Food Dispenser

ELEC 402: Synthesized Verilog Project

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Report from RTL Compiler

Food Dispenser FSM used 157 Cells and has timing slack of 31ps which meet both cells requirement and the timing requirement.

```
============================================================
  Generated by:           Encounter(R) RTL Compiler RC14.13 - v14.10-s027_1
  Generated on:           Oct 06 2021  10:01:11 pm
  Module:                 food_dispenser_fsm
  Technology library:     NanGate_15nm_OCL revision 1.0
  Operating conditions:   worst_low (balanced_tree)
  Wireload mode:          enclosed
  Area mode:              timing library
============================================================

    Instance       Cells  Cell Area  Net Area  Total Area  Wireload
-------------------------------------------------------------------------
food_dispenser_fsm    157         51         0          51    <none> (D)

 (D) = wireload is default in technology library

============================================================
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============================================================

     Pin            Type       Fanout Load Slew Delay Arrival
                                       (fF) (ps)  (ps)   (ps)
-------------------------------------------------------------
(clock clk)         launch                                0 R
state_reg[1]/CLK                             0            0 R
state_reg[1]/Q      DFFRNQ_X1        9  9.2   17   +22     22 R
g3857/A2                                          +0     22
g3857/ZN            NAND2_X1         5  4.1   12   +10     32 F
g3834/A1                                          +0     32
g3834/ZN            NOR3_X1          4  3.9   18   +12     44 R
g3793/A1                                          +0     44
g3793/ZN            NAND3_X1         2  1.6   10    +8     52 F
g3750/A2                                          +0     52
g3750/ZN            NAND2_X1         1  1.0    4    +5     57 R
g3737/A3                                          +0     57
g3737/ZN            NOR4_X1          1  0.5    5    +3     60 F
state_reg[1]/D      DFFRNQ_X1                     +0     60
state_reg[1]/CLK    setup                         0    +9     69 R
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
(clock clk)         capture                             100 R
-------------------------------------------------------------
Cost Group   : 'clk' (path_group 'clk')
Timing slack :      31ps
Start-point  : state_reg[1]/CLK
End-point    : state_reg[1]/D
```

Visual Waveforms Comparison

To match the timing slack, the main clock frequency from 50Mhz to 10Mhz. Thus, state will change much slower this time. Figures below demonstrate that the waveform before and after mapping perform the same.

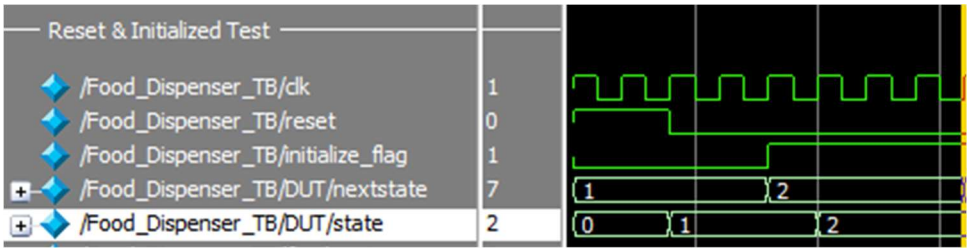


Figure 1: Reset & Initialized Test (Before Mapped)

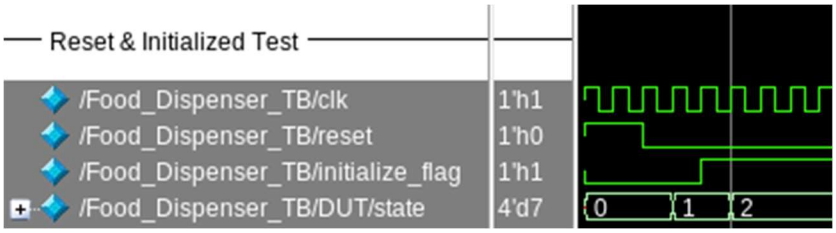


Figure 2: Reset & Initialized Test (After Mapped)

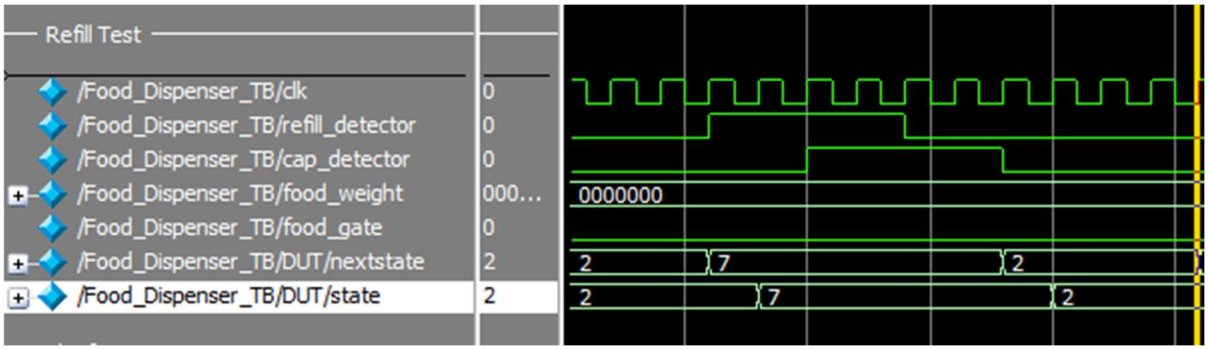


Figure 3: Refill Test (Before Mapped)

