

# 2023 Digital IC Design

## Homework 1: Max-Min Selector

### 1. Introduction:

The Max-Min selector (MMS) is a combinational circuit that can output the maximum or minimum value of a set of numbers. In this homework, you are required to design a 4-input MMS circuit, which determines the maximum or minimum value among four input numbers. The 4-input MMS circuit is then used to constitute an 8-input MMS circuit. The specifications and function of the 4-input MMS and the 8-input MMS are detailed in the following sections.

#### 1.1. The 4-input MMS

The logic diagram of the 4-input MMS for this homework is shown in Fig. 1, and its specifications of I/O interface is listed in Table I. Two-staged comparison and selection operation is adopted to select the maximum or minimum value among 4 numbers. The selection of the multiplexers is based on the comparison result and the *select* signal. The comparison and selection operation is shown in Fig. 2, and Table II lists all the selection cases of the multiplexers.

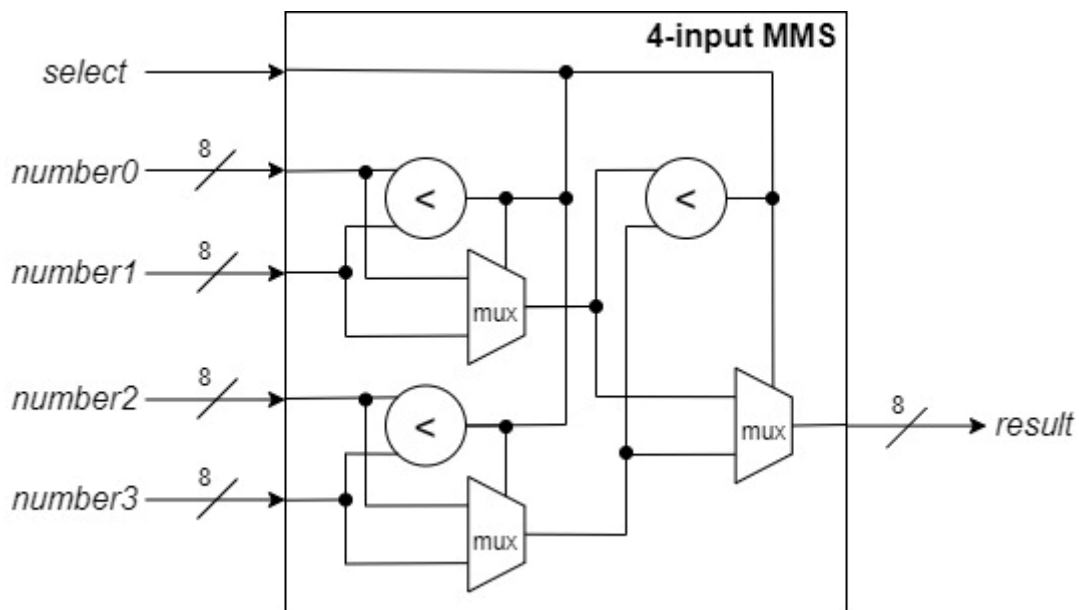


Fig. 1. The logic diagram of the 4-input MMS.

**Table I. I/O interface of the 4-input MMS.**

Signal Name	I/O	width	Description
<i>number0 ~ 3</i>	I	8	Input number 0 ~ 3
<i>select</i>	I	1	When the <i>select</i> signal is 0, <i>result</i> should be the maximum value. If the <i>select</i> signal is 1, <i>result</i> should be the minimum value
<i>result</i>	O	8	Selection result

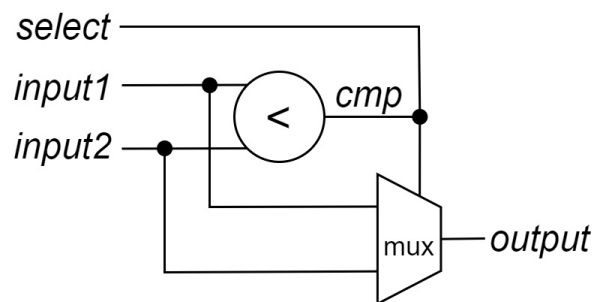


Fig. 2. The comparison and selection operation.

**Table II. The selection case of the multiplexer.**

{ <i>select</i> , <i>cmp</i> }	<i>output</i>
00	<i>input1</i>
01	<i>input2</i>
10	<i>input2</i>
11	<i>Input1</i>

## 1.2. The 8-input MMS

The logic diagram of the 8-input MMS for this homework is shown in Fig. 3, and its specifications of I/O interface is listed in Table III. **In this homework, you must construct the 8-input MMS circuit with your 4-input MMS modules.** Two 4-input MMS modules are used to select the maximum/minimum value among numbers 0~3 and numbers 4~7, respectively. A comparison and selection operation is adopted to determine the final result of the 8-input MMS.

