aktive Antenne für den Frequenzbereich von ca. 100 MHz bis ca. 3 GHz --- Ingenieurbüro Baumann --- www.leobaumann.com --- 25. März 2007

```
• reset:DIGITS:=16:Z0:=50:v:=float(10^(16/20)):
```

Liste der betrachteten Frequenzen zu den Idizes

```
• f:=[100,200,400,600,800,1000,1200,1400,1600,1800,2000,2200,2400,2600
  ,2800,3000]:
```

Scattering-Parameter des BGA2012 von Philips

```
• s11b1:=[0.775,0.761,0.709,0.646,0.581,0.519,0.461,0.401,0.350,0.313,
  0.289,0.278,0.276,0.286,0.293,0.287]:
• s11w1:=[-8.390,-16.37,-31.51,-44.97,-56.47,-66.59,-75.41,-83.99,-
  93.12,-102.0,-110.6,-118.5,-125.0,-131.9,-136.5,-141.6]:
• s12b1:=[0.005,0.011,0.020,0.028,0.034,0.039,0.043,0.047,0.051,0.054,
  0.058,0.062,0.066,0.072,0.076,0.083]:
• s12w1:=[84.9,79.39,72.23,66.03,61.82,58.86,58.07,57.92,57.26,57.37,5
  8.10,57.66,56.08,60.98,60.21,61.36]:
• s21b1:=[12.527,12.154,11.213,10.139,9.061,8.131,7.254,6.461,5.869,5.
  256,4.778,4.394,4.051,3.793,3.571,3.326]:
• s21w1:=[171.1,163.1,148.6,136.4,126.1,117.3,109.5,103.1,96.39,90.46,
  85.58,81.16,77.28,74.34,70.27,67.39]:
• s22b1:=[0.742,0.731,0.689,0.631,0.573,0.519,0.469,0.428,0.396,0.369,
  0.348,0.336,0.333,0.316,0.308,0.272]:
• s22w1:=[-6.684,-13.15,-24.85,-34.90,-43.40,-50.54,-57.19,-64.08,-
  70.03,-75.33,-80.47,-85.37,-89.83,-92.61,-94.44,-99.52]:
```

Lastimpedanz des BGA 2012

```
• ZL:=50+0*I:
```

Funktionen zur Umrechnung der S-Parameter in Z-Parameter

```
• Z11:=(S11,S12,S21,S22)->Z0*((1+S11)*(1-S22)+S12*S21)/((1-S11)*(1-
  S22)-S12*S21):
• Z12:=(S11,S12,S21,S22)->Z0*2*S12/((1-S11)*(1-S22)-S12*S21):
• Z21:=(S11,S12,S21,S22)->Z0*2*S21/((1-S11)*(1-S22)-S12*S21):
• Z22:=(S11,S12,S21,S22)->Z0*((1+S22)*(1-S11)+S12*S21)/((1-S11)*(1-
  S22)-S12*S21):
• DZ :=Z11*Z22-Z12*Z21:
• ZIn:=(z11,z12,z21,z22,zL)->(Z11*ZL+DZ)/(ZL+Z22):
```

Berechnung der Liste der Z-Parameter sowie ZIn vom BGA2012

```
• for k from 1 to 16 do
  h:=rectform(float(Z11(s11b1[k]*exp(I*s11w1[k]),s12b1[k]*exp(I*s12w1[
    k]),s21b1[k]*exp(I*s21w1[k]),s22b1[k]*exp(I*s22w1[k])))):Z111[k]:=
    h:
  h:=rectform(float(Z12(s11b1[k]*exp(I*s11w1[k]),s12b1[k]*exp(I*s12w1[
    k]),s21b1[k]*exp(I*s21w1[k]),s22b1[k]*exp(I*s22w1[k])))):Z121[k]:=
    h:
  h:=rectform(float(Z21(s11b1[k]*exp(I*s11w1[k]),s12b1[k]*exp(I*s12w1[
    k]),s21b1[k]*exp(I*s21w1[k]),s22b1[k]*exp(I*s22w1[k])))):Z211[k]:=
    h:
  h:=rectform(float(Z22(s11b1[k]*exp(I*s11w1[k]),s12b1[k]*exp(I*s12w1[
```

```
k]),s21b1[k]*exp(I*s21w1[k]),s22b1[k]*exp(I*s22w1[k])))):Z221[k]:=
h:
h:=Z111[k]*Z221[k]-Z121[k]*Z211[k]:
h:=(Z111[k]*ZL+h)/(ZL+Z221[k]):ZIn1[k]:=h:
end_for:
```

