### SYSC 5104- Modelling Discrete-Event Systems Using DEVS

### (Fall 2017)

#### Assignment1: Water Level Indicator

# Adebusola Balogun 101027260

Carleton University

**Part I**

The Water Level Indicator measures the level of water in overhead tanks, wells or standpipes. This model describes the functionality of a water level indicator in a tank, it consists of three submodels (ADC-Decide, Buzzer and Display Panel) and three outputs; display level, LED outputs and buzzer. The water level indicator detects and indicates water level, it also prevents pump damage and water overflow by alerting the user at both states. The Sensor, S reads the level of the water in the tank, sensor value ranges from 0 to 11, when the water level hits 3 and below, it gives a buzzer output and a red LED output, indicating that the water needs to be refilled. It gives another buzzer output when the water level hits 10 and above, indicating water overflow.

The Water Level Indicator comprises of four atomic models: ADC, Color Decider, Display Panel and Buzzer. The ADC and Color Decider form a coupled model, called “ADC-Decide”. The diagram below in Figure 1 describes the relationship between each submodel.

WATER LEVEL INDICATOR

ADC-Decide

SENSOR

CDIn1

DigOut

greenOut

SIn

Display Panel

DPIn1

CDOut

Color Decider

CDIn2

LevelOut

ADC

yellowOut

DPIn2

L\_Out

ToBuzz

redOut

DPLevel

buzzOut

buzzIn

Buzzer

OUT

Figure 1. Water Level Indicator Model

Conceptual Model Description

The model comprises of the following;

1. Sensor: responsible for reading the water level, it is directly connected to the ADC, and also serves as the input to the model (SIn). The sensor has values between 0 & 11.
2. ADC-Decide: the coupled model comprises of an Analog-to-Digital Converter (ADC) and a Color decider, the ADC takes the sensor readings as input and produces 2 outputs; DigOut and LevelOut which now serves as input to the Color Decider.

* Analog-to-Digital Converter (ADC); this submodel gives two outputs, one for the Color decider and the other that is finally transferred to the display panel which produces a water level value output. The output (DigOut) that goes into the Color decider is determined as follows;

{(If SIn is between 0 & 3, then DigOut=0), (If SIn is between 3 & 7, then DigOut=1), (If SIn is between 7 & 10, then DigOut=2), (If SIn is between 10 & 11, then DigOut=3)}.

* Color Decider; the decision of what LED output is taken is processed in this submodel, only 1 output is given (CDOut) which has the range of values and colors decided on each value. When the CDIn1 input is taken into the Color decider, it determines the colour as follows;

{(If DigOut = 0 & DigOut = 3, CDOut =1), (If DigOut=1, CDOut = 2), (If DigOut=2, CDOut=3)}.

The other output (L\_Out) from the Color decider is further transferred into the display panel.

1. Display Panel: indicates the digital water level value and the corresponding LED outputs. The DPIn1 input from the Color decider now produces 3 LED Outputs (greenOut, yellowOut and redOut). The LED is red at two states; when the water is below level 3, indicating low water level and also, when the water is above level 10, indicating water overflow. The LED is yellow when the water level is between 3 & 7, and there is a green LED output when the water is between 7& 10.

The other output from the Display Panel is the DPLevel; this is the digital output value that the user can view, the value ranges from 0 to 11.

1. Buzzer: alerts the user when the water hits 3 and below or when it hits 10 (at LED red output), to avoid pump damage and water overflow respectively. The buzzer is connected to the ADC, output from the ADC (buzzIn) produces an output (buzzOut) at two states; when buzzIn = 0 and when buzzIn = 3, buzzOut = 1.

**Part II**

**Formal Specifications**

The formal specifications <S, X, Y, δint, δext, λ, ta> and the state diagrams for both the atomic and coupled models are given as follows:

**Atomic Models:**

1. ADC

DigOut

ADC

LevelOut

SIn

ToBuzz

S = {passive, active}

X = {SIn}

Y = {DigOut, levelOut, ToBuzz}

δint (active) = passive

δext (SIn, passive) = active

Level = SIn

λ(active)

{If 0 <= Level <= 3, send 0 to DigOut, ToBuzz

If 4 <= Level <=7, send 1 to DigOut

If 8 <= Level <= 10, send 2 to DigOut

If 10 <= Level <= 11, send 3 to DigOut, ToBuzz

}

ta(passive) = INFINITY

ta(active) = preparationTime

1. COLOR DECIDER

CDIn1

CDOut

COLOR DECIDER

L\_Out

CDIn2

S = {passive, active}

X = {CDIn1, CDIn2}

Y = {CDOut, L\_Out}

δint (active) = passive

δext (CDIn, passive) = active

Disp = CDIn1

Clevel = CDIn2

λ(active)