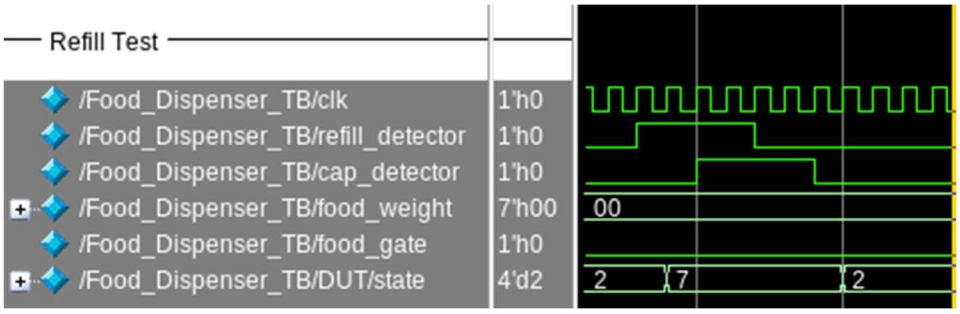


Figure 4: Refill Test (After Mapped)

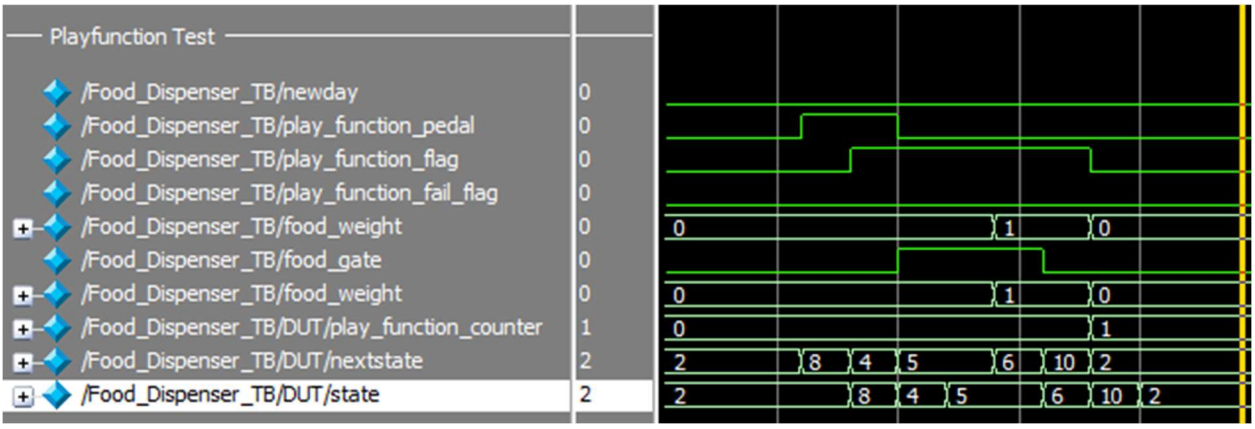


Figure 5: Playfunction Test (Before Mapped)

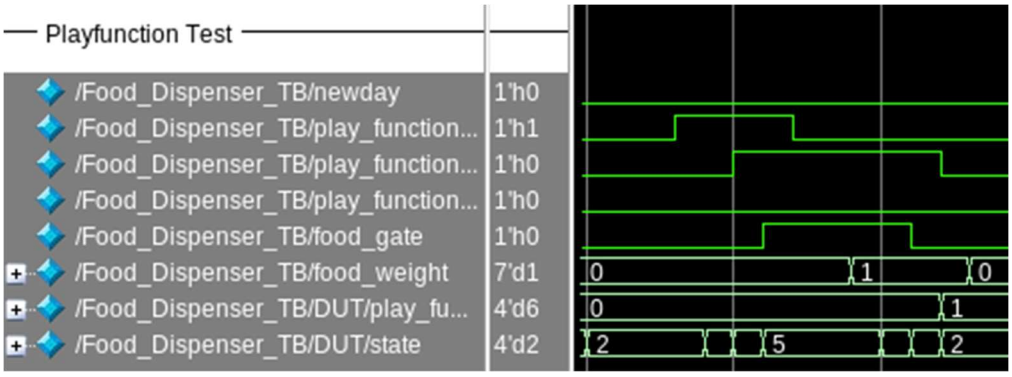


Figure 6: Playfunction Test (After Mapped)

