Note: requires **seesawSimulatorDM.wl** to be loaded.

Functions

PlotSimInput function plots a simulation including multiple trajectories of the same output, each has a distinct input.
SIMcircuit is a simulation.
input is a list of input values, relative to a standard concentration 1×.
time defines the range of time plotted, starting from 0. The unit is hours.
InputLabel is a label for the legend of inputs. The default is none.
CircuitLabel is a label for the plot. It can be the function of the circuit. The default is none.
size is the size of image. The default is 400.

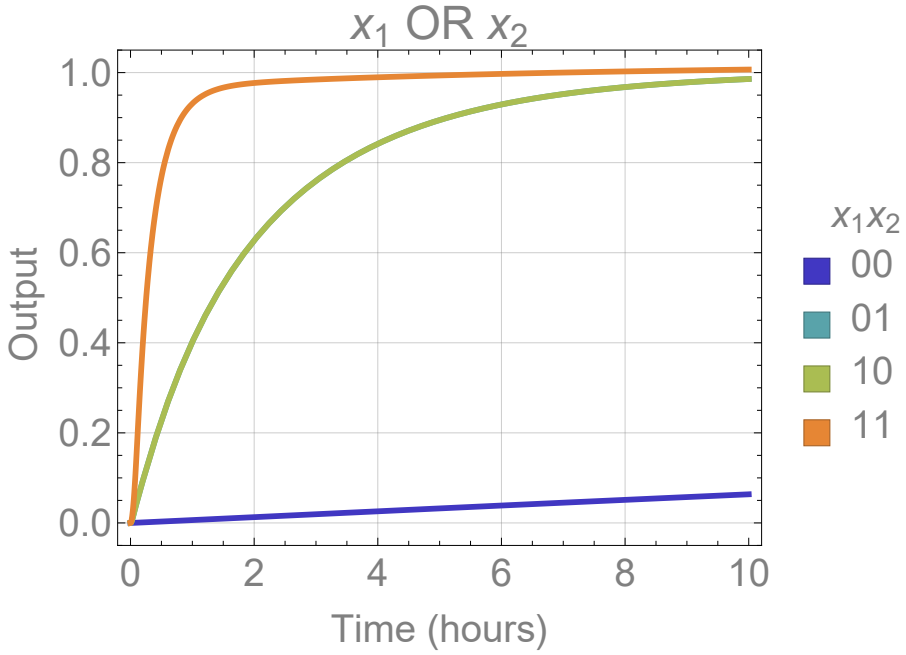
```
PlotSimInput[SIMcircuit_, input_, time_, InputLabel_: "", CircuitLabel_: "", size_: 400] :=
 Plot[SIMcircuit, {t, 0, time},
  PlotLabel → Style[CircuitLabel, 24],
  Frame -> True, FrameLabel -> {"Time (hours)", "Output"},
  PlotStyle → Table[{AbsoluteThickness[3], ColorData["Rainbow"][i]},
    {i, If[Length[input] < 8, 0.12, 0], 0.96, 0.96 / Length[input]}],
  PlotLegends → SwatchLegend[Automatic,
    Table[Row[Table[input[[i, j]], {j, 1, Length[input[[i]]]}]], {i, 1, Length[input]}],
    LegendLabel → InputLabel, LegendMarkerSize → 14],
  LabelStyle -> Directive[Gray, FontSize → 20, FontFamily -> "Helvetica"],
  GridLines → Automatic,
  PlotRange → {All, {-0.05, 1.05}}, AspectRatio -> 1 / 1.3, ImageSize → size]
```

PlotSimOutput function plots a simulation including multiple trajectories of distinct outputs, with the same input.
SIMcircuit is a simulation.
output is a list of output labels.
time defines the range of time plotted, starting from 0. The unit is hours.
OutputLabel is a label for the legend of outputs. The default is none.
CircuitLabel is a label for the plot. It can be the function of the circuit. The default is none.
size is the size of image. The default is 400.

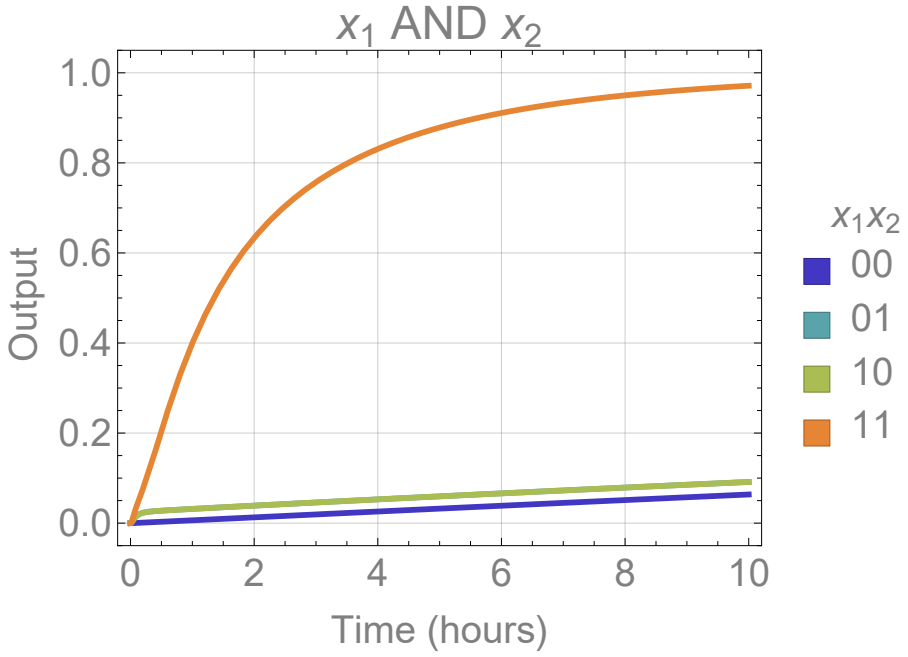
```
PlotSimOutput[SIMcircuit_, output_, time_, OutputLabel_: "", CircuitLabel_: "", size_: 400] :=
 Plot[SIMcircuit, {t, 0, time},
  PlotLabel → Style[CircuitLabel, 20],
  Frame -> True, FrameLabel -> {"Time (hours)", "Output"},
  PlotStyle →
   Table[{AbsoluteThickness[3], ColorData["FallColors"][Floor[i / 2] / (Length[output] / 2 - 1)],
     If[EvenQ[i], Dashed]}, {i, 0, Length[output] - 1}],
  PlotLegends → LineLegend[Automatic, output, LegendLabel → OutputLabel, LegendMarkerSize → 14],
  LabelStyle -> Directive[Gray, FontSize → 20, FontFamily -> "Helvetica"],
  GridLines → Automatic,
  PlotRange → {All, {-0.05, 1.05}}, AspectRatio -> 1 / 1.3, ImageSize → size]
```

