Al-Mustaqbal University

College of Engineering

Department of Biomedical Engineering

Stage: 4th

Microcontroller

2025-2026

Lecture ( ):

PC Interfacing

Fourth Level

Lecture

PIC Microcontroller Interface

By

Prof.Dr. Ibrahim A.Murdas

Why do we need to learn Microcontrollers?

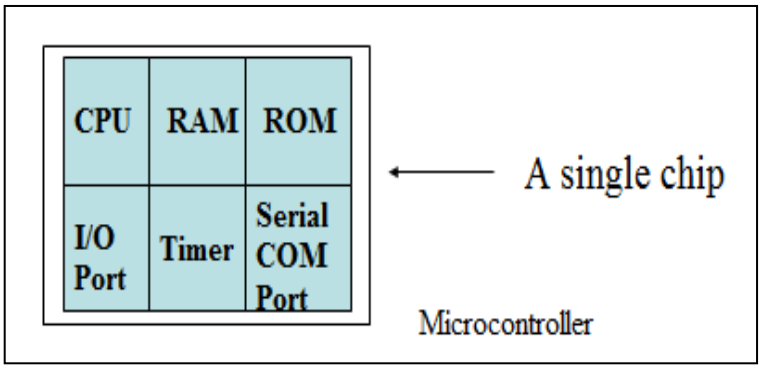
It's not an exaggeration if we say that, today there is no electronic gadget on the earth which is designed without a Microcontroller. Ex: communication devices, digital entertainment, portable devices etc… Not believable???

- Personal information products: Cell phone, pager, watch, pocket recorder, calculator
- Laptop components: mouse, keyboard, modem, sound card, battery charger.
- Home appliances: door lock, alarm clock, thermostat, air conditioner, TV remote, refrigerator, exercise equipment, washer/dryer, microwave oven.
- Industrial equipment: Temperature/pressure controllers, Counters, timers.
- Toys: video games, cars, dolls, etc.

So, a good designer should always know what type of controller he/she is using, their architecture, advantages, disadvantages, ways to reduce production costs and product reliability etc….

Components of a microcontroller:

- CPU: Central Processing Unit.
- I/O: Input /Output.
- Bus: Address bus & Data bus.
- Memory: RAM & ROM.
- Timer.
- Interrupt.
- Serial Port.
- Parallel Port.



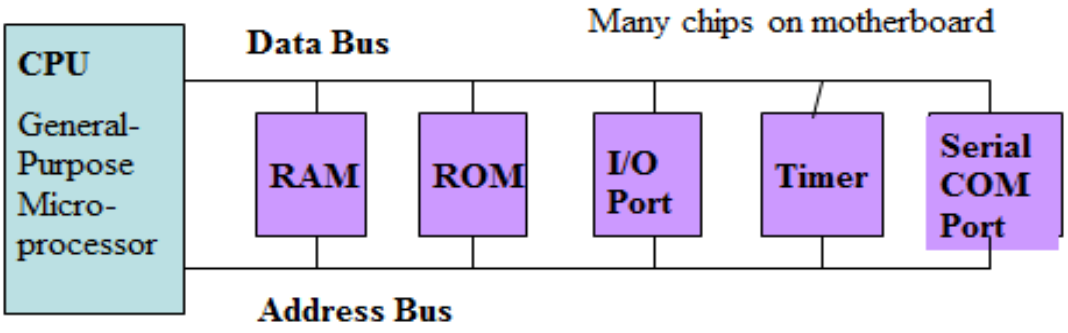
Then what is a Microcontroller?

- A single-chip computer
- On-chip RAM, ROM, I/O ports...

A single chip computer or A CPU with all the peripherals like RAM, ROM, I/O Ports, Timers, ADCs etc... on the same chip. For ex: Motorola's 6811, Intel's 8051, Zilog's Z8 and PIC 16X etc…

General-purpose microprocessor:

- CPU for Computers.
- Commonly no RAM, ROM, I/O on CPU chip itself. For ex: Intel's 8086, 8088, 80386, 80486 and Pentium, Motorola's 68000, 68010, 68020 and 68030.



A CPU built into a single chip is called a microprocessor. It is a general-purpose device. The microprocessor contains arithmetic and logic unit (ALU), Instruction decoder and control unit, Instruction register, Program counter (PC), clock circuit (internal or external), reset circuit (internal or external) and registers. But the microprocessor has no on chip I/O Ports, Timers, Memory etc. For example, Intel 8085 is an 8-bit microprocessor and Intel 8086/8088 a 16-bit microprocessor. The block diagram of the Microprocessor is shown in Fig.1.

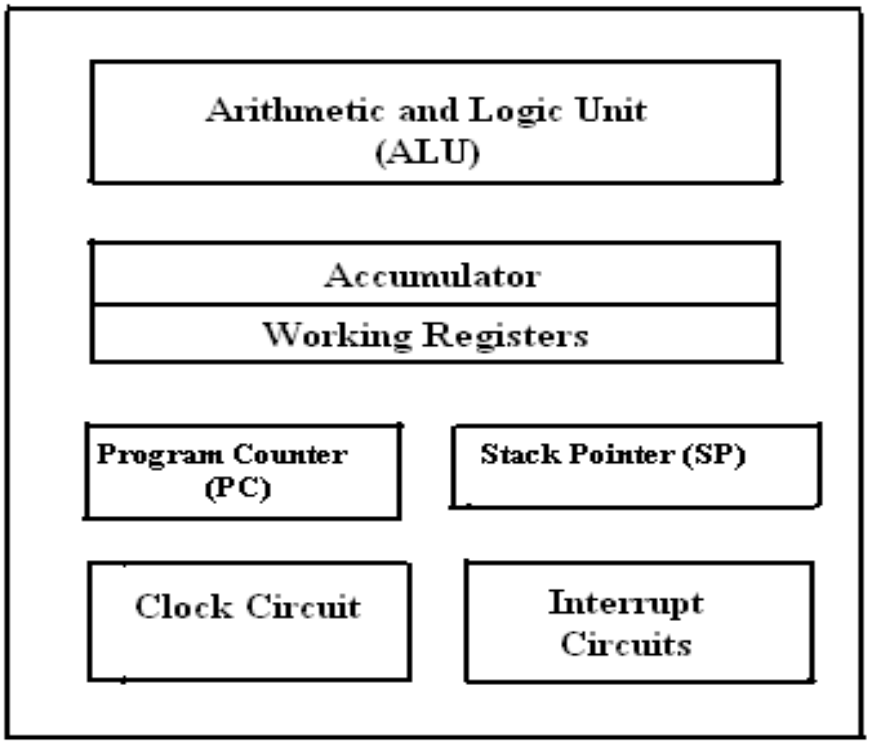


Fig.1 Block diagram of a Microprocessor.