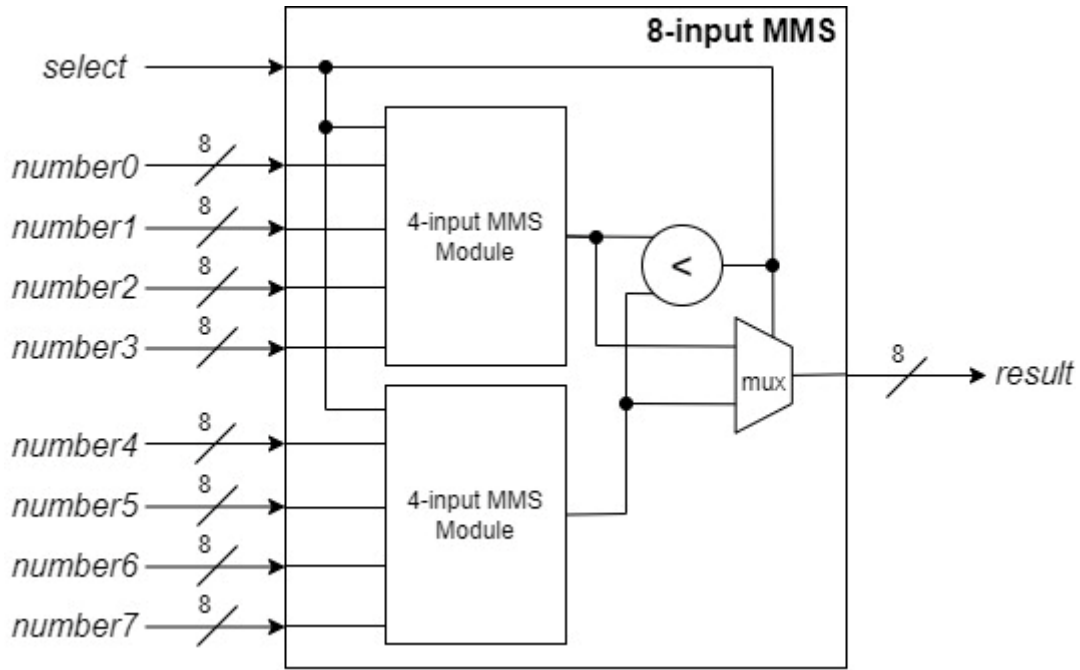


Fig. 3. The logic diagram of the 8-input MMS.

**Table III. I/O interface of the 8-input MMS.**

Signal Name	I/O	width	Description
<i>number0 ~ 7</i>	I	8	Input number 0 ~ 7.
<i>select</i>	I	1	When the <i>select</i> signal is 0, <i>result</i> should be the maximum value. If the <i>select</i> signal is 1, <i>result</i> should be the minimum value
<i>result</i>	O	8	Selection result

### 1.3 File Description

File Name	Description
MMS_4num.v	The module of 4-input MMS.
MMS_8num.v	The module of 8-input MMS.
MMS_tb.v	The testbench file. The content in this file is <b>not allowed</b> to be modified.
test_data_4num.dat	Test data for 4-input MMS verification.
test_data_8num.dat	Test data for 8-input MMS verification.
golden_data_4num.dat	Golden data for 4-input MMS verification.
golden_data_8num.dat	Golden data for 8-input MMS verification.

## 2. Scoring:

### 2.1. Maximum selection with 4-input MMS [30%]

The result should be generated correctly, and you will get the following message in ModelSim simulation.

```
# -----Stage 1 : Maximum selection with 4-input MMS-----  
#  
# -----Stage 1 : Pass!-----
```

Fig. 4. Simulation result for maximum selection with 4-input MMS.

### 2.2. Minimum selection with 4-input MMS [30%]

The result should be generated correctly, and you will get the following message in ModelSim simulation.

```
# -----Stage 2 : Minimum selection with 4-input MMS-----  
#  
# -----Stage 2 : Pass!-----
```

Fig. 5. Simulation result for minimum selection 4-input MMS.

### 2.3. Maximum selection with 8-input MMS [20%]

The result should be generated correctly, and you will get the following message in ModelSim simulation. **Please construct the 8-input MMS circuit with your 4-input MMS modules. Otherwise, you can just get half of the points.**

```
# -----Stage 3 : Maximum selection with 8-input MMS-----  
#  
# -----Stage 3 : Pass!-----
```

Fig. 6. Simulation result for maximum selection with 8-input MMS.

### 2.4. Minimum selection with 8-input MMS [20%]

The result should be generated correctly, and you will get the following message in ModelSim simulation. **Please construct the 8-input MMS circuit with your 4-input MMS modules. Otherwise, you can just get half of the points.**

```
# -----Stage 4 : Minimum selection with 8-input MMS-----  
#  
# -----Stage 4 : Pass!-----
```

Fig. 7. Simulation result for minimum selection with 8-input MMS.

### 3. Submission:

#### 3.1. Submitted files

You should classify your files into two directories and compress them to .zip format. The naming rule is HW1\_studentID\_name.zip. **If your file is not named according to the naming rule, you will lose five points.**

	RTL category
*.v	All of your Verilog RTL code
	Documentary category
*.pdf	The report file of your design (in pdf).

#### 3.2. Report file

Please follow the spec of report. You are asked to describe how the circuit is designed as detailed as possible.

#### 3.3. Note

Please submit your .zip file to folder HW1 in moodle.

**Deadline: 2023/3/20 23:55**

If you have any problem, please contact TA by email

[p76114040@gs.ncku.edu.tw](mailto:p76114040@gs.ncku.edu.tw)