Lecture 5 : Personal Computer Systems III

8253 Timer and Music

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Outline

- PC I/O Map
- 8253 Timer
- Speaker Interface
- I/O Instruction
- Generating Sound
I/O Address Map

I/O Expansion area

- COM 1
- Floppy disk
- CGA adapter
- LPT 1
- Hard disk
- COM 2
- 8255 (PPI)
- Timer
- Interrupt controller
- DMA controller
8253 Timer
# Addressing 8253 Port

<table>
<thead>
<tr>
<th>CS</th>
<th>A1</th>
<th>A0</th>
<th>Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Counter 0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Counter 1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Counter 2</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Control register</td>
</tr>
<tr>
<td>1</td>
<td>x</td>
<td>x</td>
<td>8253/54 is not selected</td>
</tr>
</tbody>
</table>
8253 Control Register

- **D7** to **D0**: 8-bit data bus
  - **SC1**: Select counter 1
  - **SC0**: Select counter 0
  - **RL1**: Read/load msb
  - **RL0**: Read/load lsb
  - **M2**: Mode select 2
  - **M1**: Mode select 1
  - **M0**: Mode select 0
  - **BCD**: BCD mode (1) or binary mode (0)

- **0** Binary counter (16-bit)
- **1** BCD (4 decades)

- **Mode 0**: 0 0 0
- **Mode 1**: 0 0 1
- **Mode 2**: 0 1 0
- **Mode 3**: 0 1 1
- **Mode 4**: 1 0 0
- **Mode 5**: 1 0 1

- **Counter latching operation**: 0 0
- **Read/load LSB only**: 0 1
- **Read/load MSB only**: 1 0
- **Read/load LSB first, then MSB**: 1 1

- **Select counter 0**: 0 0
- **Select counter 1**: 0 1
- **Select counter 2**: 1 0
- **Illegal**: 1 1
8253 Control Register (2)

Example:

Suppose that control register is programmed as 10110110b (b6h).

Then

- Select counter 2.
- Read LSB first, then MSB.
- Select mode 3.
- Select binary counting.
PC 8253 Connection
PC 8253 Connection (2)

8253

(40h) Clock 0
TIM0
Gate0
Out 0 (18.2 Hz 中斷訊號)

(41h) Clock 1
TIM1
Gate1
Out 1 (DRAM)

(42h) Clock 2
TIM2
Gate2
Out 2 (SPEAKER)

(43h) 控制輸入
TIM CTR

1190000 Hz CLOCK
Speaker Interface

1.9318 MHz

bit 1 of port 6h

bit 0 of port 6h

CLOCK

GATE

OUT

16-bit

COUNT

CONTROL

Channel 2 of 8253 Timer

SPEAKER DATA

to Speaker

to bit 5 of port 62h

port 42h

Ch. 2 Control byte (via port 43h)
Frequency Number

- Frequency Number $= \frac{1190000}{\text{Frequency}}$

- Example:
  - Frequency of Middle C $= 261.63$
  - Then Frequency Number of Middle C $= \frac{1190000}{261.63} = 4560 = 11d0h$
I/O Instruction

- in ax/al, port/dx
- out port/dx, ax/al

Example:
- in al, 61h
- out 42h, al
Generating Sound

1. Send value 182 to port 43h.
2. Send frequency number to port 42h.
3. Set bits 1 and 0 of port 61h.
Generating Sound (2)

Example:
- mov al, b6h
- out 43h, al
- mov ax, 11d0h; frequency number for middle C
- out 42h, al
- mov al, ah
- out 42h, al
- in al, 61h
- or al, 00000011b
- out 61h, al
Sound Duration

- PC makes bit 4 of port 61H toggle every 15.085 µs.
- A fixed time delay can be obtained by BIOS WAITF procedure, where register cx holds the number of 15.085 µs time delays needed.
- A half-second delay created by WAITF:
  - mov cx,33144
  - call WAITF
Sound Duration (2)

- BIOS WAITF Procedure:
  - push ax
  - waitf1: in al,61h
  - and al,10h
  - cmp al,ah
  - je waitf1
  - mov ah,al
  - loop waitf1
  - pop ax
  - ret
Turn Off Sound

- Reset bits 1 and 0 of port 61h.
- Example:
  - `in al, 61h`
  - `and al, 11111100b`
  - `out 61h, al`