```
NL = 5; (* количество полос разложения *)
Array[KN, NL]; (* массив длин КИХ фильтров нечетной длины *)
KnAll = 5; (* зададим все длины КИХ фильтров одинаковыми *)
For[i = 1, i <= NL, i++, KN[i] = KnAll];
Array[K, NL];
(* количество положительных коэффициентов КИХ фильтров *)
For[i = 1, i <= NL, i++, K[i] = (KN[i] - 1) / 2];
KMax = K[1];
For[i = 1, i < NL, i++, KMax = Max[KMax, K[i + 1]]];
(* h[i] - массивы коэффициентов прямых фильтров,
начинаются с нулевого индекса *)
For[i = 1, i <= NL, i++, Array[h[i], K[i] + 1, 0]];
(* прореженные характеристики прямых фильтров *)
(* j - индекс прореженной части *)
(* k - индекс фильтра *)
signFunk[i_, k_] := If[(i > 0) && (Mod[k, 2] == 0), -1, 1];
Do[Do[H[k][j] =
    Sum[signFunk[i, k] * h[k][Abs[i]] * x^(i + KMax), {i, -K[k] + j - 1, K[k], NL}],
   {j, 1, NL}], {k, 1, NL}];

Array[KDet, NL, 0]; (* количество коэффициентов в определителях *)
M0 = {{H[1][1], H[2][1], H[3][1], H[4][1], H[5][1]},
   {H[1][2], H[2][2], H[3][2], H[4][2], H[5][2]},
   {H[1][3], H[2][3], H[3][3], H[4][3], H[5][3]},
   {H[1][4], H[2][4], H[3][4], H[4][4], H[5][4]},
   {H[1][5], H[2][5], H[3][5], H[4][5], H[5][5]}};
DetM0 = Det[M0];
fM0 = CoefficientList[DetM0, x];
KDet[0] = Length[fM0];
M1 =
  {{1, H[2][1], H[3][1], H[4][1], H[5][1]}, {1, H[2][2], H[3][2], H[4][2], H[5][2]},
   {1, H[2][3], H[3][3], H[4][3], H[5][3]}, {1, H[2][4], H[3][4], H[4][4], H[5][4]},
   {1, H[2][5], H[3][5], H[4][5], H[5][5]}};
DetM1 = Det[M1];
fM1 = CoefficientList[DetM1, x];
KDet[1] = Length[fM1];
M2 =
  {{H[1][1], 1, H[3][1], H[4][1], H[5][1]}, {H[1][2], 1, H[3][2], H[4][2], H[5][2]},
   {H[1][3], 1, H[3][3], H[4][3], H[5][3]}, {H[1][4], 1, H[3][4], H[4][4], H[5][4]},
   {H[1][5], 1, H[3][5], H[4][5], H[5][5]}};