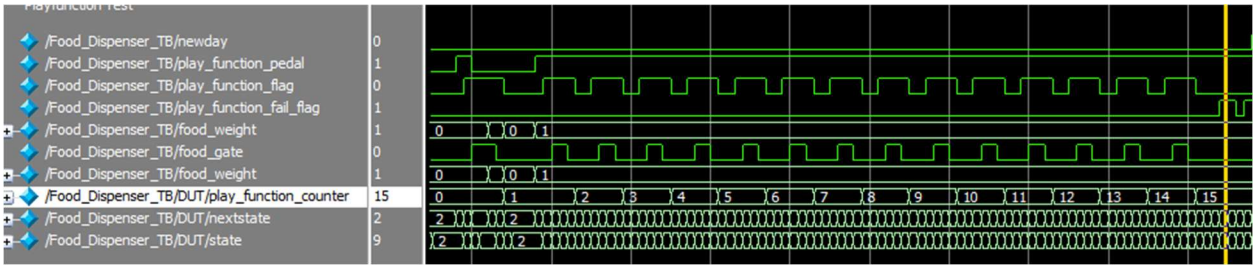
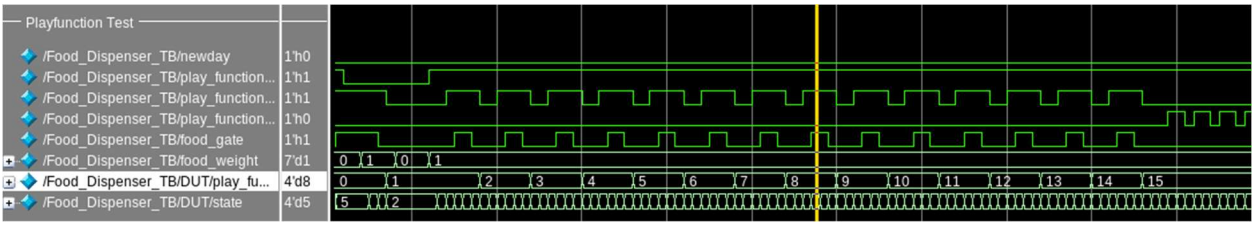


Figure 7: Daily Limit Test (Before Mapped)



Figrue 8: Daily Limit Test (After Mapped)

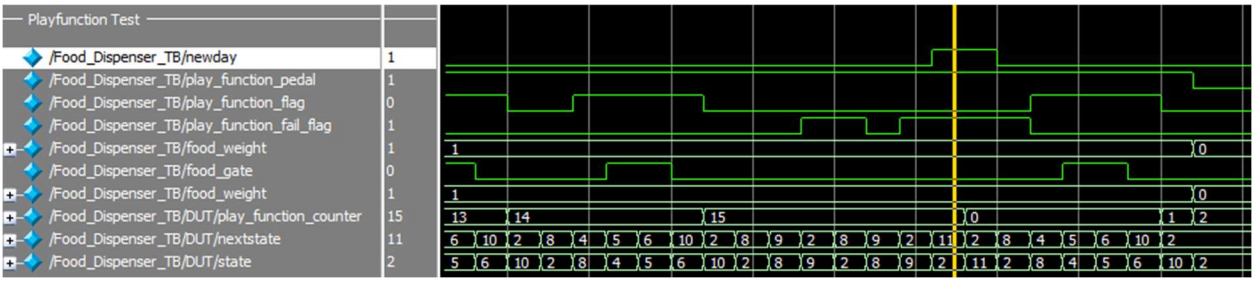


Figure 9: New Day Reset (Before Mapped)

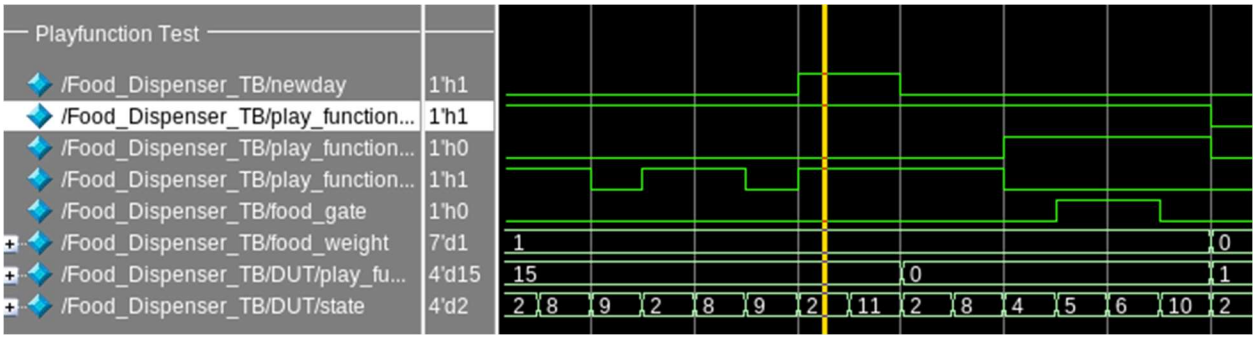


Figure 10: New Day Reset (After Mapped)

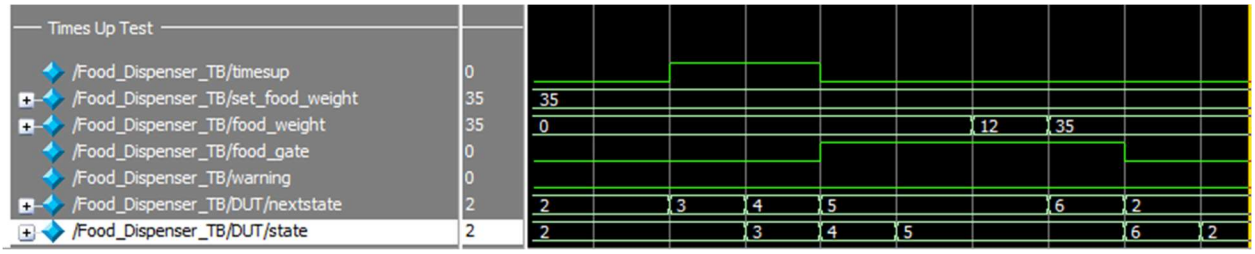


Figure 11: Autofeeding (Before Mapped)