Microcontroller:

A microcontroller is a highly integrated single chip, which consists of on chip CPU (Central Processing Unit), RAM (Random Access Memory), EPROM/PROM/ROM (Erasable Programmable Read Only Memory), I/O (input/output) – serial and parallel, timers, interrupt controller. For example, Intel 8051 is 8-bit microcontroller and Intel 8096 is 16-bit microcontroller. The block diagram of Microcontroller is shown in Fig.2.

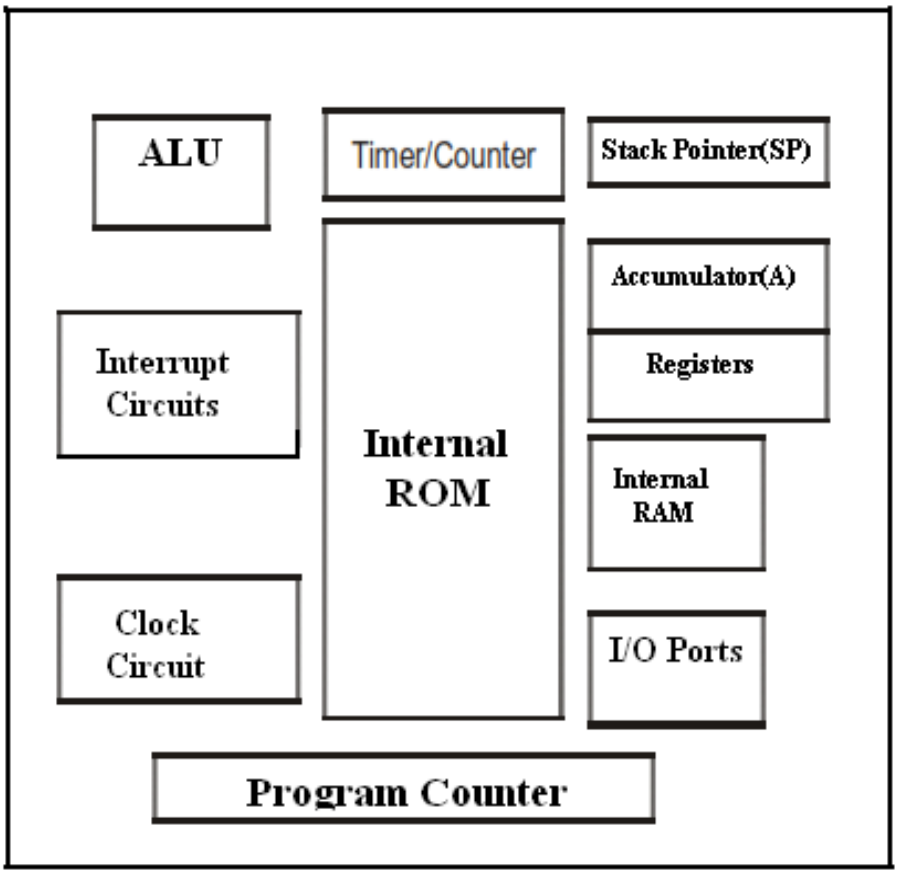
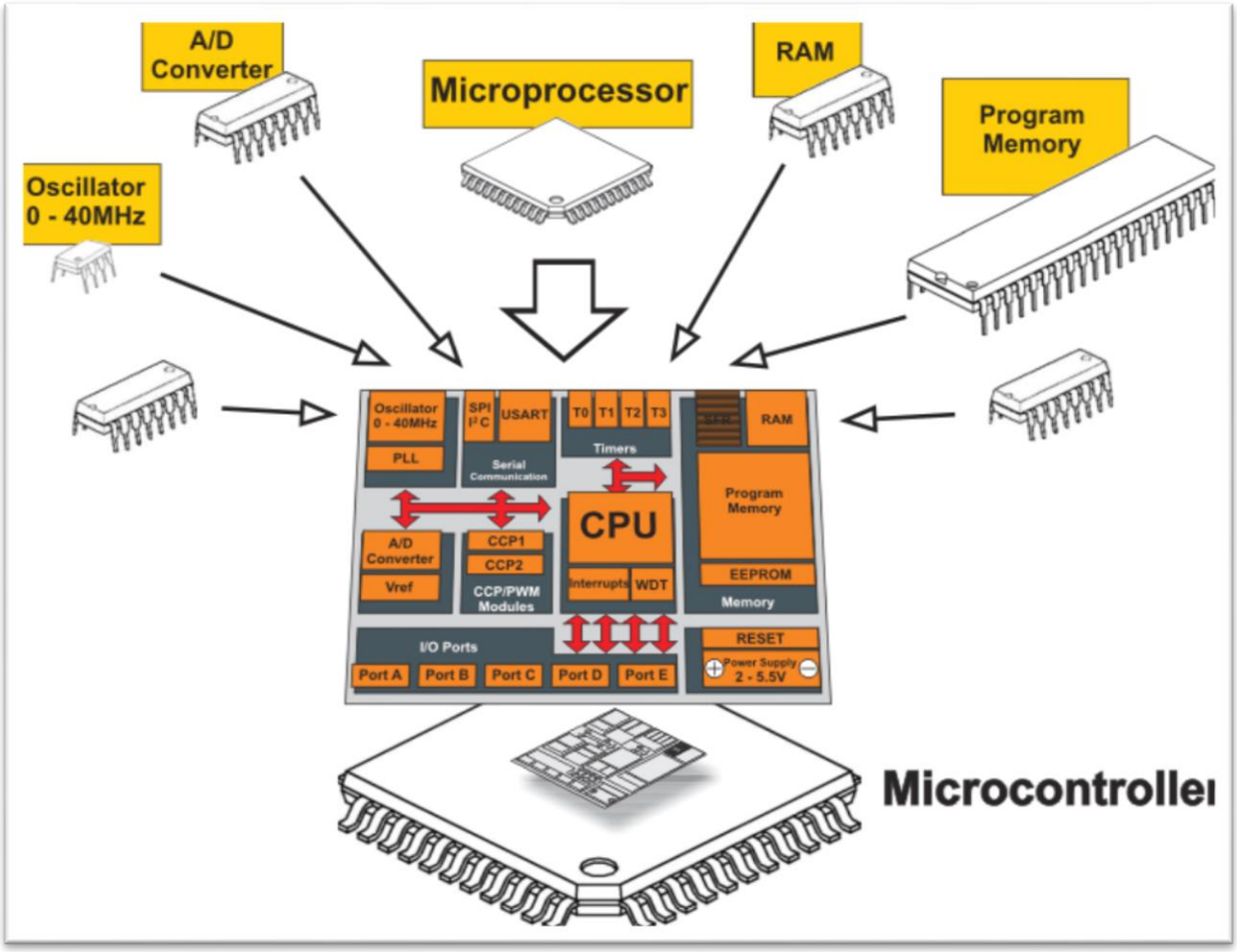


Fig.2. Block Diagram of a Microcontroller.

