

# Digital Logic Project Introduction

## CS207\_2024\_Fallterm@SUSTECH

### I. Scoring Guidelines:

**1. Group Project Score Calculation:**  $\text{Group Score} = \text{Basic Score} * \text{Defense Coefficient} + \text{Project Report} + \text{Code Standards} + \text{Bonus Points}$

**(1) Basic Score: 85**

**Project Documentation: 10**

**Code Standards: 2**

**Bonus Points: 15**

**(2) Code Standards:** structured modeling, consistent naming conventions, necessary comments)

**(3) Defense Coefficient:**

① **Early Defense:** Complete project code uploaded by Monday of Week **15, 11:59 PM**; defense completed during Week **15 lab: 1.05**

② **Regular Defense:** Complete project code uploaded by Monday of Week **16, 11:59 PM**; defense completed during Week **16 lab: 1**

③ **Late Defense:** Complete project code uploaded by Monday of Week **17, 11:59 PM**; defense completed by **Saturday of Week 17: 0.7**

**2. Individual Project Score Calculation:**  $\text{Individual Score} = \text{Group Project Score} * \text{Group Size} * \text{Individual Contribution Ratio} + \text{Defense Performance}$

**(1) Defense Performance Score: 3**

**(2) Contribution Ratio Limits:** Maximum contribution difference within the group is **10%**. For a two-person group, max distribution is 45:55; for three-person, max is 30:30:40.

### II. Project Defense Guidelines:

**1.** During the defense, download the code from the Blackboard site, compile and test on the **board** on site. For functionality issues, debugging on-site is allowed, but correctly debugged functionalities earn only half points.

**2. Attendance:** All members must attend the defense. **Absentees** receive a score of **0**, and the group member count is adjusted accordingly (e.g., in a three-person group with one absentee, the group is recalculated as a two-person group).

**3.** If on-board testing is not feasible and **only simulation testing** (the group needs to build its own testbench to carry out the test) is possible, then total group score is multiplied by **0.6**.

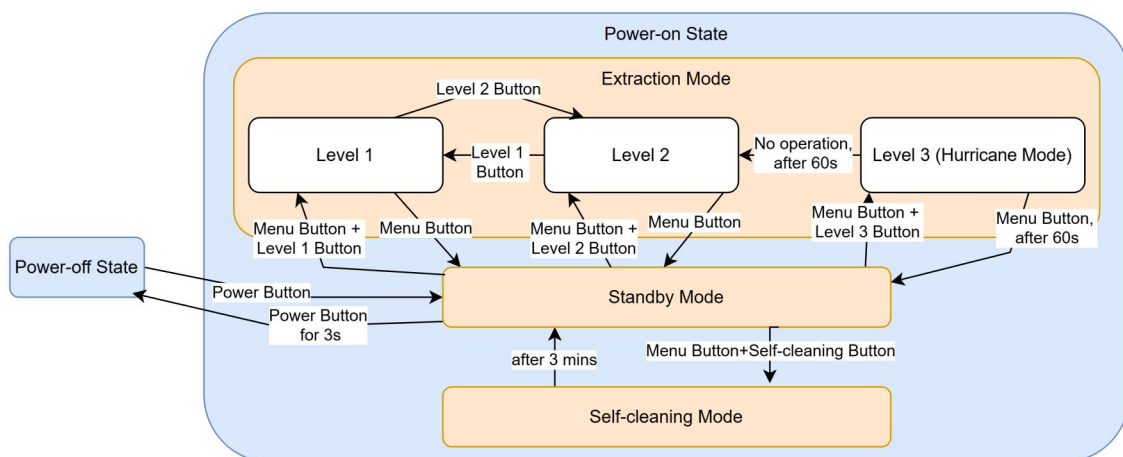
### III. Submission Guidelines:

1. Before uploading the project code, **delete** the **.run folder** and **compress** the remaining files.
2. Submit the code (code submission deadlines align with the defense coefficient section) and report (report submission deadlines is **Monday of Week 17, 11:59 PM**) through the specific submission channels on Blackboard.
3. Only **one set** of project code and report needs to be submitted **per group**, not by each individual.

