

# WEEK02 – COMPUTER HARDWARE

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# OUTLINE

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1. **History of Personal Computer & Peripherals**
2. **Numeral Systems**
3. **Computer Hardware**
  1. **CPU**
  2. Power Case
  3. Memory
  4. Motherboard
  5. Peripherals

# PERSONAL COMPUTER & PERIPHERALS

The Important Step in The World - Macintosh

Released in 1984, Macintosh series extended to 1991

CPU: Moto MC68000, CPU Speed: 8 MHz, Bus Speed: 8 MHz

Register Width: 32 bits, Data Bus Width: 16 bits, Address Bus Width 32 bits

Random Access Memory (RAM): 128 kB, Read Only Memory (ROM): 64 kB

Monitor: 9" build in, size: 512 X 342, color: 1 bit

Storage: 3.5" Floppy Drive with a size of 400 kB

Input/Output: Keyboard, Joystick/Mouse, Serial Port, Speaker, Audio Out

Operation System: Mac OS



# PERSONAL COMPUTER & PERIPHERALS

The Important Step in The World – IBM PC

1981 IBM PC 5150

CPU: Intel 8088, CPU Speed: 4.77 MHz

Register Width: 16 bits, Data Bus Width: 8 bit

RAM: 16-640 kB, ROM: 64 kB, Hard Disk: 20 MB

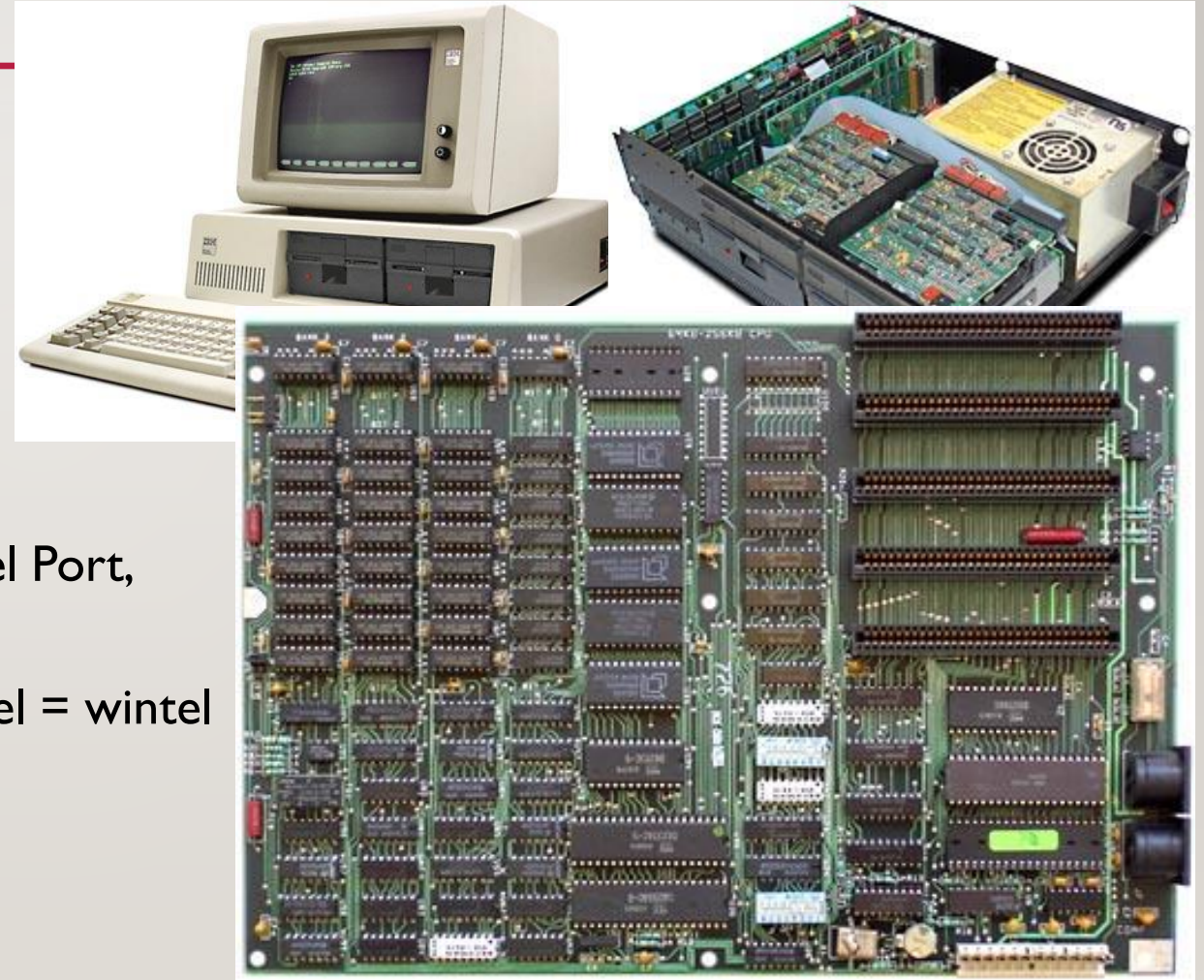
Monitor: 80 characters 25 lines

Storage: 5.25" Floppy Drive with a size of 160 kB

Input/Output: Keyboard, RS232 Serial Port, Parallel Port,  
Speaker, 8-bit Slots

Operation System: PC DOS 1.0 – Windows + Intel = wintel

Microsoft Basic ROM



# PERSONAL COMPUTER & PERIPHERALS

## The Important Step in Taiwan – ACER 710

1980 Micro-Professor (MPF) series 小教授家用電腦

1985 Multitech Accel 900, 6/10 MHz 80286 CPU

1987 ACER 710

CPU: Intel 8088, CPU Speed: 10 MHz

Register Width: 16 bits, Data Bus Width: 8 bit

RAM: 786 kB, ROM: 64 kB, Hard Disk: 20 MB

Monitor: 12" 80 characters 25 lines

Storage: 5.25" Floppy Drive with a size of 360 kB

Input/Output: Keyboard, RS232 Serial Port, Parallel Port,  
Speaker, 8-bit Slots

Operation System: MS DOS 3.2



# NUMERAL SYSTEMS – BINARY, OCTAL, DECIMAL, HEXADECIMAL

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After signals are digitalized (5/0V representing I/o), the binary number system is used for the computer design.

