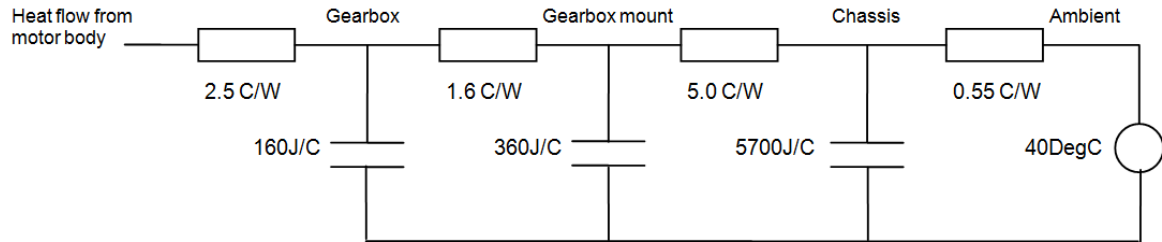
Results can also be viewed in the circuit editor shown below:



The type and amount of information displayed on the editor is selected using the radio-buttons and checkboxes on the left hand part of the screen.

Gearbox Thermal Network

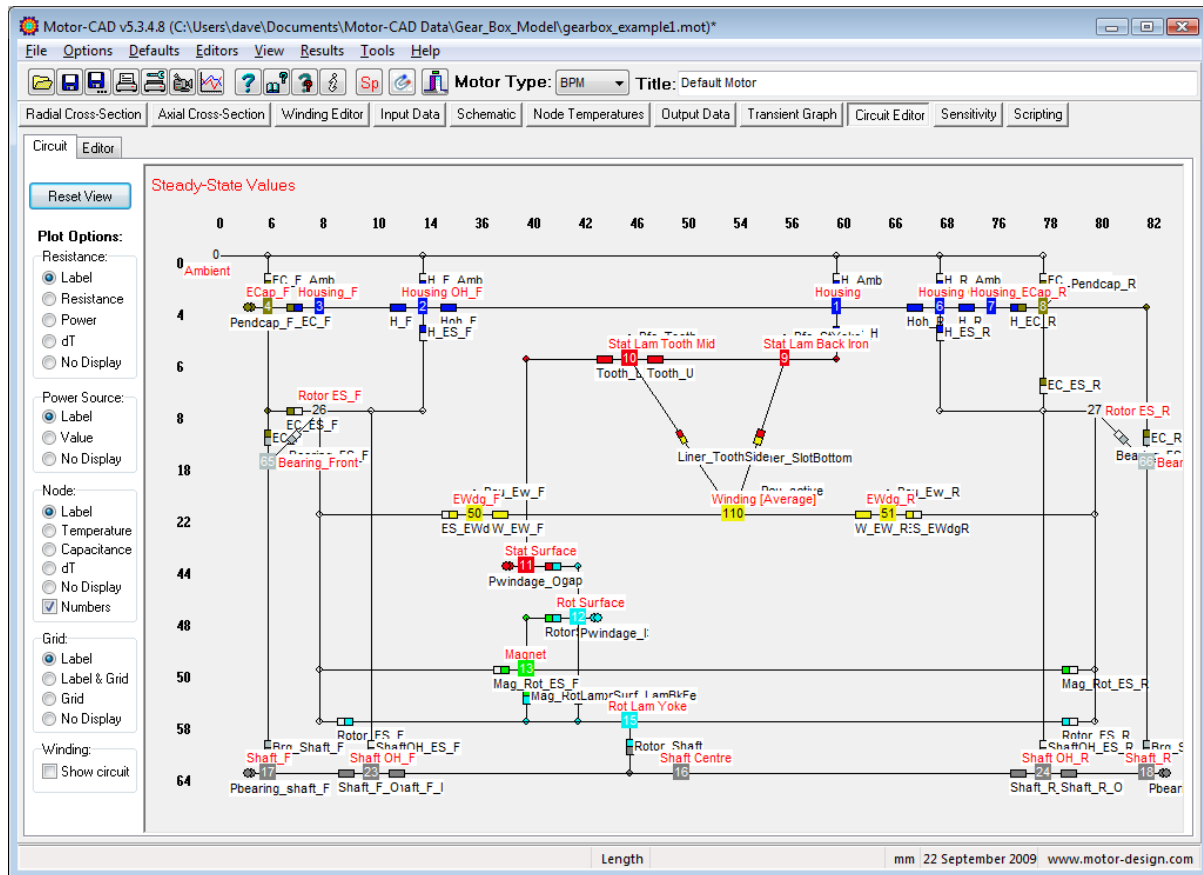
Below we see a simple thermal network model that has been created to represent the heat transfer through a flange mounted gearbox:



Motor-CAD Model With Gearbox

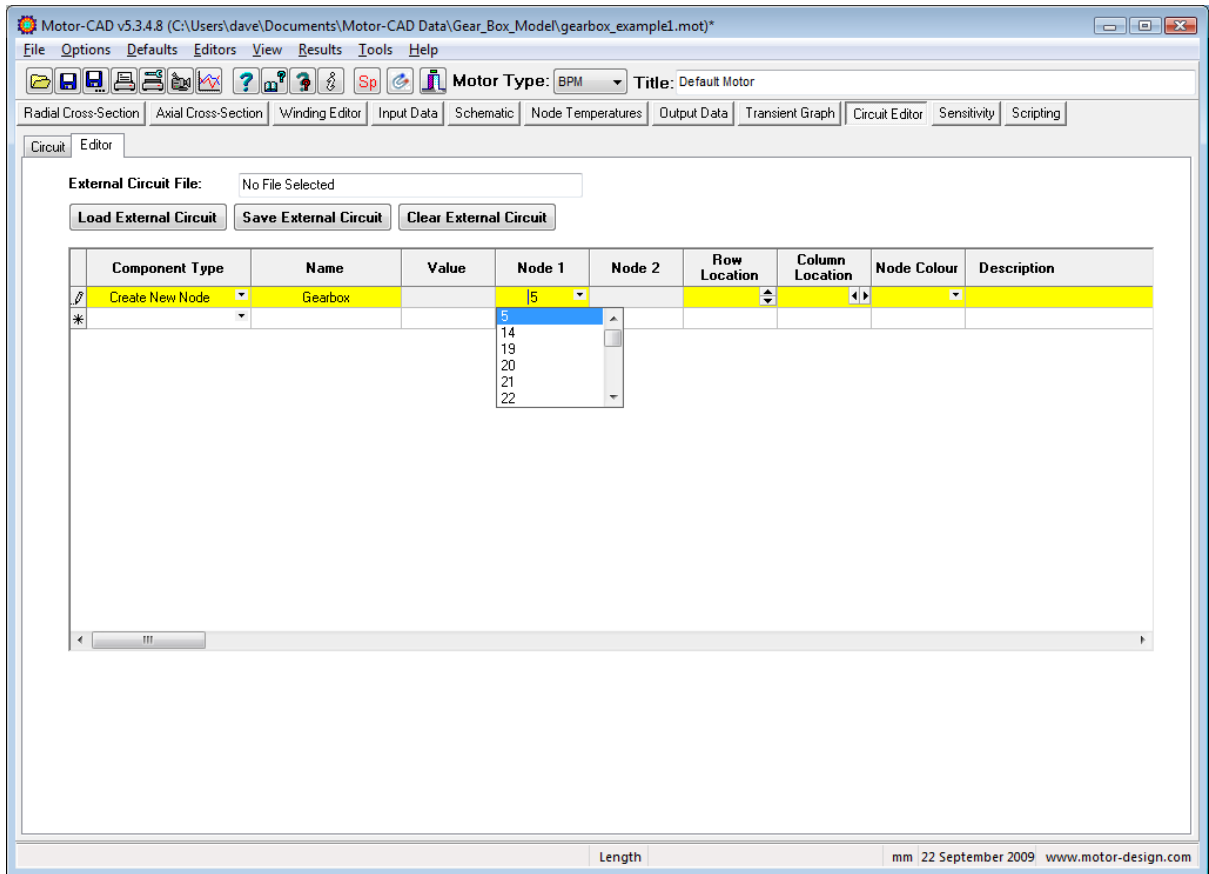
We can use the circuit editor to add the thermal network for the gearbox to the thermal network for the motor and calculate the steady-state and transient thermal performance for both together.

