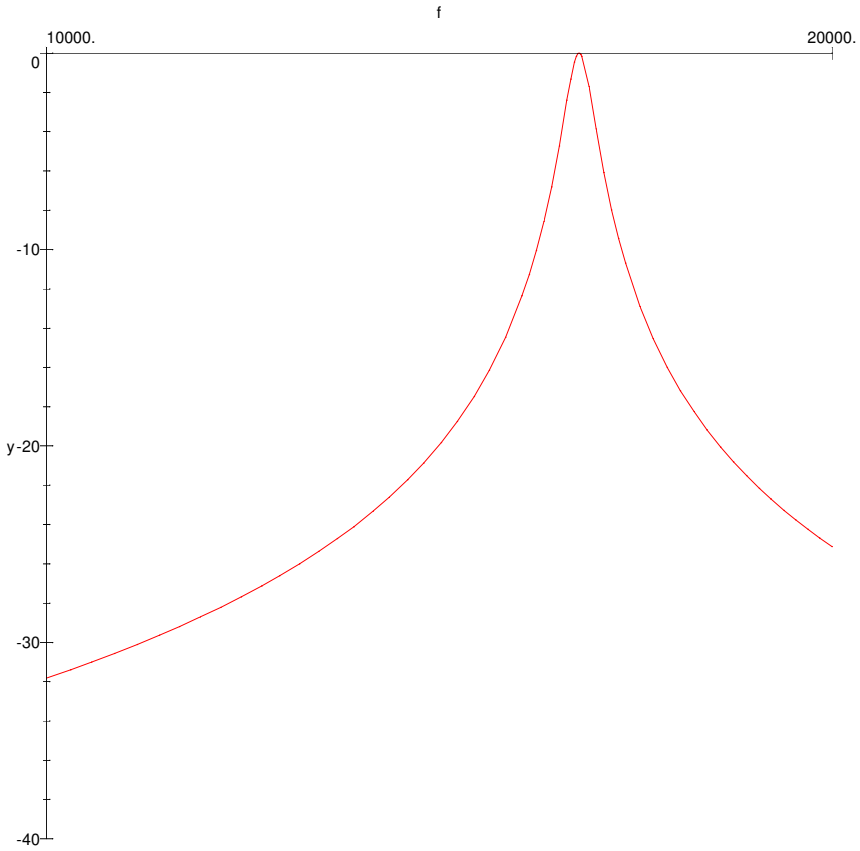
```
> restart;
> F:=H*omega[0]/Q*p/(p^2+omega[0]/Q*p+omega[0]^2);
```

$$F := \frac{H\,\omega_0\,p}{Q\left(p^2+\frac{\omega_0\,p}{Q}+\omega_0{}^2\right)}$$

```
> Fc:=subs({H=1,omega[0]=2*Pi*16000,Q=40},F);
```

$$Fc := 800\,\frac{\pi\,p}{p^2+800\,\pi\,p+1024000000\,\pi^2}$$

```
> readlib(log10):
  FF:=20*log10(evalc(abs(subs(p=I*2*Pi*f,Fc)))):
> with(plots):
  semilogplot(FF,f=10000..20000,y=-40..0);
```



jednodussi bude ziskat koeficienty nenormovane pren. funkce

```
> bi:=coeff(numer(Fc),p);
  di:=coeff(denom(Fc),p);
  ei:=coeff(denom(Fc),p,0);
```

$$bi := 800\,\pi$$

$$di := 800\,\pi$$

$$ei := 1024000000\,\pi^2$$

```
> ft:=128000;
  b:=bi/(2*ft);
  d:=di/(2*ft);
  e:=ei/(2*ft)^2;
```

$$ft := 128000$$

$$b := \frac{1}{320}\pi$$

$$d := \frac{1}{320}\pi$$

$$e := \frac{1}{64}\pi^2$$

```
> Hl:=lambda->b*lambda/(lambda^2+d*lambda+e);
```

