

■ Continuum Representation of Wound Coils via an Equivalent Foil Approach

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This notebook generates the figures comparing models of a coil in which each turn is explicitly modeled versus a continuum approximation of the coil. The notebook uses the MathFEMM interface to FEMM 4.01 to automate the evaluation of various coil geometries at various frequencies.

```
In[1]:= << c:\progra~1\femm42\mathfemm\mathfemm.m
```

```
MathFEMM 1.20
The Mathematica interface to FEMM 4.2
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```

A number of standard Mathematica packages are needed, along with some useful definitions

```
In[2]:= << Graphics`Graphics`;
<< Graphics`Legend`;
Off[General::"spell1"];
Off[General::"spell"];
$TextStyle = {FontFamily -> "Times New Roman", FontSize -> 14};
```

```
In[7]:= OpenFEMM[]
```

The "AnalyzeFile" function performs a set of analyses on a prescribed file on a frequency range of 1kHz to 1MHz at a prescribed step size on a logscale.

```
In[8]:= AnalyzeFile[fname_, stepsize_] := Module[{k, freq, result},
  OpenDocument[fname];
  MISaveAs["c:\progra~1\femm40\examples\temp.fem"];
  result = {};
  For[k = 3, k ≤ 6, k += stepsize,
    freq = 10^k;
    MIProbDef[freq, "millimeters", "axi", 10^(-8), 1, 30];
    MIAnalyze[1];
    MIOloadSolution[];
    result = Append[result, {freq, MOGetCircuitProperties["icoil"][[2]]}];
    MOClose[];
  ];
  MIClose[];
  result
]
```

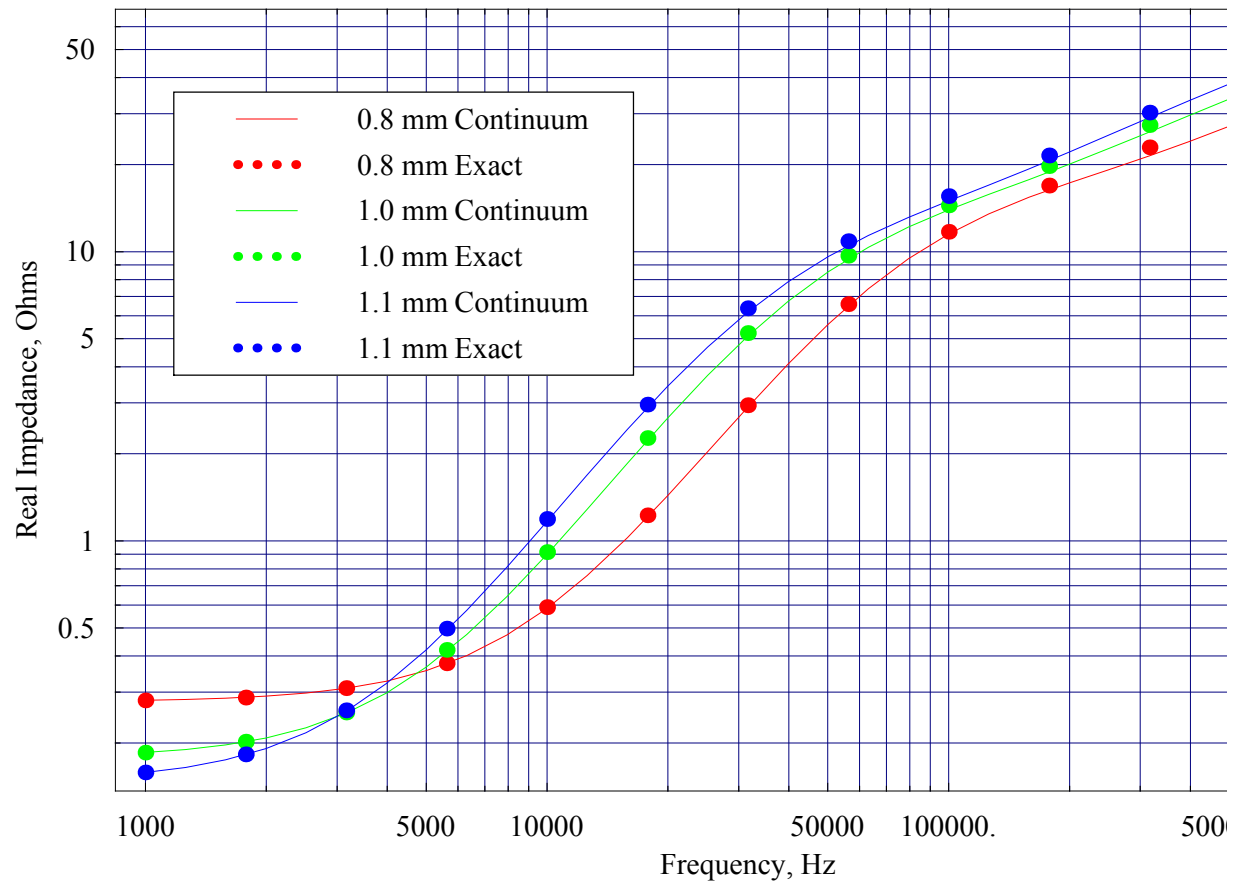
Continuum approximations and exact representations are analyzed for 0.8 mm, 1 mm, and 1.1 mm diameter copper wires at room temperature

```
a1000 = AnalyzeFile["c:\\temp\\drawfigures\\proximityapprox.fem", 0.1];
x1000 = AnalyzeFile["c:\\temp\\drawfigures\\proximityexact.fem", 0.25];
a800 = AnalyzeFile["c:\\temp\\drawfigures\\proximityapprox2.fem", 0.1];
x800 = AnalyzeFile["c:\\temp\\drawfigures\\proximityexact2.fem", 0.25];
a1100 = AnalyzeFile["c:\\temp\\drawfigures\\proximityapprox3.fem", 0.1];
x1100 = AnalyzeFile["c:\\temp\\drawfigures\\proximityexact3.fem", 0.25];
```

```
In[15]:= CloseFEMM[];
```

Now, plots can be generated that compare the impedance of the continuum model to the exact model for the various wire sizes.