The circuit before editing is shown below:

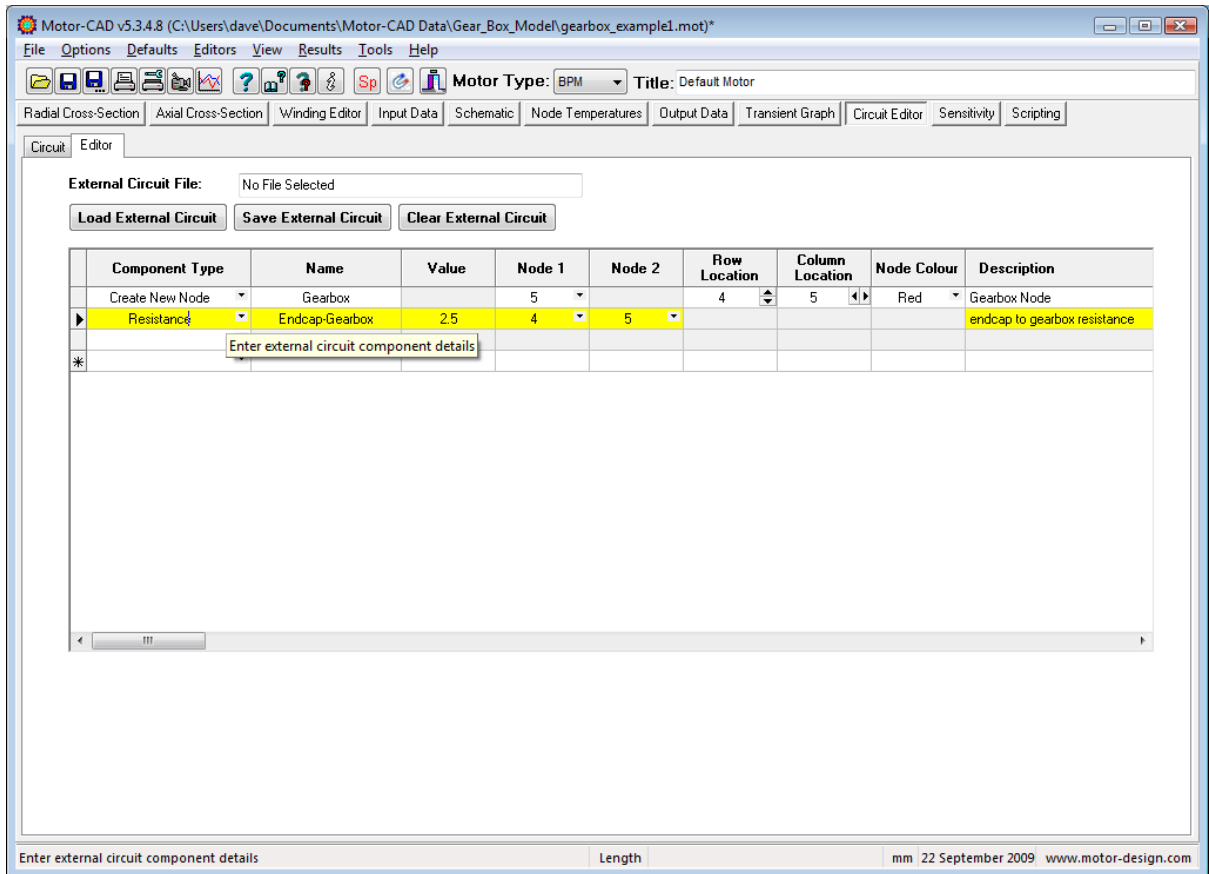


We need to add the new circuit to the [Front Endcap] node which is node number 4 in the circuit above.