{If (Disp == 0) || (Disp == 3), send 1 to CDOut,

ATM

If (Disp == 1), send 2 to CDOut,

If (Disp ==2), send 3 to CDOut

}

ta(passive) = INFINITY

ta(active) = decisionTime

1. DISPLAY PANEL

greenOut

DISPLAY PANEL

yellowOut

DPIn1

redOut

DPIn2

DPLevel

S = {passive, active}

X = {DPIn1, DPIn2}

Y = {greenOut, yellowOut, redOut, DPLevel}

δint (active) = passive

δext (DPIn, passive) = active

Color = DPIn1

D\_level = 0

λ(active)

{If Color == 1, send 1 to redOut,

If Color == 2, send 1 to greenOut,

If Color == 3, send 1 to yellowOut,

}

ta(passive) = INFINITY

ta(active) = displayTime

1. BUZZER

BUZZER

buzzOut

buzzIn

S = {passive, active}

X = {buzzIn}

Y = {buzzOut}

δint (active) = passive

δext (buzzIn, passive) = {

active

B = buzzIn

}

λ(active)

{If B == 0, send 1 to buzzOut,

If B == 3, send 1 to buzzOut

}

ta(passive) = INFINITY

ta(active) = buzzTime

**Coupled Models:**

1. ADC-DECIDE: The coupled model represents the operational model of the Analog-to-Digital Converter (ADC) and the Color Decider.

CDOut

ADC-DECIDE

SIn

L\_Out

Input Ports: SIn

Output Ports: CDOut, L\_Out

ADC-DECIDE Formal specifications:

ADC-DECIDE = <X, Y, D, EIC, EOC, IC, SELECT>

X = {SIn}

Y = {CDOut, L\_Out}

D= {ADC, Colordecider}

EIC = {(ADC-Decide.in, ADC.SIn )}

EOC = {(Colordecider.CDOut, Colordecider.L\_Out, ADC-Decide.CDOut,

ADC-Decide.L\_Out)}

IC = {(ADC.DigOut, ColorDecider.CDIn1) ,

(ADC.LevelOut, ColorDecider.CDIn2)}

SELECT: Priority order (Descending) :ColorDecider,ADC.

1. WATER LEVEL INDICATOR: The coupled model represents the input and output generated from the entire model.

greenOut

WATER LEVEL INDICATOR

yellowOut

SIn

redOut

DPLevel

buzzOut

Input Ports: SIn

Output Ports: greenOut, yellowOut, redOut, DPLevel, buzzOut

WATER LEVEL INDICATOR Formal specifications:

WATER LEVEL INDICATOR = <X, Y, D, EIC, EOC, IC, SELECT>

X = {SIn}

Y = {greenOut, yellowOut, redOut, DPLevel, buzzOut}

D={ADC-Decide, Buzzer, DisplayPanel}

EIC = {WLI.in, ADC.SIn}

EOC = {(DisplayPanel.greenOut, DisplayPanel.yellowOut, DisplayPanel.redOut, DisplayPanel.DPLevel,Buzzer.buzzOut)}

IC = {(ADC-Decide.CDOut, DisplayPanel.DPIn1),

(ADC-Decide.L-Out, DisplayPanel.DPIn2),

(ADC-Decide.ToBuzz,Buzzer.buzzIn) }

SELECT: {ADC-Decide, WLI} = WLI

{Buzzer, WLI} = WLI

{DisplayPanel,WLI}=WLI

**Part III**

**Testing Strategies**

The following describes the inputs and outputs for the test on each model, to evaluate the performance of the atomic models and the Water Level Indicator, in general.

1. **ADC**

**Input**

00:00:10:00 SIn 0

00:00:30:00 SIn 2

00:00:45:00 SIn 3

00:00:52:00 SIn 4

00:01:25:00 SIn 5

00:01:35:00 SIn 6

00:01:55:00 SIn 7

00:02:10:00 SIn 8

00:02:30:00 SIn 9

00:02:45:00 SIn 10

00:02:10:00 SIn 11

00:02:15:00 SIn 26

00:00:85:00 SIn 38

**Output**

00:00:20:000 levelout 0

00:00:20:000 digout 0

00:00:20:000 tobuzz 0

00:00:40:000 levelout 2

00:00:40:000 digout 0

00:00:40:000 tobuzz 0

00:01:02:000 levelout 4

00:01:02:000 digout 1

00:01:45:000 levelout 6

00:01:45:000 digout 1

00:02:05:000 levelout 7

00:02:05:000 digout 1

00:02:40:000 levelout 9

00:02:40:000 digout 2

00:02:55:000 levelout 10

00:02:55:000 digout 2

00:02:55:000 digout 3

00:02:55:000 tobuzz 3

The 2 outputs (levelout, digout) are given for each input value in the model, the “tobuzz” output produces just two values (0 &3), for low and high-water level alerts respectively.