The decimal number system gives a number  $abcd$ , where  $a, b, c, d$  are digital numbers from 0 to 9.

$$abcd = a \times 10^3 + b \times 10^2 + c \times 10^1 + d \times 10^0$$

In reverse direction, if you want to digitize a number  $N$  according to the decimal number system, you use division to find the digits:

Using the same way, we can find the number of a binary number 0110 0101 and find it back from a decimal number.

$$\begin{aligned} &0110\ 0101 \\ &= 2^0 + 2^2 + 2^5 + 2^6 \\ &= 101 \end{aligned}$$

$$\begin{array}{r} 10 \overline{) 2735} \\ 10 \overline{) 273 \dots 5} \\ 10 \overline{) 27 \dots 3} \\ \quad 2 \dots 7 \\ \hline N = 2735 \end{array}$$

$$\begin{array}{r} 10 \overline{) N} \\ 10 \overline{) m_0 \dots d_0} \\ 10 \overline{) m_1 \dots d_1} \\ 10 \overline{) m_2 \dots d_2} \\ \quad d_4 \dots d_3 \\ \hline N = d_4 d_3 d_2 d_1 d_0 \end{array}$$

$$\begin{array}{r} 2 \overline{) 101} \\ 2 \overline{) 50 \dots 1} \\ 2 \overline{) 25 \dots 0} \\ 2 \overline{) 12 \dots 1} \\ 2 \overline{) 6 \dots 0} \\ 2 \overline{) 3 \dots 0} \\ 2 \overline{) 1 \dots 1} \\ \hline N = 1100101 \end{array}$$

# NUMERAL SYSTEMS – BINARY, OCTAL, DECIMAL, HEXADECIMAL

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Conversion between the binary, the octal, the decimal, and the hexadecimal number systems:

binary to decimal:  $1111 = 2^4 - 1 = 15$

digits of octal numbers: 0, 1, 2, 3, 4, 5, 6, 7

binary to octal numbers:  $101\ 011 = 53$

octal to decimal numbers:  $53 = 5 \times 8^1 + 3 \times 8^0 = 43$

digits of hexadecimal numbers: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

hexadecimal to decimal:  $8FA0 = 8 \times 16^3 + 15 \times 16^2 + 10 \times 16 = 36768$

hexadecimal to binary:  $8A0 = 1000\ 1010\ 0000$

hexadecimal to octal:  $3F5 = 0011\ 1111\ 0101 = 001\ 111\ 110\ 101 = 1765$

$$\begin{array}{r} 8 \overline{) 1201} \\ 8 \overline{) 150 \dots 1} \\ 8 \overline{) 18 \dots 6} \\ \quad 2 \dots 2 \\ N = 2261 \end{array} \qquad \begin{array}{r} 16 \overline{) 1201} \\ 16 \overline{) 75 \dots 1} \\ \quad 4 \dots 11 \\ N = 4B1 \end{array}$$

# CENTRAL PROCESSING UNIT (CPU)

Arithmetic/Logic Unit (ALU)

CPU: The CPU is operated synchronously with the memory and the peripherals. They are clocked at the same rate, e.g. 5/8 MHz for 8088 CPU.

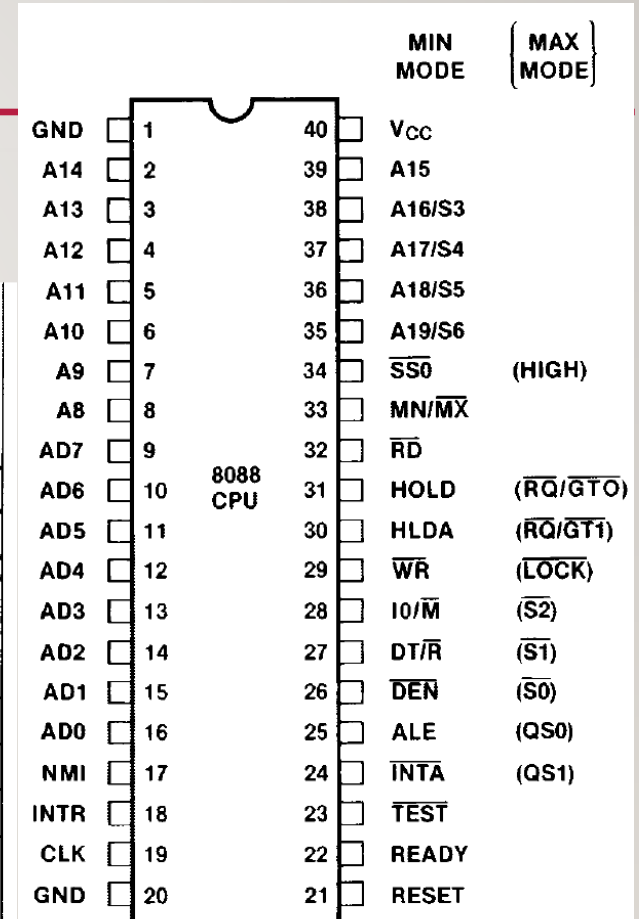
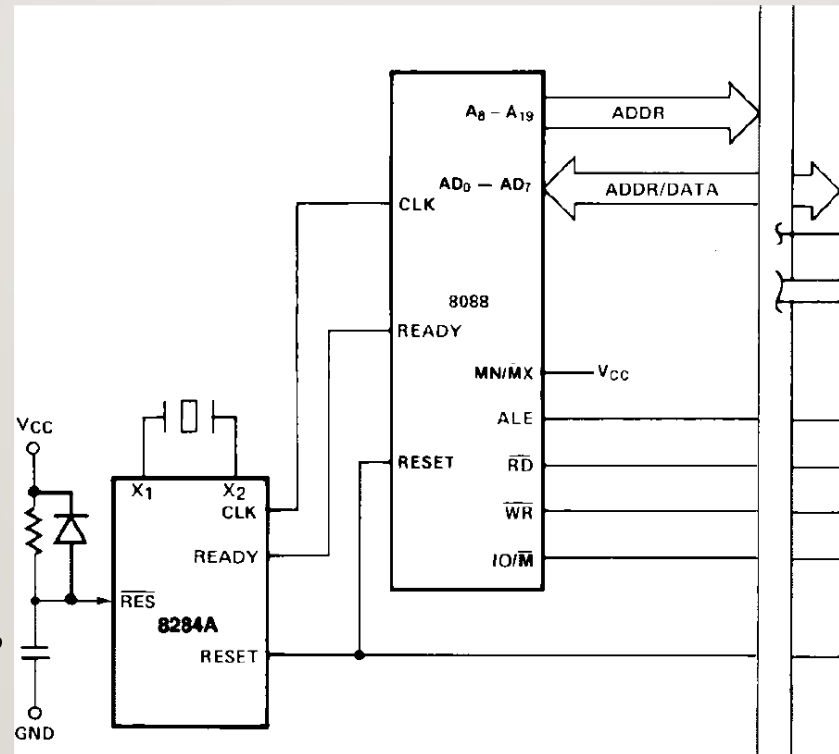
8-bit data bus interface