## Topic1. Control circuit of the kitchen exhaust hood

**Design a Kitchen Exhaust Hood:** The kitchen exhaust hood has two states: power-on and power-off. In the power-on state, it offers three operating modes: standby mode, extraction mode, and self-cleaning mode. In extraction mode, there are three levels: Level 1, Level 2, and Level 3 (hurricane mode). The kitchen exhaust hood uses the self-cleaning mode to clean itself and provides a cleaning reminder after prolonged or frequent use. When powered on, users can toggle the lighting function on or off at any time, and the hood continuously displays the time. In standby mode, the hood can enter either extraction mode or self-cleaning mode, and users can manually set the time. Through settings, users can enable a special gesture control to power the hood on and off within a specified time. (The image below shows the mode-switching options for the kitchen exhaust hood.)

Note: In the project, please make appropriate use of input and output devices to operate and indicate different states and modes. Use a 7-segment display to show time and countdown information. Once the countdown begins, display only the countdown time without showing the current time.



### 1. Parameters

- (1) **Factory Settings:** All times mentioned in the following descriptions (the 10-hour accumulated working time related to the cleaning smart reminder, the 3-minute self-cleaning operation time, the 60-second countdown in hurricane mode, and the 5-second valid time for the power-on/off gesture simulation) are set as factory defaults. For testing purposes, these time values can be

appropriately adjusted and shortened during the design of the specific plan (any adjustments must be explained in the project summary document and prior to testing).

- (2) Individual parameters can be set through the advanced settings function (refer to the "Advanced Settings" item in the "Auxiliary Functions" section).
- (3) The circuit supports restoring these parameters to their factory default values by pressing the **"Restore Factory Settings" button**.

## 2. Power on/off **【15 (10 + 5 bonus)】**

- (1) **Power on:** Short press the **power button** to turn on the kitchen exhaust hood. After powering on, the hood will complete initialization.
  - a) Initialization of the kitchen exhaust hood: The current time will be 0 hours, 0 minutes, and 0 seconds. If you query the accumulated usage time of the kitchen exhaust hood, the result will be 0. **【5】**
- (2) **Power off:** Long press the **power button** for **3 seconds** to turn off the kitchen exhaust hood. After power off, all buttons will be disabled. **【5】**
- (3) Simulate gesture control using buttons to power on/off : **【5: bonus】**
  - a) First, press the **left button** to start a **5-second countdown**. Press the **right button** within the 5 seconds to **power on**.
  - b) First, press the **right button** to start a **5-second countdown**. Press the **left button** within the 5 seconds to **power off**.
  - c) If the second button press is not completed within the 5-second countdown, the operation will be considered invalid (e.g., if the left button is pressed but the right button is not pressed within 5 seconds, the power-on operation will fail).

## 3. Mode switching **【10】**

- (1) After the kitchen exhaust hood is powered on, it enters standby mode. In standby mode, press the **menu button** to prepare for mode switching, and then press different buttons to enter different modes (extraction mode: Level 1, Level 2, Level 3; self-cleaning mode). For example, in standby mode, press the menu button first, then press the Level 1 button to enter the extraction mode at Level 1. **【5】**
- (2) Returning to standby mode from different working modes: **【5】**
  - a) The extraction modes at Level 1 and Level 2 can return to standby mode directly by pressing the menu button.
  - b) The extraction mode at Level 3 will start a 60-second countdown after pressing the menu button, and it will return to standby mode after the countdown expires.
  - c) The self-cleaning mode will start a 3-minute countdown after it begins operating, and it will return to standby mode after the countdown expires.

