Computer History

- Abacus
  - c. 500 BC – 1200 AD

  http://www.ee.ryerson.ca:8080/~elf/abacus/

- Mechanical calculating 'engines'
  - Blaise **Pascal** 1642 (adder)
  - Gottfried Wilhelm von **Leibniz** 1694 (add and multiply)
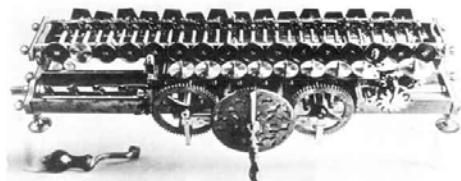
BJ Furman SJSU MAE   http://www-history.mcs.st-andrews.ac.uk/history/Bookpages/Leibniz_machine.jpeg

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Computer History, cont.

- Mechanical calculating 'engines', cont.
  - Charles **Babbage** c. 1822
    - Difference engine
      - Calculation by fixed instruction program
    - Analytical engine
      - Forerunner of the modern computer

      http://mycetes.pwp.blueyonder.co.uk/babbage/Fragment_Photo.JPG
      - Never realized due to lack of precision machining capability
  - Herman **Hollerith** 1889
    - Punched card tabulator for US Census bureau
    - Electromechanical (relays)

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Computer History, cont.

- Electronic Digital Computer
  - John P. **Eckert** and John W. **Mauchly** c. 1942 at Univ. Pennsylvania
    - ENIAC
      - WWII artillery calculations
    - "18,000 vacuum tubes, about 1,800 square feet of floor space, and consumed about 180,000 watts of electrical power" (http://www.softlord.com/comp/, 04SEP04)
    - Fast "look-up" calculation
      - 2, 10 digit number multiplication in 200 microseconds
  - John **Von Neumann** c. 1945
    - Computer 'architecture'
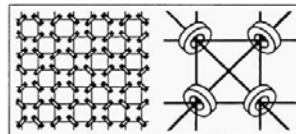   - Stored program
      - Subroutines

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Miniaturizing the Computer

- The transistor
  - John **Bardeen**, Walter **Brattain**, and William **Shockley** c. 1947
  - Shockley Semiconductor c. 1956 in Palo Alto
  - "Traitorous 8" start Fairchild Semiconductor c. 1957
  - Jack **Kilby** (TI) and Robert **Noyce** invent the IC c. 1959

http://www.101science.com/transistor.htm

- Magnetic core memory
  - c. 1952

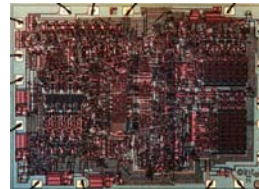BJ Furman SJSU MAE

http://www.fortunecity.com/marina/reach/435/coremem.htm

The Microprocessor

- Intel ("Integrated Electronics) c. 1969
  - Robert Noyce, Gordon Moore, Andrew Grove leave Fairchild Semiconductor
  - Busicom's desire for high-performance calculator chips (12)
    - Ted Hoff's idea to instead design a single-chip, general purpose logic device
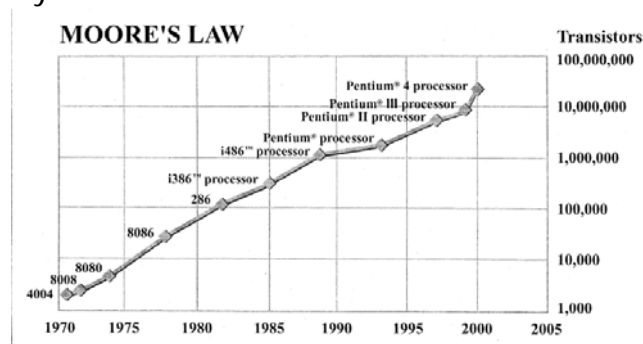   - Intel 4004 microprocessor
      - The rest is ...

http://www.antiquetech.com/chips/4004.htm

http://www.cedmagic.com/history/intel-4004.html

Moore's Law

- Doubling of the number of transistors per square inch every 18 months

MOORE'S LAW

Transistors
100,000,000

Pentium® 4 processor
Pentium® III processor
Pentium® II processor
Pentium® processor
i486™ processor
i386™ processor
286
8086
8080
8008
4004