Difference between a Microprocessor and Microcontroller

Essentially these two devices are similar, but with a little bit of difference. A CPU which is the heart of these devices needs a host of external devices to make it communicate with real-world. These devices which are independent circuits, work in harmony with the CPU, to make one system. In a Computer these devices are attached to the CPU, using hard-wired connections. This makes the system more flexible, which means you can add more memory, change capacity of hard drives, add or remove CD-ROMs, sound cards etc.

A microcontroller on the other hand is made up of most of these devices built exactly within the same package. So, microcontroller will therefore contain, the CPU, RAM, ROM, Timers, I/O etc. all packed within one integrated circuit. This facilitates the development process, as well as reduce the requirements of external components, however this also means you cannot change, the number and type of integrated devices.



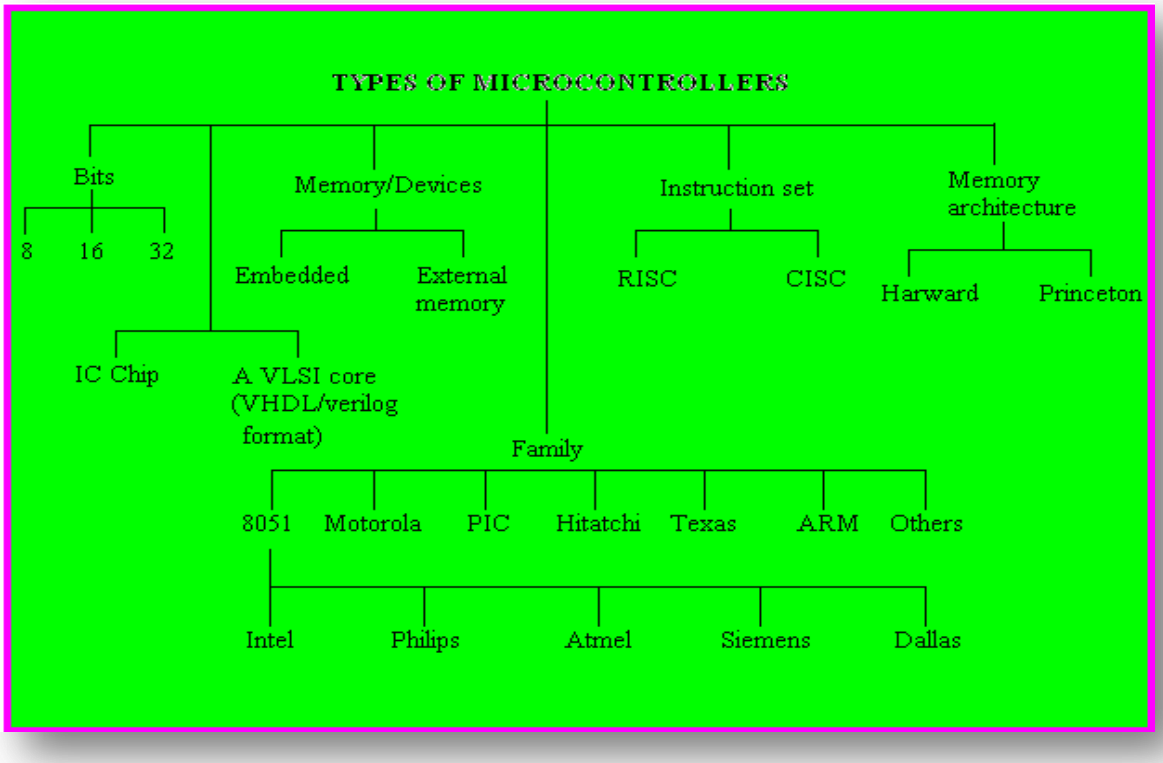
Distinguish between Microprocessor and Microcontroller

Microprocessor	Microcontroller
CPU is stand-alone, RAM, ROM, I/O, timer are separate.	CPU, RAM, ROM, I/O and timer are all on a single chip.
Designer can decide on the amount of ROM, RAM and I/O ports.	Fixed amount of on-chip ROM, RAM, I/O ports.
General-purpose.	Single-purpose.
High processing power	Low processing power
Typically 32/64 – bit	Typically 8/16 bit
High power consumption.	Low power consumption

Evolution of Microcontrollers:

In the year 1976, Motorola designed a Microprocessor chip called 6801 which replaced its earlier chip 6800 with certain add-on chips to make a computer. This paved the way for the new revolution in the history of chip design and gave birth to a new entity called "Microcontroller". Later the Intel company produced its first Microcontroller 8048 with a CPU and 1K bytes of EPROM, 64 Bytes of RAM an 8-Bit Timer and 27 I/O pins in 1976. Then followed the most popular controller 8051 in the year 1980 with 4K bytes of ROM, 128 Bytes of RAM, a serial port, two 16-bit Timers, and 32 I/O pins. The 8051 family has many additions and improvements over the years and remains a most acclaimed tool for today's circuit designers. INTEL introduced a 16 bit microcontroller 8096 in the year 1982. Later INTEL introduced 80c196 series of 16-bit Microcontrollers for mainly industrial applications. Microchip, another company has introduced an 8-bit Microcontroller PIC 16C64 in the year 1985.The 32-bit microcontrollers have been developed by IBM and Motorola. MPC 505 is a 32-bit RISC controller of Motorola. The 403 GA is a 32 -bit RISC embedded controller of IBM.

In recent times ARM Company (Advanced RISC machines) has developed and introduced 32 bit controllers for high-end application devices like mobiles, IPods etc...