$$Hl := \lambda \to \frac{b\,\lambda}{\lambda^2 + d\,\lambda + e}$$

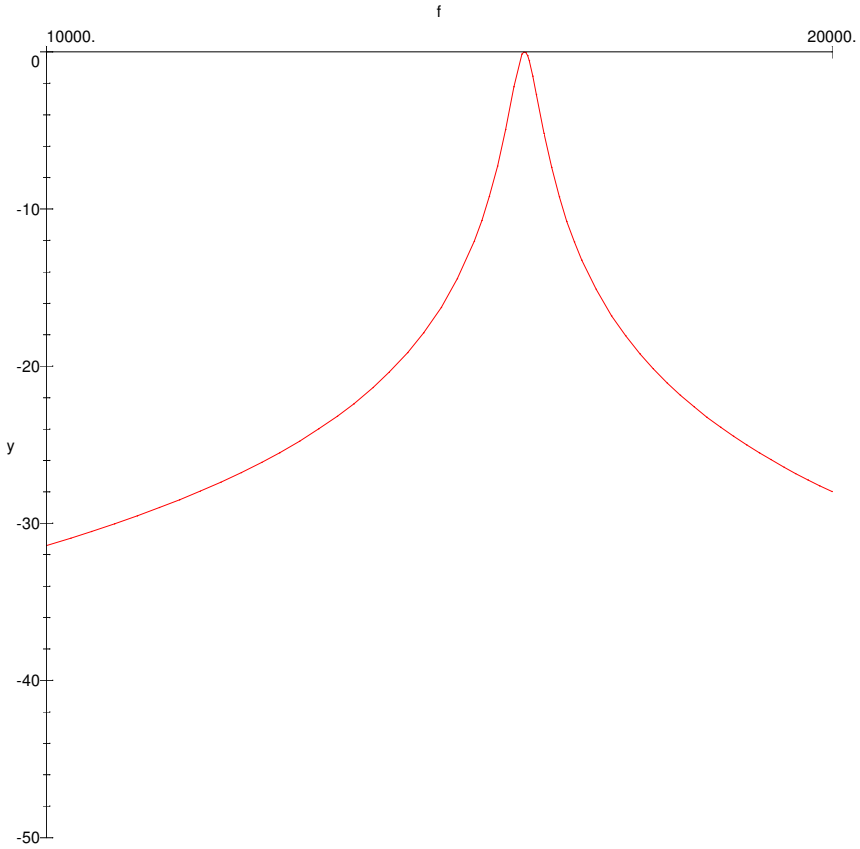
```
> Fz:=collect(simplify(Hl((z-1)/(z+1))),z);
```

$$Fz := \frac{\pi\,(z-1)\,(z+1)}{(320+5\,\pi^2+\pi)\,z^2 + (-640+10\,\pi^2)\,z - \pi + 320 + 5\,\pi^2}$$

```
> Fzp:=subs(z=exp(p/ft),Fz);
```

$$Fzp := \frac{\pi\,(e^{(1/128000\,p)}-1)\,(e^{(1/128000\,p)}+1)}{(320+5\,\pi^2+\pi)\,(e^{(1/128000\,p)})^2 + (-640+10\,\pi^2)\,e^{(1/128000\,p)} - \pi + 320 + 5\,\pi^2}$$

```
> FFzp:=20*log10(evalc(abs(subs(p=I*2*Pi*f,Fzp)))):
> semilogplot(FFzp,f=10000..20000,y=-50..0);
```



tady je videt vliv bilin. aproximace

```
> evalf(subs(f=16000,FFzp));
  evalf(solve(FFzp,f));
```

-12.83865236

$$-15246.14436,\ 15246.14436$$

predzkresleni

```
> omega1[0]:=2/T*tan(omega[0]*T/2);
> omega2[0]:=evalf(subs({omega[0]=2*Pi*16000,T=1/ft},omega1[0]));
> `omega2[0]/(2*Pi)`=evalf(omega2[0]/(2*Pi));
> Fc:=subs({H=1,omega[0]=omega2[0],Q=40},F);
```

