In[4652]:=
```
(*Directional Coupler Inital Parameters Coiuple Mode Theory *)
chi[vn_] := Sqrt[3.] / 2. Pi vn
db[z_] := Pi Exp[-kpa ( z)]
pltsph = ParametricPlot3D[{Cos[t] Cos[u], Sin[t] Cos[u], Sin[u]},
   {t, 0., 2 Pi}, {u, -Pi / 2, Pi / 2}, DisplayFunction → Identity];
kpa = 0;
zmin = 0;
zmax = 1.0;
d = .00000
si = {(1 - d) ^.5, 0, d^.5};
imres = 300;
xsize = 288;
ysize = 288;
```

Out[4658]=
```
0.
```

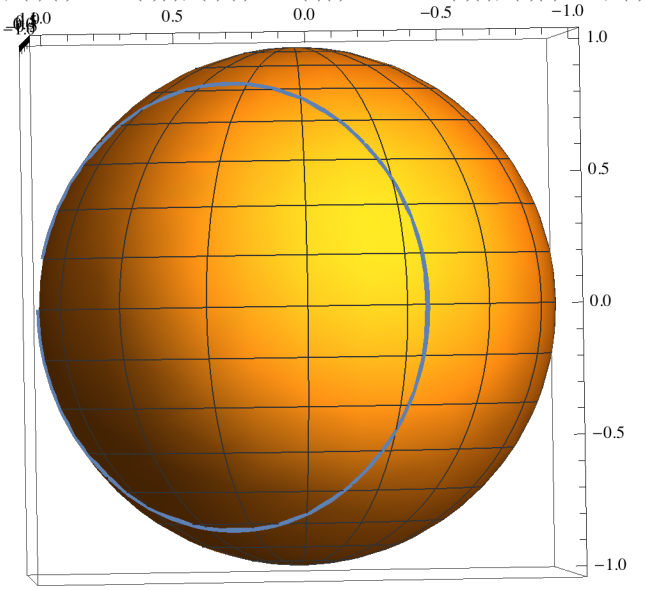
In[4663]:=
```
(*Set the viewpoint variable for 3D viewing*)
viewPoint =.
viewPoint = {1, 25, 0}
```

Out[4664]=
```
{1, 25, 0}
```

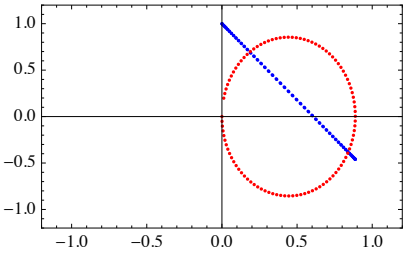
In[4665]:=
```
vn = 0.95;
eqns = {(s[1])'[z] == 2 chi[vn] s[3][z] ,
   (s[2])'[z] == -db[z] s[3][z], (s[3])'[z] == -2 chi[vn] s[1][z] + db[z] s[2][z],
   s[1][zmin] == si[[1]], s[2][zmin] == si[[2]], s[3][zmin] == si[[3]]};
soln = NDSolve[eqns, {s[1], s[2], s[3]}, {z, zmin, zmax}];
sv[z_] = {s[1][z], s[2][z], s[3][z]} /. soln[[1]];
plt123z = ParametricPlot3D[sv[z], {z, zmin, zmax},
   PlotRange → {{-1., 1.}, {-1., 1.}, {-1., 1.}}, DisplayFunction → Identity];
s2s1pts = Table[{sv[z][[2]], sv[z][[1]]},
   {z, zmin, zmax, .01}];
s2s3pts = Table[{sv[z][[2]], sv[z][[3]]},
   {z, zmin, zmax, .01}];
plt21z = ListPlot[s2s1pts, PlotRange → {{-1., 1.}, {-1., 1.}},
   PlotStyle → RGBColor[0, 0, 1], DisplayFunction → Identity];
plt23z = ListPlot[s2s3pts, PlotRange → {{-1., 1.}, {-1., 1.}},
   PlotStyle → RGBColor[1, 0, 0], DisplayFunction → Identity];
plt1z = Plot[sv[z][[1]], {z, zmin, zmax}, PlotRange → {{zmin, zmax}, {-1., 1.}},
   PlotStyle → RGBColor[1, 0, 0], DisplayFunction → Identity];
plt2z = Plot[sv[z][[2]], {z, zmin, zmax}, PlotRange → {{zmin, zmax}, {-1., 1.}},
   PlotStyle → RGBColor[0, 1, 0], DisplayFunction → Identity];
plt3z = Plot[sv[z][[3]], {z, zmin, zmax}, PlotRange → {{zmin, zmax}, {-1., 1.}},
   PlotStyle → RGBColor[0, 0, 1], DisplayFunction → Identity];
Show[pltsph, DisplayFunction → $DisplayFunction];
Show[{pltsph, plt123z}, PlotLabel → eqns, PlotLegends → Automatic,
 DisplayFunction → $DisplayFunction, ViewPoint → viewPoint]
(*Export["dcSl",%,"tiff",ImageResolution→imres,ImageSize→{xsize,ysize}];*)
Show[plt21z, plt23z, Frame → True,
 PlotRangePadding → .2, DisplayFunction → $DisplayFunction ]
Show[plt1z, plt2z, plt3z, Frame → True, PlotRangePadding → .2,
 DisplayFunction → $DisplayFunction]
Show[{plt21z, plt23z}, {plt1z, plt2z, plt3z}, Frame → True,
 PlotRangePadding → .2, DisplayFunction → $DisplayFunction]
```