## 4. Extraction Function **【20】**

- (1) In standby mode, press the **menu button** to enter mode switching, then press the **speed level button** (Level 1, Level 2, Level 3) to enter different fan speed levels in extraction mode.
- (2) When entering any extraction mode, the accumulated working time starts. When exiting the extraction mode, the timer stops and stores the cumulative working time of the hood after being powered on. This time will be used for the smart reminder function related to self-cleaning. **【10】**

- (3) **Level 1:** Press the **Level 1 button** to set the kitchen exhaust hood to Level 1 speed. Press the menu button to switch back to standby mode.
- (4) **Level 2 :** Press the **Level 2 button** to set the kitchen exhaust hood to Level 2 speed. Press the menu button to switch back to standby mode.
- (5) In both Level 1 and Level 2 extraction modes, you can switch between the levels by pressing the corresponding speed buttons.
- (6) **Level 3 (Hurricane Mode):** Press the **Level 3 button** to set the kitchen exhaust hood to Level 3 speed. **【10】**
  - a) Hurricane mode can only be used once after each power-on. If the Level 3 button is pressed multiple times, only the first press will be effective; subsequent presses will be ignored.
  - b) Pressing the Level 3 button will set the kitchen exhaust hood to Level 3 (Hurricane mode) and start a 60-second countdown for hurricane mode. After the countdown ends, it will automatically switch to Level 2 mode to continue operation.
  - c) If the 60-second countdown in Hurricane mode has not finished, pressing the menu button to force standby will start a 60-second countdown to return to standby mode. Once the countdown ends, the system will automatically enter standby mode.

## 5. Self-Cleaning Function **【5】**

- (1) **Self-Cleaning Mode:**
  - a) The self-cleaning mode can only be accessed from standby mode.
  - b) In standby mode, press the **menu button**, then press the **self-cleaning button** to enter self-cleaning mode. A 3-minute countdown will begin. Once the countdown ends, a reminder will notify that the self-cleaning is complete, and the system will automatically return to standby mode.

## 6. Auxiliary Functions **【40】**

- (1) **Lighting Function:** The lighting function can be turned on or off in any mode after powering on. **【2】**
- (2) **Time Function: **【10】****
  - a) Time Display: After powering on, the current time (hours, minutes, seconds) is dynamically displayed.
  - b) Time Setting: In standby mode, the time can be adjusted by entering the hour and minute settings.
- (3) **Smart Reminder:** In extraction mode, the accumulated working time of the kitchen exhaust hood is tracked. When the accumulated time reaches a specified value (default is 10 hours), in standby mode, the hood will remind the user via an output device to perform manual cleaning or activate self-cleaning. After each self-cleaning session, the accumulated working time of the hood is reset to zero. After manual cleaning, the user can reset the accumulated time using the manual switch. **【10】**
- (4) **Advanced Settings:** In standby mode, certain parameters can be reconfigured. **【10】**
  - a) Set the upper limit for the usage duration that triggers the smart reminder. This setting will take effect once configured; if not set, the factory default value will be used.
  - b) Set the valid time for gesture control (in seconds). For example, the default is 5 seconds, but the user can adjust it to 7 seconds (longer) or 2 seconds (shorter).

- (5) **Query Function:** In standby mode, users can query the following: **[8]**
- a) The accumulated working time in extraction mode.
  - b) The valid time for gesture control.

**Bonus Points:**

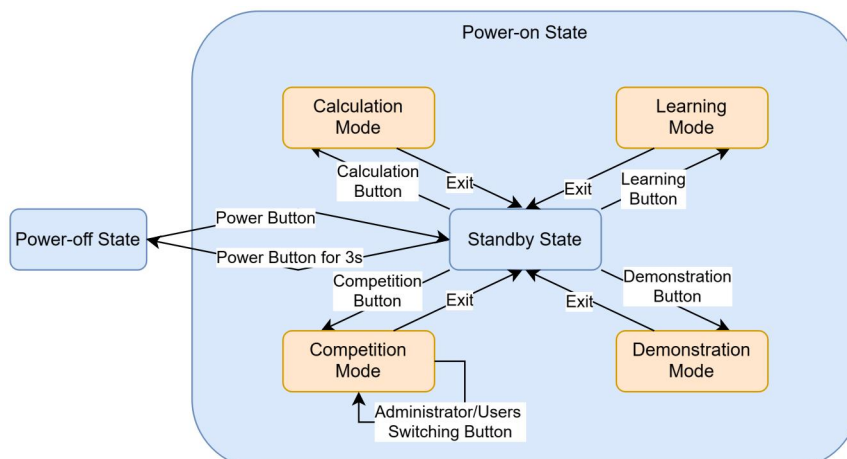
1. Simulate Gesture Control for Power On/Off Using Button Operations: +5
2. Use of Input Devices Other Than DIP Switches and Button Switches (to enhance user convenience): +5
3. Use of Output Devices Other Than Seven-Segment Displays and LEDs (to facilitate result viewing): +5