DetM2 = Det[M2];
fM2 = CoefficientList[DetM2, x];
KDet[2] = Length[fM2];
M3 =
  {{H[1][1], H[2][1], 1, H[4][1], H[5][1]}, {H[1][2], H[2][2], 1, H[4][2], H[5][2]},
```

```
    {H[1][3], H[2][3], 1, H[4][3], H[5][3]}, {H[1][4], H[2][4], 1, H[4][4], H[5][4]},
    {H[1][5], H[2][5], 1, H[4][5], H[5][5]}};
DetM3 = Det[M3];
fM3 = CoefficientList[DetM3, x];
KDet[3] = Length[fM3];
M4 =
  {{H[1][1], H[2][1], H[3][1], 1, H[5][1]}, {H[1][2], H[2][2], H[3][2], 1, H[5][2]},
   {H[1][3], H[2][3], H[3][3], 1, H[5][3]}, {H[1][4], H[2][4], H[3][4], 1, H[5][4]},
   {H[1][5], H[2][5], H[3][5], 1, H[5][5]}};
DetM4 = Det[M4];
fM4 = CoefficientList[DetM4, x];
KDet[4] = Length[fM4];
M5 =
  {{H[1][1], H[2][1], H[3][1], H[4][1], 1}, {H[1][2], H[2][2], H[3][2], H[4][2], 1},
   {H[1][3], H[2][3], H[3][3], H[4][3], 1}, {H[1][4], H[2][4], H[3][4], H[4][4], 1},
   {H[1][5], H[2][5], H[3][5], H[4][5], 1}};
DetM5 = Det[M5];
fM5 = CoefficientList[DetM5, x];
KDet[5] = Length[fM5];

Array[K1, NL]; (* количество положительных
 коэффициентов обратных КИХ фильтров *)
For[i = 1, i <= NL, i++, K1[i] = (KDet[i] - NL - 2) / 2];
(* kh[i] - массивы коэффициентов обратных фильтров,
начинаются с нулевого индекса *)
For[i = 1, i <= NL, i++, Array[kh[i], K1[i] + 1, 0]];
For[k = 1, k ≤ NL, k++, For[i = K1[k] + 1; j = KDet[k], i > 0, i--; j--,
   kh[k][i - 1] =
    Switch[k, 1, fM1[[j]], 2, fM2[[j]], 3, fM3[[j]], 4, fM4[[j]], 5, fM5[[j]]]]];

Print["K  : (", K[1], ", ", K[2], ", ", K[3], ", ", K[4], ", ", K[5], ")  (",
  2 * K[1] + 1, ", ", 2 * K[2] + 1, ", ",
  2 * K[3] + 1, ", ", 2 * K[4] + 1, ", ", 2 * K[5] + 1, ")"];
Print["K1 : (", K1[1], ", ", K1[2], ", ", K1[3], ", ", K1[4], ", ", K1[5], ")  (",
  2 * K1[1] + 1, ", ", 2 * K1[2] + 1, ", ",