A single logic gate

```
input = Flatten[Table[{x1, x2}, {x1, 0, 1}, {x2, 0, 1}], 1];
time = 10; (* unit: hour *)

OR = Table[
    gatesys = {
      seesawOR[12, 13, {5, 9}, {36}, 1],
      reporter[36, 13],
      concd[w[5, 12], x[[1]] * c],
      concd[w[9, 12], x[[2]] * c],
      conc[W, 2 * c],
      conc[G, 4.5 * c],
      conc[TH, 0.6 * c]
     };
    sol = SimulateRxnsys[gatesys, time * 60 * 60];
    Fluor[36][t * 60 * 60] / maxSignal[srb] / c /. sol, {x, input}];

PlotSimInput[OR, input, time, "   x1x2", "x1 OR x2"]
```



```
AND = Table[
    gatesys = {
      seesawAND[12, 13, {5, 9}, {36}, 1],
      reporter[36, 13],
      concd[w[5, 12], x[[1]] * c],
      concd[w[9, 12], x[[2]] * c],
      conc[W, 2 * c],
      conc[G, 4.5 * c],
      conc[TH, 1.2 * c]
     };
    sol = SimulateRxnsys[gatesys, time * 60 * 60];
    Fluor[36][t * 60 * 60] / maxSignal[srb] / c /. sol, {x, input}];

PlotSimInput[AND, input, time, "   x₁x₂", "x₁ AND x₂"]
```