```
In[16]:= ShowLegend[
  DisplayTogether[
    LogLogListPlot[Re[a800], PlotJoined → True, PlotStyle → {RGBColor[1, 0, 0]}],
    LogLogListPlot[Re[a1000], PlotJoined → True, PlotStyle → {RGBColor[0, 1, 0]}],
    LogLogListPlot[Re[a1100], PlotJoined → True, PlotStyle → {RGBColor[0, 0, 1]}],
    LogLogListPlot[Re[x800], PlotStyle → {RGBColor[1, 0, 0], PointSize[0.0125]}],
    LogLogListPlot[Re[x1000], PlotStyle → {RGBColor[0, 1, 0], PointSize[0.0125]}],
    LogLogListPlot[Re[x1100], PlotStyle → {RGBColor[0, 0, 1], PointSize[0.0125]}],
    PlotRange → All, Frame → True,
    FrameLabel → {"Frequency, Hz", "Real Impedance, Ohms"}, ImageSize → 700,
    GridLines → {LogGridMinor, LogGridMinor}, DisplayFunction → Identity],
  {{{Graphics[{RGBColor[1, 0, 0], Line[{0, 0}, {1, 0}]}]}, "0.8 mm Continuum"},
   {Graphics[Rectangle[{0, 0}, {1, 1}], ListPlot[{0, 0, 0, 0},
    Axes → False, PlotStyle → {RGBColor[1, 0, 0], PointSize[0.15]},
    DisplayFunction → Identity]}], "0.8 mm Exact"},
   {Graphics[{RGBColor[0, 1, 0], Line[{0, 0}, {1, 0}]}]}, "1.0 mm Continuum"},
   {Graphics[Rectangle[{0, 0}, {1, 1}], ListPlot[{0, 0, 0, 0},
    Axes → False, PlotStyle → {RGBColor[0, 1, 0], PointSize[0.15]},
    DisplayFunction → Identity]}], "1.0 mm Exact"},
   {Graphics[{RGBColor[0, 0, 1], Line[{0, 0}, {1, 0}]}]}, "1.1 mm Continuum"},
   {Graphics[Rectangle[{0, 0}, {1, 1}], ListPlot[{0, 0, 0, 0}, Axes → False,
    PlotStyle → {RGBColor[0, 0, 1], PointSize[0.15]}, DisplayFunction → Identity]}],
   "1.1 mm Exact"}], LegendPosition → {-0.75, 0.1},
  LegendSize → {0.65, 0.4}, LegendShadow → {0, 0}];
```



```

In[17]:= GetIm[p_] := Module[{px, py},
  px = Transpose[p][[1]];
  py = Im[Transpose[p][[2]]];
  Transpose[{px, py}]
]

```

```

In[18]:= ShowLegend[
  DisplayTogether[
    LogLogListPlot[GetIm[a800], PlotJoined → True, PlotStyle → {RGBColor[1, 0, 0]}],
    LogLogListPlot[GetIm[a1000], PlotJoined → True, PlotStyle → {RGBColor[0, 1, 0]}],
    LogLogListPlot[GetIm[a1100], PlotJoined → True, PlotStyle → {RGBColor[0, 0, 1]}],
    LogLogListPlot[GetIm[x800], PlotStyle → {RGBColor[1, 0, 0], PointSize[0.0125]}],
    LogLogListPlot[GetIm[x1000], PlotStyle → {RGBColor[0, 1, 0], PointSize[0.0125]}],
    LogLogListPlot[GetIm[x1100], PlotStyle → {RGBColor[0, 0, 1], PointSize[0.0125]}],
    Frame → True, FrameLabel → {"Frequency, Hz", "Reactive Impedance, Ohms"}, ImageSize →
      700, GridLines → {LogGridMinor, LogGridMinor}, DisplayFunction → Identity],
  {{{Graphics[{RGBColor[1, 0, 0], Line[{0, 0}, {1, 0}]}]}, "0.8 mm Continuum"},
    {Graphics[Rectangle[{0, 0}, {1, 1}], ListPlot[{0, 0, 0, 0},
      Axes → False, PlotStyle → {RGBColor[1, 0, 0], PointSize[0.15]},
      DisplayFunction → Identity]}], "0.8 mm Exact"},
    {Graphics[{RGBColor[0, 1, 0], Line[{0, 0}, {1, 0}]}]}, "1.0 mm Continuum"},
    {Graphics[Rectangle[{0, 0}, {1, 1}], ListPlot[{0, 0, 0, 0},
      Axes → False, PlotStyle → {RGBColor[0, 1, 0], PointSize[0.15]},
      DisplayFunction → Identity]}], "1.0 mm Exact"},
    {Graphics[{RGBColor[0, 0, 1], Line[{0, 0}, {1, 0}]}]}, "1.1 mm Continuum"},
    {Graphics[Rectangle[{0, 0}, {1, 1}], ListPlot[{0, 0, 0, 0}, Axes → False,
      PlotStyle → {RGBColor[0, 0, 1], PointSize[0.15]}, DisplayFunction → Identity]}],
      "1.1 mm Exact"}}, LegendPosition → {-0.75, 0.1},
  LegendSize → {0.65, 0.4}, LegendShadow → {0, 0}];

```