3)(z), s(2)′(z) = −π s(3)(z), s(3)′(z) = π s(2)(z) − 5.16933 s(1)(z), s(1)(0) = 1., s(2)

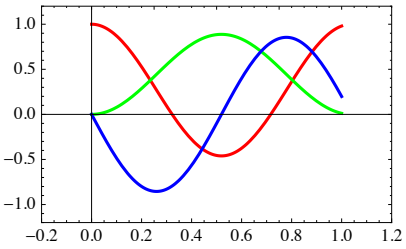
Out[4678]=



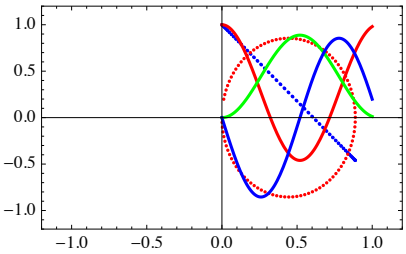
Out[4679]=



Out[4680]=

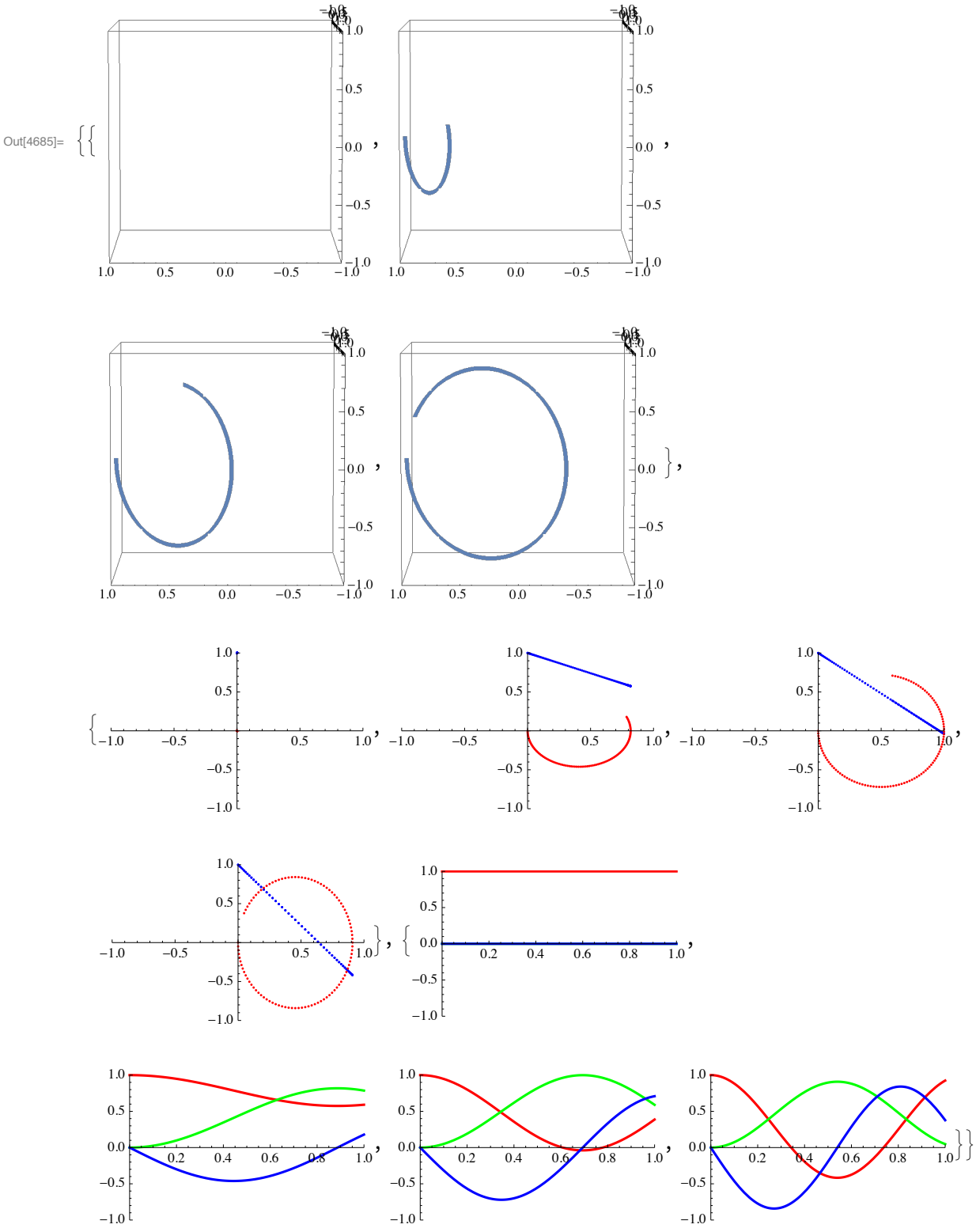


Out[4681]=

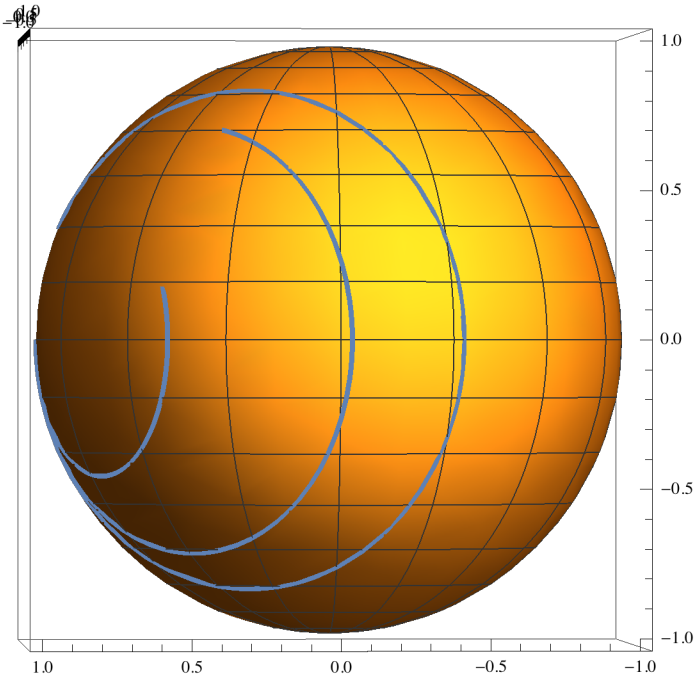


In[4682]:=
```
vnmax = 1.;
vnmin = 0.;
vninc = 0.3;
(*Define a numerical solution*)
plts = Transpose[Table[Module[{}, eqns = {
       (s[1])'[z] == 2 chi[vn] s[3][z] ,
       (s[2])'[z] == -db[z] s[3][z],
       (s[3])'[z] == -2 chi[vn] s[1][z] + db[z] s[2][z],
       s[1][zmin] == si[[1]], s[2][zmin] == si[[2]], s[3][zmin] == si[[3]]};
soln = NDSolve[eqns, {s[1], s[2], s[3]}, {z, zmin, zmax}];
sv[z_] = {s[1][z], s[2][z], s[3][z]} /. soln[[1]];
    s2s1pts = Table[{sv[z][[2]], sv[z][[1]]},
      {z, zmin, zmax, .01}];
s2s3pts = Table[{sv[z][[2]], sv[z][[3]]},
       {z, zmin, zmax, .01}];

{ParametricPlot3D[sv[z], {z, zmin, zmax}, PlotRange → {{-1., 1.}, {-1., 1.}, {-1., 1.}},
       DisplayFunction → Identity, ViewPoint → {0, 10, 1}],