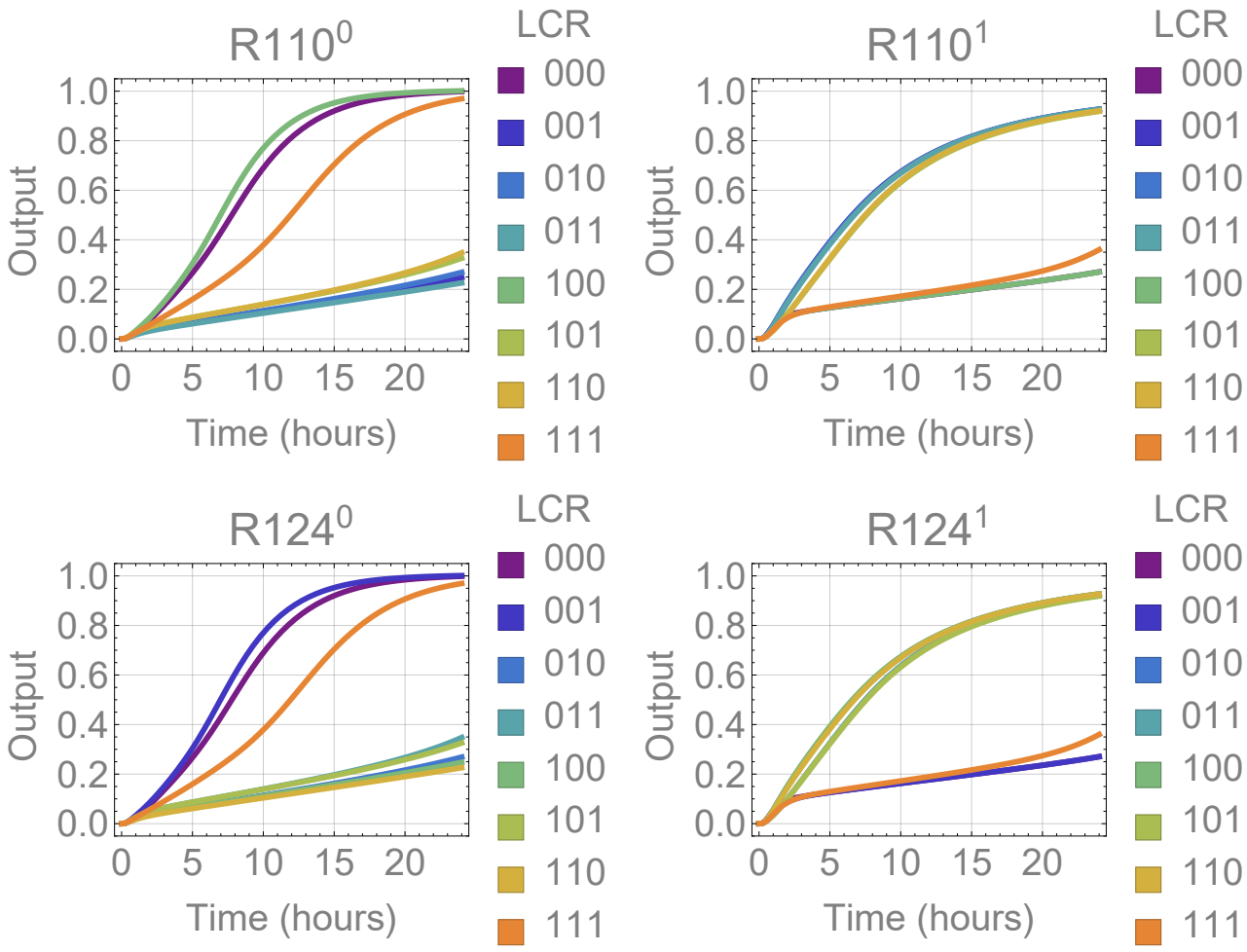


A rule 110-124 circuit

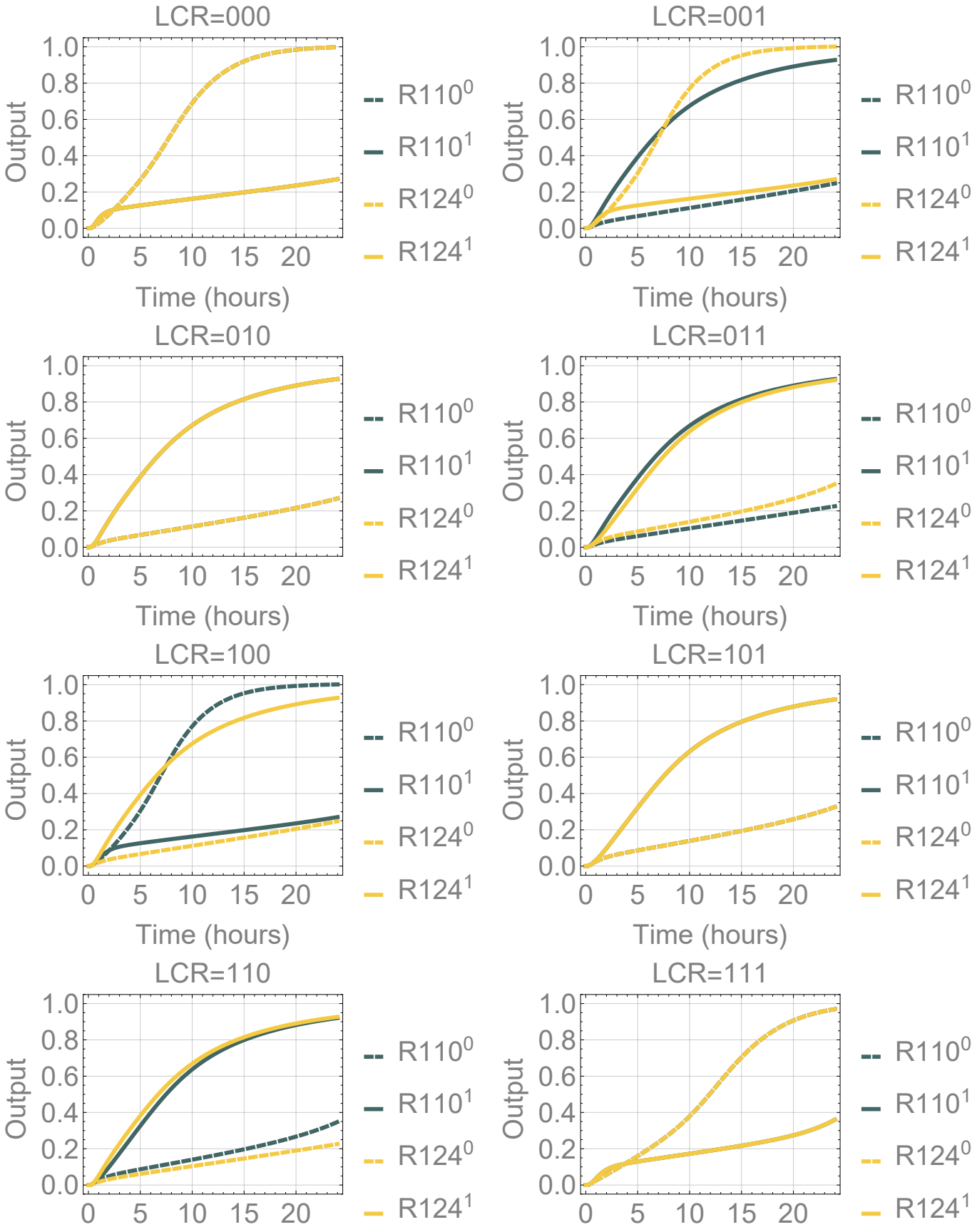
```
input = Flatten[Table[{L, C, R}, {L, 0, 1}, {C, 0, 1}, {R, 0, 1}], 2];
output = {"R110^0", "R110^1", "R124^0", "R124^1"};
time = 24; (* unit: hour *)

R110124circuit = Table[
    gatesys = {
      seesawAND[4, 5, {27, 31, 35}, {12, 20}, 0],
      seesawOR[6, 7, {25, 29, 33}, {14, 22}, 0],
      seesawAND[8, 9, {29, 33}, {12}, 0],
      seesawOR[10, 11, {31, 35}, {14}, 0],
      seesawOR[12, 13, {5, 9}, {36}, 1],
      seesawAND[14, 15, {7, 11}, {38}, 1],
      seesawAND[16, 17, {25, 29}, {20}, 0],
      seesawOR[18, 19, {27, 31}, {22}, 0],
      seesawOR[20, 21, {5, 17}, {40}, 1],
      seesawAND[22, 23, {7, 19}, {42}, 1],

      inputfanout[25, 24, {6, 16}],
      inputfanout[27, 26, {4, 18}],
      inputfanout[29, 28, {6, 8, 16}],
      inputfanout[31, 30, {4, 10, 18}],
      inputfanout[33, 32, {6, 8}],
      inputfanout[35, 34, {4, 10}],

      reporter[36, 13],
      reporter[38, 15],
      reporter[40, 21],
      reporter[42, 23],

      concd[w[24, 25], (1 - x[[1]]) * c],
      concd[w[26, 27], x[[1]] * c],
      concd[w[28, 29], (1 - x[[2]]) * c],
      concd[w[30, 31], x[[2]] * c],
      concd[w[32, 33], (1 - x[[3]]) * c],
      concd[w[34, 35], x[[3]] * c],

      conc[W, 55 * c],
      conc[G, 54 * c],
      conc[TH, 11.2 * c]
     };
```

```
sol = SimulateRxnsys[gatesys, time * 60 * 60];
{Fluor[36][t * 60 * 60] / maxSignal[srb] / c /. sol,
 Fluor[38][t * 60 * 60] / maxSignal[srb] / c /. sol,
 Fluor[40][t * 60 * 60] / maxSignal[srb] / c /. sol,
 Fluor[42][t * 60 * 60] / maxSignal[srb] / c /. sol},
{x, input}];
```

```
Grid[Partition[Table[PlotSimInput[Table[R110124circuit[[i, j]], {i, 1, Length[input]}],
    input, time, "LCR", output[[j]], 250], {j, 1, Length[output]}], 2]]
```




```
Grid[Partition[Table[PlotSimOutput[Table[R110124circuit[[i, j]], {j, 1, Length[output]}],
    output, time, "", Row[{"LCR=", Row[input[[i]]]}], 250], {i, 1, Length[input]}], 2]]
```