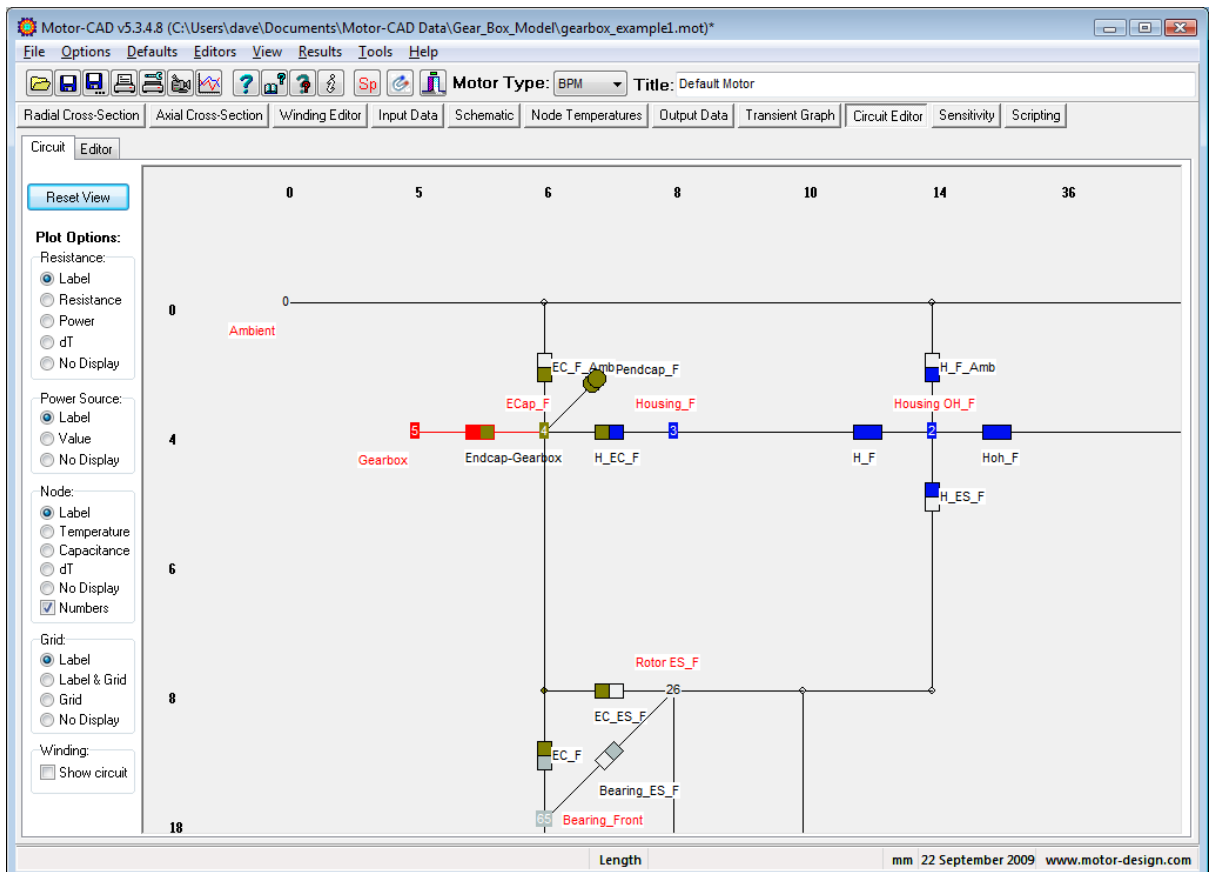
In the circuit editor we click on the [Editor] tab where we can add the additional thermal resistance and thermal capacitance components to the circuit. We can also create new nodes and add power sources. In this case we need to add three new nodes for the Gearbox, Gearbox Mount and Chassis. Below is a screen capture when we are in the process of creating the 1st new node. We can select a node number that is not being used, number 5 in this case:



The Gearbox node is connected to the [Front Endcap] node using a new resistance that we input using the editor:



Row and column number are used to control where the new circuit components are shown in the editor:



We can now add the remaining circuit components:

Motor-CAD v5.3.4.8 (C:\Users\dave\Documents\Motor-CAD Data\Gear_Box_Model\gearbox_example1.mot*)

File Options Defaults Editors View Results Tools Help

Motor Type: BPM Title: Default Motor

Radial Cross-Section Axial Cross-Section Winding Editor Input Data Schematic Node Temperatures Output Data Transient Graph Circuit Editor Sensitivity Scripting

Circuit Editor

External Circuit File: No File Selected

Load External Circuit Save External Circuit Clear External Circuit

Component Type	Name	Value	Node 1	Node 2	Row Location	Column Location	Node Colour	Description
Modify Existing Node	Gearbox		5		4	5	Red	Gearbox Node
Resistance	Endcap-Gearbox	2.5	4	5				endcap to gearbox resistance
Modify Existing Node	Gearbox Mount		14		4	4	Red	Gearbox Mount
Resistance	Mount-Gearbox	1.6	5	14				gearbox mount to gearbox
Modify Existing Node	Chassis		19		4	3	Red	Chassis
Resistance	Chassis-Gearbox Mount	5	14	19				Chassis to gearbox mount
Resistance	Chassis-Ambient	0.55	0	19				gearbox chassis to ambient
Capacitance	Gearbox Cap	160	5					gearbox thermal capacitance
Capacitance	Gearbox Mount Cap	360	14					gearbox mount thermal cap
Capacitance	Gearbox Chassis Cap	5700	19					gearbox chassis thermal cap