16-bit internal architecture

Direct addressing to memory

8-bit & 16-bit signed and unsigned arithmetic in binary or decimal including multiply and divide

CPU: input data from memory or disk, calculation, output data, interrupted processing



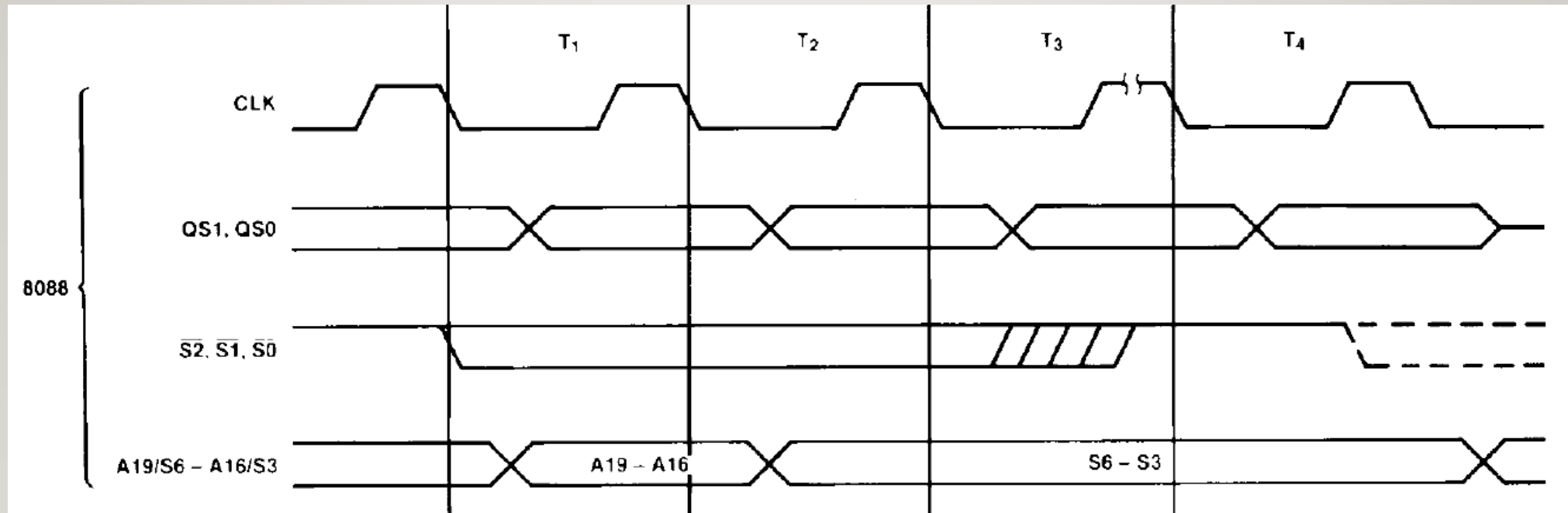
231456-2

Figure 2. 8088 Pin Configuration



# CENTRAL PROCESSING UNIT (CPU)

Operation Time: Several Cycles of Clock Time, Unit:  $0.2 \mu s$  for 8088 CPU Speed of 5 MHz



But The Operational Interrupt Speed for your program is still 1 kHz.

# CENTRAL PROCESSING UNIT (CPU)

## Another Simple CPU

Powered by USB, use FTDI Friend (a chip to convert USB signal to serial port)

Pin7, 20, 21: USB  $V_{CC}$

Pin8, 22: USB GND

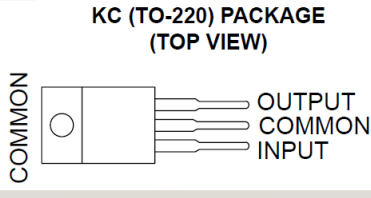
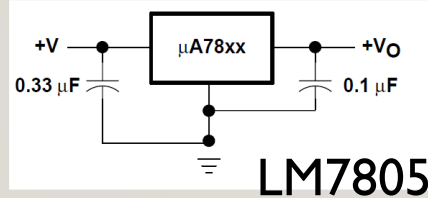
Pin3: USB RX

Pin2: USB TX

Pin9 & 10: Crystal

Pin1: 5V  $\rightarrow$  10k $\Omega$   $\rightarrow$  Pin1  $\rightarrow$  Switch  $\rightarrow$  GND

Pin19: Pin19  $\rightarrow$  220 $\Omega$   $\rightarrow$  LED  $\rightarrow$  GND