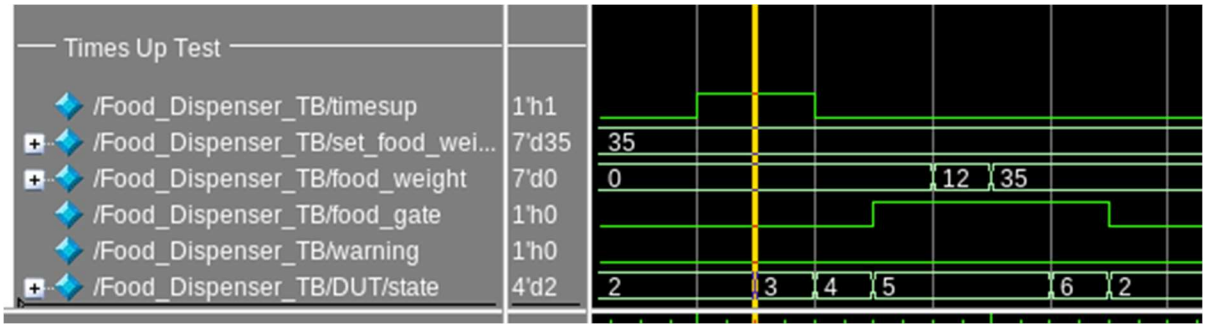


Figure 12: Autofeeding (After Mapped)

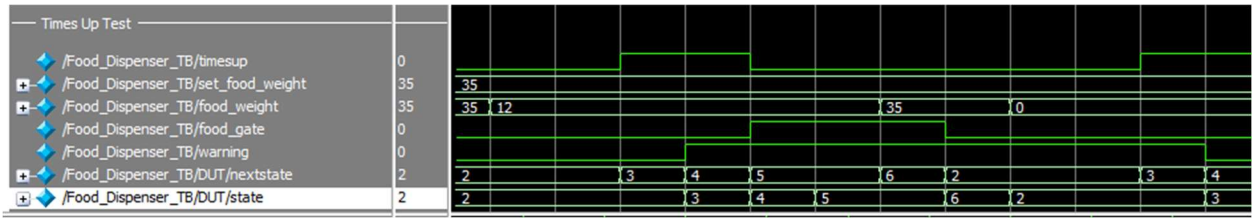


Figure 13: Warning (Before Mapped)

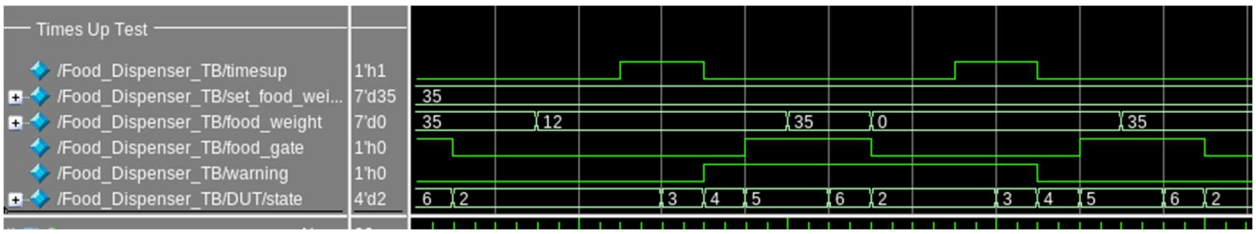


Figure 14: Warning (After Mapped)

Latency Demonstrate:

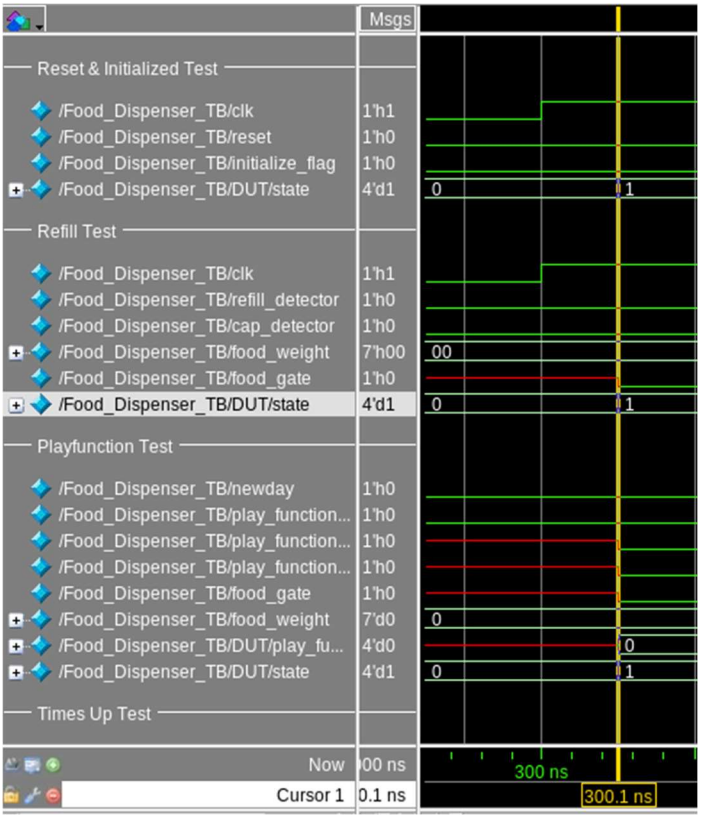


Figure 15: Delay of FSM

When mapping the code to Verilog, the latency simulation is performed. In this case FSM Food Dispenser have 0.1 ns latency from the clock signal. However, the state transition performs the same with the previous system Verilog code, thus the mapped Verilog is satisfied the timing requirement.