$$\omega 1_0 := 2\,\frac{\tan\left(\frac{1}{2}\,\omega_0\,T\right)}{T}$$

$$\omega 2_0 := 106038.6720$$

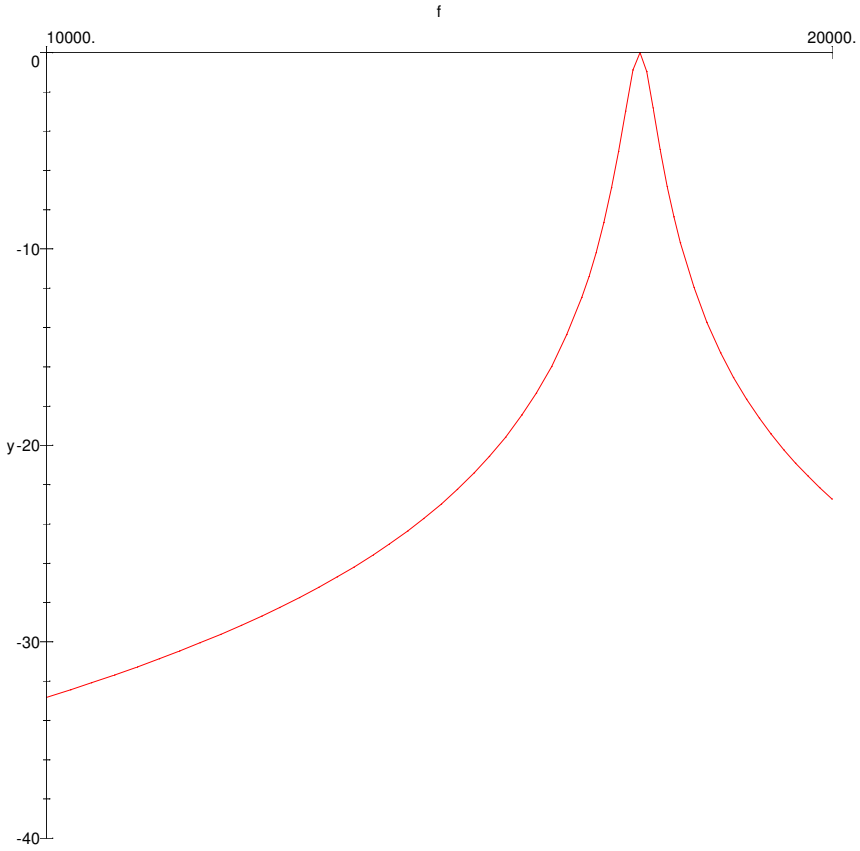
$$omega2[0]/(2*Pi) = 16876.57880$$

$$Fc := 2650.966800\,\frac{p}{p^2 + 2650.966800\,p + .1124419996\ 10^{11}}$$

```
> FF:=20*log10(evalc(abs(subs(p=I*2*Pi*f,Fc)))):
  evalf(subs(f=16000,FF));
```

$$-12.83865233$$

```
> semilogplot(FF,f=10000..20000,y=-40..0);
```



jednodussi bude ziskat koeficienty nenormovane pren. funkce

```
> bi:=coeff(numer(Fc),p);
  di:=coeff(denom(Fc),p);
  ei:=coeff(denom(Fc),p,0);
```

$$bi := 2650.966800$$

$$di := 2650.966800$$

$$ei := .1124419996\ 10^{11}$$

```
> ft:=128000;
  b:=bi/(2*ft);
  d:=di/(2*ft);
  e:=ei/(2*ft)^2;
```