LCR=000
LCR=001
LCR=010
LCR=011
LCR=100
LCR=101
LCR=110
LCR=111
Output
Time (hours)
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
R110^0
R110^1
R124^0
R124^1

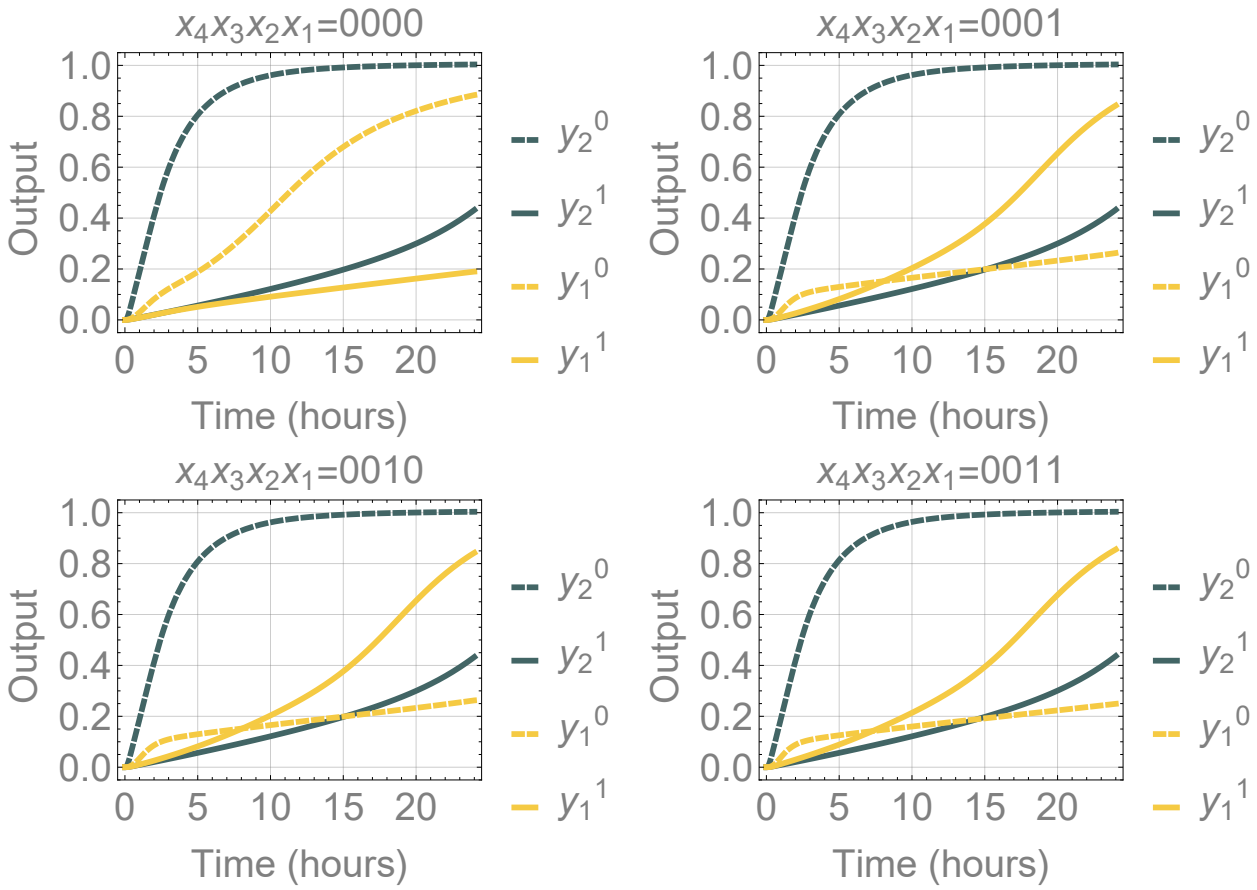
Time (hours) Time (hours)