      Show[ListPlot[s2s1pts, PlotRange → {{-1., 1.}, {-1., 1.}},
        PlotStyle → RGBColor[0, 0, 1], DisplayFunction → Identity],
       ListPlot[s2s3pts, PlotRange → {{-1., 1.}, {-1., 1.}},
        PlotStyle → RGBColor[1, 0, 0], DisplayFunction → Identity]],

      Show[Plot[sv[z][[1]], {z, zmin, zmax}, PlotRange → {{zmin, zmax}, {-1., 1.}},
        PlotStyle → RGBColor[1, 0, 0], DisplayFunction → Identity],
       Plot[sv[z][[2]], {z, zmin, zmax},
        PlotRange → {{zmin, zmax}, {-1., 1.}}, PlotStyle → RGBColor[0, 1, 0],
        DisplayFunction → Identity], Plot[sv[z][[3]], {z, zmin, zmax},
        PlotRange → {{zmin, zmax}, {-1., 1.}},
        PlotStyle → RGBColor[0, 0, 1], DisplayFunction → Identity]}],
   {vn, vnmin, vnmax, vninc}]]

splts = Table[Show[Table[plts[[k]], {vn, vnmin, vnmax, vninc}],
    DisplayFunction → $DisplayFunction], {k, 3}];
Show[vSphere, splts[[1]], Frame → True, ViewPoint → viewPoint]
Show[splts[[2]], splts[[3]], Frame → True]

(*Export["dcSlvn",splts[[1]],"tiff",ImageResolution→imres,ImageSize→{xsize,ysize}];*)
```