Enter external circuit component details Length mm 22 September 2009 www.motor-design.com

They are shown in the editor below:

Motor-CAD v5.3.4.8 (C:\Users\dave\Documents\Motor-CAD Data\Gear_Box_Model\gearbox_example1.mot*)

File Options Defaults Editors View Results Tools Help

Motor Type: BPM Title: Default Motor

Radial Cross-Section Axial Cross-Section Winding Editor Input Data Schematic Node Temperatures Output Data Transient Graph Circuit Editor Sensitivity Scripting

Circuit Editor

Reset View

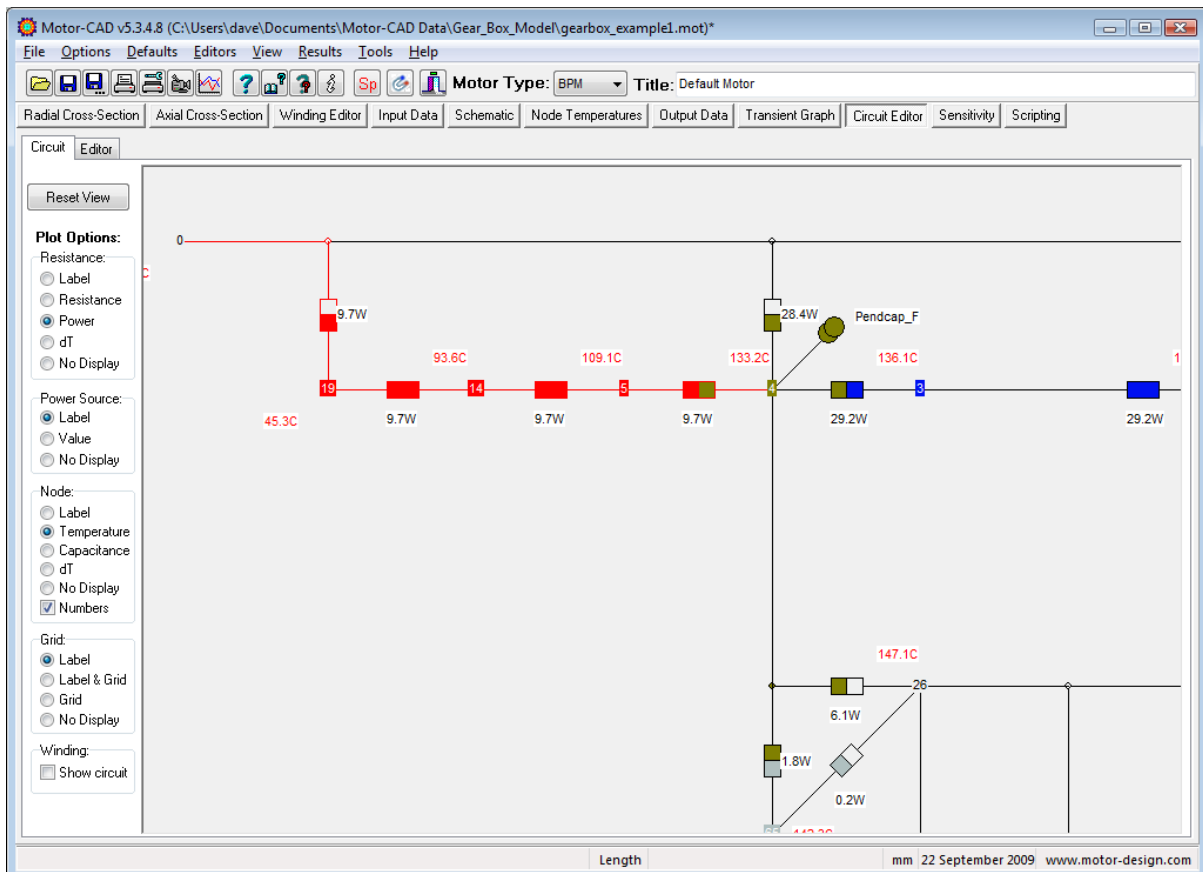
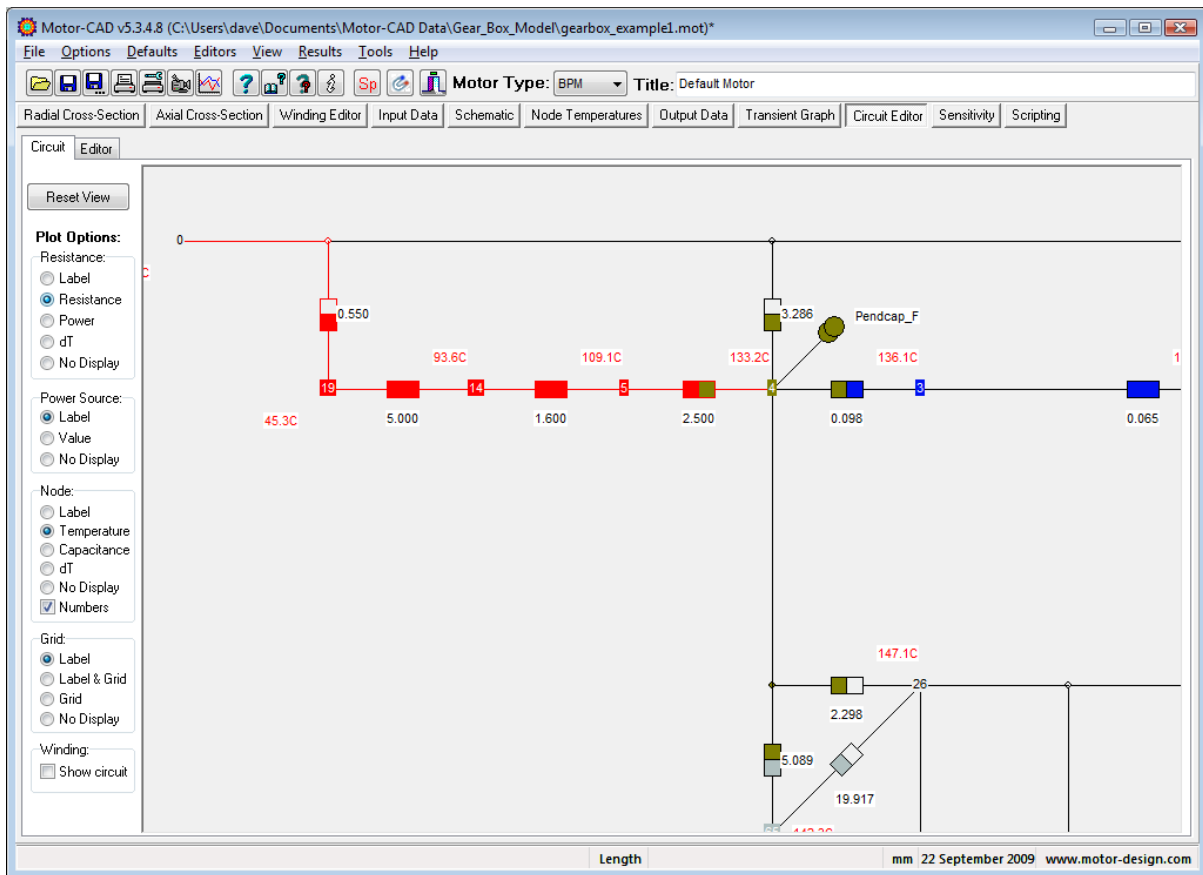
Plot Options:

- Resistance:
 - Label
 - Resistance
 - Power
 - dT
 - No Display
- Power Source:
 - Label
 - Value
 - No Display
- Node:
 - Label
 - Temperature
 - Capacitance
 - dT
 - No Display
 - Numbers
- Grid:
 - Label
 - Label & Grid
 - Grid
 - No Display
- Winding:
 - Show circuit

The schematic diagram shows a circuit with nodes 0, 19, 14, 5, 4, 5, 3, 26, and H. Components include Chassis-Ambient, Chassis, Chassis-Gearbox Mount, Gearbox Mount, Gearbox, Endcap-Gearbox, ECap_F, EC_F_Amb, Pendcap_F, H_EC_F, H_F, Rotor ES_F, EC_ES_F, EC_F, and Bearing_ES_F.

Length mm 22 September 2009 www.motor-design.com

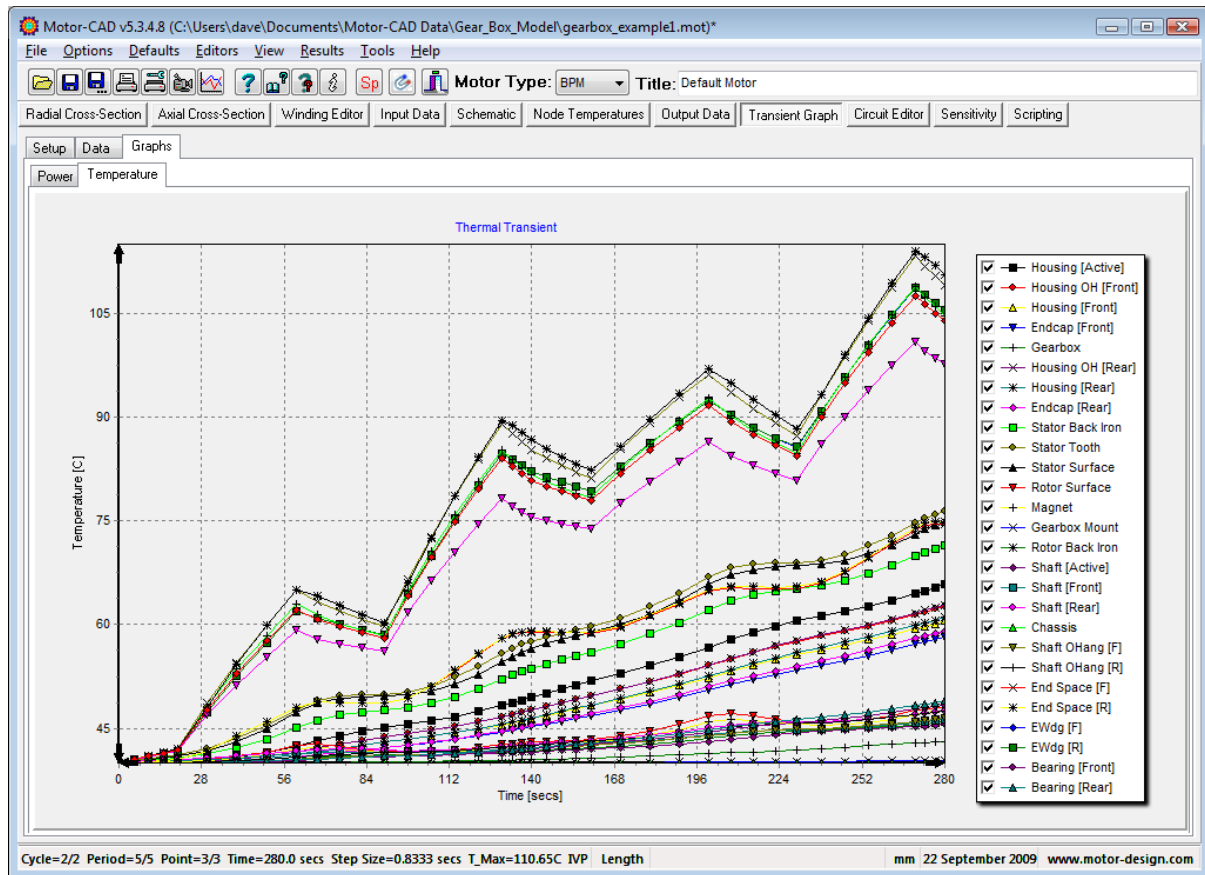
The steady-state results are displayed directly on the circuit using the options on the left hand side of the screen:



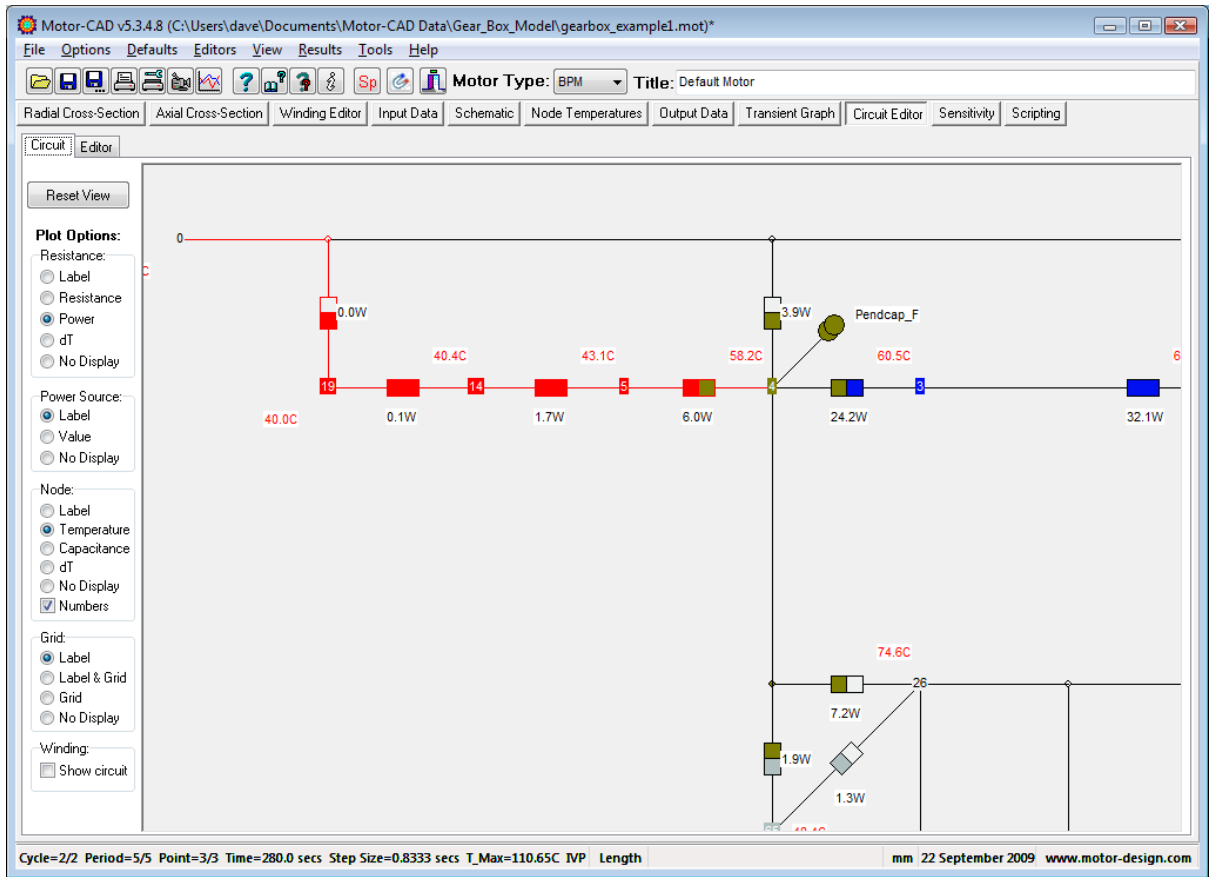
In this case we have an additional 9.7W dissipated through the gearbox. We could construct a more sophisticated circuit for the gearbox that includes additional gearbox losses that could heat the motor up rather than give additional cooling.

The [Schematic] circuit also displays the results with the gearbox attached but does not display the gearbox thermal components.

The thermal transient also includes the new nodes in the simulation as shown below:



If we go directly from the transient graph to the circuit editor we can view the final transient temperatures:



Saving and Loading Edited Circuits

We can save the new circuit created and import it into another Motor-CAD model using the options highlighted below:

The screenshot shows the Motor-CAD v5.3.4.8 software interface. The 'External Circuit File' dialog box is open, with the file path 'C:\Users\dave\Documents\Motor-CAD Data\Gear_Box_Model\gearbox_example1.mot' and three buttons: 'Load External Circuit', 'Save External Circuit', and 'Clear External Circuit'. Below the dialog box is a table of circuit components.

Component Type	Name	Value	Node 1	Node 2	Row Location	Column Location	Node Colour	Description
Modify Existing Node	Gearbox		5		4	5	Red	Gearbox Node
Resistance	Endcap-Gearbox	2.5	4	5				endcap to gearbox resistance
Modify Existing Node	Gearbox Mount		14		4	4	Red	Gearbox Mount
Resistance	Mount-Gearbox	1.6	5	14				gearbox mount to gearbox
Modify Existing Node	Chassis		19		4	3	Red	Chassis
Resistance	Chassis-Gearbox Mount	5	14	19				Chassis to gearbox mount
Resistance	Chassis-Ambient	0.55	0	19				gearbox chassis to ambient
Capacitance	Gearbox Cap	160	5					gearbox thermal capacitance
Capacitance	Gearbox Mount Cap	360	14					gearbox mount thermal cap
Capacitance	Gearbox Chassis Cap	5700	19					gearbox chassis thermal cap
*								

At the bottom of the window, the status bar shows 'Length', 'mm', '22 September 2009', and 'www.motor-design.com'.