Mapped Verilog generated by RTL Compiler

From the previous system Verilog code, I found there is a few latches and thus delete one of the always block and add reset feature to the other. No functional code being added. If needed, please refer to .sv file inside .zip.

```
// Generated by Cadence Encounter(R) RTL Compiler RC14.13 - v14.10-s027_1

// Verification Directory fv/food_dispenser_fsm

module food_dispenser_fsm(reset, clk, timesup, food_weight,
     set_food_weight, refill_detector, cap_detector,
     play_function_pedal, initialize_flag, newday, food_gate, warning,
     play_function_flag, play_function_fail_flag);
  input reset, clk, timesup, refill_detector, cap_detector,
       play_function_pedal, initialize_flag, newday;
  input [6:0] food_weight, set_food_weight;
  output food_gate, warning, play_function_flag,
       play_function_fail_flag;
  wire reset, clk, timesup, refill_detector, cap_detector,
       play_function_pedal, initialize_flag, newday;
  wire [6:0] food_weight, set_food_weight;
  wire food_gate, warning, play_function_flag, play_function_fail_flag;
  wire [3:0] state;
  wire [3:0] play_function_counter;
  wire n_0, n_1, n_2, n_3, n_4, n_5, n_6, n_7;
  wire n_8, n_9, n_10, n_11, n_12, n_13, n_14, n_15;
  wire n_16, n_17, n_18, n_19, n_20, n_21, n_22, n_23;
  wire n_24, n_25, n_26, n_27, n_28, n_29, n_30, n_31;
  wire n_32, n_33, n_34, n_35, n_36, n_37, n_38, n_39;
  wire n_40, n_41, n_42, n_43, n_44, n_45, n_46, n_47;
  wire n_48, n_49, n_50, n_51, n_52, n_53, n_54, n_55;
  wire n_56, n_57, n_58, n_59, n_60, n_61, n_62, n_63;
  wire n_64, n_65, n_66, n_67, n_68, n_69, n_70, n_71;
  wire n_72, n_73, n_74, n_75, n_76, n_77, n_78, n_79;
  wire n_80, n_81, n_82, n_83, n_84, n_85, n_86, n_87;
  wire n_88, n_89, n_90, n_91, n_92, n_93, n_94, n_95;
  wire n_96, n_97, n_98, n_99, n_100, n_101, n_102, n_103;
  wire n_104, n_105, n_106, n_107, n_108, n_109, n_110, n_111;
  wire n_112, n_113, n_114, n_116, n_117, n_118, n_119, n_120;
  wire n_121, n_122, n_123, n_124, n_125, n_126, n_127, n_128;
  wire n_129, n_130, n_131, n_132, n_133, n_134, n_135, n_136;
  wire n_137, n_138, n_139, n_140, n_141, n_142, n_143, n_144;
  wire n_145;
```

```
DFFSNQ_X1 warning_reg(.SN (1'b1), .CLK (clk), .D (n_145), .Q
     (warning));
NAND2_X1 g3725(.A1 (n_144), .A2 (n_83), .ZN (n_145));
NAND4_X1 g3726(.A1 (n_143), .A2 (n_73), .A3 (n_92), .A4 (n_53), .ZN
     (n_144));
AOI22_X1 g3727(.A1 (n_142), .A2 (n_90), .B1 (n_11), .B2 (n_3), .ZN
     (n_143));
AND2_X1 g3728(.A1 (n_141), .A2 (n_121), .Z (n_142));
AOI22_X1 g3729(.A1 (n_140), .A2 (n_123), .B1 (n_139), .B2
     (food_weight[2]), .ZN (n_141));
AOI22_X1 g3730(.A1 (n_137), .A2 (n_44), .B1 (n_127), .B2 (n_138), .ZN
     (n_140));
AOI21_X1 g3731(.A1 (n_122), .A2 (n_138), .B (n_137), .ZN (n_139));
OAI21_X1 g3732(.A1 (n_133), .A2 (food_weight[0]), .B (n_136), .ZN
     (n_137));
AOI21_X1 g3733(.A1 (n_134), .A2 (n_35), .B (n_135), .ZN (n_136));
AOI21_X1 g3735(.A1 (n_132), .A2 (food_weight[0]), .B
     (food_weight[1]), .ZN (n_135));
XNOR2_X1 g3742(.A1 (n_128), .A2 (set_food_weight[3]), .ZN (n_134));
DFFRNQ_X1 \state_reg[0] (.RN (n_130), .CLK (clk), .D (n_129), .Q
     (state[0]));
NAND2_X1 g3739(.A1 (n_131), .A2 (set_food_weight[1]), .ZN (n_133));
AOI21_X1 g3740(.A1 (set_food_weight[1]), .A2 (set_food_weight[0]), .B