T-Hochpassfilter 88 MHz vor den Halbleitern Lf in nH, Cf1, Cf2, Cf3 in pF

- `Zfi:=float(sqrt(Re(op(op(ZIn1,1),2))^2+Im(op(op(ZIn1,1),2))^2)*1.25):`
- `Lf:=float(Zfi/2/PI/108e6/2):Lfp:=float(Lf/1e-9);Cf:=float(1/(Zfi*2*PI*108e6)):Cfp:=float(Cf/1e-12);Cfp:=float(Cf/1e-12/2);Cfp:=float(Cf/1e-12);`

26.78072729434145

40.54528798862027

20.27264399431014

40.54528798862027

gewählte Bauelemente und Resonanzfrequenz des Hochpassfilters in MHz

- `Cf:=47e-12:Lf:=39e-9:frf:=float(1/(2*PI*sqrt(Cf*2*Lf))/1e6);`

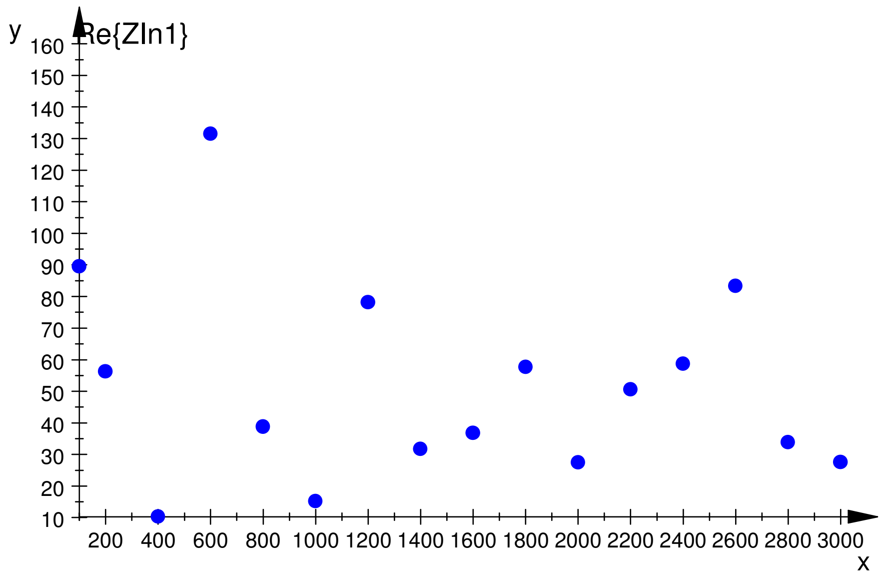
83.12351530832555

Berücksichtigung der vorliegenden Filterschaltung bei der Eingangsimpedanz des BGA2012

