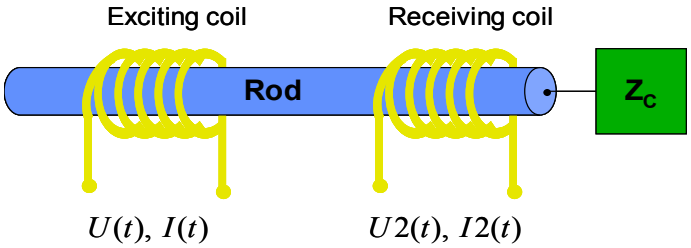
Determination of Z_C by inverse calculations

In this Notebook the resonant frequency and the peak amplitude are calculated. They are given as a function of the (real and imag. part of the) contact impedance. This relationship is interpolated.

The LabVIEW Software gives the frequency and the amplitude af a resonant peak at the detection coil. Now the the approximation can be used to determine the mechanical impedance Z_C which is attached to one end of the resonator.



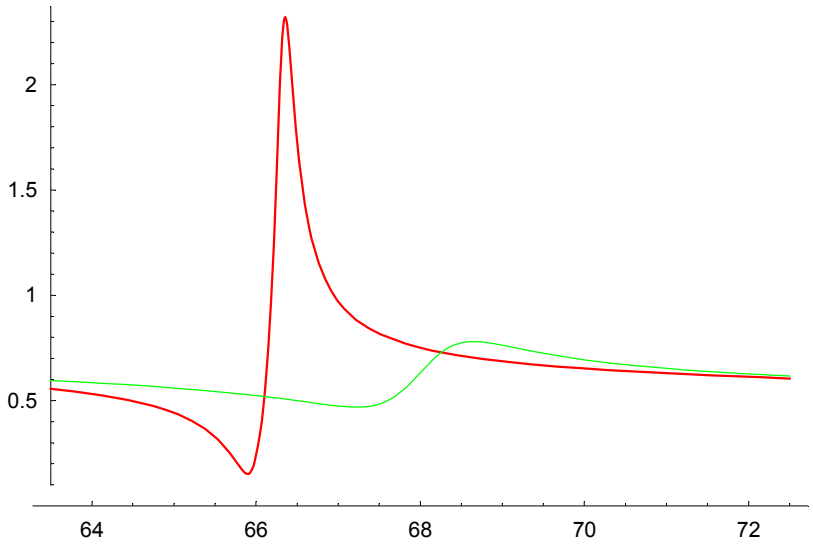
■ Initialization

■ Verification of Frequency response

- **The apparent power transfered to the ceceiving coil in uW !!!:**

```
testP2[f_] = Simplify[P2as * 1000000 //. general] // N;
```

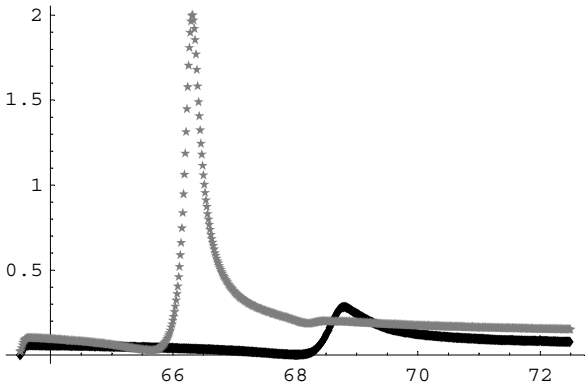
```
plotmod = Plot[{testP2[f * 1000] /. ZCr → 0.8 /. ZCi → -2.0,
    testP2[f * 1000] /. ZCr → 5.5 /. ZCi → -16}, {f, 63.500, 72.500},
  PlotPoints → 30, PlotRange → All, AxesOrigin -> {63.500, 0}, PlotStyle →
   {{Thickness[.003], RGBColor[1, 0, 0]}, {Thickness[.002], RGBColor[0, 1, 0]}},
  TextStyle → {FontFamily → "Helvetica", FontSize → 10}]
```



- Graphics -

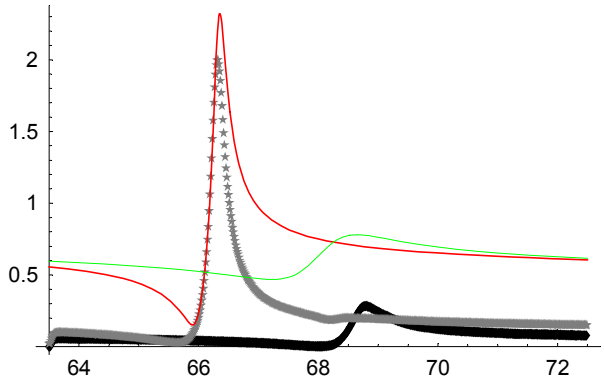
■ Importing measurement data

```
freptab1 = Import["frep1.csv"];

freptab1 = Take[freptab1, {1, 10000, 20}];

freptab2 = Import["frep2.csv"];

freptab2 = Take[freptab2, {1, 10000, 15}];

plottab = MultipleListPlot[freptab1, freptab2,
  PlotRange → All, SymbolStyle → {GrayLevel[0], GrayLevel[.5]}]
```



