

Engineering 4862 Microprocessors

Lecture 23

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Input / Output Instructions

- Since 8086/88 has a 16-bit data bus internally, it is capable of transferring 16-bit data to or from AX. → **This requires having two port addresses, one for each byte!**
- Example: AX = 9876H, Port # = 40H
OUT 40H, AX
→ Port 40 ← 76H (AL), Port 41 ← 98H(AH)
- For 8086, takes one bus cycle to complete the transfer, for 8088, two bus cycles are required

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I/O Design

- When designing an I/O port, ensure that the port is only active when selected by the microprocessor
 - Use latches (output) and buffers (input) to isolate the I/O port circuitry from the address and data bus
 - Use the correct combinatorial logic circuitry and/or decoders with address bus to select the port

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Output Design Example: 8 LEDs

- This is a byte-wide output port
- The LEDs cannot be connected directly to data bus
 - Difficult to select the LEDs
 - LEDs would only display value for *very* short period of time (about 400ns, or 2 clock cycles)
 - Only when data bus carries the correct signal
 - Microprocessor cannot sink enough current

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Input / Output Instructions

- For 8-bit port

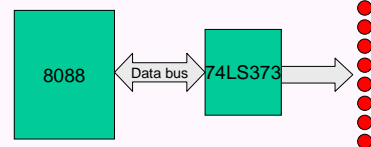
IN AL, Port #	OUT Port #, AL
MOV DX, Port #	MOV DX, Port #
IN AL, DX	OUT DX, AL
- For 16-bit port

IN AX , Port #	OUT Port #, AX
MOV DX, Port #	MOV DX, Port #
IN AX , DX	OUT DX, AX

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Example: 8 LEDs

- Instead, we need to capture the values on the data bus, and hold them until changed
 - The 74LS373 octal latch will do nicely



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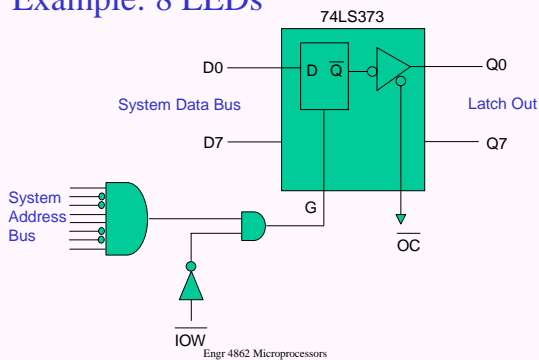
Example: 8 LEDs

- We only want the latch to load values from the data bus when the microprocessor outputs to the correct port #
 - Suggestion 1: Decode the address directly
 - Suggestion 2: Use a decoder such as the 3x8 74LS138 with lines from the address bus

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Example: 8 LEDs



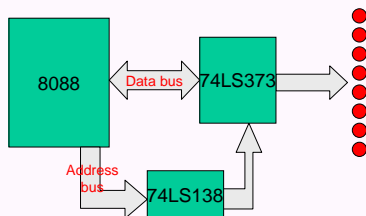
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Example: 8 LEDs

- How do we connect the LEDs?
 - 2 possibilities

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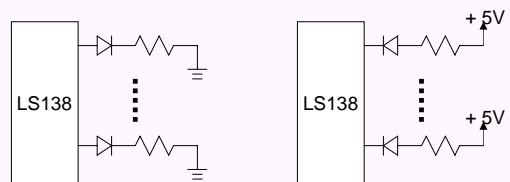
Example: 8 LEDs



Note: This is not quite enough!

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Example: 8 LEDs

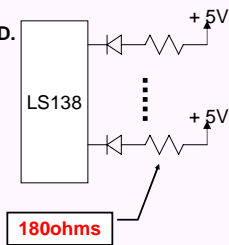


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Example: 8 LEDs

The 74LS138 does not have enough power to drive an LED.

The device can sink enough current for the LED to light (15 to 20 mA).