## Atmega168 Pin Mapping

Arduino function	Atmega168 Pin	Atmega168 Pin	Atmega168 Pin	Arduino function
reset	(PCINT14/RESET) PC6	1	28	PC5 (ADC5/SCL/PCINT13) analog input 5
digital pin 0 (RX)	(PCINT16/RXD) PD0	2	27	PC4 (ADC4/SDA/PCINT12) analog input 4
digital pin 1 (TX)	(PCINT17/TXD) PD1	3	26	PC3 (ADC3/PCINT11) analog input 3
digital pin 2	(PCINT18/INT0) PD2	4	25	PC2 (ADC2/PCINT10) analog input 2
digital pin 3 (PWM)	(PCINT19/OC2B/INT1) PD3	5	24	PC1 (ADC1/PCINT9) analog input 1
digital pin 4	(PCINT20/XCK/T0) PD4	6	23	PC0 (ADC0/PCINT8) analog input 0
VCC	VCC	7	22	GND GND
GND	GND	8	21	AREF analog reference
crystal	(PCINT6/XTAL1/TOSC1) PB6	9	20	AVCC VCC
crystal	(PCINT7/XTAL2/TOSC2) PB7	10	19	PB5 (SCK/PCINT5) digital pin 13
digital pin 5 (PWM)	(PCINT21/OC0B/T1) PD5	11	18	PB4 (MISO/PCINT4) digital pin 12
digital pin 6 (PWM)	(PCINT22/OC0A/AIN0) PD6	12	17	PB3 (MOSI/OC2A/PCINT3) digital pin 11 (PWM)
digital pin 7	(PCINT23/AIN1) PD7	13	16	PB2 (SS/OC1B/PCINT2) digital pin 10 (PWM)
digital pin 8	(PCINT0/CLKO/ICP1) PB0	14	15	PB1 (OC1A/PCINT1) digital pin 9 (PWM)

Digital Pins 11, 12 & 13 are used by the ICSP header for MISO, MOSI, SCK connections (Atmega168 pins 17, 18 & 19). Avoid low-impedance loads on these pins when using the ICSP header.

Ref1: [http://yehnan.blogspot.com/2013/09/arduino\\_9.html](http://yehnan.blogspot.com/2013/09/arduino_9.html)

# CENTRAL PROCESSING UNIT (CPU)

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Two Types of Commands Used in CPU Operation:

## 1. Reduced Instruction Set Computer (**RISC**, 精簡指令集)

Who uses it? Work Station, for example, SPARC (Oracle), Power PC (IBM), ARM CPU (for cell phone)

What is its purpose? Short time for each operation.

## 2. Complex Instruction Set Computer (**CISC**, 複雜指令集)

Who uses it? CPU for personal computers (Intel, AMD, VIA)

What is its purpose? Long time for each operation while having more powerful functions like commands for multimedia, for power saving, ...

RISC Commands:

LOAD A, 2:3

LOAD B, 5:2

PROD A, B

STORE 2:3, A

CISC Commands:

MULT 2:3, 5:2

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# POWER

Signal: 0 or 5 V, Power: 0 or 5 V, 12 V

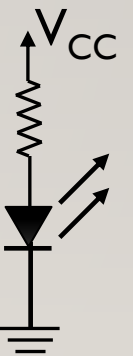
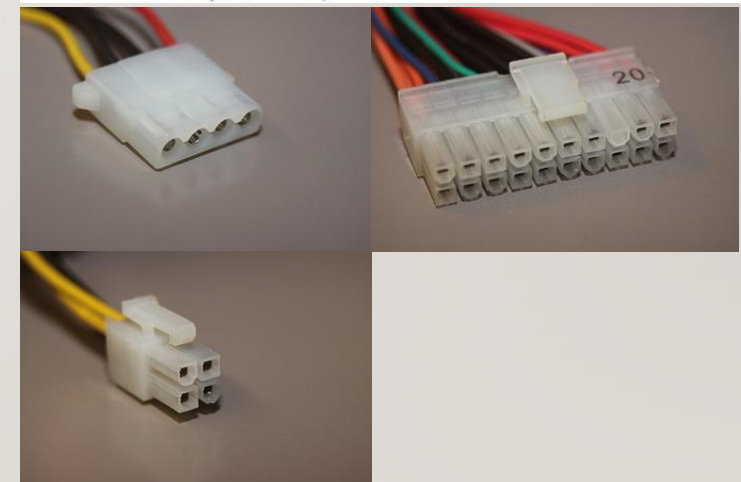
What's difference? The signal does not provide enough power. The current of the signal is small. It sometimes cannot drive the device, even a low-power consuming LED device.

4 pin peripheral power connector

ATX 20 pin main power connector

4 pin ATX + 12V power connector

Sometimes, the signal line does not have a protecting resistor. In that case, you need to add a current limiting resistor when you use the signal to light up the LED.



Ref1: <https://www.pcworld.com/article/2025425/how-to-pick-the-best-pc-power-supply.html>

Ref2: <https://forum.digikey.com/t/common-computer-power-supply-connectors/328>

# MEMORY

Accelerate the operation speed. The program and data will be loaded into the memory before the commands in the program are executed.

For the 8088 CPU, the storage size is 8 bits (1 bytes) and the addressing capability is  $2^{20}$  (1 Mega Bytes). The memory are usually separated to several parts for data, coding, and stacking pages.

The memory used by CPU is named random access memory (RAM), a dynamic RAM.

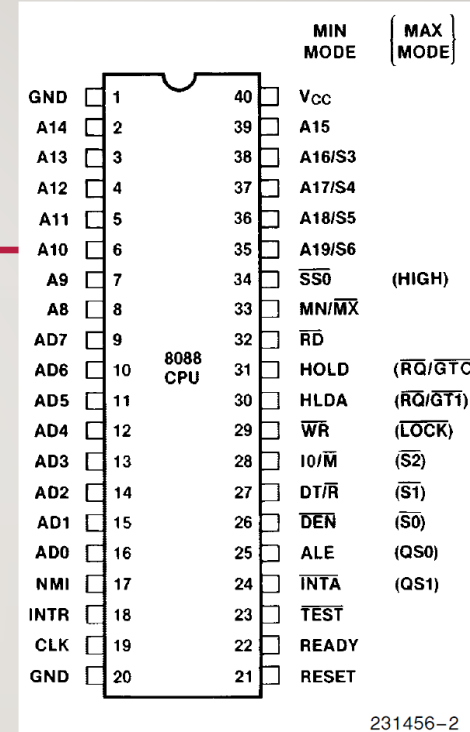
Another type – static RAM

SRAM: on-chip, fast access, short time, DRAM: off-chip, higher access time

SRAM: small size, DRAM: large storage capacity

SRAM: expensive, DRAM: cheap

SRAM: complex, DRAM: simple design



## F RAM (Random Access Memory)

SRAM – Static RAM vs. DRAM – Dynamic RAM



# MOTHERBOARD

Integrate CPU, Memory, Power, Expansion Slots like PCI Express, PCI, AGP (Accelerated Graphic Port for Video Cards)

