**5.1 Microcontroller:**

**5.1.1 Introduction:**

Microcontroller as the name suggest, a small controller. They are like single chip computersthat are often embedded into other systems to function as processing/controlling unit. Forexample, the control you are using probably has microcontrollers inside that do decoding andother controlling functions. They are also used in automobiles, washing machines, microwavesovens, toys….etc, where automation is needed.

**5.1.2 Arduino Uno Microcontroller:**

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digitalinput/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means "One" in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

The Arduino Uno can be powered via the USB connection or with an external power supply. The powersource is selected automatically.External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adaptercan be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from abattery can be inserted in the Gnd and Vin pin headers of the POWER connector.The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5Vpin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts

The power pins are as follows:·

* **VIN.** The input voltage to the Arduino board when it's using an external power source (as opposed to5 volts from the USB connection or other regulated power source). You can supply voltage throughthis pin, or, if supplying voltage via the power jack, access it through this pin.·
* **5V.** The regulated power supply used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator, or be supplied by USB or another regulated 5V supply.
* **3.3V.**A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
* **GND.** Ground pins.

**Memory:**

The Atmega328 has 32 KB of flash memory for storing code (of which 0,5 KB is used for the bootloader); Ithas also 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

**Input and Output:**

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive a maximum of 40 mA andhas an internal pull-up resistor (disconnected by default) of 20-50 kOhms. In addition, some pins havespecialized functions:

* **Serial: 0 (RX) and 1 (TX).** Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip .
* **External Interrupts: 2 and 3.** These pins can be configured to trigger an interrupt on a low value, arising or falling edge, or a change in value. See the attach Interrupt() function for details.
* **PWM: 3, 5, 6, 9, 10, and 11.** Provide 8-bit PWM output with the analogWrite() function.
* **SPI: 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK).** These pins support SPI communication, which although provided by the underlying hardware, is not currently included in the Arduino language.
* **LED: 13.** There is a built-in LED connected to digital pin 13. When the pin is HIGH value, the LED ison, when the pin is LOW, it's off.

The Uno has 6 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values). Bydefault they measure from ground to 5 volts, though is it possible to change the upper end of their rangeusing the AREF pin and the analogReference() function. Additionally, some pins have specialized

functionality:

* **I2C: 4 (SDA) and 5 (SCL).** Support I2C (TWI) communication using the Wire library.

There are a couple of other pins on the board:

* **AREF.** Reference voltage for the analog inputs. Used with analogReference().
* **Reset.** Bring this line LOW to reset the microcontroller. Typically used to add a reset button toshields which block the one on the board.

**Communication:**

The Arduino Uno has a number of facilities for communicating with a computer, another Arduino, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega8U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The '8U2 firmware uses the standard USBCOM drivers, and no external driver is needed. However, on Windows, an \*.inf file is required. The Arduino software includes a serial monitor which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-toserial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A SoftwareSerial library allows for serial communication on any of the Uno's digital pins. The ATmega328 also support I2C (TWI) and SPI communication. The Arduino software includes a Wire library to simplify use of the I2C bus

**5.1.3 ARDUINO UNO BOARD:**

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

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**Figure 5.1:** Arduino uno board

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converters.

**5.1.3.1 Technical Specifications:**



**Table 5.1:** Arduino uno specifications

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

**1.USB Interface:**

Arduino board can be powered by using the USB cable from your computer. All you need to do is connect the USB cable to the USB connection

**2.External power supply:**

Arduino boards can be powered directly from the AC mains power supply by connecting it to the power supply (Barrel Jack)

**3.Voltage Regulator:**

The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.

**4.Crystal Oscillator:**

The crystal oscillator helps Arduino in dealing with time issues. How does Arduino calculate time? The answer is, by using the crystal oscillator. The number printed on top of the Arduino crystal is 16.000H9H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.

**5,17.Arduino Reset:**

It can reset your Arduino board, i.e., start your program from the beginning. It can reset the UNO board in two ways. First, by using the reset button (17) on the board. Second, you can connect an external reset button to the Arduino pin labelled RESET (5).