Microcontrollers from different manufacturers

- Atmel
- ARM
- Intel
  - 8-bit
    - 8XC42
    - MCS48
    - MCS51
    - 8xC251
  - 16-bit
    - MCS96
    - MXS296
- National Semiconductor
  - COP8
- **Microchip** ←
  - **12-bit instruction PIC**
  - **14-bit instruction PIC**
    - **PIC16F84**
  - **16-bit instruction PIC**
- NEC
- Motorola
  - 8-bit
    - 68HC05
    - 68HC08
    - 68HC11
  - 16-bit
    - 68HC12
    - 68HC16
  - 32-bit
    - 683xx
- Texas Instruments
  - TMS370
  - MSP430
- Zilog
  - Z8
  - Z86E02

Why there are too many different Microcontrollers?

PIC Microcontrollers:

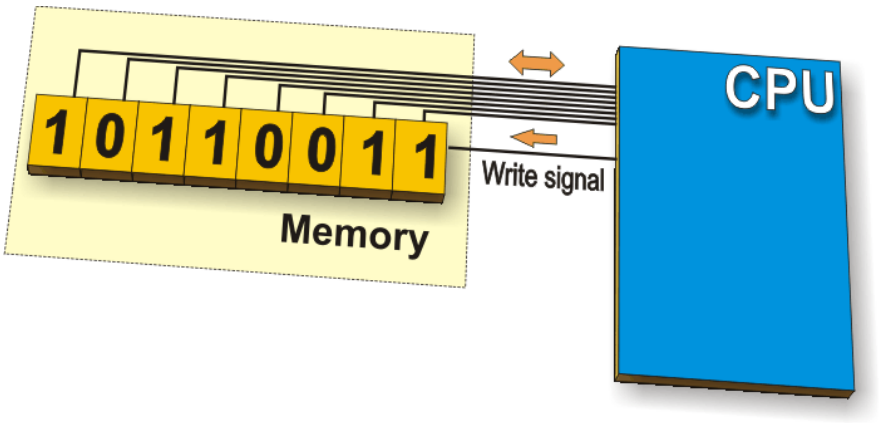
- PIC – "Peripheral Interface Controller" made by Microchip Technology.
- Most popular by industry developers and hobbyists.
  - Low cost.
  - Availability.
  - Extensive application.
  - Serial programming.

Advantages of PIC:

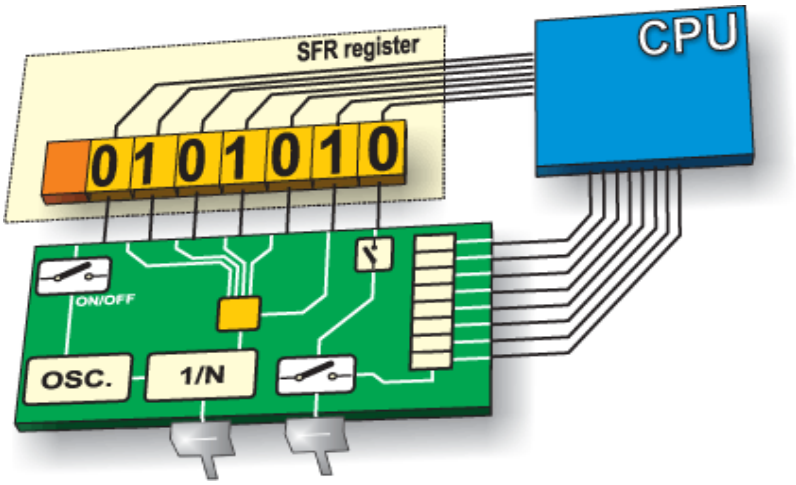
- 30 to 100 times faster than other µCs (program memory is integrated to the chip).
- Smaller size (on-board memory).
- Easy to program, reusable and inexpensive.

Internal Units description:-

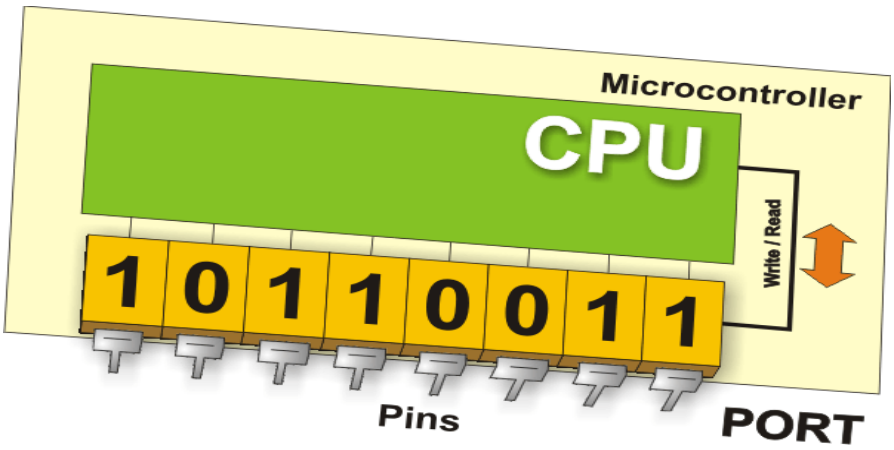
- **Register:** An electronic circuit which can memorize the state of one byte.



- **SFR (Special Function Register):** Registers whose function is predetermined by the manufacturer of the microcontroller Examples are timers, A/D converter, oscillators, etc.

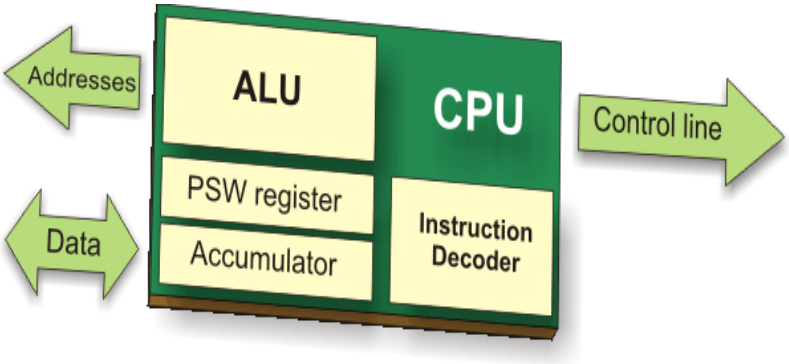


- **Input / Output Ports:** Microcontroller has one or more registers (called ports) connected to the microcontroller pins. Can change a pin function as you wish.