10,000,000

1,000,000

100,000

10,000

1,000

1970 1975 1980 1985 1990 1995 2000 2005

ftp://download.intel.com/intel/intelis/museum/research/arc_collect/history_docs/pdf/original+graph.pdf

3

Microprocessors and Microcontrollers

- Microprocessor
    - "A central processing unit (CPU) fabricated on one or more chips, containing the basic arithmetic, logic, and control elements of a computer that are required for processing data"
    (http://www.intersil.com/digital/glossary.asp, 04SEP04)
- Microcontroller
    - A single-chip computer system usually comprising a CPU, memory, input/output ports, and often, timers, counters, analog-to-digital converters (ADC), etc. used for control applications

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CPU

- What is it?
    - The "brains" of the controller
- Consists of:
    - Control unit
        - Handles timing and sequencing of operations
        - Fetches instructions, decodes instructions, executes instructions, stores results
    - Arithmetic Logic Unit (ALU)
        - Carries out data manipulation
    - Registers
        - Temporary data storage locations

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Memory

- Random Access Memory (RAM)
  - Volatile
  - Fast
- Read-only Memory (ROM)
  - PROM
  - EPROM
  - EEPROM
    - Configuration data infrequently changed
    - Slow, 10's of ms
    - Byte addressable
  - FEPROM (flash)
    - Program storage
      - Ex. Atmega128 has 128k of flash memory for program storage
      - Programmed in blocks
      - 10,000 (minimum) write cycle life

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I/O

- Data exchange with external world
  - Sensors (data IN)
  - Actuators (data OUT)
  - Communications
    - Displays
    - Serial data
- Examples:
  - Atmega128 data sheet
  - Motorola 68HC11 data sheet
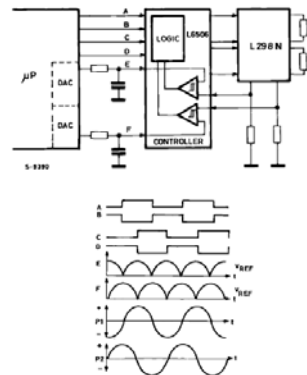
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From Stepper Motor Driving by H. Sax (ST app note AN235/0788

Timer/Counter

- Registers to capture clock cycles and count pulses for timing and counting functions
  - Generating signals with precise timing, e.g. square wave, PWM signals
    - Interrupts
  - Event timing
  - Examples
    - Encoder position sensing
    - Voltage to frequency decoding
- Clock signal
  - External crystal or onboard oscillator system sets the "beat" and synchronizes all operations
    - Ex. Atmega128, 32 kHz – 8 MHz

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Analog-to-Digital Converter

- Continuously varying values to discrete (digital levels)
- Number of channels
- Number of bits

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Busses

- The sets of internal conductors that connect the pieces of the microcontroller together
  - Address bus
    - Carries the *address* of a location in memory or I/O
    - Width (number of conductors) determines how many memory locations can be addressed
      - » Ex. 68HC11 address bus is 16 bits => ? addresses
  - Data bus
    - Carries *data* to and from memory or I/O ports
    - Width (number of conductors) determines the size of the microcontroller, e.g. an 8-bit microcontroller
  - Control bus
    - Carries *control* signals to memory and peripherals (timers, A/D, serial I/O, etc.), e.g. R/W, IRQ

History

- Intel 8048
  - Magnavox Odyssey video game and and in the original IBM PC keyboard
- Intel 8051 c. 1980
  - Harvard architecture
    - Separate program and data memory structures accessed by separate sets of conductors (busses)
    - Can fetch program and data in parallel (speed advantage)
  - Boolean processing engine for efficient bit operations on internal registers and RAM
  - Widely used (still)!
    - IBM PC keyboard controller
    - Programmable logic controllers

History, cont.

- Intel 80186 and 80188 c. 1982
  - Microcontroller version of the 8086/8088 microprocessors (IBM PC)
- Motorola 68HXXX
  - von Neumann architecture
    - Program instructions and data share the same space and are accessed by same the same lines (bus)

Overview of Major Types

- Motorola
- Microchip
- Atmel