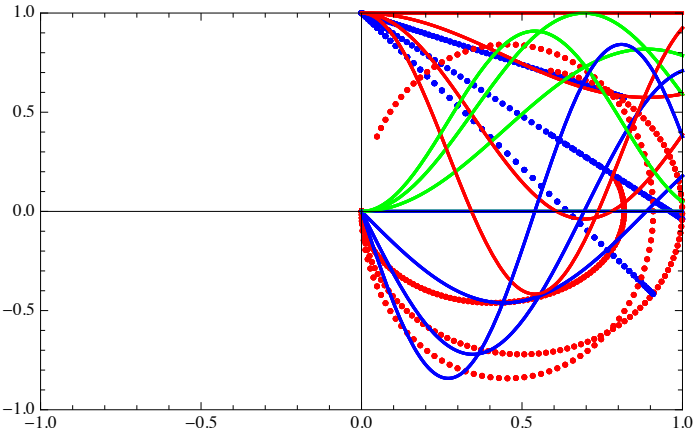
Out[4685]=



Out[4687]=



Out[4688]=

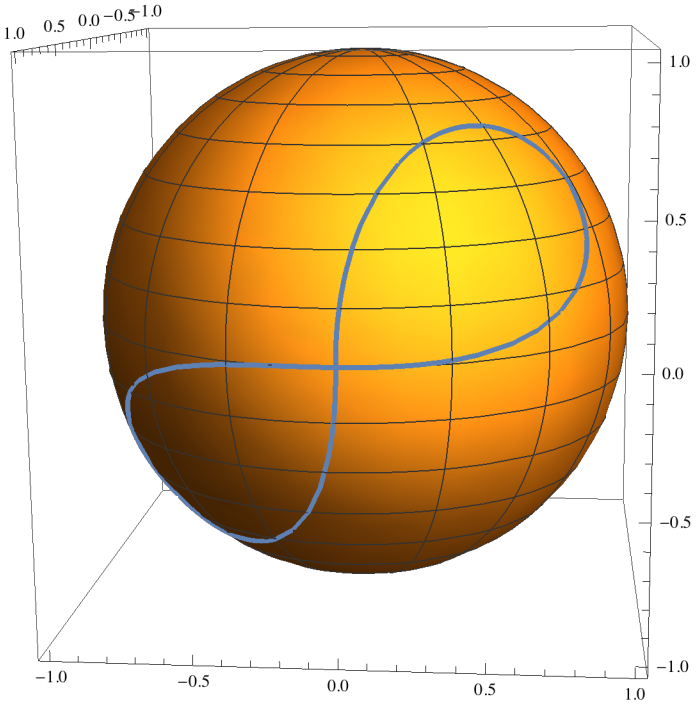


In[4689]:=
```
(*New Initial Conditions*)
vnmax = 1.;
vnmin = -vnmax;
vninc = 0.01;
svpts =
  Table[Module[{}, eqns = {(s[1])'[z] == 2 chi[vn] s[3][z] , (s[2])'[z] == -db[z] s[3][z],
      (s[3])'[z] == -2 chi[vn] s[1][z] + db[z] s[2][z], s[1][zmin] == si[[1]],
      s[2][zmin] == si[[2]], s[3][zmin] == si[[3]]};

    soln = NDSolve[eqns, {s[1], s[2], s[3]}, {z, zmin, zmax}];
sv[z_] = {s[1][z], s[2][z], s[3][z]} /. soln[[1]];
    {{vn, sv[zmax][[1]]}, {vn, sv[zmax][[2]]}, {vn, sv[zmax][[3]]},
     {vn, (1 - sv[zmax][[2]]) / 2.}}], {vn, vnmin, vnmax, vninc}];
svp = Table[Interpolation[Transpose[svpts][[i]]], {i, 3}];
trans = Interpolation[Transpose[svpts][[4]]];
TraditionalForm[eqns]
plt123 = ParametricPlot3D[{svp[[1]][vn],
    svp[[2]][vn], svp[[3]][vn]}, {vn, vnmin, vnmax},
   PlotRange → {{-1., 1.}, {-1., 1.}, {-1., 1.}}, DisplayFunction → Identity];
s2s1pts = Table[{svp[[2]][vn], svp[[1]][vn]},
   {vn, vnmin, vnmax, vninc}];
s2s3pts = Table[{svp[[2]][vn], svp[[3]][vn]},
   {vn, vnmin, vnmax, vninc}];
plt21 = ListPlot[s2s1pts, PlotRange → {{-1., 1.}, {-1., 1.}},
   PlotStyle → RGBColor[0, 0, 1], DisplayFunction → Identity];
plt23 = ListPlot[s2s3pts, PlotRange → {{-1., 1.}, {-1., 1.}},
   PlotStyle → RGBColor[1, 0, 0], DisplayFunction → Identity];
plt1 = Plot[svp[[1]][vn], {vn, vnmin, vnmax}, PlotRange → {{-1., 1.}, {-1., 1.}},
   PlotStyle → RGBColor[1, 0, 0], DisplayFunction → Identity];
plt2 = Plot[svp[[2]][vn], {vn, vnmin, vnmax}, PlotRange → {{-1., 1.}, {-1., 1.}},
   PlotStyle → RGBColor[0, 1, 0], DisplayFunction → Identity];
plt3 = Plot[svp[[3]][vn], {vn, vnmin, vnmax}, PlotRange → {{-1., 1.}, {-1., 1.}},
   PlotStyle → RGBColor[0, 0, 1], DisplayFunction → Identity];
pltrans = Plot[trans[vn], {vn, vnmin, vnmax}, PlotRange → {{-1., 1.}, {0., 1.}},
   DisplayFunction → Identity];
Show[{pltsph, plt123} , DisplayFunction → $DisplayFunction]
Show[plt123 , DisplayFunction → $DisplayFunction];
(*Export["dcSv",%,"tiff",ImageResolution→imres,ImageSize→{xsize,ysize}];*)
Show[plt21, plt23, Frame → True,
 PlotLabel → "Plt21 Plt23", DisplayFunction → $DisplayFunction]
Show[plt1, plt2, plt3, Frame → True, PlotLabel → "Plt1 Plt2 Plt3",
 DisplayFunction → $DisplayFunction]
```