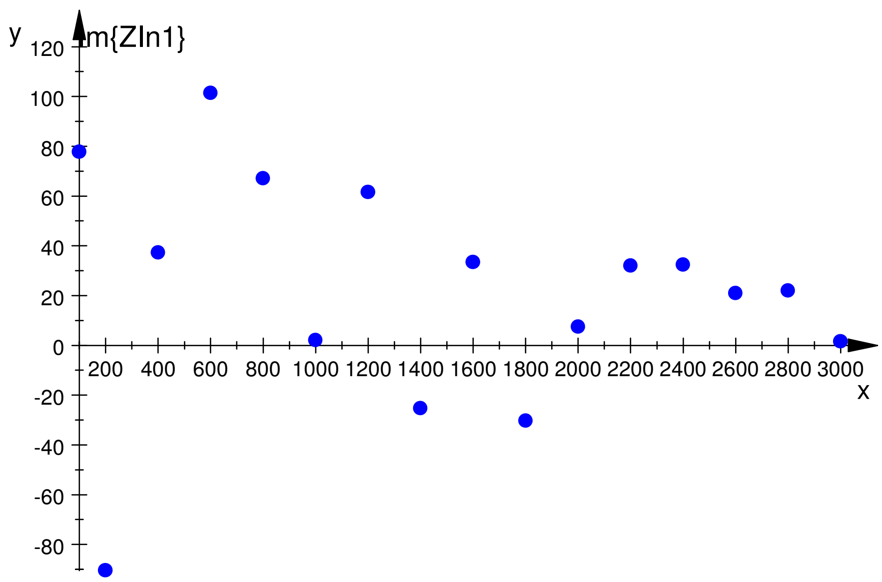
- ```
  for k from 1 to 16 do
  ZC3:=1/(I*2*PI*f[k]*1e6*Cf):
  YL2:=1/(I*2*PI*f[k]*1e6*Lf):
  ZC2:=1/(I*2*PI*f[k]*1e6*Cf/2):
  YL1:=1/(I*2*PI*f[k]*1e6*Lf):
  ZC1:=1/(I*2*PI*f[k]*1e6*Cf):
  h:=float(1/(1/(1/(1/(ZIn1[k]+ZC3)+YL2)+ZC2)+YL1)+ZC1):ZIn1[k]:=h:
  end_for:
  ```

die Impedanz am Filtereingang, Realteil, Imaginärteil und Betrag

- `plot(plot::PointList2d([[op(f,k),Re(op(op(ZIn1,k),2))] $ k=1..16],PointSize=2,Color=RGB::Blue,TitlePosition=[300,160],Title="Re{ZIn1}",TicksNumber=High)):`
  ```



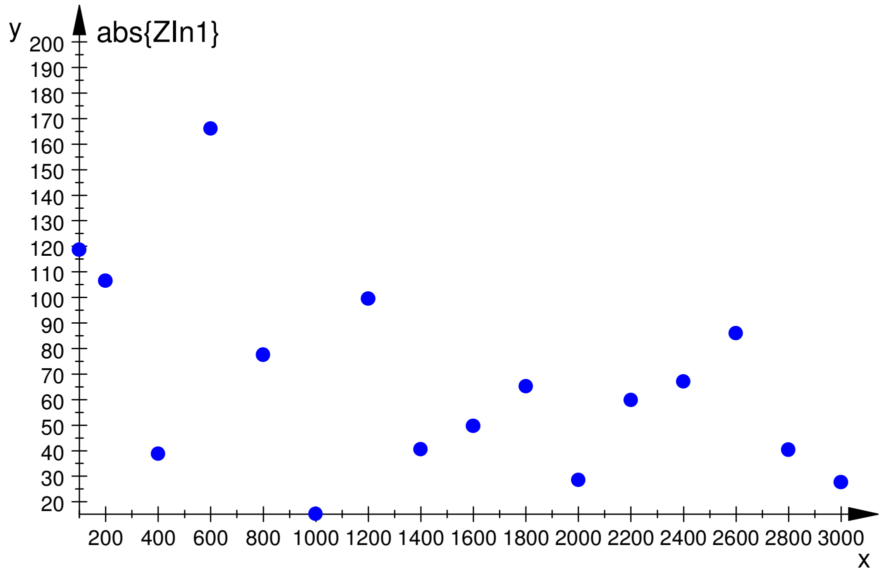

- `plot(plot::PointList2d([[op(f,k),Im(op(op(ZIn1,k),2))] $ k=1..16],PointSize=2,Color=RGB::Blue,TitlePosition=[300,120],Title=" Im{ZIn1}",TicksNumber=High)):`




- `ZIn1;`

$$\begin{bmatrix} 1 & = 89.50702189075831 + 77.72353833452895 \cdot i \\ 2 & = 56.18944126049609 - 90.48114838007525 \cdot i \\ 3 & = 10.33220749988541 + 37.32039234811158 \cdot i \\ 4 & = 131.4796331717872 + 101.427295138228 \cdot i \\ 5 & = 38.74111029574001 + 67.08203925066983 \cdot i \\ 6 & = 15.1252987571235 + 2.113161647920284 \cdot i \\ 7 & = 78.13699533190847 + 61.52163548238499 \cdot i \\ 8 & = 31.6863721313596 - 25.27037562269451 \cdot i \\ 9 & = 36.78021771011304 + 33.38474641691842 \cdot i \\ 10 & = 57.65512095434675 - 30.36081646799404 \cdot i \\ 11 & = 27.46858678415768 + 7.412956923897085 \cdot i \\ 12 & = 50.55402231636509 + 31.95954982198183 \cdot i \\ 13 & = 58.7032143344034 + 32.3748483761332 \cdot i \\ 14 & = 83.31988187839569 + 20.8874398224901 \cdot i \\ 15 & = 33.84665734831852 + 21.94966509611709 \cdot i \\ 16 & = 27.53804585458762 + 1.512606433371121 \cdot i \end{bmatrix}$$