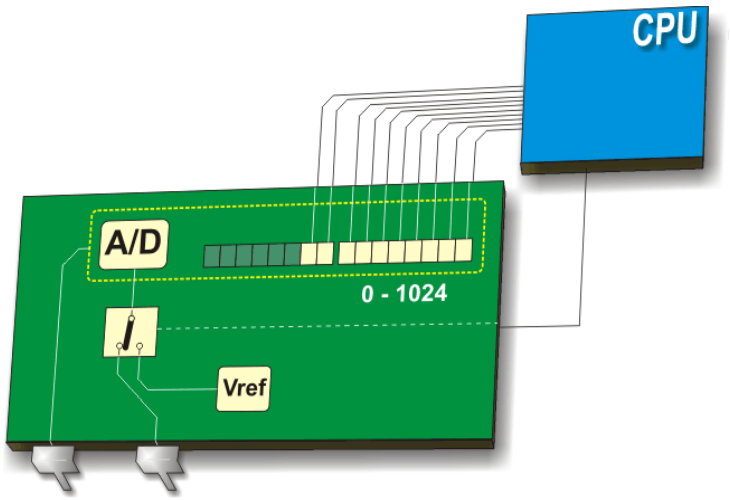


- **Memory Unit:** Memory is part of the microcontroller used for data storage. Types (RAM, ROM).

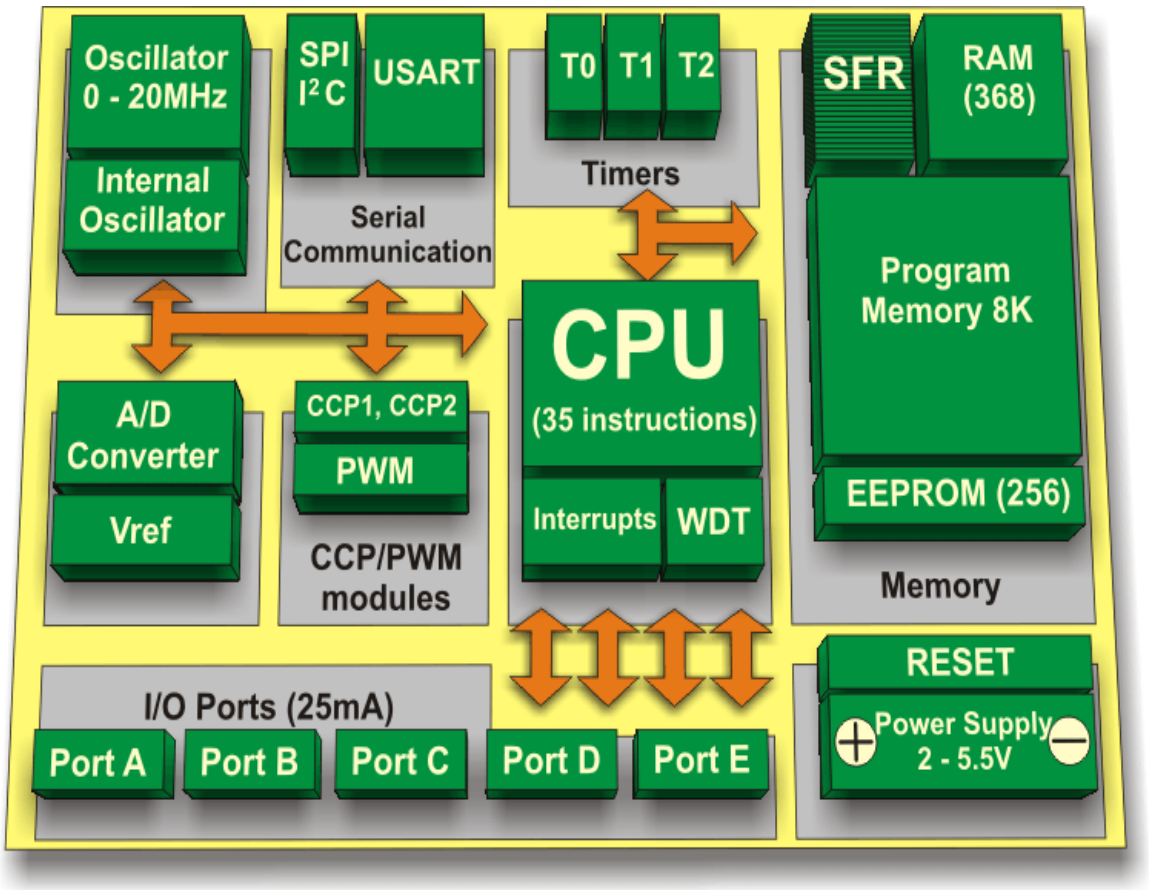
- **INTERRUPT**: Most programs use interrupts in their regular execution. The signal which informs the central processor unit about such an event is called an INTERRUPT.
- **Central Processor Unit (CPU)**: which contains instruction decoder, accumulator and ALU.