     (n_131), .ZN (n_132));
DFFRNQ_X1 \state_reg[1] (.RN (n_130), .CLK (clk), .D (n_126), .Q
     (state[1]));
OR4_X1 g3741(.A1 (n_119), .A2 (n_75), .A3 (n_86), .A4 (n_51), .Z
     (n_129));
XOR2_X1 g3745(.A1 (n_124), .A2 (set_food_weight[2]), .Z (n_131));
NAND2_X1 g3747(.A1 (n_125), .A2 (n_127), .ZN (n_128));
NOR4_X1 g3737(.A1 (n_88), .A2 (n_118), .A3 (n_108), .A4 (n_93), .ZN
     (n_126));
AOI22_X1 g3756(.A1 (n_120), .A2 (n_19), .B1 (n_116), .B2
     (set_food_weight[2]), .ZN (n_125));
AOI21_X1 g3752(.A1 (n_123), .A2 (n_122), .B (n_114), .ZN (n_124));
AOI22_X1 g3754(.A1 (n_120), .A2 (food_weight[3]), .B1 (n_99), .B2
     (food_weight[4]), .ZN (n_121));
NAND2_X1 g3743(.A1 (n_117), .A2 (n_107), .ZN (n_119));
INV_X1 g3748(.I (n_117), .ZN (n_118));
NAND2_X1 g3749(.A1 (n_87), .A2 (n_113), .ZN (n_117));
INV_X1 g3765(.I (n_123), .ZN (n_116));
DFFSNQ_X1 \play_function_counter_reg[3] (.SN (1'b1), .CLK (clk), .D
     (n_110), .Q (play_function_counter[3]));
INV_X1 g3763(.I (n_127), .ZN (n_114));
OAI21_X1 g3766(.A1 (set_food_weight[3]), .A2 (set_food_weight[2]), .B
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     (n_109), .ZN (n_123));
INV_X1 g3767(.I (n_122), .ZN (n_120));
AOI21_X1 g3751(.A1 (n_97), .A2 (n_7), .B (play_function_flag), .ZN
     (n_113));
NAND3_X1 g3764(.A1 (n_111), .A2 (n_112), .A3 (n_4), .ZN (n_127));
OAI21_X1 g3768(.A1 (n_112), .A2 (n_15), .B (n_111), .ZN (n_122));
DFFSNQ_X1 \play_function_counter_reg[2] (.SN (1'b1), .CLK (clk), .D
     (n_102), .Q (play_function_counter[2]));
DFFSNQ_X1 \play_function_counter_reg[0] (.SN (1'b1), .CLK (clk), .D
     (n_96), .Q (play_function_counter[0]));
DFFSNQ_X1 \play_function_counter_reg[1] (.SN (1'b1), .CLK (clk), .D
     (n_104), .Q (play_function_counter[1]));
DFFRNQ_X1 \state_reg[2] (.RN (n_130), .CLK (clk), .D (n_94), .Q
     (state[2]));
DFFSNQ_X1 play_function_flag_reg(.SN (1'b1), .CLK (clk), .D (n_95),
     .Q (play_function_flag));
DFFSNQ_X1 food_gate_reg(.SN (1'b1), .CLK (clk), .D (n_100), .Q
     (food_gate));
OAI21_X1 g3744(.A1 (n_85), .A2 (n_103), .B (n_77), .ZN (n_110));
DFFRNQ_X1 \state_reg[3] (.RN (n_130), .CLK (clk), .D (n_106), .Q
     (state[3]));
INV_X1 g3775(.I (n_111), .ZN (n_109));
NAND2_X1 g3750(.A1 (n_107), .A2 (n_105), .ZN (n_108));
AOI22_X1 g3776(.A1 (n_82), .A2 (set_food_weight[4]), .B1 (n_46), .B2
     (n_98), .ZN (n_111));
NAND4_X1 g3777(.A1 (n_68), .A2 (n_61), .A3 (n_105), .A4 (n_65), .ZN
     (n_106));
OAI22_X1 g3778(.A1 (n_37), .A2 (n_103), .B1 (n_24), .B2 (n_101), .ZN
     (n_104));
OAI22_X1 g3753(.A1 (n_79), .A2 (n_103), .B1 (n_78), .B2 (n_101), .ZN
     (n_102));
INV_X1 g3786(.I (n_89), .ZN (n_100));
AOI22_X1 g3788(.A1 (n_99), .A2 (set_food_weight[4]), .B1 (n_91), .B2
     (n_98), .ZN (n_112));
DFFSNQ_X1 play_function_fail_flag_reg(.SN (1'b1), .CLK (clk), .D
     (n_81), .Q (play_function_fail_flag));
NOR4_X1 g3769(.A1 (n_66), .A2 (n_28), .A3 (n_33), .A4 (n_34), .ZN
     (n_97));
NAND2_X1 g3771(.A1 (n_84), .A2 (n_63), .ZN (n_96));
OAI22_X1 g3772(.A1 (n_41), .A2 (n_80), .B1 (n_1), .B2 (n_69), .ZN
     (n_95));
NAND3_X1 g3774(.A1 (n_71), .A2 (n_74), .A3 (n_59), .ZN (n_94));
AOI21_X1 g3783(.A1 (n_39), .A2 (n_47), .B (n_60), .ZN (n_93));
NAND3_X1 g3785(.A1 (n_91), .A2 (n_90), .A3 (n_17), .ZN (n_92));