1. **COLOR DECIDER**

**Input**

00:00:10:00 CDIn1 1

00:00:30:00 CDIn1 2

00:00:45:00 CDIn1 3

00:00:52:00 CDIn1 4

00:01:25:00 CDIn1 0

00:01:35:00 CDIn1 6

00:01:55:00 CDIn1 7

00:02:10:00 CDIn1 8

00:02:30:00 CDIn1 9

00:02:45:00 CDIn1 10

00:02:10:00 CDIn1 11

00:02:15:00 CDIn1 26

00:00:10:00 CDIn2 1

00:00:30:00 CDIn2 2

00:00:45:00 CDIn2 3

00:00:52:00 CDIn2 4

00:01:25:00 CDIn2 5

00:01:35:00 CDIn2 6

00:01:55:00 CDIn2 7

00:02:10:00 CDIn2 8

00:02:30:00 CDIn2 9

00:02:45:00 CDIn2 10

00:02:20:00 CDIn2 11

00:02:15:00 CDIn2 0

**Output**

00:00:15:000 l\_out 1

00:00:15:000 cdout 2

00:00:35:000 l\_out 2

00:00:35:000 cdout 3

00:00:50:000 l\_out 3

00:00:50:000 cdout 1

00:00:57:000 l\_out 4

00:01:30:000 l\_out 5

00:01:30:000 cdout 1

00:01:40:000 l\_out 6

00:02:00:000 l\_out 7

00:02:25:000 l\_out 11

00:02:35:000 l\_out 9

00:02:50:000 l\_out 10

CDIn1 and CDIn2 both produce their respective values of CDOut and L\_Out for each values of their inputs. CDOut only ranges from 1 to 3, indicating the 3 different LED colors, and the L\_Out produces the display level values, from 0 to 11.

1. **DISPLAY PANEL**

**Input**

00:00:10:00 DPIn1 1

00:00:30:00 DPIn1 2

00:00:45:00 DPIn1 3

00:00:52:00 DPIn1 4

00:01:25:00 DPIn1 0

00:01:35:00 DPIn1 6

00:01:55:00 DPIn1 7

00:02:10:00 DPIn1 8

00:02:30:00 DPIn1 9

00:02:45:00 DPIn1 10

00:02:10:00 DPIn1 11

00:02:15:00 DPIn1 26

00:00:10:00 DPIn2 1

00:00:30:00 DPIn2 2

00:00:45:00 DPIn2 3

00:00:52:00 DPIn2 4

00:01:25:00 DPIn2 5

00:01:35:00 DPIn2 6

00:01:55:00 DPIn2 7

00:02:10:00 DPIn2 8

00:02:30:00 DPIn2 9

00:02:45:00 DPIn2 10

00:02:20:00 DPIn2 11

00:02:15:00 DPIn2 0

**Output**

00:00:12:000 dplevel 1

00:00:12:000 redout 1

00:00:32:000 dplevel 2

00:00:32:000 greenout 1

00:00:47:000 dplevel 3

00:00:47:000 yellowout 1

00:00:54:000 dplevel 4

00:01:27:000 dplevel 5

00:01:37:000 dplevel 6

00:01:57:000 dplevel 7

00:02:12:000 dplevel 8

00:02:17:000 dplevel 0

00:02:22:000 dplevel 11

00:02:32:000 dplevel 9

00:02:47:000 dplevel 10

The two inputs taken into the display panel now produces final outputs to the user; the respective LED outputs to each display level value and the actual level of water in the tank.

1. **BUZZER**

**Input**

00:00:10:00 buzzIn 3

00:00:30:00 buzzIn 3

00:00:45:00 buzzIn 3

00:00:52:00 buzzIn 4

00:01:25:00 buzzIn 0

00:01:35:00 buzzIn 6

00:01:55:00 buzzIn 7

00:02:10:00 buzzIn 8

00:02:30:00 buzzIn 3

00:02:45:00 buzzIn 0

00:02:10:00 buzzIn 0

00:02:15:00 buzzIn 0

**Output**

00:00:20:000 buzzout 1

00:00:40:000 buzzout 1

00:02:25:000 buzzout 1

00:02:40:000 buzzout 1

00:02:55:000 buzzout 1

The buzzer Output (buzzout=1) is given at two states; when the water level (buzzIn) is between 0 &3; indicating low water level and when the water level is between 10 & 11; indicating high water level. Thereby alerting the user at both states, the buzzer sounds for 10 seconds.

**WATER LEVEL INDICATOR**

**Input**

00:00:10:00 SIn 0

00:00:50:00 SIn 4

00:02:50:00 SIn 11

00:03:30:00 SIn 8

**Output**

00:00:27:000 dplevel 0

00:00:27:000 redout 1

00:00:30:000 buzzout 1

00:00:48:000 dplevel 2

00:00:48:000 redout 1

00:00:51:000 buzzout 1

00:01:09:000 dplevel 4

00:01:09:000 greenout 1

00:01:54:000 dplevel 6

00:01:54:000 greenout 1

00:02:12:000 dplevel 7

00:02:12:000 greenout 1

00:02:47:000 dplevel 9

00:02:47:000 yellowout 1

00:03:02:000 dplevel 10

00:03:02:000 redout 1

00:03:05:000 buzzout 1

The behavior of the water level indicator is described in the corresponding range of outputs produced at the different inputs taken into the model.