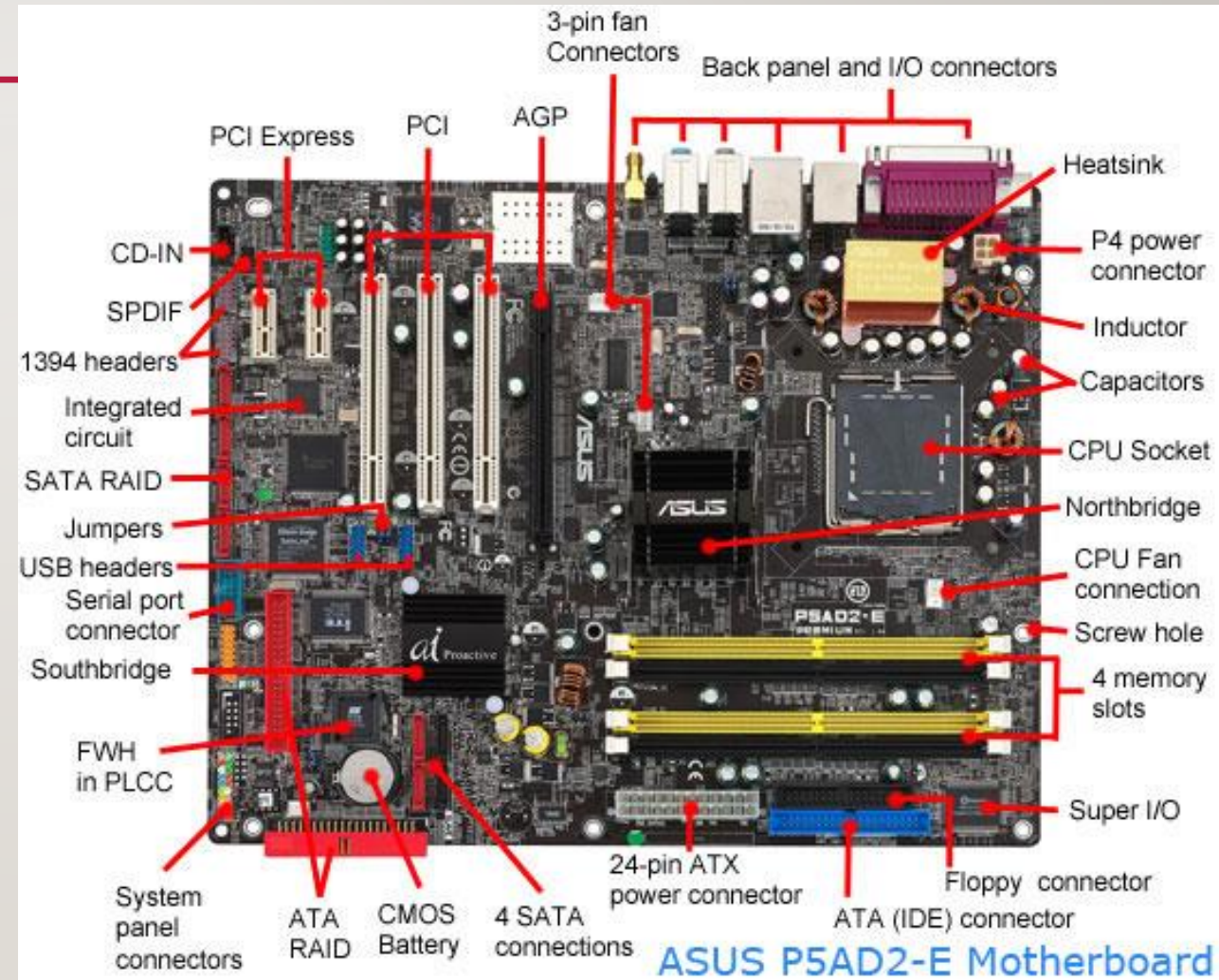
I/O Port (Mouse, Keyboard, USB, Serial Port), S/PDIF (Sony and Phillips Digital Interconnect Format - Sound I/O), Bluetooth, Wi-Fi/RJ45

Northbridge: Communications between The CPU Interface, AGP, and The Memory

Southbridge: IC for The Hard Drive Controller, I/O Controller, and Integrated Hardware

Storage Units Like Hard Disk Drive (HDD), Floppy Disk Drive (FDD), Optical Disk Drive (ODD), CD-ROM, DVD, Blue-Ray DVD

Ref1: <https://www.computerhope.com/jargon/m/mothboar.htm>



# PERIPHERALS – STANDARD INPUT & OUTPUT

Display, Mouse, Keyboard, Sound I/O, CCD (Charge-coupled Device)

The screen size of the surface pro is  $260 \times 175 \text{ mm}^2$ . The screen resolution is  $2736 \times 1824$  pixels. For a full color display, one pixel is represented by four bytes for red (R), green (G), blue (B), and alpha (A). The mapping of the screen requires 19 MBytes.



Bluetooth Mouse, Bluetooth Earphone

CCD Resolution 8 Mega Pixels

Integrated Sound Card – Realtek (瑞昱) High Definition Audio

Most hardware requires the software drivers for your operational system (OS).