- Graphics -

```
plotall = Show[plottab, plotmod, PlotRange → All,
  TextStyle → {FontFamily → "Helvetica", FontSize → 10}, AxesOrigin -> {63.500, 0}]
```




```
- Graphics -
```

■ Determination of peak frequency and amplitude

Now find maximum of testP2

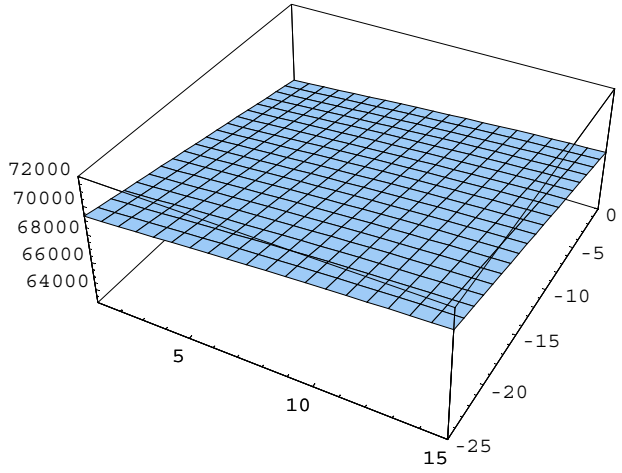
```
FindMinimum[-testP2[f] /. ZCr → 1 /. ZCi → -1, {f, 72000, 63000, 75000}]
```

```
{-1.56505, {f → 66239.7}}
```

Note: [[1]] takes the first element from this list (Amplitude) and [[2]] takes the second. Because a MINIMUM is found, the Amplitude value has to be inverted

■ Find Frequency and Power Amplitude, dependant on ZC:

```
Plot3D[f /. FindMinimum[-testP2[f], {f, 72000, 63000, 75000}][[2]], {ZCr, 1, 15},
 {ZCi, 0, -25}, PlotRange → {63000, 72000}, PlotPoints → 20, Compiled → False]
```

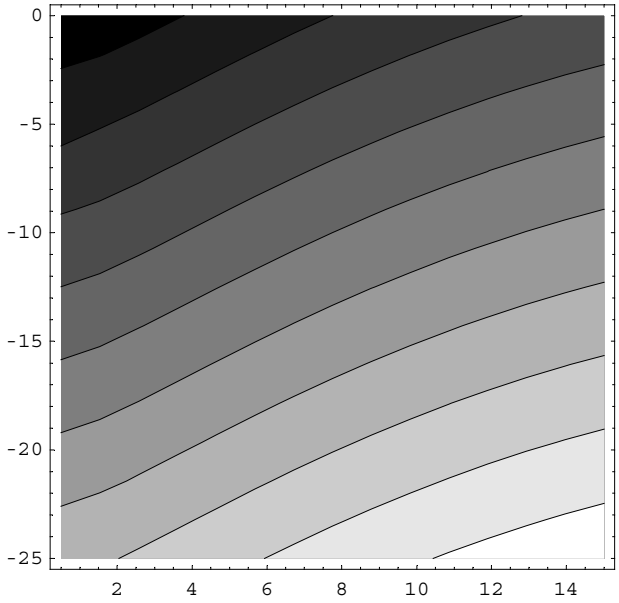


- SurfaceGraphics -

■ Frequency

```
ContourPlot[f /. FindMinimum[-testP2[f], {f, 72000, 63000, 75000}][[2]],
 {ZCr, 0.5, 15}, {ZCi, 0, -25}, PlotRange → Automatic, Compiled → False]
```

```
FindMinimum::fmcv : Failed to converge to the requested accuracy or precision within 30 iterations.
```