```
• plot(plot::PointList2d([[op(f,k),abs(op(op(ZIn1,k),2))] $
  k=1..16],PointSize=2,Color=RGB::Blue,TitlePosition=[400,200],Title="
  abs{ZIn1}",TicksNumber=High)):
```




Leitungs-Transformationsversuch zur Optimierung der Anpassung an die Antenne

```
• l:=300/2000/8:for k from 1 to 16 do
  bet:=2*PI/(300/f[k]):
  h:=(ZIn1[k]*cos(bet*l)+I*ZL*sin(bet*l))/(I*ZIn1[k]/ZL*sin(bet*l)+cos
     (bet*l)):ZIn1t[k]:=float(h):
  end_for:
```

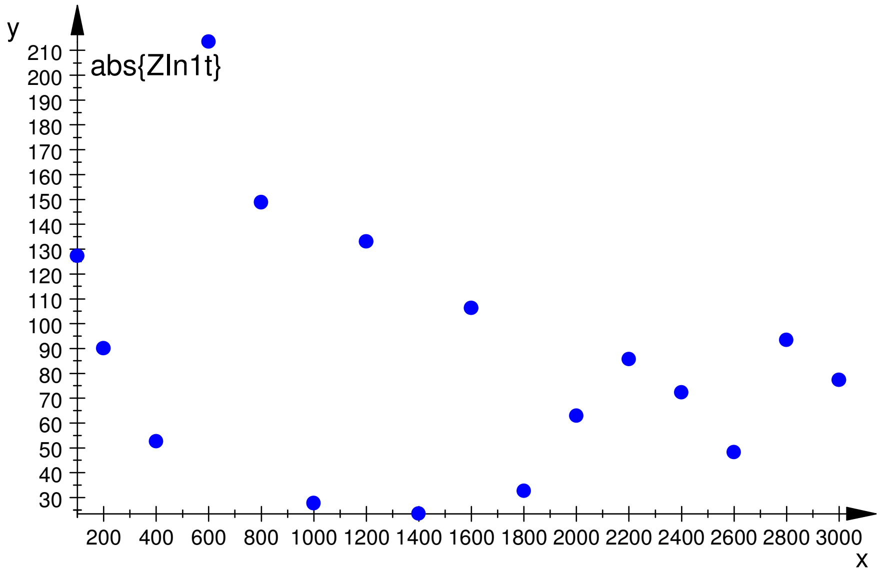
Berücksichtigung des Verkürzungsfaktors (eps_r_eff=3.6) für die Leitung ergibt die mechanische Leitungslänge in mm

```
• ll:=float(300/(2000*8*sqrt(3.6))*1000);
```

9.882117688026185

Betrag der Eingangsimpedanz am Leitungseingang

