EE4380 Microprocessor Design Project

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Introduction

- What is a Microcontroller ?

- Microcontroller Vs Microprocessor
    - Level of Integration
        - Processor, memory, timer, UART, I/O ports etc
    - Cost
        - System cost, per unit cost
    - Application domain
        - General purpose Vs specialized

- System design Issues

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Embedded Systems

- Do one specialized task
  - Efficiently
  - Cost effective manner
- Microcontroller based system + Software
- Embedded software
  - Usually small code footprint
  - Assembly Language everywhere
  - RTOS and HLLs are available
  - Need special tools for development, debugging etc

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Embedded Systems (contd.)

- Embedded system design is unique
  - *Normal* software design usually targets fixed hardware
    - gcc, gdb, gprof done !
  - Both hardware and software have to be _engineered_ together
  - Engineering decisions:
    - Hardware/Software partitioning (*open problem*)
    - Device/Peripheral selection (memory size, vendor etc)
    - Software development environment

Embedded Systems (contd.)

- Full Manual
  - Design hardware and software manually
- Vendor tool assisted flow
  - Sophisticated (high $) CAD tools
    - HLL compilers
    - Simulators, source level debuggers, ICE etc
  - Major engineering decisions are still manual
- Fully Automated Flow
  - Wish list item #1

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Review of Logic Circuits

- Hex system

    1000 1010 0011 1111b = 8A3FH

- Hex arithmetic needed to calculate jump addresses

- Hex addition

    – Simple TBT addition with 1 carry for every 16

- Hex subtraction

    – If subtrahend smaller than minuend then simple TBT subtraction

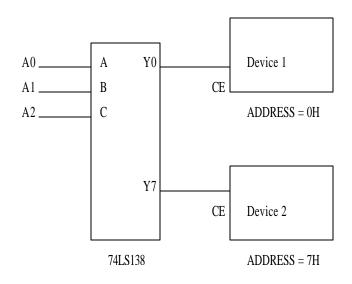   – Else, swap and then and find 2's complement of result
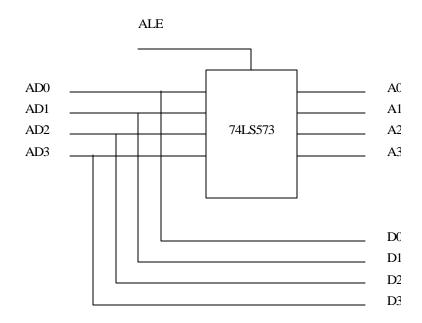
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Review of Logic Circuits (contd.)

- Logic gates
  - For loose random logic
  - Inverter, AND, OR, XOR, NAND, NOR, Tri-state buffer
- Decoders
  - Used for address decoding
- Sequential elements
  - Used for demuxing address/data lines, latches etc
  - Flip-flops, latches
  - Edge and level triggered

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Review of Logic Circuits (contd.)

- Common use of a decoder 74LS138
- Common use of a latch, AD Demuxing

74LS138 diagram: A0 → A, A1 → B, A2 → C; Y0 → CE Device 1 (ADDRESS = 0H); Y7 → CE Device 2 (ADDRESS = 7H)

74LS573 diagram: ALE; AD0, AD1, AD2, AD3 → 74LS573 → A0, A1, A2, A3, D0, D1, D2, D3
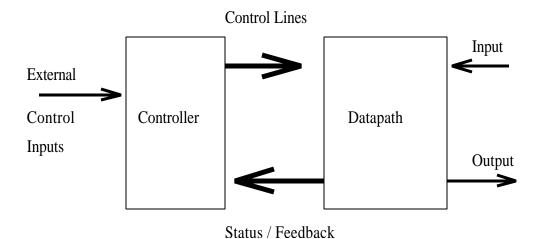
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Digital Systems

- Controller path and Data path
- Controller controls the datapath at specific control points in the datapath
- Controllers are FSMs
- Controllers can be designed up from scratch or use a Microprocessor / Microcontroller
- Microprocessor based digital system controller design is *essentially* creating the software
- Microprocessors *can also do some of the datapath's functions*
  - ALU units, IO units, special units for comm, dsp, etc

Digital Systems (contd.)