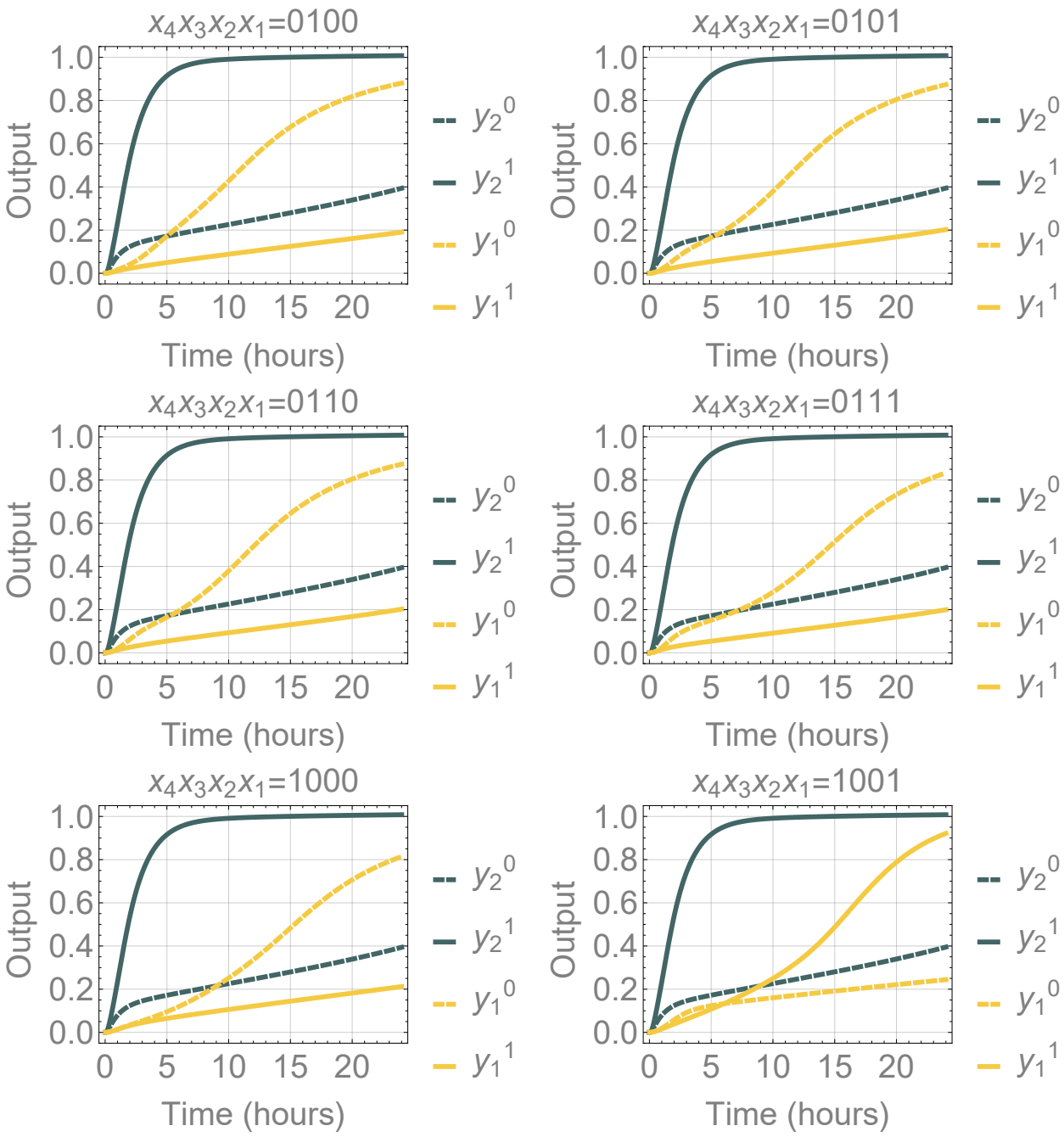
A four-bit square root circuit (worse case)

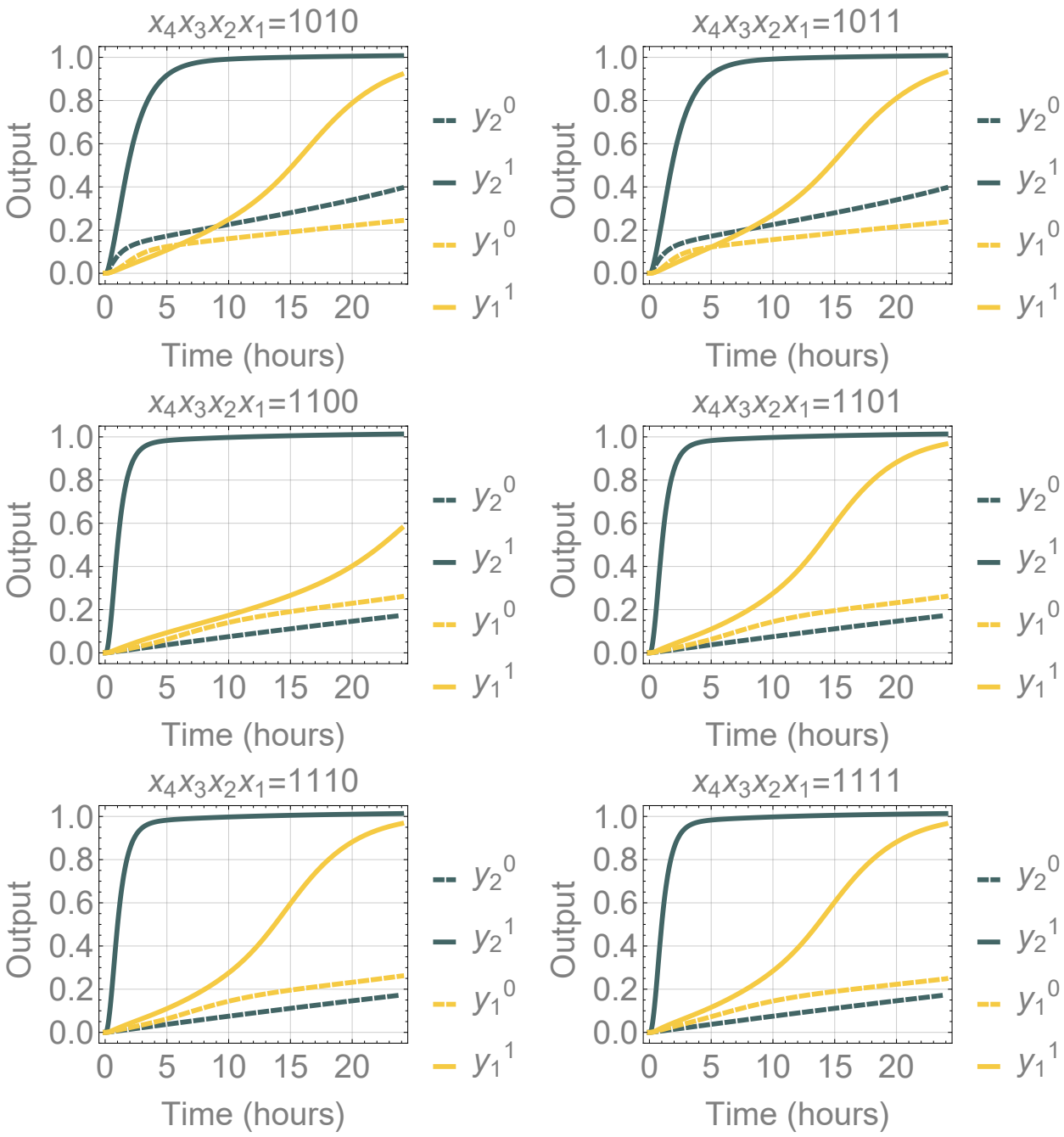
with default additional threshold adjustment in logic gates at layer two and above

```
input = Flatten[Table[{x4, x3, x2, x1}, {x4, 0, 1}, {x3, 0, 1}, {x2, 0, 1}, {x1, 0, 1}], 3];
output = {"y2^0", "y2^1", "y1^0", "y1^1"};
time = 24; (* unit: hour *)

squareroot = Table[
   gatesys = {
     inputfanout[13, 12, {28, 32, 38}],
     inputfanout[15, 14, {30, 34, 36}],
     inputfanout[17, 16, {30, 32, 38}],
     inputfanout[19, 18, {28, 34, 36}],

     seesawOR[20, 21, {7, 11}, {38, 40}, 0],
     seesawAND[22, 23, {5, 9}, {36, 42}, 0],
     seesawOR[28, 29, {13, 19}, {40}, 0],
     seesawAND[30, 31, {15, 17}, {42}, 0],
     seesawAND[32, 33, {13, 17}, {48}, 0],
     seesawOR[34, 35, {15, 19}, {50}, 0],
     seesawAND[36, 37, {23, 15, 19}, {46}, 1],
     seesawOR[38, 39, {21, 13, 17}, {44}, 1],
     seesawAND[40, 41, {21, 29}, {46}, 1],
     seesawOR[42, 43, {23, 31}, {44}, 1],
     seesawAND[44, 45, {39, 43}, {52}, 2],
     seesawOR[46, 47, {37, 41}, {54}, 2],

     reporter[48, 33],
     reporter[50, 35],
     reporter[52, 45],
     reporter[54, 47],

     concd[w[5, 22], (1 - x[[4]]) * c],
     concd[w[7, 20], x[[4]] * c],
     concd[w[9, 22], (1 - x[[3]]) * c],
     concd[w[11, 20], x[[3]] * c],
     concd[w[12, 13], (1 - x[[2]]) * c],
     concd[w[14, 15], x[[2]] * c],
     concd[w[16, 17], (1 - x[[1]]) * c],
```

```
    concd[w[18, 19], x[[1]] * c],

    conc[W, 56 * c],
    conc[G, 58 * c],
    conc[TH, 12.6 * c]
   };
  sol = SimulateRxnsys[gatesys, time * 60 * 60];
  {Fluor[48][t * 60 * 60] / maxSignal[srb] / c /. sol,
   Fluor[50][t * 60 * 60] / maxSignal[srb] / c /. sol,
   Fluor[52][t * 60 * 60] / maxSignal[srb] / c /. sol,
   Fluor[54][t * 60 * 60] / maxSignal[srb] / c /. sol},
  {x, input}];

Grid[Partition[Table[PlotSimOutput[Table[squareroot[[i, j]], {j, 1, Length[output]}], output,
    time, "", Row[{"x4x3x2x1=", Row[input[[i]]]}], 250], {i, 1, Length[input]}], 2]]
```