  2 * K1[3] + 1, ", ", 2 * K1[4] + 1, ", ", 2 * K1[5] + 1, ")"];
Print["Длина детерминанта - ", KDet[0]];
Print["Середина детерминанта, равная 1, - ", (KDet[0] - 2 * NL - 1) / 2];
Print["Количество уравнений - ", K[1] + K[2] + K[3] + K[4] + K[5] + NL];
```

```
K  : (2, 2, 2, 2, 2)  (5, 5, 5, 5, 5)

K1 : (2, 2, 2, 2, 2)  (5, 5, 5, 5, 5)

Длина детерминанта - 11

Середина детерминанта, равная 1, - 0

Количество уравнений - 15
```

```
s = 1;
NSlv = NSolve[{
    (*fM0[[KDet[0]]]==0,*)
    (*fM0[[KDet[0]-NL]]==0,*)
    (*fM0[[KDet[0]-2*NL]]==1,*)

    Sum[h[1][Abs[i]], {i, -K[1], K[1]}] == s,
    Sum[h[1][Abs[i]] * (-1)^i, {i, -K[1], K[1]}] == 0,
    (*Sum[i^2*h[1][i],{i,1,K[1]}]==0,*)
    Sum[i^2 * h[1][i] * (-1)^(i - 1), {i, 1, K[1]}] == 0,
    (*Sum[i^4*h[1][i],{i,1,K[1]}]==0,*)
    (*Sum[i^4*kh[1][i]*(-1)^(i-1),{i,1,K1[1]}]==3.5,*)

    Sum[h[2][i] * Sin[Pi * i * 0.35], {i, 1, K[2]}] == s/2,
    Sum[i * h[2][i] * Cos[Pi * i * 0.35], {i, 1, K[2]}] == 0,
    (*Sum[i*h[2][i],{i,1,K[2]}]==0,*)
    (*Sum[i*h[2][i]*(-1)^(i-1),{i,1,K[2]}]==0,*)
    (*Sum[i^3*h[2][i]*(-1)^(i-1),{i,1,K[2]}]==0,
    Sum[i^3*h[2][i],{i,1,K[2]}]==0,*)

    Sum[h[3][Abs[i]], {i, -K[3], K[3]}] == 0,
    Sum[h[3][Abs[i]] * (-1)^i, {i, -K[3], K[3]}] == 0,
    Sum[h[3][Abs[i]] * Cos[Pi * i * 0.5], {i, -K[3], K[3]}] == s,
    (*Sum[i*h[3][i]*Sin[Pi*i*0.5],{i,1,K[3]}]==0,*)
    (*Sum[i^2*h[3][i]*(-1)^(i-1),{i,1,K[3]}]==0,*)
    (*Sum[i^2*h[3][i],{i,1,K[3]}]==0,*)
    (*Sum[i*h[3][i],{i,1,K[3]}]==0,*)

    Sum[h[4][i] * Sin[Pi * i * 0.65], {i, 1, K[4]}] == s/2,
    Sum[i * h[4][i] * Cos[Pi * i * 0.65], {i, 1, K[4]}] == 0,
    (*Sum[i*h[4][i],{i,1,K[4]}]==0,*)
    (*Sum[i*h[4][i]*(-1)^(i-1),{i,1,K[4]}]==0,*)
    (*Sum[i^3*h[4][i],{i,1,K[4]}]==0,