AOI22_X1 g3787(.A1 (food_gate), .A2 (n_49), .B1 (n_88), .B2 (n_32),
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     .ZN (n_89));
NAND3_X1 g3757(.A1 (n_87), .A2 (play_function_flag), .A3 (n_45), .ZN
     (n_107));
OAI22_X1 g3800(.A1 (n_43), .A2 (n_72), .B1 (n_30), .B2 (n_70), .ZN
     (n_86));
XOR2_X1 g3755(.A1 (n_58), .A2 (play_function_counter[3]), .Z (n_85));
OAI21_X1 g3781(.A1 (n_8), .A2 (n_76), .B (play_function_counter[0]),
     .ZN (n_84));
NAND2_X1 g3782(.A1 (warning), .A2 (n_56), .ZN (n_83));
NOR2_X1 g3790(.A1 (n_99), .A2 (set_food_weight[5]), .ZN (n_82));
OAI21_X1 g3797(.A1 (n_55), .A2 (n_80), .B (n_52), .ZN (n_81));
XOR2_X1 g3779(.A1 (n_57), .A2 (n_78), .Z (n_79));
NAND2_X1 g3789(.A1 (play_function_counter[3]), .A2 (n_76), .ZN
     (n_77));
NOR2_X1 g3791(.A1 (state[3]), .A2 (n_40), .ZN (n_75));
AOI21_X1 g3792(.A1 (n_73), .A2 (n_23), .B (n_87), .ZN (n_74));
NAND3_X1 g3793(.A1 (n_64), .A2 (n_72), .A3 (play_function_pedal), .ZN
     (n_105));
NAND3_X1 g3794(.A1 (n_67), .A2 (n_70), .A3 (state[3]), .ZN (n_71));
AOI21_X1 g3795(.A1 (n_54), .A2 (state[3]), .B (n_76), .ZN (n_69));
NAND2_X1 g3796(.A1 (n_42), .A2 (n_67), .ZN (n_68));
NAND4_X1 g3799(.A1 (n_18), .A2 (n_29), .A3 (n_16), .A4 (n_20), .ZN
     (n_66));
NAND2_X1 g3801(.A1 (n_50), .A2 (n_62), .ZN (n_103));
NAND2_X1 g3803(.A1 (n_64), .A2 (newday), .ZN (n_65));
NAND2_X1 g3809(.A1 (n_36), .A2 (n_62), .ZN (n_63));
NAND3_X1 g3811(.A1 (n_60), .A2 (n_26), .A3 (play_function_flag), .ZN
     (n_61));
NAND3_X1 g3813(.A1 (n_64), .A2 (n_2), .A3 (refill_detector), .ZN
     (n_59));
INV_X1 g3818(.I (n_99), .ZN (n_91));
NAND2_X1 g3784(.A1 (n_57), .A2 (play_function_counter[2]), .ZN
     (n_58));
NAND4_X1 g3798(.A1 (n_55), .A2 (n_54), .A3 (n_48), .A4 (n_53), .ZN
     (n_56));
NAND2_X1 g3806(.A1 (play_function_fail_flag), .A2 (n_21), .ZN (n_52));
INV_X1 g3807(.I (n_76), .ZN (n_101));
NOR3_X1 g3810(.A1 (n_50), .A2 (n_31), .A3 (n_22), .ZN (n_51));
NAND4_X1 g3815(.A1 (n_48), .A2 (n_9), .A3 (n_6), .A4 (n_130), .ZN
     (n_49));
OAI21_X1 g3816(.A1 (n_12), .A2 (n_38), .B (n_48), .ZN (n_47));
AOI22_X1 g3819(.A1 (n_46), .A2 (set_food_weight[4]), .B1 (n_27), .B2
     (set_food_weight[6]), .ZN (n_99));
NAND4_X1 g3773(.A1 (n_5), .A2 (n_138), .A3 (n_44), .A4
     (food_weight[0]), .ZN (n_45));
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INV_X1 g3833(.I (n_64), .ZN (n_43));
NOR2_X1 g3802(.A1 (n_70), .A2 (n_48), .ZN (n_42));
NAND2_X1 g3804(.A1 (n_70), .A2 (n_88), .ZN (n_41));
AOI21_X1 g3805(.A1 (n_10), .A2 (food_weight[5]), .B (food_weight[6]),
     .ZN (n_90));
OAI21_X1 g3808(.A1 (n_88), .A2 (state[3]), .B (n_53), .ZN (n_76));
AOI21_X1 g3812(.A1 (n_39), .A2 (n_38), .B (n_88), .ZN (n_40));
XOR2_X1 g3817(.A1 (n_25), .A2 (play_function_counter[1]), .Z (n_37));
NOR2_X1 g3820(.A1 (n_54), .A2 (play_function_counter[0]), .ZN (n_36));
INV_X1 g3825(.I (n_80), .ZN (n_62));
NAND2_X1 g3827(.A1 (n_34), .A2 (n_33), .ZN (n_35));
NOR2_X1 g3828(.A1 (n_31), .A2 (reset), .ZN (n_32));
NOR2_X1 g3829(.A1 (n_31), .A2 (state[1]), .ZN (n_87));
INV_X1 g3830(.I (n_30), .ZN (n_67));
NOR3_X1 g3834(.A1 (n_54), .A2 (state[2]), .A3 (state[3]), .ZN (n_64));
AOI22_X1 g3840(.A1 (n_14), .A2 (set_food_weight[1]), .B1 (n_44), .B2
     (set_food_weight[2]), .ZN (n_29));
XNOR2_X1 g3841(.A1 (n_27), .A2 (food_weight[5]), .ZN (n_28));