## Topic2. Basic Computational Learning Device for Programmers

**Design of a Basic Computational Learning Device for Programmers:** The basic computational learning device for programmers has two main states: power-on and power-off. In the power-on state, there are four operational modes: calculation mode, learning mode, competition mode, and demonstration mode. (The mode-switching diagram is shown below.)

- **Calculation Mode:** The device performs various computations and outputs the results.
- **Learning Mode:** The device guides users to specify their own problems and input answers, then evaluates the answers and tracks learning progress.
- **Competition Mode:** This mode allows an administrator to set up questions, supports multiple participants in answering, and evaluates competition results based on accuracy and response time.
- **Demonstration Mode:** The device demonstrates the steps and results of multiplication calculations.

Note: The learning device has two types of users: administrator users and regular users. In competition mode, administrators have the privilege to set questions, while regular users can only participate by answering questions.



## 1. Initialization 【5】

- (1) Initialization refers to data setup when the program first runs on the development board or after pressing the **reset button** (to be implemented manually), which resets all data.
- (2) After initialization, the specific setup for the basic computational learning device in competition mode is that all participants' data is reset to zero.

## 2. Power On/Off and Mode Switching 【15】

- (1) **Power On:** Press the **power button** to turn on the device. 【5】
- (2) **Power Off: Long press** the **power button** for 3 seconds to turn off the device. 【5】
- (3) After powering on, the learning device enters standby state. Only in standby state can the device switch to different operational modes. The four modes (calculation, learning, competition, demonstration) cannot be directly switched between each other. 【5】

## 3. Calculation Mode 【20】

Note: The operands are displayed on the LED lights, and the operation results are shown on the 7-segment display or LED lights as specified.

- (1) **Binary Conversion Operation:** Enter an 8-bit binary number (unsigned) and convert it to octal, decimal, and hexadecimal. Display the conversion results on the 7-segment display. 【6】
- (2) **Signed Arithmetic Operations:** Enter two signed numbers in two's complement form to perform addition and subtraction (input through DIP switches, output on the 7-segment display). 【8】
  - a) Input a and b, and output the result of **a + b** as a **signed** calculation.
  - b) Input a and b, and output the result of **a - b** as a **signed** calculation.
  - c) Example: An input of 8'b0000\_1111 corresponds to the signed number 15, while 8'b1000\_1111 corresponds to -113.
- (3) **Shift Operations:** Enter two numbers to perform different types of shift operations (input through DIP switches, output on LED lights). 【2】
  - a) Input a and b, and output the result of a **arithmetic left-shifted** by b bits (b as an **unsigned** number).
  - b) Input a and b, and output the result of a **arithmetic right-shifted** by b bits (b as an **unsigned** number).
  - c) Input a and b, and output the result of a **logically left-shifted** by b bits (b as an **unsigned** number).
  - d) Input a and b, and output the result of a **logically right-shifted** by b bits (b as an **unsigned** number).
- (4) **Bitwise Operations:** Enter two numbers and output the results of bitwise operations (input through DIP switches, output on LED lights). 【2】
  - a) Input a and b, and output the result of **bitwise AND**.
  - b) Input a and b, and output the result of **bitwise OR**.
  - c) Input a and b, and output the result of **bitwise NOT**.
  - d) Input a and b, and output the result of **bitwise XOR**.
- (5) **Logical Operations:** Enter two numbers and output the results of logical operations (input through DIP switches, output on LED lights). 【2】
  - a) Input a and b, and output the result of **logical AND**.
  - b) Input a and b, and output the result of **logical OR**.
  - c) Input a and b, and output the result of **logical NOT**.

d) Input a and b, and output the result of **logical XOR**.