    Sum[i^3*h[4][i]*(-1)^(i-1),{i,1,K[4]}]==0,*)

    Sum[h[5][Abs[i]], {i, -K[5], K[5]}] == 0,
    Sum[h[5][Abs[i]] * (-1)^i, {i, -K[5], K[5]}] == s,
    Sum[i^2 * h[5][i], {i, 1, K[5]}] == 0,
    (*Sum[i^2*h[5][i]*(-1)^(i-1),{i,1,K[5]}]==0,*)
    (*Sum[i^4*h[5][i],{i,1,K[5]}]==0,*)
    (*Sum[i^4*h[5][i]*(-1)^(i-1),{i,1,K[5]}]==0,*)

    h[2][0] == 0,
    h[4][0] == 0
```

```
   }];
Print["Количество решений - ", Length[NSlv]]
```

```
Количество решений - 1
```

```
Do[ph[j] =
   100 * (h[j][0] + 2 * Sum[h[j][i] * Switch[j, 1, Cos[Pi * i * x], 2, Sin[Pi * i * x], 3, Cos[
           Pi * i * x], 4, Sin[Pi * i * x], 5, Cos[Pi * i * x]], {i, 1, K[1]}]), {j, 1, NL}];
Do[pkh[j] = 100 * (kh[j][0] + 2 * Sum[kh[j][i] * Switch[j, 1, Cos[Pi * i * x], 2,
           Sin[Pi * i * x], 3, Cos[Pi * i * x], 4, Sin[Pi * i * x], 5, Cos[Pi * i * x]],
         {i, 1, K1[1]}]) / fM0[[KDet[0] - ((KDet[0] - 2 * NL - 1) / 2)]], {j, 1, NL}];
Do[pkhh[i] = ph[i] * pkh[i] / (500 * fM0[[KDet[0] - ((KDet[0] - 2 * NL - 1) / 2)]]),
  {i, 1, NL}];

Do[Print["Номер решения - ", kk];
 Print["Значение детерминанта  = ",
  fM0[[KDet[0] - ((KDet[0] - 2 * NL - 1) / 2)]] /. NSlv[[kk]]];
 Array[Sq, NL];
 Do[Sq[j] = Sqrt[Sum[(kh[j][Abs[i]] /. NSlv[[kk]]) ^ 2, {i, -K1[j], K1[j]}]],
  {j, 1, NL}];
 lfhf = Sum[(kh[1][Abs[i]] /. NSlv[[kk]]) * (kh[5][Abs[i]] /. NSlv[[kk]]),
    {i, -Min[K1[1], K1[5]], Min[K1[1], K1[5]]}] / (Sq[1] * Sq[5]);
 Print["Корреляция LF-HF   = ", lfhf];
 lfmf = Sum[(kh[1][Abs[i]] /. NSlv[[kk]]) * (kh[3][Abs[i]] /. NSlv[[kk]]),
    {i, -Min[K1[1], K1[3]], Min[K1[1], K1[3]]}] / (Sq[1] * Sq[3]);
 Print["Корреляция LF-MF   = ", lfmf];
 mfhf = Sum[(kh[5][Abs[i]] /. NSlv[[kk]]) * (kh[3][Abs[i]] /. NSlv[[kk]]),
