Digital Signal Processing Labs

LazR ('3')

17 Martie, 2024

Contents

1 ATMEGA16 Microcontroller

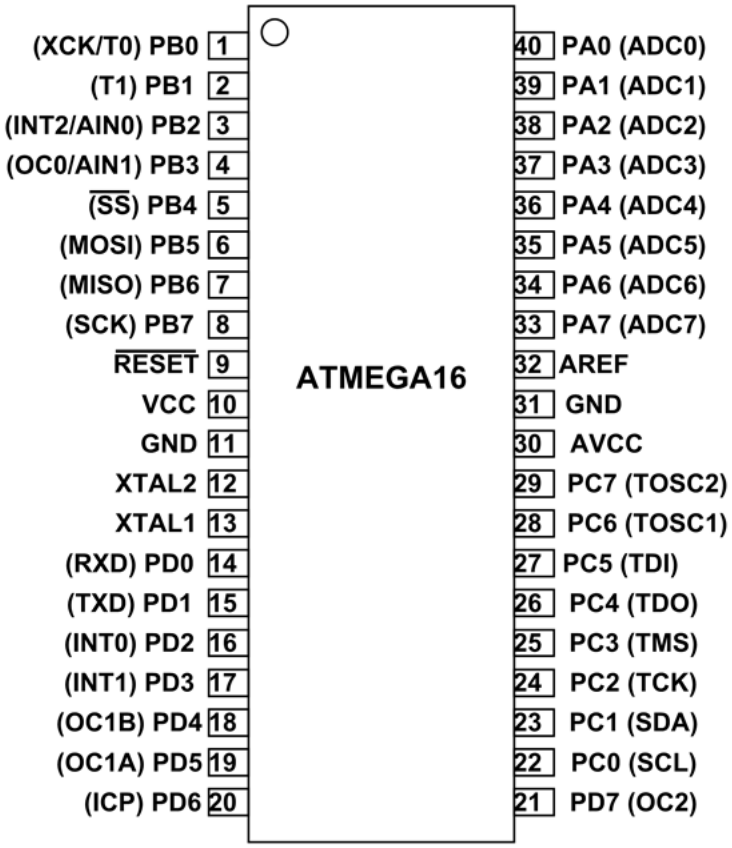
ATMEGA16 is an 8-bit ***MEGA-AVR*** microcontroller, designed around a ***RISC*** architecture core surrounded with peripheral devices. The microcontroller has:

- 16 KB of ***Flash memory*** available for code;
- 1 KB of ***SRAM***;
- 512 bytes of ***EEPROM*** memory.

The main peripheral devices available in the ATMEGA16 microcontroller are:

- 2 x 8-bit ***timers***;
- 1 x 16-bit timer;
- Real time ***counter***;
- 4 channel of ***PWM***;
- ***ISP*** interface;
- ***UART*** interface;
- ***Analog to Digital Converter***;
- 4 x 8-bit General Purpose Input Output Ports.

It is available in 40 pin ***DIP*** capsule, thus making it perfect for building small circuits on a breadboard. It can be clocked using an internal ***RC oscillator***.
The pinout is presented below.



It has 4 ports available for connections: *PORTA*, *PORTB*, *PORTC*, *PORTD*. Functions are multiplexed on one pin: each pin has its alternated function written in brackets - for example, pin *PD0* is normally a ***GPIO*** pin belonging to *PORTD*, but when the *serial interface* is activated, the function changes to the ***RXD*** signal of the serial interface. Note that in order to use the lines of *PORTA*, power needs to be applied to the ***AVCC*** pin.

ATMEGA16 may be programmed either by using the *ISP* interface (involving the *PINS* 5-11) or by using a dedicated ***JTAG*** debugger. *ISP* programming is limited only to downloading the executable code from PC into the ***MCU's*** *flash memory* and programming of the ***Fuse Bits*** - there's no real-time debugging provided by the interface, instead, a ***JTAG*** debugger is required. The debugger is conected to the ***MCU*** through dedicated pins (in this case, *PC2* - *PC5*). If the ***JTAG*** interface is enabled,

the dedicated pins cannot be used for programming. Critical settings, such as the option to enable/disable the debugger interface, are configured by accessing the ***Fuse Bits*** - registers which may only be accessed by the ***ISP*** or ***JTAG*** interfaces. They cannot be accessed by the ***Flash memory*** and are not visible to the programmer.
Using the Fuse Bits the following items may be configured:

- JTAG interface – it may be enabled or disabled;

- ISP interface – it may be enabled or disabled;

- Preservation of the contents of the internal EEPROM memory upon programming the FLASH memory;

- ***Brown-out detector***;

- ***Clock source*** – various internal RC oscillator clock frequencies, external quartz oscillator, external clock source.

The ***MCU*** will be used alongside a small header board which will export the pins on an external header. The header board will be interfaced with a peripheral board, consisting of an isolated ***breadboard*** mechanically linked to an electronic board containing peripherals such as ***LEDs***, ***push buttons***, ***serial interface***, LCD, connectors etc. The connection is purely mechanical - electrical conections require usage of the header surrounding the breadboard.