**6-9.Pins (3.3, 5, GND, Vin):**

* 3.3V (6): Supply 3.3 output volt
* 5V (7): Supply 5 output volt
* Most of the components used with Arduino board works fine with 3.3 volt

and 5 volt.

* GND (8)(Ground): There are several GND pins on the Arduino, any of which can be used to ground your circuit.
* Vin (9): This pin also can be used to power the Arduino board from an

external power source, like AC mains power supply.

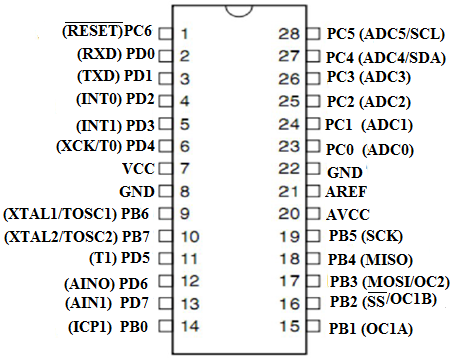
**10.Analog pins:**

The Arduino UNO board has five analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.

**11.Main microcontroller:**

Each Arduino board has its own microcontroller (11). You can assume it as the brain of your board. The main IC (integrated circuit) on the Ardsuino is slightly different from board to board. The microcontrollers are usually of the ATMEL Company. You must know what IC your board has before loading up a new program from the Arduino IDE. This information is available on the top of the IC. For more details about the IC construction and functions, you can refer to the data sheet.

Tthe Atmega8U2 programmed as a USB-to-serial converter. "Uno" means "One" in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards

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**Figure 5.2:** Pin diagram

**5.1.3.2 Pin Description:**

**VCC:** Digital supply voltage.

**GND:**Ground.

**Port B (PB[7:0]) XTAL1/XTAL2/TOSC1/TOSC2:**

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Depending on the clock selection fuse settings, PB6 can be used as input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier.

If the Internal Calibrated RC Oscillator is used as chip clock source, PB[7:6] is used as TOSC[2:1] input for the Asynchronous Timer/Counter2 if the AS2 bit in ASSR is set.

**Port C (PC[5:0]):**

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC[5:0] output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs,

Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

**PC6/RESET:**

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C.

If the RSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a Reset.

**Port D (PD[7:0]):**

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

**AVCC:** AVCC is the supply voltage pin for the A/D Converter, PC[3:0], and PE[3:2]. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC[6:4] use digital supply voltage, VCC.

**AREF:** AREF is the analog reference pin for the A/D Converter.

**ADC [7:6] (TQFP and VFQFN Package Only):** In the TQFP and VFQFN package, ADC[7:6] serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels.

**12. ICSP pin:** Mostly, ICSP (12) is an AVR, a tiny programming header for the Arduino consisting of MOSI, MISO, SCK, RESET, VCC, and GND. It is often referred to as an SPI (Serial Peripheral Interface), which could be considered as an "expansion" of the output. Actually, you are slaving the output device to the master of the SPI bus.

**13. Power LED indicator:** This LED should light up when you plug your Arduino into a power source to indicate that your board is powered up correctly. If this light does not turn on, then there is something wrong with the connection.

**14. TX and RX LEDs:** On your board, you will find two labels: TX (transmit) and RX (receive). They appear in two places on the Arduino UNO board. First, at the digital pins 0 and 1, to indicate the pins responsible for serial communication. Second, the TX and RX led (13). The TX led flashes with different speed while sending the serial data. The speed of flashing depends on the baud rate used by the board. RX flashes during the receiving process.

**15. Digital I / O:** The Arduino UNO board has 14 digital I/O pins (15) (of which 6 provide PWM (Pulse Width Modulation) output. These pins can be configured to work as input digital pins to read logic values (0 or 1) or as digital output pins to drive different modules like LEDs, relays, etc. The pins labeled “~” can be used to generate PWM.

**16. AREF:**AREF stands for Analog Reference. It is sometimes, used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pinsworking.