    {i, -Min[K1[5], K1[3]], Min[K1[5], K1[3]]}] / (Sq[5] * Sq[3]);
 Print["Корреляция MF-HF   = ", mfhf];
 mflmfh = Sum[(kh[2][Abs[i]] /. NSlv[[kk]]) * (kh[4][Abs[i]] /. NSlv[[kk]]),
    {i, -Min[K1[2], K1[4]], Min[K1[2], K1[4]]}] / (Sq[2] * Sq[4]);
 Print["Корреляция MFl-MFh = ", mflmfh];
 (*Do[Print[ssh[j]=Sqrt[Sum[(h[j][Abs[i]]/.NSlv[[kk]])^2,{i,-K[j],K[j]}]]],
   {j,1,NL}];*)
 (*Print[((h[1][0]/.NSLv[[kk]])*(g[0]/.NSLv[[kk]])+
      2*(h[1]/.NSLv[[kk]])*(g[1]/.NSLv[[kk]]))/(ssh*ssg)];*)
 (*Do[Print[Sum[(h[j][i]/.NSlv[[kk]])^2,{i,2,K[j]}]/((h[j][0]/.NSlv[[kk]])^2+
       2*Sum[(h[j][i]/.NSlv[[kk]])^2,{i,2,K[j]}])],{j,1,NL}];*)
 Print[Plot[{ph[1] /. NSlv[[kk]], ph[2] /. NSlv[[kk]], ph[3] /. NSlv[[kk]],
    ph[4] /. NSlv[[kk]], ph[5] /. NSlv[[kk]]}, {x, 0, 1}, AxesLabel → {"x", "y"},
   LabelStyle → Directive[FontFamily → "Times", FontSize → 12],
   PlotStyle → {Thickness[0.01]}, ImageSize → Medium],
  Plot[{pkh[1] /. NSlv[[kk]], pkh[2] /. NSlv[[kk]], pkh[3] /. NSlv[[kk]],
    pkh[4] /. NSlv[[kk]], pkh[5] /. NSlv[[kk]]}, {x, 0, 1}, AxesLabel → {"x", "y"},
   LabelStyle → Directive[FontFamily → "Times", FontSize → 12],
```

```
    PlotStyle → {Thickness[0.01]}, ImageSize → Medium]], {kk, Length[NSlv]}]

(*kk=1;
Plot[{ph[1]/.NSlv[[kk]],ph[2]/.NSlv[[kk]],ph[3]/.NSlv[[kk]],
    ph[4]/.NSlv[[kk]],ph[5]/.NSlv[[kk]]},{x,0,1},AxesLabel→{"x","y"},
  LabelStyle→Directive[FontFamily→"Times",FontSize→12],
  PlotStyle→{Thickness[0.01]}]
 Plot[{pkh[1]/.NSlv[[kk]],pkh[2]/.NSlv[[kk]],pkh[3]/.NSlv[[kk]],
    pkh[4]/.NSlv[[kk]],pkh[5]/.NSlv[[kk]]},{x,0,1},AxesLabel→{"x","y"},
  LabelStyle→Directive[FontFamily→"Times",FontSize→12],
  PlotStyle→{Thickness[0.01]}]*)
(*Plot[{pkhh[1]/.NSlv[[kk]],pkhh[2]/.NSlv[[kk]],