$$ft := 128000$$

$$b := .01035533907$$

$$d := .01035533907$$

$$e := .1715728754$$

```
> Hl:=lambda->b*lambda/(lambda^2+d*lambda+e);
```

$$Hl := \lambda \rightarrow \frac{b\,\lambda}{\lambda^2 + d\,\lambda + e}$$

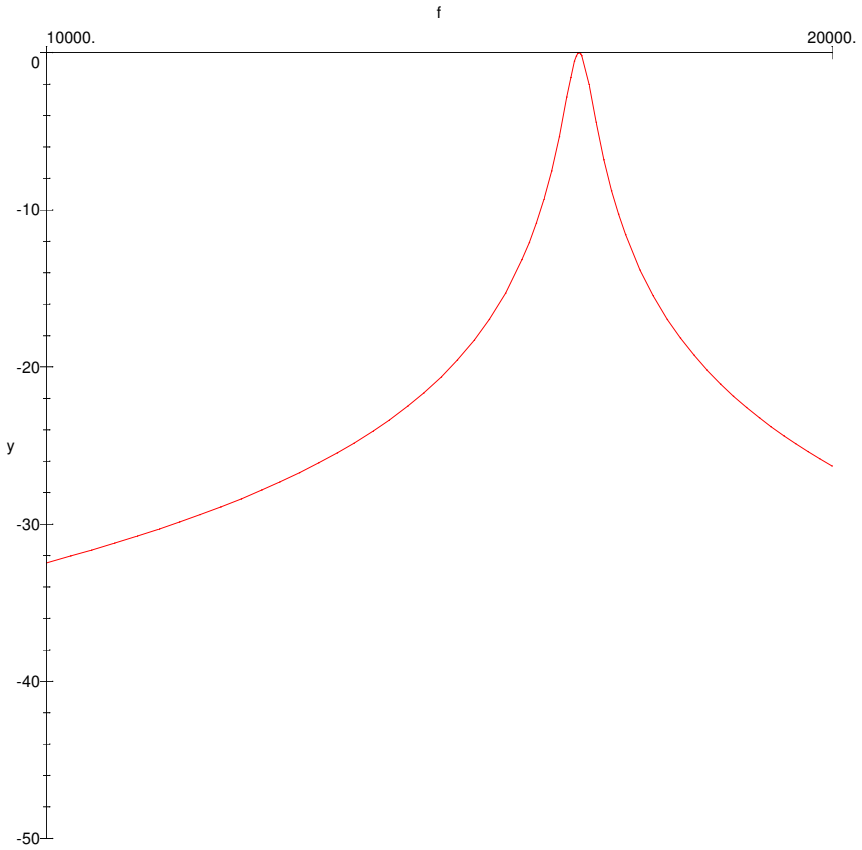
```
> Fz:=collect(simplify(Hl((z-1)/(z+1))),z);
```

$$Fz := .1035533907\ 10^{10}\ \frac{(z - 1.)\,(z + 1.)}{.1181928214\ 10^{12}\ z^2 - .1656854249\ 10^{12}\ z + .1161217536\ 10^{12}}$$

```
> Fzp:=subs(z=exp(p/ft),Fz);
```

$$Fzp := .1035533907\ 10^{10}\ \frac{(\mathbf{e}^{(1\ /\ 128000\ p)} - 1.)\,(\mathbf{e}^{(1\ /\ 128000\ p)} + 1.)}{.1181928214\ 10^{12}\ (\mathbf{e}^{(1\ /\ 128000\ p)})^2 - .1656854249\ 10^{12}\ \mathbf{e}^{(1\ /\ 128000\ p)} + .1161217536\ 10^{12}}$$

```
> FFzp:=20*log10(evalc(abs(subs(p=I*2*Pi*f,Fzp)))):
> semilogplot(FFzp,f=10000..20000,y=-50..0);
```



tady je videt vliv bilin. aproximace

```
> evalf(subs(f=16000,FFzp));
```

$$.6080122726\ 10^{-7}$$

```
> with(scsyrup);
```

[*TransferN*, *TransferS*, *_cofactor*, *_convert*, *_creatematrix*, *_createvector*, *_getlinefile*, *_getlinefileinit*, *_getlinetext*, *_getlinetextinit*, *_insertcap*, *_insertcsource*, *_makex*, *_parse*, *_renum*, *_sort*, *_switch*, *_transfer*, *_twoport*, *_twoportYpar*, *_twoportZpar*]

```
> Obvod:=TEXT(`Nazev`,
  `C1 5 6 A`,
  `C2 7 9 B`,
  `C3 4 8 C`,
  `C4 2 3 D`,
  `C5 2 9 E`,
  `C6 1 7 K`,
  `C7 1 2 L`,
  `S1 4 0 2`,
  `S2 4 2 1`,
  `S3 3 5 2`,
  `S4 5 0 1`,
  `S5 6 0 2`,
  `S6 6 7 1`,
  `S7 8 0 2`,
  `S8 8 9 1`,
  `A1 0 2 3 0`,
  `A2 0 7 9 0`,
  `C10 11 0 X`,
  `S10 10 11 1`,
  `A3 11 1 1 0`,
  `.end`);
```

$$Obvod := \mathrm{TEXT}(Nazev, C1\ 5\ 6\ A, C2\ 7\ 9\ B, C3\ 4\ 8\ C, C4\ 2\ 3\ D, C5\ 2\ 9\ E, C6\ 1\ 7\ K, C7\ 1\ 2\ L, S1\ 4\ 0\ 2, S2\ 4\ 2\ 1, S3\ 3\ 5\ 2, S4\ 5\ 0\ 1, S5\ 6\ 0\ 2, S6\ 6\ 7\ 1, S7\ 8\ 0\ 2, S8\ 8\ 9\ 1, A1\ 0\ 2\ 3\ 0, A2\ 0\ 7\ 9\ 0, C10\ 11\ 0\ X, S10\ 10\ 11\ 1, A3\ 11\ 1\ 1\ 0, .end)$$

```
> Pr:=collect(TransferN(Obvod,10,9,EE,VV,VV),z);
```