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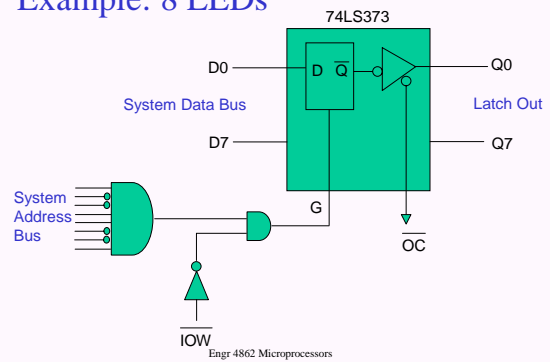
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Bus Cycles for outputting

- Assume the port address is 99H → OUT 99H, AL
 - T1: address 99H is provided to address bus A0 – A7 through AD0 – AD7 and ALE signal
 - T2: \overline{IOW} is provided and the contents of AL are released into the data bus pins AD0 – AD7
 - T3: signal propagates to the destination port
 - T4: the content of AL are latched into the 74LS373 with the \overline{IOW} going from low to high

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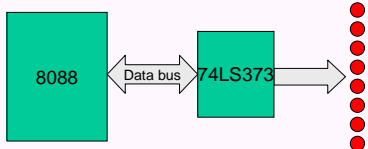
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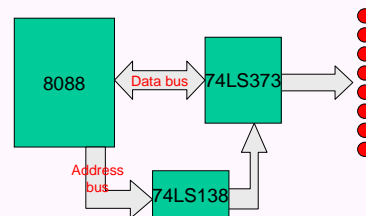
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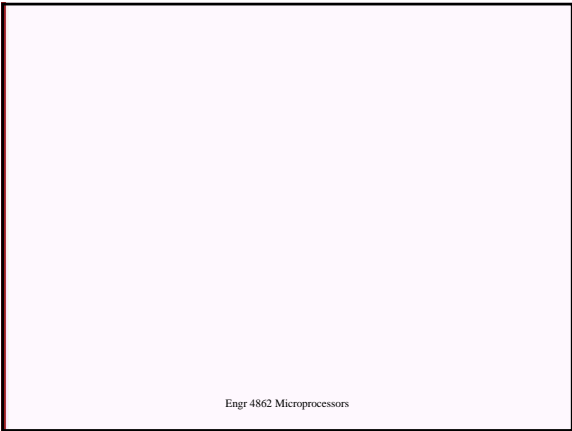
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180ohms

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Example: 8 LEDs

- How do we connect the LEDs?
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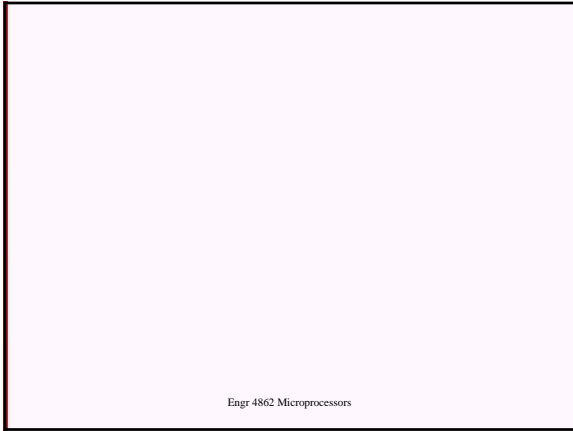
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Example: 8 LEDs

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Example: 8 Switches

- Now we will look at an 8-bit input port.
- The procedure to select the port is similar to the output case
 - Use IORD* instead of IOWR*

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Example: 8 Switches

- We cannot use a latch to separate the switches from the microprocessor
 - We only want the switch values to be on the data bus when the microprocessor asks for it
 - A latch would constantly drive the bus!

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Example: 8 Switches

- How do we set up the switches?
 - When open, one logic level
 - When closed, the other logic level

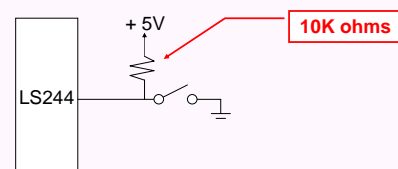
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Example: 8 Switches

- The device of interest here is the 74LS244 tristate buffer (unidirectional)
 - NOT the same as the 74LS245 transceiver (bidirectional)
- Tristate:
 - One of three states: on (1), off (0), or open (Z)
 - In the open state, the buffer does not drive the data bus