- Controller and Datapath Illustration

Control Lines

External

Input

Control

Controller

Datapath

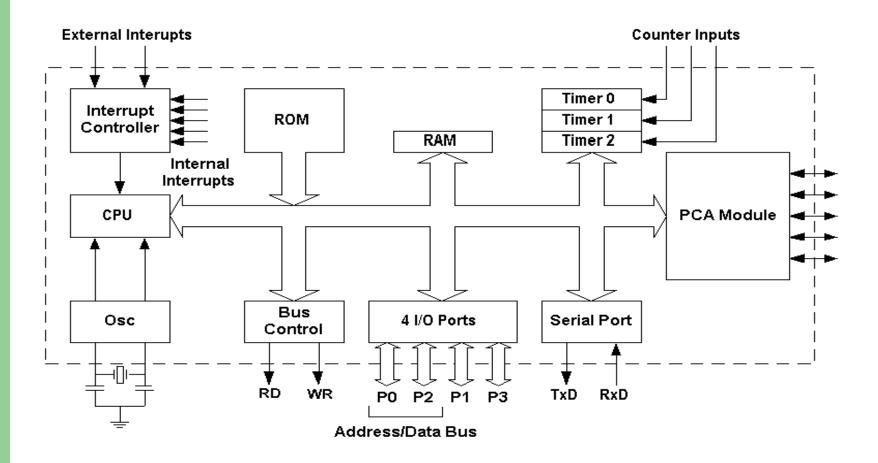Inputs

Output

Status / Feedback

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Overview of the 8051 Family

- One of the oldest (Intel MCS-51 in 1981) and probably the most popular microcontroller. Many derivatives are marketed by a number of manufacturers
- Common features,
    - 8-bit processor
    - 4 I/O ports each 8bits wide
    - max of 64K on-chip ROM (usually 0k to 4k)
    - max of 64K external data memory
    - max of 64K external code memory
    - 2 timers, one serial port
    - 128 bytes of on-chip RAM
    - various speeds from 12MHz
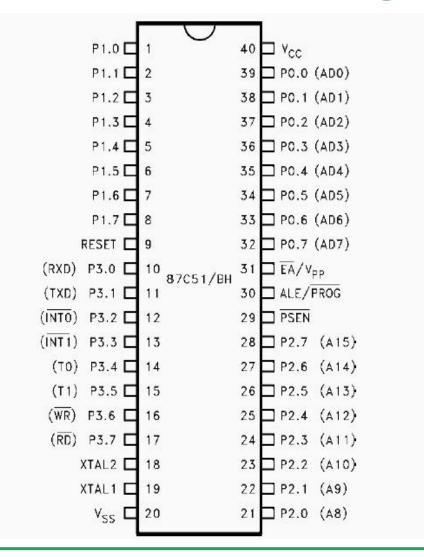- Clones may have different on-chip memory, timers etc

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8051 Block Diagram

8051 Pinout Diagram

P1.0 — 1 — 40 — V$_{CC}$
P1.1 — 2 — 39 — P0.0 (AD0)
P1.2 — 3 — 38 — P0.1 (AD1)
P1.3 — 4 — 37 — P0.2 (AD2)
P1.4 — 5 — 36 — P0.3 (AD3)
P1.5 — 6 — 35 — P0.4 (AD4)
P1.6 — 7 — 34 — P0.5 (AD5)
P1.7 — 8 — 33 — P0.6 (AD6)
RESET — 9 — 32 — P0.7 (AD7)
(RXD) P3.0 — 10 — 31 — $\overline{EA}$/V$_{PP}$
(TXD) P3.1 — 11 — 30 — ALE/$\overline{PROG}$ [87C51/BH]
($\overline{INT0}$) P3.2 — 12 — 29 — $\overline{PSEN}$
($\overline{INT1}$) P3.3 — 13 — 28 — P2.7 (A15)
(T0) P3.4 — 14 — 27 — P2.6 (A14)
(T1) P3.5 — 15 — 26 — P2.5 (A13)
($\overline{WR}$) P3.6 — 16 — 25 — P2.4 (A12)
($\overline{RD}$) P3.7 — 17 — 24 — P2.3 (A11)
XTAL2 — 18 — 23 — P2.2 (A10)
XTAL1 — 19 — 22 — P2.1 (A9)
V$_{SS}$ — 20 — 21 — P2.0 (A8)

- From Intel 87C51 datasheet
- DIP package
- Data lines and lower 8 address lines are muxed
- Two ports P0 and P2 are used by AD buses
- Clones may not be pin compatible

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Some 8051 clones

- 8031 – No on-chip ROM
- 8751 – With on-chip EPROM
- Atmel AT89C51 – With on-chip Flash ROM
- DalSemi DS5000
  - With on-chip NV-RAM
  - In system programmable via serial-port
- Philips Corp.
- 8051 cores from FPGA vendors
  - Xilinx, Altera, etc
- 8051 with programmable logic
  - Triscend etc

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