  pkhh[3]/.NSlv[[kk]],pkhh[4]/.NSlv[[kk]],pkhh[5]/.NSlv[[kk]],
  (pkhh[1]+pkhh[2]+pkhh[3]+pkhh[4]+pkhh[5])/.NSlv[[kk]]},
 {x,0,1},AxesLabel→{"x","y"},
 LabelStyle→Directive[FontFamily→"Times",FontSize→12],
 PlotStyle→{Thickness[0.01]}]*)
```

Номер решения - 1

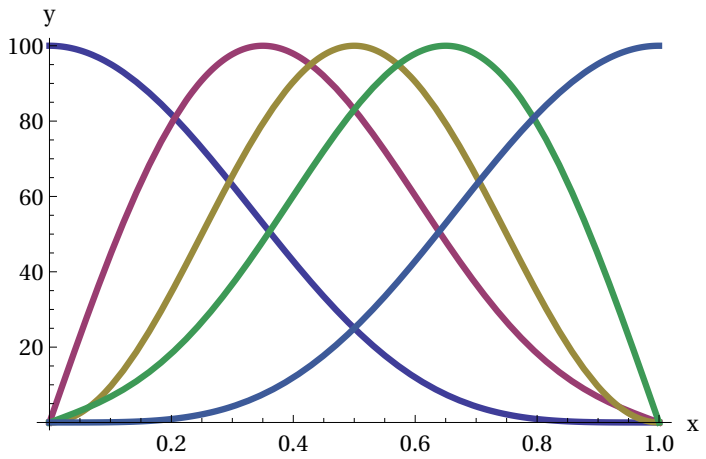
Значение детерминанта = 0.0333319

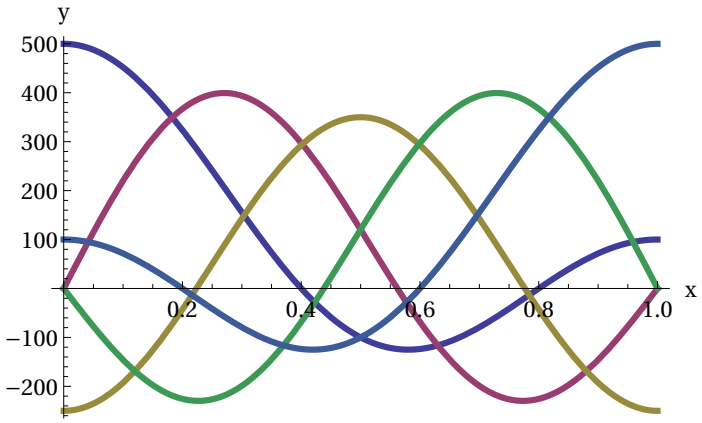
Корреляция LF-HF = 0.2

Корреляция LF-MF = -0.512989

Корреляция MF-HF = -0.512989

Корреляция MFl-MFh = -0.740431





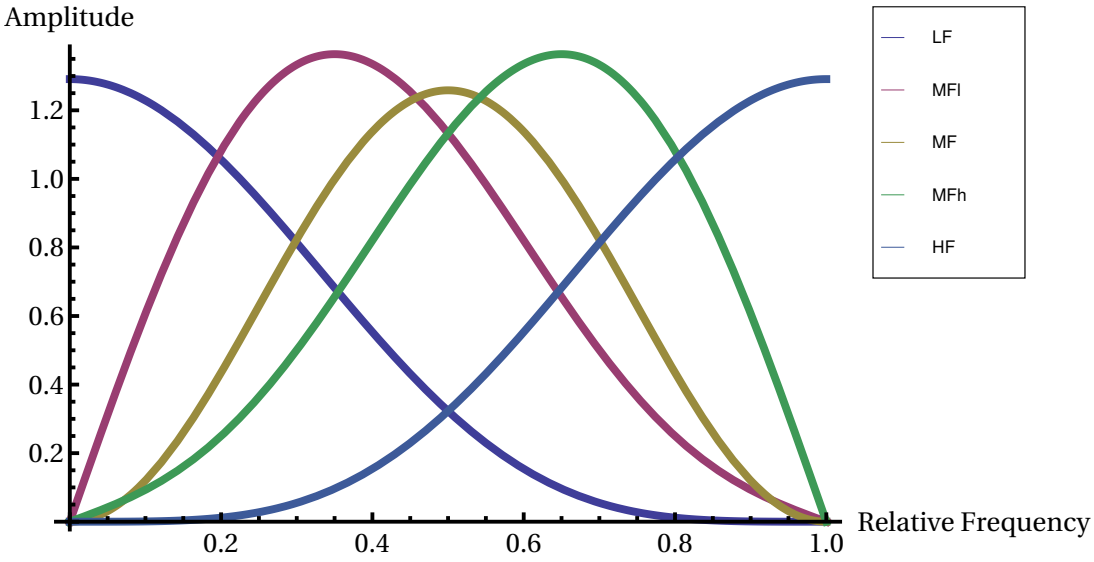

```
kk = 1;(* 0.05 - 20 28 33 *) (* 0.01 - 25 *) (* 0 - 12 13 *)
(* 0.03 - 24 27 28 *) (* 0.07 - 20 26 27 *) (* 0.1 - 20 29 30 31 34 *)
KMax2 = Max[K[1], K1[1]];
For[i = 1, i < NL, i++, KMax2 = Max[KMax2, K[i + 1], K1[i + 1]]];
min = 10^-12;

Do[
  Array[h2[j], 2 * KMax2 + 1, -KMax2];
  For[i = -KMax2, i ≤ KMax2, i++, h2[j][i] = 0.0];
  For[i = -K[j], i ≤ K[j], i++, h2[j][i] = h[j][Abs[i]] /. NSlv[[kk]]];
  Array[kh2[j], 2 * KMax2 + 1, -KMax2];
  For[i = -KMax2, i ≤ KMax2, i++, kh2[j][i] = 0.0];
  For[i = -K1[j], i ≤ K1[j], i++, kh2[j][i] =
    (kh[j][Abs[i]] / fM0[[KDet[0] - ((KDet[0] - 2 * NL - 1) / 2)]]) /. NSlv[[kk]]];
  shh[j] = Sqrt[Sum[h2[j][i]^2, {i, -K[j], K[j]}]];
  skh[j] = Sqrt[Sum[kh2[j][i]^2, {i, -K1[j], K1[j]}]],
  {j, 1, NL, 2}];
Do[
  Array[h2[j], 2 * KMax2 + 1, -KMax2];
```

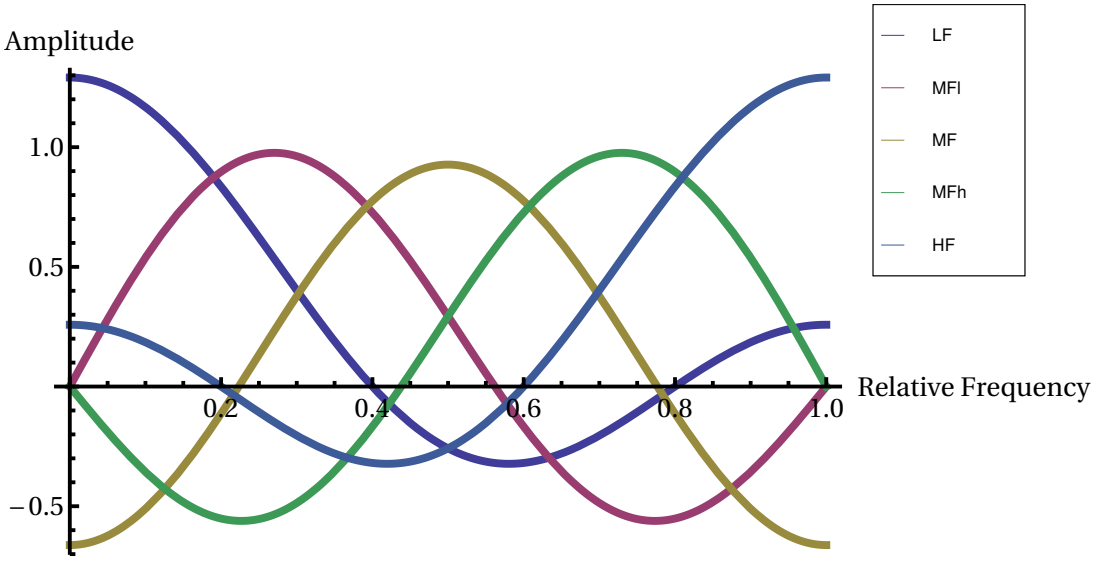
```
  For[i = -KMax2, i ≤ KMax2, i++, h2[j][i] = 0.0];
  For[i = -K[j], i ≤ K[j], i++, h2[j][i] = -Sign[i] * h[j][Abs[i]] /. NSlv[[kk]]];
  Array[kh2[j], 2 * KMax2 + 1, -KMax2];
  For[i = -KMax2, i ≤ KMax2, i++, kh2[j][i] = 0.0];
  For[i = -K1[j], i ≤ K1[j], i++,
   kh2[j][i] = (Sign[i] * kh[j][Abs[i]] / fM0[[KDet[0] - ((KDet[0] - 2 * NL - 1) / 2)]]) /.