INV_X1 g3860(.I (n_31), .ZN (n_60));
INV_X1 g3856(.I (n_54), .ZN (n_26));
NOR2_X1 g3821(.A1 (n_25), .A2 (n_24), .ZN (n_57));
NOR2_X1 g3822(.A1 (n_50), .A2 (state[3]), .ZN (n_73));
NAND2_X1 g3823(.A1 (state[2]), .A2 (n_22), .ZN (n_23));
NAND2_X1 g3824(.A1 (n_88), .A2 (n_53), .ZN (n_21));
NAND2_X1 g3826(.A1 (state[3]), .A2 (n_53), .ZN (n_80));
NAND2_X1 g3831(.A1 (n_88), .A2 (n_39), .ZN (n_30));
AOI22_X1 g3837(.A1 (n_19), .A2 (food_weight[2]), .B1 (n_13), .B2
     (set_food_weight[0]), .ZN (n_20));
AOI22_X1 g3838(.A1 (n_138), .A2 (set_food_weight[3]), .B1 (n_17), .B2
     (set_food_weight[4]), .ZN (n_18));
AOI22_X1 g3839(.A1 (n_15), .A2 (food_weight[3]), .B1 (n_98), .B2
     (food_weight[4]), .ZN (n_16));
NOR2_X1 g3858(.A1 (n_27), .A2 (set_food_weight[6]), .ZN (n_46));
NOR2_X1 g3843(.A1 (n_14), .A2 (set_food_weight[1]), .ZN (n_34));
NOR2_X1 g3842(.A1 (n_13), .A2 (set_food_weight[0]), .ZN (n_33));
INV_X1 g3846(.I (n_50), .ZN (n_12));
INV_X1 g3851(.I (n_10), .ZN (n_11));
NAND2_X1 g3855(.A1 (state[0]), .A2 (n_0), .ZN (n_55));
NAND2_X1 g3859(.A1 (n_39), .A2 (state[1]), .ZN (n_9));
NOR2_X1 g3862(.A1 (n_48), .A2 (state[1]), .ZN (n_8));
XNOR2_X1 g3835(.A1 (food_weight[6]), .A2 (set_food_weight[6]), .ZN
     (n_7));
NAND2_X1 g3857(.A1 (n_6), .A2 (state[1]), .ZN (n_54));
NAND2_X1 g3861(.A1 (state[2]), .A2 (n_48), .ZN (n_31));
NOR4_X1 g3814(.A1 (food_weight[4]), .A2 (food_weight[1]), .A3
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      (food_weight[6]), .A4 (food_weight[5]), .ZN (n_5));
  NOR3_X1 g3832(.A1 (refill_detector), .A2 (timesup), .A3 (newday), .ZN
      (n_72));
  NAND4_X1 g3836(.A1 (play_function_counter[1]), .A2
      (play_function_counter[2]), .A3 (play_function_counter[3]), .A4
      (play_function_counter[0]), .ZN (n_70));
  NAND2_X1 g3854(.A1 (set_food_weight[3]), .A2 (set_food_weight[2]),
      .ZN (n_4));
  NOR2_X1 g3844(.A1 (state[1]), .A2 (initialize_flag), .ZN (n_38));
  NOR2_X1 g3849(.A1 (food_weight[6]), .A2 (food_weight[5]), .ZN (n_3));
  NOR2_X1 g3853(.A1 (state[2]), .A2 (reset), .ZN (n_53));
  NOR2_X1 g3848(.A1 (state[0]), .A2 (state[1]), .ZN (n_88));
  NOR2_X1 g3850(.A1 (refill_detector), .A2 (cap_detector), .ZN (n_22));
  NAND2_X1 g3852(.A1 (set_food_weight[6]), .A2 (set_food_weight[5]),
      .ZN (n_10));
  NAND2_X1 g3845(.A1 (state[1]), .A2 (play_function_counter[0]), .ZN
      (n_25));
  NAND2_X1 g3847(.A1 (state[0]), .A2 (state[1]), .ZN (n_50));
  INV_X1 g3877(.I (reset), .ZN (n_130));
  INV_X1 g3872(.I (food_weight[1]), .ZN (n_14));
  INV_X1 g3871(.I (food_weight[4]), .ZN (n_17));
  INV_X1 g3868(.I (play_function_counter[2]), .ZN (n_78));
  INV_X1 g3880(.I (food_weight[2]), .ZN (n_44));
  INV_X1 g3874(.I (newday), .ZN (n_2));
  INV_X1 g3873(.I (food_weight[3]), .ZN (n_138));
  INV_X1 g3863(.I (state[2]), .ZN (n_39));
  INV_X1 g3879(.I (set_food_weight[4]), .ZN (n_98));
  INV_X1 g3878(.I (set_food_weight[3]), .ZN (n_15));
  INV_X1 g3865(.I (state[3]), .ZN (n_48));
  INV_X1 g3869(.I (play_function_counter[1]), .ZN (n_24));
  INV_X1 g3867(.I (play_function_flag), .ZN (n_1));
  INV_X1 g3875(.I (set_food_weight[2]), .ZN (n_19));
  INV_X1 g3866(.I (state[0]), .ZN (n_6));
  INV_X1 g3870(.I (food_weight[0]), .ZN (n_13));
  INV_X1 g3864(.I (state[1]), .ZN (n_0));
  INV_X1 g3876(.I (set_food_weight[5]), .ZN (n_27));
endmodule
```