$x_4x_3x_2x_1$=0100
$x_4x_3x_2x_1$=0101
$x_4x_3x_2x_1$=0110
$x_4x_3x_2x_1$=0111
$x_4x_3x_2x_1$=1000
$x_4x_3x_2x_1$=1001
Output
Time (hours)
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
y_2^0
y_2^1
y_1^0
y_1^1

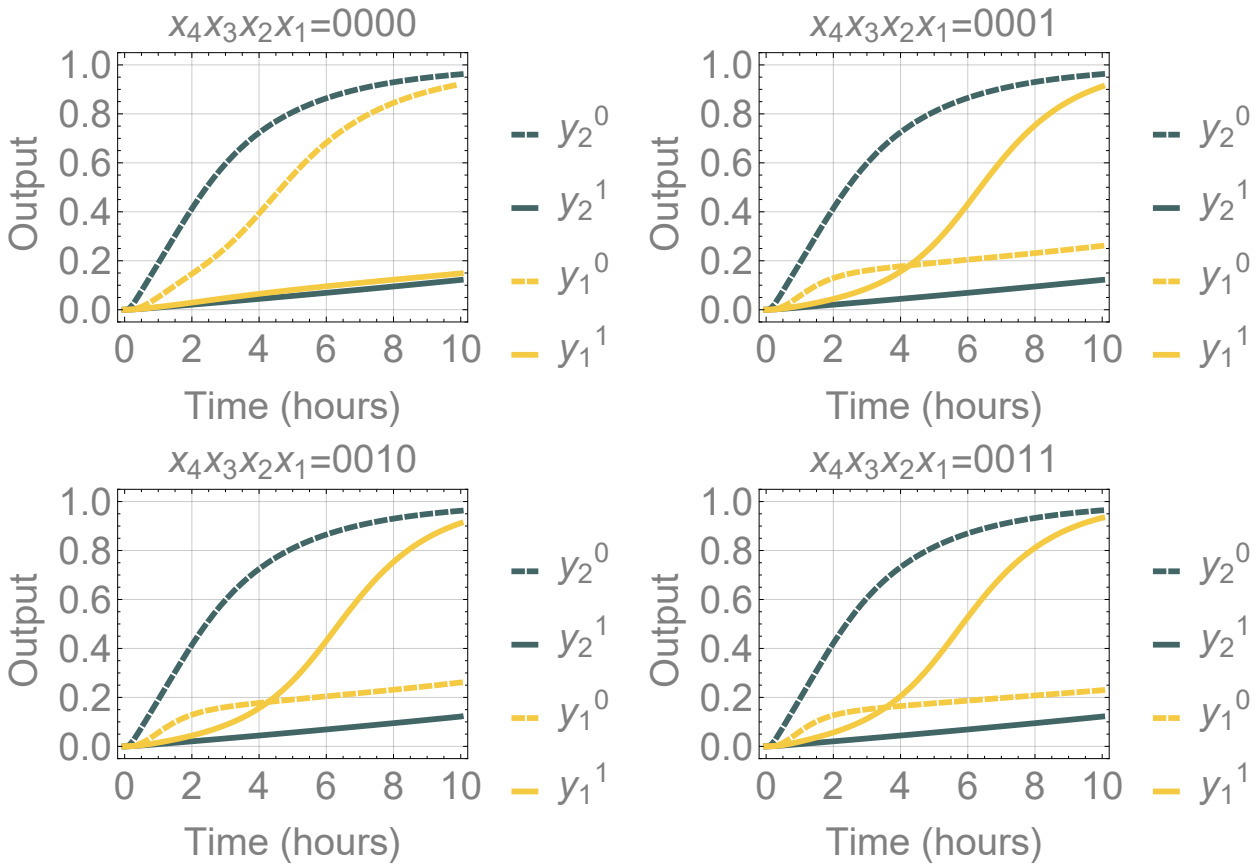

$x_4x_3x_2x_1$=1010
$x_4x_3x_2x_1$=1011
$x_4x_3x_2x_1$=1100
$x_4x_3x_2x_1$=1101
$x_4x_3x_2x_1$=1110
$x_4x_3x_2x_1$=1111
Output
Time (hours)
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
20
y_2^0
y_2^1
y_1^0
y_1^1