$$Pr := -\frac{(z-1)(K\,D\,z - K\,D + L\,A)}{B\,D\,z^2 + (A\,C + A\,E - 2\,D\,B)\,z - A\,E + D\,B}$$

```
> P:=subs({D=1,B=1},Pr);
```

$$P := -\frac{(z-1)(K\,z - K + L\,A)}{z^2 + (A\,C + A\,E - 2)\,z - A\,E + 1}$$

```
> collect(expand(-numer(P)),z);
```

$$K\,z^2 + (-2\,K + L\,A)\,z - L\,A + K$$

```
> rovnice_num:=seq(coeff(-numer(Pr),z,l)/(coeff(denom(Pr),z,2))=coeff(numer(Fz),z,l)/(coeff
  (denom(Fz),z,2)),l=0..2);
```

$$rovnice_num := \frac{K\,D - L\,A}{D\,B} = -.008761394260,\ \frac{-2\,K\,D + L\,A}{D\,B} = 0,\ \frac{K}{B} = .008761394260$$

```
> rovnice_den:=seq(coeff(denom(Pr),z,l)/(coeff(denom(Pr),z,2))=coeff(denom(Fz),z,l)/(coeff(
  denom(Fz),z,2)),l=0..1);
```

$$rovnice_den := \frac{-A\,E + D\,B}{D\,B} = .9824772116,\ \frac{A\,C + A\,E - 2\,D\,B}{D\,B} = -1.401823080$$

```
> sol:=solve({rovnice_num,rovnice_den,B=1,D=1,A=1});
```

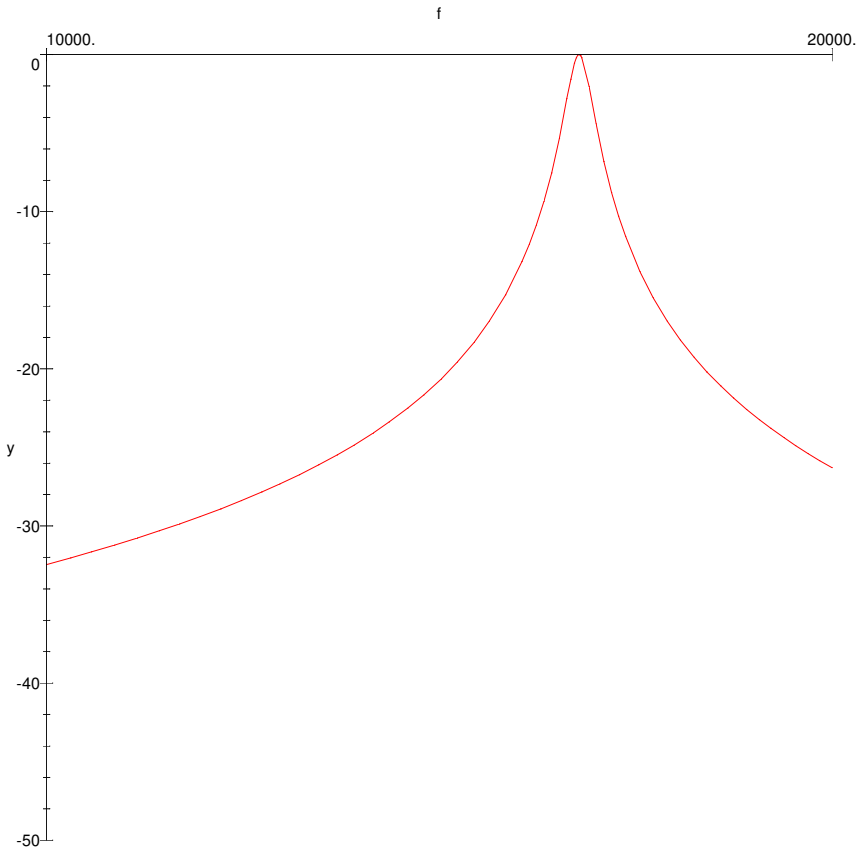
$$sol := \{A = 1.,\ D = 1.,\ B = 1.,\ E = .01752278840,\ L = .01752278852,\ K = .008761394260,\ C = .5806541316\}$$

```
> Pr2:=subs(sol,Pr);
```