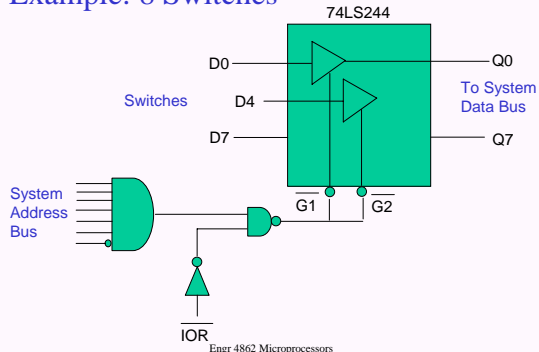
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Example: 8 Switches



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Example: 8 Switches



Programmable I/O

- The previous examples are good for many applications, but sometimes a more powerful and flexible solution is needed.
- The 8255 Programmable Peripheral Interface (PPI) is a 40-pin DIP IC that provides 3 programmable I/O ports, A, B, and C.
- One can program the individual port to be input or output port, economical and flexible than 74LS373, 73LS244, which must be hard wired)

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Summary

- Since the data provided by the CPU to the port is on the system data bus for a limited amount of time (50-1000ns), it must be latched before it is lost
- In order to prevent any unwanted data from coming into the system data bus, all input devices must be isolated through the tri-state buffer
 - The 74LS244 not only plays this role, but also provides the incoming signals sufficient strength (boosting) to travel all the ways to the CPU.
- As general, every device (memory, peripherals) connected to the global data bus must have a latch or tri-state buffer

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Programmable I/O

- How are is it programmable?
 - Configure each port as input or output
 - Different modes of operation
- You must initialize the PPI via software commands
 - Send a control byte to the device's control register port

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Pin Description

- PA0 – PA7: Port A / All / input/output/bidirectional
- PB0 – PB7: Port B / All / input/output
- PC0 – PC7: Port C / All / input/output
 - Can be split into two parts: Upper (PC7 – PC4) and Lower (PC3 – PC0).
 - Each can be used for input or output.
 - Any of PC0 – PC7 can be programmed.
- \overline{RD} and \overline{WR} : control signal input to 8255
 - \overline{IOR} and \overline{IOW} in peripheral I/O
 - \overline{MEMR} and \overline{MEMW} in memory-mapped I/O

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Pin Description

- RESET: Active high input signal to 8255
 - Used to clear the internal control register
 - When activated, all ports are initialized as **input ports**.
 - Usually connect to the RESET output of the system bus or ground
- A0, A1, and \overline{CS}
 - CS selects the entire chip, A0 and A1 select the specified port
 - Used to access port A, B, C,

\overline{CS}	A1	A0	Select
0	0	0	Port A
0	0	1	Port B
0	1	0	Port C
0	1	1	Control Reg.
1	x	x	Not Selected

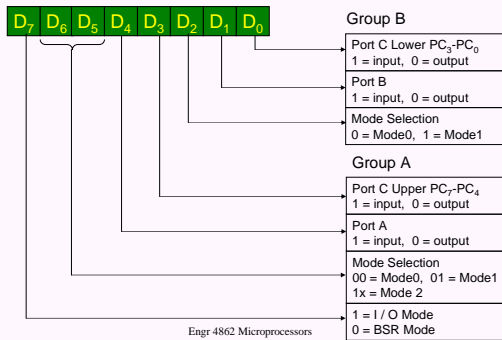
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Mode Selection

- Mode 0: simple I/O
 - Any ports: A, B, CL, CU. No control of individual bits
- Mode 1: I/O (ports A and B) with handshaking (port C)
 - Synchronizes communication between an intelligent device (printer)
- Mode 2: Bi-directional I/O with handshaking
 - Port A: bidirectional I/O with handshaking through port C
 - Port B: Simple I/O or in handshake mode 1
- BSR Mode: Bit set/reset
 - Only the individual bits on Port C can be programmed

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Control Word of 8255



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8255 Design Example

- Mode 0
 - Any of ports A, B, C can be programmed as input or output
 - Port can not be both an input and output port at the same time
 - Port C can be programmed with CL, CH separately
 - Example:

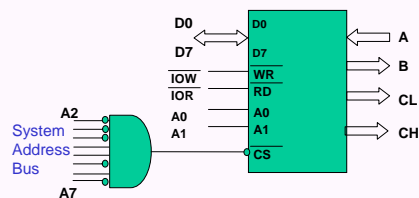
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Mode Selection

- It's the control register that must be programmed to select the operation mode of the three ports: A, B, and C
- The 8255 chip is programmed in any of the above modes by sending a byte (control word) to the control register of the 8255

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8255 Design Example



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