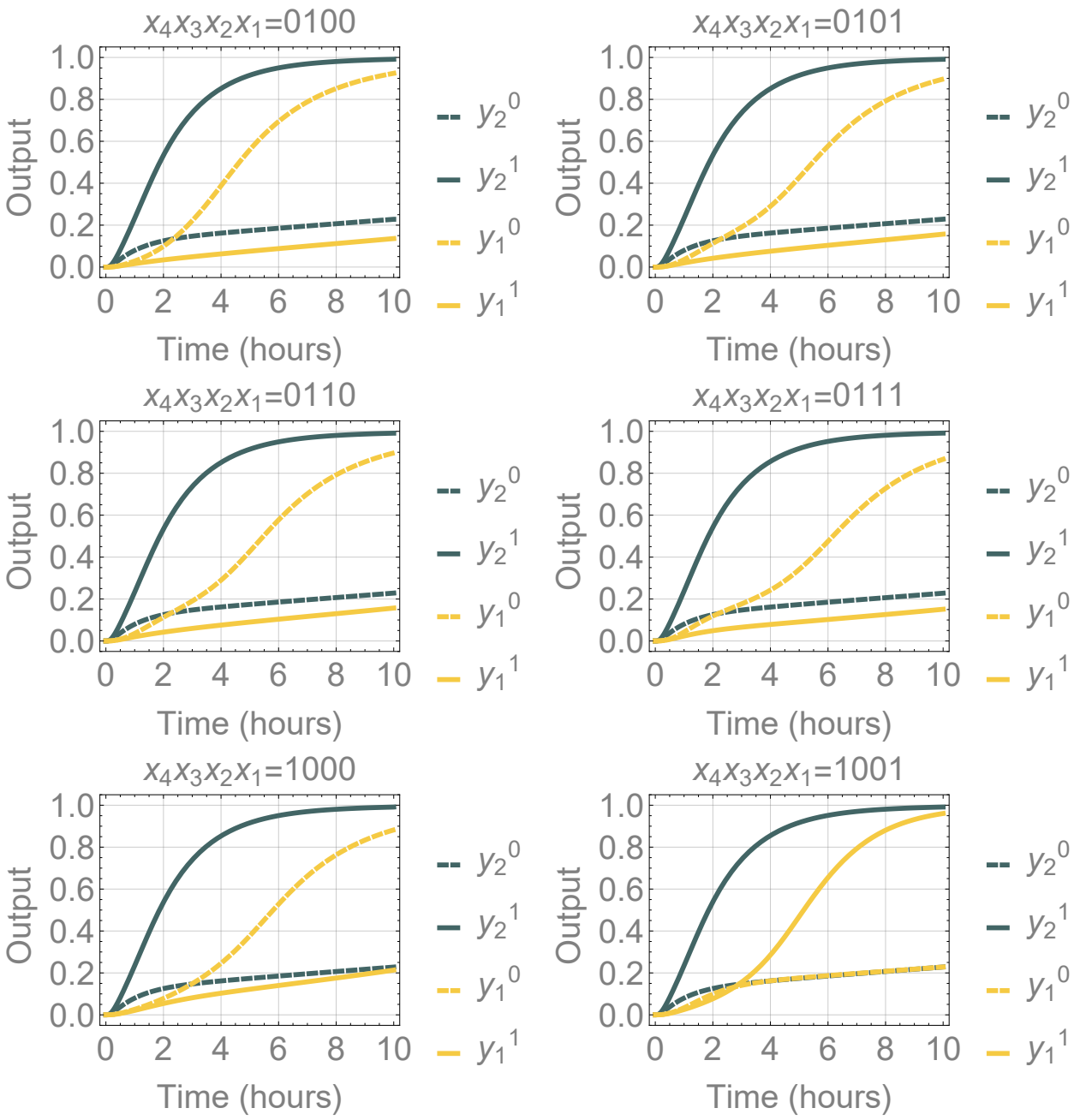
A four-bit square root circuit (better case)