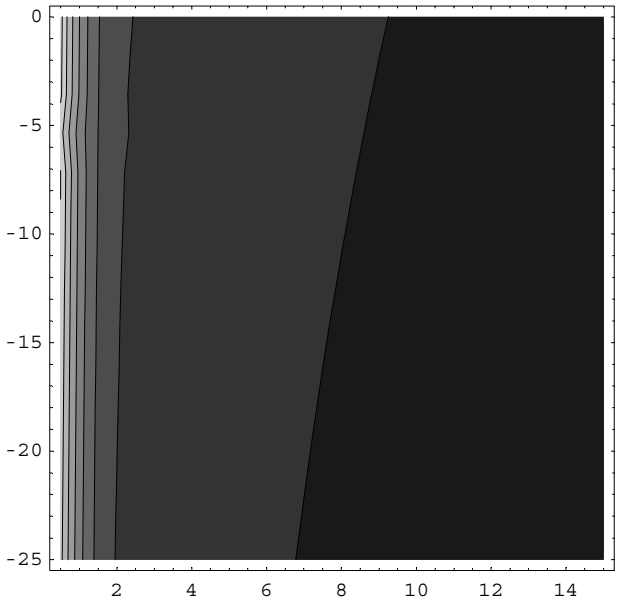


- ContourGraphics -

■ Amplitude

```
ContourPlot[-FindMinimum[-testP2[f], {f, 72000, 63000, 75000}][[1]],
 {ZCr, 0.5, 15}, {ZCi, 0, -25}, PlotRange → {0, 2}, Compiled → False]
```

```
FindMinimum::fmcv : Failed to converge to the requested accuracy or precision within 30 iterations.
```



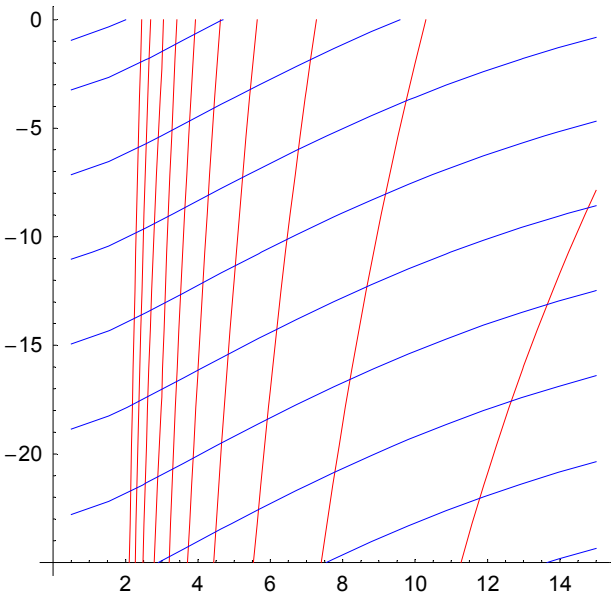
- ContourGraphics -

■ Combined

```
plot1 = ContourPlot[-FindMinimum[-testP2[f], {f, 72000, 63000, 75000}][[1]], {ZCr, 1, 15},
  {ZCi, 0, -25}, PlotRange → Automatic, Compiled → False, ContourShading → False,
  Frame → False, Axes → True, TextStyle → {FontFamily → "Helvetica", FontSize → 10},
  ContourStyle -> {Thickness[.002], RGBColor[1, 0, 0]},
  Contours → {0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 1, 1.5}]
```

```
plot2 = ContourPlot[f /. FindMinimum[-testP2[f], {f, 72000, 63000, 75000}][[2]],
  {ZCr, 0.5, 15}, {ZCi, 0, -25}, PlotRange → Automatic,
  Compiled → False, ContourShading → False, Frame → False,
  Axes → True, TextStyle → {FontFamily → "Helvetica", FontSize → 10},
  TextStyle → {FontFamily → "Helvetica", FontSize → 10},
  ContourStyle -> {Thickness[.002], RGBColor[0, 0, 1]},
  Contours → {66200, 66500, 67000, 67500, 68000, 68500, 69000, 69500, 70000, 70500}]
```

```
ZCPlot1 = Show[plot1, plot2, AxesOrigin → {0, -25}];
```



■ Polynomial fitting

■ Amplitude

```
tab = Table[{ZCr, ZCi, -FindMinimum[-testP2[f], {f, 72000, 63000, 75000}][[1]]},
   {ZCr, 0.5, 15, 0.5}, {ZCi, 0, -25, -1}];
```

```
FindMinimum::fmcv : Failed to converge to the requested accuracy or precision within 30 iterations.
```