     NSlv[[kk]]];
  shh[j] = Sqrt[Sum[h2[j][i]^2, {i, -K[j], K[j]}]];
  skh[j] = Sqrt[Sum[kh2[j][i]^2, {i, -K1[j], K1[j]}]],
  {j, 2, NL, 2}];

(* нормировка по обратным функциям *)
Do[
  For[i = -K[j], i ≤ K[j], i++, h2[j][i] = h2[j][i] * skh[j]];
  For[i = -K1[j], i ≤ K1[j], i++, kh2[j][i] = kh2[j][i] / skh[j]],
  {j, 1, NL}];

(* нормировка по прямым функциям *)
(*Do[
  For[i=-K[j],i≤K[j],i++,h2[j][i]=h2[j][i]/shh[j]];
  For[i=-K1[j],i≤K1[j],i++,kh2[j][i]=kh2[j][i]*shh[j]],
  {j,1,NL}];*)

(* ограничение *)
Do[
  For[i = -K[j], i ≤ K[j], i++, ss = h2[j][i];
   h2[j][i] = If[Abs[ss] < min, 0.0, ss]];
  For[i = -K1[j], i ≤ K1[j], i++, ss = kh2[j][i];
   kh2[j][i] = If[Abs[ss] < min, 0.0, ss]],
  {j, 1, NL}];

sep = "\t";
For[i = -KMax2, i ≤ KMax2, i++,
  Print[h2[1][i], sep, kh2[1][i], sep, h2[2][i], sep, kh2[2][i], sep, h2[3][i], sep,
   kh2[3][i], sep, h2[4][i], sep, kh2[4][i], sep, h2[5][i], sep, kh2[5][i]]];


ampl = 1.0 / Sqrt[3];
Do[
  ph2[j] =
   ampl * (h2[j][0] + 2 * Sum[h2[j][i] * Switch[j, 1, Cos[Pi * i * x], 2, -Sin[Pi * i * x], 3,
           Cos[Pi * i * x], 4, -Sin[Pi * i * x], 5, Cos[Pi * i * x]], {i, 1, KMax2}]);
  pkh2[j] = ampl * (kh2[j][0] + 2 * Sum[kh2[j][i] * Switch[j, 1,
           Cos[Pi * i * x], 2, Sin[Pi * i * x], 3, Cos[Pi * i * x], 4,
           Sin[Pi * i * x], 5, Cos[Pi * i * x]], {i, 1, KMax2}]);
```

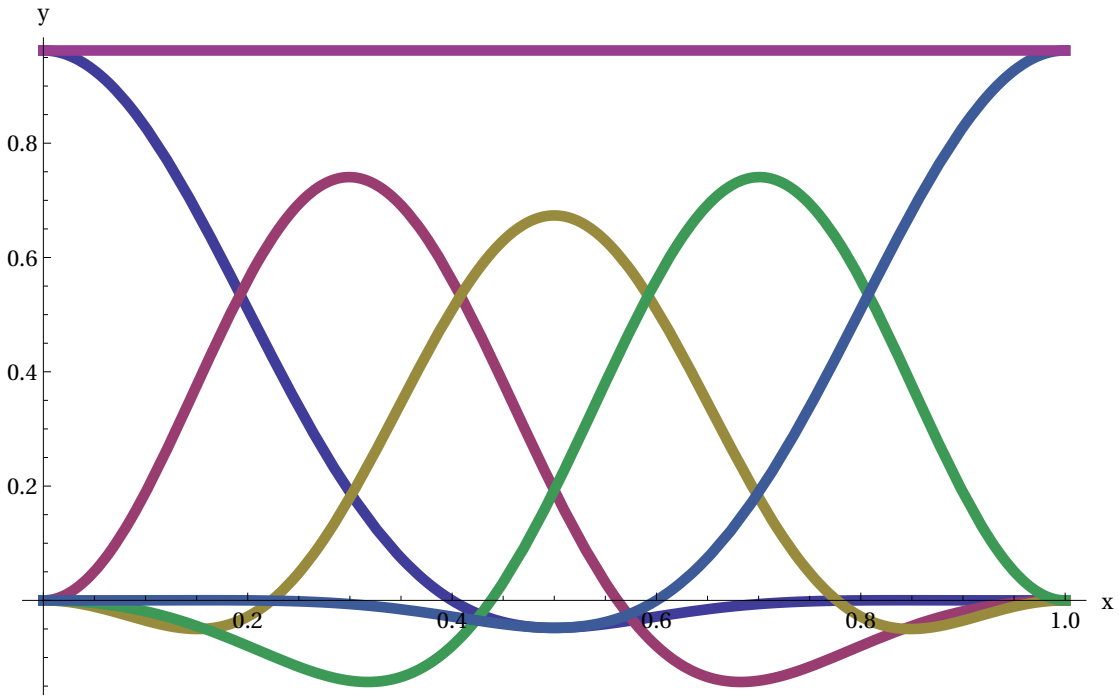
```
  pkhh2[j] = ph2[j] * pkh2[j] / (ampl * 3),
  {j, 1, NL}];

Needs["PlotLegends`"];

(*Print[h2[0]*g2[0]+2*h2[1]*g2[1]];
Print[kh2[0]*kg2[0]+2*kh2[1]*kg2[1]];*)
Plot[{ph2[1], ph2[2], ph2[3], ph2[4], ph2[5]},
 {x, 0, 1}, AxesLabel → {"Relative Frequency", "Amplitude"},
 PlotLegend → {"LF", "MFl", "MF", "MFh", "HF"},
 LabelStyle → Directive[FontFamily → "Times", FontSize → 14],
 PlotStyle → {Thickness[0.01]}, AxesStyle → Thick, ImageSize → Large,
 LegendPosition → {0.6, -0.1}, LegendSize → 0.5, LegendShadow → None]
(*plot2=Plot[{Abs[ph2[1]],Abs[ph2[2]],Abs[ph2[3]],Abs[ph2[4]],Abs[ph2[5]]},