??? Glossary

???.? A

Arithmetic logic unit - combinational digital circuit that performs arithmetic and bitwise operations on integer binary numbers; in contrast to floating-point unit;

Asynchronous device - not using an internal global clock or signal generator to synchronize its components, rather relying on external handshaking circuits.

???.? B

Ball grid array (BGA) - type of surface-mount packaging (a chip carrier) used for integrated circuits; used to permanently mount devices such as microprocessors.

Breadboard - construction base used to build semi-permanent prototypes of electronic circuits; unlike a perfboard or stripboard, breadboards do not require soldering or destruction of tracks and are hence reusable.

Brown-out - a reduction in or restriction on the availability of electrical power in a particular area.

Bus - communication system that transfers data between components inside a computer, or between computers; covers all related hardware components (wire, optical fiber, etc.) and software, including communication protocols.

???.? C

Combinational logic - type of digital logic where the output is a pure function of the present input only; in contrast to sequential logic.

???.? D

Dual in-line package (DIP) - electronic component package with a rectangular housing and two parallel rows of electrical connecting pins.

Duty cycle - the fraction of one period in which a signal or system is active; commonly expressed as a percentage or a ratio.

???.? E

Electrically erasable programmable read-only memory (EEPROM) - type of non-volatile memory; used in computers, usually integrated in microcontrollers such as smart cards and remote keyless systems, or as a separate chip device, to store relatively small amounts of data by allowing individual bytes to be erased and reprogrammed.

Electronic oscillator - electronic circuit that produces a periodic, oscillating or alternating current signal, usually a sine wave, square wave or a triangle wave, powered by a direct current source.

???.? F

Flash memory - electronic non-volatile computer memory storage medium that can be electrically erased and reprogrammed.

Flip-flops - circuits that have two stable states that can store state information – a bistable multivibrator; the circuit can be made to change state by signals applied to one or more control inputs and will output its state; it is the basic storage element in sequential logic; they are fundamental building blocks of digital electronics systems used in computers, communications, and many other types of systems.

Floating-point unit - part of a computer system specially designed to carry out operations on floating-point numbers.

???.? G

General purpose input/output (GPIO) - uncommitted digital signal pin on an integrated circuit or electronic circuit (e.g. MCUs/MPUs) board which may be used as an input or output, or both, and is controllable by software.

???.? I

???.? J

Joint Action Test Action Group (JTAG) - industry standard for verifying designs and testing printed circuit boards after manufacture; implements standards for on-chip instrumentation in electronic design automation (EDA) as a complementary tool to digital simulation.

???.? L

Latches - same as flip-flops.

Linear circuit - electronic circuit which obeys the superposition principle.

???.? M

Microcontroller - small computer on a single integrated circuit; contains one or more CPUs, along with memory and programmable input/output peripherals; intended for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications consisting of various discrete chips.

Multivibrator - electronic circuit used to implement a variety of simple two-state devices such as relaxation oscillators, timers, latches and flip-flops; they're called like that because their output waveform is rich in harmonics.

???.? N

Non-volatile memory - type of computer memory that can retain stored information even after power is removed. In contrast, volatile memory needs

constant power in order to retain data.

???.? P

Printed circuit board (PCB) - medium used to connect or ”wire” components to one another in a circuit.

Pulse-width modulation (PWM) - any method of representing a signal as a rectangular wave with a varying duty cycle (and for some methods also a varying period).

???.? R

Random access memory (RAM) - form of electronic computer memory that can be read and changed in any order, typically used to store working data and machine code.

RC osciallator - linear oscillator circuit which uses an RC network for its frequency selective part.

Resistor-capacitor circuit (RC) - electric circuit composed of resistors and capacitors.

Reduced instruction set computer (RISC) - computer architecture designed to simplify the individual instructions given to the computer to accomplish tasks; might require more instructions (more code) in order to accomplish a task because the individual instructions are written in simpler code; goal is to offset the need to process more instructions by increasing the speed of each instruction, in particular by implementing an instruction pipeline, which may be simpler to achieve given simpler instructions.

RXD - receive data.

???.? S

Sequential logic - type of logic circuit whose output depends on the present value of its input signals and on the sequence of past inputs, the input history; in contrast to combinational logic.

Serial communication - communication method that uses one or two transmission lines to send and receive data, and that data is continuously sent and received one bit at a time.

Shift register - type of digital circuit using a cascade of flip-flops where the output of one flip-flop is connected to the input of the next; they share a single clock signal, which causes the data stored in the system to shift from one location to the next.

Static random access memory (SRAM) - random-access memory that uses latching circuitry (flip-flop) to store each bit; SRAM is volatile memory; data is lost when power is removed.

System on a chip (SoC) - integrated circuit that integrates most, if not all of the components of a computer or other electronic system.

Serial Peripheral Interface - an interface bus commonly used to send data between microcontrollers and small peripherals such as shift registers, sensors, and SD cards.

???.? T

Through-hole technology - manufacturing scheme in which leads on the components are inserted through holes drilled in printed circuit boards and soldered to pads on the opposite side, either by manual assembly (hand placement) or by the use of automated insertion mount machines.

TXD - transmit data.

???.? U

Universal asynchronous receiver-transmitter (UART) - peripheral device for asynchronous serial communication in which the data format and transmission speeds are configurable.