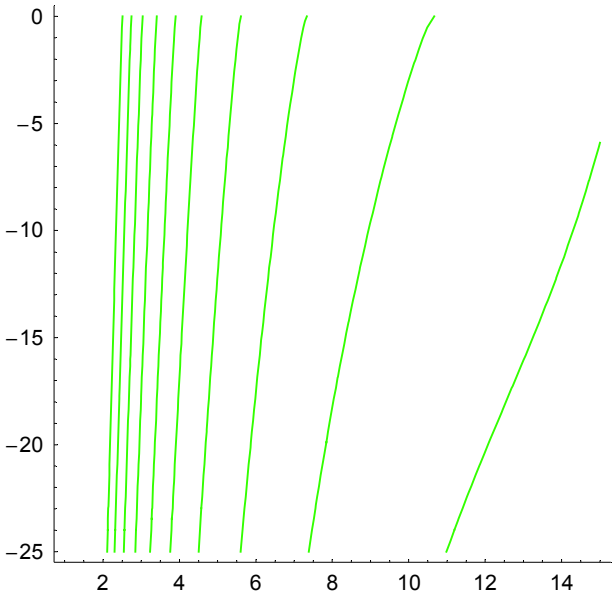
```
tab = Flatten[tab, 1];
```

Curve fit:

```
fam = Fit[tab, {1, ZCr, ZCi, ZCi * ZCr, (-ZCi) ^ (1 / 2), Sqrt[ZCr], ZCr ^ (1 / 3),
   ZCr ^ (1 / 4), ZCr ^ (1 / 5), Sqrt[ZCr] * ZCi, ZCr ^ (1 / 3) * ZCi}, {ZCr, ZCi}]
```

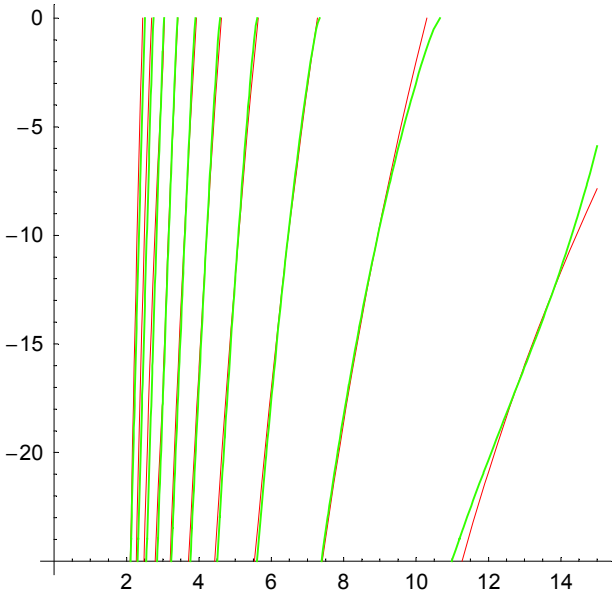
$$288.9 - 0.00166776\sqrt{-ZCi} + 0.0759347\,ZCi - 4635.94\,ZCr^{1/5} + 6754.51\,ZCr^{1/4} - 2643.56\,ZCr^{1/3} - 0.169069\,ZCi\,ZCr^{1/3} + 238.944\sqrt{ZCr} + 0.106844\,ZCi\sqrt{ZCr} - 1.28271\,ZCr - 0.0047965\,ZCi\,ZCr$$

```
fplot1 = ContourPlot[fam, {ZCr, 1, 15}, {ZCi, 0, -25},
  PlotPoints → 50, Compiled → False, ContourShading → False, Frame → False,
  Axes → True, TextStyle → {FontFamily → "Helvetica", FontSize → 10},
  ContourStyle -> {Thickness[.004], RGBColor[0.2, 1, 0]},
  Contours → {0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 1, 1.5}]
```



- ContourGraphics -

```
KombiPlot1 = Show[plot1, fplot1, AxesOrigin → {0, -25}];
```



■ Frequency

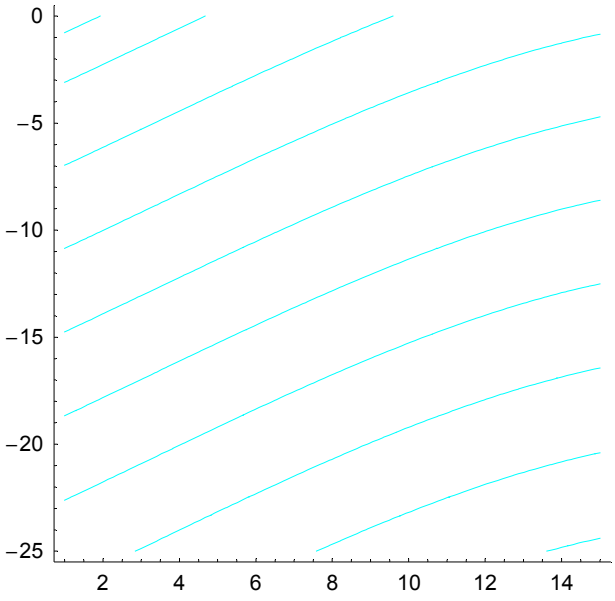
```
tab2x = Table[{ZCr, ZCi, f /. FindMinimum[-testP2[f], {f, 72000, 63000, 75000}][[2]]},
   {ZCr, 1, 15, 1}, {ZCi, 0, -25, -1}];

tab2 = Flatten[tab2x, 1];
```