# PERIPHERALS – HARD DISK, CD, DVD

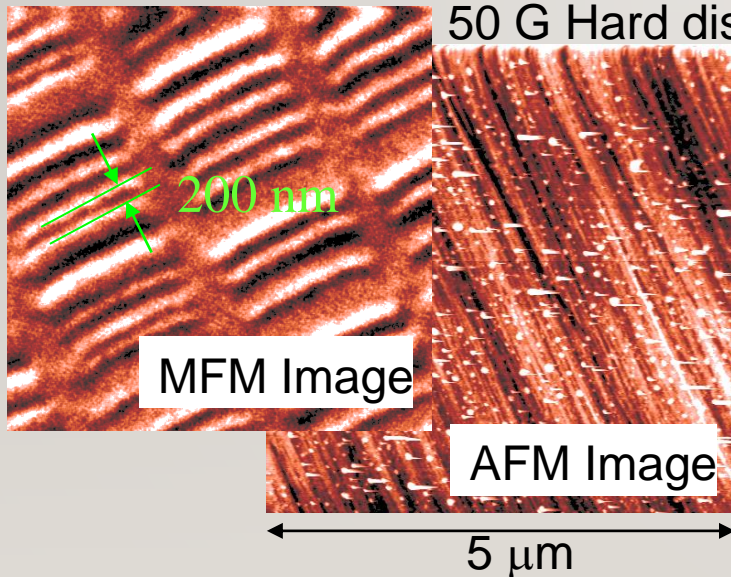
Secondary storage, permanent or long-time storage of data.  
 Magnetic domains read/write using the head made by magnetic tunneling junctions.  
 3D TLC NAND-based flash memory - a type of non-volatile memory that retains data when power is lost.



Hard Disk

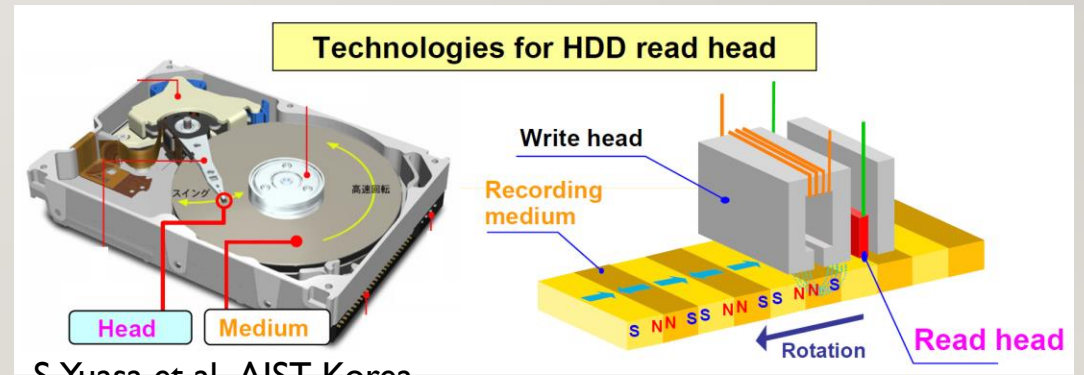
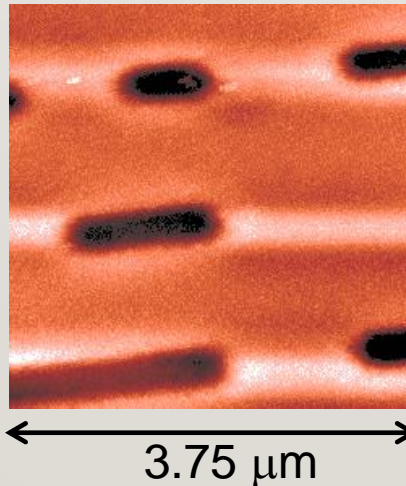


Solid State Drive



50 G Hard disk

DVD Disk



S.Yuasa et al., AIST, Korea

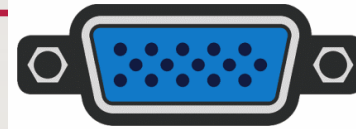
# PERIPHERALS – EXTERNAL PORTS

Display Ports, Printer Ports, Serial Ports, USB Ports

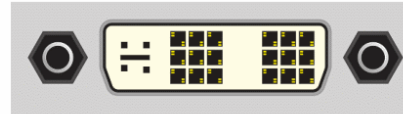
Display Ports: 15 pin VGA port, DVI-I, 19 pin HDMI, mini HDMI, micro HDMI

Parallel Port: Direct 8 bit parallel output, 4 control port

Serial Port: 9-pin RS232, now the protocol is also used for USB (4->9->24 pin Type-C) & Bluetooth connections



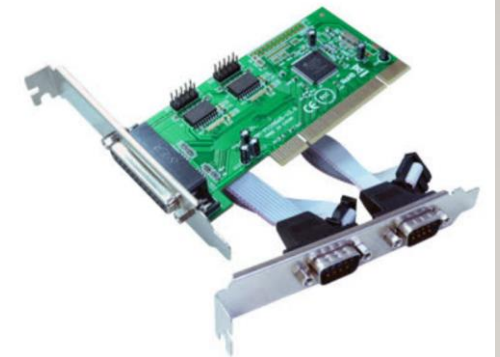
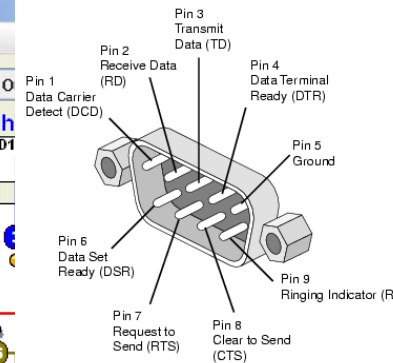
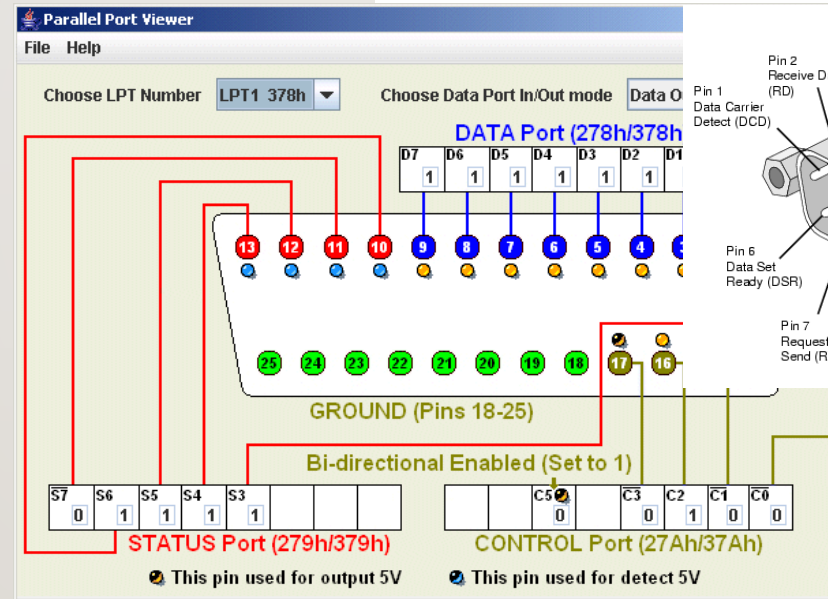
VGA