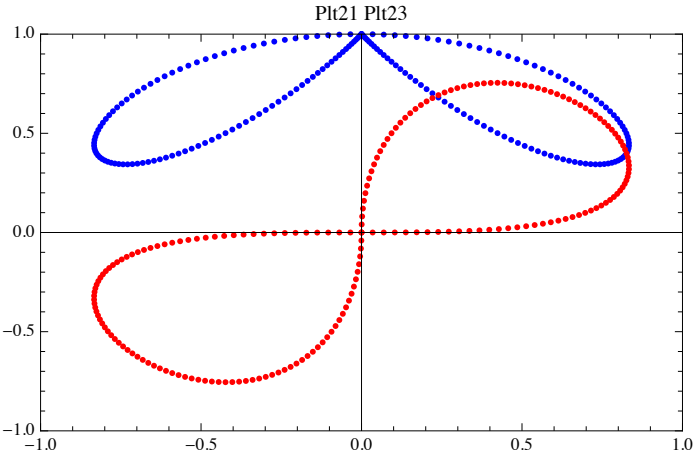
Out[4695]//TraditionalForm=

$$\{s(1)'(z) = 5.4414\, s(3)(z),\ s(2)'(z) = -\pi\, s(3)(z),\\ s(3)'(z) = \pi\, s(2)(z) - 5.4414\, s(1)(z),\ s(1)(0) = 1.,\ s(2)(0) = 0,\ s(3)(0) = 0.\}$$