```
• plot(plot::PointList2d([[op(f,k),abs(op(op(ZIn1t,k),2))] $
  k=1..16],PointSize=2,Color=RGB::Blue,TitlePosition=[400,200],Title="
  abs{ZIn1t}",TicksNumber=High)):
```

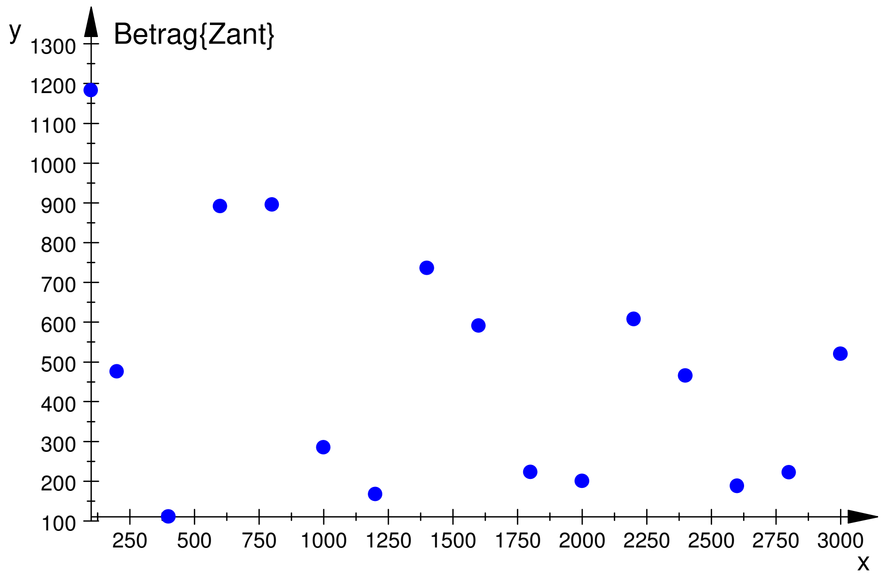



Impedanzen der Antenne berechnet mit 4NEC2 (l=0.15 m, h=10 m)

```
• Zant0:=[0.73-3188*I,2.85-1540*I,11.5-663*I,26.9-321*I,50.5-
  112*I,84.3+46.8*I,132+182*I,201+305*I,304+420*I,469+518*I,747+544*I,
  1109+256*I,924-354*I,404-361*I,203-131*I,156+50.7*I]:
```

Impedanzen der Antenne berechnet mit 4NEC2 (l=0.38 m, h=10 m)

```
• Zant:=[3.04-1183*I,13.5-476*I,92.1+62.3*I,720+526*I,509-737*I,88.7-
  271*I,147+80.8*I,724+132*I,365-465*I,101-199*I,182+83.6*I,607-
  21.3*I,301-355*I,106-155*I,208+78.9*I,514-79.3*I]:
• plot(plot::PointList2d([[op(f,k),abs(Zant[k])] $
  k=1..16],PointSize=2,Color=RGB::Blue,TitlePosition=[500,1300],Title=
  "Betrag{Zant}",TicksNumber=High)):
```




U2/U0 komplex inklusive Verstärkung

```
for k from 1 to 16 do
h:=float(ZIn1t[k]/Zant[k]*v):u2u0[k]:=h:
end_for:u2u0;
```

$$\left[\begin{array}{ll}
1 & = -0.4108763334976034 + 0.5403808200827502 \cdot i \\
2 & = 1.063709679323069 + 0.5406296393781368 \cdot i \\
3 & = 2.254472393631618 + 1.955182429359124 \cdot i \\
4 & = 1.04420674148191 - 1.091490784454877 \cdot i \\
5 & = -0.1165042959834376 + 1.041473352668192 \cdot i \\
6 & = -0.3157479360272215 + 0.5239151830356798 \cdot i \\
7 & = 3.498573290521702 - 3.575151600204024 \cdot i \\
8 & = 0.1926480971865827 - 0.05974657590143295 \cdot i \\
9 & = 0.4249161315959565 + 1.050965491115475 \cdot i \\
10 & = 0.6821814385328305 + 0.6187889816127114 \cdot i \\
11 & = 1.963773815448878 + 0.2389828700480675 \cdot i \\
12 & = 0.8587594973584545 - 0.2329819381566352 \cdot i \\
13 & = 0.8984052590673068 + 0.3895054203072939 \cdot i \\
14 & = 1.489896981718605 + 0.6384683659693466 \cdot i \\
15 & = 2.280959023045316 - 1.347133955431651 \cdot i \\
16 & = 0.8041809860214111 + 0.4823485919452521 \cdot i
\end{array}\right.$$

U2/U0 Betrag inklusive Verstärkung