DVI-I



HDMI



Ref1: <http://www.expertreviews.co.uk/accessories/pc-monitors/1404476/hdmi-vs-displayport-vs-dvi-vs-vga-every-connection-explained>

Ref2: [https://en.wikipedia.org/wiki/Parallel\\_port](https://en.wikipedia.org/wiki/Parallel_port)

# PERIPHERALS – EXTERNAL PORTS

You can write software to control or to send data to the parallel port.

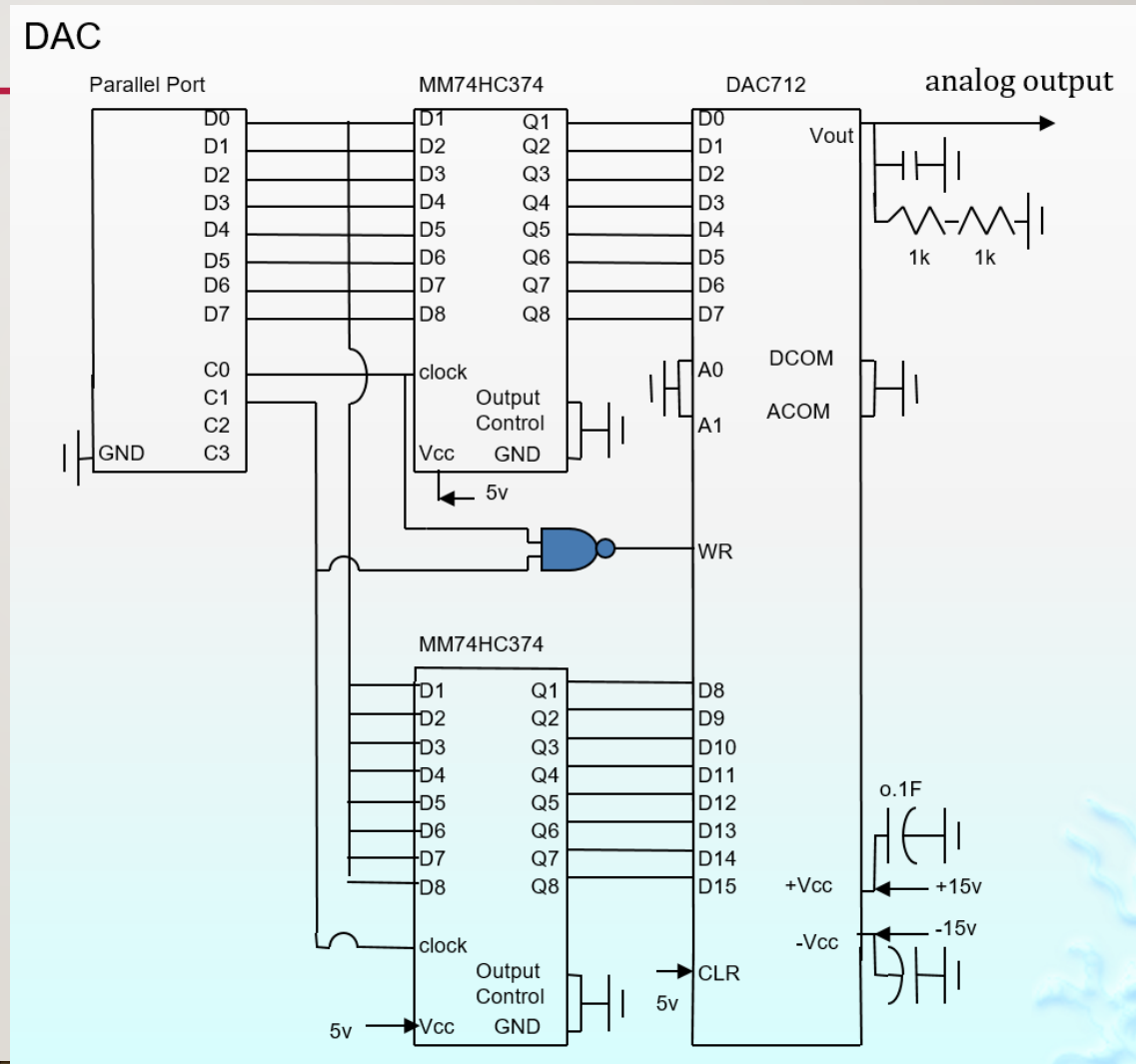
The data can be combined to form 16 bit resolution for output.

The 16 bit data can be send for digital-to-analog conversion for a 0-10V output.

The resolution of the output analog voltage is estimated by  $\frac{20}{2^{16}} = 3.05 \times 10^{-4} \text{ V}$ .

It's possible to reverse the data direction so you can read the analog voltage as a digital number.

The resolution depends on how many bits used in the AD/DA conversion.



# PERIPHERALS – INTERNET

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Ethernet is used in your everyday life. The data is predominantly transferred by cable (Ethernet cable connection) while the data transfer can be wireless for the end users (Wi-Fi-wireless fidelity, cellphone mobile data).