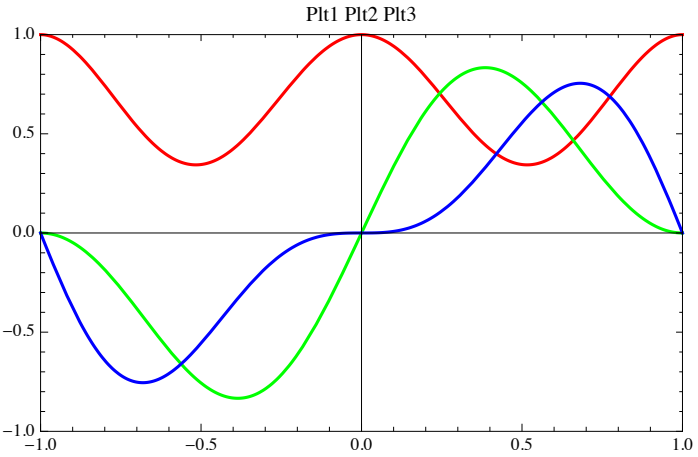
Out[4705]=



Out[4707]=

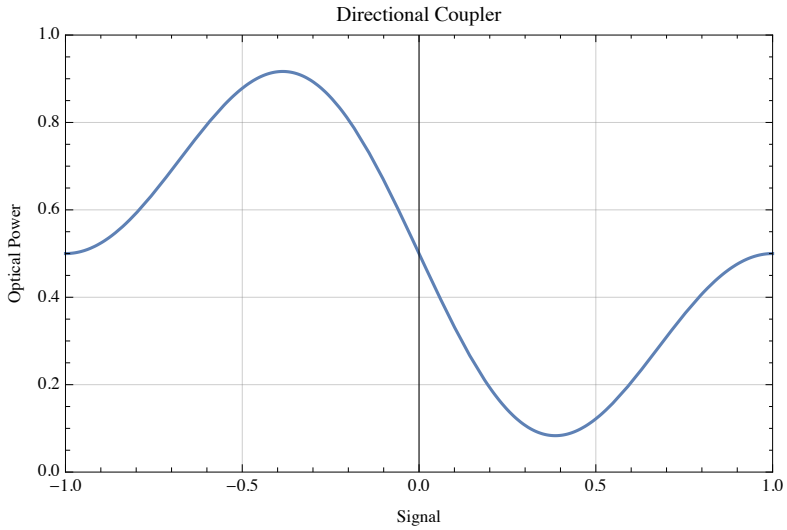


Out[4708]=

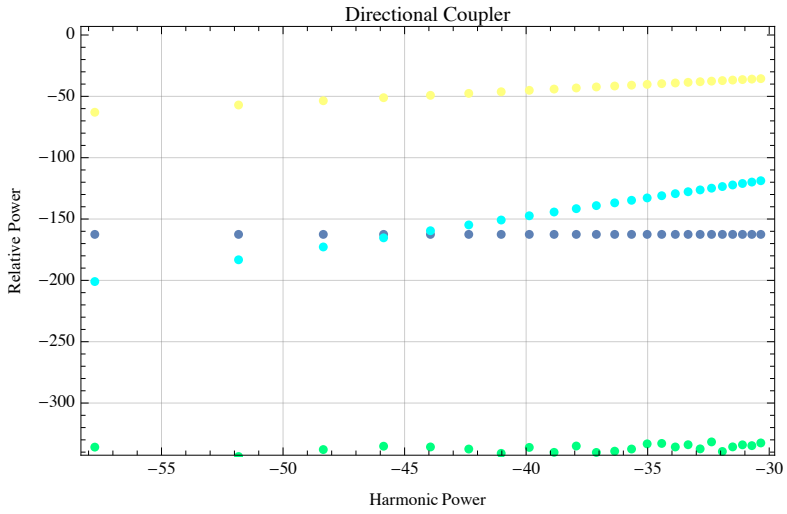


In[4709]:=
```
pin[amp_] := 0.5 amp^2 / rm;
rm = 50.;
ampmax = .01;
ampinc = ampmax / 25.;
Tav = 0.5;
Popt = 0.1;
loss = 0.1;
eta = 0.7;
idc = Tav Popt loss eta;
eelec = 1.6 × 10^(-19);
rd = 50.;
Psn = 10. (Log[10, 2. eelec idc 50.] + 3.);
nf = Psn;
nfpts = Table[{10. (Log[10, pin[amp]] + 3.), nf}, {amp, ampinc + .00001, ampmax, ampinc}];
lpnf = ListPlot[nfpts, DisplayFunction → Identity];

sfdrdata = Table[Table[{10. (Log[10, pin[amp]] + 3.), Module[{},
ntp = 1028; npr = 1;
data = Table[trans[amp Sin[2 npr Pi n / ntp]], {n, 0, ntp - 1}];
tdata = 20. (Log[10, Abs[Fourier[data]] / (Sqrt[ntp] / 2) + 10^(-100)]);
      tdata[[k + 1]]]}, {amp, ampinc + .00001, ampmax, ampinc}], {k, 5}];
lpfd =
  Table[ListPlot[sfdrdata[[k]], PlotStyle → {RGBColor[If[k == 1, 1, 0], If[k == 2, 1, 1],
       If[k == 3, 1, .5]], Thickness[If [k == 1, .003, .01]]},