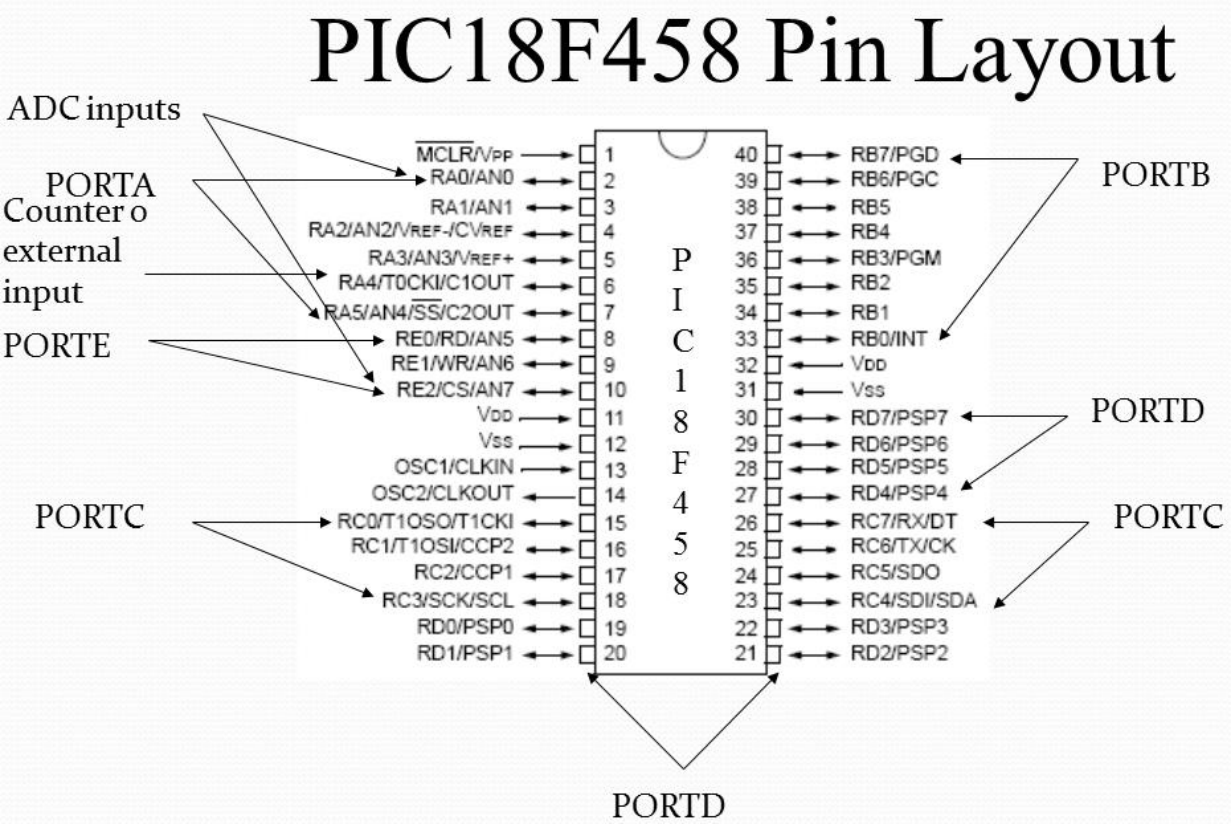


- **A/D converter**: converts continuous signals to discrete digital numbers or convert an analogue value into a binary number and passes it to the CPU for further processing.

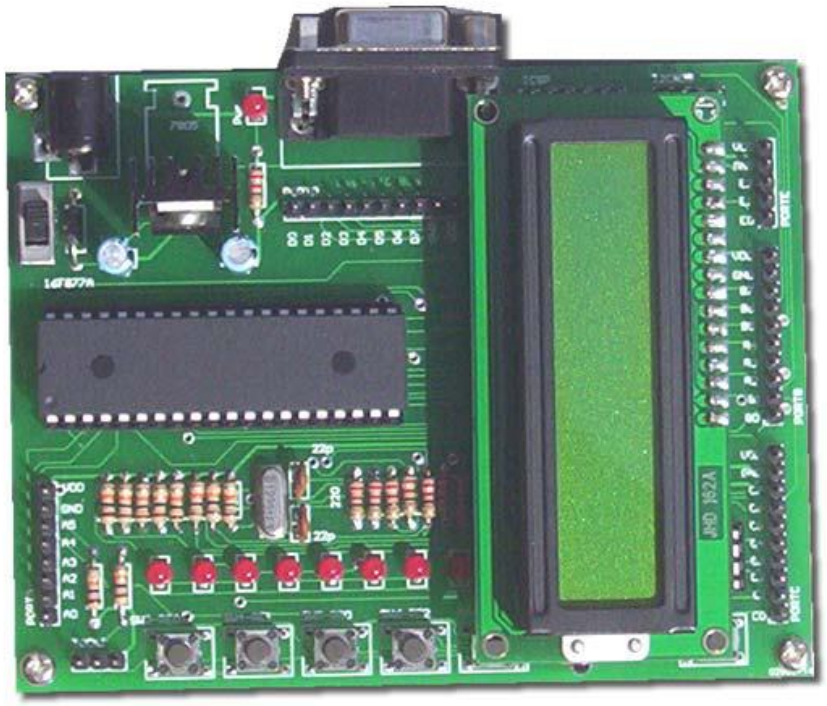


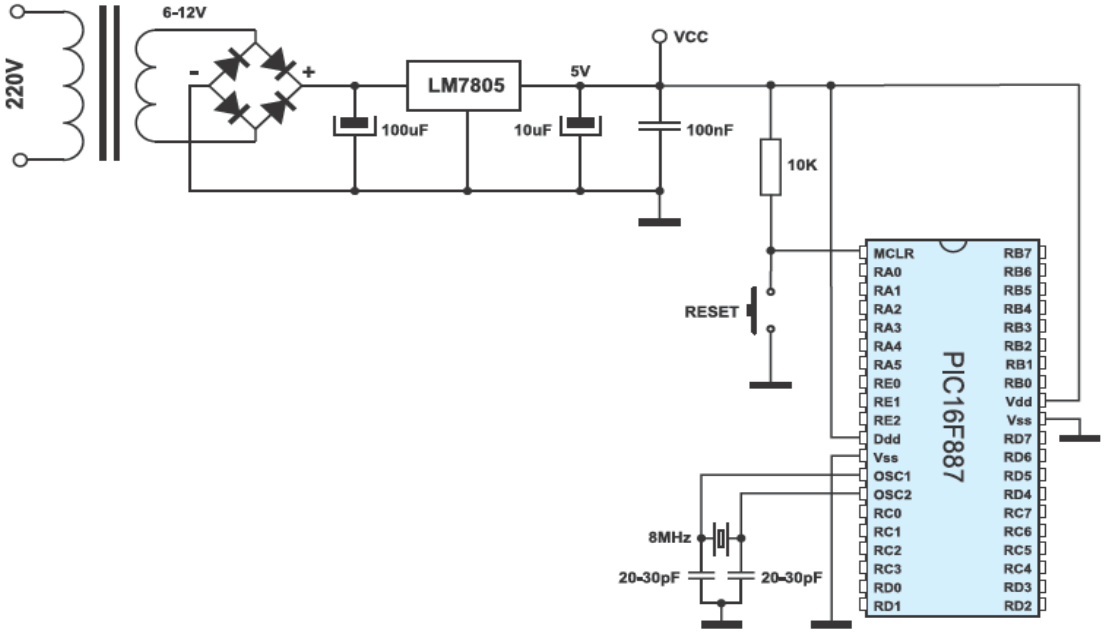
- **Bus:** the bus consists of 8, 16 or more wires. There are two types of buses: address and data bus.
- **UART (Universal Asynchronous Receiver/Transmitter).**
- **Oscillator**.
- **Power supply circuit**.
- **Timers/Counters**.