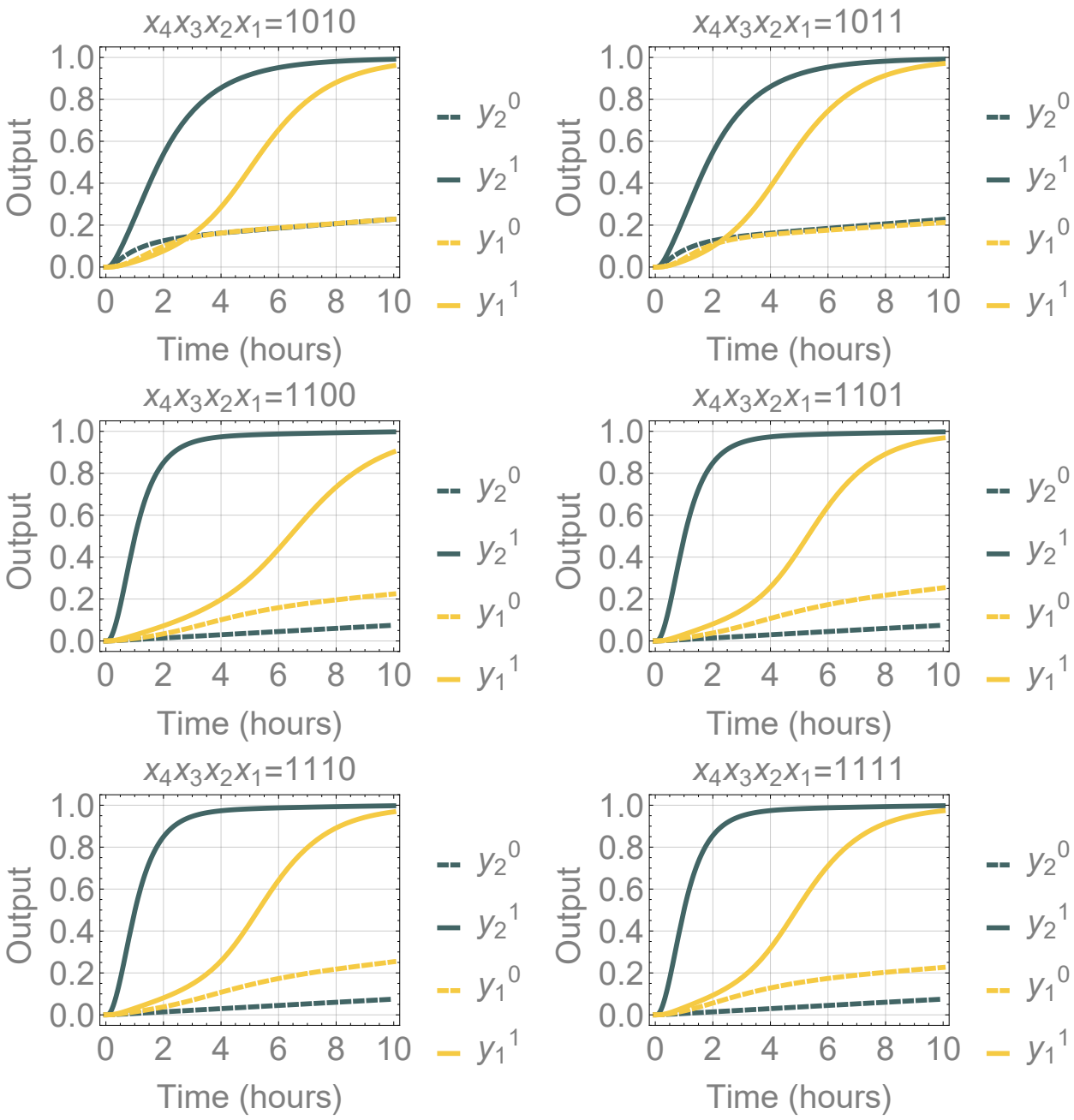
without additional threshold adjustment in logic gates at layer two and above

```
ThInc = 0;

input = Flatten[Table[{x4, x3, x2, x1}, {x4, 0, 1}, {x3, 0, 1}, {x2, 0, 1}, {x1, 0, 1}], 3];
output = {"y2^0", "y2^1", "y1^0", "y1^1"};
time = 24; (* unit: hour *)

squareroot = Table[
   gatesys = {
     inputfanout[13, 12, {28, 32, 38}],
     inputfanout[15, 14, {30, 34, 36}],
     inputfanout[17, 16, {30, 32, 38}],
     inputfanout[19, 18, {28, 34, 36}],

     seesawOR[20, 21, {7, 11}, {38, 40}, 0],
     seesawAND[22, 23, {5, 9}, {36, 42}, 0],
     seesawOR[28, 29, {13, 19}, {40}, 0],
     seesawAND[30, 31, {15, 17}, {42}, 0],
     seesawAND[32, 33, {13, 17}, {48}, 0],
     seesawOR[34, 35, {15, 19}, {50}, 0],
     seesawAND[36, 37, {23, 15, 19}, {46}, 1],
     seesawOR[38, 39, {21, 13, 17}, {44}, 1],
     seesawAND[40, 41, {21, 29}, {46}, 1],
     seesawOR[42, 43, {23, 31}, {44}, 1],
     seesawAND[44, 45, {39, 43}, {52}, 2],
     seesawOR[46, 47, {37, 41}, {54}, 2],

     reporter[48, 33],
     reporter[50, 35],
     reporter[52, 45],
     reporter[54, 47],

     concd[w[5, 22], (1 - x[[4]]) * c],
     concd[w[7, 20], x[[4]] * c],
     concd[w[9, 22], (1 - x[[3]]) * c],
     concd[w[11, 20], x[[3]] * c],
     concd[w[12, 13], (1 - x[[2]]) * c],
     concd[w[14, 15], x[[2]] * c],
     concd[w[16, 17], (1 - x[[1]]) * c],
     concd[w[18, 19], x[[1]] * c],
```

```
    conc[W, 56 * c],
    conc[G, 58 * c],
    conc[TH, 12.6 * c]
   };
  sol = SimulateRxnsys[gatesys, time * 60 * 60];
  {Fluor[48][t * 60 * 60] / maxSignal[srb] / c /. sol,
   Fluor[50][t * 60 * 60] / maxSignal[srb] / c /. sol,
   Fluor[52][t * 60 * 60] / maxSignal[srb] / c /. sol,
   Fluor[54][t * 60 * 60] / maxSignal[srb] / c /. sol},
  {x, input}];
Grid[Partition[Table[PlotSimOutput[Table[squareroot[[i, j]], {j, 1, Length[output]}],
    output, 10, "", Row[{"x4x3x2x1=", Row[input[[i]]]}], 250], {i, 1, Length[input]}], 2]]
```




$x_4x_3x_2x_1$=0100
$x_4x_3x_2x_1$=0101
$x_4x_3x_2x_1$=0110
$x_4x_3x_2x_1$=0111
$x_4x_3x_2x_1$=1000
$x_4x_3x_2x_1$=1001
Output
Time (hours)
0.0
0.2
0.4
0.6
0.8
1.0
0
2
4
6
8
10
y_2^0
y_2^1
y_1^0
y_1^1


$x_4x_3x_2x_1$=1010
$x_4x_3x_2x_1$=1011
$x_4x_3x_2x_1$=1100
$x_4x_3x_2x_1$=1101
$x_4x_3x_2x_1$=1110
$x_4x_3x_2x_1$=1111
Output
Time (hours)
0.0
0.2
0.4
0.6
0.8
1.0
0
2
4
6
8
10
y_2^0
y_2^1
y_1^0
y_1^1