$$Pr2 := -\frac{(z-1)(.008761394260\,z + .008761394260)}{1.\,z^2 - 1.401823080\,z + .9824772116}$$

```
> Prp:=subs(z=exp(p/ft),Pr2):
> Prp_mod:=20*log10(evalc(abs(subs(p=I*2*Pi*f,Prp)))):
> semilogplot(Prp_mod,f=10000..20000,y=-50..0);
```

```
> evalf(subs(f=16000,Prp_mod));
```



$$.5211533768\ 10^{-7}$$

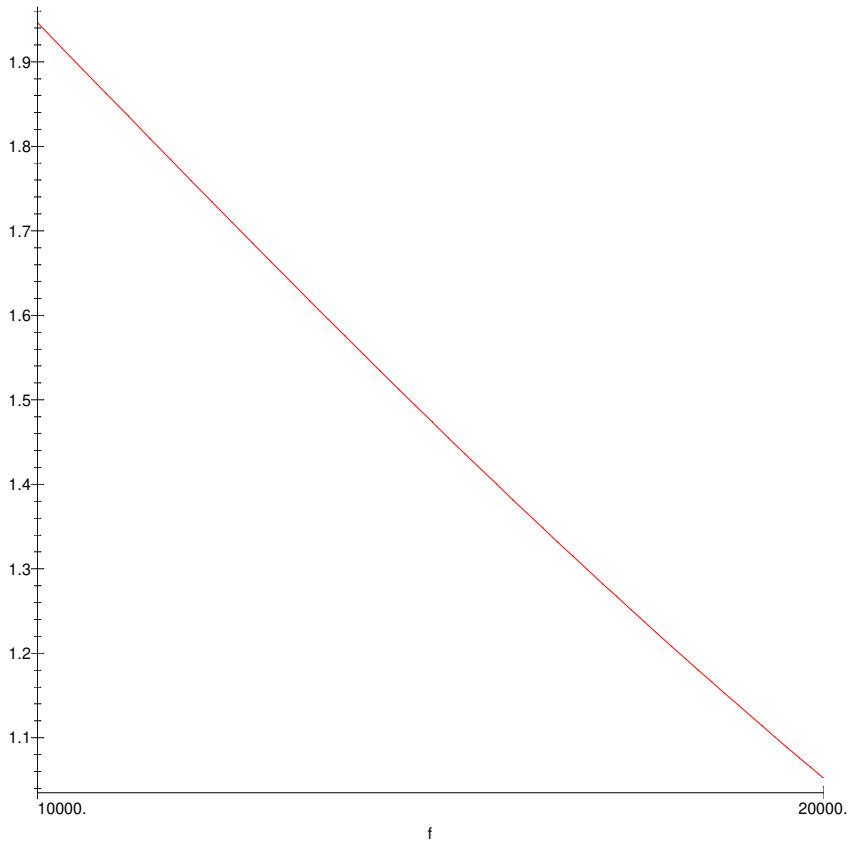
```
> PP:=collect(TransferN(Obvod,10,9,EE,VV,VV)/TransferN(Obvod,10,3,EE,VV,VV),z);
```

$$PP := \frac{(z-1)(K\,D\,z - K\,D + L\,A)}{(L\,B - K\,C - K\,E)\,z^2 + (2\,K\,E + K\,C - 2\,L\,B)\,z + L\,B - K\,E}$$

```
> PP2:=subs(sol,PP);
```

$$PP2 := \frac{(z-1)(.008761394260\,z + .008761394260)}{.01228192468\,z^2 - .02965118915\,z + .01736926446}$$

```
> PPp:=subs(z=exp(p/ft),PP2):
> PPp_mod:=evalc(abs(subs(p=I*2*Pi*f,PPp))):
> semilogplot(PPp_mod,f=10000..20000);
> evalf(subs(f=16000,PPp_mod));
```