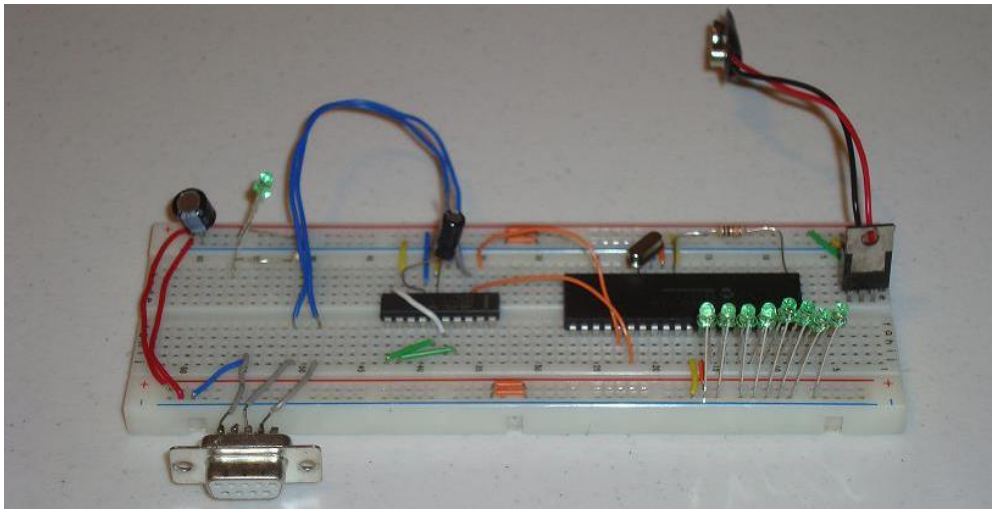




In order to do various experiments with PIC microcontroller it is advisable to have a development board. In case you don't have a development board available, you can make a simple board using bread-board or vero board.




6-12V
220V
LM7805
5V
VCC
100uF
10uF
100nF
10K
RESET
8MHz
20-30pF
20-30pF
PIC16F887
MCLR
RA0
RA1
RA2
RA3
RA4
RA5
RE0
RE1
RE2
Ddd
Vss
OSC1
OSC2
RC0
RC1
RC2
RC3
RD0
RD1
RB7
RB6
RB5
RB4
RB3
RB2
RB1
RB0
Vdd
Vss
RD7
RD6
RD5
RD4
RC7
RC6
RC5
RC4
RD3
RD2



UART (Universal Asynchronous Receiver and Transmitter) PORTC.6, 7:

The board contains a standard universal Serial Asynchronous Receiver and Transmitter. Many devices use this protocol to communicate with other devices. The communication needs two wires, one for transmission and one for receiving data. PCs and some other devices, use a level translator, to redefine the standard signals for logical 0 and 1. This is done so, to minimize noise interference as well as prolong communication distance. To use these signals, they must be converted back to TTL level logic. The PIC board contains RS232 level converter which converts these signals to TTL level, and to transmission levels while sending data. Most PIC microcontrollers contain an internal hardware to manage this communication, so that software development becomes easy. PORTC.6 and PORTC.7 are configured as hardware USART communication pins.

NOTE: since the PORTC is also connected to LEDs, if LEDs are enabled receiving data from USART is interfered. It is therefore mandatory to disable, LEDs while using UASRT.

RS232 Communication with PIC Microcontroller

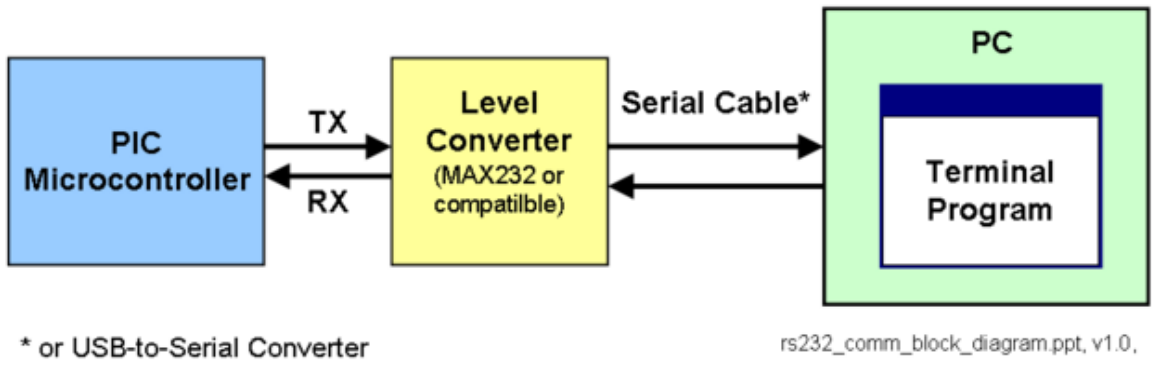
This paragraph shows how to do a simple communication via a RS232 interface with a PIC microcontroller. RS232 is a standard for a serial communication interface which allows sending and receiving data via at least three wires. With the RS232 interface it is possible to setup a connection between a microcontroller and a PC (via PC's COM port) or between two microcontrollers. So, we will show how to link a PIC microcontroller to a standard PC. On the PC we will use a program to send and receive data.

Note that modern PCs don't have a serial port so you need to get a USB to serial converter. They are available at low cost.

Fig. USB to Serial Converter

Block Diagram

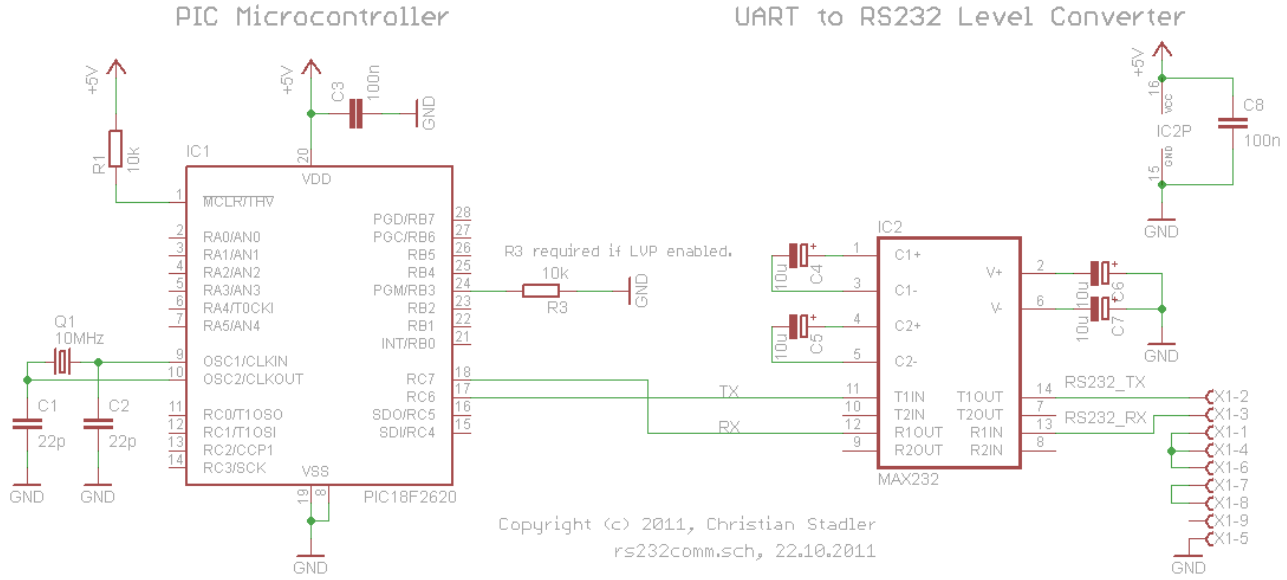
The following block diagram shows the whole setup:



For serial communication the line used to transmit data is called TX and the line used to receive data is called RX. The level converter is required to translate the voltage level of the microcontroller to RS232 voltage level. The microcontroller operates at TTL level (0V = logic 0, +5V logic 1) whereas RS232 uses around +/-12V. A very famous RS232 level converter is the MAX232 chip.

Hardware

In the schematic below a PIC microcontroller is connected to the RS232 level converter chip. A PIC18F2620 microcontroller is used, but it will also work with any other microcontroller which has a built-in UART.



The PIC usually is running at 10 MHz,

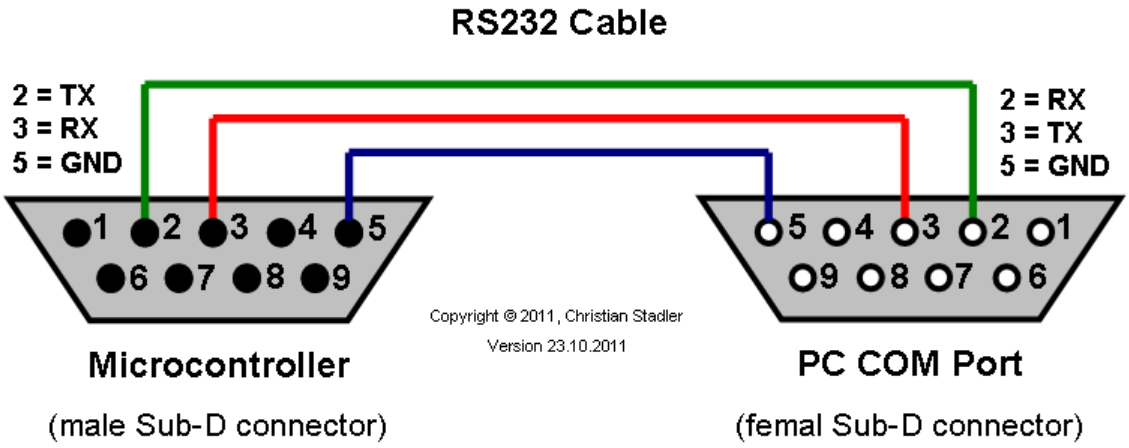
In order to properly communicate it is very important that the communication devices should have the same Baud rate usually 9600.

The RS232 level converter uses the famous MAX232 chip, but any other MAX232 compatible chip will also work. It just requires 4 capacitors to do its job. These external capacitors are required for the charge pump inside the chip which generates the required voltage levels.

The connections on the DB9 connector pins 1, 4, 6, 7, 8 and 9 are not used.

RS232 Cable

To connect the above circuit to the PC we need a RS232 cable. The below picture shows the necessary connections.



Hardware Picture:

Below a picture of the hardware setup.

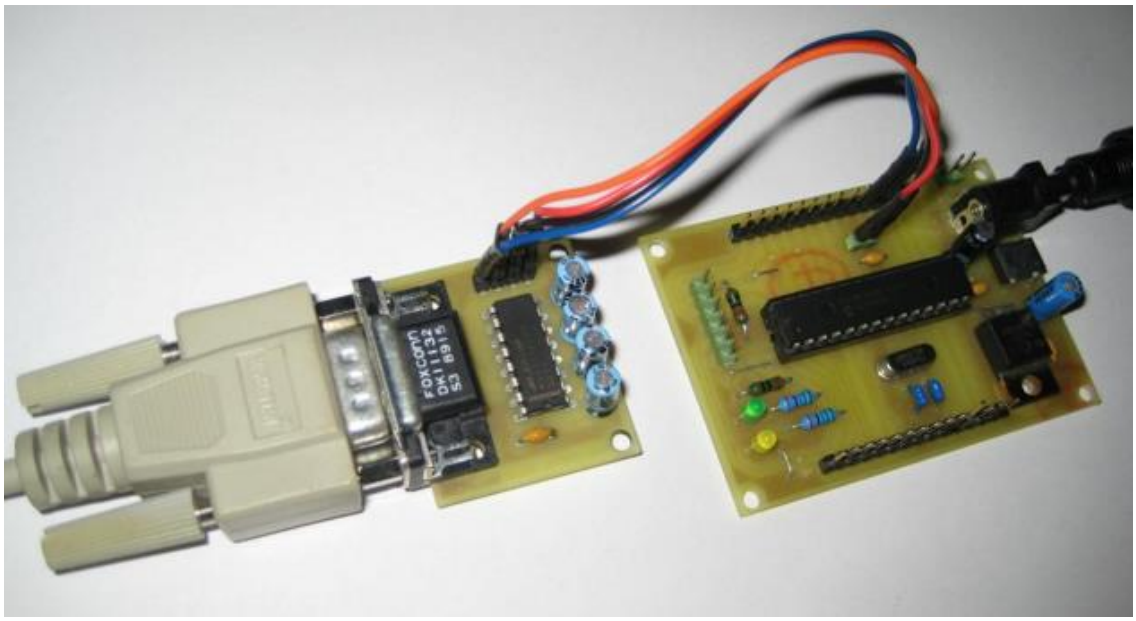


Fig. Serial Port Connected

Software

Now since the hardware is ready we have to write the software for the PIC microcontroller. The different compiler vendors provide different ways to setup the UART in the PIC.