1962 The first commercial modem – the Bell 103 developed by AT&T, full-duplex transmission, speed of 300 bps (bits per second)

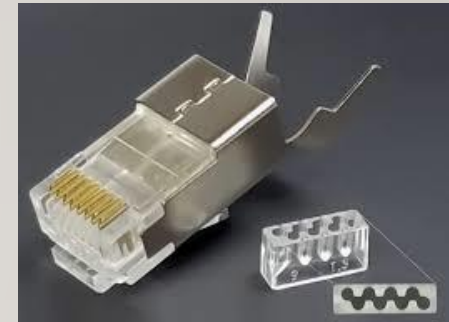
1991 The data transfer speed of the modem is increased up to 14.4 Kbps. (1990-1996 used in Taiwan -> BBS)

Sound of dial-up modem: <https://www.youtube.com/watch?v=gsNaR6FRuO0>

Ethernet is developed by the company – Xerox PARC between 1973 and 1974.

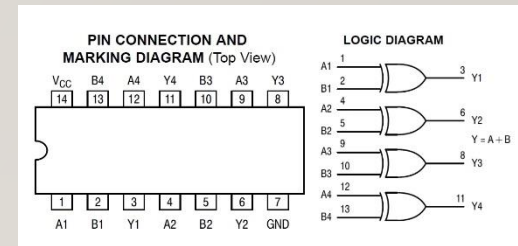
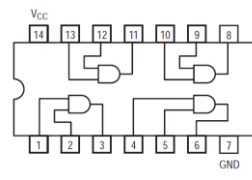
The development of Ethernet is inspired by ALOHNET. “In the late 1960s, Abramson and his team set out to connect computers across the University of Hawaii system using radio communications.”

The speed of the first Ethernet – 10BASE5 is 2.94 Mbps. Now the speed is increased up to 400 Gbps.



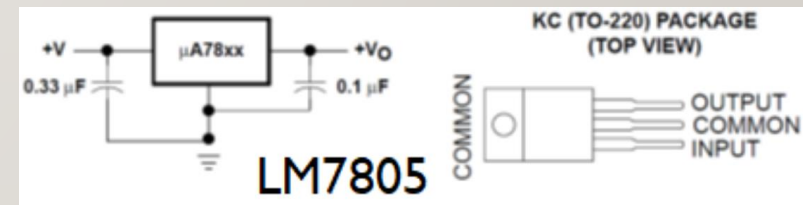
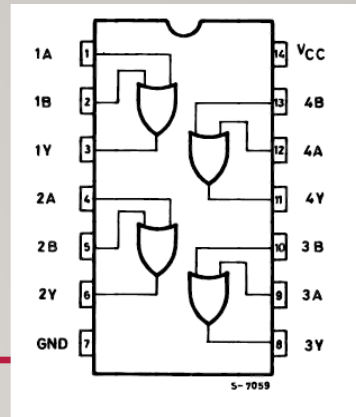
# EXERCISE

1. Please use the components of a 9V battery, LM7805, SN74LS08 to demonstrate the results of  $1 \cdot 1 = 1$  and  $1 \cdot 0 = 0$ . Please draw circuit diagram and mark the inputs and outputs for your demonstration of the 'and' operation. The  $V_{cc}$  can be provided by the battery and LM7805 (voltage regulator). You may use the circuit symbol of a battery and mark the total voltages about the battery symbols.
2. Please use four 1.5 V batteries, LM7805, and MC74VHCT86A (a 2-input xor gate) to demonstrate the results of  $1 \text{ xor } 1 = 0$  and  $1 \text{ xor } 0 = 1$ . Please draw circuit diagram and mark the inputs and outputs for your demonstration of the 'xor' operation. The  $V_{cc}$  can be provided by the batteries and LM7805 (voltage regulator). You may use the circuit symbol of a battery and mark the total voltages about the battery symbols.

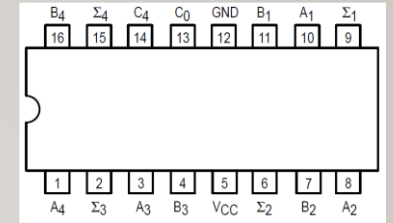


# EXERCISE

1. Please use the components of a 9V battery, LM7805, M74HC32 to demonstrate the results of  $1 \text{ or } 1 = 1$  and  $1 \text{ or } 0 = 1$ . Please draw circuit diagram and mark the inputs and outputs for your demonstration of the 'or' operation. The  $V_{cc}$  can be provided by the battery and LM7805 (voltage regulator). You may use the circuit symbol of a battery and mark the total voltages about the battery symbols.
2. Please use the voltage regulator, LM7805, and a 9-V battery to design a 5-V power supplier.



# EXERCISE



- For a Motorola 74LS83 shown in the right figure, the input pins are A<sub>1</sub>-A<sub>4</sub> and B<sub>1</sub>-B<sub>4</sub>. If you have a 5 V voltage source (use a 9V battery and LM7805), how do you connect the wire to the chip and demonstrate the addition of the binary operation of 0011 + 1011? Please write down the output voltages on the pins of Σ<sub>1</sub>-Σ<sub>4</sub>.

# EXERCISE

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1. Put decimal numbers of 13812, 217003, and 1996 into the three different forms, the binary, the octal, and the hexadecimal forms.
2. Please convert the hexadecimal numbers B, 1F, ABC, 1F5D into binary, octal, and decimal numbers.
3. Please convert the decimal numbers 9, 57, 789, 1982 into binary, octal, and hexadecimal numbers.
4. What are their decimal forms of the hexadecimal numbers, 1204, F21, and 2AF?



# EXERCISE

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1. What are all the possible data transfer speeds (baud-rates) for the RS-232 serial port?
2. What are the differences between the parallel port and the RS-232 serial port?
3. The display resolution of the monitor of the 1<sup>st</sup> Macintosh computer is 512 x 342 pixels with 1 bit (white/black) for each pixel. How many bytes are used to control the full display of the screen? The display resolution of the Surface Pro is 2736 x 1824 pixels with full color (RGBA four bytes). How many bytes are used to control the full display of the screen?
4. What is an analog to digital converter? For example, how does it convert 3.0V to a 8-bit digital signal if a full voltage range is between 0 and 5V.