#### 4. **Learning Mode: Guiding Users in Calculations, Answer Evaluation, and Learning Progress Statistics** 【10】

Note: The types of calculations in learning mode are the same as those in calculation mode.

##### (1) **Guiding Users to Enter Questions:**

a) Guide the user to set the calculation type by entering the corresponding operation type code.

b) After setting the calculation type, the device prompts the user to enter the operation data (e.g., for  $a + b$ , prompt the user to enter a; once a is finished entering, prompt for b).

(2) **Guiding Users to Enter Results:** Once the question is finished entering, the device prompts the user to input the calculated result.

(3) **Answer Evaluation:** The device evaluates the user's provided result and outputs a judgment (Correct/Incorrect). 【3】

(4) **Learning Progress Statistics:** The device tracks the user's performance during this session (from entering learning mode until exiting). It records the number of questions for each type and calculates the accuracy rate for each type, displaying the learning progress data. 【7】

#### 5. **Competition Mode: Calculating Answer Accuracy and Duration, and Determining Competition Results** 【35】

Note: The types of calculations in competition mode are the same as those in calculation mode.

(1) **Administrator Input of Competition Questions:** After entering competition mode, the administrator inputs the quantity and content of each type of question (no more than 10 questions per type, with each operand being 8 bits). The learning device stores all competition questions set by the administrator. 【10】

(2) **Multi-Player Competition:** Competition mode supports multiple participants (up to 4 players). The administrator can set the number of players in advance; if not set, the default is 4 players. 【5】

##### (3) **Starting the Competition:** 【10】

a) During the competition, the 7-segment display shows the total number of questions and the current question number, while the LED lights display the operation data. The question display on the 7-segment display flashes three times before starting the answer timer for this question, simultaneously initiating a 20-second countdown.

b) After each answer, players press the **confirmation button**, and the device records the answer and moves to the next question. If a player fails to confirm their answer within the 20-second countdown, the answer is marked as incorrect.

c) Once all questions are answered, pressing the **submit button** finalizes the results. The device calculates the total answering time and accuracy rate.

d) After the current player completes the questions, the next player begins their round, following the same process as described above.

(4) **Competition Result Evaluation:** After all players have completed their answers, the device displays the number of correct answers and the answering time for each player. The winner is determined by the highest number of correct answers; if tied, the player with the shorter answering time wins. 【5】

**(5) Review Function: [5]**

- a) Review each player's answer time for each question and the total time spent in the competition.
- b) Review the correct answer for each question (view the question type, operands, and correct result based on the question number).
- c) Review each player's answer and evaluation result for each question (enter the player number and question number to view the player's answer and the corresponding evaluation result).

**6. Calculation Demonstration Mode [5: bonus]**

**(1) Demonstrate Basic Multiplication of Unsigned Numbers:**

- a) The user inputs two 3-bit unsigned numbers. After input completion and pressing confirm, the two input numbers are displayed in their binary form on the 7-segment display. **[1]**
  - b) The LED lights sequentially display the accumulated result of each step in the multiplication process. Each intermediate result is displayed for 3 seconds, and the final result remains displayed without a time limit. **[4]**
- (2)** After the demonstration is complete, the user can choose to perform another multiplication demonstration or return to standby mode.

**(3) Basic Multiplication Example:**

- a) Input two 3-bit unsigned numbers:  $a = 3'b101$  and  $b = 3'b110$ . After confirmation,  $a$  and  $b$  are displayed as "101 110" on the 7-segment display.
- b) The LED lights display the accumulated result of each step in the multiplication, **right-aligned** for each result. Each step displays for 3 seconds, with the final result remaining on display:

$$\begin{array}{r} \cdot \quad 000 \\ \cdot \quad 1010 \\ \cdot 11110 \end{array}$$

**Bonus Points:**

- 1. **Calculation Demonstration Mode: +5**
- 2. **Use of Input Devices Other Than DIP Switches and Button Switches (to enhance user convenience): +5**
- 3. **Use of Output Devices Other Than Seven-Segment Displays and LEDs (to facilitate result viewing): +5**