    DisplayFunction → Identity], {k, 3}];

Show[pltrans, DisplayFunction → $DisplayFunction,
 Frame → True, PlotLabel -> "Directional Coupler",
 FrameLabel → {Signal, "Optical Power"}, GridLines → Automatic]

(*Export["dctf",%,"tiff",ImageResolution→imres,ImageSize→{xsize,ysize}];*)
Show[lpnf, Table[lpfd[[k]], {k, 3}], Frame → True, PlotLabel -> "Directional Coupler",
 FrameLabel → {Harmonic Power, "Relative Power"}, PlotLegends → {"1", "2", "3"},
 GridLines → Automatic, DisplayFunction → $DisplayFunction]
(*Export["dcfcs",%,"tiff",ImageResolution→imres,ImageSize→{xsize,ysize}];*)
ListPlot[sfdrdata[[1]], Frame → True, GridLines → Automatic,
 PlotRange → {0, -180}, PlotLabel → " 1st Order  Harmonic Power "]

ListPlot[sfdrdata[[3]], Frame → True, GridLines → Automatic,
 PlotRange → {0, -180}, Joined → True, PlotLabel → " 3rd Order Harmonic Power "]
ListPlot[sfdrdata[[2]], Frame → True, GridLines → Automatic,
 Joined → True, PlotLabel → " 2nd Order Power "]
```