   {x,0,1},AxesLabel→{"Relative Frequency","Amplitude"},
   PlotLegend→{"LF","MFl","MF","MFh","HF"},
   LabelStyle→Directive[FontFamily→"Times",FontSize→14],
   PlotStyle→{Thickness[0.01]},AxesStyle→Thick,ImageSize→Large,
   LegendPosition→{0.4,-0.3},LegendSize→0.5,LegendShadow→None]
  Export["d:\plot2.eps",plot2]*)
Plot[{pkh2[1], pkh2[2], pkh2[3], pkh2[4], pkh2[5]},
 {x, 0, 1}, AxesLabel → {"Relative Frequency", "Amplitude"},
 PlotLegend → {"LF", "MFl", "MF", "MFh", "HF"},
 LabelStyle → Directive[FontFamily → "Times", FontSize → 14],
 PlotStyle → {Thickness[0.01]}, AxesStyle → Thick, ImageSize → Large,
 LegendPosition → {0.6, -0.1}, LegendSize → 0.5, LegendShadow → None]
(*plot1=Plot[{Abs[pkh2[1]],Abs[pkh2[2]],Abs[pkh2[3]],Abs[pkh2[4]],Abs[pkh2[5]]},
   {x,0,1},AxesLabel→{"Relative Frequency","Amplitude"},
   PlotLegend→{"LF","MFl","MF","MFh","HF"},
   LabelStyle→Directive[FontFamily→"Times",FontSize→14],
   PlotStyle→{Thickness[0.01]},AxesStyle→Thick,ImageSize→Large,
   LegendPosition→{0.4,-0.3},LegendSize→0.5,LegendShadow→None]
  Export["d:\plot1.eps",plot1]*)
Plot[{pkhh2[1], pkhh2[2], pkhh2[3], pkhh2[4],
  pkhh2[5], (pkhh2[1] + pkhh2[2] + pkhh2[3] + pkhh2[4] + pkhh2[5])},
 {x, 0, 1}, AxesLabel → {"x", "y"},
 LabelStyle → Directive[FontFamily → "Times", FontSize → 12],
 PlotStyle → {Thickness[0.01]}]
```

```
0.139754    0.447214    0.379002    -0.659627    -0.544862
     -0.688247    -0.379002    0.659627    0.139754    0.447214

0.559017    0.447214    0.981394    -0.25474
 0.    0.    0.981394    -0.25474    -0.559017    -0.447214

0.838525    0.447214    0.    0.
 1.08972    0.229416    0.    0.    0.838525    0.447214
```

```
0.559017    0.447214    -0.981394    0.25474
 0.    0.    -0.981394    0.25474    -0.559017    -0.447214
0.139754    0.447214    -0.379002    0.659627    -0.544862
     -0.688247    0.379002    -0.659627    0.139754    0.447214
```






y
0.8
0.6
0.4
0.2
0.2
0.4
0.6
0.8
1.0
x