1.318111457

Dynamika "docela" (u9/u3=1.3 priblizne) vysla. Pro pomer 1 ve stredu prop. pasma by chtelo volit jine predpoklady (asi jine D). Ted by se vsechny velikosti kondenzatoru vynasobily nejakym cislem (normovacim) napr $10^{(-9)}$ (B=1nF, atd.) a je to hotove. Tim se prenos nezmeni, ale upravim si velikosti kond. na pouzitelne hodnoty.

```
> #alias(I=I);
  #alias(j=sqrt(-1));
  #sqrt(-1);
```

$$j$$

$$j$$

```
> Obvod:=TEXT(`Nazev`,
  `C1 7 8 A`,
  `C2 9 10 B`,
  `C3 4 11 C`,
  `C4 5 6 D`,
  `C5 5 10 E`,
  `C6 8 11 F`,
  `C7 2 4 G`,
  `C8 3 4 H`,
  `C9 2 8 I`,
  `C10 3 8 J`,
  `S1 1 2 1`,
  `S2 2 0 2`,
  `S3 1 3 2`,
  `S4 3 0 1`,
  `S5 4 0 2`,
```

```
    `S6 4 5 1`,
    `S7 6 7 2`,
    `S8 7 0 1`,
    `S9 8 0 2`,
    `S10 8 9 1`,
    `S11 11 0 2`,
    `S12 11 10 1`,
    `A1 0 5 6 0`,
    `A2 0 9 10 0`,
    `C11 13 0 P`,
    `S13 12 13 1`,
    `A3 13 1 1 0`,
    `.end`);
```

$$Obvod := \mathrm{TEXT}(Nazev, C1\ 7\ 8\ A, C2\ 9\ 10\ B, C3\ 4\ 11\ C, C4\ 5\ 6\ D, C5\ 5\ 10\ E, C6\ 8\ 11\ F, C7\ 2\ 4\ G, C8\ 3\ 4\ H, C9\ 2\ 8\ i, C10\ 3\ 8\ J, S1\ 1\ 2\ 1, S2\ 2\ 0\ 2, S3\ 1\ 3\ 2, S4\ 3\ 0\ 1, S5\ 4\ 0\ 2, S6\ 4\ 5\ 1, S7\ 6\ 7\ 2, S8\ 7\ 0\ 1, S9\ 8\ 0\ 2, S10\ 8\ 9\ 1, S11\ 11\ 0\ 2, S12\ 11\ 10\ 1, A1\ 0\ 5\ 6\ 0, A2\ 0\ 9\ 10\ 0, C11\ 13\ 0\ P, S13\ 12\ 13\ 1, A3\ 13\ 1\ 1\ 0, .end)$$

```
> TEE:=collect(TransferS(Obvod,12,10,EE,VV,VV),z);
```

$$TEE := -\frac{C9\,C4\,z^2 + (-C9\,C4 - C10\,C4 + C7\,C1)\,z - C8\,C1 + C10\,C4}{(C4\,C2 + C4\,C6)\,z^2 + (C1\,C3 - C4\,C6 - 2\,C4\,C2 + C1\,C5)\,z - C1\,C5 + C4\,C2}$$

Predelat

```
> rovnice_num:=seq(coeff(numer(TEE),z,l)=coeff(numer(Fz),z,l)/0.1*10^(10),l=0..2);
```

$$rovnice_num := C8\,C1 - C10\,C4 = -.1035533907\ 10^{21}, -C7\,C1 + C9\,C4 + C10\,C4 = 0, -C9\,C4 = .1035533907\ 10^{21}$$

```
> rovnice_den:=seq(coeff(denom(TEE),z,l)=coeff(denom(Fz),z,l)/0.1*10^(10),l=0..2);
```

$$rovnice_den := -C1\,C5 + C4\,C2 = .1161217536\ 10^{23}, C1\,C3 - C4\,C6 - 2\,C4\,C2 + C1\,C5 = -.1656854249\ 10^{23}, C4\,C2 + C4\,C6 = .1181928214\ 10^{23}$$

```
> solve({rovnice_num,rovnice_den,C10=0,C2=1,C4=1,C1=2});
```

$$\{C2 = 1., C4 = 1., C1 = 2., C10 = 0, C8 = -.5177669535\ 10^{20}, C9 = -.1035533907\ 10^{21}, C7 = -.5177669535\ 10^{20}, C3 = .3431457505\ 10^{22}, C5 = -.5806087680\ 10^{22}, C6 = .1181928214\ 10^{23}\}$$

```
>
```