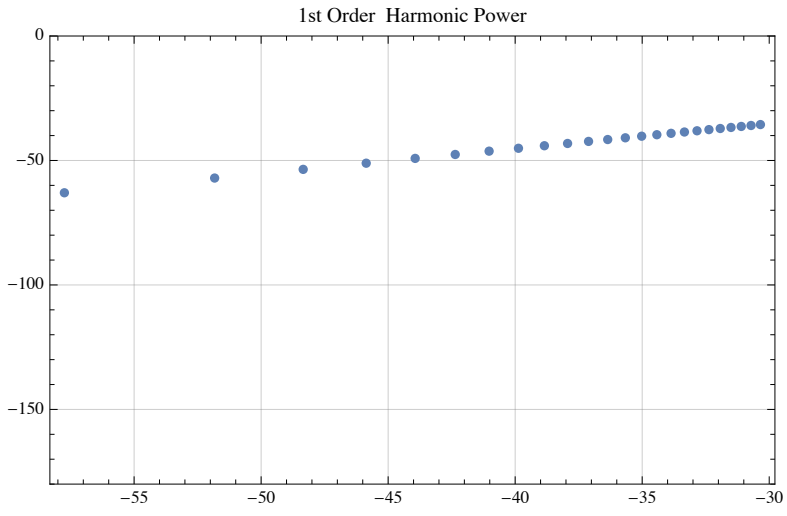
Out[4726]=



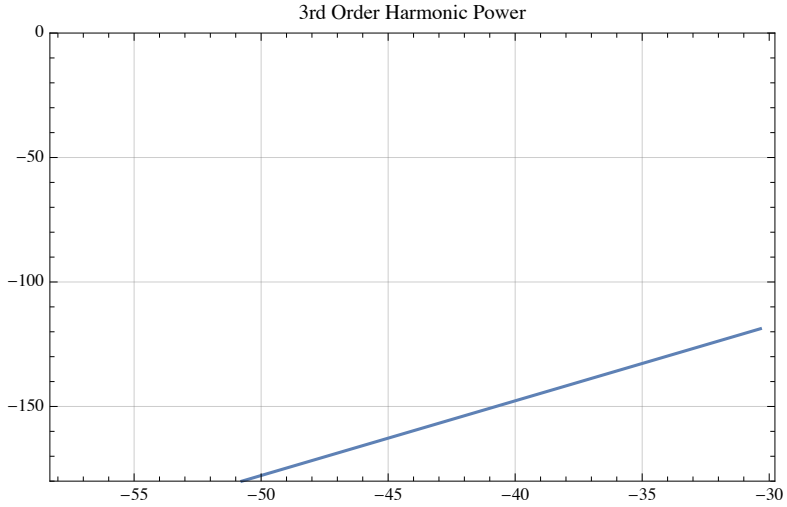
Out[4727]=



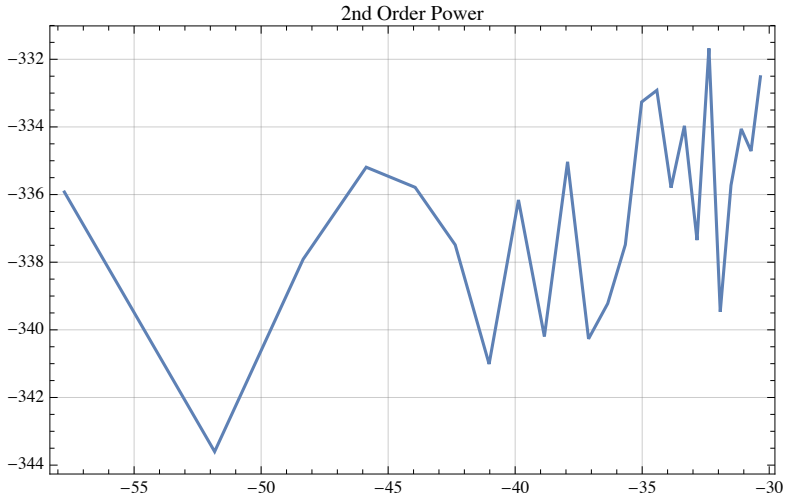
Out[4728]=



Out[4729]=



Out[4730]=



In[4731]:=