Curve fit:

```
fam2 = Fit[tab2, {1, ZCr, ZCi, ZCi * (ZCr), (ZCr) ^ 2,
   ZCi ^ 2, ZCr ^ 3, ZCi ^ 3, ZCi * ZCr ^ 2, ZCr * ZCi ^ 2}, {ZCr, ZCi}]
```

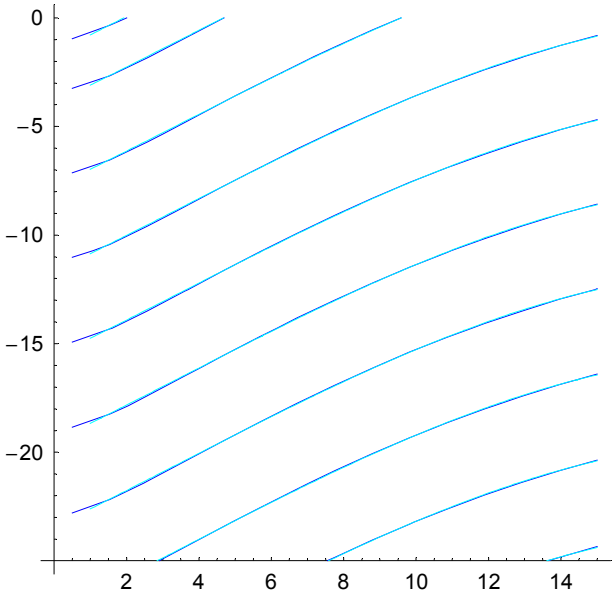
$$65993.8 - 129.226\ ZCi - 0.00642968\ ZCi^2 + 0.00152516\ ZCi^3 + 104.918\ ZCr - 0.0171216\ ZCi\ ZCr - 0.00255845\ ZCi^2\ ZCr + 1.39352\ ZCr^2 + 0.000102216\ ZCi\ ZCr^2 - 0.145336\ ZCr^3$$

```
fplot2 = ContourPlot[fam2, {ZCr, 1, 15}, {ZCi, 0, -25}, PlotRange → Automatic,
  PlotPoints → 100, Compiled → False, ContourShading → False, Frame → False,
  Axes → True, TextStyle → {FontFamily → "Helvetica", FontSize → 10},
  TextStyle → {FontFamily → "Helvetica", FontSize → 10},
  ContourStyle -> {Thickness[.002], RGBColor[0, 1, 1]},
  Contours → {66200, 66500, 67000, 67500, 68000, 68500, 69000, 69500, 70000, 70500}]
```



- ContourGraphics -

```
KombiPlotf = Show[plot2, fplot2, AxesOrigin → {0, -25}];
```



■ Error calculation

Export:

Exporting the functions to LabView

```
fam /. ZCi → z2 /. ZCr → z1 // FortranForm
```

```
      288.89962848523703 - 4635.9377535268295*z1**0.2 +
     -  6754.5131590731135*z1**0.25 -
     -  2643.5550616306323*z1**0.3333333333333333 +
     -  238.94370788865353*Sqrt(z1) - 1.2827149874861317*z1 -
     -  0.001667759804544206*Sqrt(-z2) + 0.07593467873312754*z2 -
     -  0.16906926954028373*z1**0.3333333333333333*z2 +
     -  0.10684402374177451*Sqrt(z1)*z2 - 0.004796502369839811*z1*z2
```

```
fam2 /. ZCi → z2 /. ZCr → z1 // FortranForm
```

```
      65993.75348154173 + 104.91808305524091*z1 +
     -  1.3935182319064268*z1**2 - 0.14533592822677655*z1**3 -
     -  129.22616465268254*z2 - 0.017121556852998765*z1*z2 +
     -  0.0001022161229409235 3*z1**2*z2 - 0.006429680538637683*z2**2 -
     -  0.002558446264730563*z1*z2**2 + 0.0015251649522949329*z2**3
```

```
Export["chapter8val_frep_01.wmf", plotall, ImageSize → 390]
```

```
chapter8val_frep_01.wmf
```