```
for k from 1 to 16 do
h:=float(ZIn1t[k]/Zant[k]*v):u2u0abs[k]:=abs(h):
end_for:u2u0abs;
```

| | |
|---|---|
| 1 | = 0.6788451901146088 |
| 2 | = 1.193213597332732 |
| 3 | = 2.984189019770987 |
| 4 | = 1.510536279440581 |
| 5 | = 1.047969462961837 |
| 6 | = 0.6117057120223418 |
| 7 | = 5.002171931630623 |
| 8 | = 0.2017001305938018 |
| 9 | = 1.133614653401262 |
| 10 | = 0.921016459594517 |
| 11 | = 1.978261967086022 |
| 12 | = 0.8898024824704456 |
| 13 | = 0.9792070679731414 |
| 14 | = 1.620936417777631 |
| 15 | = 2.64906473282341 |
| 16 | = 0.937745819734717 |

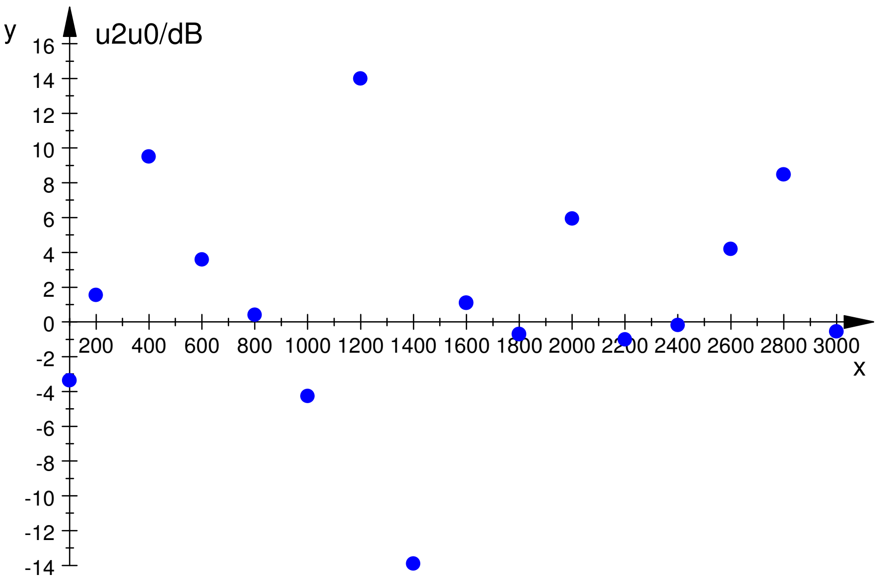
20*log(abs(U2/U0))/dB

```
for k from 1 to 16 do
h:=float(ZIn1t[k]/Zant[k]*v):u2u0abslog[k]:=20*log(10,abs(h)):
end_for:u2u0abslog;
```

| | |
|---|---|
| 1 | = −3.364585095968787 |
| 2 | = 1.534363874908905 |
| 3 | = 9.496526561291715 |
| 4 | = 3.582623208824704 |
| 5 | = 0.4069725563818417 |
| 6 | = −4.269149282043254 |
| 7 | = 13.98317229916993 |
| 8 | = −13.90587641193218 |
| 9 | = 1.089309021608445 |
| 10 | = −0.7146521681108271 |
| 11 | = 5.925676031640162 |
| 12 | = −1.014127738859687 |
| 13 | = −0.1825092084912097 |
| 14 | = 4.195319594318953 |
| 15 | = 8.461851417847338 |
| 16 | = −0.5582972632502957 |

20*log(abs(U2/U0))/dB

```
plot(plot::PointList2d([[op(f,k),op(op(u2u0abslog,k),2)] $
k=1..16],PointSize=2,Color=RGB::Blue,TitlePosition=[400,16],Title="u
2u0/dB",TicksNumber=High)):
```




durch Variation der Transformationsleitungslänge optimierte Summe

```
• h:=0:for k from 1 to 16 do
  h:=h+u2u0abslog[k]:
  end_for:h;
```

24.66661739733575

•